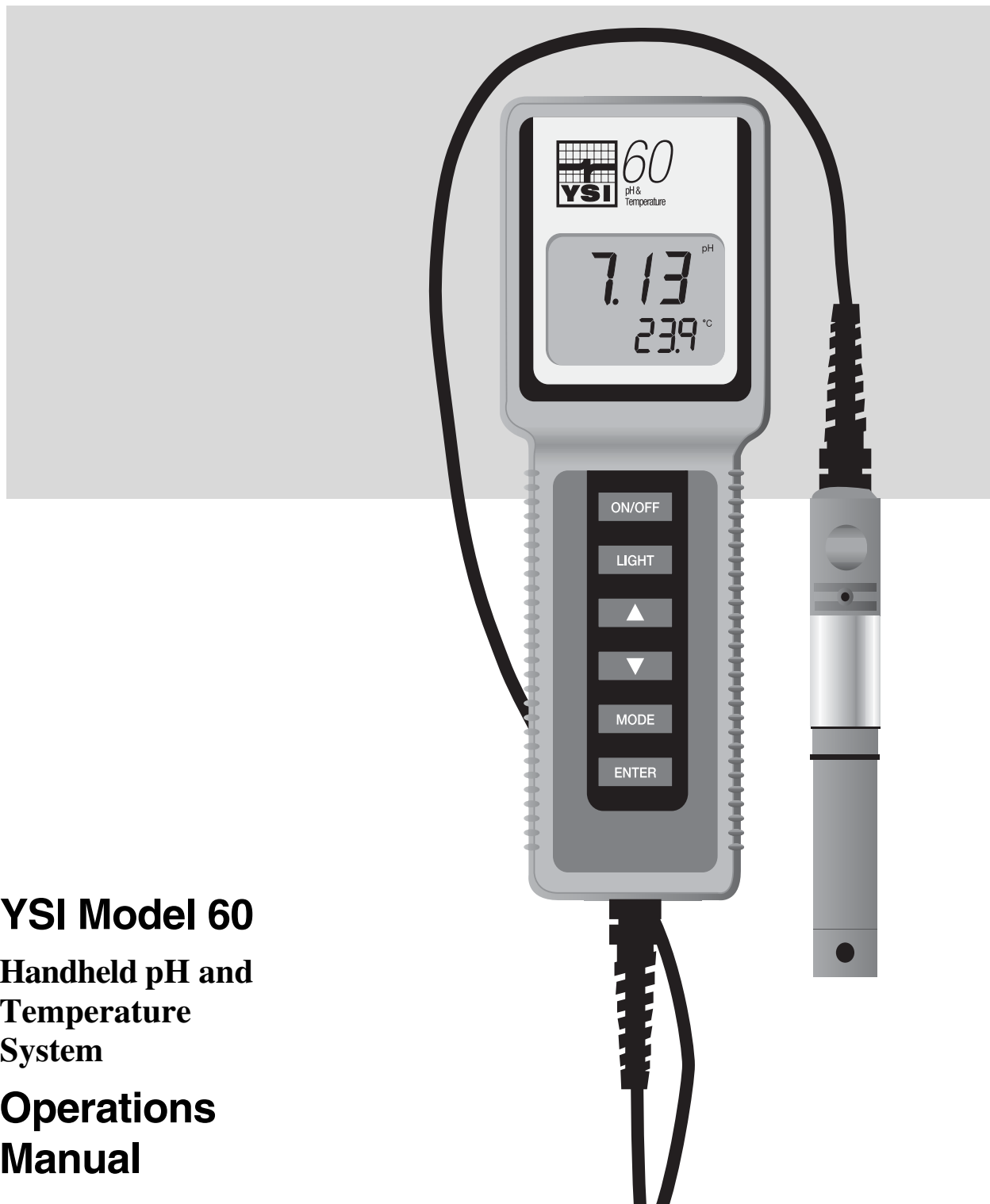




YSI incorporated



YSI Model 60
Handheld pH and
Temperature
System
Operations
Manual

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1. Introduction

The YSI Model 60 Handheld pH/Temperature System is a rugged, micro-processor based, digital meter with an attached pH and temperature probe. The pH sensor can be easily replaced in the field.

The Model 60 has a non-detachable cable available in lengths of 10, 25, 50 or 100 feet (3, 7.6, 15.2 or 30.5 meters). The probe body has been manufactured with stainless steel to add rugged durability and sinking weight.

The YSI Model 60 has the following features:

- Capability to measure at depths of up to 100 feet (30.5 meters)
- Microprocessor control
- Field replaceable low maintenance pH sensor
- Push-button calibration
- Simultaneous display of pH and temperature
- Automatic temperature compensation
- Data storage for 50 sets of readings with on screen recall
- Waterproof case (IP65)

The Model 60's micro-processor allows the system to be easily calibrated with the press of a few keys. Additionally, the micro-processor performs a self-diagnostic routine each time the instrument is turned on. The self-diagnostic routine provides useful information about the function of the instrument and probe.

A transport chamber, built into the instrument case, provides a convenient place to store the probe when transporting the system. The Model 60 case is waterproof (rated to IP65) allowing operation in the rain without damage to the instrument.

The Model 60 is powered by six AA-size alkaline batteries. A new set of alkaline batteries will provide approximately 100 hours of continuous operation. When batteries need to be replaced, the LCD will display a **“LO BAT”** message.

The YSI Model 60 is designed for use in environmental, aquaculture, and industrial applications where accurate pH and temperature measurements are desired.

2. Preparing the Meter

2.1 Unpacking

When you unpack your new YSI Model 60 Handheld pH and Temperature System for the first time, check the packing list to make sure you have received everything you should have. If there is anything missing or damaged, call the dealer from whom you purchased the system. If you do not know which of our authorized dealers sold the system to you, call YSI Customer Service at 800-765-4974 or 937-767-7241, and we'll be happy to help you.

2.2 Warranty Card

Please complete the Warranty Card and return it to YSI. This will record your purchase of this instrument in our computer system. Once your purchase is recorded, you will receive prompt, efficient service in the event any part of your YSI Model 60 should ever need repair.

2.3 Batteries

There are a few things you must do to prepare your YSI Model 60 for use. First, locate the six AA-size alkaline batteries and the battery cover kit which were included. Then locate the markings inside each of the two battery-chamber sleeves that illustrate the correct way to install the batteries. Install the batteries as shown.

NOTE: It is very important that the batteries be installed ONLY as illustrated. The instrument will not function and may be damaged if the batteries are installed incorrectly.

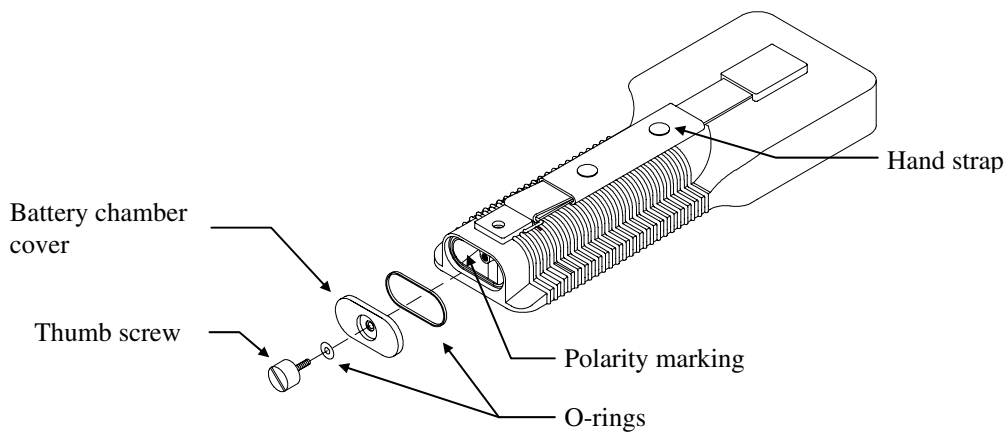


Figure 1

Attach the battery chamber cover to bottom of the instrument using the thumb screw as shown in Figure 1. Make sure that the o-rings are in place. The battery-chamber cover is marked with the words "OPEN" and "CLOSE."

Turn the instrument on by pressing and releasing the **ON/OFF** key on the front of the instrument. The liquid crystal display (LCD) should come on. Allow a few seconds for the instrument to complete its diagnostic routine. If the instrument does not operate, consult the chapter entitled *Troubleshooting*.

You may also want to take the instrument into a dark location and, with the instrument ON, hold down the **LIGHT** key. The instrument back-light should illuminate the LCD so that the display can be easily read.

2.4 Transport Chamber

The Model 60 has a convenient transport chamber built into the instrument's side. This chamber provides a storage area and protection for the pH sensor while transporting the system in the field. Insert the round sponge (provided with the Model 60) into the bottom of the chamber. Put 6-8 drops of tap water into the sponge. The wet sponge creates a humid environment for the pH sensor to prevent it from drying out during transport in the field (up to one week). The transport chamber is NOT intended for long term storage of the pH sensor. See 5.3 *pH Sensor Storage*.

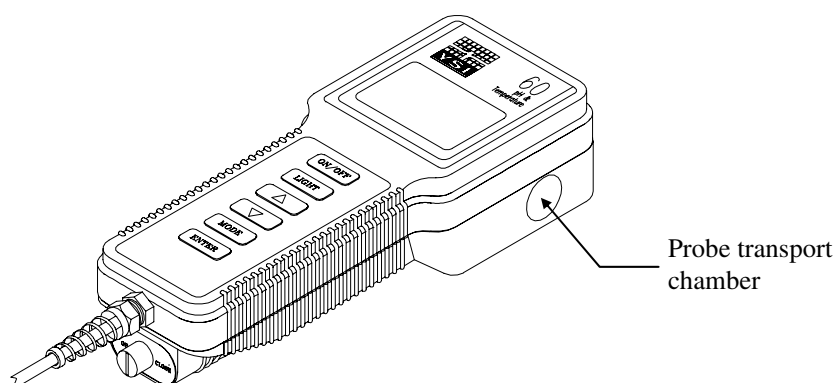


Figure 2

2.5 Hand Strap

The hand strap (see *Figure 1* on previous page) is designed to allow comfortable operation of the Model 60 with minimum effort. If the hand strap is adjusted correctly, it is unlikely that the instrument will be easily dropped or bumped from your hand.

To adjust the hand strap on the back of the meter, unsnap the vinyl cover and pull the two Velcro strips apart. Place your hand between the meter and the strap and adjust the strap length so that your hand is snugly held in place. Press the two Velcro strips back together and snap the vinyl cover back into place.

2.6 The Meter Case

The meter case is sealed at the factory and is not intended to be opened, except by authorized service technicians. **Do not attempt to separate the two halves of the meter case as this may damage the instrument, break the water-resistant seal and may void the manufacturer's warranty.**

2.7 Calibration Vessels

A plastic 100 mL graduated cylinder and a plastic container are provided with the Model 60. The graduated cylinder provides a convenient place to calibrate the pH sensor minimizing the amount of solution needed. The plastic container should be filled with distilled water and used as a rinse vessel while in the field. See section 4.2 *Calibration* for details.

3. Preparing the Probe

The YSI Model 60 is shipped without the pH sensor installed. The pH sensor must be installed before using the system (see section 3.1 *Installing the Sensor*, below). The sensor is shipped with a protective bottle filled with a mixture of pH 4 buffer and KCl solution. Do not remove the bottle until you are ready to use the instrument. Save the bottle for long term storage of the probe.

3.1 *Installing the Sensor*

A pH sensor is included with the Model 60. Install the pH sensor as follows:

1. Remove the sensor from its protective packing.
2. Insert the pH sensor into the probe body (be sure to align the tabs on the sensor with the slots in the probe body) and twist 1/4 turn to lock in place. See *Figure 3*.

NOTE: Once installed, leave the pH sensor attached to the probe until replacement is needed.

3. Carefully remove the protective bottle (containing pH 4 buffer/KCl solution) from the sensor. Save the bottle and solution for long term (over one week) storage of the sensor. Seal the storage bottle with the cap provided.
4. Rinse the sensor tip with distilled or deionized water.
5. **Calibrate the system before use.** See section 4.2 *Calibration*.

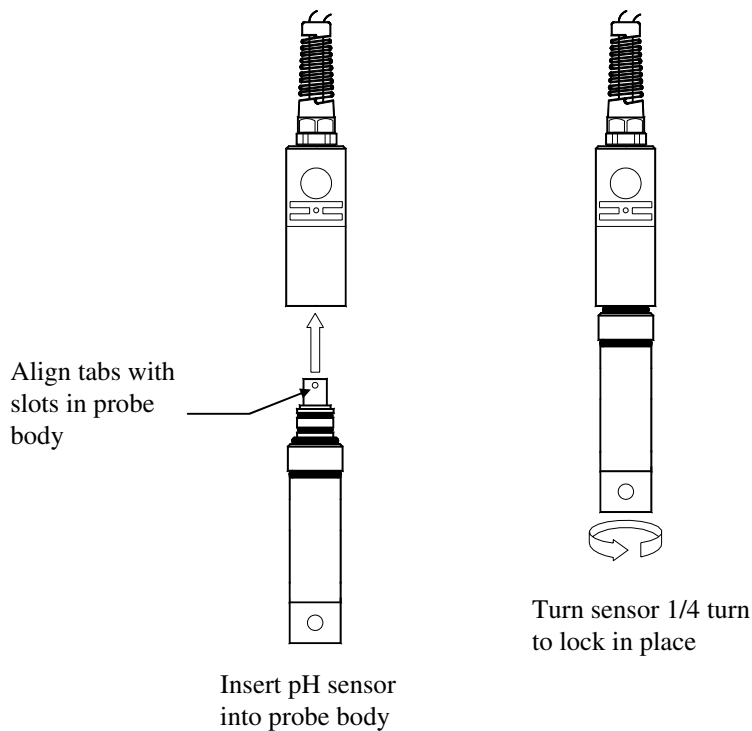


Figure 3

4. Operation

The following diagram is an overview of the operation of the Model 60. See the following sections for details of operation.

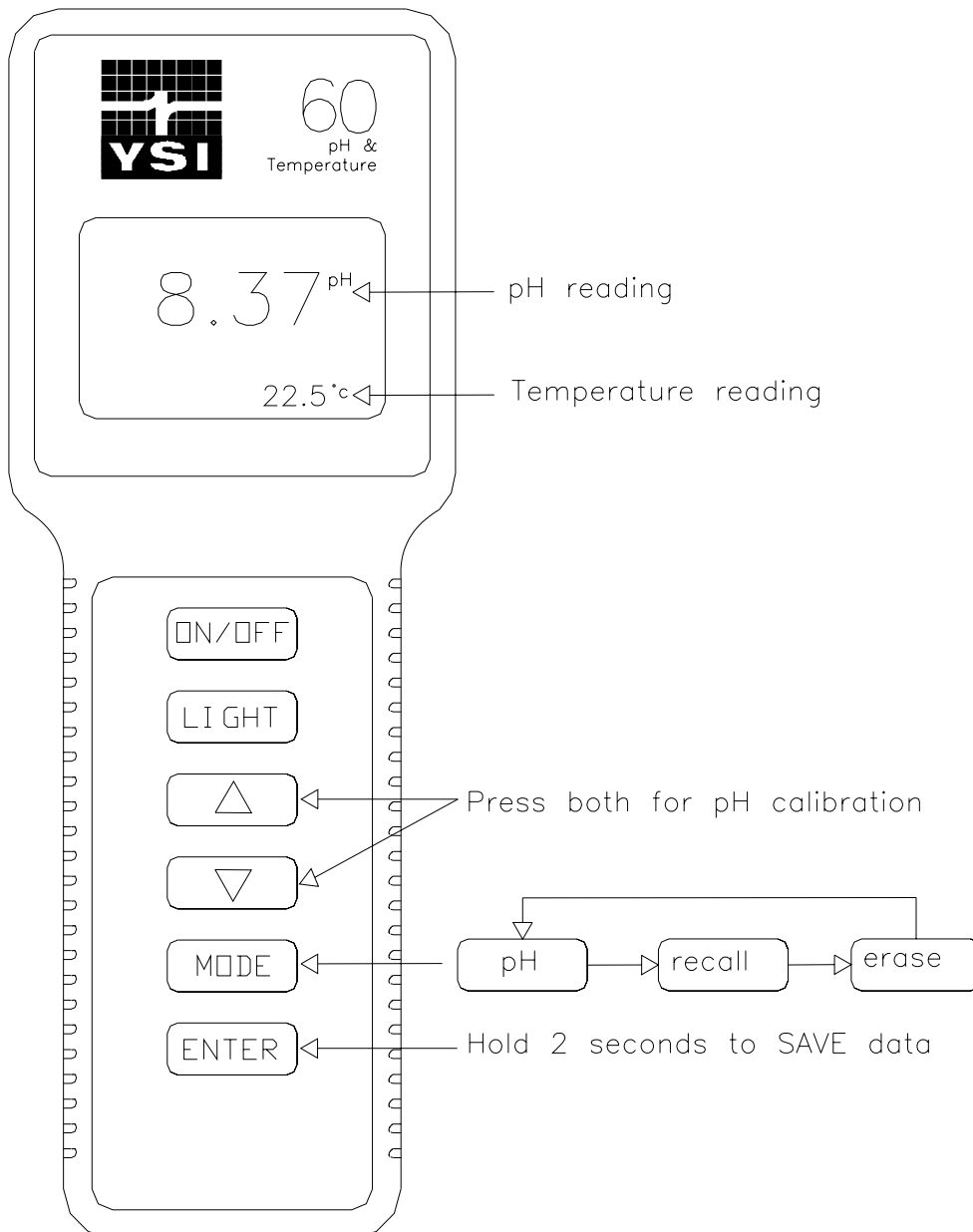
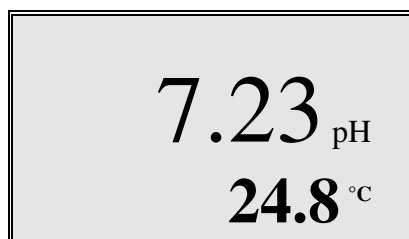


Figure 4

4.1 Turning The Instrument On

With the batteries installed correctly, press the **ON/OFF** key. The instrument will activate all segments of the display for a few seconds, which will be followed by a self test procedure which will last for several more seconds. During this power on self test sequence, the instrument's microprocessor is verifying that the system is working properly. If the instrument were to detect a problem, a **continuous** error message would be displayed. See the chapter entitled *Troubleshooting* for a list of error messages.



4.2 Calibration

The YSI Model 60 **MUST** be calibrated before making pH measurements. Calibration may be performed at 1, 2 or 3-points (at pH 7, 4 and 10, or at pH 6.86, 4.01 and 9.18). Perform a 1-point calibration (at pH 7 or at pH 6.86) **ONLY** if a previous 2 or 3-point calibration has been performed recently. In most cases, a 2-point pH calibration will be sufficient for accurate pH measurements, but if the general range of pH in the sample is not known, a 3-point calibration may be necessary. 3-point calibration assures accurate pH readings regardless of the pH value of the sample. See *Section 8.1 pH* for more details.

WARNING: Calibration reagents may be hazardous to your health. Refer to *Appendix B - Health and Safety* for more information.

Before calibrating the YSI Model 60, complete the procedures discussed in the *Preparing the Meter* and *Preparing the Probe* chapters of this manual.

The user can choose from two sets of pH buffer values for 3-point calibration. The first set consists of the standard YSI pH buffer values of pH 7 (YSI 3822), pH 4 (YSI 3821) and pH 10 (YSI 3823). The second set available is the NIST pH 6.86, 4.01 and 9.18. **Note that the first calibration point must be either pH 7 or pH 6.86.** Calibration is performed as follows:

1. Turn the instrument on by pressing the **ON/OFF** key. If the instrument was already on, press the **MODE** key until pH is displayed.
2. Rinse the probe with deionized or distilled water, then carefully dry the probe (or rinse it with some of the pH buffer solution to be used for calibration).
3. Place 30 to 35 mL of the pH buffer you have chosen to calibrate the system with (pH 7 or 6.86) in the 100 mL graduated cylinder (provided with the Model 60). The graduated cylinder minimizes the amount of solution needed. Immerse the probe making sure that both the pH and temperature sensors are covered by the solution (see *Figure 5* on the following page).

For best results:

- Calibrate as close as possible to the sample temperature.
- After storage in pH 4 buffer/KCl solution, place the pH sensor in pH 7 (6.86) buffer and allow to acclimate before calibrating (5 to 10 minutes).
- Always give the pH and temperature sensors enough time to equilibrate with the temperature of the buffer.

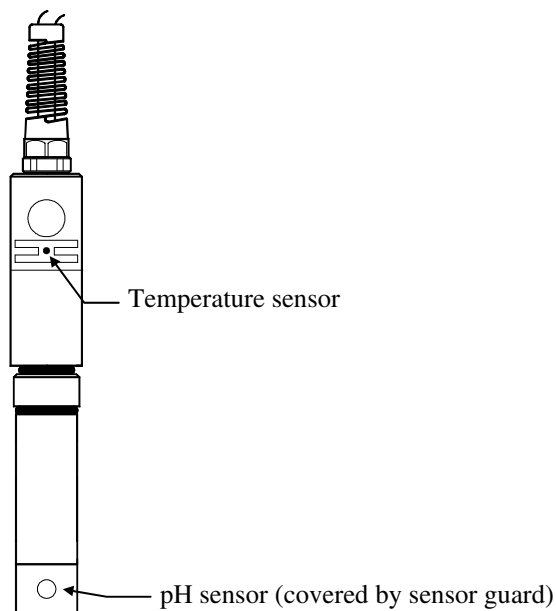
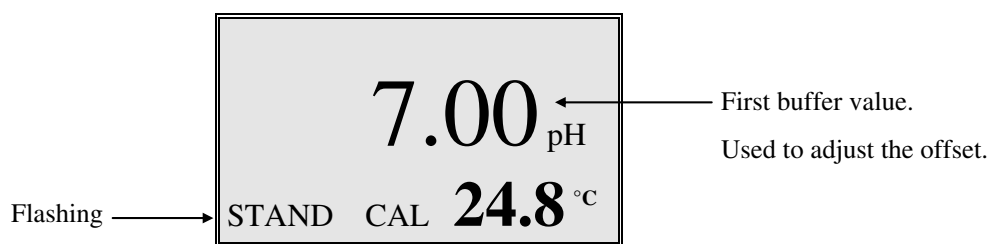


Figure 5

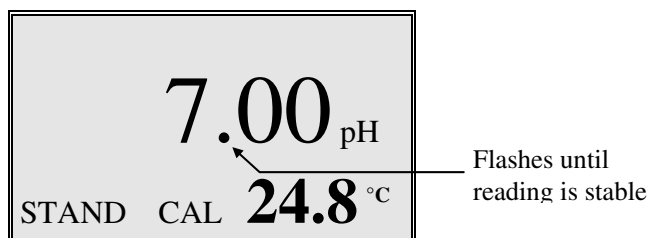
4. To enter the calibration menu, use two fingers to press and release both the **UP ARROW** and **DOWN ARROW** keys at the same time. The Model 60 display will show **CAL** at the bottom, **STAND** will be flashing and the main display will show **7.00** (the buffer to be used to adjust the offset).



NOTE: If you will be calibrating with pH buffers of 6.86, 4.01 and 9.18 (instead of 7, 4 and 10), press both the **UP ARROW** and **DOWN ARROW** keys again. The display will change to **6.86**.

NOTE: The Model 60 automatically accounts for the fact that the true pH of the buffers changes with temperature, therefore, the pH values displayed during calibration will vary with temperature. For example, pH 7 buffer at 20°C (rather than 25°C) has an actual pH of 7.02 and this number (rather than 7.00) will appear on the display when the probe is placed in the solution. See *Appendix C - pH Buffer Values*.

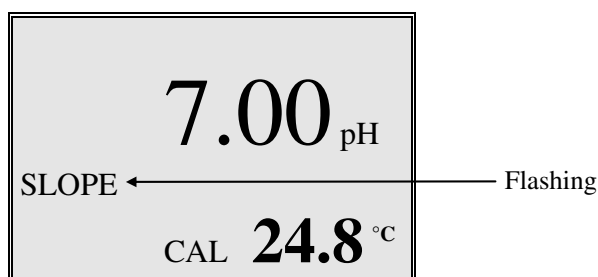
5. Press the **ENTER** key. The Model 60 display will show **CAL** at the bottom, **STAND** will stop flashing and the pH calibration value is shown with the middle decimal point flashing.



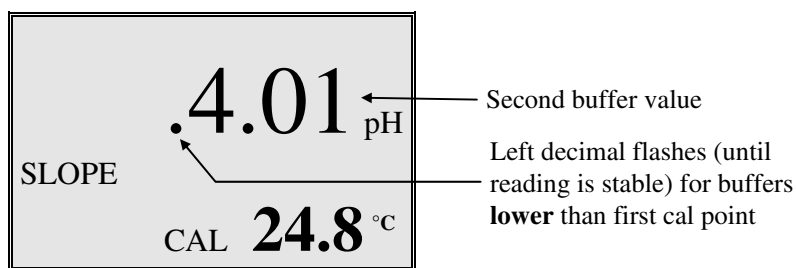
6. When the reading is stable (does not change by 0.01 pH in 10 seconds), the decimal point will stop flashing. Press and hold the **ENTER** key to save the calibration point. The Model 60 will flash **SAVE** on the display along with **OFS** to indicate that the offset value has been saved.



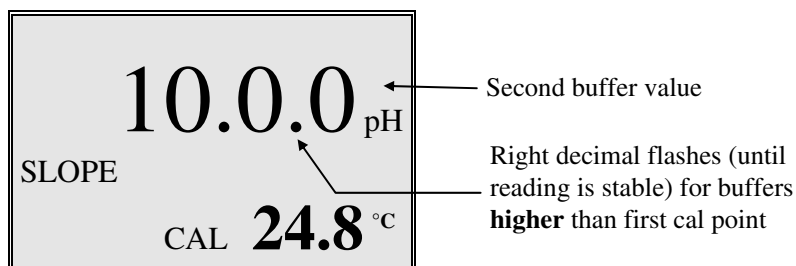
7. **SLOPE** will now appear on the display and be flashing. This indicates that the slope is ready to be set using a second pH buffer. The system is now calibrated at a single point. If you are only performing a single point calibration, press the **MODE** key to return to normal operation.



8. Rinse the probe with deionized or distilled water, then carefully dry the probe.
STOP HERE IF PERFORMING A 1-POINT CALIBRATION.
9. If you are performing a 2-point or 3-point calibration, fill a clean container with the second value pH buffer (pH 4 or 10, or pH 4.01 or 9.18) and immerse the probe into the solution. Make sure that the temperature sensor is immersed.
10. Press the **ENTER** key. The Model 60 display should now show **CAL** at the bottom, **SLOPE** will stop flashing and the pH calibration value (automatically sensed by the instrument) is shown with one of the decimal points flashing.



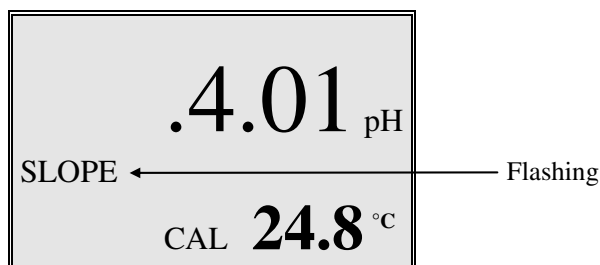
If the second pH buffer is less than the first buffer (which was used to adjust the offset; pH 7 or pH 6.86), the left decimal point will flash as shown above. If the second pH buffer is greater than the first, the right decimal point will flash as shown below.



11. When the reading is stable (does not change by 0.01 pH in 10 seconds), the decimal point will stop flashing. Press and hold the **ENTER** key to save the first SLOPE. The Model 60 will flash **SAVE** on the display along with **SLP** to indicate that the first slope value has been saved.



12. **SLOPE** will start flashing again indicating that the slope is ready to be set using a third pH buffer.



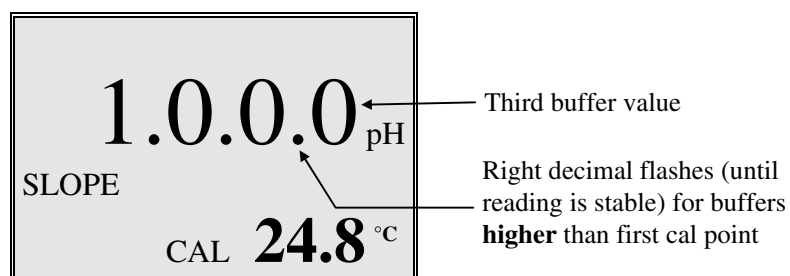
13. The system is now calibrated at two points. If you are only performing a two point calibration, press the **MODE** key to return to normal operation.
14. Rinse the probe with deionized or distilled water, then carefully dry the probe.

STOP HERE IF PERFORMING A 2-POINT CALIBRATION.

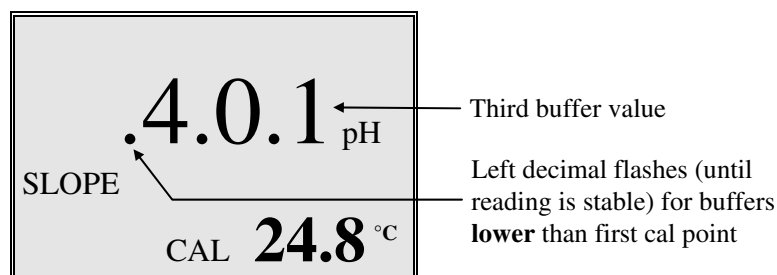
15. If you are performing a 3-point calibration, fill a clean container with the third value pH buffer (pH 4 or 10, or pH 4.01 or 9.18) and immerse the probe into the solution. Make sure that the temperature sensor is immersed.

NOTE: The third buffer must not be the same as the second buffer. For example; if the second buffer was less than pH 7, the third buffer must be greater than pH 7.

16. Press the **ENTER** key. The Model 60 display will now show **CAL** at the bottom, **SLOPE** will stop flashing and the pH calibration value (automatically sensed by the instrument) is shown with one of the decimal points flashing. If the third pH buffer is less than the first buffer (which was used to adjust the offset; usually pH 7), the left decimal point will flash. If the third pH buffer is greater than the first, the right decimal point will flash.



or



17. When the reading is stable (does not change by 0.01 pH in 10 seconds), the decimal point will stop flashing. Press and hold the **ENTER** key to save the second SLOPE. The Model 60 will flash **SAVE** on the display along with **SLP** to indicate that the second slope value has been saved.



The system is now calibrated at three points and will return to normal operation.

18. Rinse the probe with deionized or distilled water.

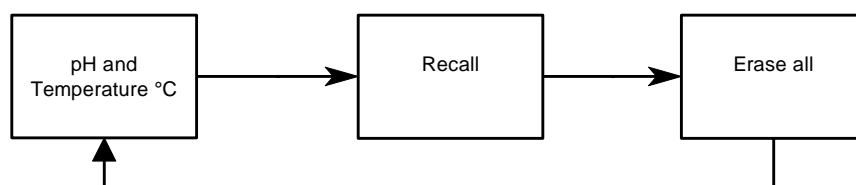
4.3 Making Measurements

After the system has been set-up and pH has been calibrated as described in 4.2 *Calibration*, it is ready to make measurements. Simply insert the probe into the sample, shake gently to remove any trapped air bubbles and wait for the readings to stabilize (approximately 60 seconds). The first reading after storage in buffers may take longer to stabilize (5 to 10 minutes), therefore, the probe should be stored in the transport chamber when making field measurements. It is important that the probe be inserted into the sample far enough so that both the pH sensor and temperature sensor are covered by the liquid (see *Figure 5* on page 7).

The Model 60 has three modes:

- **pH** -- Displays pH and temperature (°C)
- **Recall** -- Allows previously stored data to be displayed.
- **Erase all** -- Allows ALL previously stored data to be deleted.

To change between the Model 60 modes, simply press and release the **MODE** key. The Model 60 will cycle through the modes as follows:



NOTE: When the Model 60 is first turned on, it is in the pH mode.

4.4 Saving Data

The Model 60 is equipped with non-volatile memory that is capable of storing up to 50 different sets of readings. Non-volatile means that you do not need to worry that your data will be lost due to a power failure or interruption, such as when the batteries are removed. Each set consists of pH and temperature. The Model 60 will also assign a site identity number to each set of readings to allow easy review of the data. This feature is useful in situations where transcribing data is difficult or not available.



While pH is displayed on the screen, press the **ENTER** key and hold it for approximately 2 seconds. The meter will flash **SAVE** on the display along with the current site identity (1 through 50) being used.

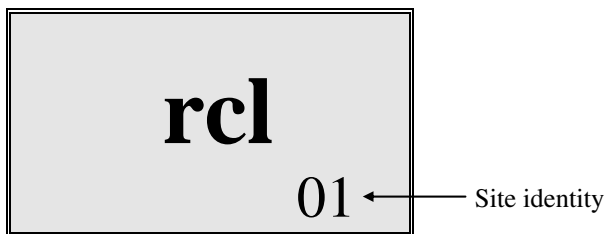
When all 50 sites are full, the display will flash **FULL** on the screen. This message will remain on the screen (even after power down) until a key is pushed.



Once you have acknowledged the memory is full, any subsequent saved data will begin overwriting existing data starting with site #1. No additional warning will be displayed.

4.5 Recalling Stored Data

1. To put the Model 60 into the **RECALL** mode, press the **MODE** key until “**rcl**” is displayed on the screen along with the site ID number in the lower right corner.



2. Press the **ENTER** key to review the last set of data that was saved. The Model 60 will display the pH and temperature.
3. Press the **UP ARROW** key to move up through the saved sets of data.
4. Press the **DOWN ARROW** key to move down through the saved sets of data.
5. When the correct Site ID# is displayed, press the **ENTER** key to display the data.
6. When you have finished recalling data, press **MODE** two times to return to normal operation.

NOTE: The Model 60 will recall data as a list. When the **UP ARROW** is pressed the Model 60 will display the Site ID# for the previously recorded data. For example: If you are reviewing Site ID# 5 and the **UP ARROW** is pressed, the Model 60 will display Site ID#4. If you are reviewing Site ID# 5 and Site ID# 5 was the last set of data stored, the **DOWN ARROW** key will display Site ID# 1.

Here is an example of the Model 60 memory.

Site ID #1
Site ID #2
Site ID #3 ←If the **UP ARROW** key was pressed the Model 60 would display Site ID #2
Site ID #4
Site ID #5

4.6 Erasing Stored Data

1. To erase the data that is stored in the Model 60's memory, press the **MODE** key until the Model 60 displays **ErAS** on the screen.
2. Press and hold the **DOWN ARROW** and **ENTER** keys simultaneously for approximately 5 seconds.



3. Successful erasure is indicated by the Model 60 displaying **DONE** on the display for 1 to 2 seconds.



The instrument will automatically change to normal operation after completion and the next saved data will be stored in site ID# 1.

IMPORTANT: Data in all 50 site ID's will be erased completely and will be lost forever. Do not use the erase function until all recorded data has been transcribed to an archive outside the Model 60.

4.7 Display Backlight

At times it may be necessary to take measurements with the Model 60 in dark or poorly lit areas. To help in this situation, the Model 60 comes equipped with a backlight which will illuminate the display so that it can be easily read. To activate the backlight, press and hold the **LIGHT** key. The display will remain lit as long as the key is pressed. When you release it, the light goes out to preserve battery life.

5. Maintenance of the pH Sensor

5.1 *pH Sensor Precautions*

1. When making measurements or performing the calibration procedure, make certain that the level of sample or pH buffer is high enough to cover both the pH and temperature sensors.
2. Rinse the probe with deionized water between changes of calibration buffer solutions.
3. During pH calibration, allow the sensors time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration protocol. The pH readings after calibration are only as good as the calibration itself.
4. Clean and store the probe according to the instructions found below.

5.2 *pH Sensor Cleaning*

Cleaning is required whenever deposits or contaminants appear on the glass pH sensor. Unscrew and remove the small guard that protects the pH sensor. Use tap water and a clean cloth or lens cleaning tissue to remove all foreign material from the glass sensor.

If good pH response is not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 10 to 15 minutes in clean water containing a few drops of commercial dishwashing liquid.
2. GENTLY clean the glass bulb by rubbing with a cotton swab soaked in the cleaning solution.
3. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then rerinse with clean water.

If good pH response is still not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 15 to 30 seconds in one molar (1 M) hydrochloric acid (HCl).
2. GENTLY clean the glass bulb by rubbing with a cotton swab soaked in the acid.
3. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then rerinse with clean water.
4. Reinstall the small guard that protects the pH sensor.

If biological contamination of the reference junction is suspected or if good response is not restored by the above procedures, perform the following additional cleaning step:

1. Soak the probe for approximately 1 hour in a 1 to 1 dilution of commercially-available chlorine bleach.
2. Rinse the probe with clean water and then soak for 1 hour in clean water to remove residual bleach from the junction.

5.3 pH Sensor Storage

For short term storage between measurements in the field (up to one week), place the probe in the transport chamber in the side of the instrument case. Make sure that the sponge inside the chamber is wet (tap water).

For long term storage (over one week), place the probe in the storage bottle (provided) containing a mixture of 50% pH 4 buffer and 50% 1.5M KCl. This will assure the fastest possible pH response. If this mixture is not available, storage in tap water is the next best choice. **Do NOT store the probe dry or in distilled or deionized water.**

NOTE: After storage in the pH 4/KCl solution described above, place the probe in the transport chamber in the side of the instrument case or soak the probe in pH 7 buffer for 5 to 10 minutes allowing it to acclimate before calibrating.

If the probe has been inadvertently left in air and the reference electrode junction has dried out, good function can usually be restored by soaking the probe in the pH 4/KCl solution described above.

6. Discussion of Measurement Errors

There are two basic types of pH errors. The first type are errors related to limitations of instrument design and tolerances of components. The second type are errors due to basic sensor accuracy tolerances, mainly background signal, linearity, and variations in temperature coefficient. It is unlikely that the actual error in any measurement will be the maximum possible error.

Errors

- Component and circuitry error: ± 0.03 pH
- pH error caused by sensor accuracy and temperature compensation:
 - ± 0.1 pH for measurements at 10°C from calibration temperature
 - ± 0.2 pH for measurements at 20°C from calibration temperature

7. Troubleshooting

Error Messages

The instrument performs a Power On Self Test each time it is turned on. The following error messages are provided to facilitate troubleshooting. They appear on the LCD when an error is detected.

Symptom	Possible Cause	Action
1. Instrument will not turn on	<ul style="list-style-type: none"> • Low battery voltage • Batteries installed wrong • Meter requires service 	<ul style="list-style-type: none"> • Replace batteries (pg 2) • Check battery polarity (pg 2) • Return system for service (pg 21)
16. Instrument "locks up"	<ul style="list-style-type: none"> • Instrument has received a shock • Batteries are low or damaged • System requires service 	<ul style="list-style-type: none"> • Remove battery lid, wait 15 seconds for reset, replace lid. (pg 2) • Replace batteries (pg 2) • Return system for service (pg 21)
16. Instrument will not calibrate due to unstable readings (decimal point keeps flashing)	<ul style="list-style-type: none"> • pH sensor is fouled • pH sensor is bad • System requires service 	<ul style="list-style-type: none"> • Clean pH sensor (pg 14) • Replace pH sensor (pg 4, 25) • Return system for service (pg 21)
16. pH readings are inaccurate	<ul style="list-style-type: none"> • pH buffers out of spec • Cal procedure not correct • Sample temperature is over 20°C from cal temperature • pH sensor is fouled or damaged • pH Sensor is bad • System requires service 	<ul style="list-style-type: none"> • Recalibrate with known good standards (pg 6) • Calibrate within $\pm 20^{\circ}\text{C}$ of sample temp ($\pm 10^{\circ}\text{C}$ for best results) • Clean pH sensor (pg 14) • Replace pH sensor (pg 4, 25) • Return system for service (pg 21)
16. LCD displays "LO BAT"	<ul style="list-style-type: none"> • Batteries are low or damaged 	<ul style="list-style-type: none"> • Replace batteries (pg 2)
16. Main Display reads "nOnE"	<ul style="list-style-type: none"> • During recall, no data is currently stored in memory. 	<ul style="list-style-type: none"> • Store data before attempting to recall (pg 11)
16. Main Display reads "OVER"	<ul style="list-style-type: none"> • When calibrating, pH level is over range allowed for the buffer value selected. • When measuring, pH level is > 14 	<ul style="list-style-type: none"> • Recalibrate with known good standards (pg 6) • Clean pH sensor (pg 14) • Replace pH sensor (pg 4, 25) • Return system for service (pg 21)
16. Main Display reads "undr"	<ul style="list-style-type: none"> • When calibrating, pH level is under range allowed for the buffer value selected. • When measuring, pH level is < 0 	<ul style="list-style-type: none"> • Recalibrate with known good standards (pg 6) • Clean pH sensor (pg 14) • Replace pH sensor (pg 4, 25) • Return system for service (pg 21)
16. Main Display reads "OVER" (Secondary display reads "ovr")	<ul style="list-style-type: none"> • Temperature reading is $> 75^{\circ}\text{C}$ 	<ul style="list-style-type: none"> • Measure samples at a temperature within the range of the system.
16. Main Display reads "undr" (Secondary display reads "udr")	<ul style="list-style-type: none"> • Temperature reading is $< -5^{\circ}\text{C}$ 	<ul style="list-style-type: none"> • Measure samples at a temperature within the range of the system.

Symptom	Possible Cause	Action
11. Main display reads "PErr"	<ul style="list-style-type: none"> • Incorrect sequence of keystrokes. 	<ul style="list-style-type: none"> • Refer to manual section for step by step instruction for the function you are attempting.
12. Main display reads "Err" (Secondary display reads "ra")	<ul style="list-style-type: none"> • System has failed its RAM test check procedure. 	<ul style="list-style-type: none"> • Turn instrument OFF and back ON again. • Return the system for service (pg 21)
13. Main display reads "Err" (Secondary display reads "ro")	<ul style="list-style-type: none"> • System has failed its ROM test check procedure. 	<ul style="list-style-type: none"> • Turn instrument OFF and back ON again. • Return the system for service (pg 21)
16. Main display reads "FAIL" (Secondary display reads "eep")	<ul style="list-style-type: none"> • EEPROM has failed to respond in time. 	<ul style="list-style-type: none"> • Return the system for service (pg 21)
16. Readings on main display don't change	<ul style="list-style-type: none"> • Meter is in recall mode. 	<ul style="list-style-type: none"> • Press MODE key to return to Normal Operation (pg 5, 11)

8. Principles of Operation

8.1 pH

The YSI Model 60 employs a field replaceable pH sensor for the determination of hydrogen ion concentration. The sensor is a combination electrode consisting of a proton selective glass reservoir filled with buffer at approximately pH 7 and a Ag/AgCl reference electrode which utilizes gelled electrolyte. A silver wire coated with AgCl is immersed in the buffer reservoir. Protons (H⁺ ions) on both sides of the glass (media and buffer reservoir) selectively interact with the glass, setting up a potential gradient across the glass membrane. Since the hydrogen ion concentration in the internal buffer solution is invariant, this potential difference, determined relative to the Ag/AgCl reference electrode, is proportional to the pH of the media.

Our testing of the Model 60 pH sensor indicates that it should provide long life, good response time and accurate readings in most environmental waters, including fresh water of low ionic strength. No special sensor is required (nor offered) for water of low conductivity.

Calibration And Effect Of Temperature

The software of the YSI Model 60 calculates pH from the established linear relationship between pH and the millivolt output as defined by a variation of the Nernst equation:

$$E = E_0 + \frac{2.3RT}{nF} * \text{pH} \quad \text{where } E = \text{millivolts output}$$

E_0 = a constant associated with the reference electrode

T = temperature of measurement in degrees Kelvin

R, n, and F are invariant constants

Thus, in simplified $y = mx + b$ form, it is (mv output) = (slope)x(pH) + (intercept). In order to quantify this simple relationship, the instrument must be calibrated properly using buffers of known pH values. In this procedure, the millivolt values for two standard buffer solutions are experimentally established and used by the YSI Model 60 software to calculate the slope and intercept of the plot of millivolts vs. pH. Once this calibration procedure has been carried out, the millivolt output of the probe in any media can readily be converted by the YSI Model 60 software into a pH value, *as long as the calibration and the reading are carried out at the same temperature*. This last qualifier is almost never met in actual environmental measurements, thus, a mechanism must be in place to compensate for temperature or, in other words, to accurately convert the slope and intercept of the plot of pH vs. millivolts established at T_c (temperature of calibration) into a slope and intercept at T_m (temperature of measurement). Fortunately, the Nernst equation provides a basis for this conversion.

According to the Nernst equation as shown above, the slope of the plot of pH vs. millivolts is *directly proportional* to the absolute temperature in degrees Kelvin. Thus, if the slope of the plot is experimentally determined to be 59 mv/pH unit at 298 K (25 C), then the slope of the plot at 313 K (40 C) must be $(313/298) * 59 = 62$ mv/pH unit. At 283 K (10 C), the slope is calculated to be 56 mv/pH unit $((283/298) * 59)$. Determination of the slope of pH vs. mv plots at temperatures different from T_c is thus relatively simple. In order to establish the intercept of the new plot, the point where plots of pH vs. mv at different temperatures intersect (the isopotential point) must be known. Using standard pH determination protocol, the YSI Model 60 software assigns the isopotential point as the mv reading at pH 7 and then calculates the intercept using this assumption. Once the slope and intercept to the plot of pH vs. mv are assigned at the new temperature, the calculation of pH under the new temperature conditions is straightforward, and is automatically carried out by the software.

Number of Calibration Points

When calibrating the YSI Model 60, you have the choice of 1-point 2-point, or 3-point calibration. **Perform a 2 or 3 point calibration at least once per day for accurate results.**

Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously (at least once per day), you can adjust the calibration by carrying out a 1-point calibration at pH 7 (or pH 6.86). This calibration procedure adjusts only the pH offset and leaves the previously-determined slope unaltered.

Select the **2-point** option to calibrate the pH probe using only two calibration standards. In this procedure, the pH sensor is calibrated using a pH 7 (or pH 6.86) buffer and *one additional* buffer. A two point calibration procedure (as opposed to a 3-point procedure) can save time if the pH of the sample is known to be either basic or acidic. For example, if the pH of a sample is known to vary between 5.5 and 7, a two point calibration with pH 7 and pH 4 buffers is appropriate. Three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.

Select the **3-point** option to calibrate the pH probe using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 (or pH 6.86) buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated.

8.2 Temperature

The YSI Model 60 system utilizes a thermistor which changes predictably in resistance with temperature variation. The algorithm for conversion of resistance to temperature is built-in to the Model 60 software, and accurate temperature readings, in degrees Celsius, are provided automatically. No calibration or maintenance of the temperature sensor is required.

9. Warranty and Repair

YSI Model 60 pH Meters are warranted for two years from date of purchase by the end user against defects in materials and workmanship. YSI Model 60 probes, cables and sensors are warranted for one year from date of purchase by the end user against defects in material and workmanship. Breakage of pH sensors is NOT covered under warranty. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, write or call your local YSI representative, or contact YSI Customer Service in Yellow Springs, Ohio. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI's written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI's written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI's LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

YSI Authorized Service Centers

Please visit www.yei.com or contact YSI Technical Support for the nearest authorized service center.

YSI Incorporated • Technical Support • Phone: +1 937 767-7241 • 800 897-4151 • Fax: 937 767-1058 • Email: environmental@ysi.com

9.1 Cleaning Instructions

NOTE: Before they can be serviced, equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with waste water. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the responsibility of the sender.

When service is required, either at the user's facility or at YSI, the following steps must be taken to insure the safety of our service personnel.

1. In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4 cup bleach to 1 gallon tap water are suitable for most disinfecting. Instruments used with waste water may be disinfected with .5% Lysol if this is more convenient to the user.
2. The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.
3. If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.
4. Any product being returned to the YSI Repair Center, should be packed securely to prevent damage.
5. Cleaning must be completed and certified on any product before returning it to YSI.

9.2 Packing Instructions

1. Clean and decontaminate items to insure the safety of the handler.
2. Complete and include the Cleaning Certificate.
3. Place the product in a plastic bag to keep out dirt and packing material.
4. Use a large carton, preferably the original, and surround the product completely with packing material.
5. Insure for the replacement value of the product.

Cleaning Certificate	
Organization _____	
Department _____	
Address _____	
City _____	State _____ Zip _____
Country _____	Phone _____
Model No. of Device _____	Lot Number _____
Contaminant (if known) _____	
Cleaning Agent(s) used _____	
Radioactive Decontamination Certified?	
(Answer only if there has been radioactive exposure)	
___ Yes ___ No	
Cleaning Certified By _____	
	Name Date

10. 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:

- re-orient 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, DC 20402, Stock No. 0004-000-00345-4.

11. Accessories and Replacement Parts

The following parts and accessories are available from YSI or any Franchise Dealer authorized by YSI.

YSI Order Number	Description
3821	pH Buffer Solution, 4
3822	pH Buffer Solution, 7
3823	pH Buffer Solution, 10
060992	Calibration buffer bottle, without cap
060991	Cap, Calibration buffer bottle
5050	Carrying Case
031133	pH sensor
113135	Probe body/Cable Assembly (10 feet)
113141	Probe body/Cable Assembly (25 feet)
113151	Probe body/Cable Assembly (50 feet)
113171	Probe body/Cable Assembly (100 feet)
031131	Front Case Cover
055242	Rear Case Cover
055210	Battery Cover Kit
055204	Case Gasket and Screw
031128	Main Board Assembly
031189	Graduated Cylinder, 100 mL
060992	Container, Plastic (uses 060991 cap)
060991	Cap, Plastic Container (for 060992 container)

12. Appendix A - Specifications

Materials: ABS, Stainless Steel, and other materials

Dimensions:

Height:	9.5 inches	(24.13 cm)
Thickness:	2.2 inches	(5.6 cm)
Width:	3.5 inches max.	(8.89 cm)
Weight:	1.7 pounds (w/ 10' cable)	(.77 kg)
Display:	2.3"W x 1.5"L	(5.8 cm W x 3.8 cm L)

Power: 6 AA-size Alkaline Batteries (included)

Approximately 100 hours operation from each new set of batteries

Automatic shutoff after 10 hours without a key press

Water Tightness: Meets or exceeds IP65 standards

Probe Operating Environment

Medium: fresh, sea, or polluted water and most other liquid solutions.

Temperature: -5 to +75 °C

Depth: 0 to 10, 0 to 25, 0 to 50, or 0 to 100 feet (depending on cable length)

Meter Ambient Operating/Storage Temperature: -5 to +45 °C

System Performance Specifications

Measurement	Range	Resolution	Accuracy
pH	0 to 14	0.01 unit	± 0.1 pH unit within $\pm 10^{\circ}\text{C}$ of calibration temperature or ± 0.2 pH unit within $\pm 20^{\circ}\text{C}$ of calibration temperature
Temperature	-5 to +75 °C	0.1 °C	$\pm 0.1^{\circ}\text{C} \pm 1$ LSD

pH Response Time: 3 sec for 95% of the change at 25°C

Temperature Response Time: 20 sec for 95% of the change

Temperature Compensation: Automatic

Data Storage: 50 points with ID number.

13. Appendix B - Health and Safety

YSI pH 4, 7 & 10 Buffer Solutions: 3821, 3822, 3823

pH 4 Ingredients:

- ☞ Potassium Hydrogen Phthalate
- ☞ Formaldehyde
- ☞ Water

pH 7 Ingredients:

- ☞ Sodium Phosphate, Dibasic
- ☞ Potassium Phosphate, Monobasic
- ☞ Water

pH 10 Ingredients:

- ☞ Potassium Borate, Tetra
- ☞ Potassium Carbonate
- ☞ Potassium Hydroxide
- ☞ Sodium (di) Ethylenediamine Tetraacetate
- ☞ Water

CAUTION - Avoid inhalation, skin contact, eye contact or ingestion. May affect mucous membranes.

Inhalation may cause severe irritation and be harmful. Skin contact may cause irritation; prolonged or repeated exposure may cause Dermatitis. Eye contact may cause irritation or conjunctivitis. Ingestion may cause nausea, vomiting and diarrhea.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

14. Appendix C - pH Buffer Values

YSI pH 4, 7 and 10 Buffer Solutions: 3821, 3822, 3823

The following table lists the values of YSI pH buffer solutions at various temperatures.

Temperature	pH 4	pH 7	pH 10
0°C	4.01	7.13	10.34
5°C	4.00	7.10	10.26
10°C	4.00	7.07	10.19
15°C	4.00	7.05	10.12
20°C	4.00	7.02	10.06
25°C	4.01	7.00	10.00
30°C	4.01	6.99	9.94
35°C	4.02	6.98	9.90
40°C	4.03	6.97	9.85
50°C	4.06	6.97	9.78
60°C	4.09	6.98	9.70

NIST pH 4.01, 6.86 and 9.18 Buffers: SRM 185g, SRM 186-Ie/IIe, SRM 187c

The following table lists the values of NIST pH buffer solutions at various temperatures.

Temperature	pH 4.01	pH 6.86	pH 9.18
0°C	4.005	6.984	9.463
5°C	4.003	6.950	9.395
10°C	4.001	6.924	9.333
15°C	4.002	6.899	9.277
20°C	4.003	6.879	9.226
25°C	4.005	6.863	9.180
30°C	4.010	6.852	9.139
35°C	4.020	6.844	9.102
37°C	4.025	6.842	N/A
40°C	4.033	6.840	9.070
45°C	4.047	6.837	9.042
50°C	4.061	6.836	9.018

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