Instruction Manual
PN 51-FCL/rev.G
January 2006

Model FCL

Free Chlorine Measuring System

ROSEMOUNT® Analytical

EMERSON™ Process Management

ESSENTIAL INSTRUCTIONS

READ THIS PAGE BEFORE PROCEEDING!

Your purchase from Rosemount Analytical, Inc. has resulted in one of the finest instruments available for your particular application. These instruments have been designed, and tested to meet many national and international standards. Experience indicates that its performance is directly related to the quality of the installation and knowledge of the user in operating and maintaining the instrument. To ensure their continued operation to the design specifications, personnel should read this manual thoroughly before proceeding with installation, commissioning, operation, and maintenance of this instrument. If this equipment is used in a manner not specified by the manufacturer, the protection provided by it against hazards may be impaired.

- Failure to follow the proper instructions may cause any one of the following situations to occur: Loss of life; personal injury; property damage; damage to this instrument; and warranty invalidation.
- Ensure that you have received the correct model and options from your purchase order. Verify that this manual covers your model and options. If not, call 1-800-854-8257 or 949-757-8500 to request correct manual.
- For clarification of instructions, contact your Rosemount representative.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Use only qualified personnel to install, operate, update, program and maintain the product.
- Educate your personnel in the proper installation, operation, and maintenance of the product.
- Install equipment as specified in the Installation section of this manual. Follow appropriate local and national codes. Only connect the product to electrical and pressure sources specified in this manual.
- Use only factory documented components for repair. Tampering or unauthorized substitution of parts and procedures can affect the performance and cause unsafe operation of your process.
- All equipment doors must be closed and protective covers must be in place unless qualified personnel are performing maintenance.
- If this equipment is used in a manner not specified by the manufacturer, the protection provided by it against hazards may be impaired.

WARNINGS

RISK OF ELECTRICAL SHOCK

□ Equipment protected throughout by double insulation.

- Installation of cable connections and servicing of this product require access to shock hazard voltage levels.
- Main power and relay contacts wired to separate power source must be disconnected before servicing.
- Do not operate or energize instrument with case open!
- Signal wiring connected in this box must be rated at least 240 V.
- Non-metallic cable strain reliefs do not provide grounding between conduit connections! Use grounding type bushings and jumper wires.
- Unused cable conduit entries must be securely sealed by non-flammable closures to provide enclosure integrity in compliance with personal safety and environmental protection requirements. Unused conduit openings must be sealed with NEMA 4X or IP65 conduit plugs to maintain the ingress protection rating (NEMA 4X).
- Electrical installation must be in accordance with the National Electrical Code (ANSI/NFPA-70) and/or any other applicable national or local codes.
- Operate only with front and rear panels fastened and in place over terminal area.
- Safety and performance require that this instrument be connected and properly grounded through a three-wire power source.
- Proper relay use and configuration is the responsibility of the user.

CAUTION

This product generates, uses, and can radiate radio frequency energy and thus can cause radio communication interference. Improper installation, or operation, may increase such interference. As temporarily permitted by regulation, this unit has not been tested for compliance within the limits of Class A computing devices, pursuant to Subpart J of Part 15, of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area may cause interference, in which case the user at his own expense, will be required to take whatever measures may be required to correct the interference.

WARNING

This product is not intended for use in the light industrial, residential or commercial environments per the instrument's certification to EN50081-2.

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QUICK START GUIDE

FOR MODEL FCL ANALYZER

1. Refer to Section 2.0 for installation instructions, and Section 3.0 for wiring instructions.
2. Once connections are secured and verified, apply power to the analyzer.
3. When the analyzer is powered up for the first time, **Quick Start** screens appear. Using **Quick Start** is easy.
   a. A blinking field shows the position of the cursor.
   b. Use the ◀ or ▶ key to move the cursor left or right. Use the ▲ or ▼ key to move the cursor up or down or to increase or decrease the value of a digit. Use the ▲ or ▼ key to move the decimal point.
   c. Press ENTER to store a setting. Press EXIT to leave without storing changes. Pressing EXIT also returns the display to the previous screen.

```
English        Fran ais
Espa ol              >>
```

4. Choose the desired language. Choose **>>** to show more choices.

```
# of sensors?
One                 Two
```

5. This screen appears if you have Model FCL-02 (free chlorine and pH). Choose **two**.

   If you have Model FCL-01 (free chlorine only), the screen does not appear.

```
S1 Chlorine Type
free      total      >>
```

6. Choose **free** for sensor 1.

```
S2 Measure?          pH
Redox               ORP
```

7. Choose **pH** for sensor 2. If you have Model FCL-01 (free chlorine only), this screen does not appear.

```
Temperature in?
 C                    F
```

8. Choose temperature units.

9. The main display appears. The outputs and alarms are assigned to default values.

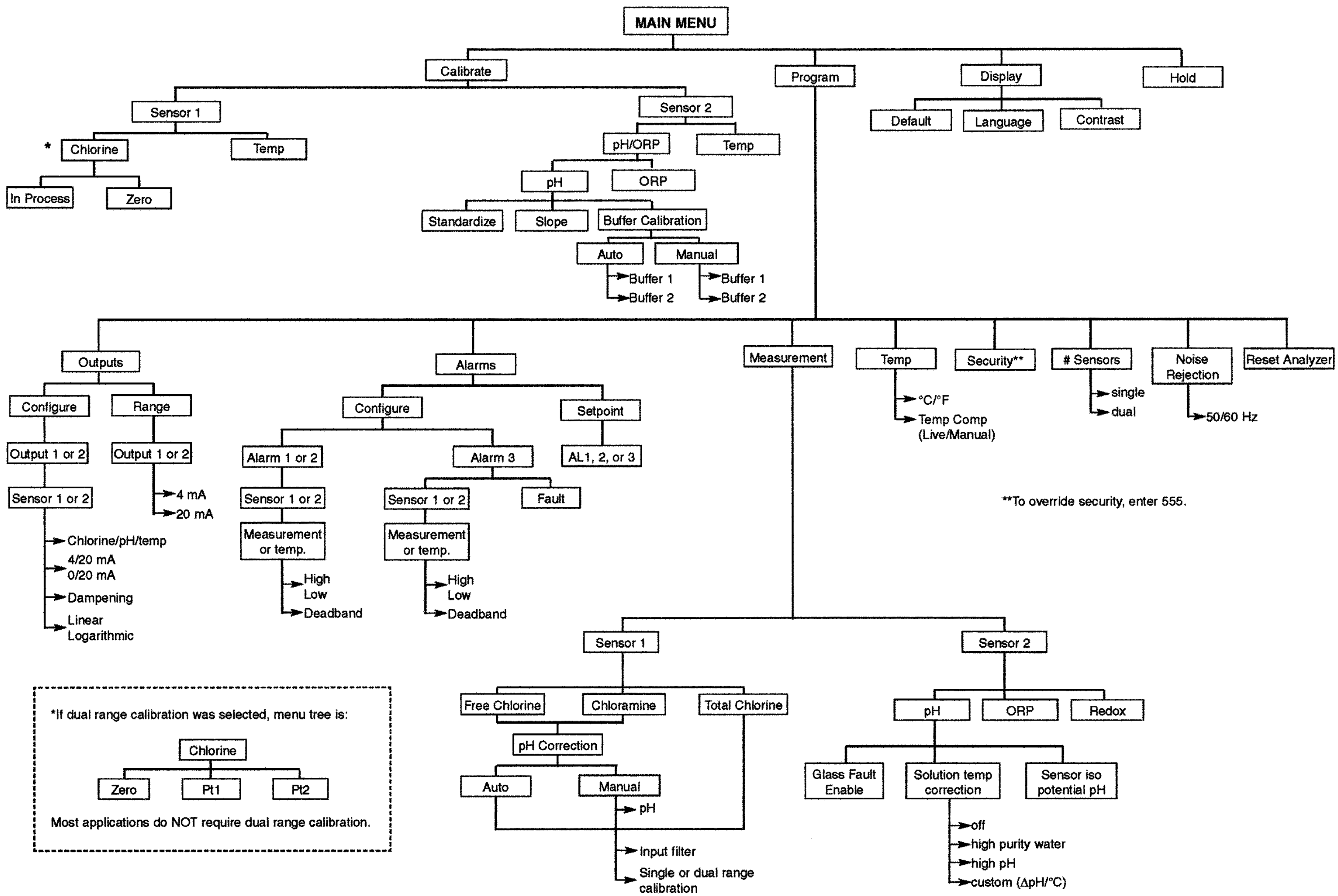
10. Configure the analyzer for automatic or manual pH correction. Go to the main menu and choose **Program** followed by **Measurement**. Choose **Sensor 1** then **Free Chlorine**. If you have Model FCL-01 (free chlorine only), choose **Manual**. In the next screen, enter the pH of the process liquid. If you have Model FCL-02 (free chlorine and pH), choose **Auto**.

11. To change outputs, alarms, and temperature-related settings, go to the main menu and choose **Program**. Follow the prompts. For a guide to the Program menu, see the menu tree on the following page.

12. To return the analyzer to the default settings, choose **Reset Analyzer** in the Program menu.

QUICK REFERENCE GUIDE

MENU TREE FOR CHLORINE/pH MEASUREMENTS



MODEL FCL
SYSTEM FOR THE DETERMINATION OF FREE CHLORINE

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About This Document

This manual contains instructions for installation and operation of the Model FCL Free Chlorine Measuring System.

The following list provides notes concerning all revisions of this document.

Rev. Level	Date	Notes
A	2/03	This is the initial release of the product manual. The manual has been reformatted to reflect the Emerson documentation style and updated to reflect any changes in the product offering.
B	4/03	Updated CE certification
C	6/03	Revisions throughout to reflect product modification.
D	12/03	Add text to Section 8.1
E	10/04	Revised dimensional and exploded view drawings.
F	1/05	Revise low flow cell wetted materials specs
G	1/06	Revised wetted parts specs

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SECTION 1.0. DESCRIPTION AND SPECIFICATIONS

1.1 FEATURES
1.2 SPECIFICATIONS
1.3 ORDERING INFORMATION AND ACCESSORIES

- COMPLETE SYSTEM INCLUDES sensor, connecting cable, analyzer, and flow controller
- CONTINUOUS pH CORRECTION eliminates expensive and messy reagents and troublesome sample conditioning systems
- MEASURES FREE CHLORINE IN SAMPLES having pH as high as 9.5 [1]
- VARIOPOL QUICK-DISCONNECT FITTINGS make replacing sensors easy
- FEATURE-PACKED ANALYZER: dual outputs, three fully-programmable alarm relays, two-line display

[1] *In some cases, the sensor can be used in samples having pH as great as 10.0. Consult the factory.*

1.1 FEATURES

The Model FCL free chlorine system is intended for the determination of free chlorine in fresh water. Unlike free chlorine analyzers from other manufacturers, the Model FCL does not use expensive sample conditioning systems or messy reagents to control pH. Instead, the analyzer automatically compensates for changes in the pH of the sample. The Model FCL is not intended for the determination of total chlorine or combined chlorine (like monochloramine). Nor, can the FCL be used for the determination of chlorine in seawater.

APPLICATIONS

The Model FCL uses a membrane-covered amperometric sensor. A polarizing voltage applied to a platinum cathode behind the membrane reduces the chlorine diffusing through the membrane and keeps the concentration of chlorine in the sensor equal to zero. The current generated by the cathode reaction is proportional to the rate of diffusion of chlorine through the membrane. Because the concentration of chlorine in the sensor is zero, the diffusion rate and the current are proportional to the concentration of chlorine in the sample.

There is a difficulty, however. Amperometric free chlorine sensors measure only hypochlorous acid. Because free chlorine is a pH-dependent mixture of hypochlorous acid and hypochlorite ion, a change in pH will cause the sensor response to change even though the free chlorine level remained constant. Most manufacturers solve the problem by treating the sample with acid, which lowers the pH and converts hypochlorite ion into hypochlorous acid. The Model FCL avoids the expense and inconvenience of sample conditioning by measuring the pH and applying a correction to the raw chlorine sensor signal. The correction is valid between pH 6.0 and 9.5. For samples having pH between 9.5 and 10.0, consult the factory.

The Model FCL is available in two options: Model FCL-01 with manual pH correction and Model FCL-02 with continuous pH correction. Choose the FCL-01 if the pH varies less than 0.2 or if pH changes are predictable or seasonal. Choose the FCL-02 if the pH varies more than 0.2. To provide the continuous pH correction, the Model FCL-02 requires a separate pH sensor.

Maintenance is fast and easy. Replacing a membrane requires no special tools or fixtures. A screw cap holds the pre-tensioned membrane in place. Replacing the electrolyte solution takes only minutes.

The Model FCL includes the easy-to-use Model 1055 analyzer. The analyzer features two fully programmable 4-20 mA outputs and three fully programmable relays. The backlit, two line display allows the user to read sample pH and chlorine concentration at a glance.

Valves, rotameters, and pressure regulators to control sample flow are things of the past with the Model FCL. A constant head overflow sampler ensures the correct sample flow to each sensor. To eliminate wiring hassles, quick-disconnect Variopol cable is standard.

Stable free chlorine standards do not exist. The chlorine sensor must be calibrated using the results of a laboratory test run on a grab sample.

1.2 SPECIFICATIONS — GENERAL

Sample requirements:

Pressure: 3 to 65 psig (122 to 549 kPa abs)

A check valve in the inlet prevents the sensor flow cells from going dry if sample flow is lost. The check valve opens at 3 psig (122 kPa abs). If the check valve is removed, minimum pressure is 1 psig (108 kpa abs).

Temperature: 32 to 122°F (0 to 50°)

Minimum Flow: 3 gal/hr (11 L/hr)

Maximum flow: 80 gal/hr (303 L/hr); high flow causes the overflow tube to back up

Sample Conductivity: >50 µS/cm at 25°C

Process connection: 1/4-in OD tubing compression fitting (can be removed and replaced with barbed fitting for soft tubing)

Drain connection: 3/4-in barbed fitting. Sample must drain to open atmosphere

Wetted parts:

Overflow sampler and flow cell: acrylic, polycarbonate, Kynar®[1], nylon, silicone

Chlorine sensor: Noryl®[2], Viton®[3], wood, silicone, polyethersulfone, polyester, and platinum

pH sensor: Tefzel®[4], Viton, glass, ceramic

Response time to step change in chlorine concentration: <80 sec to 95% of final reading for inlet sample flow of 3 gph (11 L/hr)

Weight/shipping weight:

Model FCL-01: 10 lb/13 lb (4.5 kg/6.0 kg)

Model FCL-02: 11 lb/14 lb (5.0 kg/6.5 kg)

[rounded to the nearest 1 lb. (0.5 kg)]

SPECIFICATIONS — SENSOR

Free chlorine range: 0 to 10 ppm as Cl_2. For higher ranges, consult the factory.

pH correction range: 6.0 to 9.5. For samples having pH between 9.5 and 10.0, consult the factory. For manual pH correction, choose option -01. For continuous pH correction choose option -02.

Accuracy: Accuracy depends on the accuracy of the chemical test used to calibrate the sensor.

Electrolyte volume: 25 mL (approx.)

Electrolyte life: 3 months (approx.); for best results replace electrolyte monthly.

SPECIFICATIONS — ANALYZER

Case: ABS, NEMA 4X

Display: Two-line, 16-character, back-lit. Character height: 4.8 mm.

Languages: English, German, Italian, Spanish, French, Portuguese

Ambient temperature and humidity: 0 to 50°C (32 to 122°F); RH 5 to 95% (con-condensing)

The analyzer can be operated between -20 and 60°C (-4 to 140°F) with some degradation in display performance.

Power: 115/230Vac ± 15%, 50/60 Hz ± 6%, 8.0 W. Installation category II.

□ Equipment protected throughout by double insulation.

Ordinary Location:

12RN

POLLUTION DEGREE 2: Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.

RFI/EMI: EN-61326

LVD: EN-61010-1

Outputs: Two 4-20 mA or 0-20 mA isolated outputs. Continuously adjustable. Linear or logarithmic. Maximum load 600 ohms. Output dampening with time constant of 5 sec is user-selectable.

Alarms: Three alarm relays for process measurement(s) or temperature. Alarm 3 can be configured as a fault alarm, instead of a process alarm. Each relay can be configured independently. Alarm logic (high or low activation) and deadband are user-programmable.

Relays: Form C, single pole double throw, epoxy sealed

	Resistive	Inductive
28 Vdc	5.0 A	3.0 A
115 Vac	5.0 A	3.0 A
230 Vac	5.0 A	1.5 A

[1] *Kynar is a registered trademark of Elf Atochem North America.*

[2] *Noryl is a registered trademark of General Electric.*

[3] *Viton is a registered trademark of E.I. duPont de Nemours & Co.*

[4] *Tefzel is a registered trademark of E.I. duPont de Nemours & Co.*

1.3 ORDERING INFORMATION

Model FCL Free Chlorine Measuring System. The FCL is a complete system for the determination of free chlorine in aqueous samples. It consists of the sensor(s), analyzer, and constant head overflow cup to control sample flow. All components are mounted on a backplate. Model option -02 includes a pH sensor for continuous, automatic pH correction. Three replacement membranes and a 4-oz. bottle of electrolyte solution are shipped with each sensor.

MODEL FCL	FREE CHLORINE MEASURING SYSTEM
CODE	**pH CORRECTION (required selection)**
01	Without continuous pH correction
02	With continuous pH correction
FCL-02	**EXAMPLE**

COMPONENT PARTS

ANALYZER MODEL	DESCRIPTION
1055-01-11-24-68	1055 analyzer, single input (chlorine), wall mount, 115/230 Vac
1055-01-11-24-32-68	1055 analyzer, dual input (chlorine and pH), wall mount, 115/230 Vac

SENSOR MODEL	DESCRIPTION
499ACL-01-54-VP	Free chlorine sensor with Variopol connector
399VP-09-305	pH sensor with Variopol connector

SENSOR CABLE	DESCRIPTION
23747-04	Interconnecting cable, Variopol for 499ACL sensor, 4 ft
23645-08	Interconnecting cable, Variopol for 399VP sensor, 4 ft

ACCESSORIES

PART #	DESCRIPTION
9240048-00	Tag, stainless steel (specify marking)

SECTION 2.0.
INSTALLATION

2.1 UNPACKING AND INSPECTION
2.2 INSTALLATION

2.1 UNPACKING AND INSPECTION

Inspect the shipping container. If it is damaged, contact the shipper immediately for instructions. Save the box. If there is no apparent damage, unpack the container. Be sure all items shown on the packing list are present. If items are missing, notify Rosemount Analytical immediately.

2.1.1 MODEL FCL-01 (free chlorine without continuous pH correction)

Model FCL-01 consists of the following items mounted on a back plate.

1. Model 1055-01-13-24 analyzer with sensor cable attached.
2. Constant head overflow sampler with flow cell for chlorine sensor.

The free chlorine sensor (Model 499ACL-01-54-VP), three membrane assemblies, and a bottle of electrolyte solution are in a separate package.

2.1.2 MODEL FCL-02 (free chlorine with continuous pH correction)

Model FCL-02 consists of the following items mounted on a back plate.

1. Model 1055-01-13-24-32 analyzer with sensor cables attached.
2. Constant head overflow sampler with flow cells for pH and chlorine sensors.
3. Stand to hold pH buffer solution during calibration.

The free chlorine sensor (Model 499ACL-01-54-VP), shipped with three membrane assemblies and a bottle of electrolyte solution, and the Model 399VP-09-305 pH sensor are in separate packages.

2.2 INSTALLATION

2.2.1 General Information

1. Although the system is suitable for outdoor use, do not install it in direct sunlight or in areas of extreme temperature.
2. To keep the analyzer enclosure watertight, install plugs (provided) in the unused cable openings.
3. Install the system in an area where vibrations and electromagnetic and radio frequency interference are minimized or absent.
4. Be sure there is easy access to the analyzer and sensors.

2.2.2 Sample Requirements

Be sure the sample meets the following requirements:

1. Temperature: 32 to 122ºF (0 to 50ºC)
2. Pressure: 3 to 65 psig (122 to 549 kPa abs)
3. Minimum flow: 3 gal/hr (11 L/hr)

2.2.3 Mounting, Inlet, and Drain Connections

The Model FCL is intended for wall mounting only. Refer to Figure 2-1 or 2-2 for details. The sensor(s) screw into the flow cell adapters as shown in the figures. For Model FCL-02 (free chlorine with continuous pH adjustment), the pH sensor must be installed as shown in Figure 2-2.

A 1/4-inch OD tubing compression fitting is provided for the sample inlet. If desired, the compression fitting can be removed and replaced with a barbed fitting. The fitting screws into a 1/4-inch FNPT check valve. The check valve prevents the sensor flow cells from going dry if sample flow is lost.

The sample drains through a 3/4-inch barbed fitting. Attach a piece of soft tubing to the fitting and allow the waste to drain open atmosphere. Do not restrict the drain line.

Remove the foam packing insert between the outer tube and the inner overflow tube. Adjust the sample flow until the water level is even with the central overflow tube and excess water is flowing down the tube.

2.2.4 Electrical Connections

Refer to Section 3.1 for details.

2.2.5 Installing the Sensor(s)

The Model FCL is provided with sensor cables pre-wired to the analyzer. Connect the chlorine sensor (Model 499ACL-01-54-VP) to the cable labeled CL. Connect the pH sensor (Model 399VP-09-305) to the cable labeled pH. The terminal end of the sensor is keyed to ensure proper mating with the cable receptacle. Once the key has slid into the mating slot, tighten the connection by turning the knurled ring clockwise.

The sensor(s) screw into the plastic fitting(s), which are held in the flow cell(s) by the union nut. Do not remove the protective cap on the sensor(s) until ready to put the sensor(s) in service.

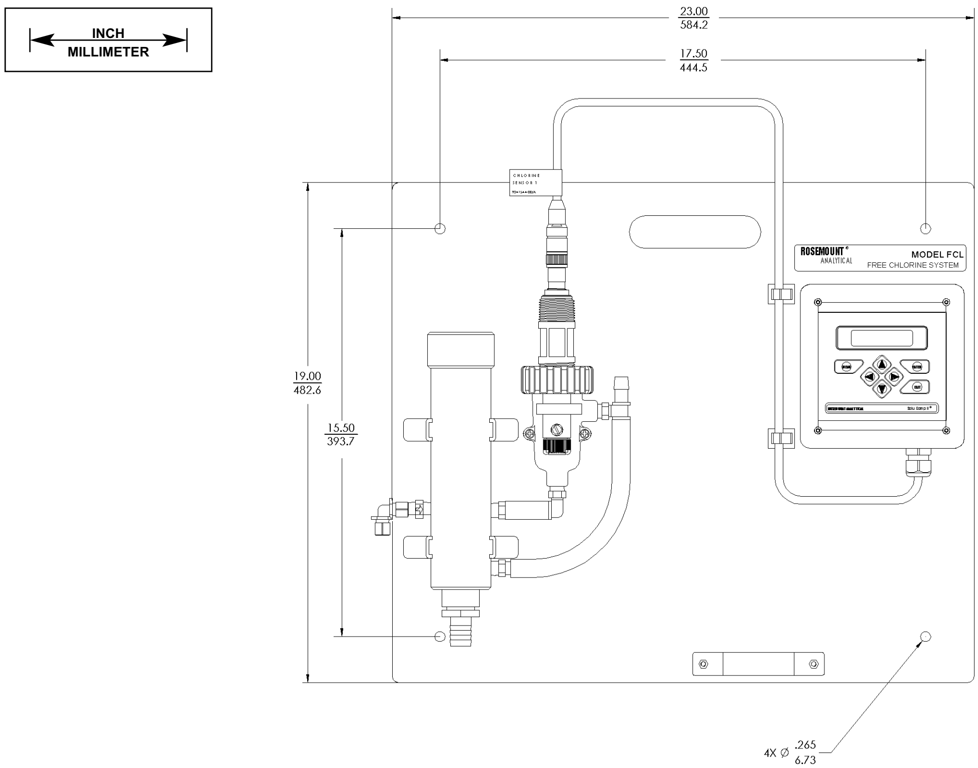

FIGURE 2-1. Model FCL-01

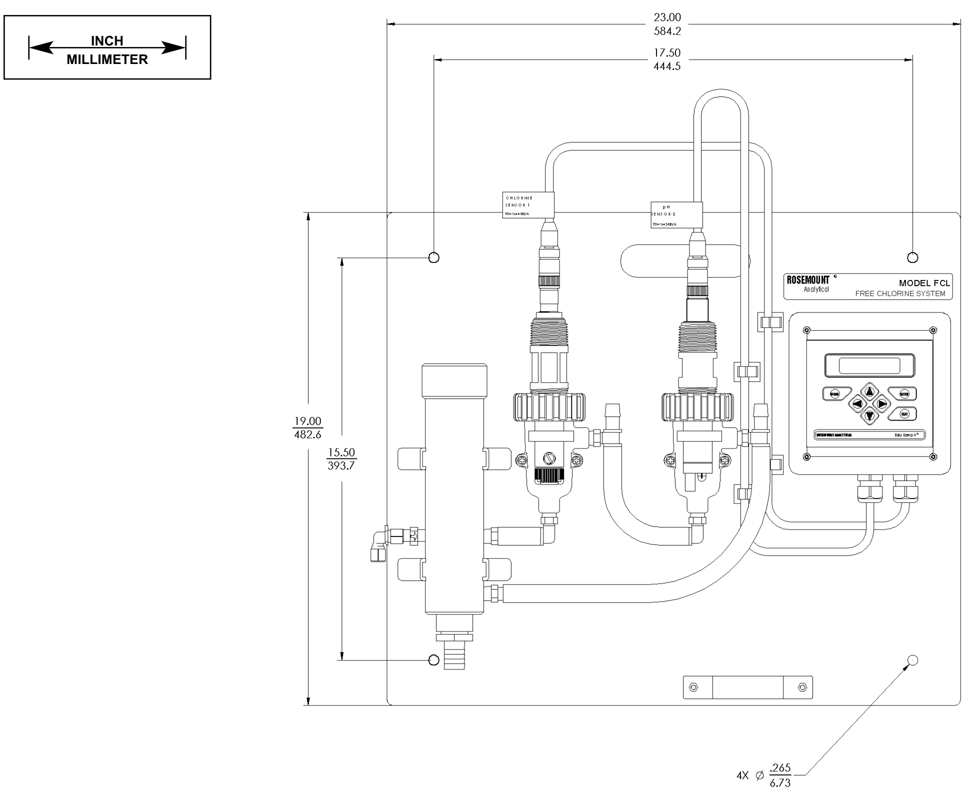

FIGURE 2-2. Model FCL-02

SECTION 3.0.
WIRING

3.1 POWER, ALARM, AND OUTPUT WIRING
3.2 SENSOR WIRING

3.1 POWER, ALARM, AND OUTPUT WIRING

See Figure 3-1 for identification of power, alarm, and output terminals. Note that the sensors are already wired to the analyzer.

AC power wiring should be 14 gauge or greater. Run the power wiring through the conduit opening nearest the power terminal (TB1). Provide a switch or breaker to disconnect the analyzer from the main power supply. Install the switch or breaker near the analyzer and label it as the disconnecting device for the analyzer.

Keep output signal wiring separate from power wiring. Do run signal and power wiring in the same conduit or close together in a cable tray.

For best EMI/RFI protection use shielded output signal cable enclosed in an earth-grounded metal conduit. Connect the shield to earth ground at TB1-4.

Keep output wiring at least one foot from high voltage conductors.

To reduce stress on the wiring connections, do not remove the hinged front panel from the base while installing wiring. Be sure the leads are sufficiently long to avoid stress on the conductors.

WARNING:
RISK OF ELECTRICAL SHOCK

AC connections and grounding must be in compliance with UL 508 or local electrical code. DO NOT apply power to the analyzer until all electrical connections are verified and secure.

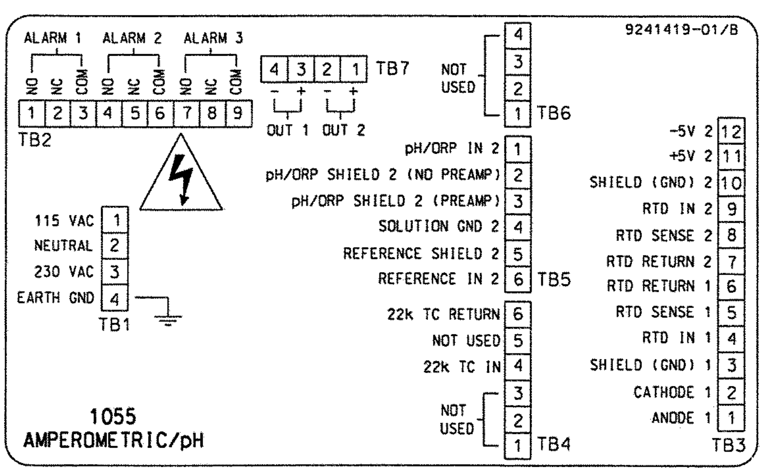

Figure 3-1. Wiring connections.

3.2 SENSOR WIRING

The Model FCL is provided with sensor cables pre-wired to the analyzer.

If it is necessary to replace the cable, refer to the wiring diagrams below. Figure 3-2 is the sensor wiring diagram for Model FCL-01 (free chlorine sensor only). Figure 3-3 is the sensor wiring diagram for Model FCL-02 (free chlorine and pH sensor). The jumper (PN 23980-00) between TB3-1 (anode) and TB5-6 (pH reference) in Figure 3-3 is an integral part of the circuit. **It must be installed as shown.**

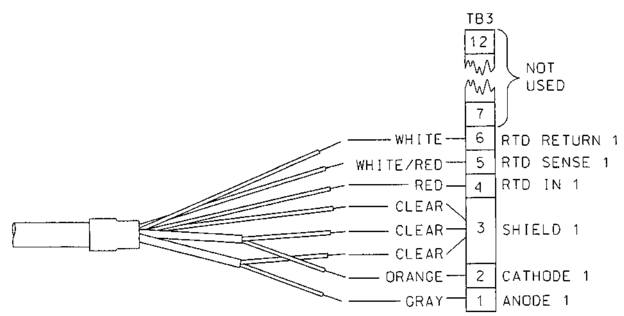

Figure 3-2. Wiring diagram for chlorine sensor.

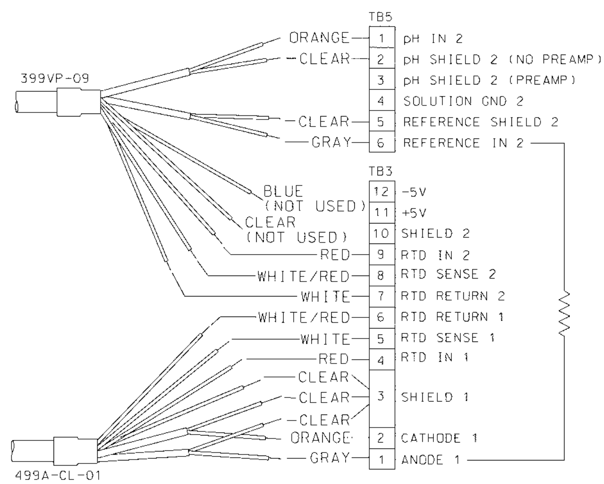

Figure 3-3. Wiring diagram for chlorine pH sensor combination.

SECTION 4.0
DISPLAY AND OPERATION

4.1 DISPLAY
4.2 KEYPAD
4.3 PROGRAMMING AND CALIBRATING THE ANALYZER - TUTORIAL
4.4 SECURITY
4.5 USING HOLD

4.1. DISPLAY

The Model FCL analyzer has a two-line display. The display can be customized to meet user requirements (see Section 5.11). Figure 4-1 shows some of the displays. View A is the default screen for Model FCL-02 (chlorine and pH sensor). View C is the default screen for Model FCL-01 (chlorine sensor only).

The FCL analyzer has information screens that supplement the data in the main display. Press or to view the information screens. **The last information screen is the software version.**

During calibration and programming, key presses cause different displays to appear. The displays are self-explanatory and guide the user step-by-step through the procedure.

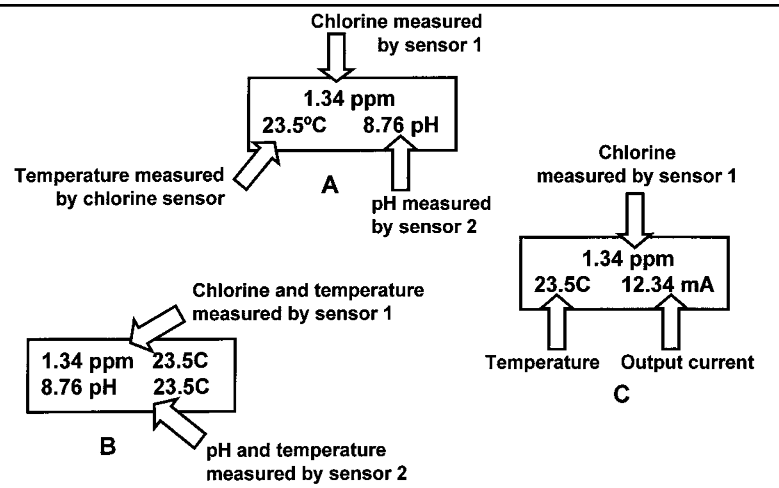

FIGURE 4-1. Displays During Normal Operation

Screen A shows chlorine and pH. The temperature shown is the temperature measured by the chlorine sensor. Screen B shows chlorine and pH and the temperature measured by each sensor. Screen C shows the data for the chlorine sensor only.

4.2 KEYPAD

Figure 4-2 shows the keypad.

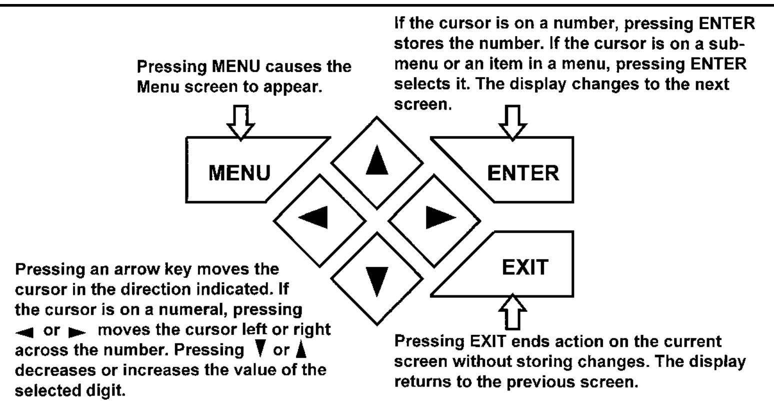

FIGURE 4-2. FCL Analyzer Keypad

Four arrow keys move the cursor around the screen. A blinking word or numeral show the position of the cursor. The arrow keys are also used to change the value of a numeral. Pressing ENTER stores numbers and settings and moves the display to the next screen. Pressing EXIT returns to the previous screen without storing changes. Pressing MENU always causes the main menu screen to appear. Pressing MENU followed by EXIT causes the main display to appear.

4.3 PROGRAMMING AND CALIBRATING THE ANALYZER - TUTORIAL

Setting up and calibrating the FCL is easy. The following tutorial describes how to move around in the programming menus. For practice, the tutorial also describes how to assign chlorine values to the 4 and 20 mA outputs for sensor 1 (free chlorine sensor).

```
Calibrate          Hold
Program         Display
```

1. If the MENU screen (shown at the left) is not already showing, press MENU. **Calibrate** is blinking, which means the cursor is on **Calibrate**.

```
Calibrate          Hold
Program         Display
```

2. To assign values to current outputs, the **Program** sub-menu must be open. Press ▼. The cursor moves to **Program** (**Program** blinking). Press ENTER. Pressing ENTER opens the **Program** sub-menu.

```
Outputs          Alarms
Measurement          >>
```

3. The **Program** sub-menu permits the user to set outputs, alarms, automatic or manual temperature compensation, and a security code. When the sub-menu opens, **Outputs** is blinking, which means the cursor is on Outputs. Press ▼ or ▶ (or any arrow key) to move the cursor around the display. Move the cursor to **>>** and press ENTER to cause a second screen with more program items to appear. There are three screens in the **Program** menu. Pressing **>>** and ENTER in the third screen causes the display to return to the first screen (**Outputs**, **Alarms**, **Measurement**).
4. For practice, assign values to the 4 and 20 mA outputs for sensor 1. Move the cursor to **Outputs** and press ENTER.

```
Output Range
Output Configure
```

5. The screen shown at left appears. The cursor is on **Output Range** (blinking). Output range is used to assign values to the low and high current outputs. Press ENTER.

```
Output Range?
Output1         Output2
```

6. The screen shown at left appears. The FCL has two outputs, output 1 and output 2. Move the cursor to the desired output and press ENTER. For purposes of the example, choose **Output 1**.

```
Out1 S1 Range?
4mA            00.00ppm
```

7. The screen shown at left appears. **Out1 S1** in the top line means output 1 (**Out1**) is assigned to sensor 1 (**S1**). Either output can be assigned to either sensor (sensor and output assignments are made under the **Output Configure** menu shown in step 5). Use the **Out1 S1 Range?** screen to assign a chlorine concentration to the **4 mA** output.
   a. Use the arrow keys to change the concentration to the desired value. Press ◀ or ▶ to move the cursor from digit to digit. Press ▲ or ▼ to increase or decrease the value of the digit. Holding ▲ or ▼ down causes the numeral to continuously scroll up or down.
   b. To move the decimal point, press ◀ or ▶ until the cursor is on the decimal point. Press ▲ to move the decimal point to the right. Press ▼ to move the decimal point to the left.
   c. Press ENTER to store the setting.

```
Out1 S1 Range?
20mA           20.00ppm
```

8. The screen shown at left appears. Use this screen to assign a full scale chlorine concentration to the **20 mA** output. Use the arrow keys to change the chlorine to the desired value. Press ENTER to store the setting.

```
Output Range?
Output1         Output2
```

9. The screen shown at left appears. To assign values to the low and high currents for output 2, select **Output 2** and follow the prompts.
10. To return to the main menu, press MENU. To return to the main display press MENU then EXIT, or press EXIT repeatedly until the main display appears. To return to the previous display press EXIT.

NOTE
To store values or settings, press ENTER before pressing EXIT.

4.4 SECURITY

4.4.1 How the Security Code Works

Use the security code to prevent accidental or unwanted changes to program settings, displays, and calibration.

Enter Security	
Code	**000**

Invalid Code

1. If a security code has been programmed, pressing MENU causes the security screen to appear.
2. Enter the three-digit security code.
3. If the entry is correct, the main menu screen appears. If the entry is incorrect, the **Invalid Code** screen appears. The **Enter Security Code** screen reappears after 2 seconds.

4.4.2 Bypassing the Security Code

Enter 555. The main menu will open.

4.4.3 Setting a Security Code

See Section 5.6.

4.5 USING HOLD

4.5.1 Purpose

The analyzer output is always proportional to measured pH or chlorine. To prevent unwanted alarms and improper operation of control systems or dosing pumps, place the analyzer in hold before removing the sensor for calibration and maintenance. Be sure to remove the analyzer from hold once calibration is complete. During hold, both outputs remain at the last value. **Once in hold, the analyzer remains there indefinitely.** While in hold, the screen shown to the left appears periodically.

Hold

4.5.2 Using the Hold Function

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

Calibrate	**Hold**
Program	Display

Hold Outputs and		
Alarms?	**Yes**	No

1. Press MENU. The main menu screen appears. Choose **Hold**.
2. The **Hold Outputs and Alarms ?** screen appears. Choose **Yes** to place the analyzer in hold. Choose **No** to take the analyzer out of hold.
3. The main display screen will appear.

SECTION 5.0
PROGRAMMING THE ANALYZER

5.1 GENERAL
5.2 CHANGING STARTUP SETTINGS
5.3 CONFIGURING AND RANGING THE OUTPUTS
5.4 CONFIGURING ALARMS AND ASSIGNING SETPOINTS
5.5 SELECTING THE TYPE OF CHLORINE MEASUREMENT
5.6 CHOOSING TEMPERATURE UNITS AND MANUAL OR AUTOMATIC TEMPERATURE COMPENSATION
5.7 SETTING A SECURITY CODE
5.8 NOISE REJECTION
5.9 SINGLE SENSOR OR DUAL SENSOR INPUT
5.10 RESETTING FACTORY CALIBRATION AND FACTORY DEFAULT SETTINGS
5.11 SELECTING A DEFAULT SCREEN, LANGUAGE, AND SCREEN CONTRAST

5.1 GENERAL

This section describes how to do the following:

1. configure and assign values to the current outputs
2. configure and assign setpoints to the alarm relays
3. choose the type of chlorine measurement being made
4. choose temperature units and manual or automatic temperature mode
5. set a security code
6. tell the analyzer the frequency of the ac power (needed for optimum noise rejection)
7. tell the analyzer the number of sensors being used
8. reset the analyzer to factory calibration and default settings
9. select a default display screen

Default settings are shown in Table 5-1 on the following page. To change a default setting, refer to the section listed in the table. To reset default settings, see Section 5.10.

5.2 CHANGING STARTUP SETTINGS

When the Model FCL analyzer is powered up for the first time, Quick Start screens appear, which enable the user to quickly configure the analyzer for free chlorine (Model FCL-01) or for free chlorine and pH (Model FCL-02). Because the analyzer can be used to measure other chlorine compounds, it must be specifically configured to measure free chlorine. If incorrect settings were entered at startup, enter the correct settings now. Refer to Section 5.9 to change the number of sensors. Refer to Section 5.5 to configure the analyzer to measure free chlorine and pH.

FOR BEST RESULTS, ENTER THE NUMBER OF SENSORS BEING USED (SECTION 5.9), AND IDENTIFY FREE CHLORINE FOR SENSOR 1 AND pH FOR SENSOR 2 (SECTION 5.5) BEFORE MAKING OTHER PROGRAM SETTINGS.

TABLE 5-1. DEFAULT SETTINGS

1. SENSOR-OUTPUT ASSIGNMENTS

Model	Output 1	Output 2	Section
FCL-01	chlorine	temperature	5.3 and 5.9
FCL-02	chlorine (sensor 1)	pH (sensor 2)	5.3 and 5.9

2. OTHER OUTPUT SETTINGS

Output	Dampening	0 or 4 mA	Mode	Section
1	off	4	Linear	5.3
2	off	4	Linear	5.3

3. OUTPUT RANGES

Measurement	Range	Section
free chlorine - ppm	0 to 20 ppm	5.3
pH	0 to 14	5.3
Temperature	0 to 100°C	5.3

4. ALARM CONFIGURATION

	Alarm			If AL3 is a sensor alarm	Section
	1	2	3		
FCL-01	chlorine	temperature	fault	chlorine	5.4
FCL-02	chlorine	pH	fault	temperature	5.4
High or low	high	high	NA	high	5.4

5. ALARM SETPOINTS

	High	Low	Deadband	Section
Chlorine	20.00	0.00	0.00	5.4
pH	14.00	0.00	0.00	5.4
Temperature	100.0	0.0	0.0	5.4

TABLE 5-1. DEFAULT SETTINGS (continued)

6. TEMPERATURE RELATED SETTINGS

		Section
Units	°C	5.6
Automatic temperature compensation (chlorine)	On	5.6
Automatic temperature compensation (pH)	On	5.6

7. MISCELLANEOUS SETTINGS

		Section
Language	English	5.11
Hold	off	4.5
Security code	000 (no security code)	5.7
ac power frequency	60 Hz	5.8

5.3 CONFIGURING AND RANGING THE OUTPUTS.

5.3.1 Purpose

The Model FCL analyzer has two current outputs. This section describes how to configure and range the outputs. **CONFIGURE THE OUTPUTS FIRST.**

1. Configuring an output means
   a. Selecting either a 4-20 mA or 0-20 mA output,
   b. Assigning a sensor and a measurement (free chlorine or pH) to output 1 and output 2,
   c. Turning on or turning off output current dampening,
   d. Choosing a linear or logarithmic output.
2. Ranging the outputs means assigning values to the low (0 or 4 mA) and high (20 mA) outputs.

5.3.2 Definitions

1. CURRENT OUTPUTS. The analyzer provides either a continuous 4-20 mA or 0-20 mA output current directly proportional to chlorine concentration or pH.
2. ASSIGNING OUTPUTS. Figure 5-1 shows the ways in which the outputs can be assigned.
3. DAMPEN. Output dampening smooths out noisy readings. It also increases the response time of the output. With output dampening the time to reach 63% of final reading following a step change is 5 sec. Output dampening does not affect the response time of the display.
4. MODE. The current output can be made directly proportional to the displayed value (linear mode) or directly proportional to the common logarithm of the displayed value (log mode).

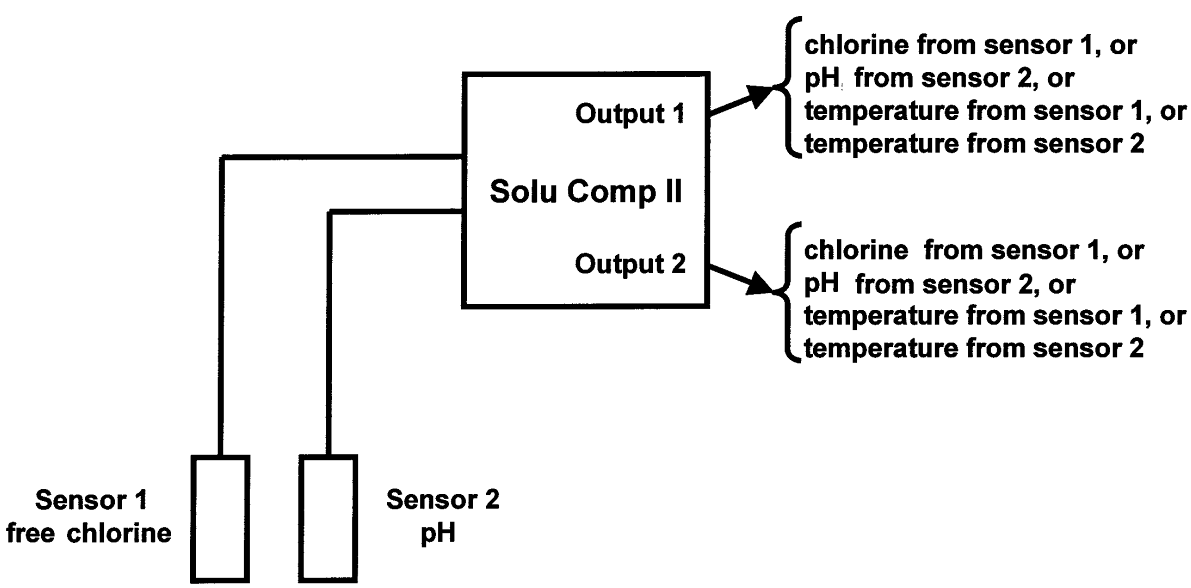

FIGURE 5-1. Assigning Outputs 1 and 2

5.3.3. Procedure: Configure Outputs.

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

```
Calibrate         Hold
Program        Display
```

```
Outputs         Alarms
Measurement         >>
```

```
Output Range
Output Configure
```

```
Output Config?
Output1        Output2
```

```
OutM is for?
Sensor1        Sensor2
```

```
OutM is for?
Measurement       Temp
```

1. Press MENU. The main menu screen appears. Choose **Program**.
2. Choose **Outputs**.
3. Choose **Output Configure**.
4. Choose **Output1** or **Output2**.
5. Choose **Sensor1** (chlorine) or **Sensor2** (pH). Either sensor can be assigned to either output.
6. Choose **Measurement** or **Temp**. If the output selected was assigned to Sensor 1, **Measurement** means chlorine. If the output selected was assigned to Sensor 2, **Measurement** means pH.
7. Make the appropriate settings:
   a. Choose **4-20 mA** or **0-20 mA**.
   b. Choose **Yes** or **No** for output dampening.
   c. Choose **Linear** or **Log** output.
8. The display returns to the **Output Config?** screen. Select the other output or press EXIT to return to the previous screen. To return to the main display, press MENU followed by EXIT.

5.3.4. Procedure: Assigning Values to the Low and High Current Outputs (Output Ranging)

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

```
Calibrate         Hold
Program        Display
```

```
Outputs         Alarms
Measurement         >>
```

```
Output Range
Output Configure
```

1. Press MENU. The main menu screen appears. Choose **Program**.
2. Choose **Outputs**.
3. Choose **Output Range**. Choose **Output1** or **Output2**.
4. Make the appropriate settings.
   a. Assign a value to the low current (**0 mA** or **4 mA**) output.
   b. Assign a value to the high current (**20 mA**) output.
5. The display returns to the **Output Range** screen. Select the other output or press EXIT to return to the previous screen. To return to the main display, press MENU followed by EXIT.

5.4 CONFIGURING ALARMS AND ASSIGNING SETPOINTS

5.4.1 Purpose

This section describes how to do the following:

1. assign an alarm relay to a sensor,
2. set the alarm logic to high or low,
3. assign values to the alarm setpoints,
4. set the alarm deadbands.

ALARM RELAYS MUST BE CONFIGURED BEFORE ASSIGNING SETPOINTS.

5.4.2 Definitions

1. ASSIGNING ALARMS. There are three alarms (**AL1**, **AL2**, and **AL3**). Alarms 1 and 2 can be assigned to either sensor. For example, **AL1** and **AL2** can be assigned to sensor 1 with, perhaps, one alarm configured as a high alarm and the other as a low alarm, and **AL3** can be assigned to sensor 2. Alarm 3 can be assigned to either sensor or used as a fault alarm. The fault alarm activates when a fault exists in a sensor or the analyzer.
2. FAULT ALARM. A fault condition exists when the Model FCL analyzer detects a problem with a sensor or with the analyzer that is likely to cause seriously erroneous readings. If Alarm 3 was programmed as a fault alarm, the alarm 3 relay will activate. The word **Fault** will appear alternately in the display with the reading.
3. ALARM LOGIC, SETPOINTS, AND DEADBANDS. See Figures 5-2 and 5-3.

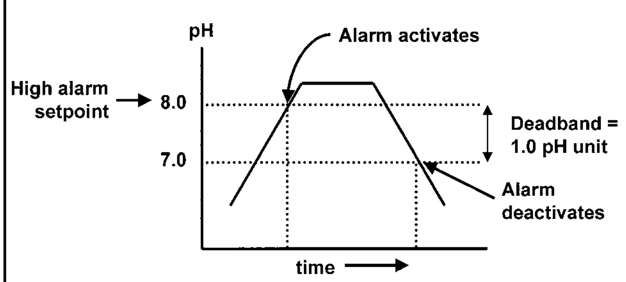

FIGURE 5-2. High Alarm Logic

The alarm activates when the pH exceeds the high setpoint. The alarm remains activated until the reading drops below the value determined by the deadband.

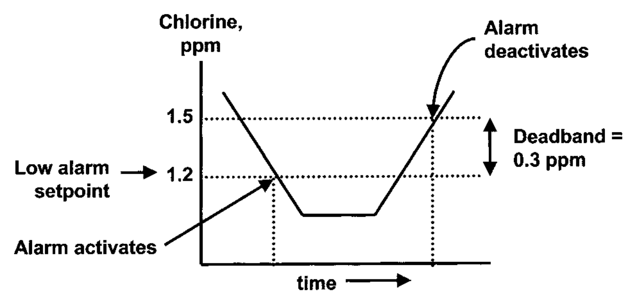

FIGURE 5-3. Low Alarm Logic

The alarm activates when the chlorine concentration drops below the low setpoint. The alarm remains activated until the reading increases above the value determined by the deadband.

Alarm relays are single pole-double throw (SPDT). When an alarm is activated, the coil is energized.

When an alarm activates, **AL1**, **AL2**, or **AL3** (as appropriate) appears periodically in the display.

5.4.3 Procedure: Configuring Alarms

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

Calibrate	Hold
Program	Display

1. Press MENU. The main menu screen appears. Choose **Program**.

Outputs	**Alarms**
Measurement	>>

2. Choose **Alarms**.

Alarm Setpoints
Alarm Configure

3. Choose **Alarm Configure**.

Alarm Config?		
AL1	AL2	AL3

4. Choose Alarm 1 (**AL1**), Alarm 2 (**AL2**), or Alarm 3 (**AL3**).

AL1 is for?	
Sensor1	Sensor2

AL1 S1 is for?	
Measurement	Temp

5. For **AL1** or **AL2**
   a. Choose **Sensor 1** (chlorine) or **Sensor 2** (pH).
   b. Choose **Measurement** or **Temp**.
   c. Choose **High** or **Low**.
   d. Set the alarm **Deadband**.

6. The display returns to the **Alarm Configure?** screen. Select another alarm or press EXIT to return to the previous screen. To return to the main display, press MENU followed by EXIT.

AL3 is for?	**Fault**
Sensor1	Sensor2

7. For **AL3**
   a. Choose **Sensor1** (chlorine), **Sensor2** (pH), or **Fault**.
   b. For sensor 1 or 2, choose **Measurement** or **Temp**.
   c. Choose **High** or **Low**. Set the deadband.
   d. Choosing **Fault** means **AL3** will activate when a sensor or analyzer fault exists. There is no user setting to make.

8. The display returns to the **Alarm Configure?** screen. Select another alarm or press EXIT to return to the previous screen. To return to the main display, press MENU followed by EXIT.

5.4.4 Procedure: Programming Alarm Setpoints

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

```
Calibrate          Hold
Program         Display
```

1. Press MENU. The main menu screen appears. Choose **Program**.

```
Outputs          Alarms
Measurement          >>
```

2. Choose **Alarms**.

```
Alarm Setpoints
Alarm Configure
```

3. Choose **Alarm Setpoints**.

```
Select Alarm?
AL1        AL2      AL3
```

4. Choose Alarm 1 **(AL1**), Alarm 2 (**AL2**), or Alarm 3 (**AL3**).

```
AL1 S1 Setpoint?
High          20.00ppm
```

5. The display shows the alarm selected (**AL1**) and the configuration. The alarm is for Sensor 1 (**S1**), and the logic is high. Use the arrow keys to change the alarm setpoint.

6. The display returns to the **Select Alarm?** screen. Select another alarm or press EXIT to return to the previous screen. To return to the main display, press MENU followed by EXIT.

5.5 SELECTING THE TYPE OF CHLORINE MEASUREMENT

5.5.1 Purpose

This section describes how to do the following:

1. Program the analyzer to measure free chlorine (and pH). This step is necessary because the Model FCL analyzer can be used with other sensors to measure other chlorine oxidants. It can also be used to measure ORP (oxidation reduction potential). When used in the Model FCL, the analyzer should be programmed to measure either free chlorine (FCL-01) or free chlorine and pH (FCL-02).
2. Set automatic or manual pH correction for the free chlorine measurement
3. Determine the level of electronic filtering of the sensor current
4. Enable or disable dual slope calibration
5. Make various pH measurement settings. The analyzer supplied with the Model FCL is designed to be as versatile as possible. The pH settings listed below are needed in some applications, but are not used when pH is measured for correcting free chlorine readings.

   a. solution temperature correction

   b. analyzer isopotential point

   c. enable or disable glass impedance fault.

   The settings should be left at their default values.

5.5.2 Definitions — Chlorine

1. FREE CHLORINE. Free chlorine is the result of adding sodium hypochlorite (bleach), calcium hypochlorite (bleaching powder), or chlorine gas to fresh water. Free chlorine is the sum of hypochlorous acid (HOCl) and hypochlorite ion (OCl^-).
2. TOTAL CHLORINE. Total chlorine is the sum of free and combined chlorine. Combined chlorine generally refers to chlorine oxidants in which chlorine is combined with ammonia or organic amines.
3. MONOCHLORAMINE. Monochloramine (NH_2Cl) is the product of a chemical reaction between ammonia and chlorine. It is commonly used to disinfect drinking water.
4. pH CORRECTION. Free chlorine is the sum of hypochlorous acid (HOCl) and hypochlorite ion (OCl^-). The relative amount of each depends on pH. As pH increases, the concentration of HOCl decreases and the concentration of OCl^- increases. Because the sensor responds only to HOCl, a pH correction is necessary to properly convert the sensor current into a free chlorine reading. The FCL uses either automatic or manual pH correction. In automatic pH correction (Model FCL-02), the analyzer continuously monitors the pH of the sample and corrects the free chlorine reading for changes in pH. In manual pH correction, the user must enter the pH of the sample. Generally, if the pH changes more than about 0.2 units over short periods of time, automatic pH correction is best. If the pH is relatively steady or subject only to seasonal changes, manual pH correction is adequate.
5. INPUT FILTER. Before converting the sensor current to a chlorine reading, the analyzer applies an input filter. The filter reduces noisy readings, but increases the response time. The level of filtering is selected by choosing the amount of time required for the display to reach 63% of a step change.
6. DUAL SLOPE CALIBRATION. The free chlorine sensor loses sensitivity at high concentrations of chlorine. The FCL analyzer has a dual slope feature that allows the user to compensate for the non-linearity of the sensor. For the vast majority of applications, dual slope calibration is unnecessary.

5.5.3 Definitions — pH/ORP

1. ORP. ORP is oxidation-reduction potential. It is the voltage difference between a noble metal (usually platinum) indicator electrode and a silver/silver chloride reference electrode. **Not used with Model FCL.**
2. REDOX. Redox is redox potential. Redox potential is measured the same way as ORP. The sign of the redox potential is the negative of ORP. **Not used with Model FCL.**
3. GLASS IMPEDANCE FAULT. The analyzer continuously measures the impedance of the pH sensor glass membrane. When the analyzer detects low glass impedance, indicating a broken or cracked glass membrane, it automatically displays a fault message.
4. SOLUTION TEMPERATURE CORRECTION. The pH of a solution, particularly an alkaline one, is a function of temperature. If the temperature changes, so does the pH, even though the concentration of the acid or base causing the pH remains constant. Solution temperature compensation converts the pH at the measurement temperature to the pH at a reference temperature (25°C).

NOTE

IN THE MODEL FCL, pH IS MEASURED FOR THE SOLE PURPOSE OF CORRECTING A FREE CHLORINE MEASUREMENT. **DO NOT** USE SOLUTION TEMPERATURE CORRECTION. FREE CHLORINE READINGS MUST BE CORRECTED USING THE pH AT THE ACTUAL SAMPLE TEMPERATURE.

5. ISOPOTENTIAL pH. Does not apply when pH is being measured to correct free chlorine readings.

5.5.4 Procedure.

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

```
Calibrate          Hold
Program         Display
```

1. Press MENU. The main menu screen appears. Choose **Program**.

```
Outputs          Alarms
Measurement          >>
```

2. Choose **Measurement**.

```
Configure?
Sensor1         Sensor2
```

3. Choose **Sensor 1** (chlorine) or **Sensor 2** (pH). For a single input configuration (Model FCL-01), the **Sensor 1 Sensor 2** screen does not appear.
   If you chose **Sensor 1**, go to step 4.
   If you chose **Sensor 2**, go to step 10.

```
S1 Chlorine Type
free     total       >>
```

4. For **Sensor 1** (chlorine), choose **free**.

```
S1 pH Comp?
Auto             Manual
```

5. Select **Auto** or **Manual** pH correction. For Model FCL-01, choose **Manual**. For Model FCL-02, choose **Auto**.

```
      Manual pH
      07.00 pH
```

6. If you chose **Manual**, enter the average pH of the sample. The analyzer will use this pH in all subsequent calculations, no matter what the true pH is.

```
Input filter?
63% in 005sec
```

7. Choose the amount of filtering desired.

```
Dual Range Cal?
Disable          Enable
```

8. Enable or disable dual slope calibration. In the vast majority of applications, dual slope calibration is unnecessary.

9. The display returns to the screen shown in step 3. To configure the pH sensor, choose **Sensor 2**. To return to the previous screen, press EXIT. To return to the main display, press MENU followed by EXIT.

```
S2Measure?           pH
Redox               ORP
```

10. If **Sensor 2** (pH) was selected, the screen at left appears. Select **pH**.

```
S1 Glass Fault?
Enable?    Yes       No
```

11. Choose **Yes**.

```
Soln Temp Corr
Sensor Isoptntl
```

12. Leave **Soln Temp Corr** and **Sensor Isoptntl** at their default values.

```
S1 SolnTempCorr?
Off    Ultrapure     >>
```

a. Leave **Soln Temp Corr** turned **Off**.

```
Sensor Isoptntl
S1:      07.00pH
```

b. Leave **Sensor Isoptntl** at 7.00 pH.

13. The display returns to the screen shown in step 3. Press EXIT to return to the previous screen. To return to the main display, press MENU followed by EXIT.

5.6 CHOOSING TEMPERATURE UNITS AND MANUAL OR AUTOMATIC TEMPERATURE COMPENSATION

5.6.1 Purpose

This section describes how to do the following:

1. Choose temperature display units (°C or °F).
2. Choose automatic or manual temperature compensation for membrane permeability.
3. Choose automatic or manual temperature compensation for pH.
4. Enter a temperature for manual temperature compensation.

5.6.3 Definitions — chlorine

1. AUTOMATIC TEMPERATURE COMPENSATION - CHLORINE.

   The chlorine sensor is a membrane-covered amperometric sensor. The permeability of the membrane is a function of temperature. As temperature increases, membrane permeability increases. Thus, an increase in temperature will cause the sensor current and the analyzer reading to increase even though the chlorine level remained constant. A correction equation in the analyzer software automatically corrects for changes in membrane permeability caused by temperature. In automatic temperature compensation, the analyzer uses the temperature measured by the sensor for the correction. Temperature is also used in the pH correction applied to free chlorine measurements.
2. MANUAL TEMPERATURE COMPENSATION - CHLORINE. In manual temperature compensation, the analyzer uses the temperature entered by the user for membrane permeability and pH correction. It does not use the actual process temperature. Do NOT use manual temperature compensation unless the measurement and calibration temperatures differ by no more than about 2°C. Manual temperature compensation is useful if the sensor temperature element has failed an a replacement sensor is not available.

5.6.3 Definitions — pH

1. AUTOMATIC TEMPERATURE COMPENSATION — pH. The analyzer uses a temperature-dependent factor to convert measured cell voltage to pH. In automatic temperature compensation, the analyzer measures the temperature and automatically calculates the correct conversion factor. For maximum accuracy, use automatic temperature compensation.
2. MANUAL TEMPERATURE COMPENSATION — pH. In manual temperature compensation, the analyzer converts measured voltage to pH using the temperature entered by the user. It does not use the actual process temperature. Do **NOT** use manual temperature compensation unless the process temperature varies no more than about ±2°C or the pH is between 6 and 8. Manual temperature compensation is useful if the sensor temperature element has failed and a replacement sensor is not available.

5.6.3 Procedure.

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

```
Calibrate         Hold
Program        Display
```

```
Outputs         Alarms
Measurement         >>
```

```
Temp          Security
#Sensors            >>
```

```
Config Temp?
°C/F       Live/Manual
```

1. Press MENU. The main menu screen appears. Choose **Program**.
2. Choose **>>**.
3. Choose **Temp.**
4. Choose **°C/F** to change temperature units. Choose **Live/Manual** to turn on (Live) or turn off (Manual) automatic temperature compensation.
   a. If **°C/F** is chosen, select **°C** or **°F** in the next screen.
   b. If **Live/Manual** is chosen, select **Live** or **Manual** for sensor 1 (chlorine) in the next screen.
   c. If **Manual** is chosen, enter the temperature in the next screen. The temperature entered in this step will be used in all subsequent measurements, no matter what the process temperature is.
   d. The display will return to the **Live/Manual** screen for sensor 2 (pH). Make the desired selections for sensor 2.

5.7 SETTING A SECURITY CODE

5.7.1 Purpose.

This section describes how to set a security code. The security code prevents program and calibration settings from accidentally being changed. Refer to Section 4.4 for additional information.

5.7.2 Procedure.

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

```
Calibrate         Hold
Program        Display
```

```
Outputs         Alarms
Measurement         >>
```

```
Temp          Security
#Sensors            >>
```

1. Press MENU. The main menu screen appears. Choose **Program**.
2. Choose **>>**, then **Security**.
3. Enter a three digit security code. The security code takes effect two minutes after the last key stroke.
4. The display returns to the security menu screen. Press EXIT to return to the previous screen. To return to the main display, press MENU followed by EXIT.

5.8 NOISE REJECTION

5.8.1 Purpose.

For maximum noise rejection, the frequency of the ac power must be entered in the analyzer.

5.8.2. Procedure.

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

```
Calibrate          Hold
Program         Display
```

1. Press MENU. The main menu screen appears. Choose **Program**.

```
Outputs          Alarms
Measurement          >>
```

2. Choose **>>**.

```
Temp           Security
#Sensors             >>
```

3. Choose **>>**.

```
Noise Rejection
ResetAnalyzer        >>
```

4. Choose **Noise Rejection**.
5. Enter the mains frequency, 50 Hz or 60 Hz.
6. The display returns to the **Noise Rejection** screen. To return to the main menu, press EXIT. To return to the main display, press MENU followed by EXIT.

5.9 SINGLE SENSOR OR DUAL SENSOR INPUT

5.9.1 Purpose

The FCL analyzer accepts input from a single chlorine sensor or from a chlorine and pH sensor. This section describes how to program the analyzer for single or dual sensors. **COMPLETE THIS SECTION BEFORE DOING OTHER PROGRAMMING.**

5.9.2 Procedure.

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

```
Calibrate          Hold
Program         Display
```

1. Press MENU. The main menu screen appears. Choose **Program**.

```
Outputs          Alarms
Measurement          >>
```

2. Choose **>>**.

```
Temp           Security
#Sensors             >>
```

3. Choose **#Sensors**.

```
# of sensors?
One                 Two
```

4. Choose **One** for the Model FCL-01 (chlorine sensor only). Choose **Two** for the Model FCL-02 (chlorine and pH sensor).
5. The display returns to the **# Sensors** screen. To return to the main menu, press MENU. To return to the main display, press MENU followed by EXIT.

5.10 RESETTING FACTORY CALIBRATION AND FACTORY DEFAULT SETTINGS

5.10.1 Purpose.

This section describes how to re-install factory calibration and default values. The process also clears all fault messages and returns the display to the first quick start screen.

5.10.2. Procedure.

To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.

Calibrate Hold **Program** Display	1. Press MENU. The main menu screen appears. Choose **Program**.
Outputs Alarms Measurement >>	2. Choose **>>**.
Temp Security #Sensors >>	3. Choose **>>**.
Noise Rejection ResetAnalyzer >>	4. Choose **ResetAnalyzer**.
Load factory settings? **Yes** No	5. Choose **Yes** or No. If **Yes** is selected, previous settings are cleared and the **Quick Start Menu** appears.

5.11 SELECTING A DEFAULT SCREEN, LANGUAGE, AND SCREEN CONTRAST

5.11.1 Purpose

This section describes how to do the following:

1. set a default display screen

   The default display screen is the screen shown during normal operation. The Model FCL analyzer allows the user to choose from a number of screens. Which screens are available depends on how the analyzer was configured. The following is an explanation of the abbreviations used in the screens.

   In the display:

   i. The units attached to the reading make clear what is being displayed, chlorine or pH. The units for chlorine are ppm (mg/L) as Cl_2.

   ii. **S2** means sensor 2. **S2** appears if the user has chosen to display data only from sensor 2 (pH).

   iii. **G** is the impedance of the glass pH electrode.

2. select a language
3. change the screen contrast

**To choose a menu item, move the cursor to the item and press ENTER.
To store a number or setting, press ENTER.**

5.11.2 Procedure: Selecting a Display Screen

Calibrate	Hold
Program	**Display**

1. Press MENU. The main menu screen appears. Choose **Display**.

Default Display	
Language	Contrst

2. Choose **Default Display**.
3. Press or until the desired display appears. Press ENTER. For an explanation of abbreviations, see Section 5.11.1.
4. The display returns to the screen in step 2. To return to the main menu, press MENU. To return to the main display, press MENU followed by EXIT.

5.11.3 Procedure: Choosing a Language

Calibrate	Hold
Program	**Display**

1. Press MENU. The main menu screen appears. Choose **Display**.

Default Display	
Language	Contrast

2. Choose **Language**.

English	Fran ais
Espa ol	>>

3. Choose English, Français, Español, Deutsch, Italiano, or Portugues.
4. The display returns to the screen in step 2. To return to the main menu, press MENU. To return to the main display, press MENU followed by EXIT.

5.11.2 Procedure: Changing Screen Contrast

Calibrate	Hold
Program	**Display**

1. Press MENU. The main menu screen appears. Choose **Display**.

Default Display	
Units	**Contrst**

2. Choose **Contrst**.

Screen Contrast:
50

3. Press or to increase or decrease the screen contrast. As contrast increases, the number increases.
4. The display returns to the screen shown in step 2. To return to the main menu, press MENU. To return to the main display, press MENU followed by EXIT.

SECTION 6.0
CALIBRATION

6.1 INTRODUCTION
6.2 CALIBRATING TEMPERATURE
6.3 CALIBRATION - FREE CHLORINE
6.4 AUTO CALIBRATION - pH
6.5 MANUAL CALIBRATION - pH
6.6 STANDARDIZATION - pH
6.7 ENTERING A KNOWN SLOPE - pH

6.1 INTRODUCTION

The Calibrate Menu allows the user to calibrate sensor 1 (chlorine) and sensor 2 (pH). The temperature element in each sensor can also be calibrated.

Chlorine sensors require periodic full-scale calibration. The purpose of the full-scale standard is to establish the slope of the calibration curve. Because stable chlorine standards do not exist, **the sensor must be calibrated against a test run a grab sample of the process liquid.** Several manufacturers offer portable test kits for this purpose.

New chlorine sensors must be zeroed before being placed in service. Sensors should also be zeroed every time the electrolyte solution is replaced. Zeroing involves placing the sensor in a chlorine-free sample until the sensor current drops to its lowest stable value.

For pH sensors, two-point buffer calibration is standard. In auto calibration the analyzer calculates the pH of the buffer from the nominal value entered by the user and does not accept calibration data until readings are stable. In manual calibration the user enters buffer values and judges when readings are stable. The pH reading can also be standardized, that is, forced to match the reading from a referee instrument. Finally, if the user knows the electrode slope (at 25°C), he can enter it directly.

6.2 CALIBRATING TEMPERATURE

6.2.1 Purpose

Temperature is important in the measurement of chlorine and pH for different reasons.

The free chlorine sensor is a membrane-covered amperometric sensor. As the sensor operates, free chlorine diffuses through the membrane and is consumed at an electrode immediately behind the membrane. The reaction produces a current that depends on the rate at which the free chlorine diffuses through the membrane. The diffusion rate, in turn, depends on the concentration of the analyte and how easily it passes through the membrane (the membrane permeability). Because membrane permeability is a function of temperature, the sensor current will change if either the concentration or temperature changes. To account for changes in sensor current caused by temperature alone, the analyzer automatically applies a membrane permeability correction. The membrane permeability changes about 3%/°C at 25°C, so a 1°C error in temperature produces about a 3% error in the reading. Temperature also plays a role in the pH correction applied to free chlorine readings.

Temperature is also important in pH measurements.

1. The analyzer uses a temperature dependent factor to convert measured cell voltage to pH. Normally, a slight inaccuracy in the temperature reading is unimportant unless the pH reading is significantly different from 7.00. Even then, the error is small. For example, at pH 12 and 25°C, a 1°C error produces a pH error less than ±0.02.
2. During auto calibration, the analyzer recognizes the buffer being used and calculates the actual pH of the buffer at the measured temperature. Because the pH of most buffers changes only slightly with temperature, reasonable errors in temperature do not produce large errors in the buffer pH. For example, a 1°C error causes **at most** an error of ±0.03 in the calculated buffer pH.

Without calibration the accuracy of the temperature measurement is about ±0.4°C. Calibrate the sensor/analyzer unit if

1. ±0.4°C accuracy is not acceptable
2. the temperature measurement is suspected of being in error. Calibrate temperature by making the analyzer reading match the temperature measured with a **standard thermometer**.

6.2.2 Procedure

1. Remove the sensor from the process. Place it in an insulated container of water along with a **calibrated thermometer**. Submerge at least the bottom two inches of the sensor. Stir continuously.
2. Allow the sensor to reach thermal equilibrium. For some sensors, the time constant for a change in temperature is 5 min., so it may take as long as 30 min. for temperature equilibration.
3. If the sensor cannot be removed from the process, measure the temperature of a flowing sample taken from a point as close to the sensor as possible. Let the sample continuously overflow an insulated container holding a **calibrated thermometer**.
4. Change the analyzer display to match the **calibrated thermometer** using the procedure below.

Calibrate	Hold
Program	Display

a. Press MENU. The main menu screen appears. Choose **Calibrate**.

Calibrate?	
Sensor1	Sensor2

b. Choose **Sensor1** (chlorine) or **Sensor2** (pH).

CalSensor1?	
Measurement	**Temp**

c. Choose **Temp**.

Live	25.0°C
CalS1	**+**25.0°C

d. If the analyzer was programmed in Section 5.6 to use the actual process temperature, the screen at left will appear. To calibrate the temperature, change the number in the second line to match the temperature measured with the **standard thermometer**. Press ENTER. Go to step f.

If the calibration temperature is more than 2 or 3°C different from the live reading, see Section 8.3.1 or Section 8.4.2.

If the analyzer was programmed to use a temperature entered by the user, go to step e.

ManualTemp?
S1: +25.0°C

e. The screen at left will appear. Change the temperature to the desired value, then press ENTER. The analyzer will use the temperature entered in this step in all measurements and calculations, no matter what the true temperature is.

CalSensor1?	
Measurement	**Temp**

f. The screen at left will appear. Press EXIT.

Calibrate?	
Sensor1	**Sensor2**

g. Choose the other sensor and calibrate its temperature response.

h. To return to the main display, press MENU followed by EXIT.

6.3 CALIBRATION — FREE CHLORINE

6.3.1 Purpose

As Figure 6-1 shows, a free chlorine sensor generates a current directly proportional to the concentration of free chlorine in the sample. Calibrating the sensor requires exposing it to a solution containing no chlorine (zero standard) and to a solution containing a known amount of chlorine (full-scale standard).

The zero standard is necessary because chlorine sensors, even when no chlorine is in the sample, generate a small current called the residual current. The analyzer compensates for the residual current by subtracting it from the measured current before converting the result to a chlorine value. New sensors require zeroing before being placed in service, and sensors should be zeroed whenever the electrolyte solution is replaced. Either of the following makes a good zero standard:

- Deionized water containing about 500 ppm sodium chloride. Dissolve 0.5 grams (1/8 teaspoonful) of table salt in 1 liter of water. DO NOT USE DEIONIZED WATER ALONE FOR ZEROING THE SENSOR. THE CONDUCTIVITY OF THE ZERO WATER MUST BE GREATER THAN 50 μS/cm.
- Tap water known to contain no chlorine. Expose tap water to bright sunlight for at least 24 hours.

The purpose of the full-scale standard is to establish the slope of the calibration curve. Because stable chlorine standards do not exist, **the sensor must be calibrated against a test run on a grab sample of the process liquid.** Several manufacturers offer portable test kits for this purpose. Observe the following precautions when taking and testing the grab sample.

- Take the grab sample from a point as close to the sensor as possible. Be sure that taking the sample does not alter the flow of the sample to the sensor. It is best to install the sample tap just downstream from the sensor.
- Chlorine solutions are unstable. Run the test immediately after taking the sample. Try to calibrate the sensor when the chlorine concentration is at the upper end of the normal operating range.

Free chlorine measurements also require a pH correction. Free chlorine is the sum of hypochlorous acid (HOCl) and hyprochlorite ion (OCl^-). The relative amount of each depends on the pH. As pH increases, the concentration of HOCl decreases and the concentration of OCl^- increases. Because the sensor responds only to HOCl, a pH correction is necessary to properly convert the sensor current into a free chlorine reading.

The analyzer can use either automatic or manual pH correction. In automatic pH correction, the analyzer continuously monitors the pH of the solution and corrects the free chlorine reading for changes in pH. In manual pH correction, the user must enter the pH of the solution. Generally, if the pH changes more than about 0.2 units over short periods of time, automatic pH correction is best. If the pH is relatively steady or subject only to seasonal changes, manual pH correction is adequate.

During calibration, the analyzer must know the pH of the solution. If the analyzer is using automatic pH correction, the pH sensor (properly calibrated) **must be in the process liquid before starting the calibration.** If the analyzer is using manual pH correction, be sure to enter the pH value before starting the calibration.

The free chlorine sensor loses sensitivity at high concentrations of chlorine. The FCL analyzer has a dual slope feature that allows the user to compensate for the non-linearity of the sensor. However, for the vast majority of applications, dual slope calibration is unnecessary.

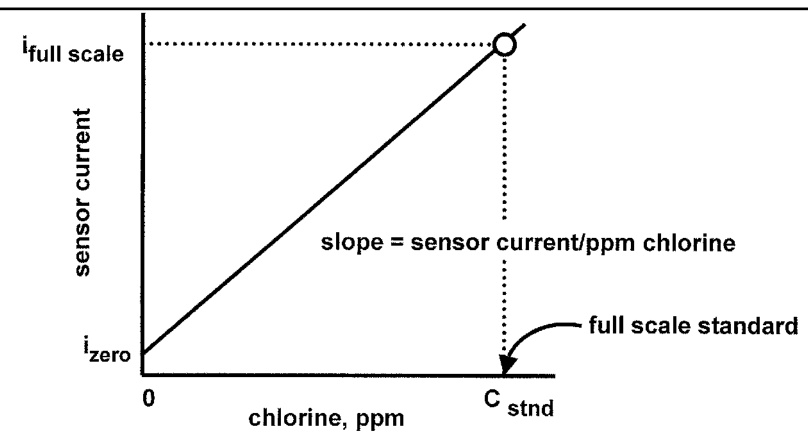

FIGURE 6-1. Sensor Current as a Function of Free Chlorine Concentration

6.3.2 Procedure — Zeroing the sensor.

1. Place the sensor in the zero standard. See Section 6.3.1 for suggested zero standards. Be sure no air bubbles are trapped against the membrane. The sensor current will drop rapidly at first and then gradually reach a stable zero value. To monitor the sensor current, go to the main display and press until the sensor input current is showing. Typical zero current for a free chlorine sensor is in the range -10 to +10 nA.

   A new sensor or a sensor in which the electrolyte solution has been replaced may require several hours (occasionally as long as overnight) to reach a minimum zero current. DO NOT START THE ZERO ROUTINE UNTIL THE SENSOR HAS BEEN IN ZERO SOLUTION FOR AT LEAST TWO HOURS.

```
Calibrate          Hold
Program         Display
```

2. Press MENU. The main menu screen appears. Choose **Calibrate**.

```
Calibrate?
Sensor1         Sensor2
```

3. Choose **Sensor 1** (free chlorine). For a single sensor configuration, this screen will not appear.

```
CalSensor1?
Measurement        Temp
```

4. Choose **Measurement**.

```
Cal S1?
InProcess          Zero
```

5. Choose **Zero**.

```
S1 Live        1.000ppm
Zeroing            Wait
```

6. The screen at left appears. The top line is the current chlorine reading based on the previous calibration or, for a first time calibration, the default sensitivity.

```
S1 Live        0.000ppm
Sensor Zero Done
```

7. Once the reading is stable, the screen at left appears. Sensor zero is complete and the analyzer has stored the zero current. The screen remains until the operator presses MENU then EXIT to return to the main display.

   NOTE

   Pressing ENTER during the zero step will cause the analyzer to use the present sensor current as the zero current. If the sensor is zeroed before the current has reached a minimum stable value, subsequent readings will be in error.

   After zeroing, leave the sensor in the zero solution and verify that the sensor current is between -10 and +10 nA. To display the sensor current, go the the main display and press until the input current is showing.

```
Sensor Zero Fail
Current Too High
```

8. This screen appears if the zero current is extremely high. See Section 8.3 for troubleshooting. To repeat the zero step, press EXIT and choose **Zero**.

```
Possible ZeroErr
Proceed?   Yes       No
```

9. This screen appears if the zero current is moderately high. To continue, choose **Yes**. To repeat the zero step, choose **No**.

6.3.3 Procedure — Calibrating the sensor (single slope)

NOTE

Single slope calibration is the commonly used calibration method for free chlorine. Dual slope calibration, described is section 6.3.4, is rarely needed.

1. Place the chlorine sensor in the chlorine flow cell. If automatic pH correction is being used, calibrate the pH sensor (section 6.4) and place it in the pH flow cell. If manual pH correction is being used, measure the pH of the sample and enter the value. See Section 5.5. Adjust the sample flow until water overflows the center tube in the constant head cup.
2. Adjust the chlorine concentration until it is near the upper end of the control range. Wait until the analyzer reading is stable before starting the calibration.

```
Calibrate           Hold
Program          Display
```

3. Press MENU. The main menu screen appears. Choose **Calibrate**.

```
Calibrate?
Sensor1          Sensor2
```

4. Choose **Sensor 1** (free chlorine). For a single sensor configuration, this screen will not appear.

```
CalSensor1?
Measurement         Temp
```

5. Choose **Measurement**.

```
Cal S1?
InProcess           Zero
```

6. Choose **InProcess**.

```
Live            2.000ppm
Cal S1          2.000ppm
```

7. The screen shown at left appears. The top line is the current chlorine reading based on the previous calibration.

   Sample the process liquid. Make a note of the reading before taking the sample. Immediately determine free chlorine. Note the analyzer reading again. If the present reading (X) differs from the reading when the sample was taken (Y), calculate the value to enter (C) from the following formula:

   $$C = (X/Y)\ (A)$$

   where A is the concentration of chlorine in the grab sample.

   Change the reading in the second line to match the results of the grab sample test.

8. During calibration, the analyzer stores the measured current and calculates the sensitivity. Sensitivity is sensor current in nA divided by the concentration of chlorine. The sensitivity of a 499ACL-01 (free chlorine) sensor is 250-350 nA/ppm at 25°C and pH 8.

```
Possible Cal Err
Proceed?   Yes        No
```

9. This screen appears if the sensitivity is much higher or lower than expected. See Section 8.3. for troubleshooting. To repeat the calibration step, press EXIT and choose **InProcess**.

```
Calibration
Error
```

10. This screen appears if the sensitivity is moderately higher or lower than expected. To continue, choose **Yes**. To repeat the calibration, choose **No**. For troubleshooting assistance, see Section 8.3.

6.3.4 Procedure — Calibrating the sensor (dual slope)

Figure 6-2 shows the principle of dual slope calibration. Between zero and concentration C1, the sensor response is linear. When the concentration of chlorine becomes greater than C1, the response is non-linear. In spite of the non-linearity, the response can be approximated by a straight line between point 1 and point 2.

Dual slope calibration is rarely needed. It is probably useful in fewer than 5% of applications.

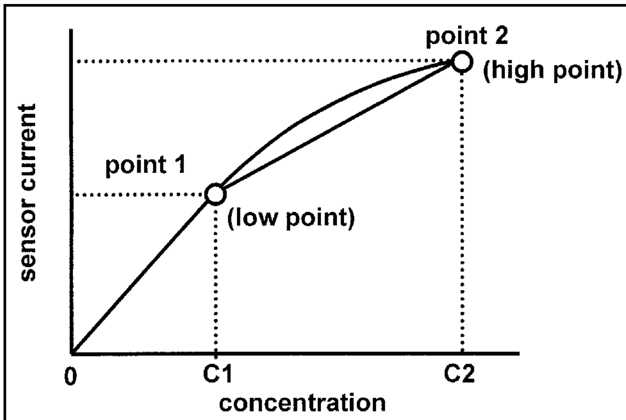

FIGURE 6-2. Dual Slope Calibration

1. Place the sensor in the zero standard. See Section 6.3.1. Be sure no air bubbles are trapped against the membrane. The sensor current will drop rapidly at first and then gradually reach a stable zero value. To monitor the sensor current, go to the main display and press until the sensor input current is showing. Typical zero current for a free chlorine sensor is between -10 and +10 nA.

   A new sensor or a sensor in which the electrolyte solution has been replaced may require several hours (occasionally as long as overnight) to reach a minimum zero current. DO NOT START THE ZERO ROUTINE UNTIL THE SENSOR HAS BEEN IN ZERO SOLUTION FOR AT LEAST TWO HOURS.

2. Be sure the analyzer has been configured for dual slope calibration. See Section 5.5.4.

```
Calibrate          Hold
Program         Display
```

3. Press MENU. The main menu screen appears. Choose **Calibrate**.

```
Calibrate?
Sensor1         Sensor2
```

4. Choose **Sensor 1** (free chlorine) for a single sensor configuration, this screen will not appear.

```
CalSensor1?
Measurement        Temp
```

5. Choose **Measurement**.

```
Cal S1?
Zero       pt1      pt2
```

6. Choose **Zero**.

```
S1 Live        1.000ppm
Zeroing            Wait
```

7. The screen at left appears. The top line is the current chlorine reading based on the previous calibration or, for a first time calibration, the default sensitivity.

```
S1 Live        0.000ppm
Sensor     Zero    Done
```

8. Once the reading is stable, the screen at left appears. Sensor zero is complete, and the analyzer has stored the zero current. The screen remains until the operator presses EXIT to return to the screen in step 9. If a "Sensor zero fail" or "Possible zero error" screen appears, refer to Section 8.3 -Troubleshooting.

```
Cal S1?
Zero       pt1      pt2
```

9. Place the chlorine sensor in the chlorine flow cell. If automatic pH correction is being used, calibrate the pH sensor (see Section 6.3) and place it in the pH flow cell. If manual pH correction is being used, measure the pH of the sample and enter the value (see section 5.5). Adjust the sample flow until the water overflows the center tube in the constant head cup.

   Adjust the concentration of chlorine until it is near the upper end of the linear response range of the sensor. (pt1 in Figure 6-2).

```
S1 Live        10.00ppm
pt1            10.00ppm
```

10. Choose **pt1**. The screen at left appears. The top line is the current chlorine reading based on the previous calibration or, for a first time calibration, the default sensitivity

11. Wait until the reading is stable.

    Sample the process liquid. Make a note of the reading before taking the sample. Immediately determine free chlorine. Note the analyzer reading again. If the present reading (X) differs from the reading when the sample was taken (Y), calculate the value to enter (C) from the following formula:

    $$C = (X/Y)\ (A)$$

    where A is the concentration of chlorine in the grab sample.

    Change the reading in the second line to match the results of the grab sample test.

```
Cal S1?
Zero       pt1      pt2
```

12. The screen returns to the display in step 9.

13. Adjust the concentration of chlorine until it is near the top end of the range (pt2 in Figure 6-2).

```
S1 Live        10.00ppm
pt2            10.00ppm
```

14. Choose **pt2**. The screen at left appears. The top line is the current chlorine reading based on the previous calibration or, for a first time calibration, the default sensitivity.

15. Following the procedure in step 11, determine chlorine in a sample of the process liquid. Change the reading in the second line to match the results of the grab sample test.

16. The display returns to the screen in step 9. Press MENU followed by EXIT to return to the main display.

6.4 AUTO CALIBRATION — pH

6.4.1 Purpose

1. New sensors must be calibrated before use. Regular recalibration is also necessary.
2. Use auto calibration instead of manual calibration. Auto calibration avoids common pitfalls and reduces errors.

6.4.2 Definitions

1. AUTO CALIBRATION. The analyzer recognizes the buffers and uses temperature-corrected pH values in the calibration. The table lists the buffers the FCL analyzer recognizes.

pH at 25°C (nominal pH)	Standard(s)
1.68	NIST, DIN 19266, JSI 8802, BSI (see note 1)
3.56	NIST, BSI
3.78	NIST
4.01	NIST, DIN 19266, JSI 8802, BSI
6.86	NIST, DIN 19266, JSI 8802, BSI
7.00	(see note 2)
7.41	NIST
9.18	NIST, DIN 19266, JSI 8802, BSI
10.01	NIST, JSI 8802, BSI
12.45	NIST, DIN 19266

Note 1: NIST is National Institute of Standards, DIN is Deutsche Institute für Normung, JSI is Japan Standards Institute, and BSI is British Standards Institute.

Note 2: pH 7 buffer is not a standard buffer. It is a popular commercial buffer in the United States.

The analyzer also measures noise and drift and does not accept calibration data until readings are stable. Calibration data will be accepted as soon as the pH reading is constant to within 0.02 units for 10 seconds. The stability settings cannot be changed.

2. SLOPE AND OFFSET. Once the analyzer successfully completes the calibration, it calculates and displays the calibration slope and offset. The slope is reported as the slope at 25°C. Figure 6-3 defines the terms.

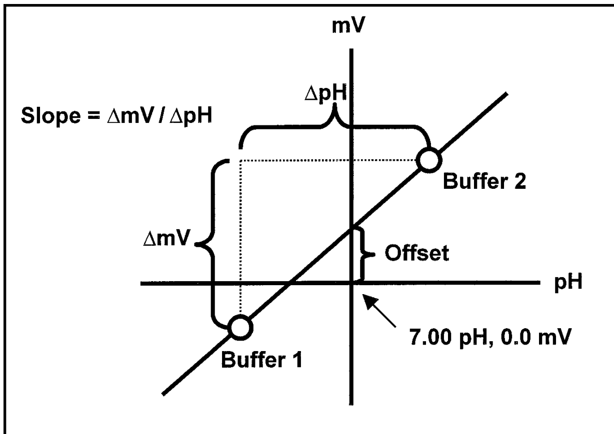

FIGURE 6-3. Calibration Slope and Offset

6.4.3 Procedure

1. Obtain two buffer solutions. Ideally the buffer pH values should bracket the range of pH values to be measured.
2. Remove the sensor from the flow cell. If the process and buffer temperatures are appreciably different, place the sensor in a container of tap water at the buffer temperature. Do not start the calibration until the sensor has reached the buffer temperature. Thirty minutes is usually adequate.
3. Calibrate the sensor by using the procedure on the following page.

```
Calibrate       Hold
Program      Display
```

a. Press MENU. The main menu screen appears. Choose **Calibrate**.

```
Calibrate?
Sensor1      Sensor2
```

b. Choose **Sensor2** (pH sensor).

```
CalSensor2?
Measurement     Temp
```

c. Choose **Measurement**.

```
S2       Standardize
Slope      BufferCal
```

d. Choose **BufferCal**.

```
S2BufferCal?
Auto          Manual
```

e. Choose **Auto**.

```
S2AutoCal?
Buffer1      Buffer2
```

f. Choose **Buffer1**.

g. Rinse the sensor with water and place it in buffer 1. Be sure the glass bulb and reference junction are completely submerged. Swirl the sensor.

```
S2Live        7.00pH
AutoBuf1        Wait
```

h. The screen at left is displayed until the reading is stable (<0.02 pH change in 10 sec). When the reading is stable, the screen in step i appears. To bypass automatic stabilization, press ENTER at any time.

```
S2Live        7.00pH
AutoBuf1      7.01pH
```

i. The top line shows the actual reading (**S2Live**). The analyzer also identifies the buffer and displays the nominal buffer value (buffer pH at 25°C). If the displayed value is not correct, press ▲ or ▼ to select the correct value. The nominal value will change, for example, from 7.01 pH to 6.86 pH. Press ENTER.

```
S2AutoCal?
Buffer1      Buffer2
```

j. The screen shown at left appears.

```
S2AutoCal?
Buffer1      Buffer2
```

k. Remove the sensor from buffer 1, rinse it with water, and place it in buffer 2. Swirl the sensor. Choose **Buffer2**.

```
S2Live        7.00pH
Buf2            Wait
```

l. The screen at left is displayed until the reading is stable (<0.02 pH change in 10 sec). When the reading is stable, the screen in step m appears. To bypass automatic stabilization, press ENTER at any time.

```
S2Live        7.00pH
AutoBuf2      7.01pH
```

m. The top line shows the actual reading (**S2Live**). The analyzer also identifies the buffer and displays the nominal buffer value (buffer pH at 25°C). If the displayed value is not correct, press ▲ or ▼ to select the correct value. The nominal value will change, for example, from 7.01 pH to 6.86 pH. Press ENTER to accept the nominal value.

```
S2Offset         6mV
Slope     59.16 25°C
```

n. If the calibration was successful, the analyzer will display the offset and slope (at 25°C). The display will return to the screen in step b. Choosing **Sensor1** (chlorine sensor) will permit the chlorine measurement to be calibrated.

```
Calibration
Error
```

o. If the slope is out of range (less than 45 mV/pH or greater than 60 mV/pH), an error screen appears. The display then returns to step f. Repeat the calibration.

p. To return to the main display, press MENU followed by EXIT.

6.5 MANUAL CALIBRATION — pH

6.5.1 Purpose

1. New sensors must be calibrated before use. Regular recalibration is also necessary.
2. Use manual calibration if non-standard buffers are being used; otherwise, use auto calibration. Auto calibration avoids common pitfalls and reduces errors.

6.5.2 Definitions

1. MANUAL CALIBRATION. In auto calibration the analyzer recognizes the buffer and uses the temperature-corrected pH value in the calibration. The analyzer also measures noise and drift and does not accept calibration data until readings are stable. During manual calibration, the user must judge when readings are stable and look up and enter the buffer values.
2. SLOPE AND OFFSET. Once the FCL successfully completes the calibration, it calculates and displays the calibration slope and offset. The slope is reported as the slope at 25ºC. Figure 6-1 defines the terms.

6.5.3 Procedure

1. Obtain two buffer solutions. Ideally, the buffer pH values should bracket the range of pH values to be measured. Also obtain a thermometer. The pH of most buffer solutions is a function of temperature. To calibrate the sensor properly, the pH of the buffer at the measurement temperature must be entered in the analyzer.
2. Remove the sensor from the process liquid. If the process and buffer temperature are appreciably different, place the sensor in a container of tap water at the buffer temperature. Do not start the calibration until the sensor has reached the buffer temperature. Thirty minutes is usually adequate.
3. Calibrate the sensor using the procedure on the following page.

```
Calibrate          Hold
Program         Display
```

a. Press MENU. The main menu screen appears. Choose **Calibrate**.

```
Calibrate?
Sensor1         Sensor2
```

b. Choose **Sensor2** (pH sensor).

```
CalSensor2?
Measurement        Temp
```

c. Choose **Measurement**.

```
S2          Standardize
Slope         BufferCal
```

d. Choose **BufferCal**.

```
S2BufferCal?
Auto             Manual
```

e. Choose **Manual**.

```
S2ManualCal?
Buffer1         Buffer2
```

f. Choose **Buffer1**.

g. Rinse the sensor with water and place it in buffer 1. Be sure the glass bulb and junction are completely submerged. Swirl the sensor. Also place a thermometer in the buffer. Press ENTER

```
S2Live           7.00pH
Buf1            07.00pH
```

h. The top line shows the actual buffer reading (**S2 Live**). Wait until the reading is stable, then note the temperature. Change the pH in the second line to the pH of the buffer at the measured temperature. Press ENTER.

```
S2ManualCal?
Buffer1         Buffer2
```

i. The screen at left appears. Choose **Buffer2**. Rinse the sensor and thermometer with water and place them in buffer 2. Be sure the bulb and junction are submerged. Swirl the sensor.

```
S2Live          10.00pH
Buf2            10.00pH
```

j. The top line shows the actual buffer reading (**S2 Live**). Wait until the reading is stable, then note the temperature. Change the pH in the second line to the pH of the buffer at the measured temperature. Press ENTER.

```
S2Offset            6mV
Slope        59.16 25°C
```

k. If the calibration was successful, the analyzer will display the offset and slope (at 25°C). The display will return to the screen in step b. Choosing **Sensor1** (chlorine sensor) will permit the chlorine measurement to be calibrated.

```
Calibration Error!
```

l. If the slope is out of range (less than 45 mV/pH or greater than 60 mV/pH), an error screen appears. The display then returns to step f. Repeat the calibration.

m. To return to the main display, press MENU followed by EXIT.

6.6 STANDARDIZATION — pH

6.6.1 Purpose

1. The pH measured by the FCL analyzer can be changed to match the reading from a second or referee instrument. The process of making the two readings agree is called standardization.
2. During standardization, the difference between the two pH values is converted to the equivalent voltage. The voltage, called the reference offset, is added to all subsequent measured cell voltages before they are converted to pH. If a standardized sensor is placed in a buffer solution, the measured pH will differ from the buffer pH by an amount equivalent to the standardization offset.

6.6.2 Procedure

1. Install the sensor in the flow cell.
2. Once readings are stable, measure the pH of the liquid using a referee instrument.
3. Because the pH of the process liquid may change if the temperature changes, measure the pH of the grab sample immediately after taking it.
4. For poorly buffered samples, it is best to determine the pH of a continuously flowing sample from a point as close as possible to the sensor.
5. Standardize the FCL analyzer by following the steps below.

```
Calibrate          Hold
Program         Display
```

a. Press MENU. The main menu screen appears. Choose **Calibrate**.

```
Calibrate?
Sensor1         Sensor2
```

b. Choose **Sensor2** (pH sensor).

```
CalSensor2?
Measurement        Temp
```

c. Choose **Measurement**.

```
S2          Standardize
Slope         BufferCal
```

d. Choose **Standardize**.

```
Live             7.00pH
CalS2           07.00pH
```

e. The top line shows the present pH reading. Change the pH reading in the second line to match the referee instrument. Press ENTER.

```
Invalid Input!
Max:            14.00pH
```

f. The screen at left appears if the entered pH was greater than 14.00. The display then returns to step e. Repeat the standardization.

```
S2          Standardize
Slope         BufferCal
```

g. If the entry was accepted, the screen at left appears. To verify that the new pH was accepted, return to the main display by pressing MENU followed by EXIT.

6.7 ENTERING A KNOWN SLOPE VALUE — pH

6.7.1 Purpose

If the electrode slope is known from other measurements, it can be entered directly in the FCL analyzer. The slope must be entered as the slope at 25°C. To calculate the slope at 25°C from the slope at temperature t°C, use the equation:

$$\text{slope at } 25°\text{C} = (\text{slope at } t°\text{C}) \frac{298}{t°\text{C} + 273}$$

Changing the slope overrides the slope determined from the previous buffer calibration.

6.7.2 Procedure

```
Calibrate          Hold
Program         Display
```

1. Press MENU. The main menu screen appears. Choose **Calibrate**.

```
Calibrate?
Sensor1         Sensor2
```

2. Choose **Sensor2** (pH sensor).

```
CalSensor2?
Measurement        Temp
```

3. Choose **Measurement**.

```
S2          Standardize
Slope         BufferCal
```

4. Choose **Slope**.

```
Changing slope
overrides bufcal.
```

5. The screen at left appears briefly.

```
pH Slope   25°C?
S2:  59.16mV/pH
```

6. Change the slope to the desired value. Press ENTER.

```
Invalid Input!
```

7. The slope must be between 45 and 60 mV/pH. If the value entered is outside this range, the screen at left appears.

```
S2          Standardize
Slope         BufferCal
```

8. If the entry was accepted, the screen at left appears.

9. To return to the main display, press MENU followed by EXIT.

SECTION 7.0
MAINTENANCE

7.1 ANALYZER
7.2 CHLORINE SENSOR
7.3 pH SENSOR
7.4 CONSTANT HEAD SAMPLER

7.1 ANALYZER

The Model FCL analyzer needs little routine maintenance.

Clean the analyzer case and front panel by wiping with a clean soft cloth dampened with water **ONLY**. Do not use solvent, like alcohol, that might cause a buildup of static charge.

Only a few components of the analyzer are replaceable. See Table 7-1 and Figure 7-1.

Circuit boards are not replaceable.

If the analyzer must be replaced, order as shown below.

Model	Order analyzer
FCL-01 (free chlorine only)	1055-01-11-24-68
FCL-02 (free chlorine and pH)	1055-01-11-24-32-68

Replacing the analyzer.

1. Turn off power to the FCL.
2. Loosen the four screws holding the front panel to the enclosure case and let the panel swing down.
3. Disconnect the power, alarm, output, and sensor wires.
4. The front panel is held to the rear enclosure by a -shaped metal pin inserted into clips on each side of the rear enclosure. To remove the front panel, close the panel until the pin moves slightly past the open end of one of the clips. Using a small screwdriver, press down on the top of the clip. At the same time lift the pin over the end of the clip. Once one end of the pin is free, the other end easily slides out of the other clip.
5. Using the procedure in step 4, remove the front panel from the replacement analyzer.
6. To install the replacement panel, place one end of the pin in one of the clips. Push the other end of the pin over the other clip. The pin will snap into place.
7. Replace the power, alarm, output, and sensor wires. See Section 3.0 for wiring connections. For Model FCL-02 (free chlorine and pH) be sure to connect the jumper between TB5-6 and TB3-1. Be sure to leave adequate slack to avoid stress on the conductors when the panel is opened.

TABLE 7-1. Replacement Parts for FCL Analyzer (1055-01-11-24-68 or 1055-01-11-24-32-68)

Location in Figure 7-1	PN	Description	Shipping Weight
1	note	Screw, 6-32 x 1.38 in.	
2	note	O-ring 2-007	
3	33655-00	Gasket for pipe/surface mount version	2 lb/1.0 kg
not shown	23833-00	Surface mount kit; consists of four self-tapping screws #6 x 1.75 in. and four O-rings	1 lb/0.5 kg

Note: Information about the size of screws and O-rings is for information only. Screws and washers cannot be purchased from Rosemount Analytical.
Shipping weights are rounded up to the nearest whole lb or 0.5 kg.

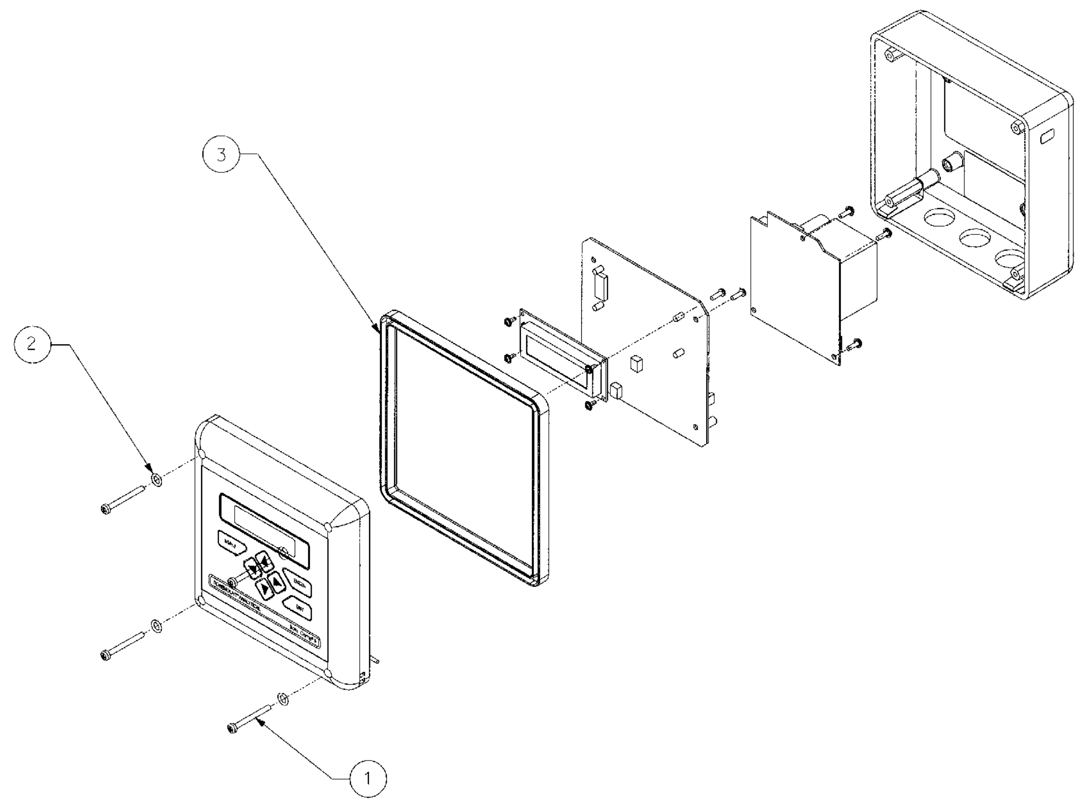

FIGURE 7-1. Exploded View of Model FCL Analyzer

7.2 CHLORINE SENSOR

CAUTION:
Fill solution may cause irritation. May be harmful if swallowed. Read and follow manual.

CAUTION:
PRESSURIZED SPRAY INJURY
Before removing the sensor from the process stream for maintenance, be sure the process pressure is reduced to 0 psig and the process temperature is at a safe level!

7.2.1 General.

When used in clean water, the chlorine sensor requires little maintenance. Generally, the sensor needs maintenance when the response becomes sluggish or noisy or when readings drift following calibration. For a sensor used in potable water, expect to clean the membrane every month and replace the membrane and electrolyte solution every three months. In water containing large amounts of suspended solids, for example open recirculating cooling water, membrane cleaning or replacement will be more frequent.

7.2.2 Cleaning the membrane.

Clean the membrane with water sprayed from a wash bottle. **Do not use tissues to clean the membrane.**

7.2.3 Replacing the electrolyte solution and membrane.

1. Unscrew the membrane retainer and remove the membrane assembly and O-ring. See Figure 7-2.
2. Hold the sensor over a container with the cathode pointing down.
3. Remove the fill plug and allow the electrolyte solution to drain out.
4. Inspect the cathode. If it is tarnished, clean it using a cotton-tipped swab dipped in baking soda or alumina. Use type A dry powder alumina intended for metallographic polishing of medium and soft metals. Rinse thoroughly with water.
5. Wrap the plug with several turns of pipe tape and set aside.
6. Prepare a new membrane. Hold the membrane assembly with the cup formed by the membrane and membrane holder pointing up. Fill the cup with electrolyte solution and allow the wooden ring to soak up the solution (usually takes several minutes).
7. Hold the sensor at about a 45-degree angle with the cathode end pointing up. Add electrolyte solution through the fill hole until the liquid overflows. Tap the sensor near the threads to release trapped air bubbles. Add more electrolyte solution if necessary.
8. Place the fill plug in the electrolyte port and begin screwing it in. After several threads have engaged, rotate the sensor so that the cathode is pointing up and continue tightening the fill plug. Do not overtighten.
9. Place a new O-ring in the groove around the cathode post. Cover the holes at the base of the cathode stem with several drops of electrolyte solution.
10. Insert a small **blunt** probe, like a toothpick with the end cut off, through the pressure equalizing port. See Figure 7-2.

    NOTE
    Do not use a sharp probe. It will puncture the bladder and destroy the sensor.

    Gently press the probe against the bladder several times to force liquid through the holes at the base of the cathode stem. Keep pressing the bladder until no air bubbles can be seen leaving the holes. Be sure the holes remain covered with electrolyte solution.
11. Place a drop of electrolyte solution on the cathode, then place the membrane assembly over the cathode. Screw the membrane retainer in place.
12. The sensor may require several hours operating at the polarizing voltage to equilibrate after the electrolyte solution has been replenished.

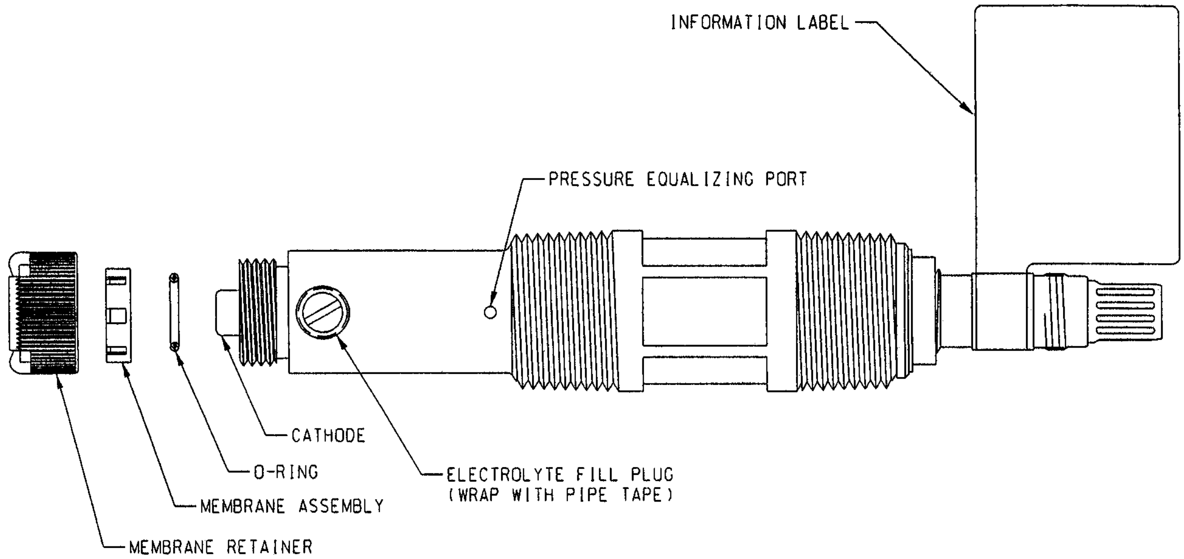

FIGURE 7-2. Chlorine Sensor Parts

TABLE 7-2. Spare Parts

33523-00	Electrolyte Fill Plug
9550094	O-Ring, Viton 2-014
33521-00	Membrane Retainer
23501-08	Free Chlorine Membrane Assembly: includes one membrane assembly and one O-ring
23502-08	Free Chlorine Membrane Kit: includes 3 membrane assemblies and 3 O-rings
9210356	#4 Free Chlorine Sensor Fill Solution, 4 oz (120 mL)

7.3 pH SENSOR

7.3.1 General.

When used in clean water, the pH sensor requires little maintenance. Generally, the sensor needs maintenance when the response becomes sluggish or noisy. In clean water the typical cleaning frequency is once a month. In water containing large amounts of suspended solids, for example open recirculating cooling water, cleaning frequency will be substantially greater.

7.3.2 Cleaning the Sensor

Remove soft deposits by rinsing with a stream of water from a wash bottle. If the sensor becomes coated with rust, dissolve the rust by soaking the sensor in dilute hydrochloric acid (mix 5 mL of concentrated hydrochloric acid with 100 mL of water) for no longer than 5 minutes at room temperature. Rinse the sensor thoroughly with water and soak in pH 4 buffer for several hours. Recalibrate the sensor in buffers before returning it to service.

7.3.3 Other Maintenance

The 399VP-09-305 pH sensor supplied with the Model FCL-02 is disposable. It has no replaceable parts.

7.4 CONSTANT HEAD FLOW CONTROLLER

7.4.1 General

After a period of time, deposits may accumulate in the constant head overflow chamber and in the tubing leading to the flow cell(s). Deposits increase the resistance to flow and cause the flow to gradually decrease. Loss of flow may ultimately have an impact on the chlorine sensor performance. The flow controller is designed to provide about 2 gal/hr flow. Loss of flow to about 1 gal/hr causes a 10-15% drop in chlorine sensor output. Loss of flow has almost no effect on pH sensor performance other than to increase the overall response time of the sensor.

7.4.2 Cleaning the flow controller

The low flow controller can be taken apart completely for cleaning. Use a strong flow of water to flush out the tubing. A pipe cleaner or a small bottlebrush can remove more adherent deposits. To prevent leaks, apply a thin layer of silicone grease (or equivalent) to the two O-rings at the base of overflow chamber and to the O-ring sealing the central overflow tube to the base.

7.4.3 Other Maintenance

Table 7-3 and Figure 7-3 show the replacement parts for the flow controller assembly used in Model FCL-01.

TABLE 7-3. Replacement parts for constant head flow controller assembly (Model FCL-01)

Location in Figure 7-3	PN	Description	Shipping Weight
1	24091-01	Flow cell for chlorine sensor with bubble shedding nozzle	1 lb/0.5 kg
2	24040-00	O-ring kit, two 2-222 and one 2-024 silicone O-rings, with lubricant	1 lb/0.5 kg
3	33812-00	Dust cap for constant head flow controller	1 lb/0.5 kg
4	9322032	Elbow, ¼ in FNPT x ¼ in OD tubing	1 lb/0.5 kg
5	9350029	Check valve, ¼ in FNPT	1 lb/0.5 kg

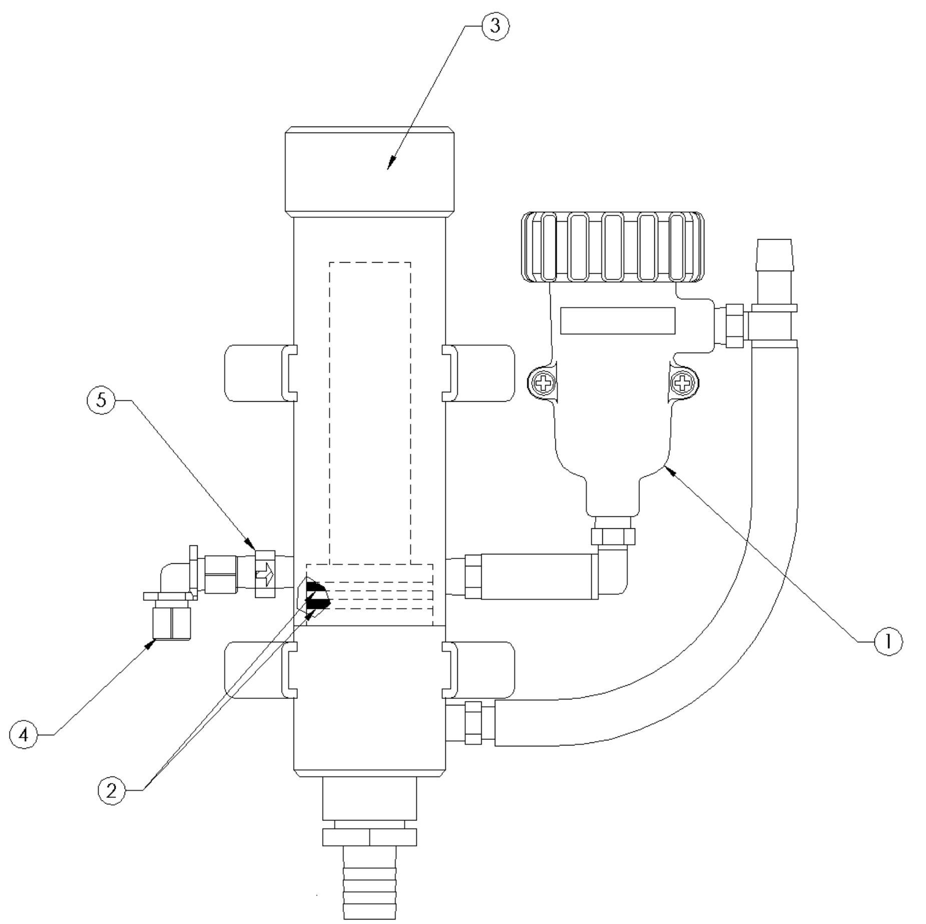

FIGURE 7-3. Replacement Parts for the Flow Controller Assembly used in Model FCL-01.

Table 7-4 and Figure 7-4 show the replacement parts for the flow controller assembly used in Model FCL-02.

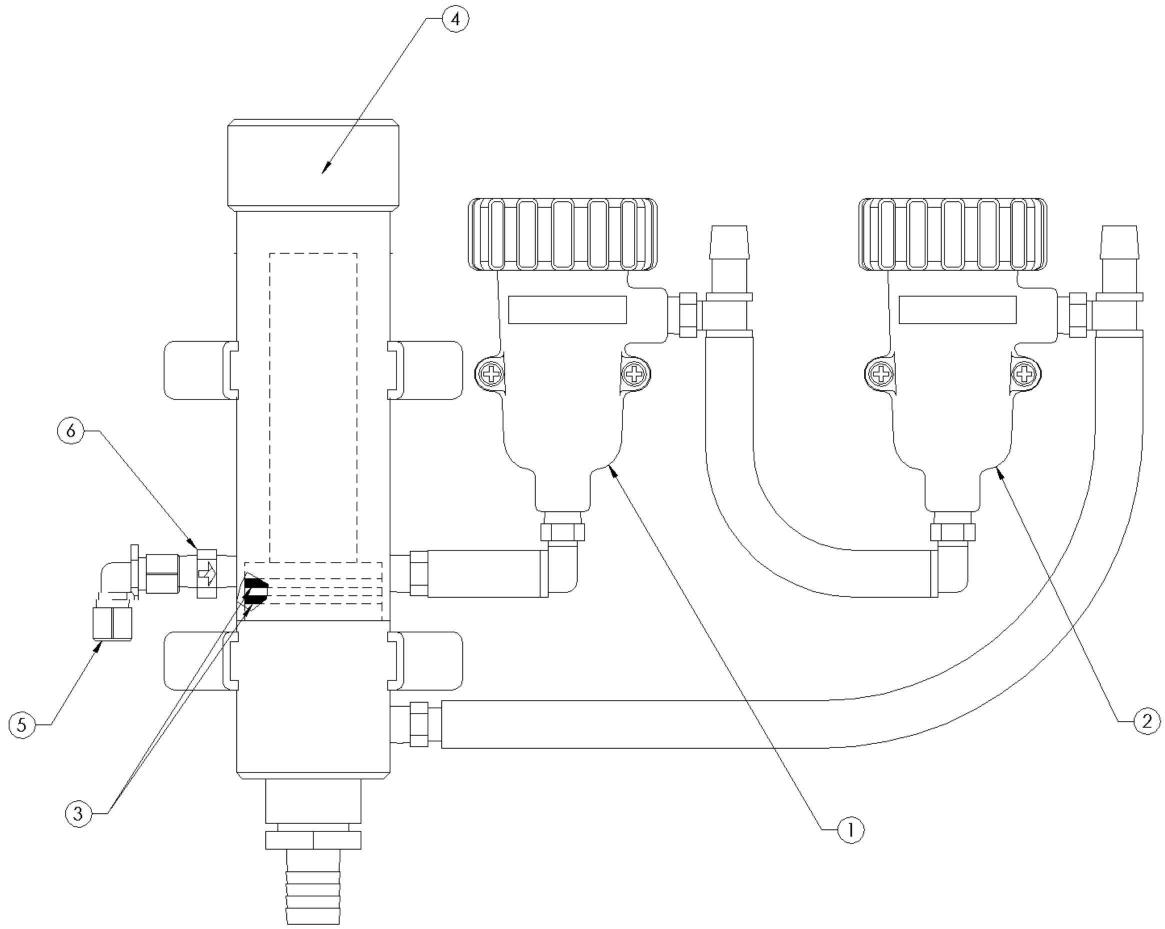

FIGURE 7-4. Replacement Parts for the Flow Controller Assembly used in Model FCL-02.

TABLE 7-4. Replacement parts for constant head flow controller assembly (Model FCL-02)

Location in Figure 7-4	PN	Description	Shipping Weight
1	24091-01	Flow cell for chlorine sensor with bubble shedding nozzle	1 lb/0.5 kg
2	24091-00	Flow cell for pH sensor	1 lb/0.5 kg
3	24040-00	O-ring kit, two 2-222 and one 2-024 silicone O-rings, with lubricant	1 lb/0.5 kg
4	33812-00	Dust cap for constant head flow controller	1 lb/0.5 kg
5	9322032	Elbow, ¼ in FNPT x ¼ in OD tubing	1 lb/0.5 kg
6	9350029	Check valve, ¼ in FNPT	1 lb/0.5 kg

SECTION 8.0
TROUBLESHOOTING

8.1 OVERVIEW
8.2 TROUBLESHOOTING USING FAULT CODES
8.3 TROUBLESHOOTING WHEN NO ERROR MESSAGE IS SHOWING — FREE CHLORINE
8.4 TROUBLESHOOTING WHEN NO ERROR MESSAGE IS SHOWING — pH
8.5 TROUBLESHOOTING WHEN NO ERROR MESSAGE IS SHOWING — GENERAL
8.6 SIMULATING INPUTS — CHLORINE
8.7 SIMULATING INPUTS — pH
8.8 SIMULATING TEMPERATURE
8.9 MEASURING REFERENCE VOLTAGE — pH

8.1 OVERVIEW

The analyzer used with the Model FCL continuously monitors itself and the sensor(s) for faults. When the analyzer detects a fault, the word *fault* appears in the display alternately with the measurement. If alarm 3 was configured as a fault alarm, the alarm relay will energize. The outputs do not change during a fault condition. They continue to reflect the measured chlorine, pH or temperature. **Press ▲ to display the fault codes.**

NOTE

A large number of information screens are available to aid troubleshooting. The most useful of these are raw sensor current and sensitivity and zero current at last calibration. For pH measurements (available with Model FCL-02), sensor slope and offset and glass impedance are also available. To view the information screens, go to the main display and press the ▼ key.

8.2 TROUBLESHOOTING USING FAULT CODES

Fault Code	Explanation	See Section
S1 Out of Range	Sensor current exceeds 210 µA (chlorine only)	8.2.1
S2 Out of Range	Absolute value of measured voltage exceeds 2500 mV (pH/ORP only)	8.2.2
S2 Broken Glass	pH sensitive glass membrane is broken	8.2.3
TC1 Open or TC2 Open	RTD for sensor 1 or sensor 2 is open	8.2.4
TC1 Shorted or TC2 Shorted	RTD for sensor 1 or sensor 2 is shorted	8.2.4
S1 or S2 Sense Line Open	RTD sense line for sensor 1 or sensor 2 is open	8.2.5
EEPROM Failure	EEPROM failure	8.2.6

8.2.1 Chlorine Sensor Current Exceeds 210 µA

Excessive sensor current implies that the chlorine sensor is miswired or the sensor has failed.

8.2.2 Absolute Value of Measured Voltage from the pH Sensor Exceeds 2500 mV

The voltage of a pH cell is usually between 600 mV and -600 mV. Readings outside the range -2500 mV to 2500 mV usually indicate a problem with sensor wiring or analyzer electronics.

A. If the sensor cable has just been replaced, check the wiring connections. See Section 3.2.

B. Verify that the sensor is completely submerged in the sample.

8.2.3 pH Sensitive Glass Membrane is Broken

The analyzer continuously measures the impedance between the reference electrode and the inside of the pH-sensing electrode. If the glass membrane is intact, the impedance is normally between 10 MΩ and 1000 MΩ. If the membrane is cracked or broken, the impedance drops below 10 MΩ. If the membrane is cracked or broken, the sensor must be replaced.

8.2.4 RTD for Sensor 1 or Sensor 2 Open or Shorted.

There is an open or short in the sensor RTD or wiring.

A. If the sensor cable has just been replaced, check the wiring connections. See Section 3.2.

B. Disconnect the sensor from the lead wire. Connect an ohmmeter across the RTD IN and RTD RETURN pins on the Variopol plug at the top of the sensor. Refer to Figure 8-1 or 8-2. The resistance should be about 110 Ω. If there is an open or short circuit, the sensor has failed and should be replaced. If the resistance is acceptable, attach the sensor the Variopol cable and disconnect the RTD IN and RTD RETURN leads at the analyzer. Refer to Figure 3-2 or Figure 3-3. Connect an ohmmeter across the leads and measure the resistance. If the circuit is open or shorted, the failure is in the cable, and the cable must be replaced.

C. If there is no open or short, check the analyzer. See Section 8.8.

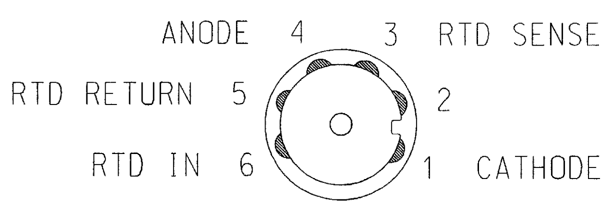

FIGURE 8-1. Pin Out Diagram for Model 499ACL-01-VP Sensor (top view of connector end of sensor)

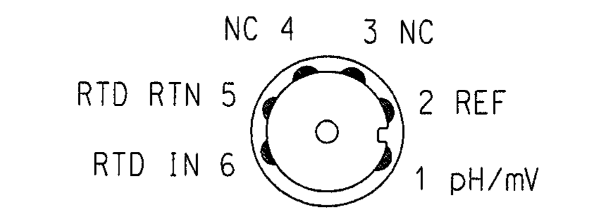

FIGURE 8-2. Pin Out Diagram for Model 399VP-09 Sensor (top view of connector end of sensor)

8.2.5 RTD Sense Line for Sensor 1 or Sensor 2 is Open.

The analyzer measures temperature using a three-wire RTD. See Figure 8-4. The in and return leads connect the RTD to the measuring circuit in the analyzer. A third wire, called the sense line, is connected to the return line. The sense line allows the analyzer to correct for the resistance of the in and return leads and to correct for changes in lead wire resistance caused by changes in the ambient temperature.

A. Verify that all wiring connections are secure.

B. The system can be operated with the sense line open. The measurement will be less accurate because the analyzer can no longer correct for lead wire resistance and for changes in lead wire resistance with ambient temperature. However, if the sensor is to be used at approximately constant temperature, the lead wire resistance error can be eliminated by calibrating the sensor at the measurement temperature. Errors caused by changes in lead wire resistance with changes in ambient temperature cannot be eliminated.To make the error message disappear, connect the RTD sense and return terminals with a jumper.

8.2.6 EEPROM Failure.

Call the factory at (800) 854-8257.

8.3 TROUBLESHOOTING WHEN NO ERROR MESSAGE IS SHOWING — FREE CHLORINE

Problem	See Section
Zero current was accepted, but the current is outside the range -10 to 10 nA	8.3.1
Error or warning message appears while zeroing the sensor (zero current is too high)	8.3.1
Zero current is unstable	8.3.2
Sensor can be calibrated, but the current is less than about 250 nA/ppm at 25°C and pH 8	8.3.3
Process readings are erratic	8.3.4
Readings drift	8.3.5
Sensor does not respond to changes in chlorine level	8.3.6
Chlorine reading spikes following rapid change in pH	8.3.7
Chlorine readings are too low	8.3.8

8.3.1 Zero current is too high

A. Is the sensor properly wired to the analyzer? See Section 3.2.

B. Is the zero solution chlorine-free? Take a sample of the solution and test it for free chlorine level. The concentration should be less than 0.02 ppm.

C. Has adequate time been allowed for the sensor to reach a minimum stable residual current? It may take several hours, sometimes as long as overnight, for a new sensor to stabilize.

D. Check the membrane for damage and replace it if necessary.

8.3.2 Zero current is unstable

A. Is the sensor properly wired to the analyzer? See Section 3.2. Verify that all wiring connections are tight.

B. Readings are often erratic when a new or rebuilt sensor is first placed in service. Readings usually stabilize after about an hour.

C. Is the conductivity of the zero solution greater than 50 µS/cm? DO NOT USE DEIONIZED OR DISTILLED WATER TO ZERO THE SENSOR. The zero solution should contain at least 0.5 grams of sodium chloride per liter.

D. Is the space between the membrane and cathode filled with electrolyte solution and is the flow path between the electrolyte reservoir and membrane clear? Often the flow of electrolyte and be started by simply holding the sensor with the membrane end pointing down and sharply shaking the sensor a few times as though shaking down a clinical thermometer.

   If shaking does not work, try clearing the holes around the cathode stem. Hold the sensor with the membrane end pointing up. Unscrew the membrane retainer and remove the membrane assembly. Be sure the wood ring remains with the membrane assembly. Use the end of a straightened paper clip to clear the holes at the base of the cathode stem. Replace the membrane.

   Verify that the sensor is filled with electrolyte solution. Refer to Section 7.2.

8.3.3 Sensor can be calibrated, but the current is too low

A. Is the temperature low or is the pH high? Sensor current is a strong function of pH and temperature. The sensor current decreases about 3% for every °C drop in temperature. Sensor current also decreases as pH increases. Above pH 7, a 0.1 unit increase in pH lowers the current about 5%.

B. Sensor current depends on the rate of sample flow past the sensor tip. If the flow is too low, chlorine readings will be low. Verify that the chlorine sensor is installed in the correct flow cell. See Figure 2-1. Be sure the liquid level in the constant head sampler is level with the central overflow tube and that excess sample is flowing down the tube. If necessary, disassemble and clean the overflow sampler. See Section 7.4.

C. Low current can be caused by lack of electrolyte flow to the cathode and membrane. See step D in Section 8.3.2.

D. Is the membrane fouled or coated? A dirty membrane inhibits diffusion of free chlorine through the membrane, reducing the sensor current and increasing the response time. Clean the membrane by rinsing it with a stream of water from a wash bottle. DO NOT use a membrane or tissue to wipe the membrane.

E. If cleaning the membrane does not improve the sensor response, replace the membrane and electrolyte solution. If necessary, polish the cathode. See Section 7.2 for details.

8.3.4 Process readings are erratic

A. Readings are often erratic when a new sensor or a rebuilt sensor is first placed in service. The current usually stabilizes after a few hours.

B. Are the holes between the membrane and the electrolyte reservoir open? Refer to Section 8.3.2.

C. Verify that wiring is correct. Pay particular attention to shield and ground connections.

D. If automatic pH correction is being used, check the pH reading. If the pH reading is noisy, the chlorine reading will also be noisy. If the pH sensor is the cause of the noise, use manual pH correction until the problem with the pH sensor can be corrected. Also, refer to Section 8.4.8 for troubleshooting noisy pH readings.

E. Is the membrane in good condition and is the sensor filled with electrolyte solution? Replace the fill solution and electrolyte. Refer to Section 7.2 for details.

8.3.5 Readings drift

A. Is the sample temperature changing? Membrane permeability is a function of temperature. The time constant for the 499ACL-01 sensor is about five minutes. Therefore, the reading may drift for a while after a sudden temperature change.

B. Is the membrane clean? For the sensor to work properly, chlorine must diffuse freely through the membrane. A coating on the membrane will interfere with the passage of chlorine, resulting in slow response. Clean the membrane by rinsing it with a stream of water from a wash bottle. **DO NOT** use a membrane or tissue to wipe the membrane.

C. Is the sample flow within the recommended range? Gradual loss of sample flow will cause a downward drift. Be sure the liquid level in the constant head sampler is level with the central overflow tube and that excess sample is flowing down the tube. If necessary, disassemble and clean the overflow sampler. See Section 7.4.

D. Is the sensor new or has it been recently serviced? New or rebuilt sensors may require several hours to stabilize.

E. Is the pH of the process changing? If manual pH correction is being used, a gradual change in pH will cause a gradual change in the chlorine reading. As pH increases, chlorine readings will decrease, even though the free chlorine level (as determined by a grab sample test) remained constant. If the pH change is no more than about 0.2, the change in the chlorine reading will be no more than about 10% of reading. If the pH changes are more than 0.2, use automatic pH correction.

8.3.6 Sensor does not respond to changes in chlorine level.

A. Is the grab sample test accurate? Is the grab sample representative of the sample flowing to the sensor?

B. Is sample flowing past the sensor? Be sure the liquid level in the constant head sampler is level with the central overflow tube and that excess sample is flowing down the tube. If necessary, disassemble and clean the overflow sampler. See Section 7.4.

C. Is the pH compensation correct? If the analyzer is using manual pH correction, verify that the pH value in the analyzer equals the actual pH to within ±0.1 pH. If the analyzer is using automatic pH correction, check the calibration of the pH sensor.

D. Is the membrane clean? Clean the membrane and replace it if necessary. Check that the holes at the base of the cathode stem are open. Use a straightened paper clip to clear blockages. Replace the electrolyte solution.

E. Replace the sensor.

8.3.7 Chlorine readings spike following sudden changes in pH (automatic pH correction).

Changes in pH alter the relative amounts of hypochlorous acid (HOCl) and hypochlorite ion (OCl^-) in the sample. Because the sensor responds only to HOCl, an increase in pH causes the sensor current (and the apparent chlorine level) to drop even though the actual free chlorine concentration remained constant. To correct for the pH effect, the controller automatically applies a correction. Generally, the pH sensor responds faster than the chlorine sensor. After a sudden pH change, the controller will temporarily over-compensate and gradually return to the correct value. The time constant for return to normal is about 5 minutes.

8.3.8 Chlorine readings are too low.

A. Was the sample tested as soon as it was taken? Chlorine solutions are unstable. Test the sample immediately after collecting it. Avoid exposing the sample to sunlight.

B. Low readings can be caused by zeroing the sensor before the residual current has reached a stable minimum value. Residual current is the current the sensor generates even when no chlorine is in the sample. Because the residual current is subtracted from subsequent measured currents, zeroing before the current is a minimum can lead to low results.

   Example: The true residual current for a free chlorine sensor is 4 nA, and the sensitivity is 350 nA/ppm. Assume the measured current is 200 nA. The true concentration is (200-4)/350 or 0.56 ppm. If the sensor was zeroed prematurely when the current was 10 nA, the measured concentration will be (200-10)/350 or 0.54 ppm. The error is 3.6%. Suppose the measured current is 400 nA. The true concentration is 1.13 ppm, and the measured concentration is 1.11 ppm. The error is now 1.8%. The absolute difference between the reading remains the same, 0.02 ppm.

C. Sensor response depends on flow. If the flow is too low, readings will be low and flow sensitive. Verify that the chlorine sensor is installed in the correct flow cell. See Figure 2-1. Verify that the liquid level in the constant head sampler is level with the central overflow tube and that excess sample is flowing down the tube. If necessary, disassemble and clean the overflow sampler. See Section 7.4.

8.4 TROUBLESHOOTING WHEN NO ERROR MESSAGE IS SHOWING — pH.

Problem	See Section
New temperature during calibration more than 2-3°C different from the live reading	8.4.1
Calibration Error warning during two-point calibration	8.4.2
Calibration Error warning during standardization	8.4.3
Invalid Input while manually entering slope	8.4.4
Sensor does not respond to known pH changes	8.4.5
Calibration was successful, but process pH is slightly different from expected value	8.4.6
Calibration was successful, but process pH is grossly wrong and/or noisy	8.4.7
pH readings are moderately noisy and tend to wander	8.4.8

8.4.1 Difference Between Analyzer and Standard Thermometer is Greater Than 3°C.

A. Is the standard thermometer, RTD, or thermistor accurate? General purpose liquid-in-glass thermometers, particularly ones that have been mistreated, can have surprisingly large errors.

B. Is the temperature element in the pH sensor completely submerged in the test liquid?

C. Is the standard temperature sensor submerged to the correct level?

D. Review Section 6.2.

8.4.2 Calibration Error During Two-Point Calibration

Once the two-point (manual or automatic) calibration is complete, the analyzer automatically calculates the sensor slope (at 25°). If the slope is greater than 60 mV/pH or less than 45 mV/pH, the analyzer displays the Calibration Error screen and does not update the calibration. Check the following:

A. Are the buffers accurate? Inspect the buffers for obvious signs of deterioration, such as turbidity or mold growth. Neutral and slightly acidic buffers are highly susceptible to molds. Alkaline buffers (pH 9 and greater), if they have been exposed to air for long periods, may also be inaccurate. Alkaline buffers absorb carbon dioxide from the atmosphere, which lowers the pH. If a high pH buffer was used in the failed calibration, repeat the calibration using a fresh buffer. If fresh buffer is not available, use a lower pH buffer. For example, use pH 4 and 7 buffer instead of pH 7 and 10 buffer.

B. Was adequate time allowed for temperature equilibration? If the sensor was in a process substantially hotter or colder than the buffer, place it in a container of water at ambient temperature for at least 20 minutes before starting the calibration. Using auto calibration avoids calibration errors caused by temperature drift. The analyzer will not update readings until the drift is less than 0.02 pH over 10 seconds.

C. Were correct pH values entered during manual calibration? Using auto calibration eliminates errors caused by improperly entering data.

D. Is the sensor properly wired to the analyzer? See Section 3.2.

E. Is the sensor dirty or coated? See Section 7.3.2..

```
      Glass Imp
123MΩ
```

F. Is the sensor faulty? With the main display showing, use ▲ or ▼ to scroll through the information screens until the electrode impedance screen (at left) is displayed. Refer to the table on the following page for an interpretation of the impedance readings.

Another way of checking for a faulty sensor is to replace it with a new one. If the new sensor can be calibrated, the old sensor has failed.

G. Is the analyzer faulty? The best way to check for a faulty analyzer is to simulate pH inputs. See Section 8.9.

GLASS IMPEDANCE (**Glass Imp**)	
less than 10 MΩ	Glass bulb is cracked or broken. Sensor has failed.
between 10 and 1000 MΩ	Normal reading.
greater than 1000 MΩ	pH sensor may be nearing the end of its service life.

8.4.3 Calibration Error during Standardization.

During standardization, the millivolt signal from the pH cell is increased or decreased until it agrees with the pH reading from a referee instrument. A unit change in pH requires an offset of about 59 mV. The analyzer limits the offset to ±1400 mV. If the standardization causes an offset greater than ±1400 mV, the analyzer will display the Calibration Error screen. The standardization will not be updated. Check the following:

A. Is the referee pH meter working and properly calibrated? Check the response of the referee sensor in buffers.

B. Is the process sensor working properly? Check the process sensor in buffers.

C. Is the sensor fully immersed in the process liquid? If the sensor is not completely submerged, it may be measuring the pH of the liquid film covering the glass bulb and reference element. The pH of this film may be different from the pH of the bulk liquid.

D. Is the sensor fouled? The sensor measures the pH of the liquid adjacent to the glass bulb. If the sensor is heavily fouled, the pH of liquid trapped against the bulb may be different from the bulk liquid.

E. Has the sensor been exposed to poisoning agents (sulfides or cyanides) or has it been exposed to extreme temperature? Poisoning agents and high temperature can shift the reference voltage many hundred millivolts. To check the reference voltage, see Section 8.9.

8.4.4 Invalid Input While Manually Entering Slope.

If the sensor slope is known from other sources, it can be entered directly into the analyzer. The FCL will not accept a slope (at 25°C) outside the range 45 to 60 mV/pH. See section 8.4.2 for troubleshooting sensor slope problems.

8.4.5 Sensor Does Not Respond to Known pH Changes.

A. Did the expected pH change really occur? If the process pH reading was not what was expected, check the performance of the sensor in buffers. Also, use a second pH meter to verify the change.

B. Is sample flowing past the sensor? Be sure the liquid level in the constant head sampler is level with the central overflow tube and that excess sample is flowing down the tube. If necessary, disassemble and clean the overflow sampler. See Section 7.4.

C. Is the sensor properly wired to the analyzer? See Section 3.2.

D. Is the glass bulb cracked or broken? Check the glass electrode impedance. See Section 8.4.2.

E. Is the analyzer working properly. Check the analyzer by simulating the pH input. See Section 8.7.

8.4.6 Buffer Calibration Is Acceptable, Process pH Is Slightly Different from Expected Value.

Differences between pH readings made with an on-line instrument and a laboratory or portable instrument are normal. The on-line instrument is subject to process variables, for example ground potentials, stray voltages, and orientation effects that may not affect the laboratory or portable instrument. To make the process reading agree with a referee instrument, see Section 6.5.

8.4.7 Calibration Was Successful, but Process pH Is Grossly Wrong and/or Noisy.

Grossly wrong or noisy readings suggest a ground loop (measurement system connected to earth ground at more than one point), a floating system (no earth ground), or noise being brought into the analyzer by the sensor cable. The problem arises from the process or installation. It is not a fault of the analyzer. The problem should disappear once the sensor is taken out of the system. Check the following:

A. Is a ground loop present?
   1. Verify that the system works properly in buffers. Be sure there is no direct electrical connection between the buffer containers and the process liquid or piping.
   2. Strip back the ends of a heavy gauge wire. Connect one end of the wire to the process piping or place it in the process liquid. Place the other end of the wire in the container of buffer with the sensor. The wire makes an electrical connection between the process and sensor.
   3. If offsets and noise appear after making the connection, a ground loop exists.

B. Is the process grounded?
   1. The measurement system needs one path to ground: through the process liquid and piping. Plastic piping, fiberglass tanks, and ungrounded or poorly grounded vessels do not provide a path. A floating system can pick up stray voltages from other electrical equipment.
   2. Ground the piping or tank to a local earth ground.
   3. If noise still persists, simple grounding is not the problem. Noise is probably being carried into the instrument through the sensor wiring.

C. Simplify the sensor wiring.
   1. Disconnect all sensor wires at the analyzer except pH/mV IN, REFERENCE IN, RTD IN and RTD RETURN. See the wiring diagrams in Section 3.2.
   2. Tape back the ends of the disconnected wires to keep them from making accidental connections with other wires or terminals.
   3. Connect a jumper wire between the RTD RETURN and RTD SENSE terminals (see wiring diagrams in Section 3.2).
   4. If noise and/or offsets disappear, the interference was coming into the analyzer through one of the sensor wires. The system can be operated permanently with the simplified wiring.

D. Check for extra ground connections or induced noise.
   1. To avoid induced noise in the sensor cable, keep the unit as far away as possible from power cables, relays, and electric motors.
   2. If ground loops persist, consult the factory. A visit from an experienced technician may be required to solve the problem.

8.4.8 pH Readings Are Moderately Noisy and Tend to Wander.

pH readings that are moderately noisy (±0.1 pH) and tend to wander are probably caused by bubbles getting trapped against the pH sensor. Although the overflow sampler is designed to allow bubbles to escape before they reach the pH sensor and the sensor itself is designed so trapped air bubbles don't interfere with the measurement, bubbles may occasionally be a problem. Shaking the sensor will dislodge the bubbles. If bubbles remain a problem, contact the factory.

8.5 TROUBLESHOOTING WHEN NO ERROR MESSAGE IS SHOWING — GENERAL

Problem	See Section
Current output is too low	8.5.1
Alarm relays do not operate when setpoint is exceeded	8.5.2
Display is unreadable — too faint or all pixels dark	8.5.3

8.5.1 Current Output Too Low.

Load resistance is too high. Maximum load is 600 Ω.

8.5.2 Alarm Relays Do Not Work

Verify the relays are properly wired.

8.5.3 Display is Unreadable.

While holding down the MENU key, press ▲ or ▼ until the display has the correct contrast.

8.6 SIMULATING INPUTS — CHLORINE

To check the performance of the analyzer, use a decade box and battery to simulate the current from the sensor. The battery, which opposes the polarizing voltage, is necessary to ensure that the sensor current has the correct sign.

A. Disconnect the anode and cathode leads from terminals 1 and 2 on TB3 and connect a decade box and battery as shown in Figure 8-3. It is not necessary to disconnect the RTD leads.

B. Set the decade box to the resistance shown below.

Polarizing Voltage	Resistance	Expected Current
200 mV	28 MΩ	500 nA

C. Note the sensor current. It should be close to the value in the table. The actual value depends on the voltage of the battery. To view the sensor current, go to the main display and press ▼ until the sensor current is displayed.

D. Change the decade box resistance and verify that the correct current is shown. Calculate current from the equation:

$$\text{current } (\mu\text{A}) = \frac{V_{battery} - V_{polarizing}\ (\text{mV})}{\text{resistance } (\text{k}\Omega)}$$

The voltage of a fresh 1.5 volt battery is about 1.6 volt (1600 mV).

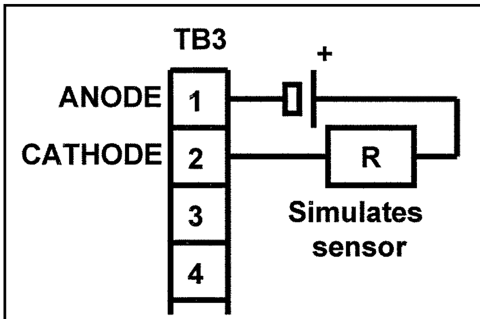

FIGURE 8-3. Simulating Chlorine

8.7 SIMULATING INPUTS — pH

8.7.1 General

This section describes how to simulate a pH input into the Model FCL analyzer. To simulate a pH measurement, connect a standard millivolt source to the analyzer. If the analyzer is working properly, it will accurately measure the input voltage and convert it to pH.

8.7.2 Simulating pH input.

1. Turn off automatic temperature correction and solution temperature correction. From the Program menu, choose **Temp**. Then choose **Live/Manual** and enter 25°C. See Section 5.6 for details.
2. Disconnect the sensor and connect a jumper wire between the pH IN and REFERENCE IN terminals.
3. From the display menu choose the pH/temperature/mV screen. The measured voltage should be 0 mV and the pH should be 7.00. Because calibration data stored in the analyzer may be offsetting the input voltage, the displayed pH may not be exactly 7.00.

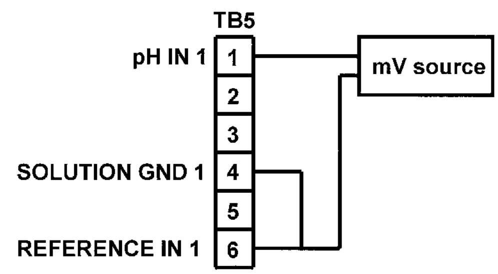

FIGURE 8-4. Simulating pH Inputs

4. If a standard millivolt source is available, disconnect the jumper wire between pH IN and REFERENCE IN and connect the voltage source as shown in Figure 8-4. Be sure to jumper the reference and solution ground terminals.
5. Calibrate the analyzer using the procedure in Section 6.3. Use 0.0 mV for Buffer 1 (pH 7.00) and -177.4 mV for Buffer 2 (pH 10.00). If the analyzer is working properly it should accept the calibration. The slope should be 59.16 mV/pH and the offset should be zero.
6. To check linearity, return to the main display and the pH/temperature/mV screen. Set the voltage source to the values shown in the table and verify that the pH and millivolt readings match the values in the table.

Voltage (mV)	pH (at 25°)
295.8	2.00
177.5	4.00
59.2	6.00
-59.2	8.00
-177.5	10.00
-295.8	12.00

8.8 SIMULATING TEMPERATURE

8.8.1 General.

The FCL analyzer accepts a Pt100 RTD (for pH and chlorine sensors). The Pt100 RTD is in a three-wire configuration. See Figure 8-5.

8.8.2 Simulating temperature

To simulate the temperature input, wire a decade box to the analyzer or junction box as shown in Figure 8-6.

To check the accuracy of the temperature measurement, set the resistor simulating the RTD to the values indicated in the table and note the temperature readings. The measured temperature might not agree with the value in the table. During sensor calibration an offset might have been applied to make the measured temperature agree with a standard thermometer. The offset is also applied to the simulated resistance. The FCL is measuring temperature correctly if the difference between measured temperatures equals the difference between the values in the table to within ±0.1°C.

For example, start with a simulated resistance of 103.9 Ω, which corresponds to 10.0°C. Assume the offset from the sensor calibration was -0.3 Ω. Because of the offset, the analyzer calculates temperature using 103.6 Ω. The result is 9.2°C. Now change the resistance to 107.8 Ω, which corresponds to 20.0°C. The analyzer uses 107.5 Ω to calculate the temperature, so the display reads 19.2°C. Because the difference between the displayed temperatures (10.0°C) is the same as the difference between the simulated temperatures, the analyzer is working correctly.

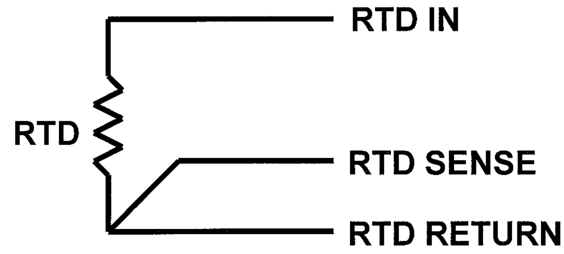

FIGURE 8-5. Three-Wire RTD Configuration.

Although only two wires are required to connect the RTD to the analyzer, using a third (and sometimes fourth) wire allows the analyzer to correct for the resistance of the lead wires and for changes in the lead wire resistance with temperature.

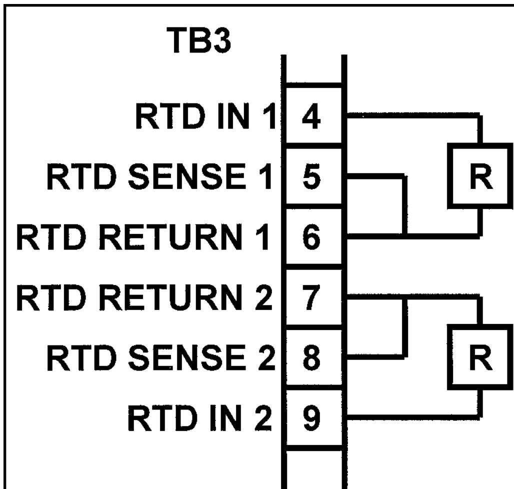

FIGURE 8-6. Simulating RTD Inputs.

Temp. (°C)	Pt 100 (Ω)
0	100.0
10	103.9
20	107.8
25	109.7
30	111.7
40	115.5
50	119.4
60	123.2
70	127.1
80	130.9
85	132.8
90	134.7
100	138.5

8.9 MEASURING REFERENCE VOLTAGE

Some processes contain substances that poison or shift the potential of the reference electrode. Sulfide is a good example. Prolonged exposure to sulfide converts the reference electrode from a silver/silver chloride electrode to a silver/silver sulfide electrode. The change in reference voltage is several hundred millivolts. A good way to check for poisoning is to compare the voltage of the reference electrode with a silver/silver chloride electrode known to be good. The reference electrode from a new sensor is best. See Figure 8-7. If the reference electrode is good, the voltage difference should be no more than about 20 mV. A poisoned reference electrode usually requires replacement.

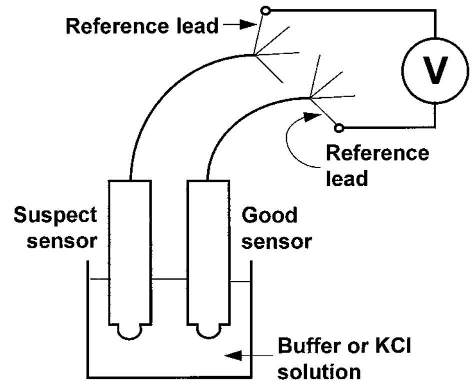

FIGURE 8-7. Checking for a Poisoned Reference Electrode.

Refer to the sensor wiring diagram to identify the reference leads. A laboratory silver/silver chloride electrode can be used in place of the second sensor.

SECTION 9.0
RETURN OF MATERIAL

9.1 GENERAL
9.2 WARRANTY REPAIR
9.3 NON-WARRANTY REPAIR

9.1 GENERAL.

To expedite the repair and return of instruments, proper communication between the customer and the factory is important. Before returning a product for repair, call 1-949-757-8500 for a Return Materials Authorization (RMA) number.

9.2 WARRANTY REPAIR.

The following is the procedure for returning instruments still under warranty:

1. Call Rosemount Analytical for authorization.
2. To verify warranty, supply the factory sales order number or the original purchase order number. In the case of individual parts or sub-assemblies, the serial number on the unit must be supplied.
3. Carefully package the materials and enclose your “Letter of Transmittal” (see Warranty). If possible, pack the materials in the same manner as they were received.
4. Send the package prepaid to:

   Emerson Process Management
   Liquid Division
   2400 Barranca Parkway
   Irvine, CA 92606

   Attn: Factory Repair

   RMA No. ____________

   Mark the package: Returned for Repair

   Model No. ____

9.3 NON-WARRANTY REPAIR.

The following is the procedure for returning for repair instruments that are no longer under warranty:

1. Call Rosemount Analytical for authorization.
2. Supply the purchase order number, and make sure to provide the name and telephone number of the individual to be contacted should additional information be needed.
3. Do Steps 3 and 4 of Section 9.2.

NOTE

Consult the factory for additional information regarding service or repair.

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Toll Free: 800-854-8257
Fax: 949-474-7250

ASIA-PACIFIC

Emerson Process Management
Asia Pacific Private Ltd.
1 Pandan Crescent
Singapore 0512
Republic of Singapore
Phone: 65-777-8211
Fax: 65-777-0947

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Bognor Regis
West Sussex PO22 9SH
England
Phone: 44-1243-863121
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WARRANTY

Seller warrants that the firmware will execute the programming instructions provided by Seller, and that the Goods manufactured or Services provided by Seller will be free from defects in materials or workmanship under normal use and care until the expiration of the applicable warranty period. Goods are warranted for twelve (12) months from the date of initial installation or eighteen (18) months from the date of shipment by Seller, whichever period expires first. **Consumables, such as glass electrodes, membranes, liquid junctions, electrolyte, o-rings, catalytic beads, etc., and Services are warranted for a period of 90 days from the date of shipment or provision.**

Products purchased by Seller from a third party for resale to Buyer ("Resale Products") shall carry only the warranty extended by the original manufacturer. Buyer agrees that Seller has no liability for Resale Products beyond making a reasonable commercial effort to arrange for procurement and shipping of the Resale Products.

If Buyer discovers any warranty defects and notifies Seller thereof in writing during the applicable warranty period, Seller shall, at its option, promptly correct any errors that are found by Seller in the firmware or Services, or repair or replace F.O.B. point of manufacture that portion of the Goods or firmware found by Seller to be defective, or refund the purchase price of the defective portion of the Goods/Services.

All replacements or repairs necessitated by inadequate maintenance, normal wear and usage, unsuitable power sources, unsuitable environmental conditions, accident, misuse, improper installation, modification, repair, storage or handling, or any other cause not the fault of Seller are not covered by this limited warranty, and shall be at Buyer's expense. Seller shall not be obligated to pay any costs or charges incurred by Buyer or any other party except as may be agreed upon in writing in advance by an authorized Seller representative. All costs of dismantling, reinstallation and freight and the time and expenses of Seller's personnel for site travel and diagnosis under this warranty clause shall be borne by Buyer unless accepted in writing by Seller.

Goods repaired and parts replaced during the warranty period shall be in warranty for the remainder of the original warranty period or ninety (90) days, whichever is longer. This limited warranty is the only warranty made by Seller and can be amended only in a writing signed by an authorized representative of Seller. Except as otherwise expressly provided in the Agreement, THERE ARE NO REPRESENTATIONS OR WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, AS TO MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE, OR ANY OTHER MATTER WITH RESPECT TO ANY OF THE GOODS OR SERVICES.

RETURN OF MATERIAL

Material returned for repair, whether in or out of warranty, should be shipped prepaid to:

Emerson Process Management
Liquid Division
2400 Barranca Parkway
Irvine, CA 92606

The shipping container should be marked:

Return for Repair
Model ________________________________

The returned material should be accompanied by a letter of transmittal which should include the following information (make a copy of the "Return of Materials Request" found on the last page of the Manual and provide the following thereon):

1. Location type of service, and length of time of service of the device.
2. Description of the faulty operation of the device and the circumstances of the failure.
3. Name and telephone number of the person to contact if there are questions about the returned material.
4. Statement as to whether warranty or non-warranty service is requested.
5. Complete shipping instructions for return of the material.

Adherence to these procedures will expedite handling of the returned material and will prevent unnecessary additional charges for inspection and testing to determine the problem with the device.

If the material is returned for out-of-warranty repairs, a purchase order for repairs should be enclosed.

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