YELLOW SPRINGS INSTRUMENT CO.
YELLOW SPRINGS, OHIO 45387

INSTRUCTIONS FOR YSI MODEL 51A DISSOLVED OXYGEN METER

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SUMMARY OF OPERATION PROCEDURES

1. Prepare the probe with membrane and KCl.
2. Connect the probe to the instrument.
3. With the instrument OFF check mechanical zero.
4. Switch to ZERO and adjust with the ZERO control.
5. Switch to FULL SCALE and adjust with the FULL SCALE control.
6. Switch to CALIB 0_2 and leave at least 5 minutes to polarize probe, then adjust to the local altitude with the CALIB knob.
7. Place probe in sample solution and allow to come to temperature.
8. Switch to TEMP and read temperature.
9. Set 0_2 SOLUBILITY FACTOR dial to temperature of sample solution, taking care to use appropriate salinity index.
10. Switch to 0_2 and read dissolved oxygen directly in PPM while stirring or agitating the water.

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YSI MODEL 51A DISSOLVED OXYGEN METER

I. General Description

The YSI Model 51A Oxygen Meter is a precision instrument for measuring dissolved oxygen and temperature in water. The sensing element is a Clark-type membrane-covered polarographic probe. Dissolved oxygen is read directly in parts per million (PPM) and temperature in °C. It is battery operated and completely portable, designed for both field and laboratory applications.

II. Specifications

Range:	Dissolved oxygen 0 to 15 PPM Temperature: – 5°C to +45°C
Accuracy:	Dissolved Oxygen: Better than ±0.2 PPM when calibrated within ±5°C of actual sample temperature. Temperature: Better than ±0.7°C
Scale Readability:	Dissolved Oxygen: Better than 0.1 PPM Temperature: Better than 0.3°C
Repeatability:	Dissolved Oxygen: ±0.1 PPM Temperature: ±0.3°C
Compensation:	Temperature compensation for oxygen probe membrane permeability 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 PPM chloride concentration.
Response Time:	90% of reading in 10 sec. dependent on temperature and oxygen level.

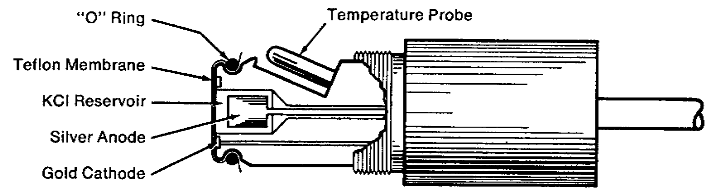
Instrument Ambient Range:	Satisfactory operation from -5°C to +45°C.
Power Supply:	Three "D" cells provide approximately 1,000 hours operation.
Probes:	YSI 5101 – Oxygen Probe, 10 ft. lead (This probe requires a separate temperature probe, any YSI Series 400 Probe can be used).
	YSI 5418 – Oxygen/Temperature Probe, 10 ft. lead.
	YSI 5419 – Oxygen/Temperature Pressure Compensating Probe, 50 ft. lead.
	YSI 5420-A – Self-Stirring BOD Oxygen/Temperature Probe.
	YSI 5450 – Non-Stirring BOD Oxygen/Temperature Probe.
	YSI 5034 – Service Kit contains membranes, KCl solution, "O" rings, etc.
Carrying Case:	YSI 5952 – 18" x 14" x 4-1/2", durable plastic and aluminum case for convenient carrying of instrument, probe with up to 50' lead, extra membrane, and KCl. Instrument can be operated without removal from the case.
Submersible Stirrer:	YSI 5491 – Battery-powered submersible stirrer for use with YSI 5418, 5419, and other field probes. The stirrer measures 6" x 3-1/2" dia. and has a 50' cable.
Battery Pack:	YSI 5492 – 6 VDC battery supply for submersible stirrer attaches to YSI Models 51A and 54 Dissolved Oxygen Meters. Measures 10" x 4" x 9"

THEORY OF OPERATION

I. How The Probe Works

The YSI Oxygen Probe is a polarographic system (See Figure 1). The cathode is a gold ring epoxied in a lucite block and the anode is a silver pellet recessed in a central well. The well is filled with an aqueous solution of potassium chloride and a Teflon membrane is stretched across the probe end isolating the probe elements from the environment.

The membrane is permeable to gases, allowing them to enter the interior of the probe. When a polarizing voltage is applied to the probe, oxygen will react at the cathode causing a current to flow in proportion to the amount of oxygen diffusing through the membrane.



TYPICAL YSI 5400 SERIES O_2/TEMPERATURE ELECTRODE

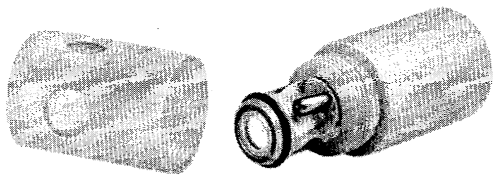


Figure 1

The probe actually measures oxygen pressure. Since oxygen is consumed at the cathode, it can be assumed that oxygen pressure under the membrane is near zero and that the force causing oxygen to diffuse through the membrane is in proportion to the absolute pressure of oxygen outside the membrane. If the oxygen pressure increases, more oxygen diffuses through the membrane and more current flows in proportion to the increase. A lower pressure results in less current.

It should be noted that temperature is an important factor, as membrane permeability varies with temperature, changing at a rate of approximately 4%/°C, depending on membrane material.

II. Oxygen Dissolved in Water

When water is saturated with oxygen the pressure of the dissolved oxygen is equal to the pressure of the oxygen above the water. In this state of equilibrium, oxygen from the gas above the water enters the surface of the water at the same rate that dissolved oxygen escapes from the water into the gas above it.

The partial pressure of oxygen is independent of sample temperature, however, the amount of oxygen that can be dissolved in the water is a function of temperature, decreasing with increasing temperature. As the temperature rises, more oxygen leaves the water then enters it from the gas and a new equilibrium is eventually established. Lowering the temperature permits more oxygen from the gas to dissolve in the water until a pressure equilibrium is again established.

The oxygen probe is responsive to oxygen pressure. Thus if a container of water is at the same temperature as the air above it and the water is saturated with the air, the oxygen probe will produce the same current whether immersed in water or exposed to the air above it. It is this characteristic of the sensor upon which air calibration techniques are based.

III. Determining Dissolved Oxygen In PPM

Tables are available which relate PPM of oxygen dissolved in water saturated with air to the temperature of the water. If a sample of air at known pressure is brought to the temperature of the water, the electrode current (measuring in air) will be the same as that obtained when the probe is dipped into the water IF the water is saturated with air.

Knowing the temperature of the water and referring to a table of PPM dissolved oxygen vs. temperature an instrument can be calibrated to read directly in PPM dissolved oxygen. Another advantage of this method is that the temperature coefficient of the probe does not influence the measurement.

Note that altitude (atmospheric pressure) affects the amount of oxygen dissolved in water and that increased salinity decreases the solubility of oxygen in water.

The YSI Model 51A Oxygen Meter is designed so that auxiliary tables or slide rules are not required for calibration and measurement. A precision thermistor compensates for the temperature coefficient of the membrane. The circuit is arranged to allow dial-in correction for oxygen solubility changes with temperature. In addition altitude compensation for calibration is provided. Direct dial-in of salinity values ranging from fresh water to sea water is also provided.

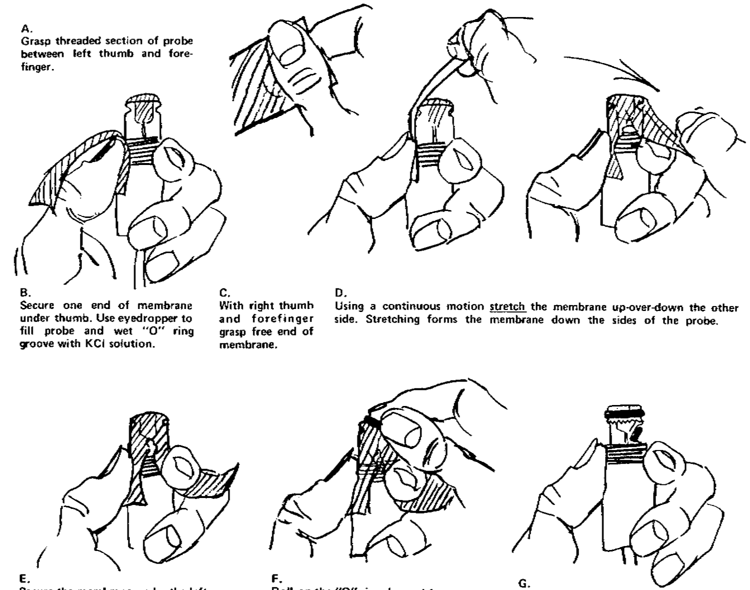
THE OXYGEN PROBE

I. Preparing the Probe

All YSI oxygen probes (See SPECIFICATIONS) have similar sensors (See Figure 1) and should be cared for in the same manner. They are precision devices and require good treatment if high accuracy measurements are to be obtained.

The YSI 5034 Service Kit contains the necessary materials, except for distilled water, to prepare the probe for operation. The procedure for preparing the probe is as follows: (see figure 2, page 9)

1. Add **distilled** water to the KCl crystals and dissolve completely. (Tap water introduces harmful contaminants to the probe.)
2. Transfer a part of the KCl solution to the eyedropper bottle.
3. Remove sensor guard from the probe (where applicable).
4. Remove the protective membrane and "O" ring.
5. Select a membrane from the vial — lay on a clean sheet of paper — handle only by the ends.
6. Support the probe in a vertical position.
7. With one thumb secure one end of the membrane to the side of the probe.
8. With the eyedropper, fill the central hole avoiding air bubbles. Wet the gold electrode, the lucite around it, and the "O" ring groove. The surface tension of the KCl will cause a large drop or meniscus to form above the electrode. This will ensure complete contact between the membrane and the KCl.
9. Stretch the membrane up and over the top of the electrode. The membrane material is very elastic and should be stretched upward about 1/2 inch and then, while still under tension, laid over the top of the probe. This will allow the membrane to conform to the shape of the electrode for better performance.
10. Stretch an "O" ring into place — inspect for wrinkle-free membrane. A taut smooth membrane surface is required. A lax membrane will result in erratic performance, slow speed of response and poor shock performance. Remove the excess membrane about 1/8" beyond the "O" ring with scissors.
11. A small air bubble may appear under the membrane. This is normal, however, strive for a bubble-free probe. New probes, or probes that have been allowed to dry out, will continue to develop bubbles until the porous anode is completely filled. Tapping the body of the probe is often helpful in releasing bubbles.



A. Grasp threaded section of probe between left thumb and forefinger.

B. Secure one end of membrane under thumb. Use eyedropper to fill probe and wet "O" ring groove with KCl solution.

C. With right thumb and forefinger grasp free end of membrane.

D. Using a continuous motion stretch the membrane up-over-down the other side. Stretching forms the membrane down the sides of the probe.

E. Secure the membrane under the left forefinger.

F. Roll on the "O" ring. Inspect to see there are no trapped air bubbles or wrinkles in the membrane.

G. Trim off excess membrane near the "O" ring. Temperature sensor must be exposed for rapid response.

Figure 2

Bubbles can cause incorrect readings when making deep water measurements. The YSI 5419 probe has a built-in pressure equilization device designed to compensate for any bubbles that might develop. Special preparation instructions are provided with this probe.

12. Rinse away excess KCl solution and replace the sensor guard.
13. The probe is ready for operation.

YSI is supplying weights attached to the cable of the YSI 5101, 5418 and 5419 probes. The YSI 5974 weights are supplied in pairs with a total weight of 4 ounces per pair. Should it become necessary to add more weight to the probe to overcome water currents we suggest limiting the total weight to two pounds. For weights in excess of two pounds use an independent suspension cable.

The small plastic bottle in the YSI 5034 Service Kit is convenient for storage of YSI 5418 and 5419 Probes. Partially fill the bottle with water and slide the probe through the hole. YSI 5420-A and 5450 BOD Probes can be stored in BOD bottles partially filled with water. The moisture will reduce probe electrolyte evaporation and prevent the probe from drying out.

II. Probe Maintenance

Keep the probe clean and avoid letting the KCl dry in the probe cavity.

When changing the membrane, flush out the probe cavity with KCl solution several times. Do not use abrasives to polish the surface of the gold and plastic. Wipe gently with a soft lint-free cloth if required. Follow Steps 3 through 13.

It should be noted that some other gases can be reduced at the cathode at the polarizing voltage for oxygen. Included are SO_2 and Halogens. H_2S reacts with the metals and poisons the cell. This poisoning can usually be overcome by periodic wiping of the gold surface with a clean lint-free coarse cloth or a hard paper. Do not use any form of abrasive. All poisoning shows as tarnish on the gold and polishing should continue until the gold is shiny.

MEASUREMENT OF DISSOLVED OXYGEN WITH YSI 5418 AND 5419 PROBES

I. Calibration Procedure

Calibration is normally required before each dissolved oxygen measurement, although under some routine conditions a calibration may be valid for multiple measurements.

As discussed in the THEORY OF OPERATION, the calibration method is based upon two facts:

(a) The oxygen concentration in FRESH air is nearly constant.
(b) When a liquid is saturated with a gas, the partial pressure of the gas dissolved in the liquid is equal to the partial pressure of the gas above the liquid.

The calibration procedure is as follows:

1. Prepare the probe for operation as described in the previous section. When using YSI 5418 and 5419 probes, the YSI 5075 Calibration Chamber is recommended for calibration because it conditions fresh air, which is the standard being used, to the temp of the water to be sampled. The chamber (See Figure 3) consists of a 4-1/2' stainless steel tube (1) attached to a calibration chamber (5) and a measuring ring (7). Insert the solid rubber stopper (6) into the bottom of the calibration chamber (5). Push the probe (4) through the hollow rubber stopper (3) as shown in Detail A. For maximum accuracy wet the inside of the calibration chamber (5) with your finger. This creates a 100% RH environment for calibration of the probe. Now insert the probe-stopper assembly in the top of the calibration chamber.
2. Connect the probe cables to the YSI Model 51A. YSI Series 5400 Oxygen/Temperature probes have two connectors of different sizes so they cannot be incorrectly attached to the instrument.
3. With the instrument OFF check mechanical zero of meter and

adjust if necessary with the screwdriver adjustment in the lower center of the meter bezel. Perform the adjustment with the instrument in the position in which it will be used.

4. Turn the selector switch to ZERO and adjust the meter to zero with the ZERO adjustment knob.
5. Turn the selector switch to FULL SCALE and adjust the meter to the full scale position. 15 PPM on the meter. If the meter cannot be adjusted to full scale, replace the batteries.
6. Set the selector switch to CALIB O_2 position and leave it in this position for at least 5 minutes to polarize the probe before making further calibrations or measurements, and 20 min. for maximum accuracy.
7. Immerse the probe mounted in the calibration chamber (See Step 1) in water near the measurement site for approximately five minutes until the probe is the same temperature as the water. This can be done simultaneously with Step 6.
8. With 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 altitude is changed. A 1000 ft. altitude change can result in a 3% reading error – 0.3 PPM at 10.0 PPM.

It is not necessary to recalibrate if sample salinity changes, just dial-in the new salinity value.

For greatest accuracy recalibration is recommended if sample temperature is more than 5°C away from calibration temperature. Typical error is 1% of reading at 5° from calibration temperature, and 3% of reading at 25°C.

The membrane must be dry for accurate calibration. Shake off or blow away any moisture on the membrane before starting calibration.

Use of the calibration chamber is the preferred method of calibration; however, there are times when this calibration procedure

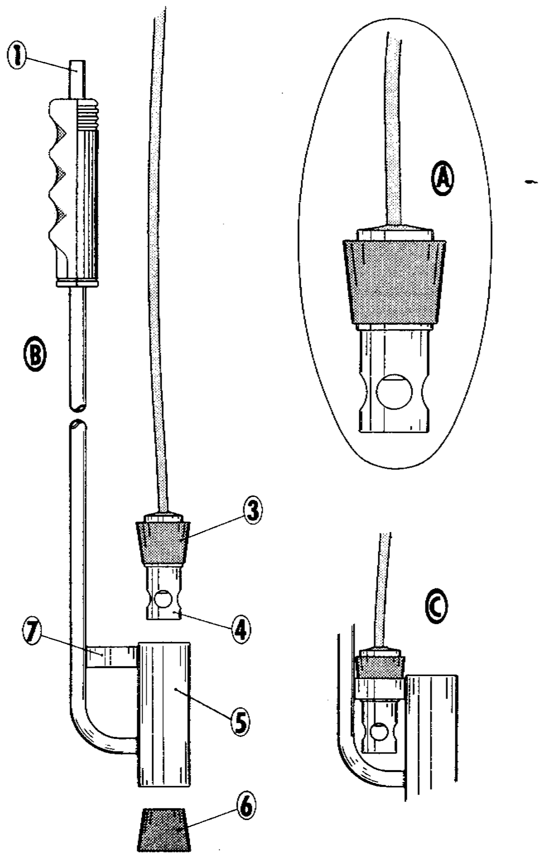


Figure 3

is not practical for one reason or another. On such occasions follow the calibration technique described in CALIBRATION PROCEDURE under BOD MEASUREMENTS. As users become proficient with the instrument, many adopt the air calibration technique as standard. Experience will determine which technique is easiest and most efficient for your particular application.

II. Measurement Procedure

After preparation of the probe and calibration of the instrument, the system is ready for measurement of dissolved oxygen according to the following procedures.

1. Transfer the probe from the calibration chamber (5) to the ring (7) and place the probe in the water at the measurement site, twisting or pumping the handle to induce water flow across the membrane (poor water flow causes low readings).

   Measurements also can be made by lowering the probe to the desired depth without use of the calibration chamber. To cause water flow across the membrane, sharply pull the cable vertically 6 to 10 inches and allow the probe to settle to the original depth. Repeat every 3 to 6 seconds in a motion similar to fishing with a handline.

   A more convenient procedure is to use the YSI 5491 Submersible Stirrer in place of the calibration chamber during measurement. This eliminates the need to pump the calibration chamber handle or pull the cable up and down to create a flow of water past the membrane. The battery-operated stirrer provides an even, continuous flow for more reliable measurement.

2. Turn the switch to TEMP and read 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).

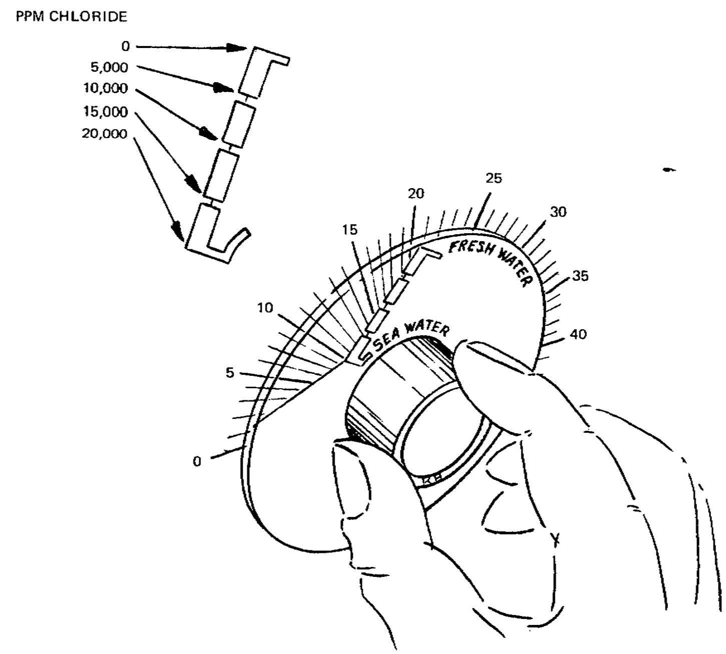


Figure 4

3. Turn the switch to O_2 and read the dissolved oxygen value in PPM directly from the meter dial.

III. 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 PPM chloride.

It is necessary for the operator to determine salinity by suitable means and then to choose the correct position along the index scale when dialing in the temperature. (See Figure 4).

Each section of the bar on the 02 SOLUBILITY FACTOR dial represents 5,000 PPM chloride concentration over a range from 0 to 20,000 PPM. 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 PPM chloride at 20°C, or 10,000 PPM chloride at 15°C, or about 18,000 PPM chloride at 10°C, etc.

IV. Multiple Measurements

If a series of measurements are made in a short time at about the same temperature (within 5°C of calibration temperature) performance will not be degraded and recalibration is not required. Simply:

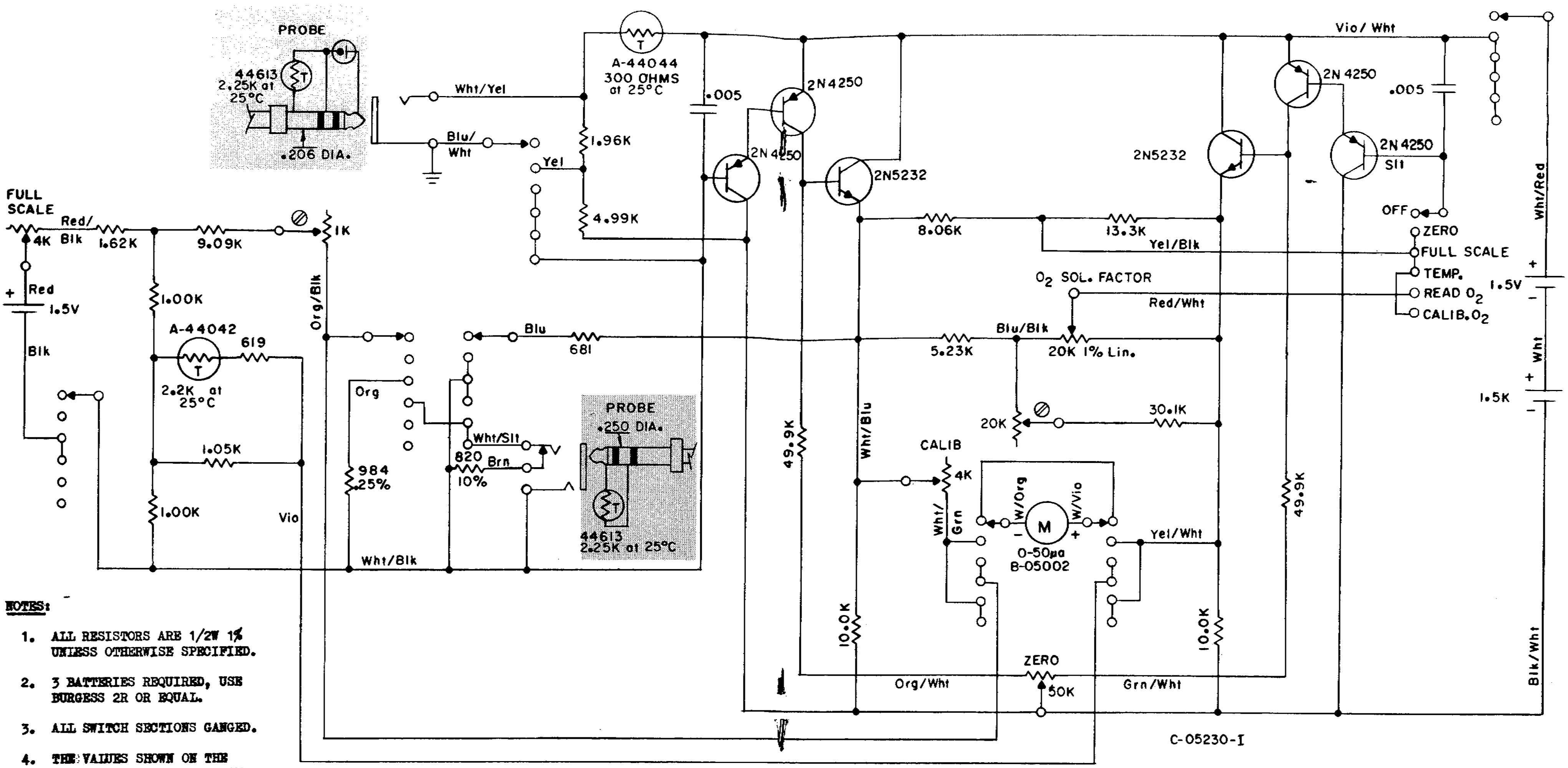
a. read temperature of new sample
b. reset 0_2 SOLUBILITY FACTOR dial
c. read oxygen concentration

Experience is the best guide for deciding how often recalibration is required. Careful probe maintenance and storage aid stability of calibration.

BOD MEASUREMENTS WITH YSI 5420-A AND 5450 PROBES

I. Calibration Procedure

The YSI 5420-A Self-Stirring and YSI 5450 Non-Stirring BOD Bottle Probes are designed for use with standard BOD bottles. The



MODEL 51A OXYGEN METER

NOTES:

1. ALL RESISTORS ARE 1/2W 1% UNLESS OTHERWISE SPECIFIED.
2. 3 BATTERIES REQUIRED, USE BURGESS 2R OR EQUAL.
3. ALL SWITCH SECTIONS GANGED.
4. THE VALUES SHOWN ON THE SCHEMATIC MAY DIFFER FROM THOSE IN THE INSTRUMENT; IF SO, EITHER VALUE CAN BE PURPOSES.
5. 2N4250 TRANSISTORS SELECTED AT FACTORY - CONSULT FACTORY.

YSI 5420-A Probe has a built-in stirring mechanism to agitate the media under study. When using the YSI 5450 Probe, stirring or agitation must be provided by other means.

Calibration of the system may be achieved in any of three ways:

1. Air saturated water can be used as the calibration standard. A beaker of distilled water open to the air and agitated for 15 to 30 minutes, or with air bubbled through it for an equal time should provide a reasonably stable reference if the saturation level of oxygen in the sample can be determined. The sample must be 100% saturated with air. Take care to avoid heating the water sample with the stirring device. A fresh calibration sample should be made every few hours.

   Immerse the probe in a BOD bottle containing the calibration sample, maintain stirring, and calibrate as discussed in CALIBRATION PROCEDURE under MEASUREMENT OF DISSOLVED OXYGEN, skipping Steps 1 and 7.

2. A frequently used method for determining the amount of oxygen in a water sample for use as a calibration standard is with Winkler analysis. Fill two BOD bottles with water from a common source. Dillution water is often used. Fill the bottles in such a way as to avoid aerating the samples.

   Titrate one sample and calibrate the system against the second sample. Follow the technique discussed in CALIBRATION PROCEDURE under MEASUREMENT OF DISSOLVED OXYGEN, skipping Steps 1, 7 and 8 and then:

   - Read temperature of calibration sample and set solubility dial to sample temperature. Observe correct salinity.
   - With switch in READ 0_2 position set CALIB 0_2 knob to proper PPM value on upper scale.
   - Recheck calibration in one minute to check for drift.

   To eliminate the potential variations of Winkler analysis, some users prefer to titrate three bottles and use an average figure for calibration in a fourth bottle.

3. The YSI Model 51A is designed to take maximum advantage of the third calibration technique, air calibration. Since the concentration of oxygen in air essentially remains constant, air can be used as a calibration standard. This is discussed in more detail in the THEORY OF OPERATION.

   For greatest accuracy place the probe in a BOD bottle half full of water, and then calibrating as discussed in CALIBRATION PROCEDURE under MEASUREMENT OF DISSOLVED OXYGEN, skipping Steps 1 and 7.

   Air calibration also can be achieved by placing the probe in air without the BOD bottle; however, there is some possibility of introducing a small error due to low humidity. This is discussed in more detail in SUMMARY OF MEASUREMENT ERRORS.

NOTE:

It is highly desirable for the temperature of the probe, calibration sample, and measurement sample to be the same and constant. We recommend keeping the BOD probe in a BOD bottle half full of water, storing both in the incubation chamber with the BOD samples, and making calibrations in the chamber. Measurement errors are usually directly related to calibration errors, and we recommend a thorough study of the SUMMARY OF MEASUREMENT ERRORS to minimize difficulties with the instrument.

II. Measurement Procedure

After preparation of the probe and calibration of the instrument, the system is ready for measurement of dissolved oxygen as follows:

1. Transfer the probe from the calibration media to the BOD bottle containing the sample to be measured. Turn on the stirring motor if using the YSI 5420-A Self-Stirring Probe, or provide agitation by other means if using the YSI 5450 Non-Stirring Probe.
2. Turn the switch to TEMP and read 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).
3. Turn the switch to O_2 and read the dissolved oxygen value in PPM directly from the meter dial.

   For information on the procedures and techniques for preparation of BOD samples, see "Standard Methods for the Examination of Water and Waste Water" published by American Public Health Association, American Water Works Association, and Water Pollution Control Federation.

% OXYGEN & % AIR SATURATION MEASUREMENTS

Occasionally it is desirable to measure the % oxygen in a sample or the % air saturation of a sample. The YSI Model 51A can be used for these measurements with any of the YSI 5400 Series Probes with an altered calibration technique as follows:

I. % Oxygen Readings

1. Prepare the probe for operation as previously discussed.
2. Connect the probe to the instrument.
3. With the instrument OFF check the mechanical zero and adjust if necessary.
4. Turn the selector switch to ZERO and adjust the meter to zero on lower scale with the ZERO adjustment knob.
5. Turn the selector switch to FULL SCALE and adjust the meter to the full scale position.
6. Switch to CALIB O_2 and leave the instrument on for 20 minutes to polarize the probe.
7. With the probe in air adjust the meter to 21 on the lower scale using the CALIB knob.

NOTE: When 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 wrapping it in a damp cloth during calibration, Steps 6 and 7.

8. Transfer the probe to the measurement sample and read on the lower scale with the instrument still in the CALIB O_2 position. All readings will be in % O_2. Accuracy will be ±1% O_2, worst case.

NOTE: Temperature readings may be made with the switch in the TEMP position. The SOLUBILITY FACTOR dial is inoperative and unnecessary when making % oxygen readings.

II. % Air Saturation Readings

1 thru 6. Same as for % OXYGEN READINGS, except in step 4 set zero on the upper scale

7. With the probe in air adjust the meter to 10 on the upper scale using the CALIB knob.

NOTE: When measurements are to be made in water greatest accuracy will be achieved if the probe is calibrated in moist air suspending it in a bottle containing a small amount of water or wrapping it in a damp cloth during calibration, Steps 6 and 7.

8. 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: Temperature readings may be made with the switch in the TEMP position. The O_2 SOLUBILITY FACTOR dial is inoperative and unnecessary when making % air saturation readings.

SUMMARY OF MEASUREMENT ERRORS

When comparative measurements are made on the same sample, under the same conditions, and with the same instrument, the reading should reproduce to ±0.1 PPM or better. Many factors can contribute to measurement errors. The error figures given below are "worst case absolute error accumulation" where each contributing factor is at its extreme tolerance value and the sum of contributing factors is taken as the worst possible combination. There are three main types of errors:

Type 1. Errors due to instrument design, quality control and component limitations. They cannot be reduced by the user without elaborate individual instrument calibration procedures.

1% meter tolerance 0.15 PPM max.
Amp and circuit 0.05 PPM max.
(Worst case Type 1 error: ±0.20 PPM max.)

Type 2. Errors arising from temperature and oxygen sensor limitations, nonlinear response, and membrane-to-membrane difference. The maximum permissible error is specified, and good maintenance will limit this type of error to those values.

Automatic temperature compensation for membrane temperature coefficient 0.03 PPM max.

Dial solubility control error
(1% component) 0.10 PPM max.

Tracking of panel dial and printing error
-5 to +30°C – 0.05 PPM max.
(30 to 45°C – 0.10 PPM max.)

Temperature measurement error
0.5°C meter error
+0.2°C probe error — 0.14 PPM max.
(Worst case Type 2 error: ±0.32 PPM max.)

Type 3. Errors arising from assumptions made about the environment in which the measurements are made and as such are subject to control by the operation.

Altitude Effect —
1000 ft. change gives about a 3% error or 0.3 PPM at 10 PPM level.

Barometric Pressure —
Normal local variation is less than ±0.5" Hg., or 0.15 PPM max.

Humidity —
If less than 100% RH in calibration chamber. Assume only 50% RH. The error varies with temperature.

Temperature	Error/PPM
0°C	0.02
10°C	0.05
20°C	0.12
30°C	0.27
40°C	0.68

Neglecting the altitude error —
(Worst case Type 3 errors at 20°C; ±0.27 PPM max.)

Under the worst conditions with all errors additive — The error at 20°C could amount to: ±0.79 PPM (max.)

If Type 3 errors are omitted — the worst case error would be: ±0.52 PPM (max.)

If calibration is achieved at or within 1°C of the sample temperature — the error can be further reduced to: ±0.38 PPM (max.)

Bearing in mind that these accumulated errors represent manufacturing acceptability limits and that probability of all errors adding in the same direction is low, the probable error accumulation is about 1/2 the maximum: 0.26 PPM if Type 3 errors are eliminated, and 0.19 PPM if careful temperature matching technique is employed.

RECORDING DATA

Although the YSI Model 51A 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 minimum 50K ohm input impedance across the meter terminals. Set up the recorder according to the manufacturer's instructions and operate the YSI Model 51A as described.

Dissolved oxygen measurements in PPM 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 recording of dissolved oxygen is required in your application, we recommend the YSI Model 54 Dissolved Oxygen Meter, which has automatic temperature compensation and is designed with recorder output terminals.

CIRCUIT DESCRIPTION, MAINTENANCE AND CALIBRATION

The Model 51A contains two separate circuits:

1. A temperature bridge circuit
2. An amplifier for oxygen measurement

The amplifier is a six transistor balanced feedback amplifier featuring good temperature stability, low voltage power requirements and long battery life. Current from the oxygen 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 specific manipulations on the input signal to achieve dial-in O_2 solubility factor and to provide calibration adjustment means.

The only normal maintenance is battery replacement. Three "D" size flashlight batteries are required. Battery life is at least 1000 hours of operation or 6 months shelf life.

Battery replacement is indicated if the "full scale" adjustment cannot be made or O_2 calibration cannot be achieved. (Warning: a faulty probe will also not permit O_2 calibration.)

Replace batteries every six months to reduce danger of corrosion due to leaky batteries. To replace batteries – remove six screws from bottom plate – battery holders are color coded. Positive (+ button) end of battery must go to red.

It is possible that the O_2 SOLUBILITY FACTOR dial can become loose and slip from its normal position. In an emergency the dial can be repositioned with the following procedure. It must be emphasized that this is an emergency procedure only, and that the instrument should be returned to the factory for proper recalibration at the earliest opportunity.

1. Calibrate in air to the local altitude in the normal fashion.
2. Switch to TEMP and read temperature of the probe.
3. Refer to Table I and determine solubility of oxygen in water at the observed temperature and current barometric pressure. Consult Table II or call the local Weather Bureau for an exact reading. The more accurate the reading the more accurate will be the calibration.
4. Switch to O_2 and set the O_2 SOLUBILITY FACTOR dial to the observed temperature with salinity of fresh water. The PPM indication should agree with Table I. If it does not, rotate the SOLUBILITY FACTOR dial until the PPM indication does agree with Table I. Loosen the dial reposition so the pointer indicates the observed temperature. This is a temporary calibration only. As soon as possible the instrument should be returned for factory recalibration. YSI maintains complete facilities for repair and

recalibration of all YSI products.

TABLES FOR CALIBRATION

The PPM tables in accordance with standard practice include the vapor pressure of water in the indicated pressure. The sample of air used for calibration should be saturated with water vapor for greatest calibration accuracy.

The error which may result from use of completely dry air (extreme condition) is small and is maximum at higher temperatures and altitudes. At 25°C and 760 mm pressure the extreme error would be 0.3 PPM; for 50% RH, 0.15 PPM. If the error is of concern, wet the inside of the sampler cup before use to provide 100% RH. Then no error will occur using the tables provided.

Table I

SOLUBILITY OF OXYGEN IN WATER (Saturated with Air) IN PPM AT VARIOUS TEMPERATURES AND PRESSURES

P mm	775	760	750	725	700	675	650	625
P Inches	30.51	29.92	29.53	28.54	27.56	26.57	25.59	24.61
TEMPERATURE IN DEGREES CENTIGRADE								
0	14.9	14.6	14.4	13.9	13.5	12.9	12.5	12.0
1	14.5	14.2	14.1	13.6	13.1	12.6	12.2	11.7
2	14.1	13.9	13.7	13.2	12.9	12.3	11.8	11.4
3	13.8	13.5	13.3	12.9	12.4	12.0	11.5	11.1
4	13.4	13.2	13.0	12.5	12.1	11.7	11.2	10.8
5	13.1	12.8	12.6	12.2	11.8	11.4	10.9	10.5
6	12.7	12.5	12.3	11.9	11.5	11.1	10.7	10.3
7	12.4	12.2	12.0	11.6	11.2	10.8	10.4	10.0
8	12.1	11.9	11.7	11.3	10.9	10.5	10.1	9.8
9	11.8	11.6	11.5	11.1	10.7	10.3	9.9	9.5
10	11.6	11.3	11.2	10.8	10.4	10.1	9.7	9.3
11	11.3	11.1	10.9	10.6	10.2	9.8	9.5	9.1
12	11.1	10.8	10.7	10.3	10.0	9.6	9.2	8.9
13	10.8	10.6	10.5	10.1	9.8	9.4	9.1	8.7
14	10.6	10.4	10.2	9.9	9.5	9.2	8.9	8.5
15	10.4	10.2	10.0	9.7	9.3	9.0	8.7	8.3
16	10.1	9.9	9.8	9.5	9.1	8.8	8.5	8.1
17	9.9	9.7	9.6	9.3	9.0	8.6	8.3	8.0
18	9.7	9.5	9.4	9.1	8.8	8.4	8.1	7.8
19	9.5	9.3	9.2	8.9	8.6	8.3	8.0	7.6
20	9.3	9.2	9.1	8.7	8.4	8.1	7.8	7.5
21	9.2	9.0	8.9	8.6	8.3	8.0	7.7	7.4
22	9.0	8.8	8.7	8.4	8.1	7.8	7.5	7.2
23	8.8	8.7	8.5	8.2	8.0	7.7	7.4	7.1
24	8.7	8.5	8.4	8.1	7.8	7.5	7.2	7.0
25	8.5	8.4	8.3	8.0	7.7	7.4	7.1	6.8
26	8.4	8.2	8.1	7.8	7.6	7.3	7.0	6.7
27	8.2	8.1	8.0	7.7	7.4	7.1	6.9	6.6

Table I – Continued

SOLUBILITY OF OXYGEN IN WATER (Saturated with Air) IN PPM AT VARIOUS TEMPERATURES AND PRESSURES

P mm	775	760	750	725	700	675	650	625
P Inches	30.51	29.92	29.53	28.54	27.56	26.57	25.59	24.61
TEMPERATURE IN DEGREES CENTIGRADE								
28	8.1	7.9	7.8	7.6	7.3	7.0	6.7	6.5
29	7.9	7.8	7.7	7.4	7.2	6.9	6.6	6.4
30	7.8	7.7	7.6	7.3	7.0	6.8	6.5	6.2
31	7.7	7.5	7.4	7.2	6.9	6.7	6.4	6.1
32	7.6	7.4	7.3	7.0	6.8	6.6	6.3	6.0
33	7.4	7.3	7.2	6.9	6.7	6.4	6.2	5.9
34	7.3	7.2	7.1	6.8	6.6	6.3	6.1	5.8
35	7.2	7.1	7.0	6.7	6.5	6.2	6.0	5.7
36	7.1	7.0	6.9	6.6	6.4	6.1	5.9	5.6
37	7.0	6.8	6.7	6.5	6.3	6.0	5.8	5.6
38	6.9	6.7	6.6	6.4	6.2	5.9	5.7	5.5
39	6.8	6.6	6.5	6.3	6.1	5.8	5.6	5.4
40	6.7	6.5	6.4	6.2	6.0	5.7	5.5	5.3
41	6.6	6.4	6.3	6.1	5.9	5.6	5.4	5.2
42	6.5	6.3	6.2	6.0	5.8	5.6	5.3	5.1
43	6.4	6.2	6.1	5.9	5.7	5.5	5.2	5.0
44	6.3	6.1	6.0	5.8	5.6	5.4	5.2	4.9
45	6.2	6.0	5.9	5.7	5.5	5.3	5.1	4.8
46	6.1	5.9	5.9	5.6	5.4	5.2	5.0	4.8
47	6.0	5.9	5.8	5.6	5.3	5.1	4.9	4.7
48	5.9	5.8	5.7	5.5	5.3	5.0	4.8	4.6
49	5.8	5.7	5.6	5.4	5.2	5.0	4.7	4.5
50	5.7	5.6	5.5	5.3	5.1	4.9	4.7	4.4

It should be noted that the barometric pressure as quoted by the Weather Bureau is not the true atmospheric pressure of the locale, but it is corrected to an equivalent sea level reading.

For a reported pressure of 760 mm the true atmospheric pressure at a given altitude is shown.

Table II

RELATION OF ATMOSPHERIC PRESSURE TO ALTITUDE

Altitude	True Atmospheric Pressure	CALIB Setting for Altitudes Above 7000 Feet Set Meter to Read PPM
Sea Level	760	
1000 Feet	733	
2000 Feet	707	
3000 Feet	681	
4000 Feet	656	
5000 Feet	632	
6000 Feet	609	
7000 Feet	586	
8000 Feet	564	10.02
9000 Feet	543	9.64
10,000 Feet	523	9.29
11,000 Feet	503	8.93

The temperature-solubility relationship of oxygen in sea water is not the same as that in fresh water.

The solubility of oxygen in sea water is given in Table III.

Table III

SOLUBILITY OF OXYGEN IN SEA WATER

(Chloride concentration 20,000 mg/1)

Temp. °C	Solubility PPM	Temp. °C	Solubility PPM
−2.6	12.1	14	8.3
−2	11.9	15	8.1
−1	11.6	16	8.0
0	11.3	17	7.8
1	11.0	18	7.7
2	10.8	19	7.5
3	10.5	20	7.4
4	10.3	21	7.3
5	10.1	22	7.1
6	9.8	23	7.0
7	9.6	24	6.9
8	9.4	25	6.7
9	9.2	26	6.6
10	9.0	27	6.5
11	8.8	28	6.4
12	8.6	29	6.2
13	8.4	30	6.1

PROBE REPLACEMENT PARTS AND ACCESSORIES

	PROBE MODELS (X indicates "normal use")				
	5101	5418	5419	5420-A	5450
YSI 5034 Probe Service Kit—includes:					
(1) 5033 Storage Bottle	x	x	x	Not Used	Not Used
(2) 5352 Membrane Kit	x	x	x	x	x
KCl with Kodak Photo-Flo	x	x	x	x	x
(1) 5945 "O" Ring Pack	x	x	x	x	x
YSI 5352 Membrane Kit—includes: (25) .001" thk. standard membranes	x	x	x	x	x
YSI 5937 High Sensitivity Membrane Kit —includes: (25) .0005" thk. membranes	x	x	x	x	x
YSI 5945 "O" Ring Pack—includes:					
(6) 5/16" I.D. x 7/16" O.D. x 1/16" W Precision 011-7507	x	x	x	x	x
(6) 3/8" I.D. x 9/16" O.D. x 3/32" W Anchor 11-110-7446-70	Do Not Use On 5420A				
YSI 5075 Calibration Chamber	x	x	x	Not Used	Not Used
YSI 5486 Beater Boot—includes:					
(6) A-05486 Boot	Not Used	Not Used	Not Used	x	Not Used
(1) A-05484 Tip	Not Used	Not Used	Not Used	x	Not Used
(4) A-05485 Spring	Not Used	Not Used	Not Used	x	Not Used
YSI 5959 Tubing Kit (24") 1/8" I.D. x 1/32" wall Silicone tubing	Not Used	Not Used	x	Not Used	Not Used
YSI 5974 Weight (2) A-05974 Weight (2) Screws	x	x	x	Not Used	Not Used

GUARANTEE

The YSI Model 51A Dissolved Oxygen Meter, and all YSI Oxygen Probes designed for use with this instrument, are guaranteed for one year against defects in workmanship and components. Damage through accident, misuse, or tampering will be repaired at a nominal charge when the instrument is returned to the factory. YSI maintains complete repair and calibration facilities and is equipped to provide prompt service on all YSI equipment.

In communications regarding this instrument please mention model and serial number.