

User Guide

Cyanide Ion
Selective
Electrode



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Orion NoCal electrodes with stabilized potential patent pending.

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This publication supersedes all previous publications on this subject.

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GENERAL INFORMATION

Introduction

This user guide contains information on the preparation, operation and maintenance for the cyanide ion selective electrode (ISE). General analytical procedures, electrode characteristics and electrode theory are also included in this user guide. Cyanide electrodes measure cyanide ions in aqueous solutions quickly, simply, accurately and economically.

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.

Cyanide ionplus[®] Sure-Flow[®] Solid State Combination ISE

The reference and sensing electrodes are built into one electrode, which decreases the amount of required solution and reduces waste. The built-in Sure-Flow reference junction prevents electrode clogging and provides fast and stable readings. The cyanide ionplus combination ISE is available with a waterproof BNC connector, Cat. No. 9606BNWP.

Cyanide Solid State Half-Cell ISE

The cyanide half-cell electrode must be used with the double junction reference electrode, Cat. No. 900200. The cyanide half-cell is available with a BNC connector, Cat. No. 9406BN and a screw cap connector, Cat. No. 9406SC.

Required Solutions

Distilled or Deionized Water

Reference Filling Solution

Use Optimum Results B filling solution, Cat. No. 900062, with the 9606BNWP cyanide combination electrode.

Use the outer chamber filling solution, Cat. No. 900003, and inner chamber filling solution, Cat. No. 900002, that are supplied with the reference electrode, Cat. No. 900200, that is used with the 9406BN and 9406SC cyanide half-cell electrodes.

Ionic Strength Adjustor (ISA), Cat. No. 951011

To adjust solution pH to operating range of electrode and keep a constant background ionic strength.

Cyanide Standard Solutions

Required Chemicals: Reagent-grade sodium cyanide or reagent-grade potassium cyanide

10⁻² M cyanide stock standard– Add 0.490 g dry, reagent-grade NaCN or 0.651 g dry, reagent-grade KCN to a 1 liter volumetric flask. Add 10 mL ISA and 500 mL distilled water to dissolve the solid. Add distilled water to the one liter volume mark.

1000 ppm cyanide stock standard– Add 1.88 g dry, reagent-grade NaCN or 2.50 g dry, reagent-grade KCN to a 1 liter volumetric flask. Add 10 mL ISA and 500 mL distilled water to dissolve the solid. Add distilled water to bring the volume to one liter.

Store stock standards in plastic bottles and prepare fresh weekly. Lower concentration working standards used for calibration should be prepared daily.

Checking Electrode Operation (Slope)

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

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

1. If electrode(s) have been stored dry, prepare the electrode(s) as described in **Electrode Preparation**.
2. Connect the electrode(s) to the meter as described in the meter user guide. Non-Thermo Scientific Orion meters may require special adapters. Consult your meter user guide.
3. Place 100 mL distilled water into a 150-mL beaker. Add 1 mL ISA (Cat. No. 951011). Stir thoroughly at a slow to moderate speed.

NOTE: Do not create a vortex in the solution. Do not change the position of the electrode during this procedure.

4. Set the meter to the mV mode.
5. Rinse electrode(s) with distilled water, blot dry, and place in the solution prepared in Step 3 above.
6. Use 0.1 M or 1000 ppm cyanide standard in the following steps. Pipet 1 mL of the standard into the beaker. Stir thoroughly as directed in step 3. When a stable reading is displayed, record the electrode potential in millivolts.
7. Pipet 10 mL of the same standard into the same beaker. Stir thoroughly as directed in step 3. When a stable reading is displayed record the electrode potential in millivolts.
8. The difference between the first and second potential reading is defined as the slope of the electrode. The difference should be in the range of (-) 54-60 mV/ decade when the solution temperature is between 20 and 25 °C. If the slope is not within the appropriate range refer to the **Troubleshooting** section.

GLP Measuring Hints

See **Figure 1**.

- Stir all standards and samples at a uniform rate during measurement. Stir thoroughly at a slow to moderate speed. Do not create a vortex in the solution. Do not change the position of the electrode while calibrating or measuring samples. Magnetic stirrers may generate sufficient heat to change solution temperature. Place a piece of insulating material such as cork, cardboard, or styrofoam between the stirrer and sample beaker.
- Prepare fresh working standards for calibration daily.
- Always rinse electrode(s) with distilled water between measurements. Shake after rinsing to prevent solution carryover. Blot dry.
- Allow all standards and samples to come to the same temperature for precise measurement.
- The 900200 reference electrode (when used with the 9406BN and 9406SC cyanide half-cell electrode) should be submerged to the same depth as the cyanide electrode.
- Concentrated samples (> 25 ppm or 10^{-3} M cyanide) should be diluted before measurement.
- After immersion in solution, check electrode(s) for any air bubbles on the sensing element and remove by gently tapping the electrode(s).
- For high ionic strength samples, prepare standards with composition similar to that of the sample.

CHOOSING THE RIGHT MEASURING TECHNIQUE

A variety of analytical techniques are available to the analyst.

Direct Measurement is a simple procedure for measuring a large number of samples. Only one meter reading is required for each sample. Calibration is performed in a series of standards. The concentration of the samples is determined by comparison to the standards. ISA is added to all solutions to ensure that samples and standards have similar ionic strength and proper pH.

Low-Level Measurement is similar to Direct Measurement. This method is recommended when the expected sample concentration is less than 0.5 ppm or 2×10^{-5} M CN⁻. A minimum three point calibration is recommended to compensate for the electrode's non-linear response at these concentrations. A special procedure describes the best means of preparing low-level calibration standards.

Known Addition is a useful method for measuring samples, since calibration is not required. This method is recommended when measuring only a few samples, or when samples have a high (> 0.1 M) ionic strength, or a complicated back-ground matrix. Refer to **Theory of Operation** for explanation of these effects. The electrodes are immersed in the sample solution and an aliquot of a standard solution containing the measured species is added to the sample. From the change in potential before and after the addition, the original sample concentration is determined. As in direct calibration, any convenient concentration unit can be used.

Direct Measurement Procedure using ISE Meter

See the meter user guide for more specific calibration information.

1. Prepare electrode(s) as described in **Electrode Preparation**.
2. Connect electrode(s) to the meter, and adjust the meter to measure concentration.
3. Prepare two standards that bracket the expected sample range and differ in concentration by a factor of ten. Standards can be prepared in any concentration unit to suit the particular analysis requirement. All standards should be at the same temperature as the samples. For details on temperature effects on electrode performance, refer to **Temperature Effects**.
4. Measure 100 mL of each standard and sample into separate 150 mL beakers. Add 1 mL ISA to each beaker. Stir thoroughly.

NOTE: Other solution volumes may be used, as long as the ratio of solution to ISA remains 100:1.

5. Rinse electrode(s) with distilled water, blot dry and place into the beaker containing the most dilute standard. Wait for a stable reading, then calibrate the meter to display the value of the standard as described in the meter user guide.
6. Rinse electrode(s) with distilled water, blot dry, and place into the beaker with the next standard. Wait for a stable reading, then adjust the meter to display the value of this standard, as described in the meter user guide.
7. Repeat step 6 for all standards, working from the least concentrated to most concentrated standard.
8. Rinse electrode(s) with distilled water, blot dry, and place into sample. The concentration will be displayed on the meter.

Direct Measurement Procedure using a meter with mV readout

1. Prepare electrode(s) as described in **Electrode Preparation**.
2. Connect electrode(s) to the meter, and adjust the meter measure mV.
3. Prepare two standards that bracket the expected sample range and differ in concentration by a factor of ten. Standards can be prepared in any concentration unit to suit the particular analysis requirement. All standards should be at the same temperature as the samples. For details on temperature effects on electrode performance, refer to **Temperature Effects**.
4. Measure 100 mL of each standard and sample into separate 150 mL beakers. Add 1 mL ISA to each beaker. Stir thoroughly.

NOTE: Other solution volumes may be used, as long as the ratio of solution to ISA remains 100:1.

5. Rinse electrode(s) with distilled water, blot dry and place into the beaker containing the most dilute standard. When a stable reading is displayed, record the mV value and corresponding standard concentration.
6. Rinse electrode(s) with distilled water, blot dry, and place into the beaker with the next standard. When a stable reading is displayed, record the mV value and corresponding standard concentration.
7. Repeat step 6 for all standards, working from the least concentrated to most concentrated standard.
8. Using semi-logarithmic graph paper, prepare a calibration curve by plotting the millivolt values on the linear axis and the standard concentration values on the logarithmic axis. See **Figure 2**.
9. Rinse electrode(s) with distilled water, blot dry, and place into sample. When a stable reading is displayed, record the mV value.
10. Using the calibration curve prepared in step 8, determine the unknown sample concentration.

- When not using an ISE meter, a calibration curve can be drawn on semi-logarithmic graph paper, or the data can be processed at the discretion of the user by means of a spreadsheet or graphing program with a non-linear curve fitting feature.
 - When using ISE meters, three calibration points are sufficient. If a calibration curve is prepared manually, additional points may be helpful to facilitate drawing the curve.
- Remember to stir all standards and samples at a uniform rate. Stir thoroughly at a slow to moderate speed. Do not create a vortex in the solution. Do not change the position of the electrode while calibrating or measuring samples.
 - Typical response time for this electrode is approximately 1 minute. Low-level measurements may take longer to stabilize. Wait for 3 minutes or the meter’s “ready” signal, whichever takes longer, before calibrating the meter or recording the sample value.
 - Review section entitled **GLP Measuring Hints**.

Low-Level Measurement Procedure using ISE Meter

Follow the above procedure entitled **Direct Measurement Procedure using ISE Meter**. Use at least three calibration standards. Read the **Measuring Hints** section to select appropriate standard concentrations. Refer to the meter user guide for detailed calibration procedures. If not using a meter with the autoblack feature, preparation of a blank solution is recommended to ensure accurate results.

Low-Level Measurement Procedure using a meter with mV readout (see Table 2)

Setup

1. Prepare electrode(s) as described in **Electrode Preparation**.
2. Connect electrode(s) to the meter. Set the meter to read mV.
3. Select a standard solution. Use either a 10 ppm cyanide standard or a 10^{-3} M cyanide solution.

Known Addition

Known addition is a convenient technique for measuring samples in the linear range, greater than 0.5 ppm or 2×10^{-5} M CN^- , because no calibration curve is needed. The sample potential is measured before and after addition of a standard solution. Many meters have the known addition algorithms preprogrammed. This programming allows multiple standard additions to be made to the sample, thereby allowing the meter to calculate the electrode slope as well. Having the ability to read the sample concentration directly from the meter is a great convenience and ensures accuracy.

Measuring Hints

- Sample concentration should be known within a factor of three.
- Concentration should approximately double as a result of the first standard addition.
- With double or multiple known addition, the final addition should be 10 to 100 times the sample concentration.
- All samples and standards should be at the same temperature.
- Add 1 mL ISA to every 100 mL of sample before analysis.
- Standard addition volume should be no more than 10% of the sample volume, or standard should be pre-treated with ISA in a 100:1 ratio. See **Table 3**.
- Review section entitled **GLP Measuring Hints**.

Known Addition Measurement Procedure using a meter with mV readout

See the meter user guide for more specific information.

1. Set the meter to millivolt mode.
2. Measure 100 mL of the sample into a 150 mL beaker. Add 1 mL ISA. Stir thoroughly.
3. Rinse electrode(s) with distilled water, blot dry, and place into beaker. When a stable reading is displayed, record the mV value as E_1 .
4. Pipet the appropriate amount of standard solution into the beaker. See **Table 3**. Stir thoroughly.
5. When a stable reading is displayed, record the mV value as E_2 . Subtract the first reading from the second to find DE.
6. From **Table 5**, find the value Q, that corresponds to the change in potential, DE. To determine the original sample concentration, multiply Q by the concentration of the added standard:

$$C_{sam} = Q * C_{std}$$

where:

C_{std} = standard concentration

C_{sam} = sample concentration

Q = reading from known addition table

The table of Q values is calculated for a 10% volume change for electrodes with slopes of -57, -58, -59, -60 mV/decade for cyanide. The equation for the calculation of Q for different slopes and volume changes is given below:

$$Q = \frac{p * r}{(1+p)10DE/S - 1}$$

where:

Q = reading from known addition table

DE = $E_2 - E_1$

S = slope of the electrode

p = (volume of standard) / (volume of sample & ISA)

r = (volume of sample & ISA) / (volume of sample)

Table 5
Known Addition Table for an added volume one-tenth the total volume. Slopes, in the column headings, are in units of mV/decade.

ΔE	Q, Concentration Ratio (slope)			
	57.2	58.2	59.2	60.1
5.0	0.2917	0.2957	0.2996	0.3031
5.2	0.2827	0.2867	0.2906	0.2940
5.4	0.2742	0.2781	0.2820	0.2854
5.6	0.2662	0.2700	0.2738	0.2772
5.8	0.2585	0.2623	0.2660	0.2693
6.0	0.2512	0.2550	0.2586	0.2619
6.2	0.2443	0.2480	0.2516	0.2548
6.4	0.2377	0.2413	0.2449	0.2480
6.6	0.2314	0.2349	0.2384	0.2416
6.8	0.2253	0.2288	0.2323	0.2354
7.0	0.2196	0.2230	0.2264	0.2295
7.2	0.2140	0.2174	0.2208	0.2238
7.4	0.2087	0.2121	0.2154	0.2184
7.6	0.2037	0.2070	0.2102	0.2131
7.8	0.1988	0.2020	0.2052	0.2081
8.0	0.1941	0.1973	0.2005	0.2033
8.2	0.1896	0.1927	0.1959	0.1987
8.4	0.1852	0.1884	0.1914	0.1942
8.6	0.1811	0.1841	0.1872	0.1899
8.8	0.1770	0.1801	0.1831	0.1858
9.0	0.1732	0.1762	0.1791	0.1818
9.2	0.1694	0.1724	0.1753	0.1779
9.4	0.1658	0.1687	0.1716	0.1742
9.6	0.1623	0.1652	0.1680	0.1706
9.8	0.1590	0.1618	0.1646	0.1671
10.0	0.1557	0.1585	0.1613	0.1638
10.2	0.1525	0.1553	0.1580	0.1605
10.4	0.1495	0.1522	0.1549	0.1573
10.6	0.1465	0.1492	0.1519	0.1543
10.8	0.1437	0.1463	0.1490	0.1513
11.0	0.1409	0.1435	0.1461	0.1485
11.2	0.1382	0.1408	0.1434	0.1457
11.4	0.1356	0.1382	0.1407	0.1430
11.6	0.1331	0.1356	0.1381	0.1404
11.8	0.1306	0.1331	0.1356	0.1378
12.0	0.1282	0.1307	0.1331	0.1353
12.2	0.1259	0.1283	0.1308	0.1329
12.4	0.1236	0.1260	0.1284	0.1306
12.6	0.1214	0.1238	0.1262	0.1283
12.8	0.1193	0.1217	0.1240	0.1261
13.0	0.1172	0.1195	0.1219	0.1239
13.2	0.1152	0.1175	0.1198	0.1218
13.4	0.1132	0.1155	0.1178	0.1198
13.6	0.1113	0.1136	0.1158	0.1178
13.8	0.1094	0.1117	0.1139	0.1159
14.0	0.1076	0.1098	0.1120	0.1140
14.2	0.1058	0.1080	0.1102	0.1121
14.4	0.1041	0.1063	0.1084	0.1103
14.6	0.1024	0.1045	0.1067	0.1086
14.8	0.1008	0.1029	0.1050	0.1069

ΔE	Q, Concentration Ratio (slope)			
	57.2	58.2	59.2	60.1
40.0	0.0223	0.0230	0.0238	0.0245
40.5	0.0217	0.0225	0.0232	0.0239
41.0	0.0212	0.0219	0.0227	0.0234
41.5	0.0207	0.0214	0.0221	0.0228
42.0	0.0202	0.0209	0.0216	0.0223
42.5	0.0197	0.0204	0.0211	0.0218
43.0	0.0192	0.0199	0.0206	0.0213
43.5	0.0188	0.0195	0.0202	0.0208
44.0	0.0183	0.0190	0.0197	0.0203
44.5	0.0179	0.0186	0.0192	0.0198
45.0	0.0175	0.0181	0.0188	0.0194
45.5	0.0171	0.0177	0.0184	0.0190
46.0	0.0167	0.0173	0.0179	0.0185
46.5	0.0163	0.0169	0.0175	0.0181
47.0	0.0159	0.0165	0.0171	0.0177
47.5	0.0156	0.0162	0.0168	0.0173
48.0	0.0152	0.0158	0.0164	0.0169
48.5	0.0148	0.0154	0.0160	0.0166
49.0	0.0145	0.0151	0.0157	0.0162
49.5	0.0142	0.0147	0.0153	0.0158
50.0	0.0139	0.0144	0.0150	0.0155
50.5	0.0135	0.0141	0.0146	0.0151
51.0	0.0132	0.0138	0.0143	0.0148
51.5	0.0129	0.0135	0.0140	0.0145
52.0	0.0126	0.0132	0.0137	0.0142
52.5	0.0124	0.0129	0.0134	0.0139
53.0	0.0121	0.0126	0.0131	0.0136
53.5	0.0118	0.0123	0.0128	0.0133
54.0	0.0116	0.0120	0.0125	0.0130
54.5	0.0113	0.0118	0.0123	0.0127
55.0	0.0110	0.0115	0.0120	0.0125
55.5	0.0108	0.0113	0.0118	0.0122
56.0	0.0106	0.0110	0.0115	0.0119
56.5	0.0103	0.0108	0.0113	0.0117
57.0	0.0101	0.0106	0.0110	0.0114
57.5	0.0099	0.0103	0.0108	0.0112
58.0	0.0097	0.0101	0.0105	0.0110
58.5	0.0095	0.0099	0.0103	0.0107
59.0	0.0093	0.0097	0.0101	0.0105
59.5	0.0091	0.0095	0.0099	0.0103
60.0	0.0089	0.0093	0.0097	0.0101

ELECTRODE MAINTENANCE

Cyanide Electrode Polishing Procedure

To be used when electrode becomes sluggish or drifts

1. Cut off a 1-inch length of the polishing strip, Cat. No. 948201
2. Hold electrode with the sensing element facing upwards.
3. Place a few drops of distilled water on the sensing element surface.
4. With the frosted side down, place the polishing strip on the sensing element using light finger pressure.
5. Rotate the electrode for about 30 seconds.
6. Rinse and soak in a 1 ppm or 10^{-5} M CN^- standard solution for about two minutes before use.

Disassembly And Cleaning of 9606BNWP Sure-Flow Cyanide Combination Electrode

Disassembly is not normally required or recommended. When the area between the electrode sleeve and inner cone becomes clogged with sample or precipitate from the filling solution, the chamber can be cleaned by flushing out with filling solution. (Hold the electrode by the cap with one hand and push the outer sleeve of the electrode up into the cap to drain the chamber.) If the chamber is not completely clean, repeat the procedure. Refill with the appropriate filling solution.

TROUBLESHOOTING

Troubleshooting Checklist

Symptom	Possible Causes
Off-scale or Over-range reading	Defective meter
	Defective electrode
	Electrodes not plugged improperly
	Reference electrode junction is dry
	 Reference electrode chamber not filled
	Air bubble on electrode
Electrodes not in solution	
Noisy or unstable readings (readings continuously or rapidly changing)	Defective meter
	Meter or stirrer improperly grounded
	Air bubble on electrode
	Wrong reference electrode
	ISA not used
Drift (Reading slowly changing in one direction)	Samples and standards at different temperatures
	Sensing element dirty or etched
	Incorrect reference filling solution

Symptom	Possible Causes
Low slope or No slope	Electrodes not properly conditioned Standards contaminated or incorrectly made ISA not used Standard used as ISA Electrode exposed to interferences
High Slope	Stirring solution too rapidly
“Wrong Answer” (But calibration curve is OK)	Incorrect scaling of semilog paper Incorrect sign Incorrect standards Wrong units used Complexing agents in sample

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) Standard 4) Sample and 5) Technique.

See also **GLP Measuring Hints** section.

Meter

The meter is the easiest component to eliminate as a possible cause of error. Thermo Scientific Orion meters are provided with an instrument checkout procedure in the user guide and a shorting cap 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 electrode(s) thoroughly with distilled water.
2. Determine electrode slope, see **Checking Electrode Operation**.
3. If electrode fails this procedure, prepare electrode(s) as directed in **Electrode Preparation**. Clean electrode(s) as described in **Electrode Maintenance**.
4. Repeat step 2, **Checking Electrode Operation**.
- 5a. For the 9406BN and 9406SC Cyanide Half-Cell Electrode:
If the electrodes still do not perform as described, determine whether the cyanide or reference electrode is at fault. To do this, substitute a known working electrode for the electrode in question and repeat the slope check.
- 5b. For the 9606BNWP Sure-Flow Cyanide Combination Electrode:
If the electrode still does not perform as described replace the electrode.
6. 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, Sample, and Technique sections**.

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/water.

Warranty

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

Temperature Effects

Since the electrode potentials are affected by changes in temperature, samples and standard solutions should be within $\pm 1\text{ }^{\circ}\text{C}$ ($\pm 2\text{ }^{\circ}\text{F}$) of each other. At the 10^{-3} M level, a $1\text{ }^{\circ}\text{C}$ difference in temperature results in errors greater than 2%. The absolute potential of the reference electrode changes slowly with temperature because of the solubility equilibria on which the electrode depends. The slope of the electrode also varies with temperature, as indicated by the "S" in the Nernst equation, see **Theory of Operation**. Theoretical values of the slope at different temperatures are given in **Table 6**. If temperature changes occur, meter and electrodes should be recalibrated.

The electrode can be used at temperatures from 0° to $80\text{ }^{\circ}\text{C}$, 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. Electrode life is significantly shorter when used above $80\text{ }^{\circ}\text{C}$.

Table 6
Theoretical Values of Electrode
Slope vs. Temperature

$^{\circ}\text{C}$	Slope (CN ⁻)
0	- 54.2
10	- 56.2
20	- 58.2
25	- 59.2
30	- 60.1
40	- 62.1
50	- 64.1

Limits of Detection

Although the electrode responds to cyanide levels from 8×10^{-6} M to 10^{-2} M, cyanide ion attacks the sensing element. Measurements above 10^{-3} M should be done only intermittently.

The lower limit of detection is determined by the very slight water solubility of the sensing element. At low levels the electrode responds to cyanide in the sample as well as to ions dissolved from the sensing element. The discrepancy between the theoretical linear response in comparison with the actual response (full line) curves is due to the response to dissolved ions from the sensing element.

For low levels, care must be taken not to lose cyanide. Use plastic labware. Cover beakers with Parafilm. Allow longer stabilization time prior to reading meter to assure best results.

Complexation

The electrode is strongly selective for cyanide, and will detect not only free cyanide ions, but cyanide in certain weak complexes with metals. The response depends on the stability of the metal-cyanide complex. Thus, for a zinc or cadmium complex, if the solution is diluted to between 10^{-2} and 10^{-5} M in cyanide, the electrode will give the total cyanide present, regardless of the amount of the zinc or cadmium in the solution. Stronger complexes, like copper, silver or gold, give only the free cyanide.

Many metal ions, such as copper and nickel, complex cyanide strongly. These can be broken up with EDTA. To a sample whose cyanide concentration is not more than 10 ppm, or about 10^{-3} M (dilute more concentrated samples), add enough acetic acid to make the sample solution pH 4, then add tetrasodium EDTA to a level of 0.02 M (0.76 g Na_4 EDTA per 100 mL sample). Heat in a hood to about 50°C for five minutes to speed up the decomplexing. Cool the solution. Add 10 M NaOH ISA to raise the pH to 13. EDTA complexes of the metals break up very slowly so that the cyanide remains free long enough for concentration measurements to be made.

Mathematically, ionic strength is defined as:

$$I = \frac{1}{2} \sum (C_i Z_i^2)$$

where:

C_i	=	concentration of ion i
Z_i	=	charge of ion i
\sum	=	symbolizes the sum of all the types of ions in solution.

If the background ionic strength is high and constant relative to the ion concentration, the activity coefficient is constant and activity is directly proportional to concentration. Ionic strength adjustor (ISA) is added to all standards and samples so that the background ionic strength is high and constant relative to variable concentrations of cyanide. For cyanide the recommended ISA is 10 M NaOH. Other solutions can be used as long as they do not contain ions that would interfere with the electrode's response to cyanide. If samples have a high ionic strength (above 0.1 M), standards should be prepared with a composition similar to the samples.

Reference electrode conditions must also be considered. Liquid-junction potentials arise any time two solutions of different composition are brought into contact. The potential results from the interdiffusion of ions in the two solutions. Since ions diffuse at different rates, electrode charge will be carried unequally across the solution boundary resulting in a potential difference between the two solutions. In making electrode measurements, it is important that this potential be the same in the standardizing solution as in the sample solution; otherwise, the change in liquid-junction potential will appear as an error in the measured electrode potential.

Optimum Results filling solutions are specifically designed to meet all reference electrode conditions. The filling solution is equitransferent. Therefore, the speed with which the positive and negative ions in the filling solution diffuse into the sample is as nearly equal as possible. If the rate at which positive and negative charge is carried into the sample solution is equal, then minimum junction potential can result.

SPECIFICATIONS

Concentration Range:

8×10^{-6} M to 10^{-2} M (0.2 ppm to 260 ppm)

pH Range:

0 to 14 (sample pH range 10-14 recommended)

Temperature Range:

0 - 80 °C

Electrode Resistance:

Less than 30 megohms

Reproducibility:

$\pm 2\%$

Size:

Length:	110 mm (excluding cap)
Diameter:	12 mm (9406BN and 9406SC) 13 mm (9609BNWP)
Cap Diameter:	16 mm
Cable Length:	1 meter

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