ANALYTICAL PROCESS CONTROL

6

LEARNING ACTIVITY PACKET

pH METERS AND TRANSMITTERS

AMATROL®

B33303-AB06AEN

pH METERS AND TRANSMITTERS

INTRODUCTION

A pH electrode measures the pH of a solution based on the potential (voltage) between the measuring electrode and the reference electrode. However, another device is needed to convert that potential to a pH value. That device is a pH meter.

In addition, a transmitter is needed to convert the pH measurement into an analog signal (i.e. 4-20mA) for the controller. In most cases, the pH meter and transmitter are combined into one instrument.

This LAP covers the operation, calibration, and diagnostics for pH meters and transmitters.

ITEMS NEEDED

Amatrol Supplied
T5554 Analytical Process Control Learning System

School Supplied
pH Buffer Solutions (4, 7, and 10 pH)
1 Bottle Distilled Water
1 Municipal Water Supply
1 Squirt Bottle
1 Multimeter

FIRST EDITION, LAP 6, REV. A

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SEGMENT 1

pH METERS

OBJECTIVE 1 — DESCRIBE THE OPERATION OF A pH METER

A pH meter takes the potential (mV) between the measurement and reference electrodes and converts it into a pH value, as shown in figure 1. This makes the output from the pH electrode meaningful.

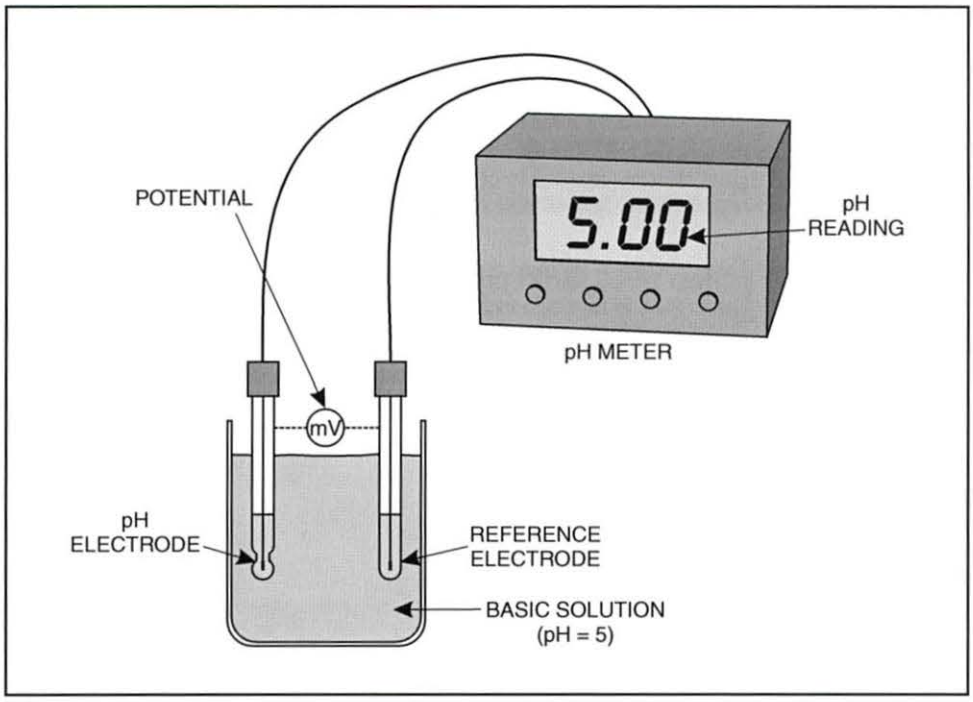

Figure 1. pH Meter Converts Potential into pH Value

A typical pH meter includes a display, programming keys, and connection terminals. The display is usually an LCD display that provides a digital indication of the pH level. The programming keys allow the user to set up the meter. Setup includes entering electrode data, the type of measurement, and calibrating the meter to the electrode. The connection terminals allow the electrodes to be connected to the meter, as well as connecting the meter to other instruments such as a controller. Figure 2 shows an example of a pH meter.

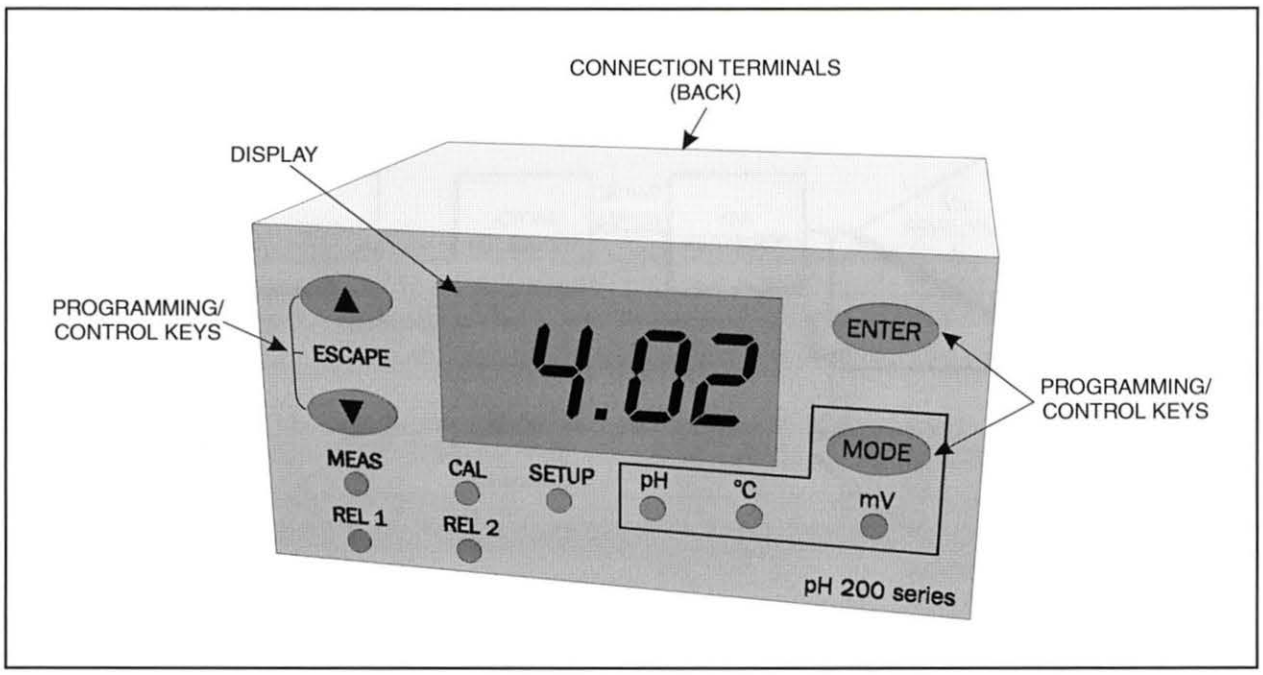

Figure 2. Basic Components of a pH Meter

Figure 3 shows a simplified block diagram of a typical pH meter. The potential between the pH electrode and the reference electrode is amplified. The amplified signal feeds into an analog-to-digital (A/D) converter, which converts the signal to a digital signal.

The microprocessor converts the signal into the appropriate pH value and provides this value to the display. The microprocessor also provides the pH value to the transmitter. The transmitter converts the pH value to an analog signal (typically 4-20mA) that is proportional to the pH value and sends the analog signal to the desired device (usually a controller).

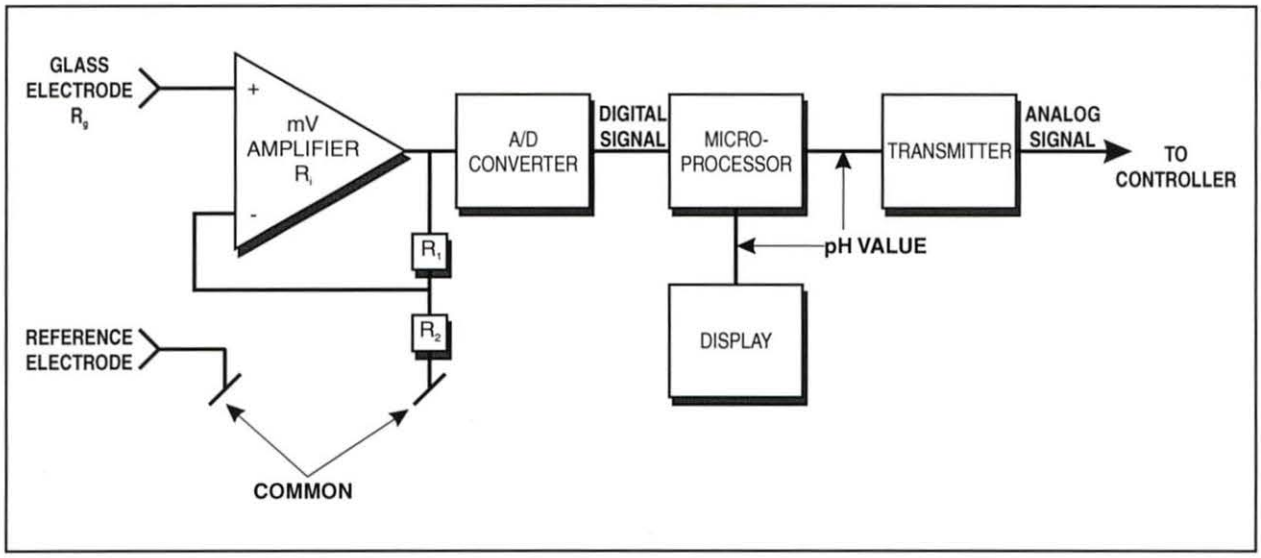

Figure 3. Block Diagram of a pH Meter

The meters microprocessor uses an equation called the Nernst equation (named after its developer Walther Hermann Nernst) to convert the signal to pH. The Nernst equation is as follows:

NERNST EQUATION

$$E = E^0 + E_N \times \log a_{H+}$$

Where

E	=	*measured potential (mV)*
E^0	=	*standard potential of electrode assembly (mV)*
E_N	=	*Nernst potential (mV) v*
	=	*54.2 mV at 0° C*
	=	*59.2 mV at 25° C*
	=	*64.1 mV at 50° C*
$\log a_{H+}$	=	*logarithm of hydrogen ion activity*

To achieve accurate pH measurement, the pH meter must be properly programmed and calibrated.

OBJECTIVE 2 DESCRIBE THE OPERATION OF THE HONEYWELL DL421 pH SENSOR MODULE AND GIVE AN ADVANTAGE

The Honeywell DL421 pH Sensor Module, shown in figure 4, is a pH meter that connects directly to many of Honeywells pH electrodes, such as the Meridian II glass electrode or the Durafet II electrode. The DL421 pH Sensor Module provides a pH reading at the location of the measurement and transmits a 4-20mA signal for closed-loop control.

Figure 4. The Honeywell DL421 pH Sensor Module

The components of the DL421 pH Sensor Module shown in figure 5 are:

- Display
- Programming Keys
- Electrode Connector
- Output Connector
- Housing

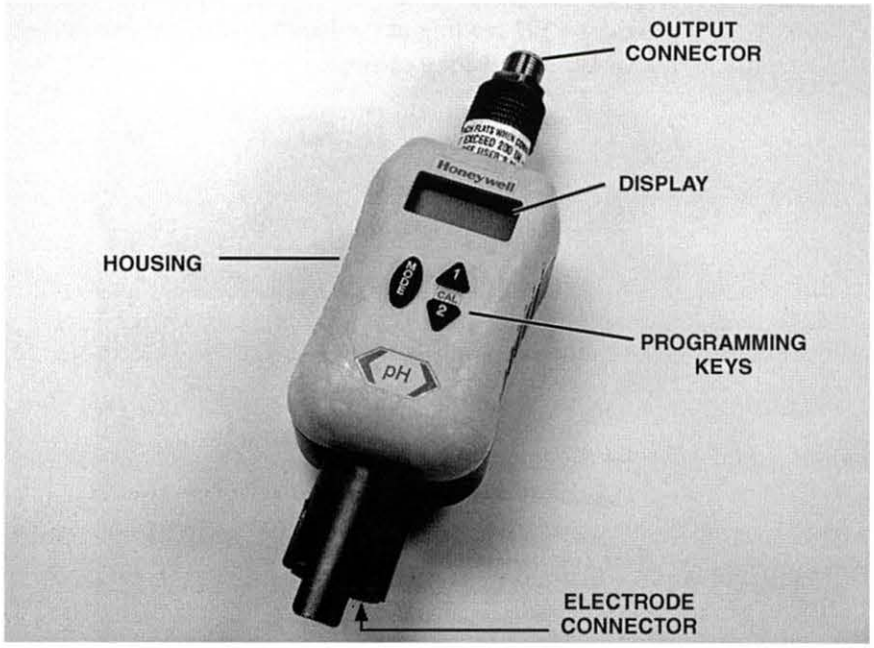

Figure 5. Components of the DL421 pH Sensor Module

Display

The display is a 4-digit, 7-segment LCD display. The display shows the measured value, allows the user to calibrate the module to an electrode, and provides diagnostic information concerning the module or the electrode.

Programming Keys

The programming keys are used to program the module and to navigate the various parameters, settings, and diagnostic data. The programming keys include the MODE key and the CAL1 and CAL2 keys, as shown in figure 6. The MODE key allows the user to select the type of data displayed. The CAL1 and CAL2 keys allow the user to scroll through different data to change values.

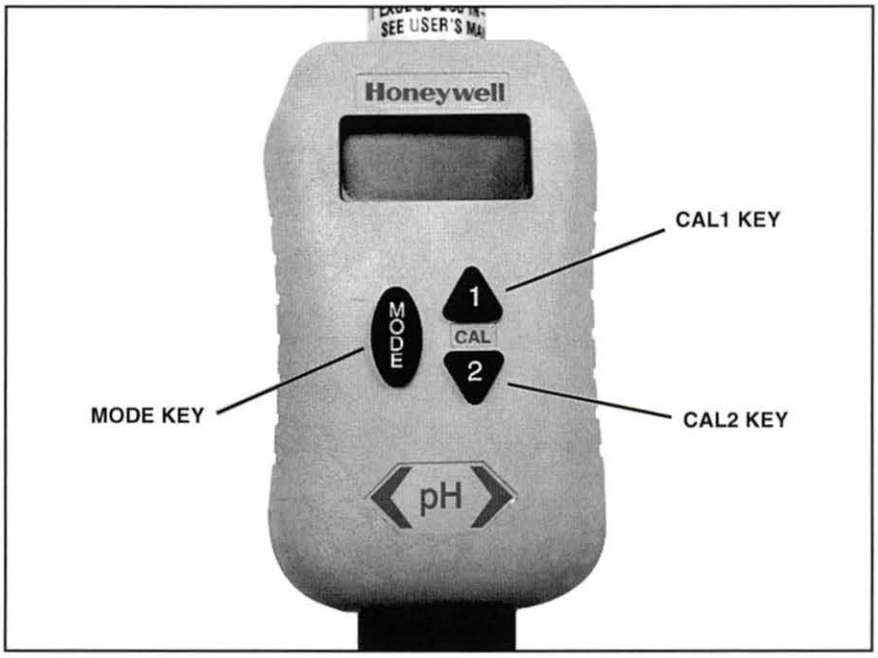

Figure 6. The Programming Keys

Electrode Connector

The electrode connector, shown in figure 7, is located at the bottom of the module and is designed so that the connector of the electrode plugs directly into the module. This design makes it easy to quickly remove the module from an electrode and connect it to another one as needed.

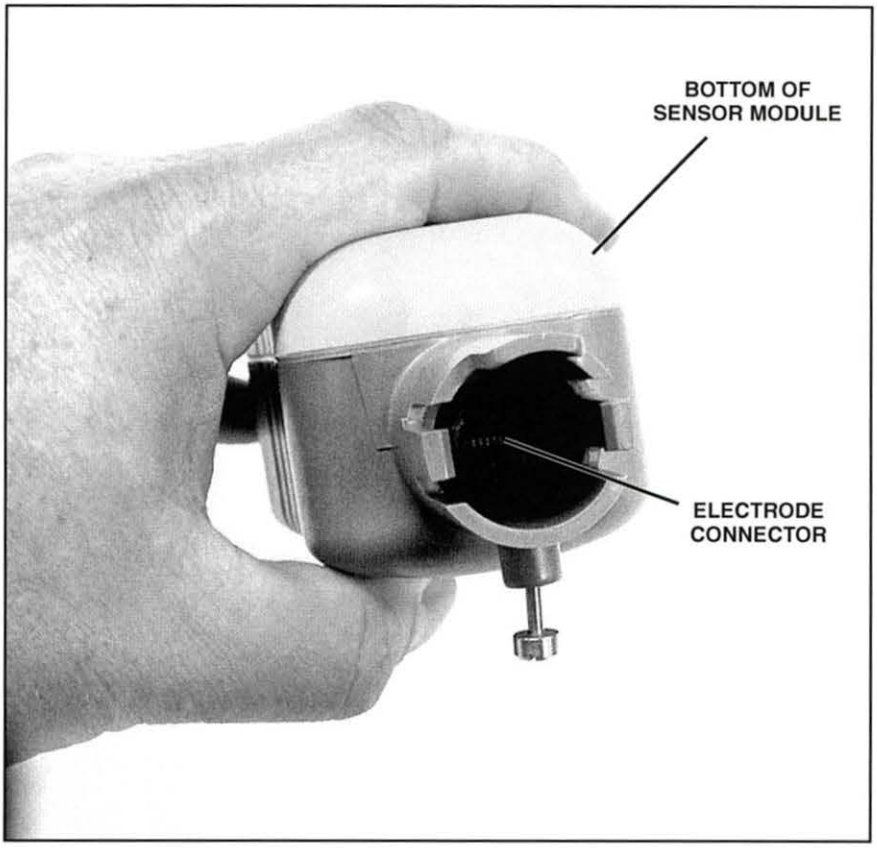

Figure 7. The Electrode Connector

Output Connector

The output connector is located on the top of the module and is designed so a cable can be connected to it, as shown in figure 8. This cable carries the output signal (4-20mA) from the module to the control device.

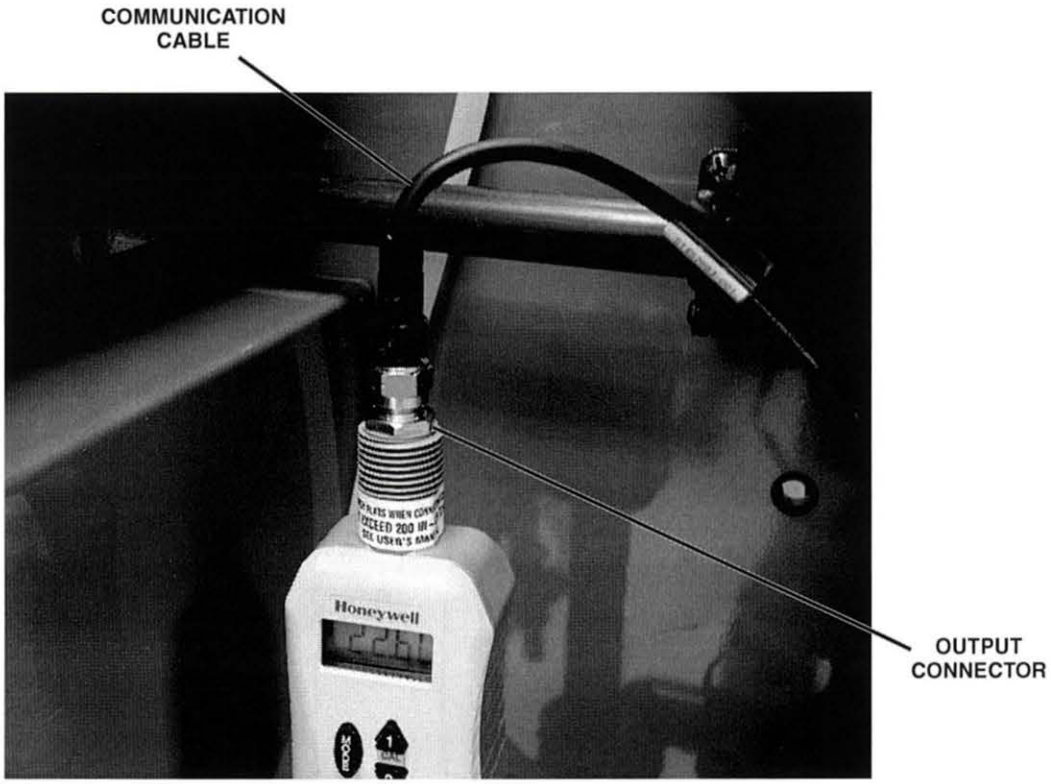

Figure 8. Cable Connected to Output Connector

Housing

The housing, which is waterproof and corrosion-proof, is made of plastic. This provides protection for the internal circuitry. The housing also makes the module easy to handle.

Operation

The DL421 module works the same as most pH meters. It takes the potential measured between the pH and reference electrodes and converts that measurement into a pH value based on the data entered using the programming keys. The pH value is shown on the display and a built-in transmitter sends out a 4-20mA signal that represents the pH value, as figure 9 shows. The sensor module also accepts a temperature signal from the electrode that the microprocessor uses for automatic temperature compensation.

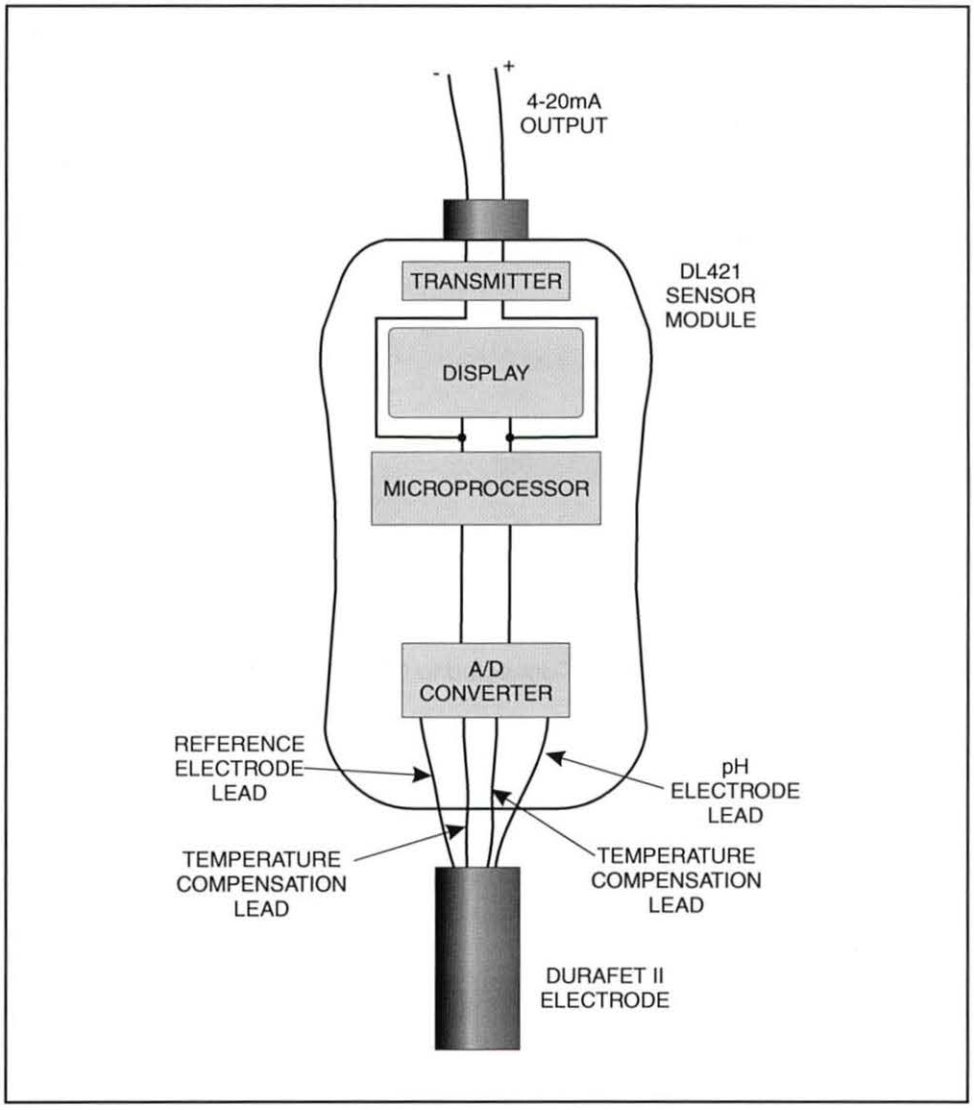

Figure 9. Wiring Diagram for DL421 Sensor Module

The DL421 module plugs directly into the top of the electrode, as shown in figure 10. This places it directly at the sight of the measurement and makes calibration much easier. In many applications, the pH meter is located in the control room, while the electrode is located in the process.

Having the electrode and meter in different locations complicates the calibration process. The complicating factor is that the person performing the calibration cannot see the display of the meter when an electrode is placed in a calibration buffer solution. The plug-in DL421 module eliminates this complication.

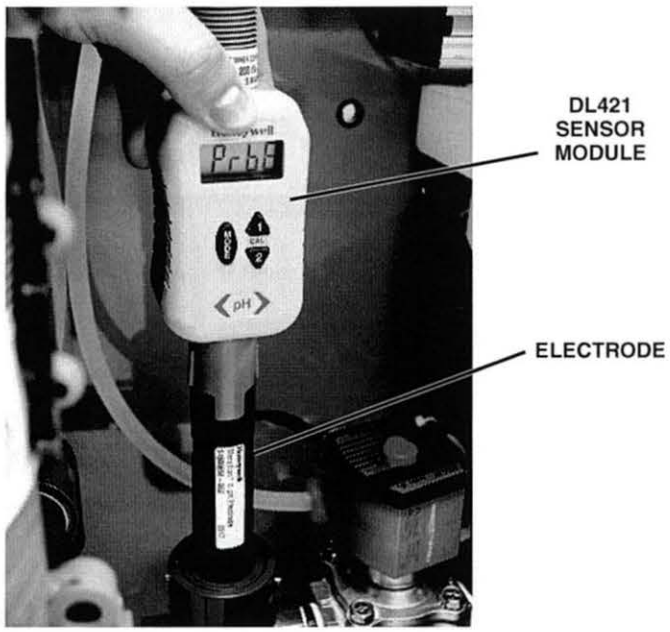

Figure 10. The DL421 Module Plugged into an Electrode

OBJECTIVE 3 DESCRIBE HOW TO CONNECT THE HONEYWELL DL421 SENSOR MODULE TO AN ELECTRODE

The DL421 sensor module is designed to plug directly into many of Honeywells pH electrodes, including the Durafet II electrode and the Meridian II glass electrode. Connecting the DL421 sensor module to an electrode is a simple process. To do so, first locate the Honeywell DL421 Sensor Module and make sure the locking screw on the back of the sensor module is retracted (pulled out), as shown in figure 11. The locking screw must be retracted to allow the module to fit onto the top of the electrode.

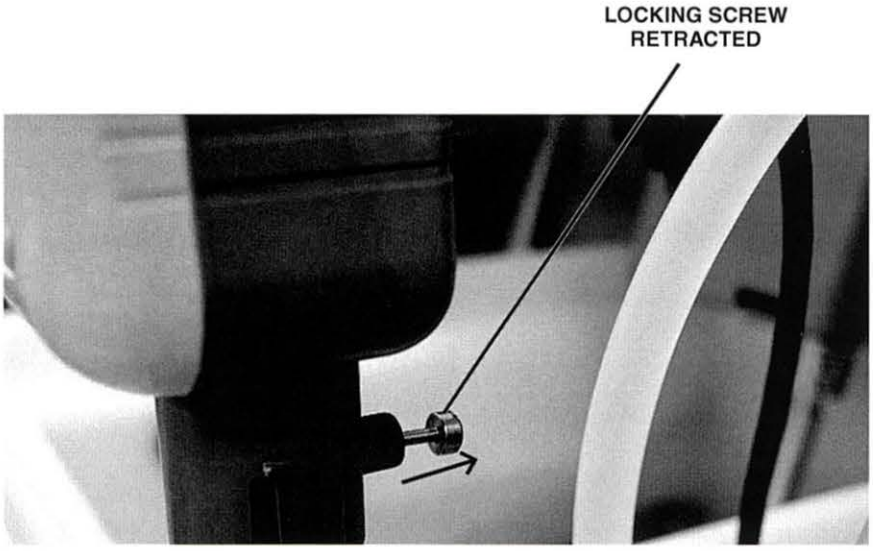

Figure 11. Locking Screw on DL421 Retracted

Next, locate the electrode on which the DL421 module is to be connected and make sure the module is properly aligned with the electrode housing. There is a notch in the electrode housing, as shown in figure 12. The tab on the DL421 module, also shown in figure 12, should fit into the notch when the module is connected to the electrode.

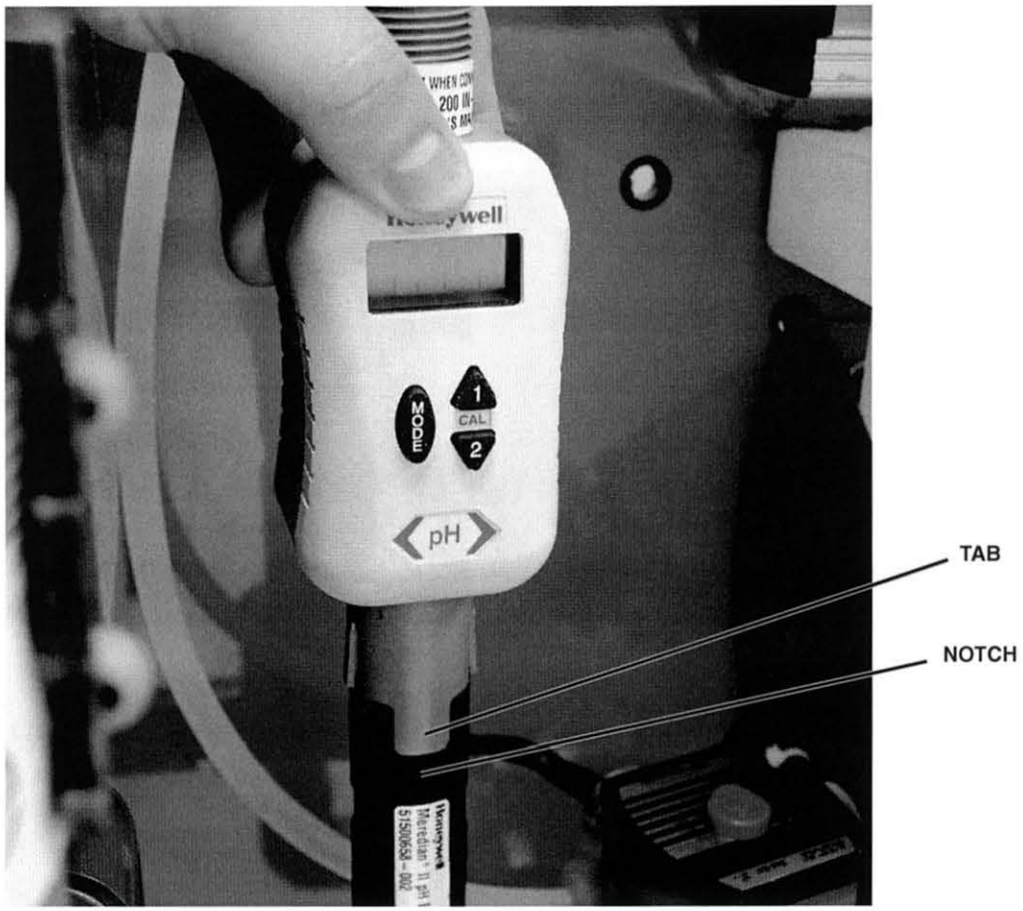

Figure 12. Tab Aligned with Notch

When the alignment is correct, push the DL421 module onto the top of the electrode housing, as shown in figure 13. Make sure the module is fully seated. This connects the module to the electrode via an edge connector so the module can measure the potential from the electrode.

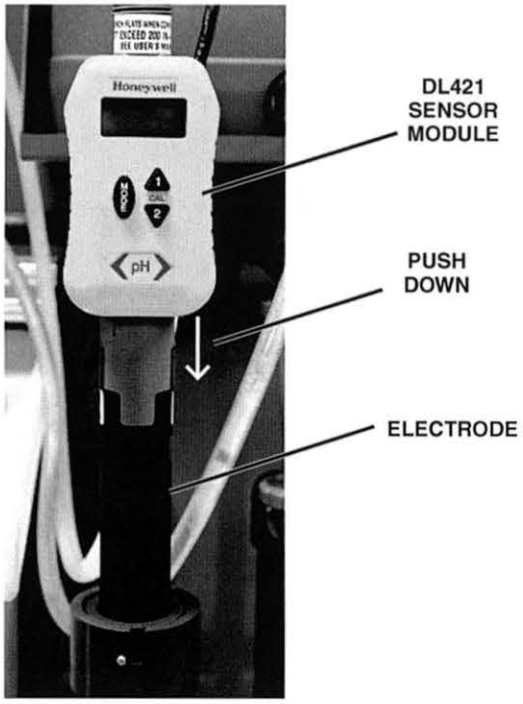

Figure 13. DL421 Module Connected to the Electrode

Once the DL421 module is installed, secure the connection by turning the securing screw shown in figure 14 clockwise. The electrode housing has a threaded hole in which the securing screw fits.

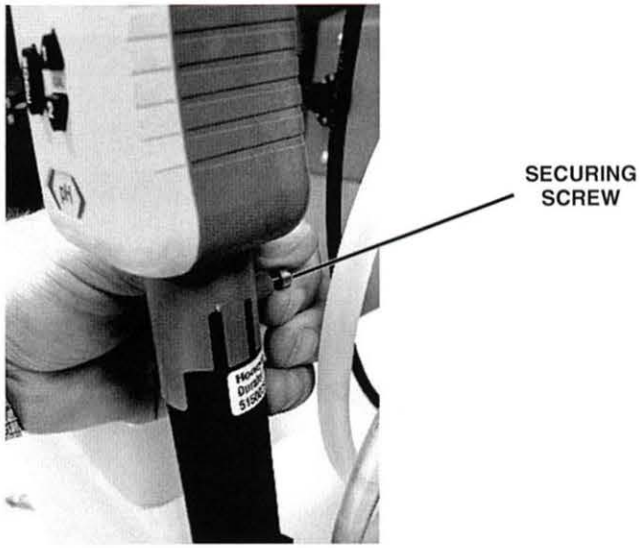

Figure 14. DL421 Module Secured with Securing Screw

Finally, the output cable for the DL421 module is connected using the connection on the top of the module, as shown in figure 15. The connector on the cable screws into the connector on top of the module. The other end of the cable is typically connected to some type of control device.

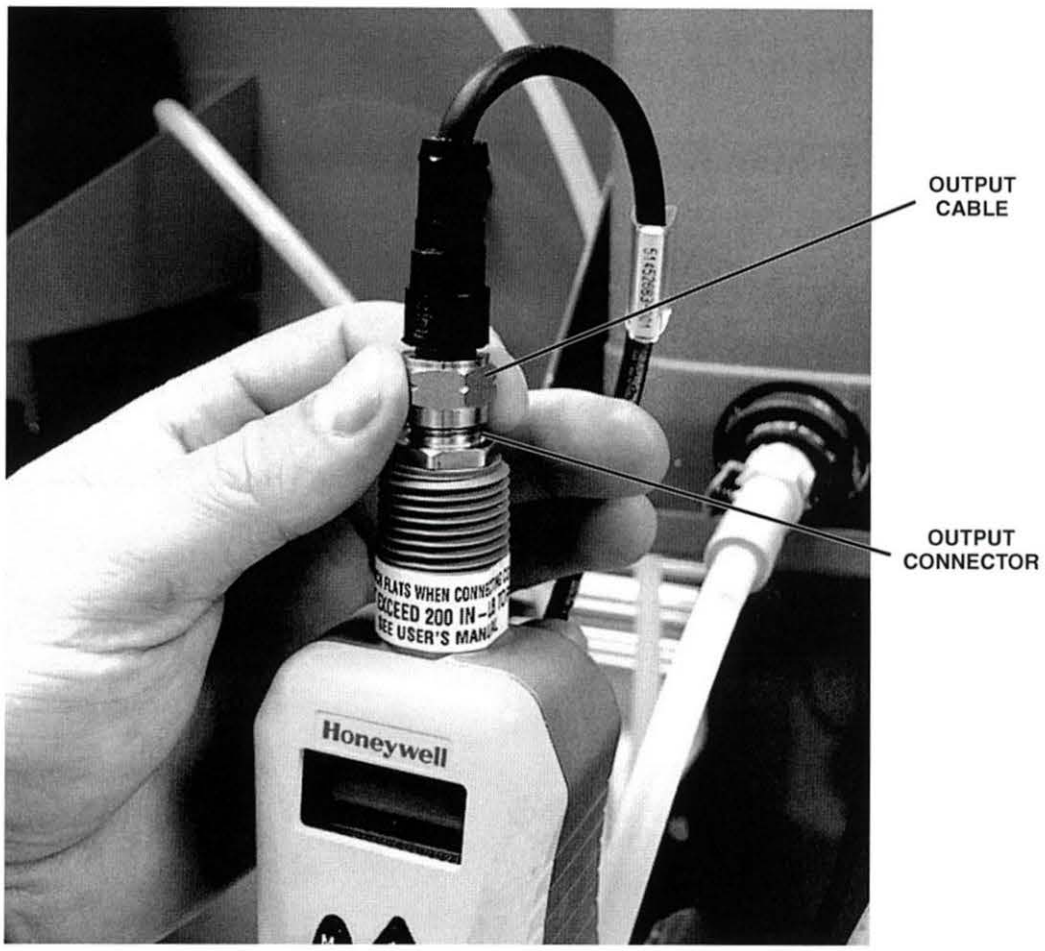

Figure 15. Output Cable Connected

SKILL 1 CONNECT THE HONEYWELL DL421 pH SENSOR MODULE TO AN ELECTRODE

Procedure Overview

In this procedure, you will connect the Honeywell DL421 pH Sensor Module to an electrode on the T5554 Analytical Process Control System. The module connects to either the Durafet II electrode or the Meridian II glass electrode.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. If the DL421 Sensor Module is currently connected to an electrode, ask your instructor to remove it for this skill.
- ❑ 3. Perform the following substeps to install the DL421 Sensor Module onto one of the electrodes on the T5554.

  A. Take the DL421 Sensor Module and make sure the securing screw is retracted, as shown in figure 16.

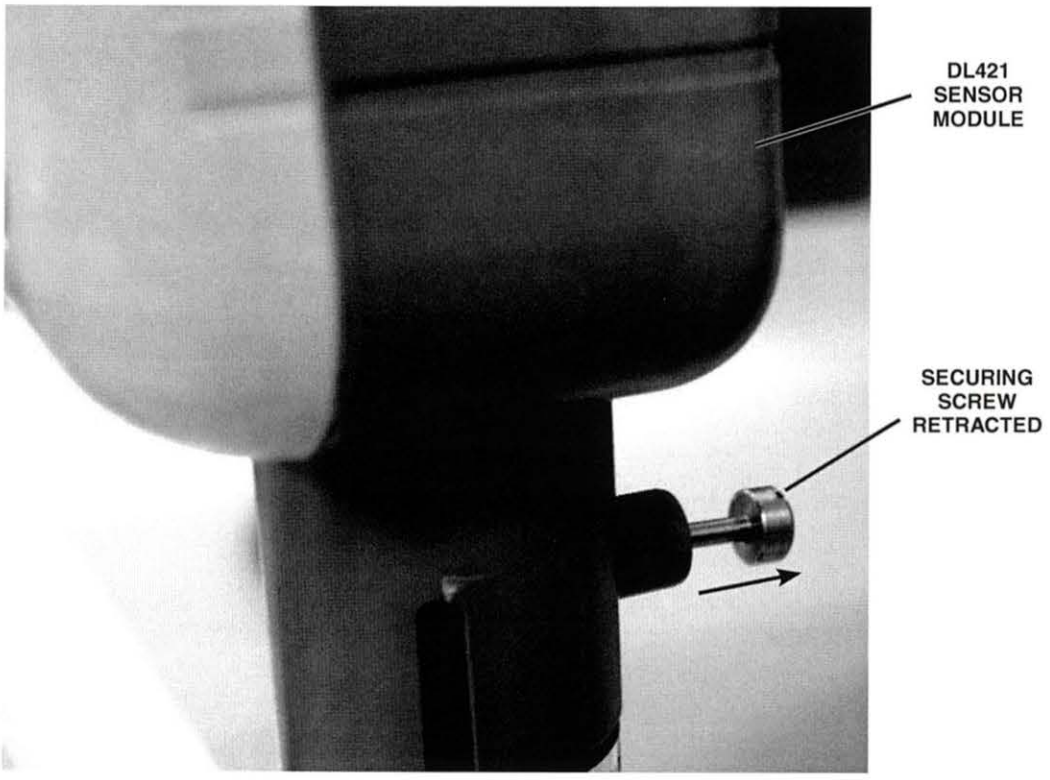

Figure 16. Securing Screw Retracted

B. Align the tab on the DL421 Sensor Module with the notch in the electrode housing, as shown in figure 17.

This should have the display of the module facing toward the front, as figure 17 also shows.

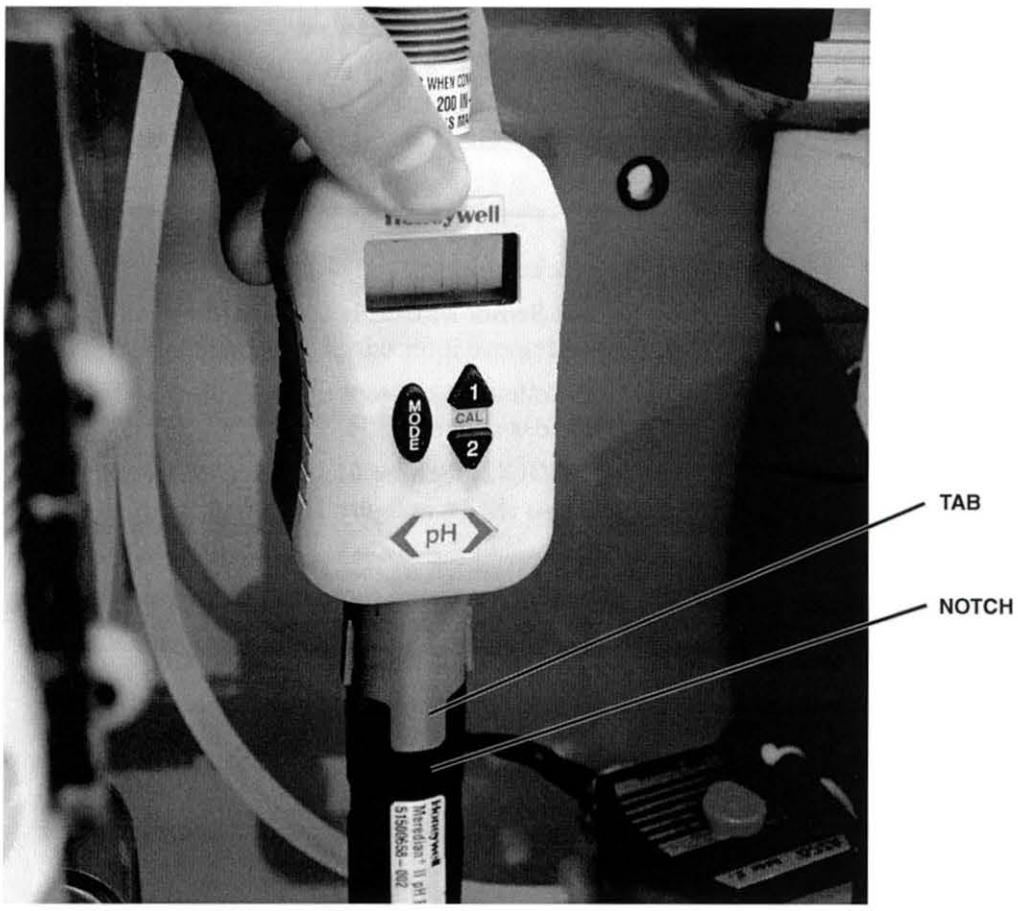

Figure 17. Tab Aligned with Notch

C. Connect the DL421 Sensor Module to the electrode by pushing the module straight down, as shown in figure 18.

This also makes the electrical connection between the electrode and the module.

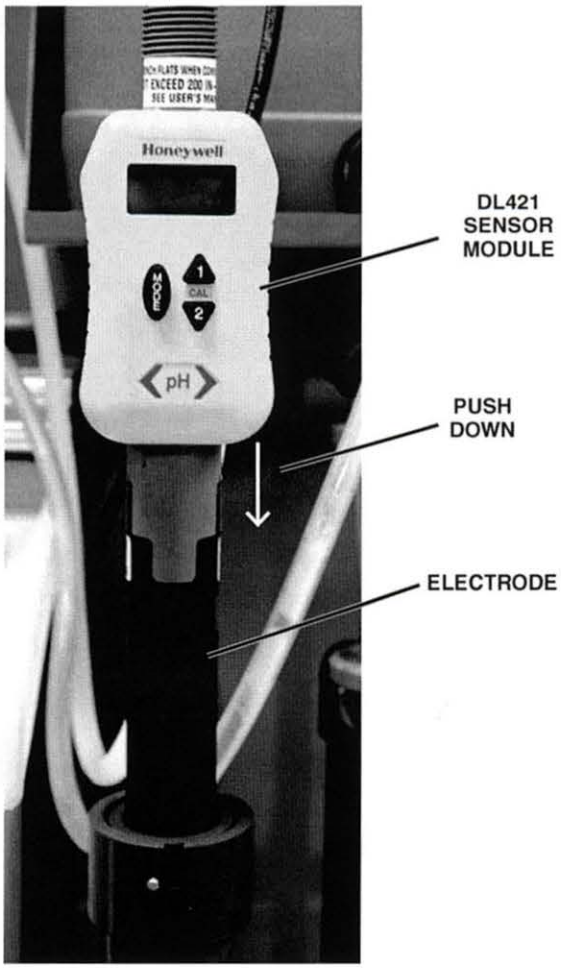

Figure 18. Module Connected to Electrode

D. Tighten the securing screw by turning it clockwise, as shown in figure 19. This secures the module to the electrode housing.

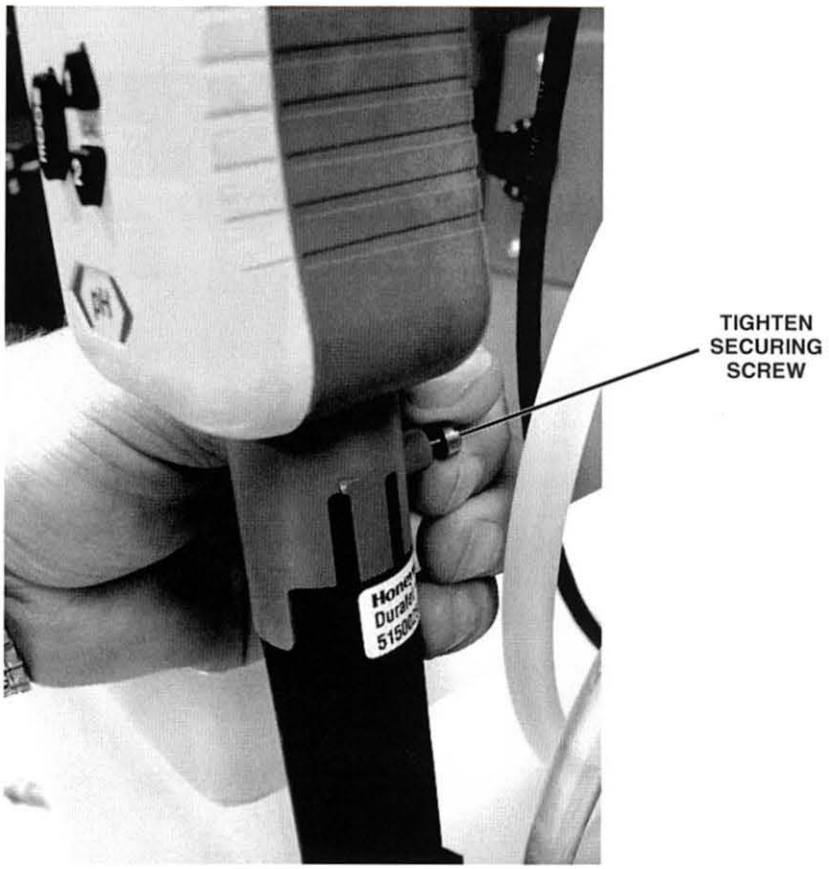

Figure 19. Tightening the Securing Screw

❑ 4. Perform the following substeps to connect the output cable to the DL421 module.

A. Locate the output cable for the module, as shown in figure 20.

This cable has a connector that screws into the connector at the top of the module. The other end of the cable is connected to connection jacks (Analytical Signal) located on the Operator Interface Panel of the T5554 control panel.

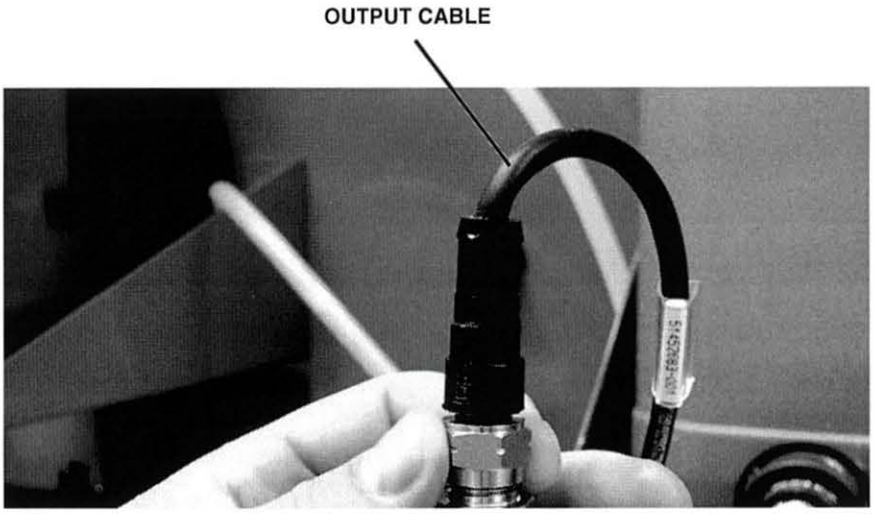

Figure 20. Output Cable

B. Align the connector of the cable with the connector on the module.

The connectors are keyed, as shown in figure 21, so they cannot be connected incorrectly.

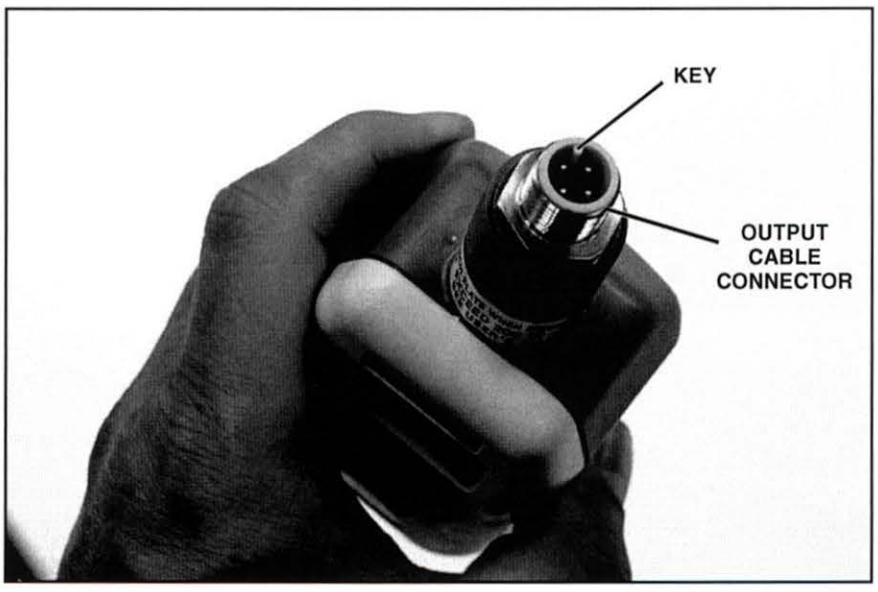

Figure 21. Connector Keyed to Prevent Incorrect Connection

C. Connect the cable to the connector on top of the module and turn the cables connector clockwise, as shown in figure 22, to tighten it.

Make sure the connection is secure. If not, continue turning the cable connector clockwise until the connection is secure.

Figure 22. Turn Cable Connector Clockwise to Tighten

That completes the installation of the DL421 Sensor Module on the electrode.

❑ 5. Remove the lockout/tagout.

SEGMENT 1

SELF REVIEW

1. A pH _____ takes the potential (mV) between the measurement and reference electrodes and coverts into a pH value.

2. The display of a Honeywell DL421 pH Sensor Module is a 4-digit, _____ LCD display.

3. The programming keys for the Honeywell DL421 pH Sensor Module include the _____ key and the CAL1 and CAL2 keys.

4. The DL421 module plugs directly into the _____ of an electrode.

5. The tab on the DL421 module should fit into the _____ on the electrode housing when the module is connected to the electrode.

6. Once the DL421 module is installed on an electrode, secure the connection by turning the securing screw on back of the module _____ (clockwise/counterclockwise).

SEGMENT 2

pH METER CALIBRATION

OBJECTIVE 4 — DESCRIBE THE FUNCTION OF pH METER CALIBRATION AND EXPLAIN ITS IMPORTANCE

Calibrating the pH meter allows the meter to compensate when the measurement values from the electrodes do not match theoretical values. Ideally, the potential of the pH electrode in a buffer solution with a pH of 7 is zero (0 mV). In addition, the ideal slope (sensitivity) of the electrode is 59.2 mV/pH at 25° C, as figure 23 shows. However, a typical pH electrode cannot exactly match these ideal values.

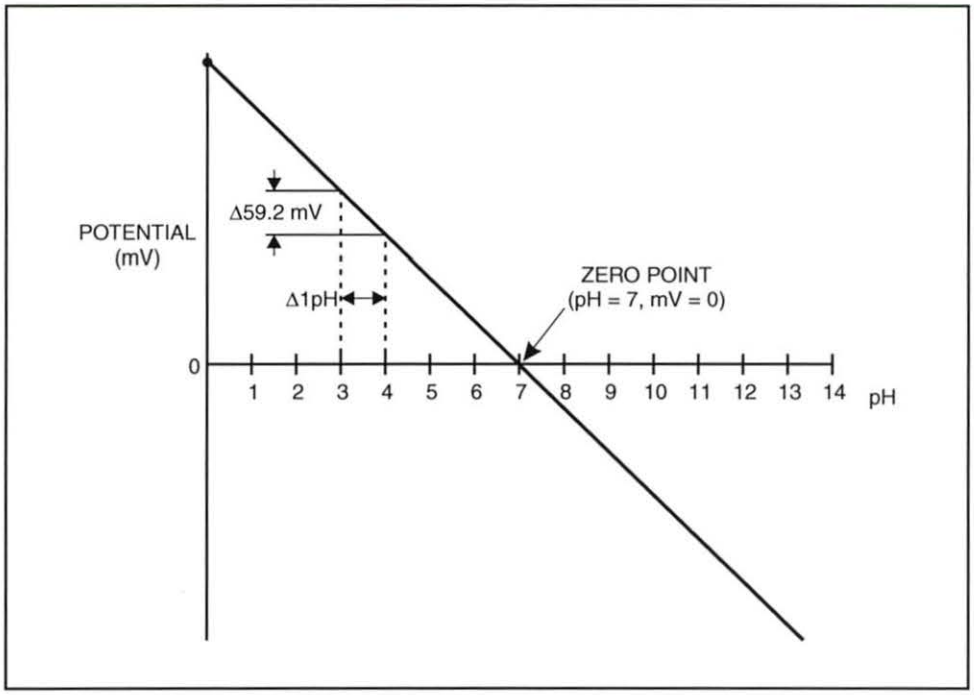

Figure 23. Ideal Slope for a pH Electrode

In most instances, two-point calibration is used to adjust for any variations. The first calibration point checks the output of the pH electrode when immersed in a buffer solution with a pH of 7. This allows the meter to compensate for the deviation from the theoretical zero point (7 pH = 0 mV), as figure 24 shows.

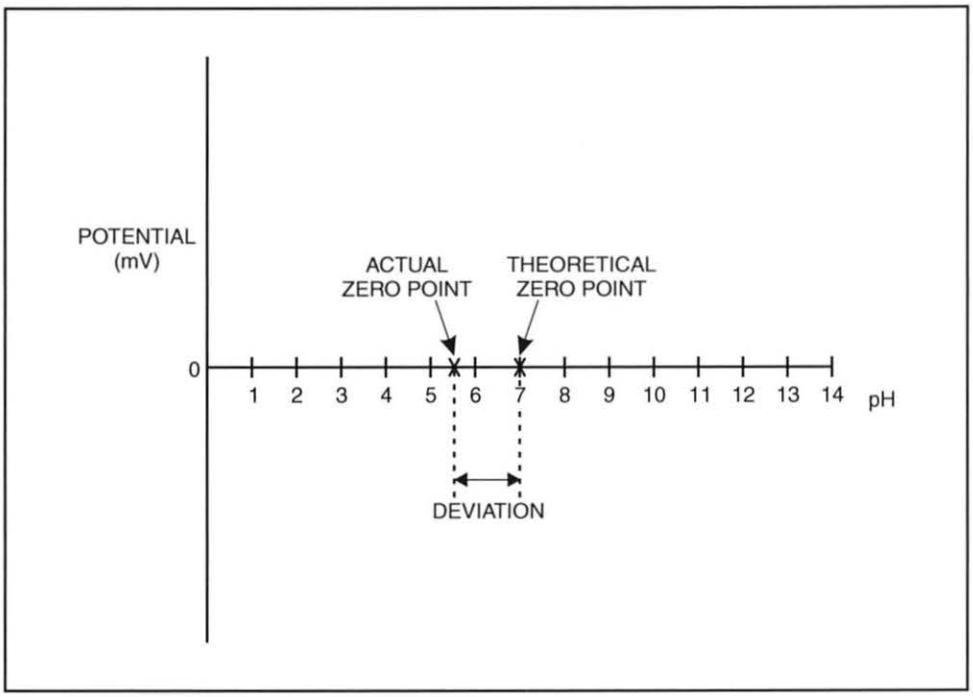

Figure 24. First Calibration Points Compensates for Deviation from Zero Point

The second calibration point checks the slope of the pH electrode. This is accomplished by immersing the electrode in either a buffer solution with a pH of 4 or 10. The meter then adjusts the slope of the pH electrode using the zero point reading and the second calibration point reading.

The deciding factor in choosing which buffer solution to use (4 or 10 pH) is the range of pH to be measured. If the value will be mostly above 7 (basic), use the 10 pH buffer solution. If the value will be mostly below 7 (acidic), use the 4 pH buffer solution.

For example, figure 25 shows how the meter adjusts the slope using the second calibration point (i.e. 4 pH). This adjustment results in a slope of approximately 59.2 mV/pH. Typically, the resulting slope should be between 96% and 102% of the theoretical value.

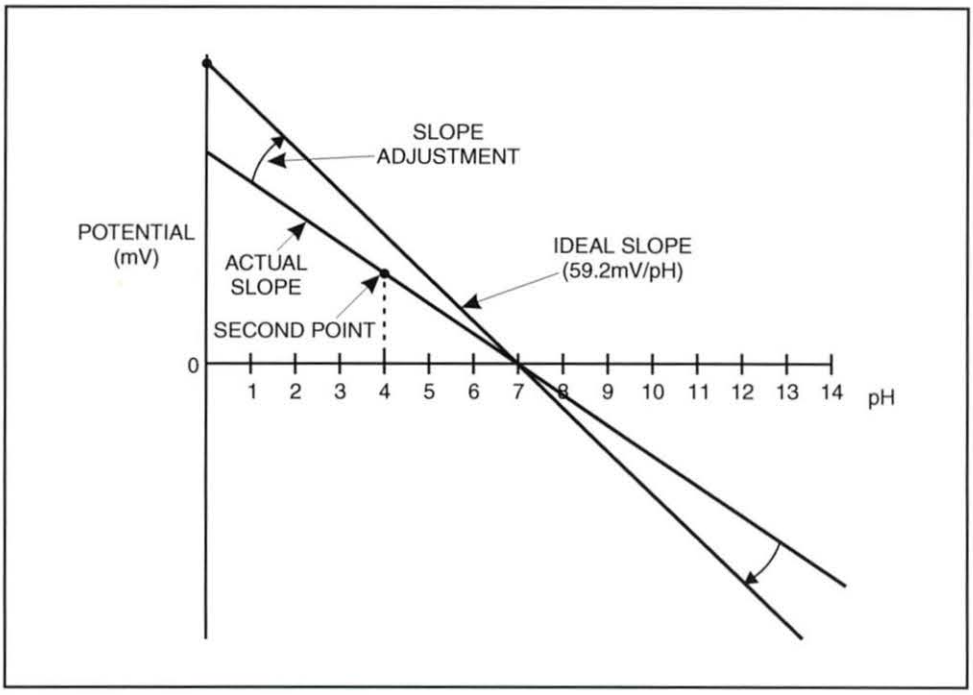

Figure 25. Adjusting the Slope of a pH Electrode

If the process requires accurate pH readings, proper calibration is essential to ensure the readings are as accurate as possible. In some applications, such the production of pharmaceuticals, accurate pH measurement is critical to producing a safe product. If the pH measurements are not accurate, the product could be dangerous or even deadly. Such applications require frequent checks of the calibration.

OBJECTIVE 5 DESCRIBE THE IMPORTANCE OF TEMPERATURE COMPENSATION IN pH MEASUREMENT

Up to this point, the effect of temperature on pH measurement has not been discussed. Temperature is an important consideration when measuring pH for two reasons:

- A solutions pH value changes with the temperature
- An electrodes output signal slope changes with the temperature

The effect temperature has on the pH of a solution basically depends on whether the solution is acidic or basic. Generally, acidic solutions experience a rise in pH as the temperature increases and a drop in pH as the temperature decreases. In contract, basic solutions experience a drop in pH as the temperature increases and a rise in pH as the temperature falls. For example, figure 26 shows pH vs. Temperature for a 4.01 pH buffer solution (acid) and a 9.18 pH buffer solution (base).

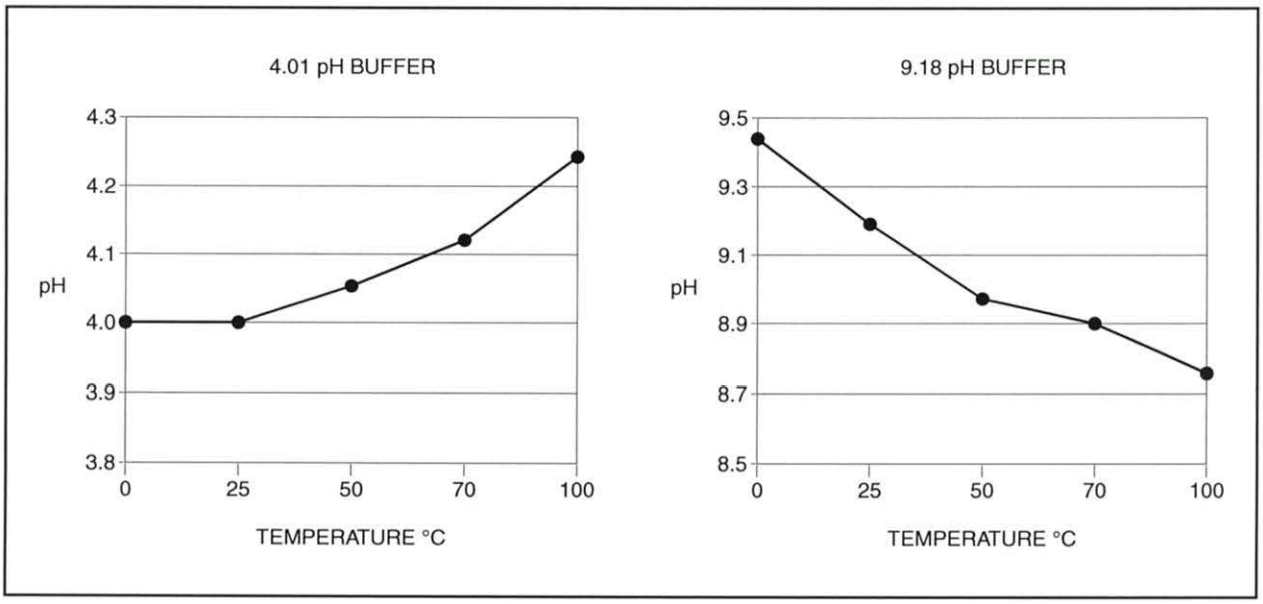

Figure 26. pH vs. Temperature for a 4.01 pH and 9.18 pH Buffer Solution

To minimize the effects of temperature variations on the measured pH values, it is important to maintain the temperature of the solution at as constant a temperature as possible. Otherwise, the pH measurement errors occur. It is difficult to correct for these errors.

Changes in temperature also cause an electrodes slope to shift, as figure 27 shows. This causes the measurement error to increase as the measured value moves away from the zero point (pH = 7). There are compensation methods to correct for this.

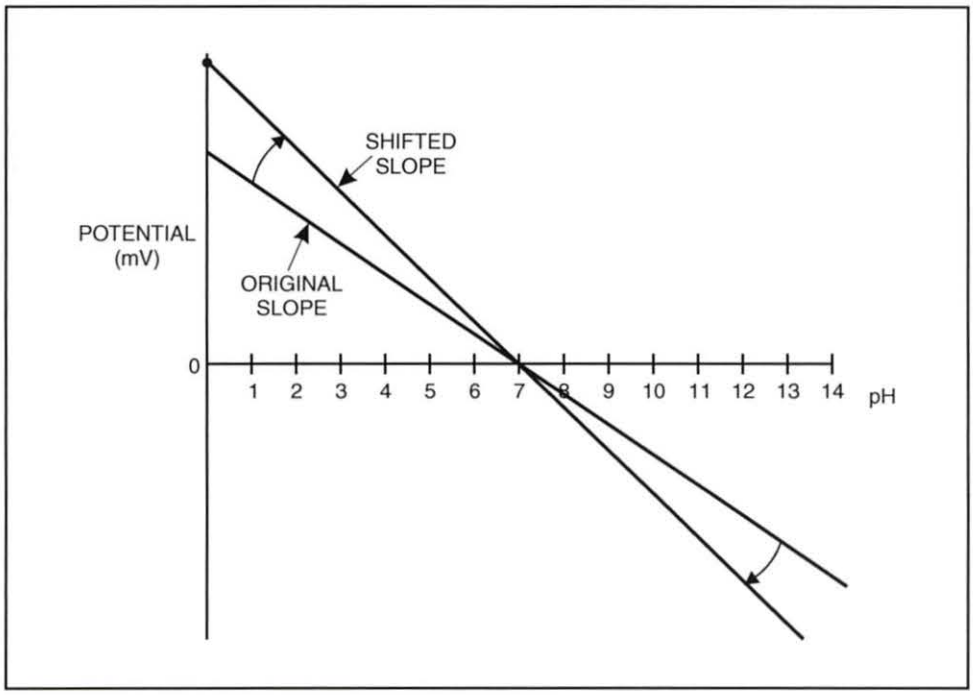

Figure 27. Temperature's Effect on an Electrode's Slope

Automatic Temperature Compensation

To compensate for temperature related shifts in an electrodes slope, many pH meters now include an automatic temperature compensation (ATC) function. This allows the meters microprocessor to automatically compensate for the temperatures effect on the slope.

To take advantage of the ATC function, many electrodes now include a temperature sensor, like the combination glass electrode shown in figure 28. This temperature sensor (often a thermistor) provides the meter with the temperature of the solution at the point of measurement. As long as the meter knows the temperature, the processor adjusts the slope as needed to reduce measurement errors.

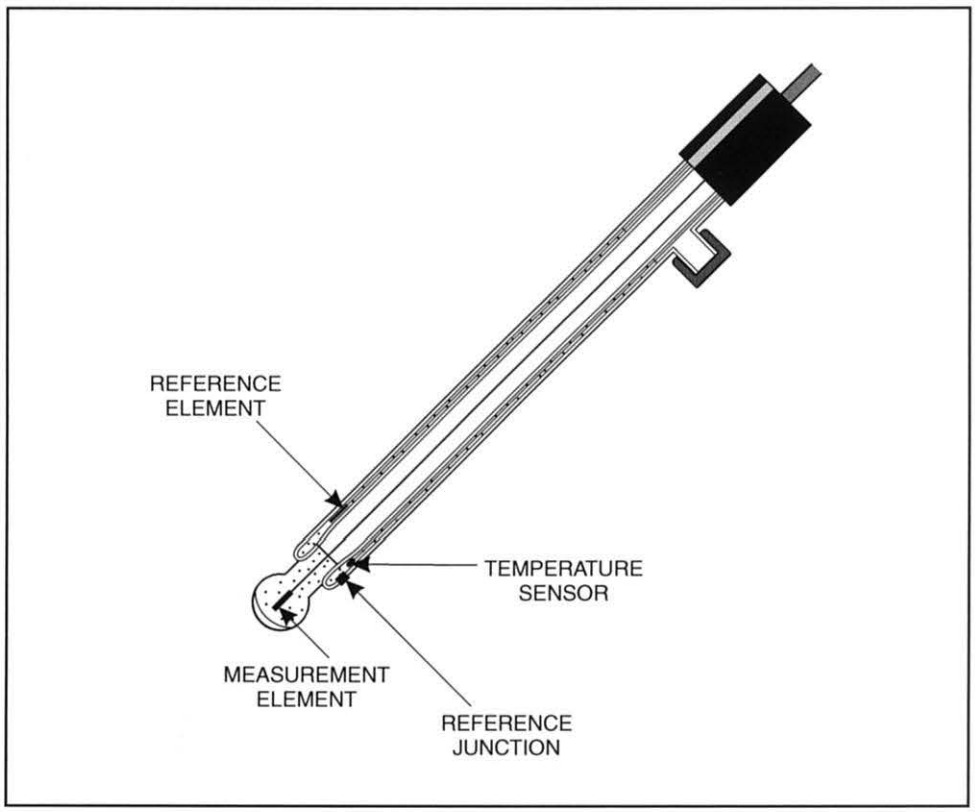

Figure 28. Combination Glass Electrode with a Temperature Sensor

Adding the temperature sensor to the electrode assembly allows for better accuracy since the sensor remains in close proximity to the sensing elements of the electrode. The Honeywell Durafet II electrode includes a temperature sensor for the temperature compensation.

OBJECTIVE 6 DESCRIBE HOW TO CALIBRATE THE HONEYWELL DL421 pH SENSOR MODULE

Proper calibration is essential to ensure that the pH measurements displayed by a pH meter are as accurate as possible. Without calibration, pH measurements cannot be trusted and are useless to the process. Typically, two-point calibration is used.

The following steps describe the procedure to calibrate the Honeywell DL421 pH Sensor Module:

Step 1: Remove the pH electrode from the process or storage vessel - If the electrode is currently in use, you need to remove it from the vessel in which it is mounted. If the electrode is new or has been in storage, remove the electrode from the storage vessel. Handle the electrode carefully when you remove it.

Step 2: Rinse the sensing end using distilled water - Distilled water has a pH of 7 (neutral). It is best to use a squirt bottle, as shown in figure 29, to rinse the sensing end of the electrode. This includes any of the electrode housing that was in contact with the process solution. You can dip the end of the electrode in distilled water. However, this contaminates the distilled water and reduces the effectiveness. Dab the sensing end with a soft paper or cloth to remove any excess water. Do not rub the sensing end. Rubbing it can damage the electrode.

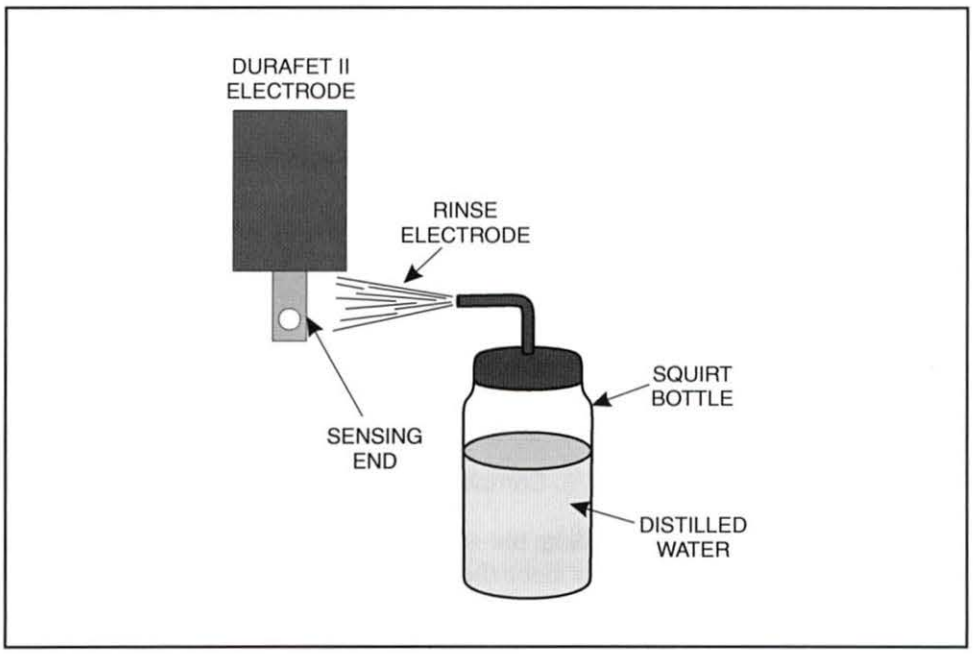

Figure 29. Rinse Electrode Sensing End with Distilled Water

Step 3: Connect the DL421 module to the pH electrode (if necessary) - Make sure the electrode is connected to the meter. If the electrode is currently in use, it is most likely already connected to the meter.

Step 4: Place the electrode in the 7 pH buffer solution - Make sure you have enough of the 7 pH buffer solution in a container, such as a glass beaker, to completely immerse the sensing end of the electrode. Place the sensing end of the electrode in the buffer solution and hold it there, as figure 30 shows, to allow the electrode to stabilize. This may take one minute or longer.

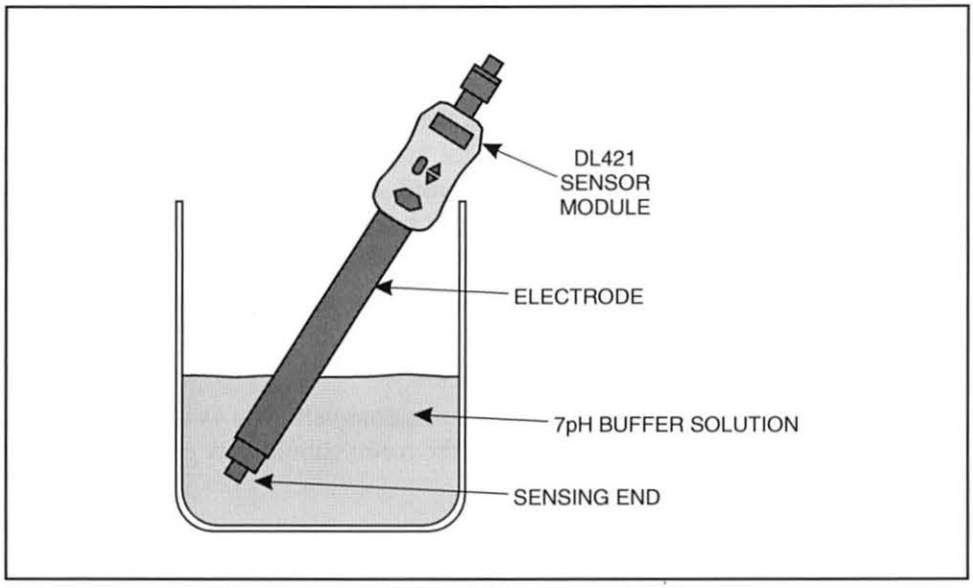

Figure 30. pH Electrode Placed in Buffer Solution (pH = 7)

Step 5: Calibrate the meter for the zero point - This involves using the programming keys on the DL421 module to enter the value of the buffer solution (7). The DL421 has automatic buffer recognition, which makes calibration easy when using standard buffer solutions.

Press and hold the CAL1 key until the display changes. This places the module in the zero calibration mode. Press the CAL1 key again for one second. This causes the module to display the closest value for the buffer. If the display does not display 7.0, use the CAL1 and CAL2 keys to increase or decrease the displayed value until it reads 7.0. After a few seconds the display should return to the online mode, displaying the pH value.

Step 6: Remove the electrode from the 7 pH buffer solution and rinse - Remove the electrode from the buffer solution and rinse the sensing end with the distilled water. Dab the sensing end with soft paper or cloth to dry it.

Step 7: Place the electrode in the second buffer solution - Completely immerse the sensing end of the electrode in the buffer solution, either 4 pH or 10 pH. Hold it there and allow it to stabilize. This may take one minute or longer.

If you use the same container for both buffer solutions, make sure to pour out the 7 pH buffer and rinse the container with distilled water before pouring the second buffer solution into the container. Failing to do so contaminates the buffer solutions and adversely affects the calibration.

Step 8: Calibrate the meter for the second point - Pressing and holding the CAL2 key causes the DL421 module to enter the slope calibration mode. Press and hold the CAL2 key again for one second. This causes the display to show the closest buffer value. If the value displayed is not correct (4.0 or 10.0), use the CAL1 and CAL2 keys to adjust the displayed value. After a few seconds, the module should return to the online mode, displaying the pH value.

Step 9: Remove the electrode from the second buffer solution and rinse - Again, remove the electrode from the buffer solution, rinse the sensing end with the distilled water, and dab it dry. Discard the buffer solution.

Once calibration is complete, you can place the electrode back in the process. The electrode and the meter should now provide reliable results.

Procedure Overview

In this procedure, you will calibrate the Honeywell DL421 pH Sensor Module using buffer solutions with a pH of 7 and 10. The 7 pH buffer is used for the zero calibration. The 10 pH buffer solution is used for slope calibration.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Locate the buffer solutions (pH of 7 and 10).

  The 7 pH buffer solution is typically green in color and the 10 pH buffer solution is typically blue in color. The other common buffer solution, 4 pH, is typically pink.

  The DL421 pH Sensor Module must be connected to a 24VDC power source. This is accomplished through the output cable. In the next step, you will connect the module to the T5554s 24VDC power supply.
- ❑ 3. Perform the following substeps to connect the DL421 pH Sensor Module to the 24VDC power supply.

  A. Make sure the output cable is connected to the module, as shown in figure 31.

  If the cable is not connected, connect it now.

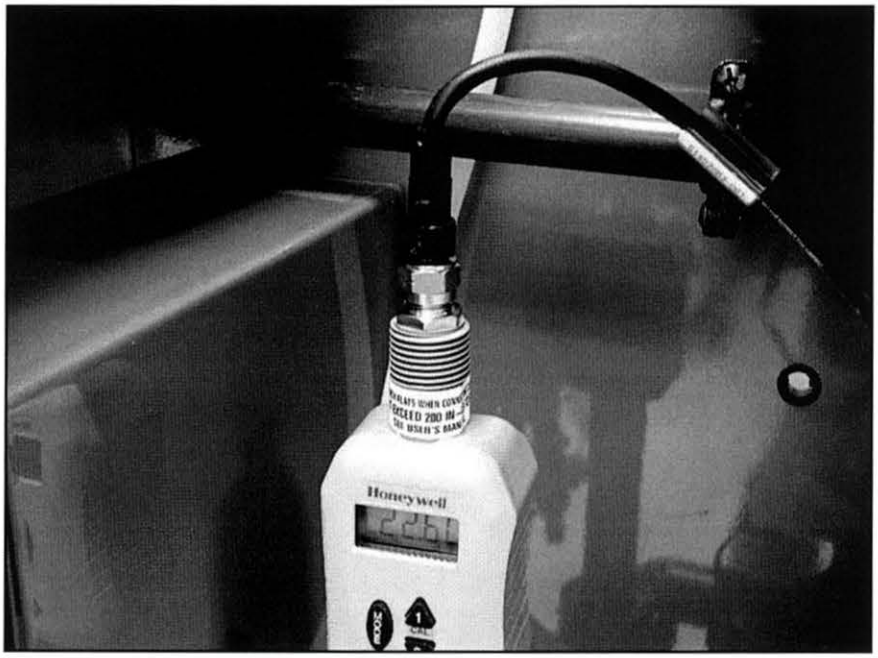

Figure 31. Output Cable Connected to the DL421 Module

B. Connect the output jacks labeled Analytical Signal to the 24VDC power supply jacks, as shown in figure 32.

This supplies 24VDC to the module through the output cable.

The transmitter module is a 2 wire transmitter and requires the external power source.

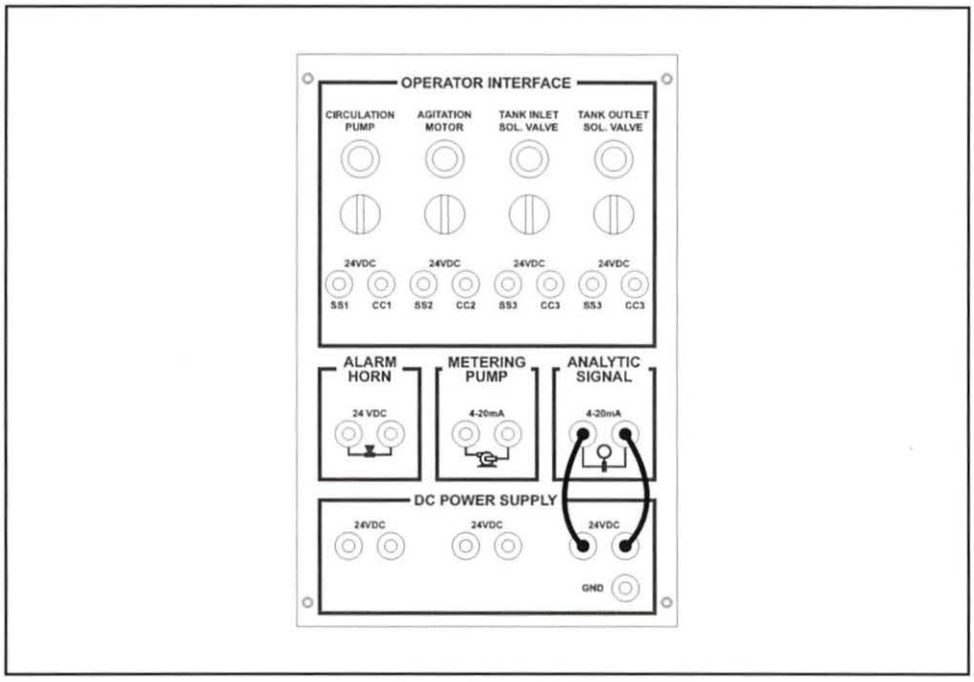

Figure 32. Connections to Supply 24VDC to DL421 Module

C. Remove the lockout/tagout and turn on the main circuit breaker.

The DL421 module should go through a short startup procedure in which varying information appears on the display. Once the startup is complete, a pH value should be displayed, similar to figure 33.

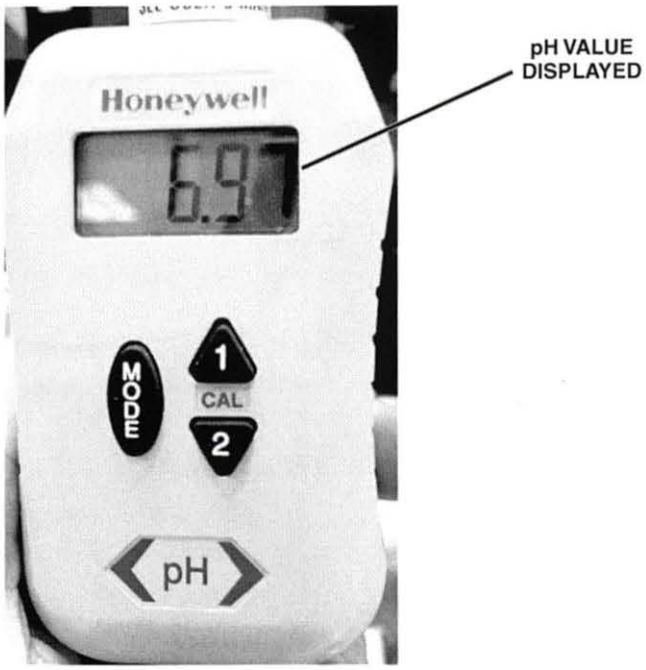

Figure 33. pH Value Displayed after Startup

❑ 4. Perform the following substeps to set the zero calibration at 7 pH for the module.

A. Locate a container, such as a beaker, and pour in about 2 inches of the 7 pH buffer solution, as shown in figure 34.

This should be enough buffer solution to completely submerge the sensing area of the electrode.

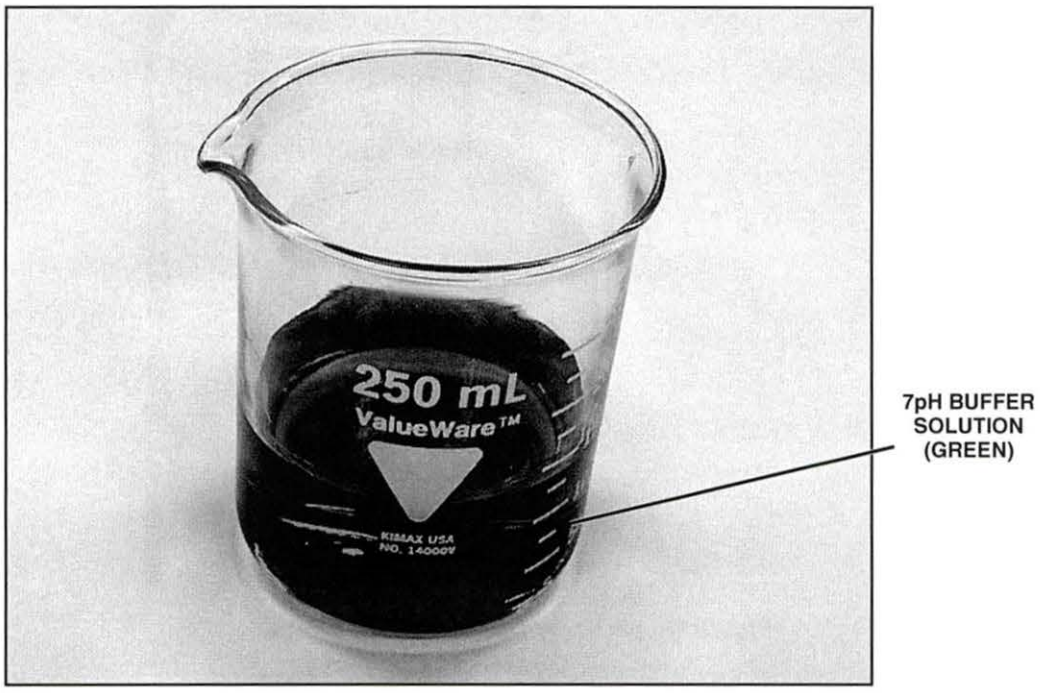

Figure 34.2 Inches of 7 pH Buffer Solution in a Container

B. Carefully remove the electrode/sensor module assembly from the T5554 process piping.

To do so, you will need to close one of the branch valves to relieve the back pressure.

C. Clean the electrode sensing end with distilled water and place the sensing end of the electrode into the buffer solution in the container, as shown in figure 35. Make sure the sensing area is completely submerged. If not, add more of the buffer solution.

You will need to hold the electrode/sensor module assembly with your hand. The electrode sensing end should remain in the solution for at least one minute to stabilize before calibrating it.

Figure 35. Sensing End of Electrode Placed into the Buffer Solution

D. With your free hand, press and hold the **CAL1** key on the sensor module, shown in figure 36, until the display changes from the pH reading.

   This sets the module to the zero calibration mode.

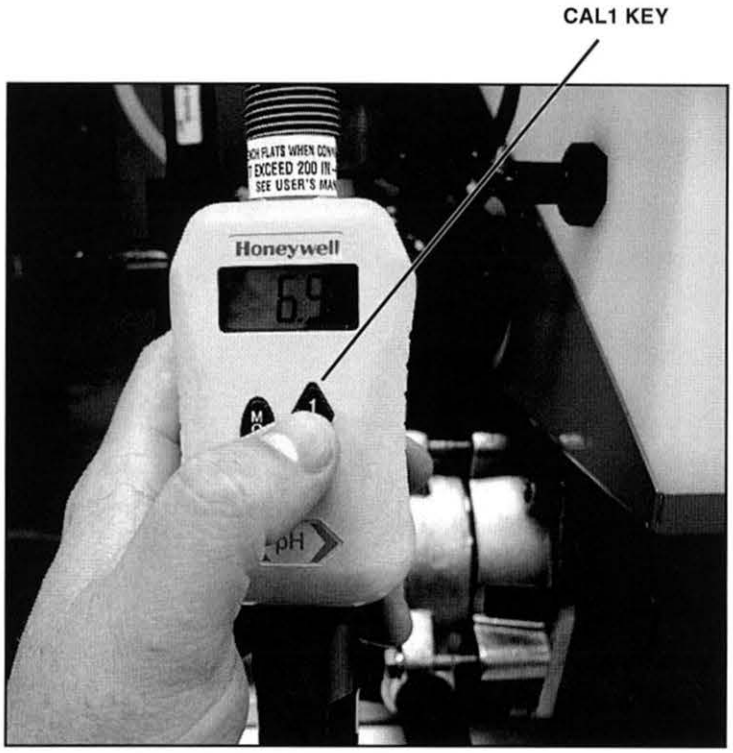

Figure 36. The CAL1 Key

E. Press the **CAL1** key again for 1 second.

   This causes SCAL to briefly appear on the display, followed by the buffer pH value.

F. If the displayed value is not 7.0, use the **CAL1** and **CAL2** keys to adjust the value until it reads **7.0**.

   While you are adjusting the value, you should notice that the value on the display blinks to indicate that the value can be adjusted. Once the value is 7.0, the display should continue to blink until you accept the setting for the zero calibration.

G. Momentarily press the **MODE** key to accept the setting for zero calibration.

The module should return to the Online mode, with the pH value of the buffer solution on the display, as shown in figure 37.

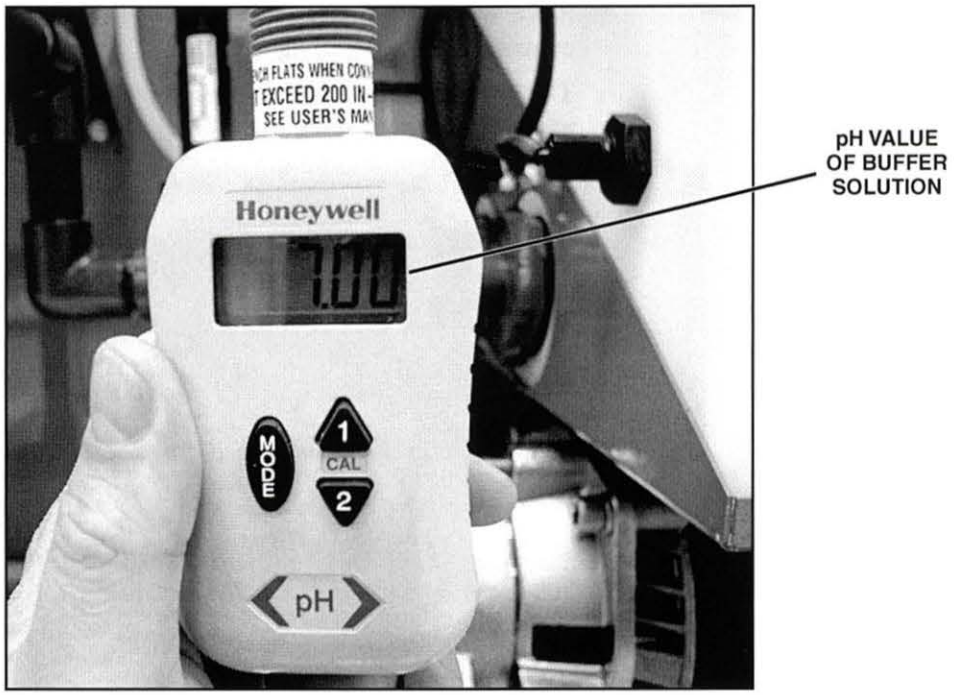

Figure 37. pH Value of Buffer Solution on Display

H. Remove the electrode from the buffer solution and rinse the sensing end with distilled water. Dab the sensing end dry with a cloth or paper towel.

I. Pour the used buffer solution from the container and rinse the container with distilled water.

Do not pour the buffer solution back into the buffer solution bottle. This may contaminate the buffer solution. Instead, dispose of the used buffer solution by pouring it down an available drain.

NOTE

The slope calibration must be performed with 10 minutes of the zero calibration. If not, the data for the zero calibration is lost and the procedure must be repeated

❑ 5. Perform the following substeps to set the slope calibration for the module.

A. Pour approximately 2 inches of the 10 pH buffer solution in the cleaned container for slope calibration.

B. Place the sensing end of the electrode into the buffer solution in the container, as shown in figure 38.

The sensing end needs to remain in the solution for more than one minute to stabilize before calibrating it.

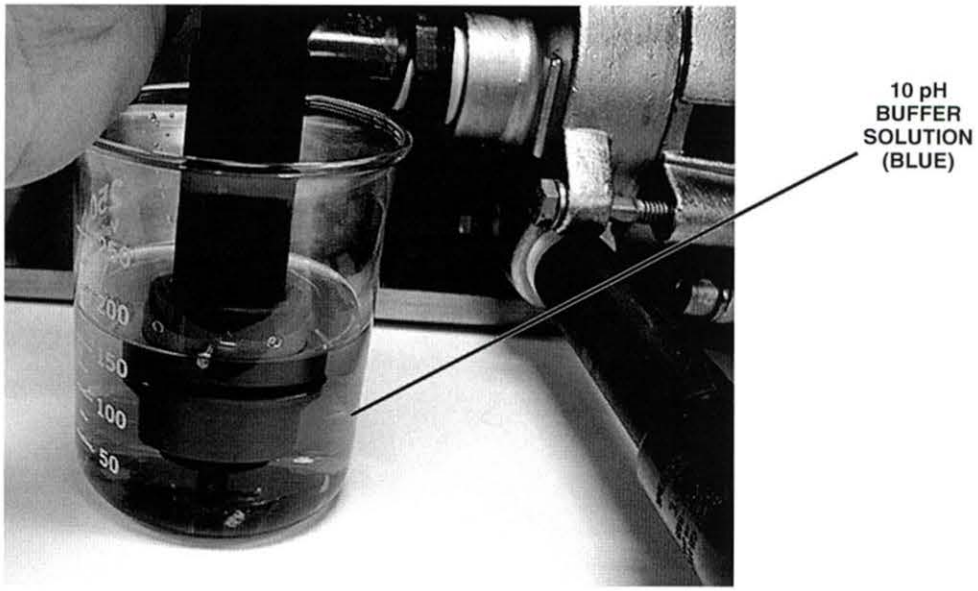

Figure 38. Sensing End of Electrode in 10 pH Buffer Solution

C. With your free hand, press and hold the **CAL2** key on the sensor module, shown in figure 39, until the display changes from the pH reading.

This sets the module to the slope calibration mode.

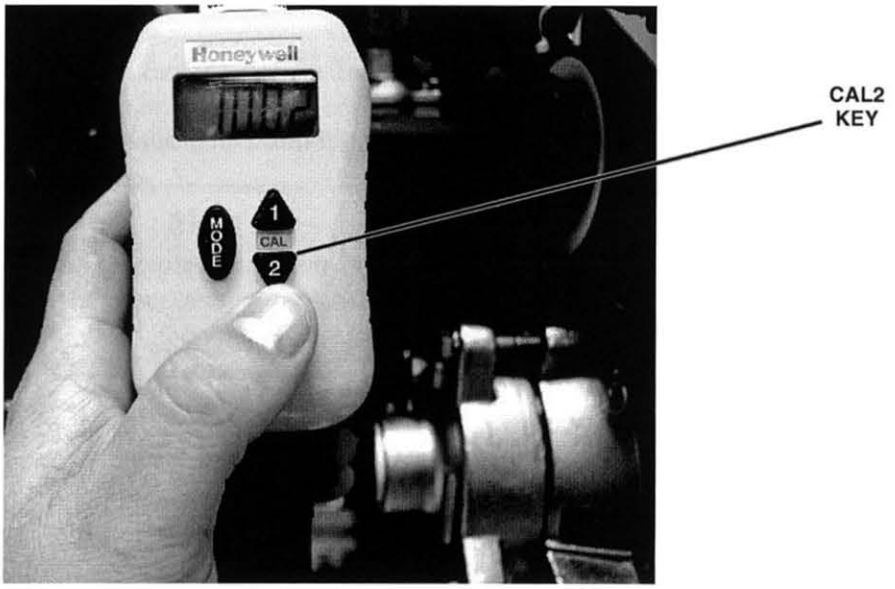

Figure 39. The CAL2 Key

D. Press the **CAL2** key again for 1 second.

This causes SCAL to briefly appear on the display, followed by the buffer pH value.

E. If the displayed value is not 10.0, use the **CAL1** and **CAL2** keys to adjust the value until it reads **10.0**.

While you are adjusting the value, you should notice that the value on the display blinks as it did when you set the zero calibration value. Once the value is 10.0, the display should continue to blink until you accept the setting for the slope calibration.

F. Momentarily press the **MODE** key to accept the setting for slope calibration.

G. Remove the electrode from the buffer solution and rinse the sensing end with distilled water. Dab the sensing end dry with a cloth or paper towel.

H. Pour the used buffer solution from the container and rinse the container with distilled water.

Do not pour the buffer solution back into the buffer solution bottle to avoid contamination. Instead, dispose of the used buffer solution by pouring it down an available drain.

❑ 6. Return the electrode/sensor module assembly to the appropriate location in the T5554 process piping and open the branch valve that was previously closed.

The value on the display of the sensor module should decrease until it settles at the pH value of the fluid in the process piping. This normally takes between 45 and 60 seconds.

❑ 7. Turn off the main circuit breaker and perform a lockout/tagout.

❑ 8. Disconnect the wires from the Operator Interface of the control panel on the T5554.

❑ 9. Return the container, buffer solutions, and other supplies to their proper storage area.

❑10. Remove the lockout/tagout.

SELF REVIEW

1. Ideally, the potential of a pH electrode in a 7 pH buffer solution is _____.

2. When using two-point calibration, the second calibration point checks the _____ of the electrode.

3. A solution's pH value changes with _____.

4. Many pH meters include _____ to compensate for temperature related shifts in an electrode's slope.

5. Proper _____ is essential to ensure that the pH measurements displayed by a pH meter are accurate.

6. You should rinse a pH electrode with _____ before placing it in a buffer solution for calibration.

SEGMENT 3

pH TRANSMITTERS

OBJECTIVE 7 DESCRIBE THE OPERATION OF THE BUILT-IN TRANSMITTER FOR THE HONEYWELL DL421 pH SENSOR MODULE

A pH meter typically includes a built-in pH transmitter that sends out a 4-20mA signal that represents the measured pH value. Typically, the output of the transmitter is scaled so that the range of 4-20mA represents a pH range of 0-14, as the graph in figure 40 shows.

This is also true of the Honeywell DL421 pH Sensor Module.

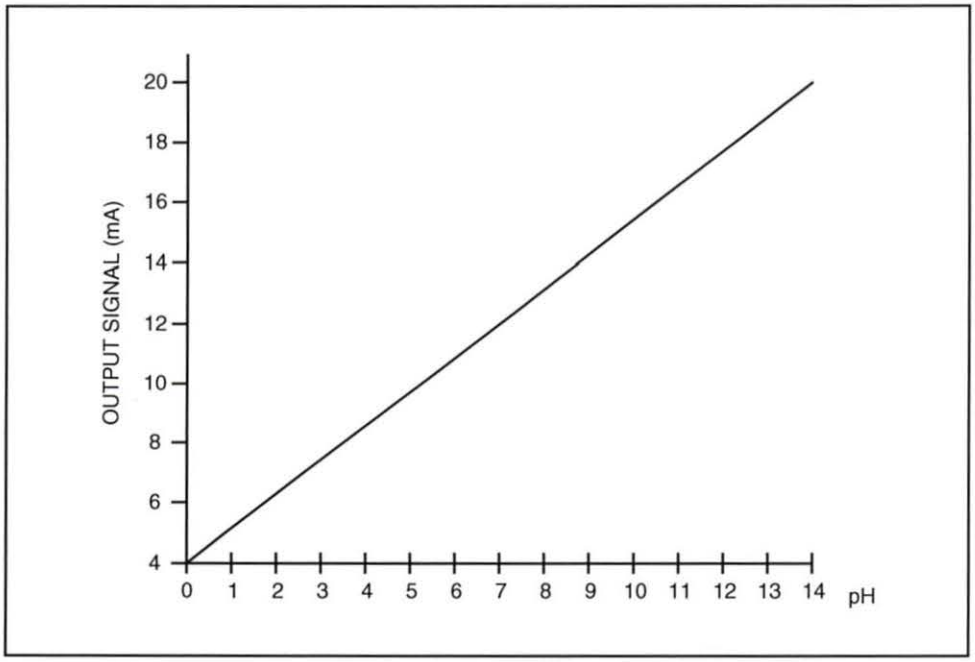

Figure 40. Transmitter Output Signal vs. pH

The DL421 pH Sensor Module includes a set of parameters that must be set to establish the value range for the transmitter. These parameters, along with the typical value or range, are shown in the table of figure 41. Once these parameters are set, the transmitter outputs the appropriate signal for the pH measurement.

OUTPUT CONFIGURATION PARAMETERS FOR DL421 pH SENSOR MODULE		
PARAMETER	**DISPLAY**	**VALUE OR RANGE**
0% Range	rnGL	0.00 pH
100% Range	rnGH	14.00 pH
0% Calibration	AdjL	3.80 – 4.40 mA
100% Calibration	AdjH	19.60 –20.40 mA

Figure 41. Output Range Parameters for the DL421 pH Sensor Module

SKILL 3 MEASURE THE TRANSMITTER OUTPUT OF THE HONEYWELL DL421 pH SENSOR MODULE WITH A MULTIMETER

Procedure Overview

In this procedure, you will measure the output from the DL421 pH Sensor Module's transmitter using a multimeter. You will then observe how the signal changes based on the measure pH.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Connect the circuit shown in figure 42 on the control panel of the T5554.

  This circuit connects the sensor module to the 24VDC power supply and connects a multimeter to measure the output signal from the transmitter of the sensor module. The multimeter should be set to measure DC milliamps (DC mA), as figure 42 shows.

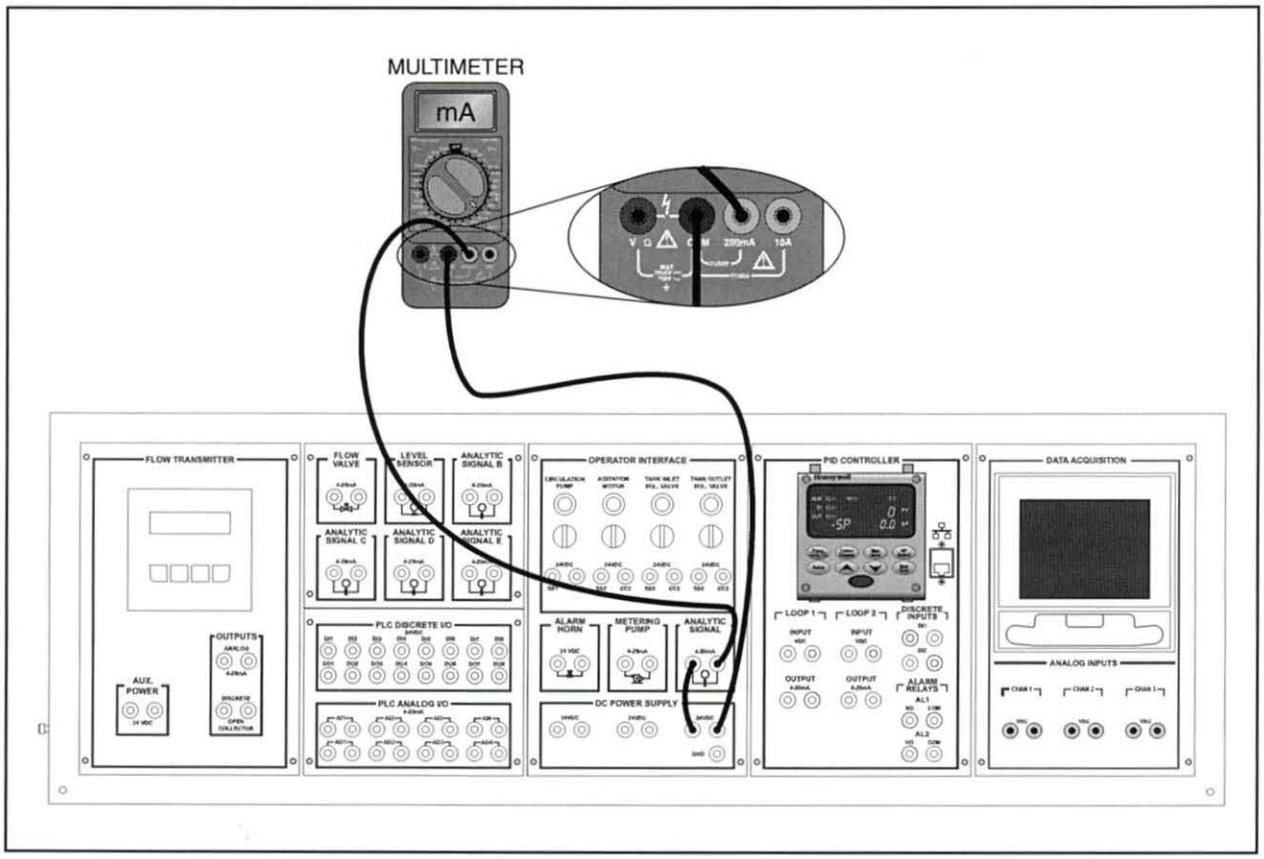

Figure 42. Circuit to Measure Output of the Transmitter

❑ 3. Locate buffer solutions of 4, 7, and 10 pH, as shown in figure 43.

Figure 43. Buffer Solutions

❑ 4. Pour about 2 inches of the 4 pH solution into a clean container.

❑ 5. Remove the electrode/sensor module assembly from the process piping of the T5554, clean the sensing end with distilled water, and place the sensing end of the electrode into the 4 pH buffer solution.

Wait one minute to allow the electrode to stabilize.

❑ 6. Remove the lockout/tagout and turn on the main circuit breaker.

This applies power to the T5554.

❑ 7. Wait until the sensor module completes the startup procedure, then record the pH reading shown on the display of the sensor module.

pH Reading _____ (pH)

You should find that the value is approximately 4.00.

The pH reading may be off slightly if the electrode's slope was previously calibrated using the 10 pH buffer solution.

❑ 8. Observe the value of the output signal on the display of the multimeter, similar to figure 44.

Output Signal _____ (mA)

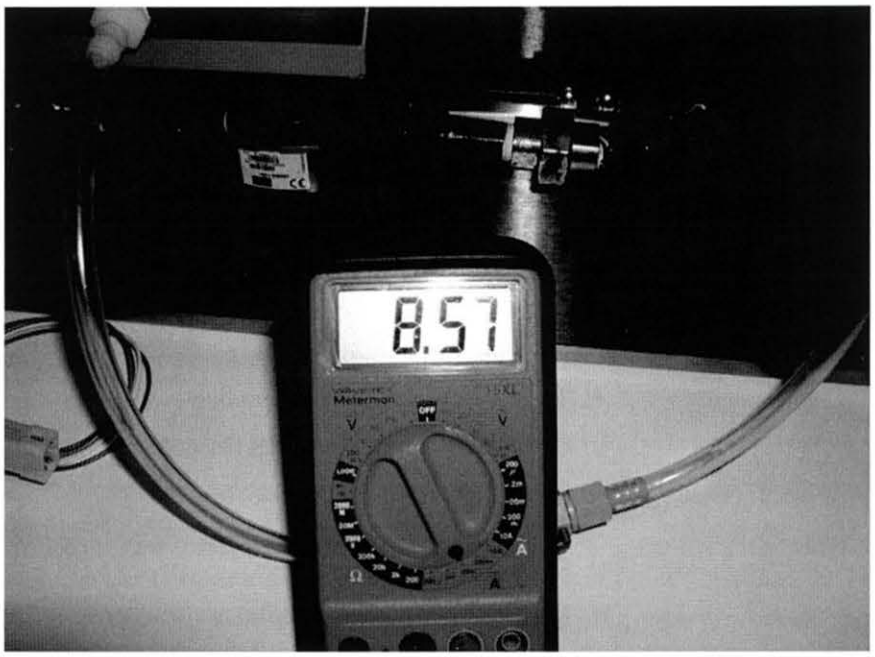

Figure 44. Output Signal Value Displayed by Multimeter

You should find that the value is approximately 8.57 mA.

This value may be off if the electrode was previously calibrated using the 10 pH buffer solution.

❑ 9. Remove the electrode from the 4 pH buffer solution and rinse the sensing end with distilled water.

❑10. Dispose of the used buffer solution and rinse the container with distilled water.

❑11. Pour about 2 inches of the 7 pH buffer solution into the container.

❑12. Place the sensing end of the electrode into the 7 pH buffer solution and hold it there for approximately one minute to allow it to stabilize.

❑13. Record the pH reading on the display of the sensor module.

pH Reading _____ (pH)

You should find that the value is approximately 7.00. If not, calibration is necessary.

❑14. Observe the value of the output signal on the display of the multimeter.

Output Signal _____ (mA)

You should find that the value is approximately 12.00 mA.

❑15. Remove the electrode from the 7 pH buffer solution and rinse the sensing end with distilled water.

❑16. Dispose of the used buffer solution and rinse the container with distilled water.

❑17. Repeat steps 11-16 using the 10 pH buffer solution.

pH Reading _____ (pH)

Output Signal _____ (mA)

You should find that the pH reading is approximately 10.00 and the value of the output signal is approximately 15.43 mA.

This reading may be off if the electrode was previously calibrated using the 4 pH buffer solution.

❑18. Perform the following substeps to shut down the T5554.

A. Turn off the main circuit breaker and perform a lockout/tagout.

B. Disconnect the circuit from the control panel.

C. Return the electrode/sensor module assembly to the process piping of the T5554.

D. Remove the lockout/tagout.

E. Return the container and the multimeter to the proper storage area.

SEGMENT 3

SELF REVIEW

1. The DL421 pH Sensor Module includes a built-in pH transmitter that sends out a(n) _____ signal that represents the measured pH value.

2. Typically, the output of the transmitter is scaled so that the range of 4-20mA represents a pH range of _____.

3. For the DL421 pH sensor, the 0% Range parameter is indicated by _____ on the display.

4. The DL421 pH Sensor Module includes a set of _____ that must be set to establish the value range for the transmitter.

5. The 0% calibration parameter for the DL421 pH Sensor Module has a range of 3.80 -_____ mA.

6. The 100% calibration parameter for the DL421 Sensor Module has a range of _____ - 20.40 mA.

SEGMENT 4

HONEYWELL DL421 pH SENSOR MODULE DIAGNOSTICS

OBJECTIVE 8 — DESCRIBE THE FUNCTION OF THE DIAGNOSTICS OF THE HONEYWELL DL421 pH SENSOR MODULE

Due to advances in technology, many pH meters today include diagnostic functions that help an operator or technician to diagnose problems with the device. This is true of the Honeywell DL421 pH Sensor Module.

The DL421 Sensor Module has a diagnostic program that monitors the electrode to which it is connected. The diagnostic program also monitors the internal electronics of the sensor module and the programmed parameters. When a problem occurs, the diagnostic program detects it and information concerning the problem appears on the display of the sensor module, as shown in figure 45.

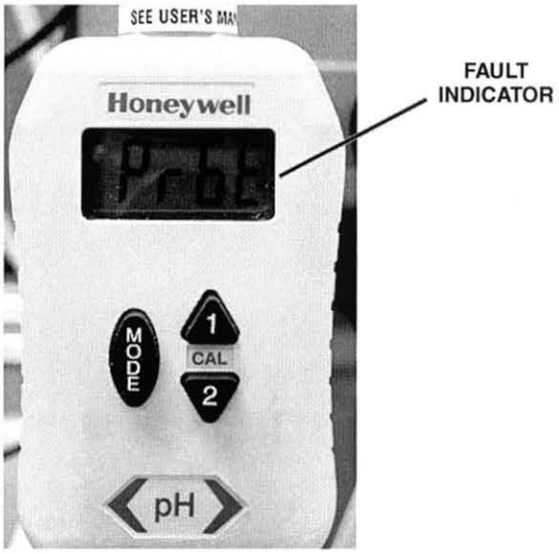

Figure 45. Fault Indicated on the Display

OBJECTIVE 9 DESCRIBE HOW TO VIEW DIAGNOSTIC INFORMATION USING THE HONEYWELL DL421 pH SENSOR MODULE

When a fault occurs, the display of the sensor module alternately displays the measured pH and the fault text. For example, if the probe becomes defective, a probe error occurs and the display alternates between the pH value and the text message PrbE, similar to figure 46.

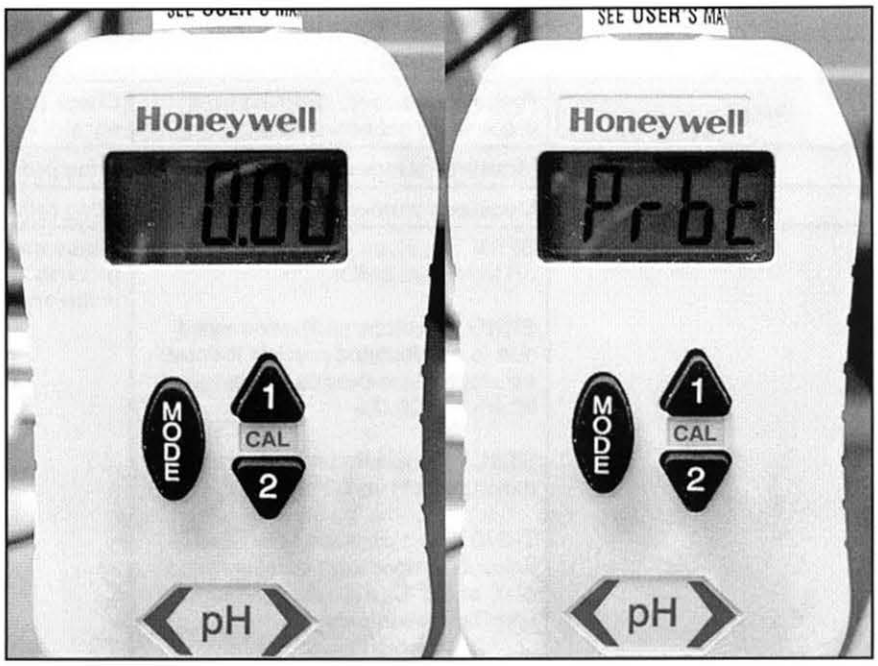

Figure 46. Display Alternates Between pH Measurement (Left) and Text Message (right)

The user manual for the Honeywell DL421 pH Sensor Module includes a troubleshooting table, similar to figure 47, that identifies each of the diagnostic text messages, their description, and the corrective action to take.

TROUBLESHOOTING TABLE FOR DL421 pH SENSOR MODULE		
DISPLAY	**DESCRIPTION**	**CORRECTIVE ACTION**
CNFG	Data error detected	Reset unit or cycle power
FALT	Unit electronics are defective	Replace electronic module
P HI	Measured pH is > 14.00	Bring process within limits
P LO	Measured pH is < 0.00	Bring process within limits
PRBE	Probe is defective, removed from process, or not connected	Check probe, connection, and presence of sample
T HI	Measured temperature is > 110°C	Bring process within limits
T LO	Measured temperature is < -10°C	Bring process within limit
FAIL	**BFRS** The slope buffer is less than 2 pH from zero buffer. **SRNG** The slope calibration failed due to a calculated percent theoretical slope value outside the range of 80.0% to 105.0% **STBL** The calibration failed due to measured pH instability **TRNG** The calibration failed due to solution temperature outside range of 0° to 50° C (Auto Buffer Recognition Calibration only) **ZRNG** The zero standard calibration failed due to calculated zero offset value outside the range of -2.00 to 2.00 pH	These errors abort the calibration process. Press MODE to return to online mode.

Figure 47. Troubleshooting Table

If the temperature value or pH value goes out of range, the Sensor Module drives the output current to 21.8mA as well as displaying a fault code on the display (T HI or T LO for temperature and P HI or P LO for pH). Driving the output current to 21.8mA indicates to the control device that a problem exists with the electrode or the sensor module and causes an alarm condition in the control device.

Some of the faults require a unit reset for the sensor module. Pressing the CAL1 and CAL2 keys simultaneously initiates a unit reset. During the reset process, rSEt appears on the sensors modules display and remains until the process is complete. Once the reset process is complete, the module returns to the online mode with the pH value displayed.

When a reset occurs, the system parameters are returned to their default settings, which are shown in figure 48.

FACTORY DEFAULT VALUES FOR DL421 pH SENSOR MODULE	
PARAMETER	**DEFAULT VALUE**
Zero Offset	0.00 pH
Slope	100.0%
Online Temperature	°C
Buffer Group Selection	US
Solution Temperature Coefficient Selection	0.00 pH @ 10° C
Noise Suppression Frequency Selection	60 Hz
Output Configuration – 0% Range Value	0.00 pH
Output Configuration – 100% Range Value	14.00 pH
Output Configuration – 0% Calibration	4.00 mA
Output Configuration – 100% Calibration	20.00 mA

Figure 48. Factory Defaults Values

If problems occur during calibration, a unit reset is recommended before attempting to calibrate the unit again.

SEGMENT 4

SELF REVIEW

1. Many pH meters today include _____ functions that help an operator or technician to diagnose problems with the device.

2. The diagnostic program of the DL421 Sensor Module monitors the electrode, the internal electronics of the module, and the _____.

3. When a problem occurs, the diagnostic program detects it and information concerning the problem appears on the _____ of the sensor module.

4. When a fault occurs, the display of the sensor module alternately displays the _____ and the fault text.

5. If the display of the sensor module flashes CNFG, a _____ is detected.

6. When a reset occurs, the system parameters are returned to their _____ settings.

7. If the temperature value or pH value goes out of range, the Sensor Module drives the output current to _____ mA.