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# Broadley-James® DynaProbe® ORP Sensors

Designed with a  
**Patented Solid State**  
REFERENCE HALF-CELL

*For use in all industrial process ORP  
(Redox) measurement applications.*

### SENSOR SPECIFICATIONS

ORP Range:	±5000 mV
Sensing Tip:	Platinum Band, 99.99% pure, 0.25" O.D. x 0.1" L
Temperature Range:	0 - 140°C*
Pressure Range:	50 - 300 psig*
Cable:	Dual Shielded, Low Noise Coax

\* varies depending upon Model selected

### PREPARATION FOR USE:

1. Remove storage boot containing the storage solution (3.8 Molar KCl) by unwinding the black sealing tape from the sensor housing.

#### NOTE:

- **DO NOT** remove the wetted fiber pack from inside the storage boot.

2. Save the storage boot with fiber pack for future use as a storage container and bulb protector when sensor is not in service. Be certain to use 3.8M KCl (BJC P/N: AS-3120-C20-0500) as the storage solution. Seal boot to sensor with black electrician's tape using 3 to 5 complete wraps.

3. *For first-time use after removing the storage boot:* Inspect the sensor for any signs of breakage or shipping damage and commence with Calibration Procedures.

4. *For sensors with replaceable O ring seals:* All O rings require proper lubrication. We recommend use of **PARKER O LUBE** or equal for this purpose. Follow the instructions provided with lubricant. For best results we recommend that all O rings be replaced whenever sensor is removed for service or inspection.

#### CAUTION:

**Hand-tighten only!** It is not necessary to apply excessive torque to achieve a liquid tight installation. Severe twisting of the sensor housing could cause internal damage. If necessary, use wrench for removal only! For valve retractable sensors, refer to the SA857/SA858 or SA864 **Service Manual** for assembly, installation, and complete service instructions.

### CALIBRATION PROCEDURE:

1. Unlike pH sensors, the measurement half-cell of the ORP (Redox) sensors undergo no changes of zero-point nor of slope. Nevertheless, incorrect redox potentials may be occasionally measured and the cause of these errors is usually a contaminated Pt surface. In such cases, the sensor may be regenerated by cleaning as described in the next section. To test the Redox DynaProbe's accuracy proceed with the following Quinhydrone tests.

#### CAUTION:

**Quinhydrone is very toxic and should be handled by qualified technicians only. Handle with care and avoid ingesting. Avoid contact with bare skin. Dispose of the Quinhydrone solutions per your local waste water regulations.**

2. The oxidation-reduction potential of a Quinhydrone solution is pH dependent. By saturating pH buffers with Quinhydrone you can make stable mV standard solutions to use in testing your Redox DynaProbe. Ideal values for some common buffers (saturated with Quinhydrone) are listed below:

7.00 pH            +86 mV

4.01 pH            +263 mV

$\Delta = 2.99 \text{ pH}$      $\Delta = 177 \text{ mV}$

3. Sensor construction and prior usage will make the actual magnitude of the first two test readings vary. The actual readings in the buffers could vary by ± 20 mV.

However, a clean Redox DynaProbe will give reproducible  $\Delta$  values of  $\Delta 173 \pm 4\text{mV}$ . It is this  $\Delta$  value that provides an indication of the functional performance of the sensor.

#### Procedure:

1. Place 50 -100 ml of pH 7.00 and 4.01 buffers in suitably sized beakers, stir about 0.2g/100ml of Quinhydrone into each buffer.

#### NOTE:

- The Quinhydrone will not all dissolve. The intention here is to prepare a saturated solution. There should be a little of the powder undissolved.

2. Prepare the Redox DynaProbe for testing by cleaning the platinum surface with a liquid hand soap and soft toothbrush (do not scar or scratch the platinum surface). Consult factory prior to use of solvents or other cleaning agents. Rinse thoroughly with clean tap water.

3. Connect the Redox DynaProbe to a suitable pH Meter, set to the millivolt scale.

4. Immerse the sensor in the pH 7.00-Quinhydrone mixture. The meter should read between +70 and +110 millivolts.

5. Rinse the sensor thoroughly with clean tap water, and immerse it in the pH 4.01-Quinhydrone mixture. The meter should now read between +240 and +280 millivolts.

#### NOTES:

- This test verifies the function of the platinum combination Redox (ORP) sensor by actual measurement of a known oxidation-reduction potential change. If a sensor responds ad-

equately in this test (e.g.  $\Delta 169$  to  $\Delta 177$  mV between the 7 and 4 buffer-Quinhydrone mixtures) but the values fall outside of these ranges, it indicates a plugged reference junction or a contaminated reference internal solution.

- The buffer-Quinhydrone mixtures will not remain useful for more than two hours since the Quinhydrone decomposes slowly in contact with air. Dispose of this solution per local waste water regulations.

### CLEANING A DYNAPROBE® WITH IMPAIRED RESPONSE:

Used sensors which are physically intact can sometimes be restored to an improved level of performance. All sensors have a given useful lifespan depending on the conditions of use. One of the following procedures may prove helpful in restoring a used sensor.

1. **Initial Cleaning:** Wash with a solution of liquid detergent or enzyme detergent and warm water by gently scrubbing with a soft toothbrush or tissue. Follow with thorough rinse in D.I. or clean tap water.

2. **Inorganic Scale Deposits:** Dissolve deposit by immersion of the sensor's measurement tip in **dilute** hydrochloric acid for a few minutes followed by a thorough rinse with D.I. or clean tap water. Platinum bands can be polished with a fine grade of alumina (Al<sub>2</sub>O<sub>3</sub>) or some similarly fine polishing compound.

3. **Organic Oil or Grease Films:** If film is known to be soluble in a particular organic solvent which is not harmful to platinum or glass, wash it with this solvent. Repeat step #1 above. Depending on the extent of and/or grease

### CLEANING DynaProbe® -continued-

contamination, it should be noted that the reference half-cell's ceramic liquid junction may be damaged beyond recovery.

- Plugged or Dry Ceramic Liquid Junction:** Remove contaminant with one of the above procedures, then soak in 3.8M KCl solution for 30 - 45 minutes.

#### NOTES:

- Do not permit sensor to dehydrate or dry out. Always keep in a wetted environment especially when not in service.
- Cracked or broken sensors are not repairable.
- Inspect cable and connector to ensure that the insulation is intact and that there are no signs of corrosion or contaminants on the metal components.

#### STORAGE:

- Short Term:** Immerse sensor measurement tip and liquid junction surface areas in 3.8M KCl. If this solution is not available, use 4.01 pH buffer, clean tap water, or lastly, a sample of the process being measured to keep the sensor hydrated.
- Long Term:** Fill storage boot that the sensor was originally shipped in with a freshly prepared 3.8M KCl solution and insert sensor. Seal boot to sensor with black electrician's tape using 3 to 5 complete wraps. The sensor should be stored in an upright (vertical) position.

### OXIDATION-REDUCTION POTENTIAL MEASUREMENTS WITH REDOX DynaProbes®

The Redox DynaProbe sensors are designed for the measurement of the Oxidation-Reduction Potential of an aqueous process medium or waste water. The sensor is used in conjunction with a pH meter or other electroanalytical instrumentation that can be set to read millivolts.

The Redox DynaProbe is a combination sensor with a reference half-cell and Platinum band measurement half-cell built into one body. Essentially the measured redox potential is the EMF difference between the potential on the Platinum band and the potential of the built-in reference half-cell.

The potential measured with the Redox DynaProbe is proportional to the ratio of the concentration of the oxidized and reduced states of the elements and compounds that make up the test sample. The potential of the Redox DynaProbe can be expressed by the general form of the Nernst equation:

#### Equation 1.

$$E = E_0 + \frac{E_N}{N} \log \frac{[\text{Oxidant}]}{[\text{Reductant}]} @ 25^\circ\text{C}$$

#### Where:

E = the voltage potential observed with the Redox DynaProbe

$E_0$  = A constant characteristic of the system in question (mV)

$E_N$  = Nernst potential ( 59.2 mV @ 25° C)

N = the number of electrons reacting in the redox equation.

Some work requires that the measured potential E be converted to  $E_h$ . The value  $E_h$  is the observed potential difference between the Platinum band and a normal Hydrogen sensor as the reference; (the potential of which is zero by definition). Since the normal Hydrogen sensor is rarely used as a reference in actual measurements, the measured potential E will not be equal to  $E_h$ .

However,  $E_h$  can be calculated by adding algebraically the measured potential E and the standard potential,  $E_R$ , of the reference sensor that is actually used for the sample measurement. The standard potential  $E_R$  is the difference between the measuring reference sensor and the normal Hydrogen sensor at 25° C. Therefore:

#### Equation 2.

$$E_h = E + E_R$$

#### Where:

$E_R$  = standard potential of the reference sensor.

Please note that the reference sensors used in the DynaProbe series of combination sensors are the Ag-AgCl type utilizing a 3.8 M KCl electrolyte salt bridge. The standard potential  $E_R$  of the DynaProbe series reference is + 202 mV at 25° C (see Table 1 for other temperatures).

#### Example:

If the potential E is measured with the Redox DynaProbe and is found to be 400 mV at 25° C, then the  $E_h$  (at 25° C) of the test sample is calculated as follows:

$$E_h = E + E_R$$

$$E_h = 400 \text{ mV} + 202 \text{ mV}$$

$$E_h = 602 \text{ mV}$$

Please note that the values E and  $E_h$ , and  $E_R$ , are all temperature dependent.

Use Table 1 for values of  $E_R$  at temperatures other than 25° C. These values are necessary to calculate  $E_h$  at temperatures other than 25° C with Equation 2.

TABLE 1

#### $E_R$ Values for the Redox DynaProbe®

Temp.(°C)	$E_R$ (mV)
15°	209
20°	206
25°	202
30°	198
35°	195
38°	193
40°	191

TABLE 2

#### Nernst Potentials ( $E_N$ ) from 15° to 40° C

Temp.(°C)	$E_N$ (mV)
15°	57.2
20°	58.2
25°	59.2
30°	60.1
35°	61.1
38°	61.7
40°	62.1

The actual magnitude of the potentials E or  $E_h$  of any particular Oxidation-Reduction system will depend on three things:

- The constants of that system,  $E_0$  and N.
- The temperature dependent values,  $E_N$  and  $E_R$  (see tables 1 and 2).
- The ratio of concentrations of the oxidants and reductants in the system.

Therefore, in any reversible Oxidation-Reduction system the measured potential E and the calculated potential  $E_h$  are both functions of the temperature and of the ratio of concentrations of the oxidants and the reductants. Please note that if all measurements are done at the same temperature, the temperature dependent values become constants.

Regardless of the initial magnitude of the values E and  $E_h$ , both values will become more positive when the concentration of the oxidant increases relative to the reductant (oxidizing intensity becomes greater).

Conversely, the values of E and  $E_h$  will become more negative when the concentration of the reductant increases relative to the oxidant (reducing intensity becomes greater).