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Manufacturers of pH & D.O. Sensors for Science and Industry

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Broadley-James® ProcessProbe™ ORP Sensors

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

SENSOR SPECIFICATIONS

Table with 2 columns: Specification and Value. Includes ORP Range, Sensing Tip, Temperature Range, Pressure Range, and Cable details.

\* varies depending upon Model selected

PREPARATION FOR USE:

- 1. Remove protective cap containing the storage solution (3.8 Molar KCl).
2. Save the protective cap for future use as a storage container and bulb protector when sensor is not in service.
3. For first-time use after removing the storage boot: Inspect the sensor for any signs of breakage or shipping damage...
4. For sensors with replaceable O-ring seals: All O-rings require proper lubrication.

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.

CALIBRATION PROCEDURE:

- 1. Unlike pH sensors, the measurement half-cell of the ORP (Redox) sensors undergo no zero-point or slope changes. 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.

CAUTION:

Quinhydrone is very toxic and should be handled by qualified technicians only. Handle with care and avoid ingesting. Avoid contact with bare skin.

- 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 ProcessProbe.

Table with 3 columns: pH, mV, and Delta. Values: 7.00 pH (+86 mV), 4.01 pH (+263 mV), Delta = 2.99 pH, Delta = 177 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 ProcessProbe will give reproducible Delta values of Delta173 ± 4mV. 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 probe for testing by cleaning the platinum surface with a liquid hand soap and soft toothbrush...
3. Connect the Redox probe to a suitable pH meter, set to the millivolt scale.
4. Immerse the sensor in the pH 7.00/Quinhydrone mixture.
5. Rinse the sensor thoroughly with clean tap water, and immerse it in the pH 4.01/Quinhydrone mixture.

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 adequately in this test...

- The buffer/Quinhydrone mixtures will not remain useful for more than two hours since the Quinhydrone decomposes slowly in contact with air.

CLEANING A PROCESSPROBE 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.

- 1. Initial Cleaning: Wash with a solution of liquid detergent or enzyme detergent and warm water...
2. Inorganic Scale Deposits: Dissolve deposit by immersing the sensor's measurement tip in dilute hydrochloric acid...
3. Organic Oil or Grease Films: If film is known to be soluble in a particular organic solvent...

**CLEANING ProcessProbe®**

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3. **Plugged or Dry 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 protective cap that the sensor was originally shipped in with a freshly prepared 3.8M KCl solution and insert sensor. The sensor should be stored in an upright (vertical) position.

**OXIDATION-REDUCTION POTENTIAL MEASUREMENTS WITH REDOX PROCESSPROBES**

The Redox sensors are designed for the measurement of the Oxidation-Reduction Potential of an aqueous process medium

or wastewater. The sensor is used in conjunction with a pH meter or other electroanalytical instrumentation that can be set to read millivolts.

The Redox probe 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 probe 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 probe 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 ProcessProbe

$E_0$  = 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 ProcessProbe 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 ProcessProbe series reference is +202 mV at 25° C (see Table 1 for other temperatures).

**Example:**

If the potential E is measured with the Redox probe 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,  $E_H$  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 ProcessProbe®**

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 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).