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# INSTRUCTION MANUAL

## ISO<sub>2</sub>

*Isolated dissolved oxygen meter and oxygen electrode*

Serial No. \_\_\_\_\_

[www.wpiinc.com](http://www.wpiinc.com)

030416



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## ABOUT THIS MANUAL

The following symbols are used in this guide:



This symbol indicates a **CAUTION**. Cautions warn against actions that can cause damage to equipment. Please read these carefully.



This symbol indicates a **WARNING**. Warnings alert you to actions that can cause personal injury or pose a physical threat. Please read these carefully.

NOTES and TIPS contain helpful information.

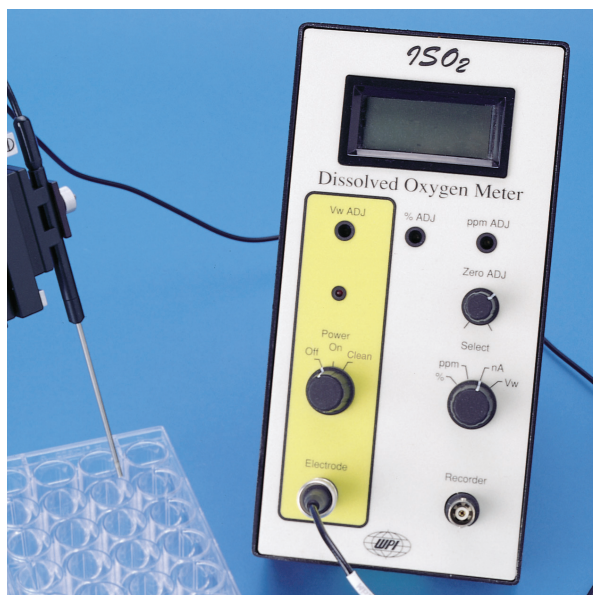


Fig. 1—The ISO<sub>2</sub> meter works with the OXELP oxygen sensor.

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**IMPORTANT NOTE:** Before using the ISO<sub>2</sub> dissolved oxygen meter for the first time, connect the sensor and apply power to the instrument overnight.

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**IMPORTANT NOTE:** The **OXELP** oxygen sensor is specifically designed to be used with WPI's ISO<sub>2</sub> dissolved oxygen meter. To use the **OXELP** with other instruments, see Fig. 2 on page 3 for plug information.

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## INTRODUCTION

ISO<sub>2</sub> and its associated **OXELP** sensor provide accurate, stable and electrically isolated oxygen measurements. The recorder output is not electrically connected to the **OXELP** sensor circuitry. This offers the important advantage that other sensors may be used in the same sample as the **OXELP** without interfering with one another, and background noise is greatly reduced. With a sensor tip diameter of just 2mm and low oxygen consumption, ISO<sub>2</sub> and its associated sensor excel in making measurements

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in small sample volumes. Other features include a fast response time and a sturdy stainless steel sensor body.

The instrument amperometrically measures the concentration of oxygen in aqueous solutions and gas mixtures. Measurements can be displayed either as a percentage of atmospheric pressure, parts per million (ppm), or as a redox current in nanoamperes (nA). The oxygen sensor houses a platinum working electrode and a silver counter/reference sensor inside a stainless steel sleeve. A gas permeable polymer membrane fits over the end of the sleeve which allows oxygen to pass while blocking liquids, ions and particulate matter. Oxygen diffuses through the membrane and is reduced at the platinum cathode which is held at  $-0.7\text{V}$  when the instrument is on. This results in an electrical current being generated, the magnitude of which is determined by the rate of diffusion to the sensor which is proportional to the partial pressure of oxygen outside the membrane. The current serves as a measure of the partial pressure of oxygen.

**ISO<sub>2</sub>** comes ready to use. Just attach the **OXELP** sensor to the meter, turn the power on and wait for the current to decay to a stable value. This usually takes a couple of hours. The current can be monitored by setting the **ISO<sub>2</sub>** to the nA setting. Once the current stabilizes you may then calibrate the instrument.

## Parts List

After unpacking, verify that there is no visible damage to the sensor. Verify that all items are included:

- (1) **5377 OXELP** Startup kit, including:
  - (2) 2mm **OXELP** sleeves
  - (1) **3563** 1CC syringe without needle
  - (1) **5379** Filler bottle
  - (1) **7326** Bottle of filling solution, 10mL
  - (1) **MF28G67** Microfil, 28 gauge
- (1) **ISO2** Dissolved oxygen meter
- (1) **OXELP** Oxygen electrode probe
- (1) Instruction Manual

## Unpacking

Upon receipt of this instrument, make a thorough inspection of the contents and check for possible damage. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed damage should be reported at once to the carrier and an inspection requested. Please read the section entitled "Claims and Returns" on page 19 of this manual. Please contact WPI Customer Service if any parts are missing at 941-301-1003 or [customerservice@wpiinc.com](mailto:customerservice@wpiinc.com).

**Returns:** Do not return any goods to WPI without obtaining prior approval (RMA # required) and instructions from WPI's Returns Department. Goods returned (unauthorized) by collect freight may be refused. If a return shipment is necessary, use the original container, if possible. If the original container is not available, use a suitable substitute that is rigid and of adequate size. Wrap the instrument in paper or plastic surrounded with at least 100mm (four inches) of shock absorbing material. For further details, please read the section entitled "Claims and Returns" on page 19 of this manual.

## INSTRUMENT DESCRIPTION

### Sensor Structure and Assembly

The basic structure of the **OXELP** sensor is shown below (Fig. 2).

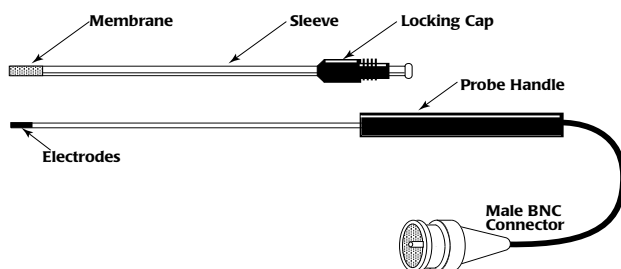


Fig. 2—OXELP Sensor assembly

**Membrane**—Gas permeable, polymeric membrane covering the end of the stainless sleeve to separate it from the external environment

**Sleeve**—Disposable, protective stainless steel sleeve (WPI#5378) that houses the sensitive electrode pair. The sleeve is flanged to properly connect with the locking cap. It must contain fresh electrolyte (WPI#7326).

**Electrode**—Internal O<sub>2</sub>-sensing pair of working and counter (reference) electrodes

**Probe Handle**

**Locking Cap**—Attaches the sleeve to the probe handle

When the sensor is fully assembled (with locking cap and sleeve in place) the internal electrode should press gently against the polymeric membrane, which will be *slightly stretched*. This ensures that the electrolyte diffusion is as thin as possible, minimizing sensor response time.

**NOTE:** Once a membrane is stretched it is permanently deformed and should not be reused if the sleeve is removed from the electrode.

Additional membrane sleeves are available in packages of 4 with electrolyte filling solution (WPI #5378). The start-up kit (WPI #5377) also includes replacement membrane sleeves, along with all the accessories to fill them properly with electrolyte solution.

Fig. 3—(Right) The 5377 ISO<sub>2</sub> startup kit includes a calibration bottle, filling solution, syringe, MicroFil and two membrane sleeves.



### Recorder Output

The recorder output terminal is electrically isolated. This offers an important recording advantage because other sensors in the same test medium will not interact adversely with **OXELP**. The output signal from the **Recorder** connector is 1mV/nA of sensor current regardless of whether the selector switch is in the %, ppm or nA range.

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# OPERATING INSTRUCTIONS

## Calibration

For accurate results the sensor should be calibrated as closely as possible to the temperature and medium at which the measurement is to be made (if measurements are in gas, calibrate in gas).

To calibrate the sensor:

1. Turn on the **ISO<sub>2</sub>** and polarize the sensor ("Polarization" on page 4).
2. Zero the sensor ("Zero (Oxygen) Point Calibration" on page 5).
3. Adjust the scale factor ("Scale Factor Adjustment" on page 6).

**NOTE:** The O<sub>2</sub> solubility ppm tables are located in the Appendix.

**NOTE:** With an external data recorder, a three-point calibration can be used. Refer to the **ISO-OXY-2/OXELP** manual available from [www.wpiinc.com/manuals](http://www.wpiinc.com/manuals).

## Polarization

The **OXELP** sensor should always remain connected to the **ISO<sub>2</sub>**. When the **ISO<sub>2</sub>** is turned off a potential of -0.2V is applied to the platinum working electrode. This is done to minimize the time required for the current to decay when the instrument is turned on and a potential of -0.7V is applied to the working electrode.

The **ISO<sub>2</sub>** meter will keep the **OXELP** sensor polarized if it is left connected to the meter, even when the meter is switched off. For best results, polarization of a new sensor should be performed over a 24-hour period. However, a 2-hour period will polarize the sensor enough for 95% accuracy.

**TIP:** You can determine whether or not the correct potential is being applied to the working electrode when the instrument is on by placing the instrument in the **Vw** setting. The LCD display shows the potential being applied. If the potential is not -0.7V, then change the potential to the correct value by using a small screw driver to adjust the **Vw ADJ** screw on the front panel of the instrument.

To polarize the sensor:

1. Place the sensor in 0.1M PBS solution or water.
2. Connect the sensor to the **ISO<sub>2</sub>**. Position the BNC connector, push it into place and turn the locking nut clockwise to securely connect it.
3. Turn on the **ISO<sub>2</sub>** and switch the meter to the **nA** mode.
4. The sensor current initially will be high, but it will fall and settle to a stable value usually after about two hours. The sensor should be allowed at least one hour to reach a stable baseline current of 16–80nA before it is used for measurement. Once the current stabilizes, calibrate the instrument.
5. If the stabilized baseline value exceeds 80nA, see "Replacing the Membrane Sleeve" on page 10.

**NOTE:** This polarization procedure assumes the temperature is 25°C. At 37°C the baseline current is higher.



## Zero (Oxygen) Point Calibration

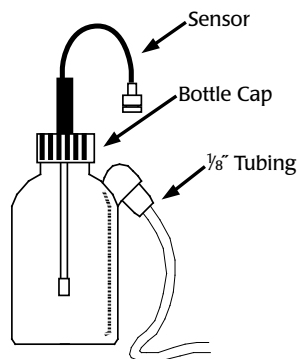
The true electronic zero reading can be obtained by removing the sensor from the **ISO<sub>2</sub>** meter. At that point, the meter has no current running through it and is at the electronic zero. The meter should read zero. As soon as you connect the sensor to the meter, you can have a small current leakage, called the baseline current. We calibrate an instrument to correct for the baseline current. To ensure that the sensor is registering only the baseline current, ALL oxygen must be purged from the calibration medium.

There are several methods for calibrating the sensor:

- In liquid (water or PBS) bubbled with  $N_2$  gas to purge any intrinsically dissolved  $O_2$
- In liquid saturated with sodium hydrosulfide (Na-Dithionite  $Na_2SO_4$ ) to inhibit any intrinsically dissolved  $O_2$
- In a pure  $N_2$  gas environment

Choose the calibration method that most closely approximates the conditions of the experiment to be run. For example, if you are measuring oxygen in a PBS solution, use the liquid calibration method.

*Fig. 4—(Right) The calibration bottle is included with the ISO<sub>2</sub> system.*



## Liquid Calibration

The **OXELP** sensor is designed for measurement of oxygen in liquids. For short periods of time, it can be used in a gas environment. If the sensor will be used in a gas environment, use the gas calibration method (page 6).

1. Polarize the sensor. See “Polarization” on page 4. Leave the polarized sensor immersed in PBS and plugged into the **ISO<sub>2</sub>** meter until you are ready to calibrate it.
2. Fill the supplied plastic calibration bottle (Fig. 4) about  $2/3$  full of distilled water. Screw the bottle cap on the bottle.

**TIP:** If your experiment uses PBS solution, use PBS to calibrate the sensor and purge the oxygen by bubbling nitrogen in the mixture (Step 3).

3. To purge the oxygen from the liquid, connect  $1/8$ ” ID plastic tubing (not supplied) to the port on the side of the bottle. Connect the other end of the tubing to a pure nitrogen gas source at a low pressure (less than 5 PSI). Bubble nitrogen into the calibration medium for at least 10 minutes.

**TIP:** If you prefer, you may use an oxygen scavenger like  $Na_2S_2O_4$  (Sigma-Aldrich #157953) or  $Na_2SO_3$  (Sigma-Aldrich #71988) to inhibit the oxygen action in the distilled water. Be aware that temperature and salinity changes affect the concentration of the solute needed to purge the oxygen. Solubility tables can be found in the “Appendix” on page 15. Be sure to use enough of your oxygen scavenger to completely eliminate the oxygen in the bottle for the duration of the calibration procedure.



**CAUTION:** Wear nitrile gloves when handling sodium sulfite ( $\text{Na}_2\text{SO}_3$ ).

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4. Carefully slide the tip of the **OXELP** sensor through the hole in the top of the bottle cap. Position the sensor so that the probe handle rests against the bottle cap. If the bottle is top heavy, you may need to support the sensor. The current should drop rapidly (after a few seconds) to a value of 0nA.
5. If the current value is not zero, use the **Zero ADJ** knob to get a zero reading. Use this procedure to obtain a zero reading on any scale setting (nA, ppm, %). Do not rotate the zero adjust knob after the zero calibration is complete.

**NOTE:** If you move the sensor to a liquid that has a change in salinity, it may take a few minutes for the sensor current to re-stabilize.

## Gas Calibration

The **OXELP** sensor is not designed for long-term use in a gas environment, but may be used for short experiments.

1. Polarize the sensor. See "Polarization" on page 4. Leave the polarized sensor immersed in PBS and plugged into the **ISO<sub>2</sub>** meter until you are ready to calibrate it.
2. Screw the bottle cap on the plastic calibration bottle. Connect 1/8" ID plastic tubing (not supplied) to the port on the side of the bottle. Connect the other end of the tubing to a pure nitrogen gas source at a low pressure (less than 5 PSI). Fill the supplied plastic calibration bottle with pure nitrogen gas for 10 minutes.
3. Carefully slide the tip of the **OXELP** sensor through the hole in the top of the bottle cap. Position the sensor so that the probe handle rests against the bottle cap. If the bottle is top heavy, you may need to support the sensor. The current should drop rapidly (after a few seconds) to a value of 0nA.
4. If the current value is not zero, use the **Zero ADJ** knob to get a zero reading. Use this procedure to obtain a zero reading on any scale setting (nA, ppm, %). Do not rotate the zero adjust knob after the zero calibration is complete.

## Scale Factor Adjustment

After the instrument has been zeroed, you must adjust the scale factor according to whether or not the intended measurements are to be made in the gas phase or aqueous medium.

## Gas Phase Measurements

Sensor calibration for gas phase measurements can be accomplished using the calibration bottle, as described above for zeroing the instrument with nitrogen. Further calibration can be performed using a tank of known oxygen concentration (for example, 100%  $\text{O}_2$  or carbogen-95%  $\text{O}_2$ ).

1. Turn the **Select** knob to %.
2. When the bottle is purged with nitrogen as described in "Gas Calibration" on page 6, the display should read 0.
3. Use the same method to purge the bottle with a known concentration of oxygen.

If you use pure oxygen, the display should read 100. If the display does not show the correct value, use a small screwdriver to adjust the % adjustment screw so that the meter reads 100%.

**TIP:** Air can also be used as a calibration standard, but since water vapor affects the sensor reading it is best to use dry air unless the ambient humidity is accurately known. Dry air can be obtained by passing room air through a column containing a solid drying agent such as silica gel or calcium chloride and then into the calibration bottle for calibration. To do this, turn the **Select** knob to %. The display should read 21. If not, use a small screwdriver to adjust the % adjustment screw so that the meter reads 21. If ambient air is used to calibrate at 21%, ambient humidity may cause a calibration error of as much as 1% O<sub>2</sub>.

In the % mode, the **ISO<sub>2</sub>** meter displays the percentage of atmospheric pressure that the oxygen present exerts. For example:

- In a 100% oxygen environment, the display will read 100 which means that the partial pressure of oxygen is 1atm (760mmHg).
- If the display reads 21, then the partial pressure of oxygen is 0.21atm (160mmHg).

## Aqueous Measurements

1. For aqueous calibration, fill the calibration bottle about 2/3 full with distilled water or PBS.
2. Carefully slide the tip of the **OXELP** sensor through the hole in the top of the bottle cap and immerse the sensor tip in the water.
3. Aerate the solution, for a few minutes, by bubbling air through the side arm of the bottle at a low pressure using a simple aquarium aeration pump.
4. Turn the **Select** knob to %. The scale reading should be allowed to settle to a stable reading.
5. Dissolved oxygen calibration is corrected for the effect of water vapor by the following equations:

$$(1) \text{po}_2 = 21\% \times (1 - \text{p}_{\text{H}_2\text{O}})$$

or

$$(2) \text{po}_2 = 21\% \times (1 - \text{p}'_{\text{H}_2\text{O}}/760)$$

where  $\text{p}_{\text{H}_2\text{O}}$  and  $\text{p}'_{\text{H}_2\text{O}}$  are the partial pressure of water vapor at standard atmospheric pressure in atmospheres and in mmHg, respectively.

For example, the  $\text{p}_{\text{H}_2\text{O}}$  in water-saturated air at 24° is 22mmHg. Therefore, the  $\text{po}_2 = 21\% \times (1 - 22/760) = 20.4\%$ . Note that for purposes of oxygen measurements, liquid water is considered to be “water-saturated air.” The display should read 20.4%. If it does not, use a screwdriver to adjust the % adjustment screw so that the meter reads the correct calibration value. The values of water vapor pressures at different temperatures are listed in the Appendix, Table 3, page 17.

6. To measure dissolved oxygen in parts per million (ppm), switch the **Select** knob to ppm. See Appendix, Table 1a, page 15. This table gives the solubility of oxygen in water at different temperatures at an ambient pressure of 1 atm. If

the solution temperature is 25°C, for example, the proper oxygen reading when the sensor is in fresh water should be 8.4 ppm. If the display does not show this value, adjust the **ppm** screw with a screwdriver so that the meter displays the correct value. You do not need to correct for the water-vapor effect for a ppm calibration since the values in Table 1a are obtained in “water-saturated air” at an atmospheric pressure of 760mmHg.

## Parts Per Million

The unit ppm is equivalent to mg/L. The solubility of oxygen in water at 0°C according to the Merck index is 4.889mL/100mL. Using the ideal gas law, we can calculate the number of moles of oxygen present in 100mL:

$$PV = nRT$$

$$n = P \times V / R \times T$$

$$n = (0.21) \times (4.889 \times 10^{-3}) / (0.08206) \times (273)$$

$$n = 45.8 \times 10^{-6} \text{ moles}$$

Where P is the partial pressure of oxygen, V is the volume of oxygen, n is the number of moles of oxygen, R is the universal gas constant, and T is the absolute temperature.

From the number of moles of oxygen we can calculate the number of grams of oxygen:  $45.8 \times 10^{-6} \text{ mol} \times 32 \text{ g/mol} = 1.46 \times 10^{-3} \text{ g}$

There is  $(1.46 \times 10^{-3} \text{ g} / 0.1 \text{ L})$  14.6mg of oxygen per liter.

Since 1L of water has a mass of 1000g, and there are 1,000,000mg in 1000g, the concentration in ppm is:  $(14.6 \times 10^{-3} \text{ g/L}) / (1000 \text{ g/L}) = 14.6 \text{ ppm}$

This value corresponds to that given in Table 1a.

For accurate results, the temperature of the water sample and the fluid being tested should be identical. They should be continuously stirred using a magnetic stirrer. Redox current can be measured by switching the **Select** switch to nA.

When measuring fluid samples for dissolved oxygen, periodically rinse the exterior of the sensor with distilled water, blot the membrane dry and recheck the sensor's calibration as described above.

## Calibration for O<sub>2</sub> in Living Tissue/Blood

The **ISO<sub>2</sub>** meter and **OXELP** sensor may be used in applications involving O<sub>2</sub> measurements *in vitro* or *in vivo* in living tissue or fluids such as blood. You may still use the calibration procedure in this manual for these measurements since a membrane-covered amperometric oxygen sensor always measures oxygen activity, not concentration. Although it is normal to think in terms of dissolved oxygen concentration, it is actually more appropriate to define oxygen in solution in terms of activity, since this is the “effective concentration.” For example, in distilled water the activity coefficient,  $\gamma_c$ , is close to unity, but in solutions with high salt concentration the activity coefficient is different from unity and concentration and activity of dissolved oxygen are no longer equal. The concentration falls while activity remains constant. For a membrane-covered oxygen sensor, this is an important effect, since an oxygen detector only responds to the difference in activity across the membrane rather than the concentration difference. In samples containing an electrolyte, while the oxygen

concentration falls with increasing salt concentration, the sensor current remains constant.

If it is necessary to have a measure of dissolved oxygen in terms of concentration, then the calibration is somewhat more complicated since the relationship between activity and concentration may change with the change of salt concentration in the samples. The activity coefficient, a ratio of the activity to the concentration, generally cannot be predicted and we rely on empirical determinations since the compositions of living fluids such as blood are extremely complicated. Use the fluid to be tested as a “solvent” to prepare a calibration standard. Alternatively, use the Bunsen absorption coefficient,  $\alpha$ , to calculate the oxygen concentration in blood in terms of the results with the oxygen sensor. The equation is:

$$\dot{C} = \frac{\alpha}{\text{molar volume} \times K} \times (p_t - p_{H_2O}) \times p_{O_2}$$

where  $K$  is a conversion factor depending on the unit of pressure chosen (1 for atm),  $p_t$  and  $p_{H_2O}$  are the total pressure of gas and the partial pressures of water, respectively.  $p_{O_2}$  is the partial pressure of oxygen in blood obtained from the measurements with the oxygen sensor. Bunsen Coefficients for solubility of oxygen in plasma and blood can be found in the Appendix, Table 4 on page 17. **It is very important to calibrate at the same temperature as that of the measurement site.**

## MAINTENANCE

### Durability and Handling

The **OXELP** sensor is designed to be used in buffered aqueous solutions and in gases at ambient pressure. The use of the sensor in other fluids or pressures may damage the membrane. Organic solvents must not be used. If you have a particular solution that may be in question, please contact WPI for information.

The sensor is relatively durable, except for the membrane sleeve. Exercise caution when handling any sensor to avoid actions that could damage the sensor tip. Pay particular attention to the sensor membrane, because the membrane is extremely delicate and improper handling will lead to damage. Refer to the Sensor Unpacking Instructions that came with your sensor for handling instructions.



**CAUTION:** Do NOT scratch the sensor membrane sleeve. Do NOT wipe the *sensor membrane* with anything, even Kimwipes. If necessary, squirt it with distilled water or compressed air. The sensor membrane is easily punctured if it comes into contact with sharp objects. Do NOT let a stir bar come into contact with the sensor membrane.

### Storing the Sensor

With proper care and by following the instructions below a membrane sleeve should last for one month. Use the following guidelines to maximize the life of the sensor:

**STANDBY:** If the oxygen sensor is being used on a daily basis, leave the monitoring device ON continuously with the sensor plugged in and its tip suspended in distilled water to maintain polarization.

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**SHORT-TERM:** The reduction of oxygen and other trace impurities on the electrode surface causes a decrease in the surface activity of the working electrode. This phenomenon is referred to as “poisoning,” and over time has the effect of gradually reducing the electrode’s capability to generate a sufficient redox current. If the sensor is not to be used for a period of more than 2-3 days, disconnect it from the monitoring device, and store it with the tip immersed in distilled water. This practice reduces the possibility of a gradual reduction of the electrode surface activity under long-term polarization.



**CAUTION:** Storing the sensor short-term in this condition can cause the inner filling solution to dry out as the solution evaporates out of the top of membrane sleeve. The membrane itself is water impermeable. Crystallization of the filling solution inside a sleeve can cause damage to the electrode when the sleeve is removed. (An electrode with crystallized particles on the tip gives high readings on the meter.)

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**LONG-TERM:** For long-term storage of more than one week, remove the membrane sleeve, clean the sensor tip with deionized water and dry it carefully. Protect the tip and store the sensor with the membrane sleeve removed in a dry, cool environment. See “Replacing the Membrane Sleeve” on page 10.

**TIP:** Used membrane sleeves (with or without the membrane) make an ideal cover for protecting a dry sensor in long-term storage.

## Cleaning the Membrane

The membrane sleeve itself requires very little maintenance. The primary concern is to avoid damage to the membrane and to keep it as clean as possible. After each use the membrane should be cleaned by suspending the tip in distilled water for 20–30 minutes to dissolve salts and remove particles which may have accumulated on it. If the probe was used in a protein-rich solution, the tip should first be soaked in a protease solution for several minutes to remove protein build-up, and then in distilled water. Enzymatic detergent (for example, Enzol, WPI#**7363**) can also be used.

Accumulated organic matter can be removed by briefly immersing the tip in a 0.1M HCl or 0.1M NaOH (at times both may be necessary) for 10 seconds.

A good indication of a dirty membrane sleeve is a sluggish response or an unusually low sensitivity. If these problems are not rectified by cleaning, then the membrane sleeve should be replaced.

## Sterilizing the Membrane

The membrane sleeves can be sterilized chemically using an appropriate disinfectant (for example, Cidex, WPI#**7364**).



**CAUTION:** Do not use alcohol on the sensors, and do NOT expose them to organic solvents

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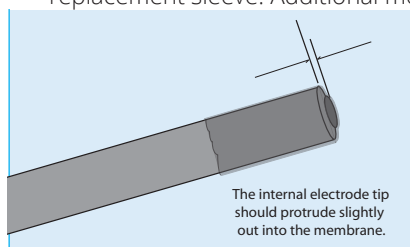
## Replacing the Membrane Sleeve

Even with the best of care and proper maintenance, the membrane sleeve will eventually need to be replaced.

1. Unscrew the locking cap from the handle.
2. Hold the stainless steel sleeve and the locking cap and pull them away from

the internal electrode assembly. Be careful not to bend the internal electrode assembly.

3. Rinse the internal electrode with distilled water (particularly the tip) and let it soak for at least 15 minutes. Be careful not to let water get up into the handle.
4. Gently dry the sensor with a soft tissue (Kimwipes). Be sure to dry thoroughly the flat surface at the tip of the electrode. After drying the current should stabilize fairly quickly to a low value (for example, 0-20pA). If this occurs, it is a good indication that the electrode is functioning properly.
5. If the electrode is not clean, repeat steps 3 and 4.
6. Slide the locking cap from the old, used sleeve, and gently slide it onto the new replacement sleeve. Additional membrane kits with sleeves and filling solution (WPI#**5378**) may be purchased separately.



**Fig. 5—(Right) Membrane placement. The internal electrode tip should protrude slightly out into the membrane.**

7. Dip the internal electrode 1–2cm into the **ISO<sub>2</sub>** Filling Solution (WPI #**7326**) included in the start-up kit (WPI #**5377**). In the 100nA range, the current rises rapidly (for example, 60–300nA). Then, the current value will begin

to fall. Using the MicroFil™ nonmetallic syringe needle (WPI #**MF28G67-5**) and 1mL plastic syringe (included in the start-up kit) inject approximately 100μL of electrolyte directly into the new sleeve. Insert the MicroFil in as far as it will go, and slowly draw the MicroFil out of the sleeve as it fills. The filling process should be performed slowly enough so as not to create turbulence, which could introduce air bubbles into the electrolyte. The MicroFil (#**MF28G67**) included in the startup kit is less than the length of the sleeve, so that it will not puncture the delicate membrane at the tip of the sleeve during injection.

**TIP:** If air bubbles form in the electrolyte, gently flick or tap the side of the sleeve to remove the bubbles.

8. Slowly and smoothly insert the electrode into the sleeve, and screw the locking cap into the handle. The locking cap screws into the probe handle. Tighten it just enough for the membrane to touch the electrode. **DO NOT OVER-TIGHTEN.** The electrode should be observed to press gently against the membrane (**Fig. 5**).
9. The current displayed on the meter at this time will be high or offscale.
10. Suspend the tip of the newly assembled probe in 0.1M PBS buffer solution.
11. After 10-15 minutes the current should no longer be offscale and will gradually decrease with time. It may take up to one hour for the sensor current to reach a low stable value, at which time it will be ready for use.

**TIP:** The integrity of the new membrane can be determined by immersing the probe tip into a strong saline solution (1M). If the current increases dramatically or is offscale, then the membrane integrity is not good and a new membrane will have to be fitted. Additional membranes (packages of 4) with filling solution are available from WPI (#**5378**).

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## Cleaning the Electrode Surface

The reduction of oxygen causes a decrease in the surface activity of the working electrode which gradually “poisons” it. This poisoning reduces the redox current from the reduction of oxygen. In order for the **ISO<sub>2</sub>** to function properly, the minimum current required at room temperature and 21% oxygen (air) is 15nA. If the reduction current drop below this value, then the instrument no longer functions properly.

Once the reduction current does drop below 15nA, there is a **CLEAN** function which may be used to reverse some of the damage and restore activity so that the sensor can continue to be used. This function can be used every two months or so when the sensitivity of the sensor drops to 25% of its original sensitivity.

1. Switch the power knob to the **CLEAN** setting. When this is done the potential applied to the platinum electrode changes to +0.9V. This causes a change of polarity on the surface of the electrode to reverse some of the oxidation that has taken place on the tip of the electrode. This helps to restore the electrode activity.
2. Leave the instrument on this setting for a period of 30 minutes. The LCD display output in this setting is meaningless and should be ignored.
3. After the 30 minutes, turn the instrument off and leave it off for at least one hour before using the sensor. It may be necessary to experiment with the timing of the cleaning process, since each sensor is unique.

The cleaning process will not indefinitely extend the life of an electrode. Eventually, the electrode must be replaced, but if it is well cared for, an electrode can last a long time.

## Batteries

The battery operated **ISO<sub>2</sub>** should work for hundreds of hours before its two 9V batteries require replacement. A low battery indicator on the panel LCD appears if the batteries are low. To replace the batteries, first turn the power off. Remove the four screws on the bottom of the instrument case and then remove the entire front panel assembly. Replace the batteries and then reassemble the case.

Remember to turn the instrument power off when it is not in use.

## ACCESSORIES

- |              |   |
|--------------|---|
| <b>OXELP</b> | Oxygen electrode in sealed bottle   |
| <b>5378</b>  | Package of 4 replacement sleeves with membranes   |
| <b>7326</b>  | <b>ISO<sub>2</sub></b> filling solution (10mL)  |
| <b>5377</b>  | Replacement Startup kit includes a Calibration Bottle, 10mL Filling Solution, 1cc Syringe, 2 Replacement Membranes Sleeves, MicroFil (28 ga.) |
| <b>5399</b>  | T-Adaptor Flow-Through Kit includes: 2 female luer T's, 3 luer lock fittings, 3 2mm gaskets, and 6 male luer to 1/8 inch tubing               |
| <b>5381</b>  | Rack Mount Kit  |



## TROUBLESHOOTING

Issue	Possible Cause	Solution
Meter reads -1	Sensor is shorted	Test the sensor with the dry sensor test. See "Dry Sensor Test" on page <OV>.
Unstable readings	Sensor surfaces may be coated	Try the clean function and retest. See "Cleaning the Electrode Surface" on page 12.
Sensor is not responding to O <sub>2</sub> or is showing a longer response time	Sensor has aged	Try the dry sensor test and compare the wet test current consumption results after a 2 hour polarization to the proof of performance sheet. If the current is outside the upper ranges of 30–50nA and the sensor detects O <sub>2</sub> and is still linear, but sluggish, then one of the electrodes may be compromised. This sensor should be replaced soon.
	The membrane is clogged	Replace the membrane sleeve. See "Replacing the Membrane Sleeve" on page 10.
	<b>ISO<sub>2</sub></b> meter tests	Remove the electrode from the BNC. Zero the meter and place a 1MΩ resistor across the input BNC. At 700mV the display should read 700nA. The <b>ISO<sub>2</sub></b> can measure up to ±2000nA.

## Dry Sensor Test

Liquid sensors that are stored assembled for more than 45 to 60 days may dry out internally and may no longer be functional or recoverable. To determine if the sensor itself is defective or has a short, you may perform a dry sensor test on a sensor without a sleeve.

1. Carefully remove the membrane sleeve. See "Replacing the Membrane Sleeve" on page 10.

**NOTE:** If the sensor has not been used for several months, the electrolyte solution may have dried out. If this is the case, the membrane sleeve is more difficult to remove, because it tends to stick to the sensor. Soak the assembly in distilled water for 2 hours and gently remove the sleeve to avoid damaging the delicate sensor tip.

- 
2. Remove any crystals and lightly wash the sensor with distilled water.
  3. Allow sensor to air dry.
  4. Without the sensor connected to the meter, turn on the **ISO<sub>2</sub>** meter and zero the instrument to 0nA. Do not move the zero set control from this point.
  5. DRY TEST: Connect the dry electrode and observe the display. You should see a near zero reading (~0nA). If the reading is higher, the sensor is defective and needs to be replaced.
  6. WET TEST: If the sensor passed the test in step 5, insert the sensor into a vial with filling solution. The **ISO<sub>2</sub>** should display a reading between 50–3000nA and then slowly decrease over the next few minutes. If the value does not fall below 10nA, then this sensor is damaged and should be replaced. Try cleaning the sensor. See “Cleaning the Electrode Surface” on page 12.
  7. If the sensor passed the tests in steps 5 and 6, the sensor itself is probably working properly. Install a new membrane sleeve and calibrate it in normal test solutions to determine the new sensitivity slope of the electrode. See “Replacing the Membrane Sleeve” on page 10.

**NOTE:** If the sensor does not read a high nA value on refilling the membrane sleeve, then an air pocket may be trapped in the bottom of the sleeve. Use care in the refilling process with the correct length of Microfil (WPI #**MF28G67-5**) and gently tap the sensor to dislodge these air pockets.

**TIP:** Do not reuse an old membrane, because the membrane itself is stretched once it is used. After it is removed, it maintains the surface deformity and system performance may diminish.

**NOTE:** If you have a problem/issue that falls outside the definitions of this troubleshooting section, contact the WPI Technical Support team at 941-301-1003 or [technicalsupport@wpiinc.com](mailto:technicalsupport@wpiinc.com).

SPECIFICATIONS

This unit conforms to the following specifications:

Modes.....% O<sub>2</sub>: 0–100%, ppm: 0–20, Current: 0–199.9nA

Resolution.....0.1 ppm

Accuracy.....±1.5%

Output Resistance.....1000Ω

Display.....3.5-digit LCD

Recorder Output.....1mv = 1nA (i.e., 10mV = 10% O<sub>2</sub> = 10ppm = 10nA)

Power.....Two 9V alkaline batteries (included) NEDA: MN1604, 6LR61

Battery Life .....1000 hours (approx.)

Dimensions .....20.3 x 10.2 x 5.1cm (8 x 4 x 2 in.)

Weight/ Shipping Weight .....2 lb (0.9kg)/5 lb (2.3kg)

OXELP

Tip Length.....76mm

Overall Length .....137mm

Tip Diameter .....2mm

Cable Length.....22cm (4 ft), including BNC connector

Response Time.....10 seconds, 90% response in well-stirred solution

Drift .....< 1%/min.

APPENDIX

Table 1a: Solubility of Oxygen in Fresh Water

°F	°C	ppm	°F	°C	ppm
32	0	14.6	66	19	9.4
34	1	14.2	68	20	9.2
35	2	13.8	70	21	9.0
37	3	13.5	72	22	8.8
39	4	13.1	73	23	8.7
41	5	12.8	75	24	8.5
43	6	12.5	77	25	8.4
45	7	12.2	79	26	8.2
46	8	11.9	81	27	8.1
48	9	11.6	82	28	7.9
50	10	11.3	84	29	7.8
52	11	11.1	86	30	7.6
54	12	10.8	88	31	7.5
55	13	10.6	90	32	7.4
57	14	10.4	91	33	7.3
59	15	10.2	93	34	7.2
61	16	10.0	95	35	7.1
63	17	9.7	97	36	7.0
64	18	9.5	99	37	6.9

Solubility of oxygen in parts per million (ppm) in fresh water at different temperatures, in equilibrium with air at barometric pressure of 760mmHg (101.3 kPa) and oxygen partial pressure of 159mmHg (21.1 kPa).

**Table 1b: Solubility of Oxygen in Seawater**

°C	5 g/L	10 g/L	15 g/L	20 g/L
0	13.8	13.0	12.1	11.3
1	13.4	12.6	11.8	11.0
2	13.1	12.3	11.5	10.8
3	12.7	12.0	11.2	10.5
4	12.4	11.7	11.0	10.3
5	12.1	11.4	10.7	10.0
6	11.8	11.1	10.5	9.8
7	11.5	10.9	10.2	9.6
8	11.2	10.6	10.0	9.4
9	11.0	10.4	9.8	9.2
10	10.7	10.1	9.6	9.0
11	10.5	9.9	9.4	8.8
12	10.3	9.7	9.2	8.6
13	10.1	9.5	9.0	8.5
14	9.9	9.3	8.8	8.3
15	9.7	9.1	8.6	8.1
16	9.5	9.0	8.5	8.0
17	9.3	8.8	8.3	7.8
18	9.1	8.6	8.2	7.7
20	8.7	8.3	7.9	7.4
21	8.6	8.1	7.7	7.3
22	8.4	8.0	7.6	7.1
23	8.3	7.9	7.4	7.0
24	8.1	7.7	7.3	6.9
25	8.0	7.6	7.2	6.7
26	7.8	7.4	7.2	6.7
27	7.7	7.3	6.9	6.5
28	7.5	7.1	6.8	6.4
30	7.3	6.9	6.5	6.1

*Solubility of oxygen (milligrams/liter) in seawater of different salinities, in equilibrium with air at barometric pressure of 760mmHg (101.3kPa) and oxygen partial pressure of 159mmHg (21.2kPa).*

**Table 2: Oxygen Solubility vs. Altitude**

Altitude (ft)	Pressure (mmHg)	Solubility Correction Factor
-540	775	1.02
Sea Level	760	1.00
500	746	0.98
1000	732	0.96
1500	720	0.95
2000	707	0.93
2500	694	0.91
3000	681	0.90
3500	668	0.88
4000	656	0.86
4500	644	0.85
5000	632	0.83
5500	621	0.82
6000	609	0.80

*Oxygen solubility obtained from Table 1a or Table 1b should be corrected if barometric pressure is different than 760mmHg or at altitudes other than sea level.*

**Table 3: Water-vapor Partial Pressure**

<b>Temp.</b>	<b>Pv</b>	<b>Temp.</b>	<b>Pv</b>
°C	mmHg	°C	mmHg
0	5	20	18
2	5	22	20
4	6	24	22
6	7	26	25
8	8	28	28
10	9	30	32
12	11	32	36
14	12	34	40
16	14	36	45
18	16	38	50
		40	55

**Table 4: Bunsen Coefficients (a) for Solubility of Oxygen in Plasma and Blood**

<b>Temp °C</b>	<b>Blood Hb g/100 mL</b>				
	<b>Plasma</b>	<b>5 g</b>	<b>10 g</b>	<b>15 g</b>	<b>20 g</b>
15	0.0302	0.0310	0.0312	0.0316	0.0323
20	0.0277	0.0282	0.0284	0.0287	0.0293
25	0.0257	0.0261	0.0263	0.0265	0.0271
28	0.0246	0.0249	0.0251	0.0253	0.0259
30	0.0238	0.0241	0.0243	0.0245	0.0251
35	0.0220	0.0226	0.0227	0.0229	0.0234
37	0.0214	0.0220	0.0221	0.0223	0.0228
40	0.0208	0.0221	0.0212	0.0214	0.0219

# DECLARATION OF CONFORMITY



**WORLD PRECISION INSTRUMENTS, INC.**  
175 Sarasota Center Boulevard  
Sarasota, FL 34240-9258 USA  
Telephone: (941) 371-1003 Fax: (941) 377-5428  
e-mail wpi@wpiinc.com

## DECLARATION OF CONFORMITY

We: World Precision Instruments, Inc.  
175 Sarasota Center Boulevard  
Sarasota FL 34240-9258  
USA

as the manufacturers of the apparatus listed, declare under sole responsibility that the product(s):

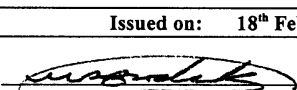
**Title: ISO2**

to which this declaration relates is/are in conformity with the following standards or other normative documents:

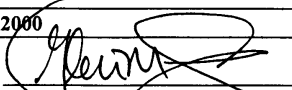
**Safety:** EN 61010-1:1993 (IEC 1010-1:1990)  
**EMC:** EN 50081-1:1992  
EN 50082-1:1992

and therefore conform(s) with the protection requirements of Council Directive 89/336/EEC relating to electromagnetic compatibility and Council Directive 73/23/EEC relating to safety requirements.

**Issued on: 18<sup>th</sup> February 2000**

  
**Dr. Mark P. Broderick**  
**President and COO**

**World Precision Instruments, Inc.**  
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**Mr. Glen Carlquist**  
**Production Manager**

**World Precision Instruments, Inc.**  
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Sarasota, FL 34240-9258 USA

## WARRANTY

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of 30 days\* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

## Claims and Returns

Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within ten (10) days after receipt of shipment. Claims for lost shipments must be made within thirty (30) days of receipt of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim is settled. In some instances, photographic documentation may be required. Some items are time-sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container

Do not return any goods to us without obtaining prior approval and instructions from our Returns Department. Goods returned (unauthorized) by collect freight may be refused. Goods accepted for restocking will be exchanged or credited to your WPI account. Goods returned which were ordered by customers in error are subject to a 25% restocking charge. Equipment which was built as a special order cannot be returned.

## Repairs

Contact our Customer Service Department for assistance in the repair of apparatus. Do not return goods until instructions have been received. Returned items must be securely packed to prevent further damage in transit. The Customer is responsible for paying shipping expenses, including adequate insurance on all items returned for repairs. Identification of the item(s) by model number, name, as well as complete description of the difficulties experienced should be written on the repair purchase order and on a tag attached to the item.

*\* Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*

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