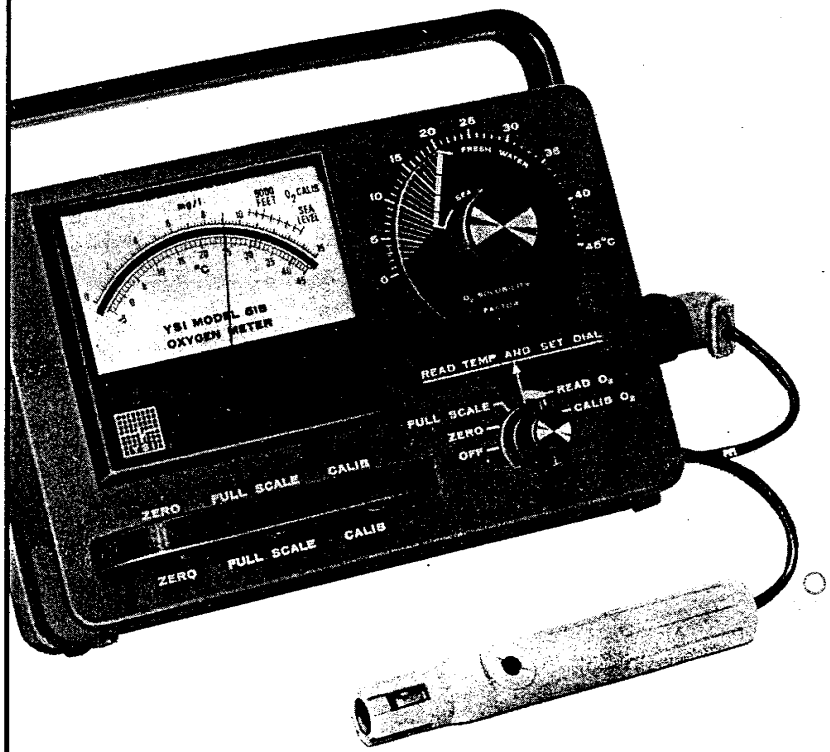
YSI Incorporated
Yellow Springs, Ohio 45387 USA

Item 065000 PN A05231 AJ

YSI MODEL 51B

Dissolved Oxygen Meter Instructions



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DESCRIPTION

The YSI Model 51B Dissolved Oxygen Meter is intended for dissolved oxygen and temperature measurement in water and wastewater applications, but is also suitable for use in certain other liquids. Dissolved Oxygen is indicated in mg/L (milligrams per liter) on a 0-15 mg/L scale. Temperature is indicated in °C on a -5° to +45°C scale. The dissolved oxygen range is automatically temperature compensated for permeability of the probe membrane, and manually by direct dial for changes in water temperature.

The probes use Clark-type membrane covered polarographic sensors with built-in thermistors for temperature measurement and compensation. A thin, permeable membrane stretched over the sensor isolates the sensor elements from the environment, but allows oxygen and certain other gases to enter. When a polarizing voltage is applied across the sensor, oxygen that has passed through the membrane reacts at the cathode, causing a current to flow.

The membrane passes oxygen at a rate proportional to the pressure difference across it. Since oxygen is rapidly consumed at the cathode, it can be assumed that the oxygen pressure inside the membrane is zero. Hence, the force causing the oxygen to diffuse through the membrane is proportional to the absolute pressure of oxygen outside the membrane. If the oxygen pressure increases, more oxygen diffuses through the membrane and more current flows through the sensor. A lower pressure results in less current.

SPECIFICATIONS

Oxygen Measurement

Range: 0-15 mg/L

Accuracy: Better than ±0.2 mg/L when calibrated within ±5°C of actual sample temperature.

Readability: Better than 0.1 mg/L

Temperature Measurement

Range: -5°C to +45°C

Accuracy: ±0.7°C, including probe

Readability: 0.25°C

Compensation

Temperature compensation for oxygen probe membrane coefficient is automatic.

Temperature compensation for oxygen solubility is manual by direct dial from 0°C to 45°C for fresh water and -5°C to +37°C for sea water.

Altitude compensation is manual by direct dial from 0 to 11,000 feet.

Salinity compensation is manual by direct dial from fresh water to sea water of 20,000 mg/L chloride concentration.

System Response Time

Typical response for temperature and DO readings is 90% in 10 seconds at constant temperature of 30°C.

DO response at low temperature and low DO is typically 90% in 30 seconds.

If response time under any operating conditions exceeds two minutes, probe service is needed.

Ambient Range

Satisfactory operation from -5°C to +45°C.

Power Supply

Power is supplied by four C size batteries, providing approximately 1000 hours of operation.

PREPARING THE INSTRUMENT

It is important that before the meter is prepared for use and calibrated, it should be placed in the intended operating position: vertical, tilted, or on its back: Readjustment may be necessary when the instrument operating position is changed. Prepare the probe as described in the probe instructions, then proceed as follows:

1. With switch set to OFF, adjust the meter pointer to zero with the screw in the center of the meter panel. Do not force this adjustment, or you may damage the meter.

2. Switch to ZERO and adjust to zero with ZERO knob.

3. Switch to FULL SCALE and adjust the FULL SCALE knob until the meter needle aligns with the 15 mark on the mg/L scale.

4. Attach the prepared probe to the probe connector of the instrument and adjust the retaining ring finger tight.

5. Before calibrating, allow 15 minutes for optimum probe stabilization and polarization.. Allow 15 minutes for repolarization whenever the instrument has been off, or the probe has been disconnected.

CALIBRATION

Calibration is accomplished by exposing the probe to a known oxygen concentration, such as water-saturated air (%), or water of a known oxygen content (mg/L), and then adjusting the calibration controls so the meter indicates a reading matching the oxygen concentration of the known sample.

The operator has a choice of three calibration methods: Winkler Titration, Saturated Water, and Air. Experience has shown that air calibration is quite reliable, yet far simpler than the other two methods.

Daily calibration is generally appropriate. Calibration can be disturbed by physical shock, touching the membrane, fouling of the membrane or drying out of the electrolyte. Check calibration after each series of measurements. In time you will develop a realistic schedule for recalibration. When probes are not in use, store them as described in the probe instructions.

Air Calibration

1. Switch to CALIB O_2.

2. Place the probe in moist air. BOD probes can be placed in partially filled (50 mL) BOD bottles. Other probes can be placed in the 5075A

Calibration Chamber (see the following section) or the small calibration bottle (the one with the hole in the bottom) along with a few drops of water. The probe can also be wrapped loosely in a damp cloth taking care the cloth does not touch the membrane. Wait approximately 10 minutes for temperature stabilization. This may be done at the same time that the probe is stabilizing.

3. Using the CALIB knob, set the meter pointer to the mark for the local altitude. Be sure reading is steady. For calibration at altitudes higher than 7000 feet above sea level, see Table II. Recalibration is recommended when you change altitude. A 1000 ft. altitude change can result in a 3% reading error: 0.3 mg/L at 10.0 mg/L.

Calibration Chamber

The YSI 5075A Calibration Chamber helps obtain optimum air calibration conditions in the field.

It is also a useful tool for measuring at shallow depths (less than 4 feet) and in rapidly flowing streams. It is used only with the YSI 5739 probe, and is illustrated below.

It consists of 4-1/2 ft. stainless steel tube (1) attached to the calibration chamber (2) and the measuring ring (3) and two stoppers (4) and (5).

For calibration, insert the solid rubber stopper (4) into the bottom of the calibration chamber (2). Push the probe (6) through the hollow

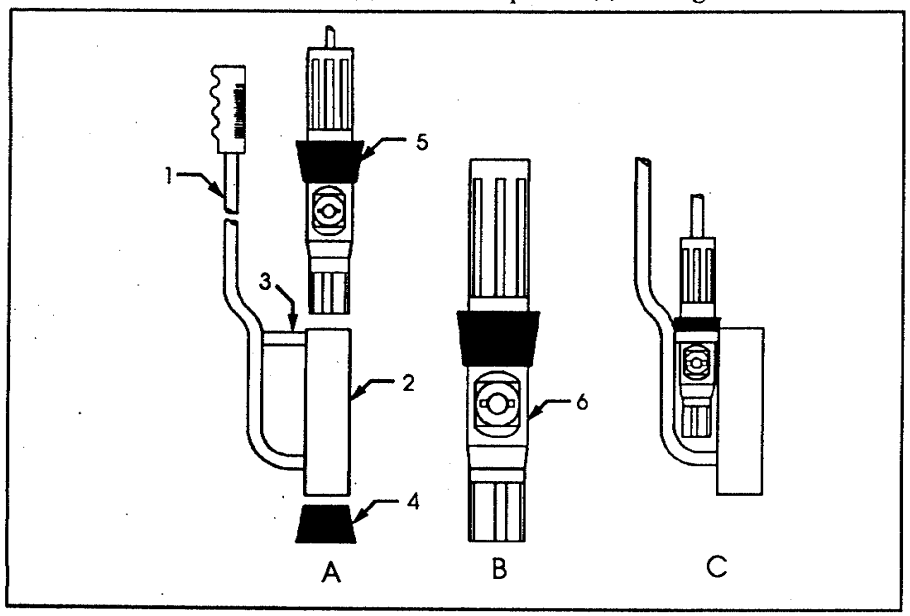


Figure 1. The YSI 5075A Calibration Chamber

stopper (5) until the small end of the stopper is situated at about the notch where the pressure compensation unit is located. It is important that this stopper be positioned so that a water-tight seal is formed when the stopper and probe are inserted into the calibration chamber.

Place the probe in the measuring ring (view C), and immerse it in the sample for five minutes. This permits the probe to come to the same temperature as the sample. Wet the inside of the calibration chamber with fresh water to create a 100% relative humidity environment for calibration. Drain excess water from the chamber, shake any droplets from the probe membrane, and promptly insert the probe into the calibration chamber. Place the chamber in the sample for an additional five minutes for final thermal equilibration. Calibrate as described in the air calibration procedure. Keep the handle above water at all times. After calibration, return the probe to the measuring ring.

For shallow measurements, move the probe up and down, or horizontally, approximately one foot a second while measuring. In rapid streams flowing at 5 feet per second or more, install the probe in the measuring ring with the pressure compensating diaphragm toward the chamber.

Air-Saturated Water Calibration

1. Air saturate a volume of water (300 to 500 mL) by aerating or stirring for at least 15 minutes at a relatively constant temperature.

2. Place the probe in the sample and stir.

3. With the function switch at CALIB O_2, adjust the CALIB knob so the needle indicates the local altitude. Leave probe in sample for 2 minutes to verify stability.

Winkler Titration

1. Carefully divide a volume of water into four samples. Determine the oxygen in three samples using the Winkler Titration technique and average the three values. If one of the values differs from the other two by more than 0.5 mg/L, discard that value and average the remaining two.

2. Place the probe in the fourth sample and stir.

3. Read the temperature of the calibration sample and set the solubility dial to sample temperature. Ascertain that the salinity setting is correct. Allow the probe to remain in the sample at least two minutes before setting temperature.

4. With the function switch set to READ O_2, use the CALIB knob to set the meter to the average value determined in Step 1. Leave the probe in the sample for an additional two minutes to verify stability.

Calibration Tables

Table I shows the amount of oxygen in mg/L that is dissolved in air saturated fresh water at sea level (760 mmHg atmospheric pressure) as temperature varies from 0° to 45°C.

Table I - Solubility of Oxygen in Fresh Water

Temp °C	Solubility mg/L	Temp °C	Solubility mg/L	Temp °C	Solubility mg/L
0	14.62	17	9.67	34	7.07
1	14.22	18	9.47	35	6.95
2	13.83	19	9.28	36	6.84
3	13.46	20	9.09	37	6.73
4	13.11	21	8.92	38	6.62
5	12.77	22	8.74	39	6.52
6	12.45	23	8.58	40	6.41
7	12.14	24	8.42	41	8.31
8	11.84	25	8.26	42	6.21
9	11.56	26	8.11	43	6.12
10	11.29	27	7.97	44	6.02
11	11.03	28	7.83	45	5.93
12	10.78	29	7.69	46	5.84
13	10.54	30	7.56	47	5.74
14	10.31	31	7.43	48	5.65
15	10.08	32	7.31	49	5.56
16	9.87	33	7.18	50	5.47

Derived from 17th Edition, *Standard Methods for the Examination of Water and Wastewater.*

Table II shows the correction factor that should be used to compensate for the effects of variation in atmospheric pressure or altitude. Find true atmospheric pressure in the left hand column and read across to the right hand column to determine the correction factor. (Note that "true" atmospheric pressure is as read on a barometer. Weather Bureau reporting of atmospheric pressure is corrected to sea level.) If atmospheric pressure is unknown, the local altitude may be substituted. Select the altitude in the center column and read across to the right hand column for the correction factor.

Table II - Altitude Correction Factors

Pressure in inches Hg	mm Hg	kPa	Altitude in Feet	Meters	Correction Factor (%)
30.23	768	102.3	-276	-84	101
29.92	760	101.3	0	0	100
29.33	745	99.3	558	170	98
28.74	730	97.3	1126	343	96
28.11	714	95.2	1703	519	94
27.52	699	93.2	2290	698	92
26.93	684	91.2	2887	880	90
26.34	669	89.2	3496	1066	88
25.75	654	87.1	4115	1254	86
25.12	638	85.1	4747	1447	84
24.53	623	83.1	5391	1643	82
23.94	608	81.1	6047	1843	80
23.35	593	79.0	6717	2047	78
22.76	578	77.0	7401	2256	76
22.13	562	75.0	8100	2469	74
21.54	547	73.0	8815	2687	72
20.94	532	70.9	9545	2909	70
20.35	517	68.9	10293	3137	68
19.76	502	66.9	11058	3371	66

The temperature/solubility relationship of oxygen in sea water is not the same as that in fresh water. Oxygen solubility in sea water is shown in Table III.

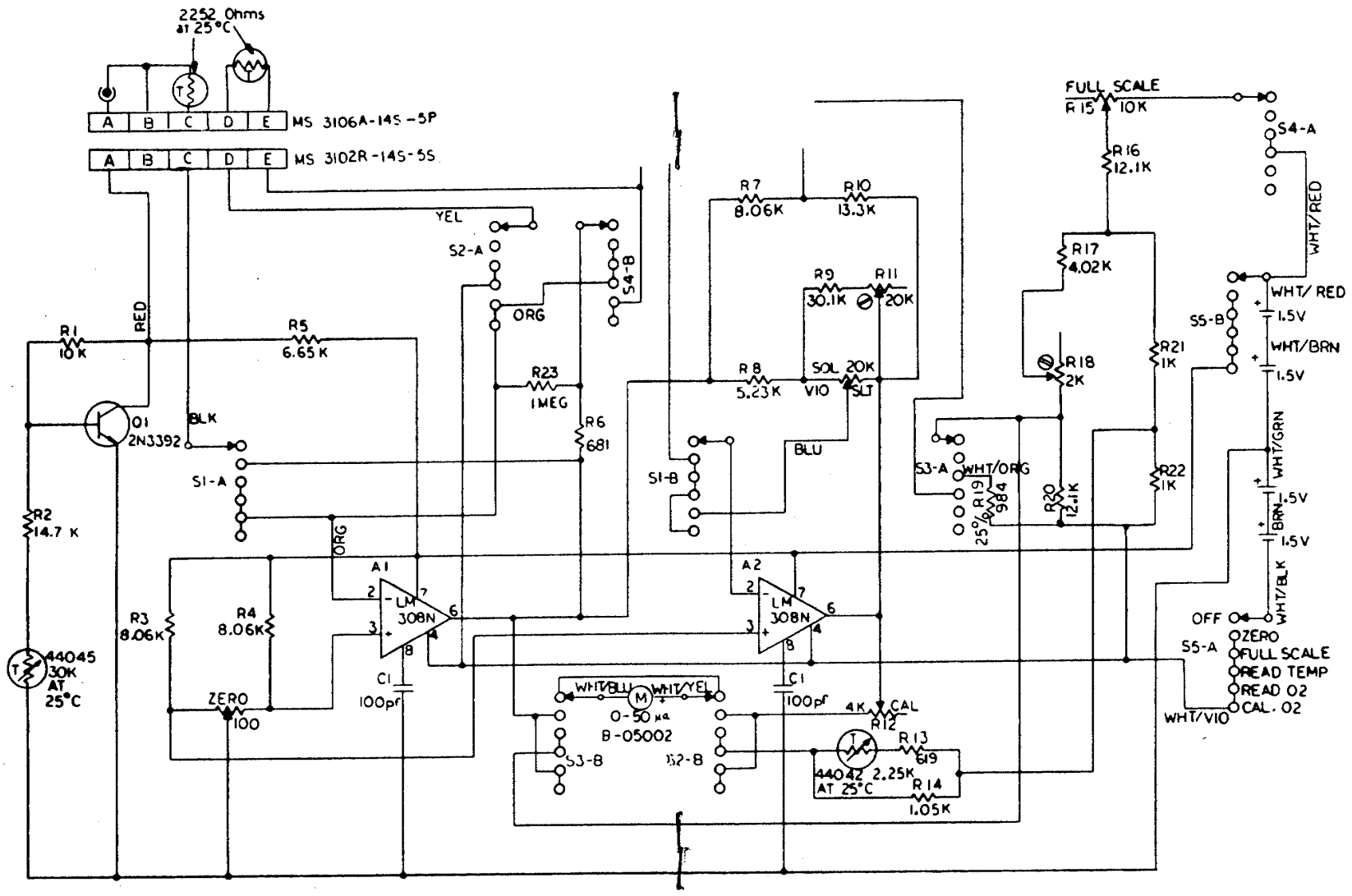
Table III - Solubility of Oxygen in Sea Water

(Chloride concentration 20,000 mg/L)

Temp. °C	Solubility mg/L	Temp. °C	Solubility mg/L	Temp. °C	Solubility mg/L
0	11.41	11	8.77	21	7.20
1	11.11	12	8.58	22	7.07
2	10.83	13	8.41	23	6.95
3	10.56	14	8.24	24	6.83
4	10.30	15	8.07	25	6.71
5	10.05	16	7.91	26	6.60
6	9.82	17	7.78	27	6.49
7	9.59	18	7.61	28	6.38
8	9.37	19	7.47	29	6.28
9	9.16	20	7.33	30	6.18
10	8.96				

Derived from 15th Edition, *Standard Methods for the Examination of Water and Wastewater*

YSI 51B SCHEMATIC



NOTES:
1. Resistor values are in ohms. K = 1,000. Unless otherwise specified, all resistors are 1/4 watt, 1%.
2. 4 batteries are required. Use Eveready 935 cells, or equivalent.
3. All switch sections are ganged.
4. This schematic is representatie and may be slightly different from the circuit in your instrument. If the values shown here are different from those in your meter, either may be used for replacement purposes.

DISSOLVED OXYGEN MEASUREMENT

With the instrument prepared for use and the probe calibrated, place the probe in the sample to be measured and provide stirring.

1. Stirring for the 5739 Probe can best be accomplished with a YSI Submersible Stirrer. If the Submersible Stirrer is not used, provide manual stirring by raising and lowering the probe about 1 ft. per second. If the 5075A Calibration Chamber is used, the entire chamber may be moved up and down in the water at about 1 ft. per second.

2. The 5720A and 5730 probes have built-in stirrers.

3. With the YSI 5750, sample stirring must be accomplished by other means, such as with the use of a magnetic stirring bar.

4. Allow sufficient time for probe to stabilize to sample temperature and dissolved oxygen.

5. Switch to TEMP and read the temperature from the lower meter scale. Set the O_2 SOLUBILITY FACTOR dial to the observed temperature, taking care to use the appropriate salinity index. (See Salinity Correction).

6. Switch to READ O_2 and read the dissolved oxygen value in mg/L directly from the meter.

Salinity Correction

Less oxygen can be dissolved in salt water than in fresh water. The amount varies directly with the degree of salinity and, at constant temperature, the relationship can be considered linear for the range of fresh water to sea water, which corresponds to the instrument range of 0 to 20,000 mg/L chloride.

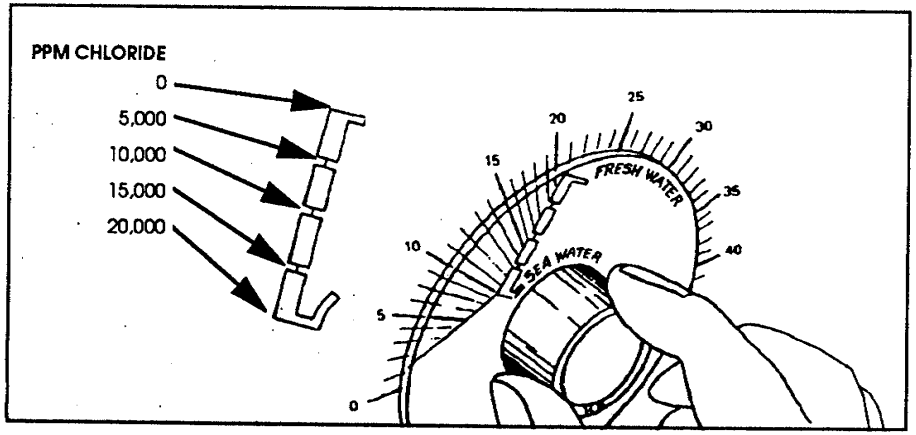


Figure 2. The O_2 Solubility Factor Dial.

The user must determine salinity by suitable means (such as with the YSI Model 33 S-C-T Meter) and then choose the correct position along the index scale when dialing in the temperature. See Figure 2.

Each section of the bar on the O_2 SOLUBILITY FACTOR dial represents 5,000 mg/L chloride concentration over a range from 0 to 20,000 mg/L. The line leading to the correct temperature should intersect the left edge of the bar at the proper salinity concentration. The drawing shows the dial set for 0 mg/L chloride a 20°C, or 10,000 mg/L chloride at 15°C, or about 18,000 mg/L chloride at 10°C, etc.

High Sensitivity Membrane

An extremely thin membrane increases oxygen permeability and probe signal current, and hastens a probe's response; but it achieves this at the expense of ruggedness. For special circumstances, an 0.5 mil (.0005") membrane is available. (Order YSI 5776 Membrane and KCl Kit, High Sensitivity.) This half-thickness membrane hastens response at low temperatures and helps suppress background current at very low dissolved oxygen levels. (When data is routinely collected with sample temperatures below 15°C and at dissolved oxygen levels below 20% air saturation, the low signal current resulting from the use of the standard membranes tends to magnify the probe's inherent constant background signal. Using the high sensitivity membranes in this situation will decrease the percentage of error due to the probe's background current.)

Multiple Measurements

If a series of measurements are made in a short time at about the same temperature (within 5°C of calibration temperature), recalibration is not required to maintain specification performance.

Read the temperature of the new sample, reset the O_2 SOLUBILITY FACTOR dial and read the oxygen concentration. Experience is the best guide for deciding how often recalibration is required. Careful probe maintenance and correct probe storage aid stability of calibration.

Recording Data

Although the YSI Model 51B is not designed with recorder output, it is possible for the user to modify the instrument slightly in order to record % O_2 and % air saturation. Connect a 100 mV recorder with at least 50,000 ohm input impedance across the meter terminals. Set up the recorder according to the manufacturer's instructions and operate the YSI Model 51B normally.

Dissolved oxygen measurements in mg/L cannot be recorded accurately except under constant temperature conditions. This is because the solubility of oxygen in water is temperature dependent and instrument correction is manual. If you need to record dissolved oxygen, we recommend either the YSI Model 54A or Model 57 Dissolved Oxygen Meter, which have automatic temperature compensation and are designed with recorder output terminals.

% Oxygen and % Air Saturation Measurements

Occasionally it is desirable to measure the % oxygen in a sample or the % air saturation of a sample. The YSI Model 51B can be used for these measurements with any of the YSI 5700 Series Probes. When this is done, you should calibrate as follows:

% Oxygen Readings Calibration Procedure (0-45%)

1. With a probe connected, and the function switch set to Off, adjust the meter to zero on the upper scale, using the adjustment screw.

2. Switch to FULL SCALE and use the FULL SCALE knob to set the meter to 15 on the upper scale.

3. Switch to READ O_2 and leave the instrument on for up to 20 minutes to stabilize the probe

4. Set the O_2 SOLUBILITY FACTOR dial to 25°C.

5. Switch to ZERO and adjust the meter to zero on the lower scale with the ZERO knob.

6. Switch to READ O_2, and with the probe in air, adjust the meter to 21 on the lower scale, using the CALIB knob.

7. Repeat Steps 5 and 6 until no further adjustment is required.

8. Transfer the probe to the measurement sample and read on the lower scale with the switch still at READ O_2. All readings will be in % O_2.

NOTE: Temperature readings are made with the switch set to TEMP.

The SOLUBILITY FACTOR dial must be left at 25°C.

% Air Saturation Readings (0-100%)

1. With a probe connected, and the function switch set to Off, adjust the meter to zero on the upper scale, using the adjustment screw.

2. Switch to FULL SCALE and use the FULL SCALE knob to set the meter to 15 on the upper scale.

3. Turn the selector switch to ZERO and adjust the meter to zero on the upper scale using the ZERO adjustment knob.

4. Switch to CALIB O_2 and with the probe in air, adjust the meter to 10 on the upper scale using the CALIB knob.

5. Transfer the probe to the measurement sample and read on the upper scale with the instrument still in the CALIB O_2 position. Multiply by 10 to obtain % air saturation. For example, if the meter reads 8.5 multiply by 10 for an answer of 85% air saturation.

Note that temperature readings are made with the switch set to TEMP. The O_2 SOLUBILITY FACTOR dial is inoperative and unnecessary when making % air saturation readings.

When % O_2 or % air saturation measurements are to be made in water, greatest accuracy will be achieved if the probe is calibrated in moist air by suspending it in a bottle containing a small amount of water, or by wrapping it in a damp cloth during calibration.

DISCUSSION OF MEASUREMENT ERRORS

There are three basic types of error. Type 1 errors are related to limitation of instrument design and tolerances of instrument components. These are chiefly the meter linearity and the resistor tolerances. Type 2 errors are due to basic probe accuracy tolerances, chiefly background signal, probe linearity, and variations in membrane temperature coefficient. Type 3 errors are related to the operator's ability to determine the conditions at the time of calibration. If calibration is performed against more accurately known conditions, type 3 errors are appropriately reduced.

The calculations that follow are for a near extreme set of conditions.

Type 1 Errors

a. Meter linearity error: ±1% of full scale reading, or ±0.15 mg/L

b. Component and circuitry error: ±0.05 mg/L

c. O_2 Solubility Factor dial error: ±0.10 mg/L

d. Positioning accuracy of dial and background legend:
-5 to +30°C: ±0.05 mg/L
30 to 45°C: ±0.10 mg/L

Type 2 Errors:

a. Temperature compensation for membrane temperature coefficient: ±0.03 mg/L

b. Temperature measurement errors
a maximum ±0.2°C probe error is equal to ±0.14 mg/L
meter error: ±0.5°C

Type 3 Errors:

a. Pressure or altitude:
Normal local barometric variation is usually less than ±0.5" Hg, which would yield a ±0.15 mg/L maximum error
A 1000 foot change in altitude is equal to an error of approximately 3% at the 10 mg/L level.

b. Humidity: errors occur if calibration is performed at less than 100% humidity. The error varies with the temperature as follows:

TEMPERATURE	ERROR
0°C	0.02 mg/L
10°C	0.05 mg/L
20°C	0.12 mg/L
30°C	0.27 mg/L
40°C	0.68 mg/L

Approximating the Error

It is unlikely that the actual error in any measurement will be the maximum possible error. A better error approximation is obtained by an r.m.s. calculation:

$$\text{r.m.s.error} = \pm [1a^2 + 1b^2 + 1c^2 + 1d^2 + 2a^2 + 2b^2 + 3a^2 + 3b^2]^{1/2} \text{ mg/L}$$

CIRCUIT DESCRIPTION

The YSI 51B contains two separate circuits, a temperature bridge circuit and an amplifier for oxygen measurement. See the schematic.

The amplifier features integrated circuitry for good temperature stability, low voltage power requirements and long battery life. Current from the probe develops a voltage across a resistor network which includes a thermistor (kept at O_2 probe temperature). This voltage is applied to the input of the circuit. A portion of the amplifier output is applied to the amplifier input in a standard negative feedback configuration.

The amplifier output circuitry is designed to perform certain specific manipulations on the input signal to achieve dial-in O_2 solubility factor, and to provide means for calibration adjustment.

MAINTENANCE

The only normal maintenance is battery replacement. Replace the four C size batteries every six months, or whenever you cannot make the "Full Scale" adjustment or accomplish O_2 calibration. (Note: A faulty probe will also prevent O_2 calibration.) To replace the batteries, remove the four screws holding the back of the case. The battery holders are color coded. The positive (+) end of the batter must be at the red terminal.

It is possible for the O_2 SOLUBILITY FACTOR dial to become loose and slip from its normal position. If this happens, you should return the instrument to the factory for recalibration. However, in an emergency, you can reposition it as follows:

1. Calibrate by air calibration.

2. Switch to CALIB O_2 and adjust the CALIB knob so the meter indicates SEA LEVEL on the upper scale.

3.Switch to READ TEMP and note the temperature reading.

4. Determine the sea level saturation value for that temperature from Table I.

5. Switch to READ O_2 and adjust the O_2 SOLUBILITY FACTOR dial to the saturation value determined in step 4.

6. Loosen the dial set screws and reposition the dial so the SEA LEVEL mark is aligned with the measurement temperature. Retighten the set screws, being careful not to change the position of the dial.

Note that this is a temporary calibration only. As soon as possible the instrument should be returned for factory recalibration.

WARRANTY AND REPAIR

All YSI products carry a one-year warranty on workmanship and parts, exclusive of batteries. Damage through accident, misuse, or tampering will be repaired at a nominal charge, if possible, when the item is returned to the factory or to an authorized dealer.

If you are experiencing difficulty with any YSI product, it may be returned for repair, even if the warranty has expired.

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ACCESSORIES AND REPLACEMENT PARTS

Oxygen Probes

YSI 5720A: Self Stirring BOD Bottle Probe

YSI 5750: Non-Stirring BOD Bottle Probe

YSI 5730: Self-stirring Dissolved Oxygen probe for laboratory use.

YSI 5739: Dissolved Oxygen probe for field use. Use with the YSI 5740 detachable cable, listed below.

for the 5720A, 5739 and 5750

YSI 5680: Probe Reconditioning Kit. Includes a sanding tool and ten adhesive disks.

YSI 5775: Membrane and KCL Kit, Standard. Includes two 15-membrane packets (.001" thick FEP Teflon membranes) and a 30 mL bottle of KCl with Kodak Photo Flo.

YSI 5793: Membranes, Standard. Ten 15-membrane packets.

YSI 5776: Membrane and KCL Kit, High Sensitivity. Includes two 15-membrane packets (.0005" thick FEP Teflon membranes) and a 30 mL bottle of KCl with Kodak Photo Flo. Used for measurements below 15°C, or for low oxygen levels.

YSI 5794 High Sensitivity Membranes. Ten 15-membrane packets.

YSI 5945: Six replacement sensor body O-rings.

YSI 5486: Stirrer Boot Assembly, for the 5720A only.

for the 5739 Only

YSI 5975A Calibration Chamber.

YSI 5986 Diaphragm Kit.

YSI 5740-10: 10' cable

YSI 5740-25: 25' cable

YSI 5740-50: 50' cable

YSI 5740-100: 100' cable

YSI 5740-150: 150' cable

YSI 5740-200: 200' cable

YSI 5795A: Submersible Stirrer with 50' combined probe and stirrer cable.

YSI 5492A: Battery pack. Powers the submersible stirrer.

for the 5730 Only

YS 5732: Battery Adapter Cable.

YSI 5731: Six Membrane Assemblies, and KCl with Kodak Photo Flo, plus a replacement sensor body O-ring.