YSI Model 59
Dissolved Oxygen Meter Instructions

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I. DESCRIPTION

The YSI Model 59 is a microprocessor-based instrument designed for field and laboratory measurement of dissolved oxygen. Readings are automatically compensated for temperature. When calibrated to % air saturation, the display simultaneously shows dissolved oxygen in mg/L and in % air saturation as well as temperature in degrees Celsius. An RS232 port permits results to be sent directly to your serial printer or personal computer. Salinity compensation can be adjusted manually. To assure the highest accuracy, an autostable feature indicates when the readings have reached user-defined criteria for stability. To assure correct operation, the meter performs a self-testing routine each time it is turned on; any error is then signaled on the display.

Calibration is quick and easy. Procedures for calibrating with and without compensation for temperature, altitude, pressure, and salinity are described in this manual. Abbreviated instructions are printed on the back of the instrument, but operators should become familiar with the contents of this manual and the principles of dissolved oxygen measurement.

The YSI Model 59 is also equipped with non-volatile memory, capable of storing up to 50 DO and temperature readings. Any data stored in internal memory can be reviewed on the LCD, or batch uploaded to a PC or an RS232 printer.

Power is provided by an AC adapter, or by batteries which permit field use. A YSI 5795A Submersible Field Stirrer can operate directly from the internal batteries of the Model 59.

I.A. Principles of Operation

YSI dissolved oxygen probes use membrane covered, Clark-type 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.

Oxygen diffuses through the membrane 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 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.

I.B. Display and Function Keys

A rotary function switch and five keys provide complete control of the Model 59. One key controls sample stirring. The other keys are ***SKIP***, ▲, ▼, and ***CONFIRM*** ▲ and ▼ are used to modify a setting either up or down (for example, calibration or salinity values can be modified for each calibration process if required). The ***CONFIRM*** key is used to accept your setting.

The display often asks questions, such as "Calibrate in percent?" Use ***CONFIRM*** to answer yes. Use ***SKIP*** to go on to the next choice. The ***SKIP*** key can also be used to select among several default values.

I.C. Function Switch

The rotary function switch allows easy selection among the meter's basic functions. In O2-TEMP, the instrument is measuring dissolved oxygen and temperature. To begin calibrating, switch to CALIBRATE. To begin setting clock, communication, and autostable parameters, switch to SYSTEM SETUP. EXTERNAL CONTROL activates the RS232 port. Salinity can be set after switching to SALINITY.

I.D. Power On Self Test (POST)

A Power On Self Test (POST) takes place whenever the meter is turned on. This ensures correct performance. If anything is wrong, the operator is signaled and the error identified. An error message will appear on the display. See section X.B.

I.E. Bar Code Option

A bar code option for large scale BOD operations includes additional electronics, a bar code wand, and a set of bar code labels. The labels can be affixed to your BOD bottles, permitting easy sample identification. If you did not choose the bar code option at the time you purchased the Model 59, the instrument can be upgraded any time by returning it to YSI. Call YSI for cost and additional information.

II. SPECIFICATIONS

Oxygen Measurement

Ranges: 0.0 to 19.99 mg/L dissolved oxygen

0.0 to 199.9% air saturation

Accuracy: ±0.1% of saturation value, plus 1 Least Significant Digit for mg/L readings, plus probe error

±0.1% of air saturation, plus 1 Least Significant Digit for % readings, plus probe error

Resolution: 0.1% of the saturation value, expressed in mg/L, or 0.01 mg/L , whichever is greater;

0.1% air saturation

Temperature Measurement

Range: -5.0 to +45.0℃

Accuracy: ±0.1℃, plus probe error

Resolution: 0.1℃

Temperature Compensation

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

The % air saturation mode is automatically temperature-compensated to an accuracy of ±0.5% of calibration values between 0 and 5℃, and to an accuracy of ±0.3% of values between 5 and 45℃.

Salinity Compensation

Range: 0.0 to 40.0 ppt

Accuracy: ±.02 mg/L

Operating Environment

0 to 45℃, 10 to 90% humidity, non-condensing

Water Resistance

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

Power

The Model 59 is powered by an AC adaptor or 6 alkaline D cells. Batteries power the instrument for approximately 100 hours; less when using the stirrer or the bar code reader option.

Size and Weight

21.6 by 28 by 9.5 cm; 2.4 kg
8.5 by 11 by 3.75 inches; 5.2 pounds

III. PREPARATION FOR USE

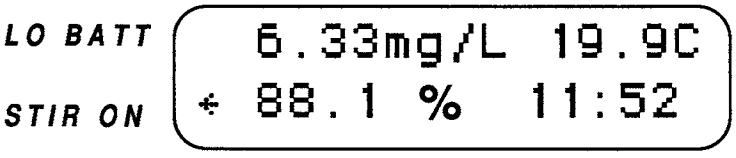
If you will be using any accessories, this is a good time to attach the appropriate connectors and prepare for your calibration and measurement procedures.

Connect a prepared probe to the meter (see probe instructions, Appendix A). Set the function switch to O_2-TEMP. Observe temperature and oxygen readings for stability, or see section VIII.B to set up Autostable. Since complete equilibration can take as long as 15 minutes after the meter is turned on, it is customary to leave the instrument on throughout the working day.

When the instrument is turned on, a beep signals the beginning of a Power On Self Test (POST). A series of displays will appear. A final beep and a return to the normal display signal the conclusion of the test. The whole process takes about 10 seconds. If the instrument detects an error, it will display an error message. These messages, with appropriate corrective actions, are listed in the Maintenance and Troubleshooting section of this manual (see section X.B.). If you have a problem you cannot resolve, call YSI Product Service, (513) 767-7241 or (800) 765-9974.

Stirring: Since the oxygen level in the layer of liquid at the membrane surface is continuously depleted, it is essential that water movement of 1 foot per second or more be maintained while making dissolved oxygen measurements. When using the Model 59 in field applications, a moving stream will usually provide adequate motion, as will moving the probe through the sample by hand. For lab applications, we recommend one of the YSI self-stirring BOD probes.

For field applications, the YSI 5795A Submersible Stirrer provides the necessary stirring for use with the YSI 5739 probe. The Model 59 can power the 5795A directly. Plug in the stirrer connector and press the ***STIR*** key to begin stirring. Turn off the stirrer by pressing the key again. An arrow in the display indicates when the stirrer is on.



Do *not* use the stirrer drive while powering the meter with the AC adaptor; this could cause incorrect readings. YSI's self-stirring BOD probes come with their own adaptors; use them instead. If you prefer to provide stirring with a magnetic stir plate or some other device, we recommend the non-stirring YSI 5750 BOD probe.

When the temperature and oxygen readings have stabilized, you are ready to begin calibration.

IV. CALIBRATION

The response of the Model 59 to a given signal is very consistent. Probes, however, vary in their response according to several factors, including temperature, pressure, and probe and membrane history. The principal purpose of calibration is to adjust for variations in probe response.

Calibration is accomplished by exposing the probe to a known concentration of oxygen and then adjusting the calibration value to match. Since the oxygen content of our atmosphere varies predictably according to relative humidity and atmospheric pressure, we recommend that you calibrate in air. (See section IV.C.)

Daily calibration is usually appropriate. Calibration can be disturbed by a 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.

IV.A. Percent and mg/L

100 percent air saturation corrected to standard pressure is the dissolved oxygen value of water saturated with air at 760 mm Hg (1013 millibars or 29.92 inches Hg). The mg/L values describe the concentration of oxygen. Since calibrations in mg/L do not necessarily yield correct percent readings, the percent readings are disabled after calibrations in mg/L. Calibrations in percent are correct for both percent and mg/L readings.

IV.B. Determining Calibration Value

The correct calibration value is the solubility of oxygen in fresh water at your barometric pressure as a percentage of the solubility of oxygen at standard pressure.

Typically, local barometric pressure is not equal to "standard pressure." Therefore, unless you are calibrating with a known sample determined by a Winkler titration, you should determine the proper calibration point for the local barometric pressure. This corresponds to a reading from a mercury barometer. Do **not** use the pressure reported by the Weather Bureau which has been adjusted to sea level. The calibration value for a given barometric pressure can be read from the chart on the back of the meter, or the one in Appendix B. of this manual.

The chart also lists calibration values according to altitude. These values are only approximate because they are derived from the **average** pressure at the given altitudes, and do not take pressure variations into account. The typical error resulting from calibration to altitude alone will be ±4% of your reading. Use altitude values only when you cannot determine the true barometric pressure.

IV.C. Calibration in Air

Three separate calibration techniques are discussed here: calibration in air, calibration in air-saturated water, and calibration by Winkler titration. Choose the **one** technique which best fits your application. Calibration in air is the simplest and most accurate method of calibration.

To calibrate in air:

1. Place a prepared probe in air at 100% relative humidity. To achieve this, BOD probes can be placed in a BOD bottle with approximately 1" of water. Field probes can be placed in the plastic calibration bottle with a moistened sponge, or calibrated with the 5075A Calibration Chamber (see probe instructions Appendix A).

2. Switch to CALIBRATE. The display will read:

```
Calibrate
    in percent?
```

Select percent calibration by pressing ***CONFIRM***. A display similar to the one below will be shown.

```
Enter cal value
Last=  96.4 %
```

3. Using ▲ and ▼, adjust the number to the calibration value determined from the altitude or pressure chart on the back of the Model 59. ***SKIP*** sets the value to 100.0%; and shows the following display:

```
Enter cal value
Sat. = 100%
```

you may wish to do this to bring the setting quickly to a value near the one you want, then continue with ▲ and ▼. Pressing ***SKIP*** again sets the value to 0.0% (see Zeroing the Probe). Pressing ***SKIP*** a third time brings it back to the last calibration value.

4. When you have adjusted the reading to the desired value (let's say you chose 98.0%), press ***CONFIRM.*** The instrument will display the legend "Please wait" for a few seconds. Then it will display:

You are now ready to measure dissolved oxygen.

IV.D. Calibration in Air-Saturated Water

A second alternative for calibration is to calibrate in air-saturated water. This procedure is the same as the procedure for calibration in air except that the calibration medium is saturated water rather than saturated air.

To calibrate in air-saturated water:

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

2. Place the probe in the sample and provide adequate stirring (at least 1 foot per second). Switch to O_2-TEMP and observe temperature and oxygen readings for stability. It may take 5 minutes for the temperature to come to equilibrium. If you have just turned the instrument on, allow 15 minutes for the system to equilibrate.

3. Switch to CALIBRATE, select percent calibration, then adjust the number in the display to the correct value based on current barometric pressure or altitude (see IV B)and press ***CONFIRM.***

IV.E. Calibration by Winkler Titration

A third alternative for calibration is to calibrate to a known oxygen value determined by a Winkler titration.

To calibrate using a Winkler-titrated sample:

1. Determine the dissolved oxygen value of a sample by Winkler titration.

2. Place the probe in the sample and provide adequate stirring (at least 1 foot per second). Switch to O_2-TEMP and observe temperature and oxygen readings for stability.

3. Switch to CALIBRATE. The display will read:

```
Calibrate
    in percent?
```

Press ***SKIP***. The display will read:

```
Calibrate
       in mg/L?
```

Press ***CONFIRM*** to select mg/L calibration. A display similar to the one below will be shown.

```
Enter cal value
Last= 8.15 mg/L
```

4. Use ▲ and ▼ to set the calibration value determined by Winkler titration. You may be able to set the value more quickly by using the ***SKIP*** key to bring the value near the one you want, then continuing with ▲ and ▼. Pressing ***SKIP*** once sets the value to the saturation value of oxygen in water at the probe temperature. A display similar to the one below will be shown.

```
Enter cal value
Sat. = 8.58 mg/L
```

Pressing ***SKIP*** again sets the value to 0.00 mg/L. (See Zero Calibration, below.) Pressing ***SKIP*** a third time brings it back to the last calibration value.

5. When the correct value is set, press ***CONFIRM***. The display will show the legend "Please wait" for a few seconds, and then display "Calibrated to..." To take dissolved oxygen readings in mg/L, switch to O2-TEMP.

Note: Since there is no way to determine percent air saturation after a calibration in mg/L, the % reading will be disabled.

IV.F.Zero Calibration

In rare applications, the accuracy of the calibration can be improved by performing a zero calibration along with one of the procedures discussed previously.

All oxygen probes have a small background current, even in the absence of oxygen. Model 59 compensation is based on the average background current of YSI 5700 Series probes. This is the default zero value. Although using this average will result in errors with probes whose background current differs from the average.

Note: Errors will be insignificant in most applications. See Discussion of Measurement Errors Section IX.

For highest accuracy measurements, a zero calibration should be performed to compensate for the specific background current of the probe in use.

To calibrate to a true zero, place the probe in a zero oxygen environment and adjust the calibration value to zero.

A standard method for creating such an environment is to dissolve in water (preferably the water should come from the sample to be measured) excess sodium sulfite (Na_2SO_3), and a trace of cobalt chloride ($CoCl_2$). These chemicals will remove all oxygen from the sample (See Standard Methods for the Examination of Water & Wastewater, 17th edition, 1989, page 4-161.) Alternatively, you may place the probe in 100% nitrogen gas. Place the probe in the zero oxygen sample, switch to O_2-TEMP and allow at least 20 minutes for the probe to come to equilibrium.

At this point the DO reading will be near zero, and may be positive or negative.

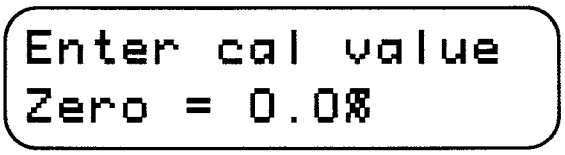
Switch to CALIBRATE. The display will show:

```
Calibrate
     in percent?
```

Select percent calibration by pressing ***CONFIRM.*** A display similar to the one below will be shown:

```
Enter cal value
Last = 92.5%
```

Press ***SKIP*** twice to set the calibration value to 0.0% . The following display will be shown.



Press ***CONFIRM*** to calibrate to zero. The display will ask you to wait, then show "Calibrated to 0.0 %." After zeroing, rinse the probe thoroughly to remove any residual trace of chemicals.

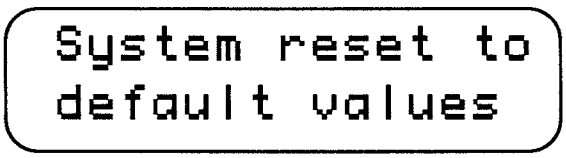
The Model 59 is calibrated at two points: the calibration value you select, and its default zero.

Note: When you change the zero calibration point, you offset the other value, so that after zeroing the probe for zero oxygen, you must recalibrate in an oxygen environment. If you try to take readings without recalibrating, the display will provide this warning:

You may also select mg/L calibration and then zero calibrate; the result will be the same.

IV.G. Resetting the Default Zero Calibration

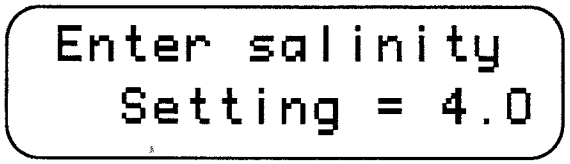
To reset the zero calibration to its default value, turn the instrument off and then hold down ***SKIP*** and ▲ while turning the instrument back on again. The display below will show briefly, then the POST operation and display will resume.



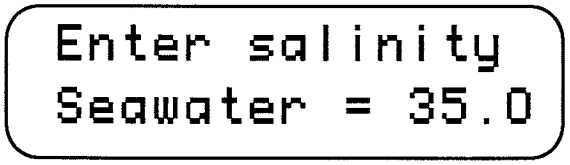
This procedure resets the meter to its original state. You must reset the time, date, salinity, and the RS232 parameters after restoring the default zero. As with the zero calibration, you must also recalibrate after restoring the default zero.

V. SALINITY

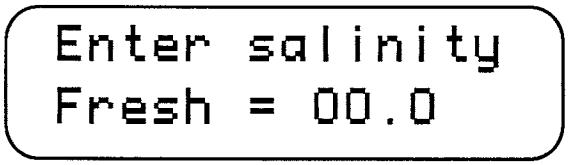
Salt reduces the ability of water to hold oxygen in solution. Enter the salinity of the sample you are measuring, and the meter will automatically compensate for the effect of salinity on dissolved oxygen. The default salinity setting is 0.0 ppt. You can enter any salinity setting between 0.0 and 40.0 ppt. To do this, turn the function switch to SALINITY. A display similar to the one below will show:



Use ▲ and ▼ to adjust the salinity setting. You might find it quicker to press ***SKIP*** first, which will set the value to 35.0 ppt. The following display will be shown:



Pressing ***SKIP*** again will set the value to 0.0 ppt for fresh water measurements. The following display will be shown:



Pressing ***SKIP*** once more will bring the setting to its original value. Once you have set the salinity correctly, press ***CONFIRM***. The instrument will ask you to wait, then show you the new salinity setting.

If you have calibrated using the air saturation method, there is no need to recalibrate after changing the salinity setting. If you have calibrated in mg/L, then you must recalibrate after setting the salinity.

After calibrating in air or in air-saturated water, you may change the meter's salinity setting without recalibrating. You may, for instance, calibrate only once and then proceed to measure oxygen in a variety of samples at different salinities by simply setting the proper salinity before making each measurement.

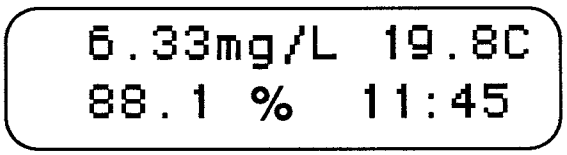
Even if your sample is saline, it is still best to calibrate in air. However, if you must calibrate in air-saturated water, it is best if the calibration sample is similar to the sample you intend to measure. Disregard the mg/L reading when measuring non-aqueous liquids. Such samples may have an oxygen solubility or Bunsen coefficient significantly different from those used in the Model 59.

Note: If you are calibrating in mg/L, the salinity must be set before calibration.

If you are calibrating by a Winkler titration, the salinity of the calibration sample must be the same as that of the samples you intend to measure. It is not necessary to know the salinity value, only that it is the same in both the calibration and measured samples. You **must not** change the salinity setting after calibration. If you do change it after a mg/L calibration, you must recalibrate.

For instructions on how to send your measurements directly to your PC, see System Setup and Personal Computer Interface sections, VIII & IX.

After calibrating, switch to O2-TEMP. The display will simultaneously show temperature, % air saturation, and oxygen concentration.



VI. MAKING MEASUREMENTS

VI.A. Temperature Measurement

Allow 3 to 5 minutes for temperature equilibration, and then take the temperature reading.

VI.B. Dissolved Oxygen Measurement

Should negative values appear while measuring very low oxygen samples, you should perform a zero calibration.

While the selector switch is set to O_2-Temp, place the prepared probe in the sample to be measured. Allow 3 to 5 minutes for temperature equilibration, or wait for the * to display if using the autostable feature. See section VIII C.. Begin stirring at least 30 seconds before taking readings. Observe readings for stability and record measurements. The last digit suppression feature of the Model 59 can be activated and deactivated by pressing the ***SKIP*** button. This feature will "hide" the last digit in both the mg/L and % oxygen readings and round each reading to the nearest whole digit.

VI.C. Measuring Oxygen in Fluids Other Than Water

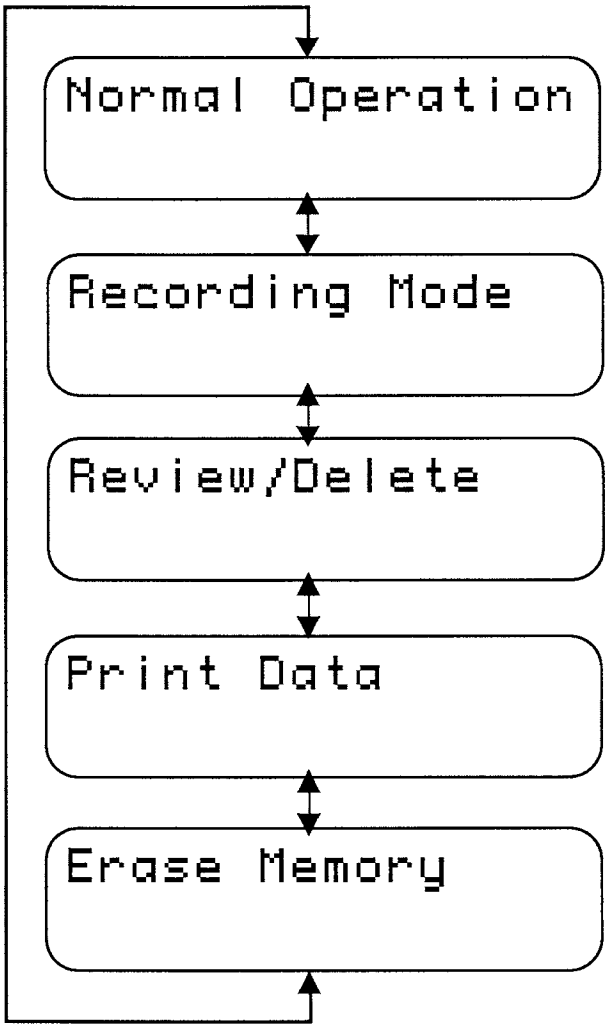
The Model 59 is normally used for measuring the oxygen content of naturally occurring waters and of wastewaters. The % air saturation mode also permits oxygen measurement in some non-water fluids including air, most gases, foods, and some non-aqueous liquids.

Fluids which are suitable for measurement are those which do not attack the sensor materials and are of sufficiently low viscosity to permit sample stirring across the probe membrane. Strong acids and solvents capable of swelling or dissolving the ABS plastic body of the probe or the EPR O-ring must be avoided. (See the list of interfering gases in Appendix A.) The % air saturation of any fluid not excluded in the foregoing may be measured directly. Calibrate by the customary air calibration technique and measure as in natural waters.

Disregard the mg/L reading when measuring non-aqueous liquids. Such samples may have an oxygen solubility or Bunsen coefficient significantly different from those used in the Model 59.

VII. RECORDING TO INTERNAL MEMORY

The Model 59 has several functions available while the function switch is set to "On-Temp." Use the arrow keys to see the following menu options.



To activate the Memory feature of the YSI Model 59, press the ▼ key while the function switch is set to O_2-TEMP. A display similar to the following will appear:

```
7.0 mg/L 23.4C
Recording Mode?
```

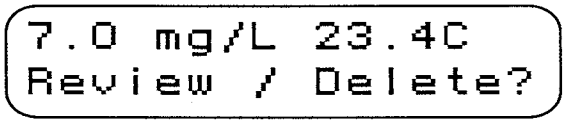
Press the ***CONFIRM*** key to enter Recording Mode. A display similar to the following will appear:

To record a reading now, press ***CONFIRM.*** The message "Data Stored" will flash across the display. You may continue to press ***CONFIRM*** for each data point you wish to record (up to a maximum of 50). With each press of the ***CONFIRM*** key, the number in the lower left of the display will increase by one.

To cancel Recording Mode at any time, press the ***SKIP*** key twice.

VII.A. Reviewing Recorded Data

To review data which has been previously stored in memory, set the function switch to O_2-TEMP and press the ▼ key repeatedly until a display similar to the following appears:



Press ***CONFIRM.*** All of the information (DO, Temp, Date, Time, and ID #) from a single data point will scroll across the top of the LCD display. Use the arrow keys to review earlier or later data points.

Caution: Pressing the ***CONFIRM*** key a second time (while data is scrolling across the display) will begin the DELETE function! Pressing the ***CONFIRM*** key a third time will delete the record being reviewed.

The Delete function is useful if you want to edit what has been stored in memory, or if you want to free up some memory space without erasing the entire memory.

To cancel Review Mode at any time, press the ***SKIP*** key twice.

VII.B. Printing Data from Memory

To send all data from the YSI Model 59 memory to a serial printer, attach the RS232 Cable (supplied) to the Model 59 and your printer. With the function switch set to O2-TEMP press the ▼ key repeatedly until a display similar to the following appears:

```
7.0 mg/L 23.4C
Print Data?
```

Press the ***CONFIRM*** key. All of the data currently stored in the Model 59 memory will be sent to your printer.

Note: There is no way to send individual records from memory. All data from memory will be sent in batch to the printer every time the "Print Data" command is confirmed.

VII.C. Sending Recorded Data to a Personal Computer

To send data from the Model 59 memory to a personal computer (PC), run a communications program such as ProComm™, CROSSTALK™, or PC Talk™, and enter terminal mode. (See section IX). Connect the RS232 cable (supplied) to the Model 59 and your PC. With the function switch set to O2-TEMP press the ▼ key repeatedly until a display similar to the following appears:

```
7.0 mg/L 23.4C
Print Data?
```

Note: Be sure that the baud rate of the 59 and the communication program on your PC are the same. (See section VIII.C.)

Press the ***CONFIRM*** key. All of the data currently stored in the Model 59 memory will be sent to your PC.

Note: There is no way to send individual records from memory. All data from memory will be sent in batch to the PC every time the "Print Data" command is confirmed.

VII.D. Erasing the Model 59 Memory

To erase the entire memory of the Model 59, set the function switch to O_2-TEMP and press the ◄▬► key until a display similar to the following appears:

```
7.0 mg/L 23.4C
Erase Memory?
```

Caution: All data stored in memory will be lost forever!

Press ***CONFIRM*** while the above display is visible. A display similar to the following will appear:

```
Erase Data? No
```

If you do **not**wish to erase all of the Model 59 memory, press confirm now. If you **do** want to erase all of the Model 59 memory, press the ◄▬► key. A display similar to the following will appear:

```
Erase Data? Yes
```

Press confirm while this display is visible to erase all of the Model 59 memory.The message "Erasing Memory" will flash across the display. The memory of the Model 59 is now free to record up to 50 new data points.

Press ***SKIP*** to return to non-memory operation of the Model 59.

VII.E. Using a Bar Code Reader with Memory

The bar code reader can also be used to input readings into the Model 59 memory. Enter memory operation of the Model 59 as described at the beginning of section VII. Use the bar code reader to swipe a bar code label. The instrument will beep and the label ID and current DO and temperature information will be displayed. Press ***CONFIRM*** to store the data in memory.

Note: Any data stored **without** the use of the bar code reader will have an ID number which begins with **R.** Any data stored using the bar code reader will have an ID number which begins with **B.**

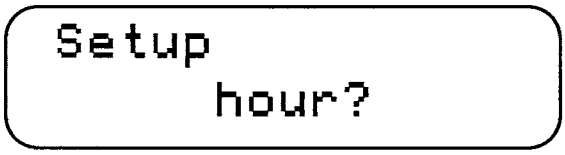
VIII. SYSTEM SETUP

VIII.A.Setting the Time and Date

It is especially important to assure that the date and time have been correctly set when using a PC or the Model 59 memory to record readings. When using either of these features the Model 59 will also record the date and time of each reading.

Set the function switch to SYSTEM SETUP. The first display will read:

Press ***CONFIRM***. The display will show



You may use ***SKIP*** to go on to the next choice, or press ***CONFIRM*** to change the hour. If you pressed ***CONFIRM***, the display would show the present clock hour. Use ▲ and ▼ to change the hour, and press ***CONFIRM*** to enter it.

Proceed exactly as you did for setting the hour to set the minute, seconds, year, month, date and day of week.

VIII.B. Setting Up Autostable

When using the autostable feature, the Model 59 indicates that all O2-TEMP readings are stable by displaying an * to the left of the time. The Model 59 uses criteria that you input, to determine what a stable reading is. You select the maximum % of change which you allow to occur during a selected number of readings. Once these two variables are defined (% change & # of readings), the Model 59 will display an * **only** when your criteria are met.

To set the autostable criteria, set the function switch to ***SYSTEM SETUP.*** Press the ***SKIP*** button repeatedly until the following display appears:

```
Setup
autostable?
```

Press the ***CONFIRM*** button. The following display will appear:

```
Setup
autostbl on/off
```

Press the ***CONFIRM*** button. The following display will appear:

```
Setup
autostbl = off
```

Use either arrow key to select ON, then press ***CONFIRM.*** The following display will appear:

```
Setup
change in %?
```

Press ***CONFIRM.*** A display similar to the following will appear:

```
Setup
change in %= 0.4
```

Use the arrow keys to select the desired autostable % (the smaller the %, the more accurate your reading and the more time it will take to achieve). Press ***CONFIRM.*** The following display will appear:

```
Setup
# of rdgs?
```

Press ***CONFIRM.*** The following display will appear:

```
Setup
# of rdgs = 5
```

Use the arrow keys to select the # of readings which must pass while complying with the % change entered previously. (The larger the #, the greater the accuracy and the longer it will take.)

VIII.C. Setting Communication Parameters

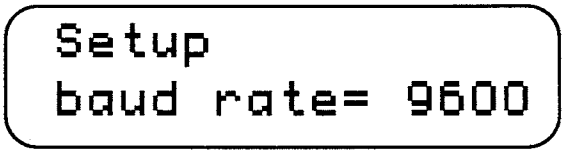
The Model 59 will default to communications values which are appropirate for most printers and personal computers. The defaults are Baud rate: 9600; parity = none; word length = 8; and stop bits = 1. We recommend that you try these default settings before attempting to change them. If you must change communication parameters on the Model 59, do so before using the RS232 port. Before beginning this sequence you must know the baud rate, word length, number of stop bits, and parity of the PC in use. To find this information, consult the documentation which accompanies your printer or PC. The Model 59 supports all common variations of these parameters.

To change a communication parameter, turn the function switch to SYSTEM SETUP. Press ***SKIP*** repeatedly until the following display appears:

```
Setup
 communication?
```

Press ***CONFIRM*** to select communications setup. The following display will appear:

Use ***SKIP*** to go on to the next choice, or press ***CONFIRM*** to change the baud rate. If you pressed ***CONFIRM***, you would see:



Use ▲ to increase the baud rate and ▼ to decrease it. The Model 59 supports 110, 300, 1200, 2400, 4800, and 9600 baud and defaults to 9600. When you have selected the correct baud rate, press ***CONFIRM*** to enter the value. The following display will appear:

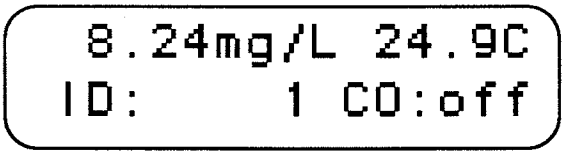
Proceed exactly as you did for baud rate to set word length (7 or 8), then parity (odd, even or none), then stop bits (0, 1, or 2).

IX. PERSONAL COMPUTER INTERFACE

The RS232 port allows you to connect your Model 59 meter directly to an IBM compatible personal computer (PC). Your PC can then gather, store and analyze the dissolved oxygen data generated by the meter. The system includes an RS232 cable and an adapter for either 9 pin or 25 pin communication ports. We recommend that you use a commercially available communication software product to interface the Model 59 to your PC. Some of the products that will work are CROSSTALK™, ProComm™, and PC Talk™.

An example of this easy-to-use feature can be seen by explaining how to use one of the commercially available communications software packages. To use ProComm, run the software package and enter the terminal mode. Press Alt-F1 to open a log file. A prompt on the computer screen will ask you to define the directory and file name to which you will send readings from the Model 59. Press enter, then switch the Model 59 to external control. A new reading will scroll to the screen approxiamtely once per second. To close a log file and save it as an ASCII file, press Alt-F1 again. This ASCII file can then be imported to a spreadsheet program such as Quattro Pro™ or Lotus 123™.

Set the communications parameters required by your PC (see System Setup), then switch to EXTERNAL CONTROL. The default display is



The top line shows the current dissolved oxygen reading in mg/L. The bottom line displays an identification number and the status of the communication port. The identification number increases by one with each dissolved oxygen reading. Each reading is sent to the PC (about 1 reading a second) as a line of ASCII characters. An excerpt from a file of readings would look something like this:

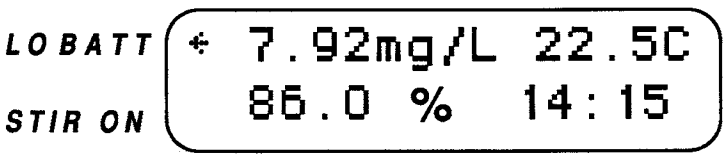
ID: 64 7.62 mg/L 83.9 % 20.0 C S= 0.0 03/19/90 02:06
ID: 65 7.62 mg/L 83.9 % 20.0 C S= 0.0 03/19/90 02:06
ID: 66 7.62 mg/L 83.9 % 20.0 C S= 0.0 03/19/90 02:06
ID: 67 7.62 mg/L 83.9 % 20.0 C S= 0.0 03/19/90 02:07
ID: 68 7.62...

IX.A. Writing Your Own Applications Software

For specific applications, you may design your own software. All functions of the Model 59 can be put under software control: calibration, salinity setting, display, keys, and even the beeper. Contact YSI Water Quality Systems Technical Support for more information.

X.A. Batteries

Low batteries are indicated in the display by an arrow pointing to LO BATT, as shown here



When this happens, replace the batteries with 6 fresh alkaline batteries as soon as possible. Remove the 4 case screws from the back of the meter and carefully lift the back cover away from the rest of the meter. The battery pack is attached to the back cover. Insert three fresh alkaline batteries into each tube. Always observe the correct polarity while installing new batteries.

Should you accidentally pull the case halves too far apart, an in-line connector will unplug, preventing any damage. If this happens, rejoin the connectors. (You cannot do it wrong.) Before closing the case be sure that the connector is seated in the clip attached to the side of the battery pack. This will help keep the wires out of the way and prevent interference with the circuit boards.

Before rejoining the case halves, be sure the O-ring gasket is properly seated in its groove on the front case half. It must be evenly distributed along the perimeter without any kinks. With the O-ring properly seated in the front half of the case, replace the back half and install the four screws.

X.B. Power On Self Testing and Error Display Messages

The instrument will perform a Power On Self Test each time it is turned on. The following error codes are provided to facilitate troubleshooting. The E.0 through E.1 Error Modes could be displayed at any time if a system error is detected. The E.2 through E.4 messages can be displayed only during calibration.

CODE	ERROR	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 Temp probe	Connector improperly installed	Check connection
		Intermittent connection in cable or plug	Repair or replace
		Faulty temperature sensor	Repair or replace
E .2	High background	Insufficient warm-up time	See Preparation for Use
		Incorrect probe zeroing procedure	See Zero Calibration
		Probe needs servicing	See probe instructions
		Probe malfunction	Repair or replace
E .3	Low sensitivity	Insufficient electrolyte	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 cable connector	Repair or replace
M.XX	Incorrect Mode (x may be any digit or any letter	Switch or circuit defect	Return for service

XI. DISCUSSION OF MEASUREMENT ERRORS

The major sources of error in DO measurement are the accuracy of the instrument components, the accuracy of the probe, and the user's ability to calibrate the system precisely. Most errors can be reduced substantially by calibrating at DO levels and probe temperatures as close as possible to the expected measurement DO levels and temperatures.

In the following, individual sources of error and their ranges are listed. By calculating the root-mean-squared sum of these individual uncertainties (usually less than half the possible error), the user can estimate the probable error in any reading.

Note that not all types of errors discussed are necessarily present in a given situation. If salinity compensation is not used, for example, no salinity compensation error need be considered. If calibration is to a Winkler Titration sample, calibration errors are replaced by the Winkler uncertainty.

XI.A. Type 1 Errors: Instrument Components

a. Instrument accuracy: ±0.1% plus 1 least significant digit.

XI.B. Type 2 Errors: Probe Accuracy

a. Probe background current error:
background factor x (1 - **a/b)c**

where **a** is the calibration value, **b** is the solubility of oxygen in fresh water at 760 mm Hg and at measurement temperature, and **c** is the measured DO value

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

Use the following table to determine the background factor:

probe temp. in ℃	background factor (%)
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 variation from nominal response to sample temperature is ±0.2% of the DO reading per degree C of the temperature difference between the temperature of the sample and the temperature at which the probe was calibrated.

XI.C. Type 3 Errors: Calibration

a. Sample temperature uncertainty error: ±1% of reading

This error is zero when calibrating in the % air saturation mode or when calibrating to a Winkler titration sample.

b. Error due to barometric pressure uncertainty of 13mm Hg: ±1.7% of reading

c. Error due to altitude estimation uncertainty of 500 ft: ±1.8% of reading

XI.D. Error Calculation Example

The example given presumes that air calibration is used. If the Winkler titration calibration method is used, type 3 errors are replaced by the uncertainty attributable to the overall Winkler determination. This example is for an extreme combination of conditions.

Calibration conditions:

method:	air calibration
temperature:	24℃
altitude:	600 feet
calibrated to:	8.24 mg/L

Measurement conditions:

temperature:	20℃
reading:	7.26 mg/L
mode:	mg/L

Calculation

TYPE	DESCRIPTION	CALCULATION	ERROR(mg/L)
1a	instrument accuracy	±0.001 x 8.24 + 0.01	±0.02
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	temp. compensation	±(24-20) x 0.002 x 7.26	±0.06
3a	temp. uncertainty	±0.01 x 7.26	±0.07
3b	pressure	±0.017 x 7.26	±0.12
3c	altitude	±0.018 x 7.26	±0.13

Probable error can be determined by an r.s.s. calculation:

r.s.s. error = $[.02^2 + .01^2 + .02^2 + .06^2 + .12^2 + .13^2]^{1/2} = \pm 0.19$ mg/L

XII. WARRANTY AND REPAIR

The YSI Model 59 Dissolved Oxygen Meter is warranted for two years against defects in material and workmanship, exclusive of batteries, from the date of purchase. All YSI dissolved oxygen probes are warranted for one year against defects in material and workmanship from date of purchase.

If you are experiencing difficulty with any YSI product, during or after the warranty period, contact the YSI dealer from whom you bought the product, YSI European Service Center, or YSI Product Service Department. If a YSI product is returned for service during the warranty period, supply proof of purchase with the product.

YSI Incorporated
Product Service Department
1725 Brannum Lane
Yellow Springs, Ohio 45387

Telephone 513 767-7241
800 765-9974
Fax 513 767-9353

YSI European Service Center
Lynchford House
Lynchford Lane
Farnborough, Hampshire
GU14 GLT, England

Telephone 44 252 514711
Fax 44 252 511855

REQUIRED NOTICE

The Federal Communications Commission defines this product as a computing device and requires the following notice.

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. There is no guarantee that interference will not occur in a particular installation. 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.

Appendix B

OXYGEN SOLUBILITY AND CALIBRATION TABLES

Table A: Solubility of Oxygen in mg/L in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure

Temp	Chlorinity:0	5.0	10.0	15.0	20.0	25.0
℃	Salinity:0	9.0	18.1	27.1	36.1	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

Appendix B

Table B: Calibration Values for Various Atmospheric Pressures and Altitudes

PRESSURE			ALTITUDE		CALIBRATION
inches 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