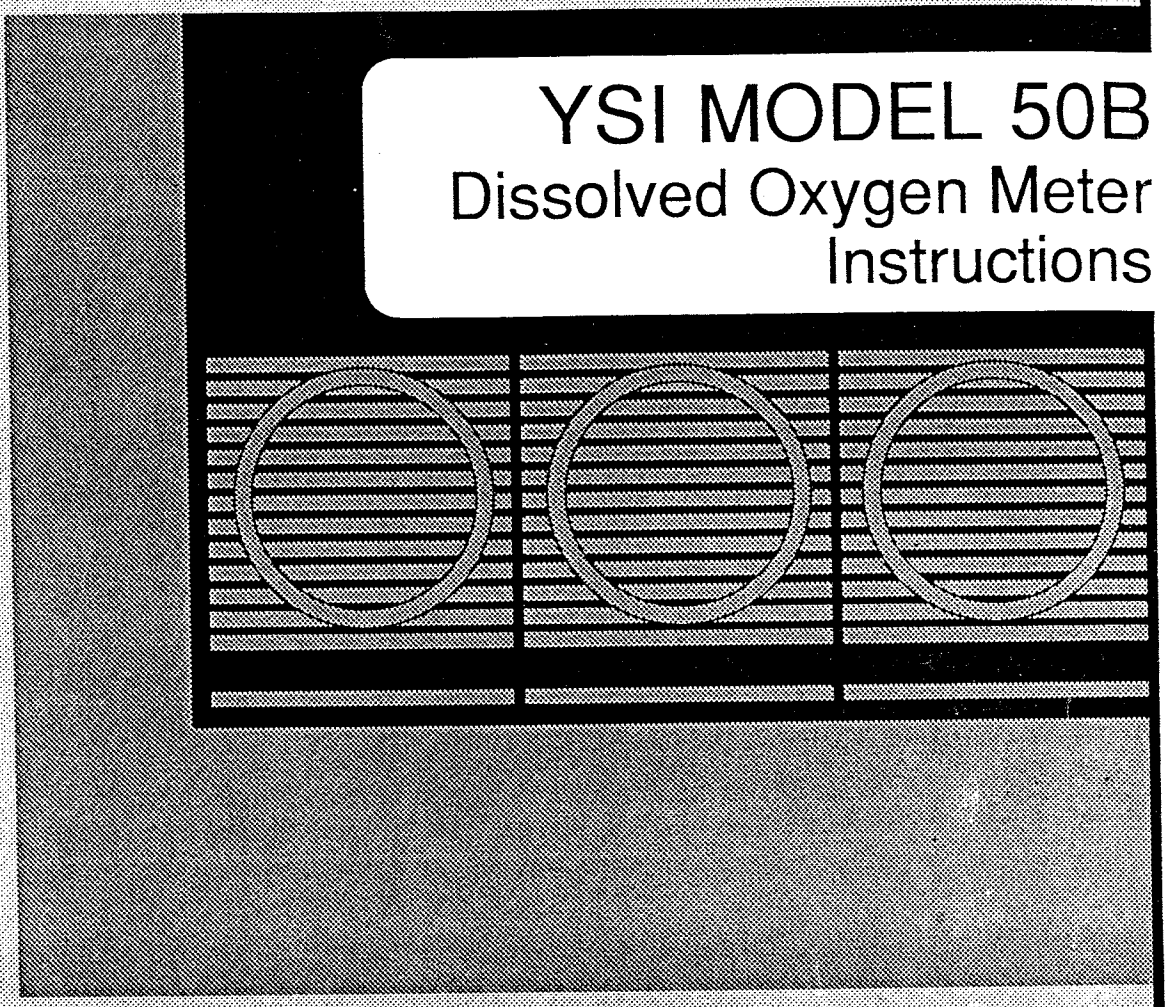
YSI MODEL 50B
Dissolved Oxygen Meter Instructions



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GENERAL DESCRIPTION

The YSI Model 50B Dissolved Oxygen Meter is a microprocessor-based instrument designed for field or laboratory measurement of dissolved oxygen and temperature in water and wastewater applications. The meter may be used with any YSI Series 5700 probe. Dissolved oxygen may be read in either mg/L or in % air saturation. The display provides a reading to two decimal places in the mg/L mode, and to one decimal place in the % air saturation and temperature modes. The last digit of the reading may be suppressed if desired when reading dissolved oxygen. Temperature is indicated in degrees Celsius. Both the mg/L and the % air saturation modes are automatically temperature compensated for changing permeability of the oxygen probe membrane and for the changing solubility of oxygen in water with changes in temperature. The autoread function causes a tone to sound to indicate that the reading is stable.

The capacity of a liquid to carry dissolved oxygen is affected by temperature, pressure, and the presence of other substances in solution, such as salt. The Model 50B incorporates features to simplify and make more rapid the determination of the amount of dissolved oxygen in a wide variety of liquid environments. Instrument calibration is easily performed.

To assure correct operation, the meter performs a self testing routine each time it is turned on. When an error is discovered, the display automatically signals the operator.

Because the measurement of dissolved oxygen is subject to so many variables, this manual provides detailed instructions for a variety of calibration methods to suit different circumstances. Procedures for calibrating both with and without compensation for temperature, altitude, pressure and salinity are described. Abbreviated instructions are located on a label on the instrument and on the back page of this manual. It is recommended, however, that instrument operators make themselves as familiar as possible with the contents of these instructions and with the principles of dissolved oxygen measurement.

Principles of Operation

The probes use Clark-type membrane covered polarographic sensors with built-in thermistors for temperature measurement and compensation. The 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 probe's cathode, it can be assumed that the oxygen pressure inside the membrane is zero. Hence, the amount of oxygen diffusing 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.

Oxygen Probes and Accessories

YSI oxygen probes available for the Model 50B are the 5720A self-stirring BOD bottle probe, the 5750 non-stirring BOD bottle probe, the 5730 self-stirring BOD probe for laboratory use, and the 5739 dissolved oxygen probe for field use. The 5739 is used with a YSI 5740 detachable cable, available in lengths of 10, 25, 50, 100, 150, and 200 feet.

Probe accessories include O-rings, membrane kits and reconditioning kits; and, for specific probes, a stirrer boot assembly for the 5720A, a calibration chamber, a diaphragm kit, a submersible stirrer and battery pack for the 5739. See the YSI 5700 probe instructions for descriptions and model numbers.

INSTRUMENT SPECIFICATIONS

Oxygen Measurement

Ranges: 0 to 19.99 mg/L dissolved oxygen
0 to 199.9 % air saturation

Accuracy: ±0.1% of saturation value, plus 1 LSD, plus probe error

Temperature Compensation: This instrument is automatically temperature compensated for probe response to changes in temperature.

The % air saturation mode is automatically temperature compensated to an accuracy of ±0.5% of calibration values between 0 and 5°C; and to an accuracy of ±0.3% of calibration values between 5 and 45°C

The mg/L mode is automatically temperature compensated to an accuracy of ±1% of DO readings between 0° and 5°C; and to an accuracy of ±0.6% of readings between 5° and 45°C.

Resolution: 0.01 mg/L in the mg/L mode

0.1% in the % air saturation mode

Temperature Measurement

Range: -5.0 to 45.0°C

Accuracy: ±0.1°C, plus probe error

Resolution: ±0.1°C

Instrument Environment

The ambient temperature range for specification performance is 0 to 45°C.

Water Resistance

With the probe receptacle capped, every case opening is gasketed to resist the entry of water.

Power Supply

6 D-size alkaline batteries typically provide approximately 1000 hours of useful life. Replace with 6 fresh alkaline batteries as soon as possible when **LO BAT** appears on the display. An AC adapter is also supplied with the instrument to allow operation without batteries.

Self Testing and Error Display

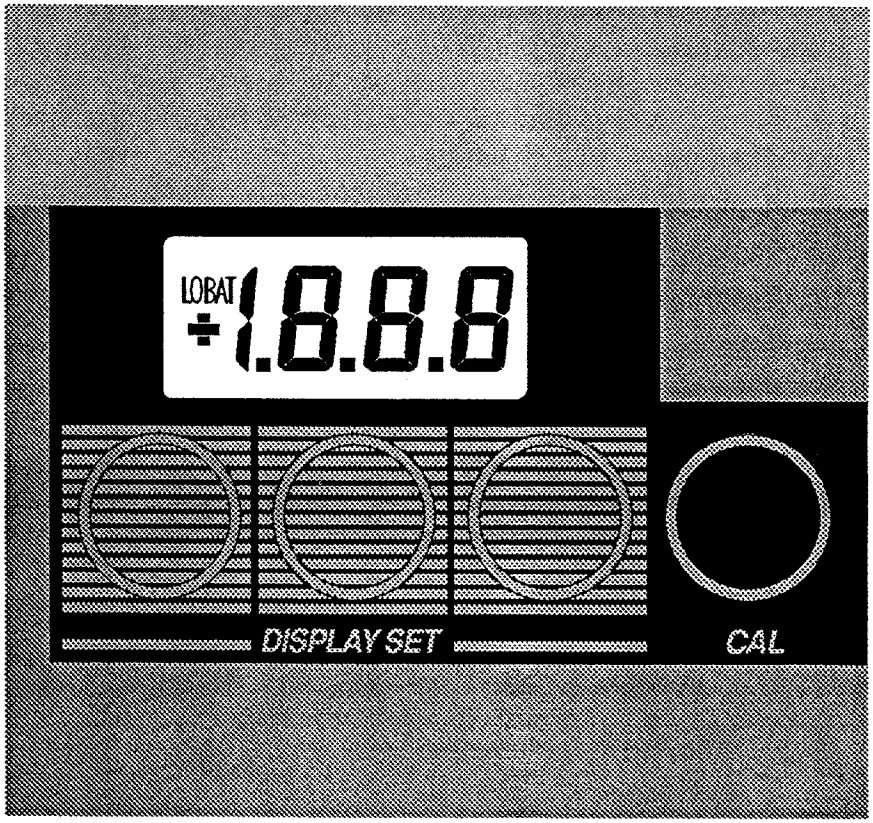
Each time the Model 50B is turned on, a Power On Self Testing (POST) routine is executed to determine whether all functions are operating correctly. Oxygen sensor errors are automatically signaled on the display with the letter **E** and a number whenever they occur during calibration; temperature sensor errors are likewise automatically signaled on the display whenever they occur. The **LO BAT** indication will be signaled when it is time to replace the battery.

Error display messages, with their explanations, are listed in the table in the Troubleshooting section.

1. Prepare the probe according to the 5700 probe instructions.

2. Connect the probe to the meter, then place the probe in a constant oxygen environment, such as a BOD bottle or the calibration bottle supplied.

3. Set the function switch to the °C position. An audible tone will sound. This is a signal that the microprocessor's Power On Self Testing (POST) diagnostic mode has been activated. Simultaneously, the display shown below will appear. Check to see that all meter segments are displayed. A second tone will sound in about 7 seconds to signal the end of the POST diagnosis, and the display will blank briefly.



The Model 50B Meter Display and Keyboard.

4. If the POST diagnosis discovers a fault in instrument operation, the display shown in the illustration will not appear, or will "freeze." Should this occur, it is necessary to return the instrument for repair to the dealer or to YSI. See Warranty and Repair.

5. Temperature will be displayed after the second tone. Observe the reading for stability. Temperature equilibration may take up to 5 minutes.

6. Set the function switch to either the **%** or the **mg/L** position and allow 15 minutes for the system to stabilize. If calibration is attempted prematurely, calibration values will drift and may be out of specification.

It is not necessary or desirable to turn the instrument off after each measurement. In normal laboratory use, the meter may be left on in any switch position between measurements, and turned off only at the end of the day. Each startup from OFF could require a 5 to 15 minute wait for probe stabilization.

USING THE MODEL 50B KEYBOARD

Using the keyboard to set calibration values is very simple. There are only four keys (see Figure 2). The key on the right is labeled **CAL.** It has several functions, depending on switch position.

The Cal Keypad

1. With the function switch set to **% CAL**, press **CAL** once to set the display to 100.0. Do this when you are calibrating to 100% air saturation.

2. Press **CAL** 3 times to set the display to **0.0**. Do this only when you are offsetting the zero (see Highest Accuracy Measurements under OPERATION).

3. With the function switch set to **mg/L CAL**, press **CAL** once; the display will automatically make the mg/L reading correspond to the percentage of oxygen dissolved in the sample. (For fresh water measurements only.) When you turn the switch to **mg/L**, the display will show **CAL** and the instrument will automatically calibrate and reset, then show the correct reading in mg/L.

The Display Setting Keypads

The three **DISPLAY SET** keys lower the digit in the display directly above each key by one count. If you miss the number you mean to set, continue pressing the key, and the display will cycle through **1**, **0**, **9**, and so forth. The leftmost key controls two positions in the display, and permits cycling through **1**, **0**, **19**, **18**, etc. The other two keys work the same as this one does for the corresponding digits on the display.

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 display shows a reading that matches the oxygen concentration of the known sample.

The Model 50B may be calibrated in either air or in water. Both pressure compensated and uncompensated calibration methods are described in the following instructions, which include procedures for Winkler Titration and for calibration in salt water.

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, and in time you will develop a realistic schedule for recalibration. When probes are not in use, store them according to the procedures recommended in Probe Service.

IMPORTANT NOTE: For measurements of the very highest accuracy, particularly when measuring very low oxygen samples, it is desirable to offset the meter zero in order to cancel out any background signals which might influence the reading. This should be done before calibration. For the appropriate procedures, consult Highest Accuracy Measurements, at the end of the OPERATION section.

Calibration in Air

It is quicker and easier to calibrate in air than in water. Experience has shown air calibration to be reliable and accurate, and it is the technique recommended by YSI for the Model 50B.

Calibration in air, for either the % air saturation or the mg/L mode, is quick and simple. Instructions for compensated calibration in air are also given.

Calibration to 100% Air Saturation:

The measurement displayed when the function switch is set to the **%** position is the percent of oxygen saturation in a liquid sample saturated with air under a barometric pressure of 1013 millibars (760 mm or 29.92 inches of mercury). Measurements resulting from calibration by this method should be reported as % air saturation corrected to "standard pressure."

For highest accuracy, calibrate at a temperature as close as possible to the temperature of the sample to be measured. Proceed as follows:

1. Set the function switch to **% CAL.**

2. Any of the YSI 5700 Series BOD probes may be placed in a BOD bottle containing about 1" of water to provide a 100% relative humidity calibration environment. To calibrate the YSI 5739 probe, place a moist sponge or a wet piece of cloth in the plastic calibration bottle provided with the probe. Slip the bottle over the probe guard up to the body. Place the probe in a protected location where temperature is not changing, or wrap in a cloth or other insulator, and allow 3 to 5 minutes for temperature equilibration.

3. Press the **CAL** key once. **100.0** will appear on the display.

4. Turn the function switch to **%. CAL** will appear on the display, then one or two audible tones will sound, followed by the display of **100.0** (+0.2). Observe the reading for stability for one minute. Drift in the reading of more than two digits may mean that insufficient time was allowed for instrument stabilization.

This completes Calibration to 100% Air Saturation.

NOTE: If you are calibrating at an altitude or pressure significantly different from "standard," you should adjust the calibration value according to the data in Table B.

EXAMPLE: At 5067 feet, or 631 mm Hg, the calibration value you would enter (see Using The Model 50B Keyboard) instead of 100 would be 83.0.

Calibration in Air in mg/L for Fresh Water Measurements:

1. Follow the procedures described for 100% air saturation

2. Set the function switch to **mg/L CAL.**

3. Place the probe in moist air as described in the previous calibration instructions.

4. Press the **CAL** key once. The mg/L reading will automatically correspond to the percentage of oxygen in the sample. This is true for fresh water (zero salinity) only.

5. Turn the function switch to **mg/L.** The display will show **CAL.** In a few seconds one or two audible tones will sound.

Next, the appropriate calibration value in mg/L (+0.02 mg/L) will be displayed. Observe the reading for stability for two or three minutes. Drift in the reading of more than two digits may mean that insufficient time was allowed for instrument stabilization.

This completes Calibration in Air in mg/L for fresh water measurements.

Calibration in Air in mg/L, Correcting for Atmospheric Pressure or Altitude

1. Follow the Initial Setup procedures described for 100% air saturation.

2. Set the function switch to **°C.**

3. Place the probe in moist air as described previously. From the Solubility of Oxygen Chart (Table A), find the mg/L value for zero salinity corresponding to the temperature indicated on the display. This chart appears later in the manual and on the back panel of the instrument.

4. Determine the local altitude or the true atmospheric pressure. (Note that "true" atmospheric pressure is as read on a mercury barometer. Weather Bureau reporting of atmospheric pressure is corrected to sea level.) Using the Atmospheric Pressures and Altitudes Table, determine the calibration correction for your pressure or altitude.

5. Multiply the value in mg/L found in step 3 by the correction determined in step 4. The result divided by 100 is the correct calibration value.

EXAMPLE USING ALTITUDE: At a temperature of 21°C, the oxygen value at sea level or 760 mm Hg atmospheric pressure is 8.92 mg/L for saturated air (Table A).

At an altitude of 1400 feet, the calibration correction is 95% (Table B).

The correct calibration value is (8.92 mg/L x 95)/100 = 8.47 mg/L.

EXAMPLE USING ATMOSPHERIC PRESSURE: At a temperature of 18°C, the oxygen value at sea level is 9.47 mg/L.

At a pressure of 745 mm Hg, the calibration correction is 98%.

The correct calibration value is (9.47 mg/L x 98)/100 = 9.28 mg/L.

6. Turn the function switch to **mg/L CAL**. Using the keys beneath the digit positions in the display, set the calibration value determined in step 5.

Each separate pressure on a key lowers the displayed digit by one count. Continuous pressure will cause the displayed value to cycle.

7. Turn the function switch to **mg/L**. The display will show **CAL**. In a few seconds one or two audible tones Next the calibration value you have set will appear. Observe the reading for stability for two or three minutes. Drift in the reading of more than two digits may mean that insufficient warm-up time was allowed.

This completes the Manual Calibration in Air in mg/L.

Calibration in Water

Calibration in air-saturated water may also be accomplished by both semi-automatic and manual methods. These are described below.

Note that oversaturating or undersaturating the sample will affect calibration accuracy.

Calibration in Air Saturated Water to 100% Air Saturation:

1. Follow the Initial Setup procedures described for 100% air saturation.

2. Air-saturate a volume of water by aerating for at least 15 minutes at a constant temperature.

3. Place the probe in the sample and stir.

4. Set the function switch to **% CAL**. Press the CAL key once. **100.0** will appear on the display.

5. Turn the function switch to **mg/L**. The display will show **CAL**. In a few seconds one or two audible tones will sound.

Next, the display will show the calibration value **100.0** (±0.2). Leave the probe in the sample for two minutes to ascertain stability. Repeat steps 4 and 5 if necessary.

This completes Calibration in Air Saturated Water to 100% Air Saturation.

Calibration in Air Saturated Water in mg/L:

1. Follow the Initial Setup procedures described for 100% air saturation.

2. Air-saturate a volume of water by aerating for at least 15 minutes at a constant temperature.

3. Place the probe in the sample and stir. Set the function switch to **°C**. From the Solubility of Oxygen Chart (Table A), find the mg/L value for zero salinity corresponding to the temperature indicated.

4. Determine the local altitude or the true atmospheric pressure. (Note that "true" atmospheric pressure is as read on a mercury barometer. Weather Bureau reporting of atmospheric pressure is corrected to sea level.) Using the Atmospheric Pressures and Altitudes Chart (Table B), determine the calibration correction for your pressure or altitude.

5. Multiply the value in mg/L found in step 3 by the correction determined in step 4. The result divided by 100 is the correct calibration value.

EXAMPLE: At a temperature of 21°C, the oxygen value at sea level or 760 mm Hg atmospheric pressure is 8.92 mg/L (Table A).

At an altitude of 1400 feet, the calibration correction is 95 (Table B).

The correct calibration value is (8.92 mg/L x 95)/100 = 8.47 mg/L.

EXAMPLE USING ATMOSPHERIC PRESSURE: At a temperature of 18°C, the oxygen value at sea level is 9.47 mg/L.

At a pressure of 745 mm Hg, the calibration correction is 98%.

The correct calibration value is (9.47 mg/L x 98)/100 = 9.28 mg/L.

6. Turn the function switch to **mg/L CAL**. Using the key beneath the digit positions in the display, set the calibration value determined in step 5. Each time you press a key, the displayed digit is lowered by one count. Continuous pressure will cause the displayed value to cycle.

7. Turn the function switch to **mg/L**. The display will show **CAL**. In a few seconds one or two audible tones will sound.

Next, the calibration value you have set (±0.02 mg/L) will appear. Observe the reading for stability for two to three minutes. Drift in the reading of more than two digits may mean that insufficient warm-up time was allowed.

This completes the Manual Calibration in Air Saturated Water in mg/L.

NOTE: If a calibration value for fresh water in mg/L was set, the value in the % saturation mode will automatically correspond to the mg/L value. However, if a mg/L value was entered for a non-fresh water sample, or a sample that is not 100% saturated, the value in the % saturation mode will neither correspond nor be correct. In other words, when measuring fresh water, you may switch from **mg/L** to **%** and back without recalibrating; when measuring saline water, you may not switch between measurement modes without recalibrating.

Calibration by Winkler Titration:

Winkler titration is a traditional method of calibration.

1. Follow the Initial Setup procedures described for 100% air saturation.

2. Draw a volume of air-saturated water from a single source and divide it into four samples. Determine the oxygen content in three of the samples using standard Winkler Titration techniques, and average the three values. If one of the values differs from the other two by more than 0.5 mg/L, discard it and average the remaining two.

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

4. Set the function to **mg/L CAL** and leave the probe in the sample for at least 2 minutes while continuing to stir. Using the calibration setting keys, set the display to the average value determined above.

5. Turn the function switch to **mg/L**. The display will show **CAL**. In a few seconds one or two audible tones will sound.

Next, the calibration value you have set (±0.02%) will appear on the display. Leave the probe in the sample for an additional two minutes to verify stability. Repeat steps 4 and 5 if necessary.

This completes Calibration by Winkler Titration.

NOTE: If a calibration value for fresh water in mg/L was set, the value in the % saturation mode will automatically correspond to the mg/L value. However, if an mg/L value for a non-fresh water sample was entered, the value in the % saturation mode will neither correspond nor be correct. In other words, when measuring fresh water, you may switch from **mg/L** to **%** and back without recalibrating; when measuring saline waters, you may not switch between measurement modes without recalibrating.

Salt Water Calibration:

To calibrate for estuarial waters where fresh and sea water are mixed in changing or undetermined proportions, the solubility of oxygen in the particular sample to be measured must be determined by calculations which take account of salinity, temperature and pressure. Even water drawn from the open sea will vary in salinity, and of course in temperature as well.

Calibration in mg/L for salt water is accomplished as follows:

1. Follow the Initial Setup procedures described for 100% air saturation.

2. Air-saturate a sample of the water to be measured, and determine its salinity or chlorinity (as with a YSI Model 33). Chlorinity is defined as salinity/1.806.

3. Measure the temperature of the sample. Referring to the Solubility of Oxygen Chart (Table A), find the mg/L value corresponding to the temperature and salinity determined above.

EXAMPLE: In water at a temperature of 21°C and a salinity of 9.0 (ppt), the solubility of oxygen is 8.46 mg/L.

4. Turn the function switch to **mg/L CAL** and, using the calibration setting keys, set the display to the value recorded. Correct for altitude or pressure if desired, as described in Calibration in Air in mg/L, Correcting for Atmospheric Pressure.

5. Turn the function switch to mg/L. The display will show **CAL**. In a few seconds one or two audible tones will sound.

Next, the calibration value you have set (±0.02%) will be displayed. Observe for stability.

This completes calibration for mg/L in salt water.

NOTE: If a calibration value for fresh water in mg/L was set, the value in the % saturation mode will automatically correspond to the mg/L value. However, if an mg/L value was entered for a non-fresh water sample, or a sample that is not 100% saturated, the value in the % saturation mode will neither correspond nor be correct. In other words, when measuring fresh water, you may switch from **mg/L** to **%** and back without recalibrating; when measuring saline waters, you may not switch between measurement modes without recalibrating.

A brief summary of these procedures is printed on the back panel of the instrument. A copy of the abbreviated instructions is also included at the back of this manual. The operator should be thoroughly familiar with the contents of this manual, however, before using the instrument.

Temperature Measurement

1. Connect a YSI 5700 probe and set the function switch to the °C position.

2. Place the probe in the sample and wait 3 to 5 minutes for temperature equilibration.

3. Observe the temperature reading.

Dissolved Oxygen Measurement

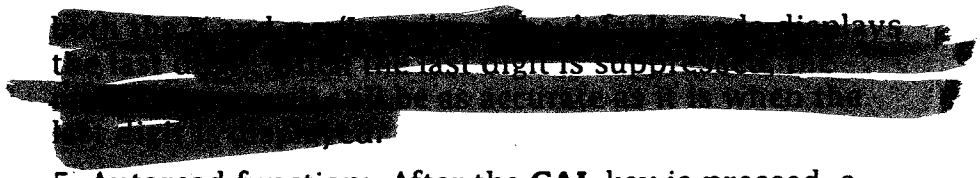
Because the oxygen level in the layer of liquid sample at the membrane surface is continuously being depleted, it is essential that water movement of 1 foot per second or more be maintained when making measurements. A moving stream will usually provide this motion, as will moving the probe through the sample by hand. The YSI 5795A Submersible Stirrer provides the necessary stirring for use with the YSI 5739 Probe. YSI 5720 BOD probes have their own line powered stirrers for laboratory use. When the YSI 5750 BOD probe is used, auxiliary stirring must be provided, as with a magnetic stirrer.

Make oxygen measurements as follows:

1. Perform the initial setup and calibration procedures as described in earlier sections of this manual.

2. Set the function switch to the position appropriate to the sample and the read-out desired (**%** or **mg/L**). Allow 3 to 5 minutes for the probe to come to temperature equilibrium with the sample.

3. Begin stirring at least 30 seconds before taking the reading. Observe the reading when the display has stabilized.



5. Autoread function: After the **CAL** key is pressed, a tone will sound when the reading is stable. This does not affect the instrument's measurement in any way. Autoread is off in the default mode and works only for DO measurements.

6. Should negative values appear when measuring low or zero oxygen samples, see Highest Accuracy Measurements, below.

NOTE: Should it ever happen that the instrument is operated in a **LOBAT** condition when it has not been possible to replace the batteries immediately, confirm your reading by repeating the INITIAL SETUP procedures

Measuring Oxygen In Fluids Other Than Water

The Model 50B is normally used for measuring the oxygen content of naturally occurring waters and of wastewaters. The % air saturation feature of the instrument permits oxygen measurement in some non-water fluids including air, most gases, foods, and some non-aqueous liquids.

Suitable fluids for measurement are those which do not attack the sensor materials and are of sufficiently low viscosity to permit sample stirring across the probe's membrane. Strong acids and solvents capable of swelling or dissolving the probe's ABS plastic body or EPR O-rings must be avoided. (Also see list of interfering gases under Operation and Operating Precautions.)

The % air saturation of any fluid not excluded in the description above may be measured directly. The instrument is calibrated by the customary air calibration technique and measurement is carried out just as in natural waters.

In measuring non-aqueous liquids, the mg/L mode should not be used. Such samples may have an oxygen solubility or Bunsen coefficient significantly different from that automatically programmed in the mg/L mode for water.

Highest Accuracy Measurements

Setup, calibration and measurement procedures already described will give specification performance with the Model 50B. However, the background current of any probe will shift slightly over time, depending on use and the history of the membrane in place. This is of little consequence when measuring high oxygen levels; but when measuring very low oxygen samples, or samples containing interfering substances, offsetting the meter zero will cancel out background signals influencing the reading.

Offset the meter zero as follows:

1. Perform the initial setup procedures.

2. Place the probe in a zero oxygen environment, such as 100% nitrogen or a saturated sodium sulfite solution (see below), for at least 20 minutes.

3. Set the function switch to **% CAL** and observe the display for stability. If the reading is **0.0**, no offset is needed. If it is not, proceed with the following steps.

4. When the display is stable, turn the function switch to **% CAL**.

5. Press the leftmost calibration setting key three times to set the display to **0.0**.

6. Recalibrate, and proceed with oxygen measurement as described above.

7. Repeat all of the preceding steps once more to verify correct zeroing and calibration. If the meter shows a negative value when you switch to **% CAL** the second time, allow 15 more minutes for further system stabilization, then repeat the zeroing procedures again. Repeated negative readings indicate a malfunctioning probe.

NOTE: It is absolutely essential that the probe be connected to the instrument and in a known zero oxygen environment when this procedure is done. If the probe is disconnected, or is exposed to oxygen when the zero offset is attempted, an E2 message may be displayed. Should a mistake in zero offsetting occur, correct the setup error and repeat the procedure.

A standard method for creating a zero oxygen environment is to dissolve in water (preferably from the sample to be measured) excess sodium sulfite Na_2SO_3 and a trace of cobalt chloride $CoCl_2$. After zeroing, rinse the probe thoroughly to remove any residual trace of chemicals. (See Standard Methods, 16th edition, 1985, page 424.)

Restoring the Zero Value

Whenever the meter zero has been offset by the method described above, the programmed default value for zero is rendered inoperative. Whenever installing a new probe or probe membrane, you must either restore the default value or else repeat the zero offset procedures to assure correct meter operation. To restore the default value, proceed as follows:

1. Turn the meter off. Press and hold down both of the two leftmost Display Set keys at the same time, and turn the switch to the °C position while continuing to hold down both keys.

2. Several displays will appear briefly. When the display shows **E.00**, release the keypads.

3. Recalibrate.

Batteries

IMPORTANT: Clean the battery terminals every 250 hours by rubbing them with a pencil eraser or similar material to remove the oxide layer.

Whenever **LOBAT** appears on the display, replace the batteries with 6 fresh alkaline batteries as soon as possible. When the 4 case screws are removed, the back lifts off and the batteries are accessible. Carefully observe correct battery polarity. NOTE: Each opening of the case is gasketed to resist entry of water. When the case has been opened for any reason, be sure that the main case gasket is accurately seated between both halves of the case, and that the four case screws are drawn down securely (but not so tightly as to deform the rubber feet).

Power On Self Testing and Error Display Messages

The instrument will perform a Power On Self Test each time it is turned on. In addition, the following error displays are provided to facilitate troubleshooting. The E0 through E1 Error Modes are operational throughout the operation of the Model 50B; E2 through E4 are active only during calibration.

ERROR INDICATION	CAUSE	CORRECTION
E. 0 System error	Defective ROM	Return for service
E.00 Lost calibration value	Defective RAM backup battery	Return for service
E.01 Defective RAM	Defective RAM	Return for service
E .1 Open circuit in Temperature Probe	Connector improperly installed	Check connection
	Intermittent connection in cable or plug	Repair or replace
	Faulty temp sensor	Repair or replace
E .2 High background	Insufficient warm-up time	See start-up procedures
	Improper probe zeroing procedure	See Highest Accuracy Measurements
	Probe needs servicing	See probe instructions
	Probe malfunction	Repair or replace
E .3 Low sensitivity	Insufficient electyrolyte	See probe instructions
	Contaminated electrodes or fouled membrane	See probe instructions
	Membrane too thick	Try another membrane
	High resistance in probe connection	Return for evaluation
E .4 Output too high	Membrane too thin	Try another membrane
	Short circuit	Repair or replace
	Electrodes need resurfacing	Repair or replace
	Internal leakage in probe or in cable connector	Repair or replace
F.XX Incorrect Mode (X may be any digit or any letter between A and F)	Switch or Circuit defect	Return for service

TABLE A — Solubility of Oxygen in mg/L in Water Exposed to Air at 760 mm Hg Pressure

Temp °C	Chlorinity:0 Salinity: 0	5.0 9.0	10.0 18.1	15.0 27.1	20.0 36.1	25.0 45.2
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.73	6.39
26.0	8.11	7.71	7.33	6.96	6.62	6.29
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.96	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	6.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.93	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

TABLE B — Calibration Values for Various Atmospheric Pressures and Altitudes

PRESSURE		ALTITUDE			CALIBRATION
in. Hg	mm Hg	kPa	Feet	m	VALUE
30.23	768	102.3	-276	-84	101
29.92	760	101.3	0	0	100
29.61	752	100.3	278	85	99
29.33	745	99.3	558	170	98
29.02	737	98.3	841	256	97
28.74	730	97.3	1126	343	96
28.43	722	96.3	1413	431	95
28.11	714	95.2	1703	519	94
27.83	707	94.2	1995	608	93
27.52	699	93.2	2290	698	92
27.24	692	92.2	2587	789	91
26.93	684	91.2	2887	880	90
26.61	676	90.2	3190	972	89
26.34	669	89.2	3496	1066	88
26.02	661	88.2	3804	1160	87
25.75	654	87.1	4115	1254	86
25.43	646	86.1	4430	1350	85
25.12	638	85.1	4747	1447	84
24.84	631	84.1	5067	1544	83
24.53	623	83.1	5391	1643	82
24.25	616	82.1	5717	1743	81
23.94	608	81.1	6047	1843	80
23.62	600	80.0	6381	1945	79
23.35	593	79.0	6717	2047	78
23.03	585	78.0	7058	2151	77
22.76	578	77.0	7401	2256	76
22.44	570	76.0	7749	2362	75
22.13	562	75.0	8100	2469	74
21.85	555	74.0	8455	2577	73
21.54	547	73.0	8815	2687	72
21.26	540	71.9	9178	2797	71
20.94	532	70.9	9545	2909	70
20.63	524	69.9	9917	3023	69
20.35	517	68.9	10293	3137	68
20.04	509	67.9	10673	3253	67
19.76	502	66.9	11058	3371	66

There are three basic types of error. Type 1 errors are related to limitations of instrument design, and tolerances of instrument components. These are chiefly the meter linearity and the resistor tolerances. Type 2 errors are related 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 proportionally reduced. The errors described below are maximum errors; most errors will be far less than the values listed.

Individual Sources of Error

This description of sources of error can be used to attach a confidence to any particular reading of dissolved oxygen. The example given is for a near extreme set of conditions. In general, overall error is diminished when the probe and instrument are calibrated under conditions of temperature and dissolved oxygen which closely match the sample temperature and dissolved oxygen.

Type 1 Errors

A. Mode to mode error (due to taking a reading on a different range of the instrument than the calibration range) ±0.25% of the reading ±2 least significant digits in the mg/L mode.

Type 2 Errors

A. Probe background current error:
Background Factor x (1 - a/b) c)

where a = calibration value

b = solubility of oxygen in fresh water at 760 mm Hg at measurement temperature

c=measured DO value

a, b and c are all measured in mg/L, or all are measured in % air saturation

Probe Temperature in °C	Background Factor in %
0	2.3
10	1.5
20	1.0
30	0.8
40	0.6

B. Probe nonlinearity error: ±0.3% of reading

C. The temperature compensation error is ±0.2% per °C of the difference between the temperature of the sample and the temperature at which the probe was calibrated, times the measured DO value.

Type 3 Errors

A. Sample temperature uncertainty error: ±1% of the reading. This error is zero when calibrationg in the % air saturation mode, or when calibrating to a Winkler titration sample.

B. Error due to barometric uncertainty of ±13 mm Hg: ±1.7% of the reading

C. Error due to altitude estimate uncertainty of ±500 feet: ±1.8% of the reading

Error Calculation Example

The example given presumes that air calibration is used. If Winkler calibration is used, Type 3 error are replaced by the uncertainty attributable to the overall Winkler determination.

Calibration conditions:

Method:	Air Calibration in mg/L mode
Temperature:	24°C
Altitude:	600 feet
Calibrated to:	8.24 mg/L

Measurement conditions:

Temperature:	20°C
Reading:	7.26 mg/L
Mode:	mg/L

Type	Description	Calculation	Error (mg/L)
1A	Mode to mode	±0.0025 x 7.26 +0.02	±0.04
2A	Probe background	±0.01 x (1 -8.24/9.07) x 7.26	±0.01
2B	Probe nonlinearity	±0.003 x 7.26	±0.02
2C	Temperature Compensation	±(24 - 20) x 0.002 x 7.26	±0.06
3A	Temperature uncertainty	±0.00 x 7.26	±0.00
3B	Pressure	±0.017 x 7.26	±0.12
3C	Altitude	±0.018 x 7.26	±0.13
		Maximum possible error =	±0.38 mg/L

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

R.M.S. Error = $\pm[0.04^2 + 0.01^2 + 0.02^2 + 0.06^2 + 0.12^2 + 0.13^2]^{1/2} = \pm 0.19$ mg/L

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 YSI dealer. Electrode cleaning is not covered by warranty.

If you are experiencing difficulty with any YSI product, it may be returned for repair, even if the warranty has expired. YSI maintains complete facilities for prompt servicing on all its products. This warranty is limited to repair or replacement (YSI's option) at no charge.

Yellow Springs Instrument Co., Inc.
Product Service
1725 Brannum Lane
Yellow Springs, Ohio 45387
Telephone: (513) 767 - 7241
Toll Free: (800) 343 - HELP

Notice

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- reorient the receiving antenna
- relocate the computer with respect to the receiver
- move the computer away from the receiver
- plug the computer into a different outlet so that the computer and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: "How to Identify and Resolve Radio-TV Interference Problems." This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 0004-000-00345-4.

Item 050046 PN A50046 A

YSI MODEL 50B OPERATING INSTRUCTIONS

IMPORTANT: Before using this instrument, operators should be familiar with the Model 50B manual and with the 5700 Series oxygen probe instructions.

YSI Incorporated
Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio 45387 USA

Item 050046 PN A50046 A

SETUP

1. Prepare and connect a YSI 5700 Series dissolved oxygen probe. (See probe instruction sheet or instrument manual for more details.)

2. Switch to TEMP °C; observe reading for stability within ± 0.2°C.

3. Replace batteries if **LO BAT** appears on the display.

4. Errors in instrument operation are automatically signaled by the following messages:

E .0	System ROM
E .00	Lost calibration value
E .01	Defective RAM
E .1	Temperature probe
E .2	High background
E .3	Low sensitivity
E .4	High output

CALIBRATION

CALIBRATION TO 100% AIR SATURATION
(Other calibration procedures are described in the CALIBRATION section of your instrument manual.)

1. Place YSI 5700 Series Probe in BOD bottle containing about 1" of water. (Place 5739 probe in calibration bottle with moist sponge or wrap in moist cloth to provide stable humidity.) Wait for temperature equilibration; temperature stability is essential for precise calibration.

2. Set switch to % CAL. To calibrate in mg/L, see instruction manual.

3. Press CAL button once and switch to %. **100.0** (± 0.2) will appear on the display. Observe reading for stability for at least one minute.

MEASUREMENT

TEMPERATURE

1. Place probe in sample.

2. Switch to TEMP °C. Observe reading for stability.

OXYGEN

1. Place calibrated probe in sample and stir.

2. Switch to % and wait until you can ascertain probe equilibration by observing temperature and dissolved oxygen readings that are stable for a full minute. (To read in mg/L, see instruction manual.)

3. For measuring low levels of dissolved oxygen (1.00 mg/L or 10.0% air saturation), refer to "Highest Accuracy Measurements" in the instruction manual. Also, consult the manual for a discussion of salinity compensation.

4. The instrument should normally be left on during the work day to avoid the delay of waiting for probe repolarization.

5. The rightmost DISPLAY SET button can be used to toggle between displaying and suppressing the last digit of the DO reading.

6. Autoread function: Pushing the CAL button causes the instrument to beep when the reading is stable in % and mg/L modes.

CARE AND MAINTENANCE

Replace the membrane every 2 to 4 weeks, depending on application. Probes should be stored in humid environment to prevent drying out.

TABLE I. SOLUBILITY OF OXYGEN IN WATER EXPOSED TO WATER SATURATED AIR AT 760 mm Hg PRESSURE

Temp. °C	Solubility mg/L	Temp. °C	Solubility mg/L	Temp. °C	Solubility mg/L
0	14.62	16	9.87	32	7.31
1	14.22	17	9.67	33	7.18
2	13.83	18	9.47	34	7.07
3	13.46	19	9.28	35	6.95
4	13.11	20	9.09	36	6.84
5	12.77	21	8.92	37	6.73
6	12.45	22	8.74	38	6.62
7	12.14	23	8.58	39	6.52
8	11.84	24	8.42	40	6.41
9	11.56	25	8.26	41	6.31
10	11.29	26	8.11	42	6.21
11	11.03	27	7.97	43	6.12
12	10.78	28	7.83	44	6.02
13	10.54	29	7.69	45	5.93
14	10.31	30	7.56	46	5.84
15	10.08	31	7.43	47	5.74

TABLE II. CALIBRATION VALUES FOR VARIOUS ATMOSPHERIC PRESSURES AND ALTITUDES.

Pressure Inches Hg	mm Hg	kPa	Altitude Ft.	m	Calibration Value (%)
30.23	768	102.3	−276	−84	101
29.92	760	101.3	0	0	100
29.61	752	100.3	278	85	99
29.33	745	99.3	558.	170	98
29.02	737	98.3	841	256	97
28.74	730	97.3	1126	343	96
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23.62	600	80.0	6381	1945	79
23.35	593	79.0	6717	2047	78
23.03	585	78.0	7058	2151	77
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22.44	570	76.0	7749	2362	75
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20.35	517	68.9	10293	3137	68
20.04	509	67.9	10673	3253	67
19.76	502	66.9	11058	3371	66