INSTRUCTION MANUAL

Oxygen Meter

LIMITED ONE YEAR WARRANTY

Manufacturer warranties all instruments (excluding batteries, damage caused by batteries, probes, standards, buffers) against defects in materials and workmanship for one year from date of original purchase. During this warranty period, the manufacturer will repair or at their option, replace at no charge a product which proves to be defective, provided the product is returned, shipping prepaid to the manufacturer's service center.

This warranty does not apply to damage caused by accident or misuse or as a result of service or modification by other than an authorized service center. No other express warranty is given. Repair or replacement of product is your exclusive remedy. In no event shall the manufacturer be liable for consequential damages.

If any of these problems exist, change the membrane and solution, also check batteries.

9.3 No response or readings are inconsistent.
The **batteries** should provide about 100 hours of continuous operation. An analog meter will have no response when the batteries need to be replaced. A digital meter will display "BAT" when the batteries are low. Inspect the meter and batteries for corrosion.

9.3.1 To replace batteries in bench models:

9.3.1.1 Turn the meter off.
9.3.1.2 Remove screws, one in each foot on bottom.
9.3.1.3 Gently lift the shroud off.
9.3.1.4 Remove batteries and replace, noting polarities.
9.3.1.5 Reassemble meter.

9.3.2 To replace batteries in field units, follow sections 9.3.1.1 and 9.3.1.4.

9.3.3 On Unit with rechargable battiries return to dealer for repair.

If the problem continues, call your distributor/dealer.

TABLE OF CONTENTS

8.2 Membrane Life

Depending on usage and environment, membranes can last from a few hours to as long as several months. The membrane should be replaced when readings become erratic or the calibration is unstable. If the filling solution evaporates or a large bubble forms in the reservoir, the probe should be refilled.

8.3 Stirring Effects

Since oxygen is reduced as it reaches the electrode, it is necessary to insure a continuous supply of fresh sample in order not to deplete the oxygen surrounding the probe. A flow of at least one foot per second is ideal, do not exceed five feet per second. When there is no flow, stirring can be accomplished by raising and lowering the probe, in the sample. In the lab, a magnetic stirrer works well. Adjust the stirring speed until increasing the speed has no affect on the oxygen reading. Keep in mind that the heat from the stirrer will affect the sample, the sample should therefore be insulated.

8.4 Measurement Errors

The membrane is a gas permeable teflon fluorocarbon resin. In addition to oxygen, the following gases will affect the meter reading; sulfites, sulfates, carbon monoxide, carbon dioxide, hydrogen, nitrogen, chlorine, nitrous oxide, and nitric oxide. If an erroneous reading is suspected, the interfering gas should be removed by chemical means.

In some applications (i.e.. .sea water or muddy water tests), build-ups may form on the membrane and reduce permeability. Frequent cleaning or membrane replacement may be required. Avoid submersing the probe into chemicals that may attack the probe. Consult a Chemical Resistance chart if you are not sure of the affect on the probe.

9.0 TROUBLESHOOTING

9.1 First isolate the problem to the meter or the probe.

9.2 If the **sensitivity** of the oxygen sensor decreases:

9.2.1 Inspect the probe membrane for air bubbles, wrinkles or tears in the membrane, and adequate reservoir solution.

EXAMPLE: IF TEMPERATURE = 20°C
TABLE III PRESSURE = 760 mmHg
CHLORINITY = 20 g/L
TABLE III OXYGEN = 7.3 mg/L
ACTUAL PRESSURE = 775 mmHg
CORRECTION FACTOR = 1.02
THEN OXYGEN = (7.3 mg/L x 1.02)
= 7.45 mg/L

TABLE IV ALTITUDE CORRECTION FACTOR[5]

Atmospheric Pressure (mmHg) or	Equivalent Altitude (ft)	Correction Factor =	Atmospheric Pressure (mmHg) or	Equivalent Altitude (ft)	Correction Factor =
775	-540	1.02	638	4,756	.84
760	0	1.00	623	5,403	.82
745	542	.98	608	6,065	.80
730	1,094	.96	593	6,744	.78
714	1,688	.94	578	7,440	.76
699	2,274	.92	562	8,204	.74
684	2,864	.90	547	8,939	.72
669	3,466	.88	532	9,694	.70
654	4,082	.86			

8.0 MEASUREMENT GUIDELINES

8.1 Membrane Function

In a polarographic probe, the membrane is one of the most important elements. The thin, permeable membrane must be stretched uniformly over the sensor. This isolates the internal sensor elements and filling solution from the environment while still allowing oxygen to enter. When polarizing voltage is applied to the sensor, the oxygen which passes through the membrane reacts, at the cathode, causing a current flow.

Oxygen passes through the membrane at a rate proportional to the pressure difference across it. The oxygen pressure inside is zero, due to its rapid consumption at the cathode. Therefore, the oxygen diffusion through the membrane is proportional only to the absolute oxygen pressure outside the membrane.

$$O_2 \text{ pressure} = O_2 \text{ diffusion} = \text{CURRENT}$$

Any large air bubbles trapped under the membrane will cause the membrane to deform as the pressure changes. It is, therefore, desirable to eliminate the bubbles. Tapping the probe gently will eliminate the bubbles.

[5]Derived from the "CRC Handbook of Chemistry and Physics," 69th Ed., 1988 - 1989.

1.0 INTRODUCTION

Your new dissolved oxygen meter is a compact, battery operated, field or lab instrument designed to measure the dissolved oxygen level and temperature of water and aqueous solutions. This meter is rugged and weather resistant. It is not, however, waterproof. Do not drop the meter into a lake, pond or other body of water, nor allow it to become overly wet in the rain. The heart of the meter is the oxygen probe, a polarographic sensor designed for fast response and low maintenance. It includes a thermistor for temperature measurement and to compensate for changes in oxygen sensor response due to temperature.

Some models have analog (continuous needle movement) displays. Others have digital (numeric) displays. All models are powered with 8 AA batteries. Bench models will also operate from an optional 9 VDC 200 mA wall plug adaptor. The battery pack disconnects when the adaptor is plugged into the meter.

2.0 THEORY OF OPERATION

There are two basic methods used to measure dissolved oxygen; the chemical methods, such as the Winkler or iodometric method, and the instrument method, which uses a membrane electrode. The test method used depends on the interferences present, the accuracy desired, convenience, and expedience.

The chemical methods are the methods of choice when interferences are minimal, the required number of tests are small, and high precision and reliability are required. Measuring dissolved oxygen with an instrument using a membrane electrode is preferred for field testing, continuous monitoring, in situation determinations, or anytime a quantity of samples need to be read in a short time period. For nondestructive testing, instrumental methods are the only methods available.

The membrane electrode is composed of a cathode and anode in contact with an electrolyte solution, separated from the sample by an oxygen permeable plastic membrane, usually made of polyethylene or fluorocarbon, which is permeable to oxygen and acts as a diffusion barrier against impurities.

The measurement of oxygen is accomplished by applying a voltage across the sensor, reducing the oxygen which has passed through the membrane. The resulting diffusion current is linearly proportional to the concentration units displayed on the meter display.

A change in temperature will have a significant effect on the dissolved oxygen measurement. Many oxygen sensors include thermistors, in the electrode circuit, to automatically compensate for temperature changes. If the oxygen sensor does not have a thermistor or if very high temperatures are present, then a calibrated nomographic chart should be used to correct for the temperature effect.

3.0 SPECIFICATIONS

Readout:	6"Analog Meter	3 " Digital LCD
Range:	0 - 15 ppm	0 - 19.99 ppm
Accuracy:	0.1ppm	0.1ppm
Saturation Range:	0 - 120%	NA
Saturation Accuracy:	1%	NA
Temperature Compensation:	Automatic	
Temperature Readout:	0 - 50 °C	
Electrode:	Polarographic	
Size		
Bench Models:	5"H x 8"W x 5"D	
Field Models:	4"H x 12"W x 8"D	
Weight		
Bench Models:	2.7 lbs (1.2 Kg)	
Field Models:	4 lbs (1.8 Kg)	
Power		
Bench Models:	8 - 1.5 V AA Batteries or Optional Wall Plug Adaptor	
Field Models:	8 - 1.5 V AA Batteries or 8 AA Nicads	
Battery Life:	approx. 200 hrs.	

Determine the chlorinity and temperature of the sample, then the air saturated oxygen can be found, using the table. The chlorinity is found by using this formula:

Chlorinity = salinity **:** 1.80655

EXAMPLE: IF TEMPERATURE = 20°C
PRESSURE = 760 mmHg
SALINITY = 36.1 g/L
CHLORINITY = 20 g/L
THEN OXYGEN = 7.3 ppm (mg/L)

TABLE III SOLUBILITY OF OXYGEN IN WATER AT ATMOSPHERIC PRESSURE (760 mmHg)[4]

	Chlorinity g/L				
	0	5	10	15	20
Temp °C	Dissolved Oxygen mg/L				
0	14.6	13.7	12.9	12.1	11.4
2	13.8	13.0	12.2	11.5	10.8
4	13.1	12.3	11.6	10.9	10.3
6	12.5	11.7	11.0	10.4	9.8
8	11.8	11.2	10.5	9.9	9.4
10	11.3	10.7	10.0	9.5	9.0
12	10.8	10.2	9.6	9.1	8.6
14	10.3	9.7	9.2	8.7	8.2
16	9.9	9.3	8.8	8.4	7.9
18	9.5	9.0	8.5	8.0	7.6
20	9.1	8.6	8.2	7.7	7.3
22	8.7	8.3	7.9	7.5	7.1
24	8.4	8.0	7.6	7.2	6.8
26	8.1	7.7	7.3	7.0	6.6
28	7.8	7.4	7.1	6.7	6.4
30	7.6	7.2	6.8	6.5	6.2

7.2.4 Atmospheric Pressure Compensation

Table III gives dissolved oxygen concentrations at various chlorinity (salinity) concentrations at an atmospheric pressure of 760 mmHg. To determine the dissolved oxygen concentration at other atmospheric pressures, multiply the values obtained from Table III by the correction factor given in Table IV.

[4] "Standard Methods for the Examination of Water & Wastewater," 17th Ed., pg 4 - 154, 1989.

TABLE II DISSOLVED OXYGEN CALIBRATION VALUES[3] (ppm)

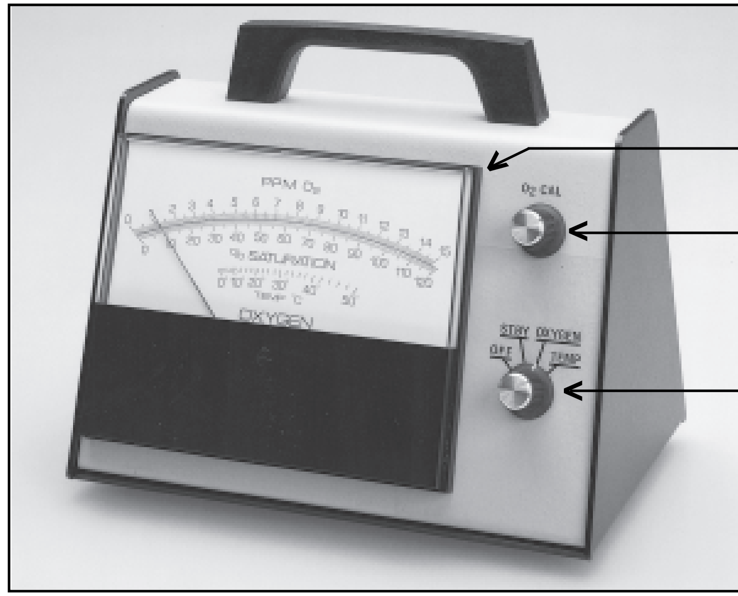
TEMP. °C	°F	PRESSURE mmHg 775	760	750	725	700	675
0	32	14.9	14.6	14.4	13.9	13.4	12.9
2	36	14.1	13.8	13.6	13.2	12.7	12.2
4	39	13.3	13.1	12.9	12.5	12.0	11.6
6	43	12.7	12.4	12.3	11.8	11.4	11.0
8	46	12.0	11.8	11.7	11.3	10.9	10.5
10	50	11.5	11.3	11.1	10.7	10.4	10.0
12	54	11.0	10.7	10.6	10.2	9.9	9.5
14	57	10.5	10.3	10.1	9.8	9.5	9.1
16	61	10.0	9.8	9.7	9.4	9.0	8.7
18	64	9.6	9.4	9.3	9.0	8.7	8.4
20	68	9.2	9.1	8.9	8.6	8.3	8.0
22	72	8.9	8.7	8.6	8.3	8.0	7.7
24	75	8.6	8.4	8.3	8.0	7.7	7.4
26	79	8.3	8.1	8.0	7.7	7.4	7.2
28	82	8.0	7.8	7.7	7.4	7.2	6.9
30	86	7.7	7.6	7.4	7.2	6.9	6.7
32	90	7.4	7.3	7.2	7.0	6.7	6.4
34	93	7.2	7.1	7.0	6.7	6.5	6.2
36	97	7.0	6.8	6.7	6.5	6.3	6.0
38	100	6.8	6.6	6.5	6.3	6.1	5.8
40	104	6.6	6.4	6.2	6.1	5.9	5.7
42	108	6.4	6.2	6.1	5.9	5.7	5.5
44	111	6.2	6.0	5.9	5.7	5.5	5.3
46	115	6.0	5.8	5.8	5.5	5.3	5.1
48	118	5.8	5.7	5.6	5.4	5.2	5.0
50	122	5.6	5.5	5.4	5.2	5.0	4.8

7.2.3 Salinity Compensation

The following table shows the dissolved oxygen concentration in air saturated water at an atmospheric pressure of 760 mmHg and at various chlorinity (salinity) concentrations.

[3] Michael L. Hitchman, Measurement of Dissolved Oxygen, John Wiley & Sons, New York, NY, 1978.

4.0 INSTRUMENT FAMILIARITY



4.1 Readout

4.1.1 Analog Meter - displays oxygen in ppm, percent saturation, and temperature in degrees centigrade.

4.1.2 Digital LCD - displays oxygen in mg/L (ppm) and temperature in degrees centigrade.

4.2 Function Selector

4.2.1 OFF - power is removed from circuit.

4.2.2 STBY - power is applied to circuit, no input signal is available.

4.2.3 O_2 - meter displays dissolved oxygen level of sample.

4.2.4 TEMP - meter displays temperature of the sample.

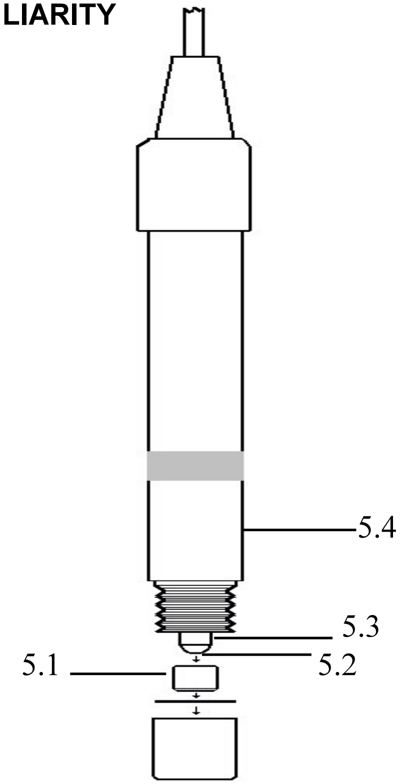
4.3 O_2 CAL - calibration adjustment when measuring dissolved oxygen.

4.4 REAR PANEL

4.4.1 PROBE INPUT - 5 pin DIN jack connector for detachable oxygen probe.

4.4.2 POWER - input for optional AC wall plug adapter. Batteries disconnect when plug is inserted into jack. (Available for bench models only.)

5.0 PROBE FAMILIARITY



5.1 Membrane - Membrane Cartridge- a special telfon material with a metal cartridge in the membrane cover. This allows gases to pass through, but not liquids.

5.2 Cathode - platinum tip of probe.

5.3 Anode - silver coil inside probe chamber.

5.4 Thermistor - responsible for temperature readout and temperature compensation in the O_2 mode.

5.5 Membrane Applicator - this unique device serves as both a membrane applicator and an "O" ring applicator.

The barometric pressure, as reported by radio and television stations, is not the actual atmospheric pressure. For standardization, the values reported are corrected to sea level. To convert these reported values to the actual atmospheric pressure, your altitude above sea level must be known. A local airport should be able to provide this information.

To convert from a reported, standard barometric pressure to an actual atmospheric pressure, in Torr (mm of mercury), the values from the following table may be used.

TABLE I ALTITUDE MULTIPLIER[2]

Altitude	Multiplier	Altitude	Multiplier
-500 ft	1.018	3500 ft	0.880
sea level	1.000	4000 ft	0.864
500 ft	0.982	5000 ft	0.832
1000 ft	0.964	6000 ft	0.801
1500 ft	0.947	7000 ft	0.772
2000 ft	0.930	8000 ft	0.743
2500 ft	0.913	9000 ft	0.715
3000 ft	0.896	10000 ft	0.688

Take the multiplier from the table corresponding to your altitude and multiply the reported barometric pressure by it. This is your actual atmospheric pressure.

7.2.2 Dissolved Oxygen Calibration

Obtain the temperature of the sample, with the meter in TEMP mode, and the atmospheric pressure as described in section 7.2.1. Use the following table (Table II) to determine the calibration value for dissolved oxygen in air saturated water.

EXAMPLE:	IF	TEMPERATURE =	20°C
		PRESSURE =	750 mmHg
	THEN	OXYGEN =	8.9 mg/L

[2] Derived from : "U.S. Standard Atmosphere (1976)", CRC Handbook of Chemistry & Physics, 69th Ed., 1988-1989, pg.F-147.

7.0 CALIBRATION

The dissolved oxygen probe requires periodic calibration. Organic matter can foul the membrane pores, reducing its effectiveness. Since the probe's response is dependent upon the mass transport characteristics of the membrane, as well as the condition of the silver electrode, it needs to be calibrated whenever the membrane is replaced.

7.1 Air Calibration

7.1.1 For maximum accuracy, calibration should be done within 5°C of measurement temperature.

7.1.2 The calibration point, for the oxygen sensor, is water saturated air (100% humidity). This value is determined using the calibration tables in section 7.2.

7.1.3 Wrap the probe in a wet cloth. DO NOT TOUCH THE MEMBRANE.

7.1.4 The membrane should remain covered with a thin layer of water, while wrapped in the cloth.

7.1.5 Allow the probe to stabilize (approx. 2 min.).

7.1.6 Adjust the **CAL** control for the value determined from the calibration tables in section 7.2.

7.2 Calibration Tables

The amount of oxygen dissolved in water is dependent upon several parameters. Temperature, salinity, and atmospheric pressure each have an effect on the measurement of dissolved oxygen. The following tables provide the necessary information to correctly compensate for your specific environment.

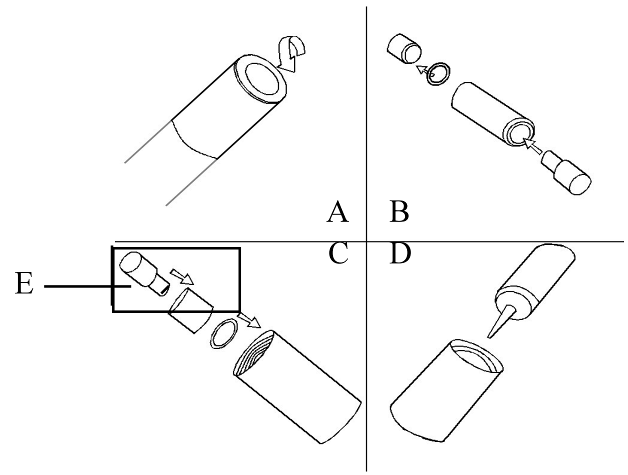
7.2.1 Altitude Pressure Compensation

Prior to calibrating the oxygen meter for ppm or mg/L, the correct atmospheric pressure must be determined. This is due to the solubility of oxygen in water being dependent upon the partial pressure of oxygen in the atmosphere which is dependent on your altitude or elevation.

6.0 OPERATION

6.1 Probe Preparation

6.2 Membrane Replacement



A. Removing membrane cover
B. Membrane removal
C. Membrane insertion
D. Probe filling solution (note: when filling with solution to the mem brane fill only to white teflon inside the cartridge)

E. Membrane Applicator 5.5

6.3 Probe Polarization

6.3.1 Whenever a new membrane or filling solution is used, the oxygen probe must be polarized prior to use.

6.3.2 Polarization requires placing the prepared probe on the meter and turning the function selector to the $\mathbf{O_2}$ position.

6.3.3 Run the probe for 20 to 30 minutes.

6.3.4 Wrap the probe in a moist cloth or paper towel to allow for quick calibration once the probe polarizes.

6.3.5 After 30 minutes, calibrate the instrument.

6.4 Calibration

The oxygen probe requires periodic calibration. How often depends on it's use. The following is a simple and quick calibration method for general use. For additional calibration information and concerns (high elevations, high or low temperatures, etc.), see section 7.0.

6.4.1 Wrap the probe in a moist cloth or paper towel. The purpose is to create a water saturated environment (100% humidity.)

6.4.2 From Table II determine the atmospheric oxygen level for your air temperature and normal air pressure. If you are at sea level and the air temperature is 72°F, your atmospheric oxygen level would be 8.7 ppm (mg/L).

6.4.3 Allow the instrument 20 to 30 minutes to polarize if it hasn't already been done.

6.4.4 Using the CAL knob, set the display to read the value determined from Table II.

6.4.5 Your instrument is now calibrated.

6.5 Dissolved Oxygen Measurement

Use the following steps to determine your dissolved oxygen concentration.

6.5.1 Connect prepared probe to the DIN jack on instrument.

6.5.2 Turn instrument to the $\mathbf{O_2}$ position.

6.5.3 Calibrate the instrument following the procedure in section 6.4 or 7.0.

6.5.4 Place probe in test sample and gently stir. If the sample temperature is different from calibration temperature, allow 3 minutes for reading to stabilize.

6.5.5 Read the dissolved oxygen in ppm (mg/L).

6.5.6 Turn the instrument to **TEMP** position and read sample temperature.

6.5.7 Rinse probe with deionized water in-between sample readings and upon completion of meter use.

6.6 Dissolved Oxygen Units

Dissolved oxygen units are usually reported in units of parts per million (ppm) or milligrams/liter (mg/L). To convert from mg/L to ppm or ppm to mg/L, the specific gravity of the sample must be known. This instrument will read either ppm or mg/L depending on what it is calibrated to.

The formula for conversion is:

$$\text{ppm} = \frac{\text{mg/L}}{\text{specific gravity}} \quad \text{or} \quad \text{mg/L} = \text{ppm} \times \text{specific gravity}$$

For 0 to 30°C temperature ranges, the difference between ppm and mg/L is less than 0.5% in fresh water and less than 5% for most sea water.[1]

[1]CRC "Handbook of Chemistry & Physics", 69th ED., pgs D-250 & F-10, 1988 - 1989.