

Instruction Manual

PN 51-FCL-54eA rev.B

March 2012

FCL with 54eA Analyzer



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.



WARNING 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.

Emerson Process Management

2400 Barranca Parkway
Irvine, CA 92606 USA
Tel: (949) 757-8500
Fax: (949) 474-7250

<http://www.rosemountanalytical.com>

About This Document

This manual contains instructions for installation and operation of the Model FCL-54eA

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

<u>Rev. Level</u>	<u>Date</u>	<u>Notes</u>
A	5/09	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	3/12	Update addresses - mail and web and DNV certificate logo.

FCL-54eA

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SECTION 1.0. DESCRIPTION AND SPECIFICATIONS

- COMPLETE SYSTEM INCLUDES sensors, connecting cables, 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.

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

1.1 APPLICATIONS

The FCL free chlorine system is intended for the determination of free chlorine in fresh water. Unlike free chlorine analyzers from other manufacturers, the 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 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.

1.2 FEATURES

The FCL uses a membrane-covered amperometric sensor. A polarizing voltage applied to a platinum cathode behind the membrane destroys any chlorine that diffuses through the membrane, keeping 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.

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 FCL avoids the expense and inconvenience of sample conditioning by measuring the pH and applying a cor-

rection to the raw chlorine sensor signal. The correction is valid between pH 6.0 and 9.5. Below pH 6.0, no correction is needed. For samples having pH between 9.5 and 10.0, consult the factory.

The 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 FCL includes the easy-to-use Model 54eA analyzer. The analyzer features two fully programmable 4-20 mA analog outputs and three alarm relays. Programming and calibration are simple and intuitive. The large backlit display allows the user to read chlorine at a single 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 the sensors. 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.

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 a barbed fitting for use with 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-01-230: 10 lb/13 lb (4.5 kg/6.0 kg)

Model FCL-02-230: 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 Cl₂. 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 — MODEL 54eA ANALYZER

Case: Epoxy-painted cast aluminum, NEMA4X (IP65).

Front Panel: Membrane keypad with tactile feedback. Three green LEDs indicate alarm status. Red LED indicates fault condition.

Conduit Openings: Accepts PG 13.5 or 1/2 inch conduit fittings

Display: Three-line, back-lit, dot matrix LCD, 70 x 35 mm. First line is measurement reading. Second line is temperature and current output. Third line is user-selectable. Character heights: 1st line - 16 mm (0.6 in.), 2nd and 3rd lines - 7 mm (0.3 in.).

Ambient Temperature and Humidity: 0 to 50°C (32 to 122°F). 95% (maximum) non-condensing. Analyzer can be operated between -20 and 60°C (-4 to 140°F) with some degradation in display quality.

Power: 100-127 Vac ± 10%, 50/60 Hz ± 6%, 8 W
200-253 Vac ± 10%, 50/60 Hz ± 6%, 8 W

RFI/EMI: EN-61326

LVD: EN-61010-1



Outputs: Two 4-20 mA or 0-20 mA isolated outputs. Continuously adjustable. Outputs can be assigned to chlorine or temperature. Output dampening is user-selectable. Maximum load at 115/230 Vac is 600Ω. Maximum load at 100/200 Vac is 550Ω.



Alarms: Three alarm relays for process measurement, temperature or interval timer. The fourth alarm relay is a sensor/analyzer fault alarm.

Relay Contacts: Relays 1-3: Form A, SPST, NO, epoxy sealed. Relay 4: Form C, SPDT, epoxy sealed



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

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

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

² Noryl is a registered trademark of General Electric.

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

SECTION 2.0. 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 FCL-01-230 (free chlorine without continuous pH correction)

Model FCL-01-230 consists of the following items mounted on a back plate.

1. Model 54eA-01 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), shipped with three membrane assemblies and a bottle of electrolyte solution, are in a separate package.

2.1.2 FCL-02-230 (free chlorine with continuous pH correction)

Model FCL-02-230 consists of the following items mounted on a back plate.

1. Model 54eA-01 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 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 122°F (0 to 50°C)
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.

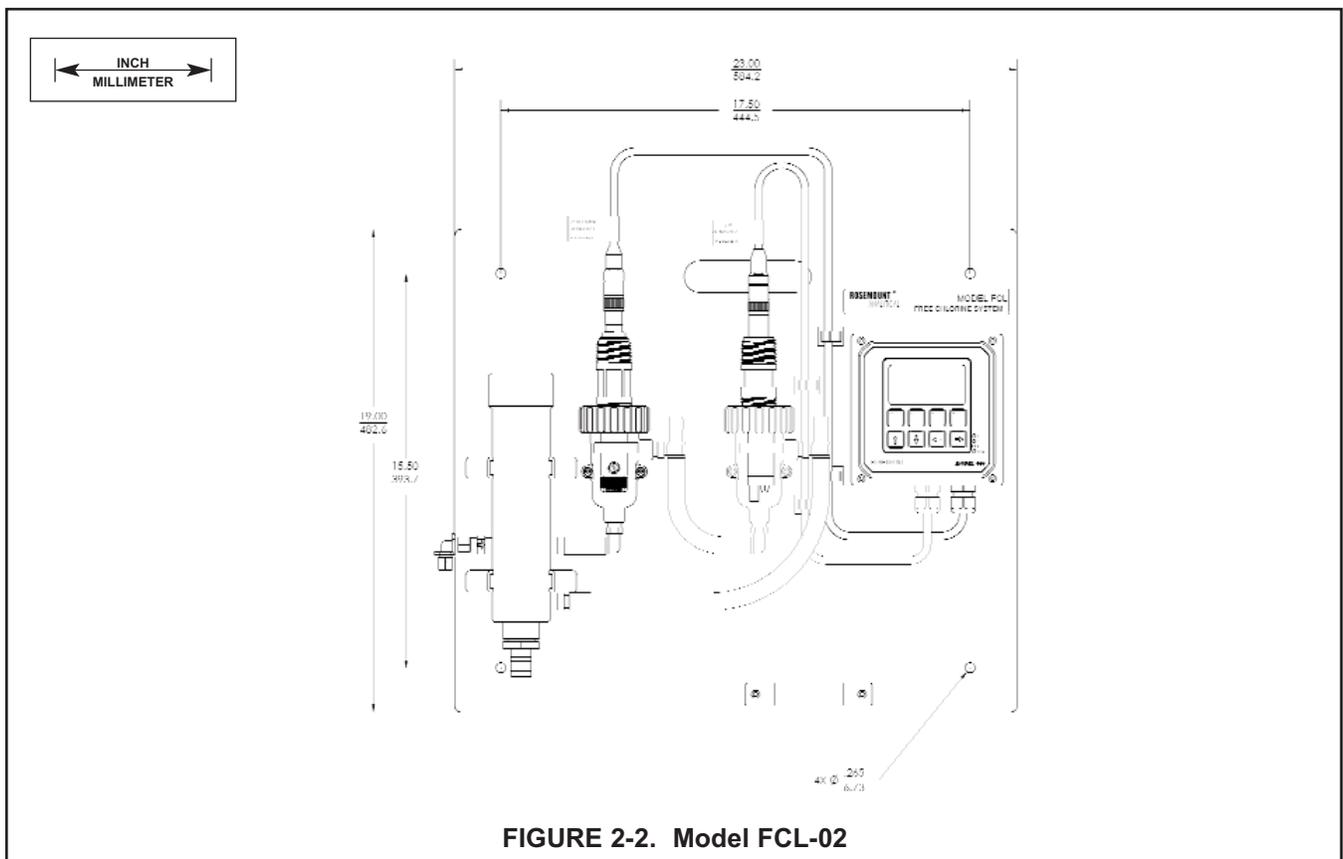
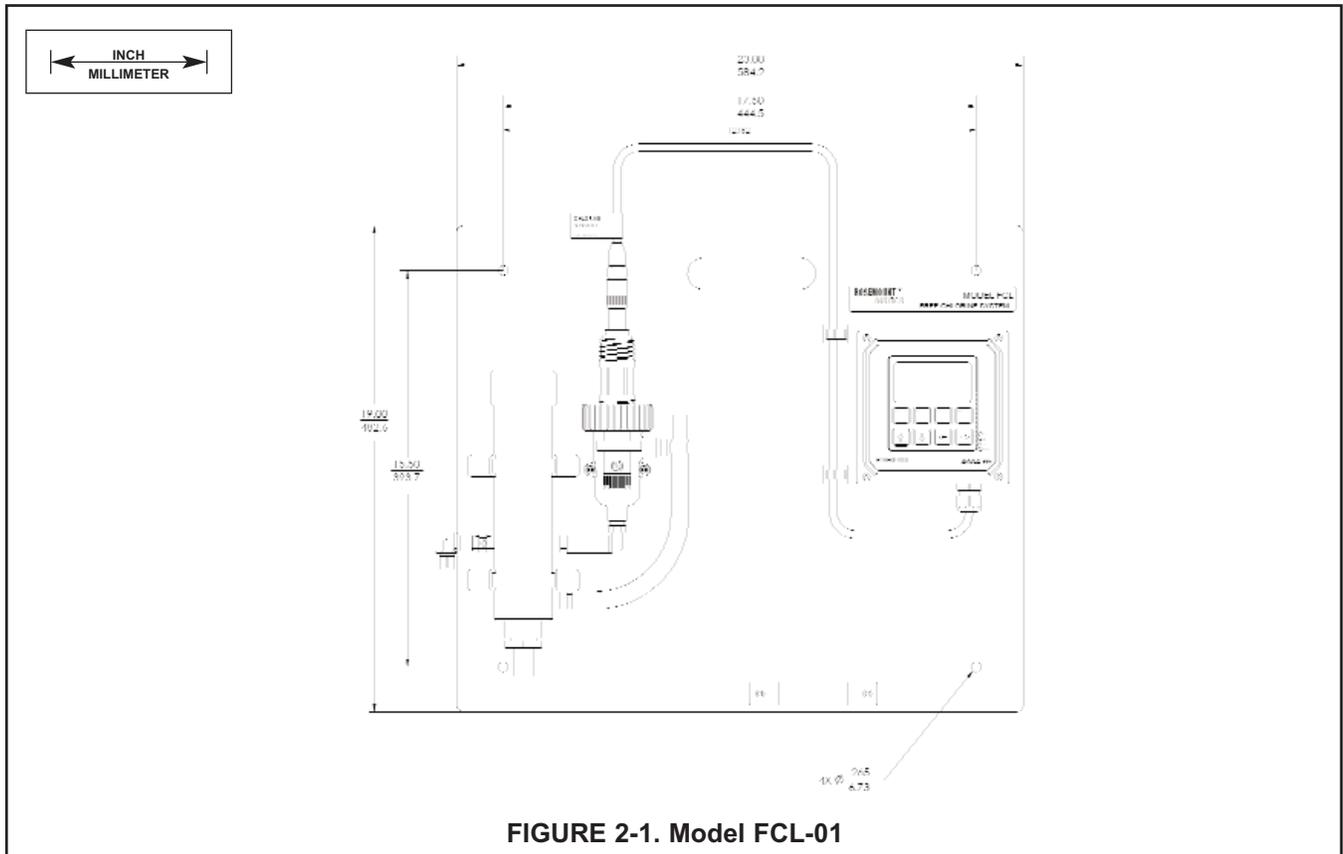
2.2.4 Electrical Connections

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 CHLORINE. Connect the pH sensor (Model 399VP-09) 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.



SECTION 3.0. WIRING

NOTE

The Model 54eA analyzer leaves the factory configured to measure dissolved oxygen, not free chlorine. Before connecting the sensor to the cable, configure the analyzer to measure free chlorine. See section 5.4

3.1 GENERAL

WARNING

Electrical installation must conform to the National Electrical Code, all state and local codes, and all plant codes and standards for electrical equipment. Electrical installation and wiring must be done by qualified personnel.

The five holes in the bottom of the instrument case accept 1/2-in. strain relief connectors or conduit fittings. The rear openings are for power and alarm relay wiring. The left front opening is for sensor wiring (already installed) and the right front opening is for analog output wiring. Seal unused openings with conduit plugs.

3.2 POWER, ALARM, AND OUTPUT WIRING

Refer to Figure 3-1. Make power and alarm connections on TB3. Make analog output wiring connections on TB2. For access to power and alarm terminals, loosen the screw holding the protective cover in place and remove the cover.

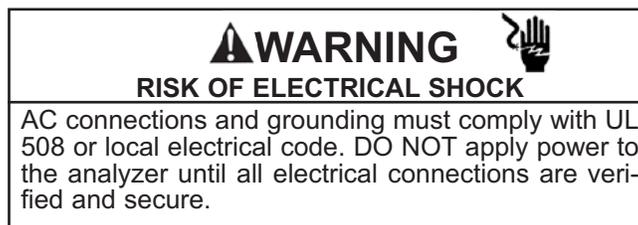


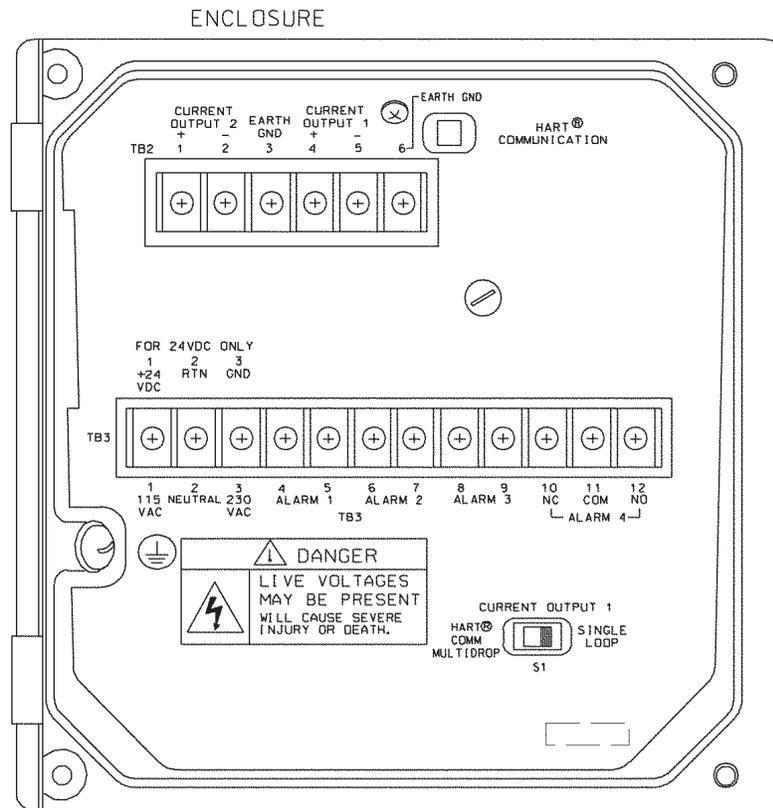
Alarm contacts are dry (i.e., not powered) and are normally open. Refer to Section 1.0 for relay specifications.

For best EMI/RFI protection, shield the output cable and enclose it in an earth-grounded, rigid, metal conduit. Connect the outer shield of the output cable to the earth ground connection on TB2 (see Figure 3-1).

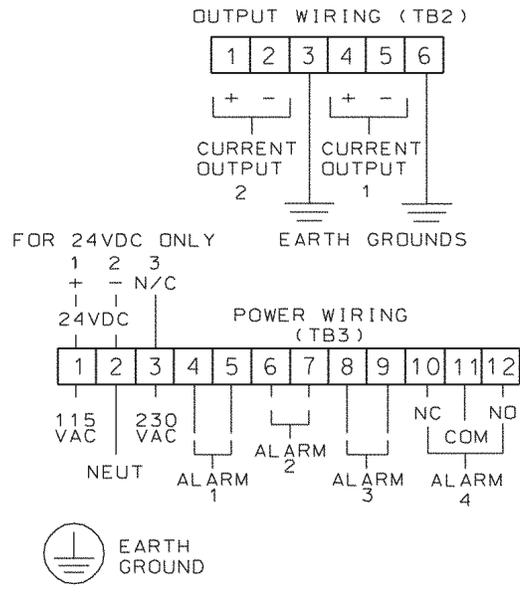
Keep sensor and output signal wiring separate from power wiring. Do not run sensor and power cables in the same conduit or close together in a cable tray.

AC wiring must be 14 gauge or greater. Be sure to connect earth ground from the power cable to the nearby ground lug. A good earth ground is necessary for proper operation of the controller. 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.





OUTPUT AND POWER WIRING



DWG. NO. 454EPH02	REV. D
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FIGURE 3-1. Power Input and Relay Output Wiring for Model 54eA

3.3 SENSOR WIRING

3.3.1 General

The wiring label is a general purpose label. It has wiring information concerning other sensors, for example, contacting and inductive conductivity sensors, that can be used with the 54e instrument platform. The Model FCLi is provided with sensor cable pre-wired to the analyzer. If it is necessary to replace the cable, refer to Figures 3-2 (wiring label) and 3-3 and 3-4 (wiring diagrams).

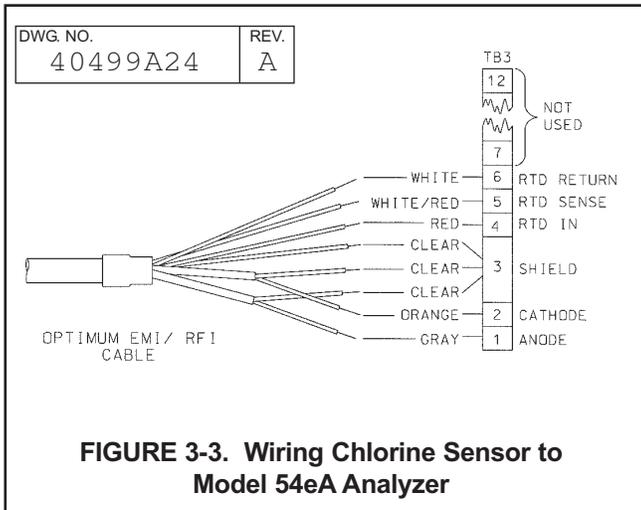


FIGURE 3-3. Wiring Chlorine Sensor to Model 54eA Analyzer

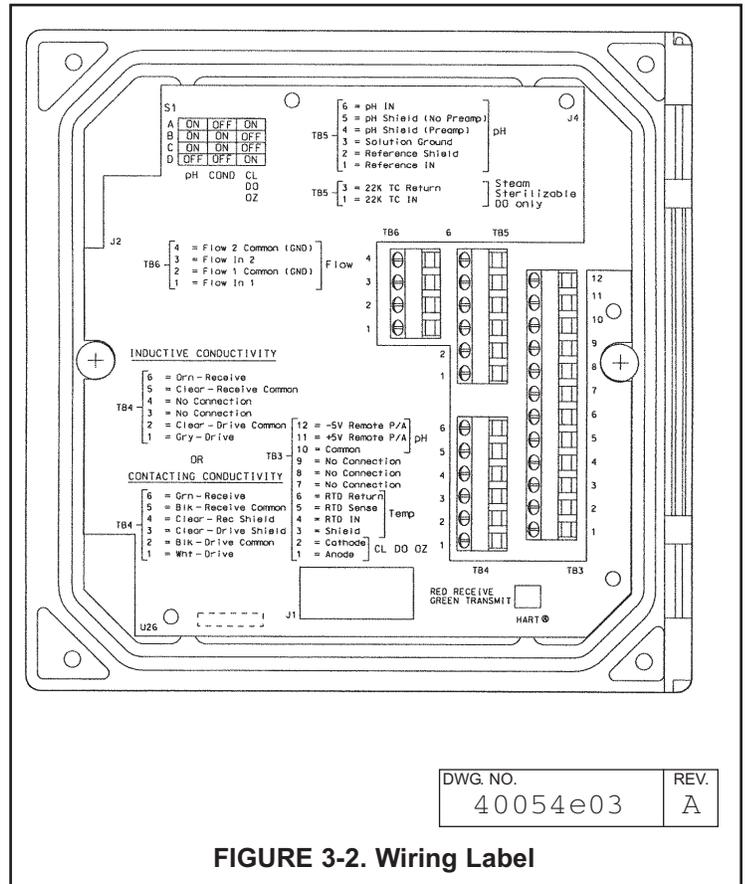


FIGURE 3-2. Wiring Label

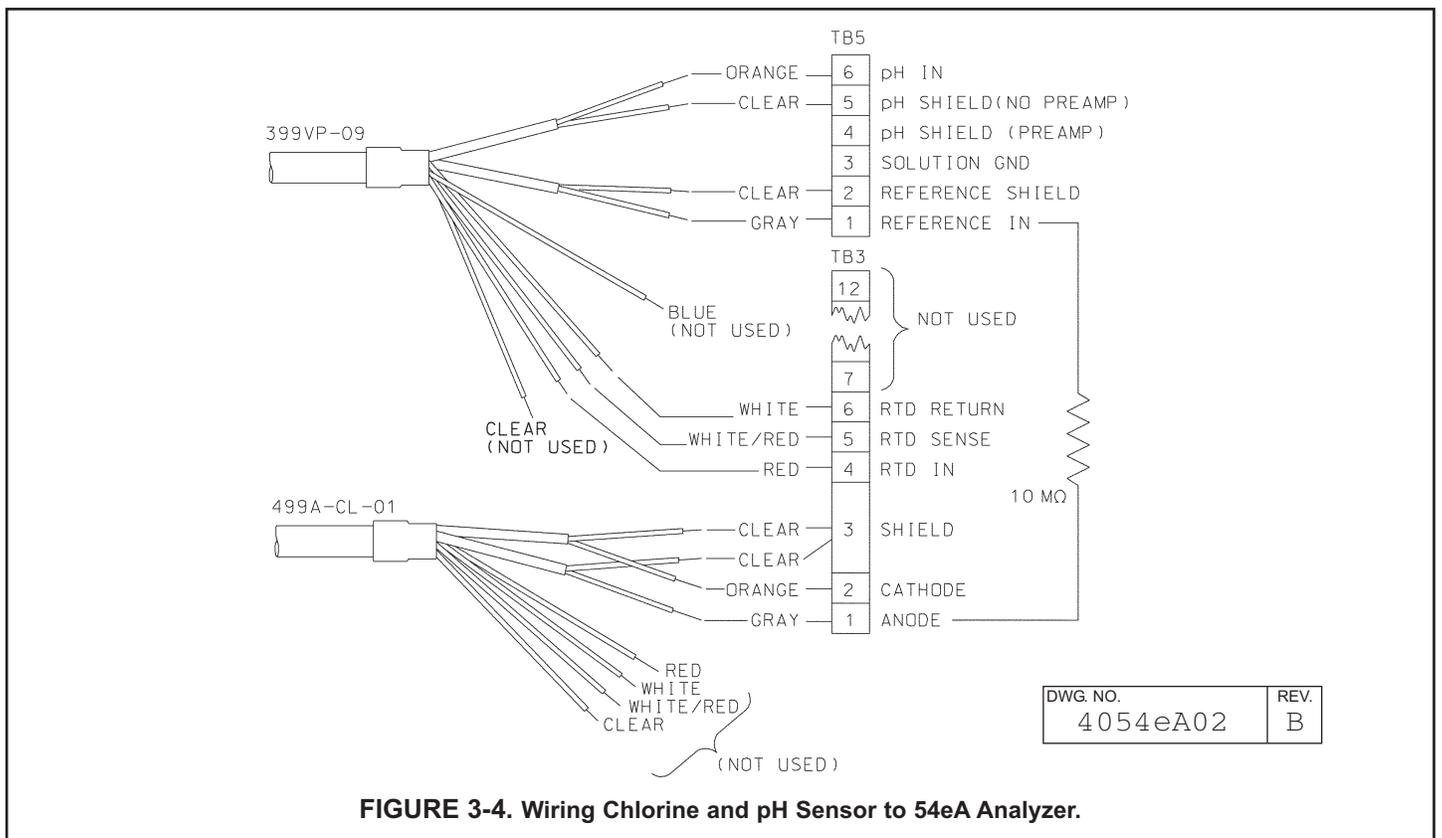


FIGURE 3-4. Wiring Chlorine and pH Sensor to 54eA Analyzer.

SECTION 4.0

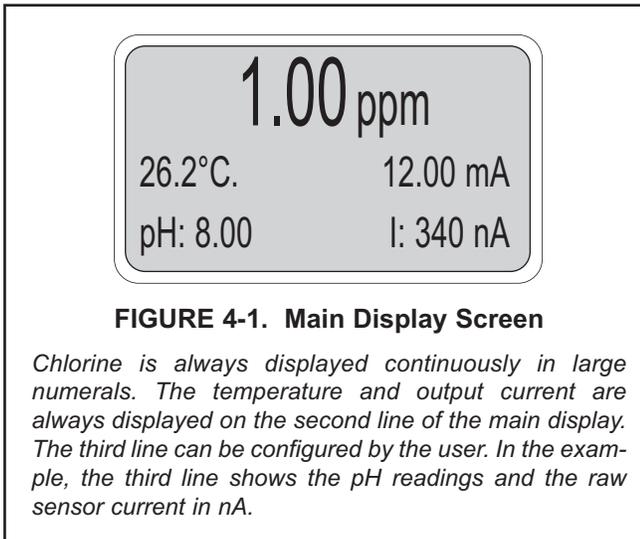
DISPLAY AND OPERATION

4.1 GENERAL DESCRIPTION

The 54eA analyzer is a single input, dual output instrument. It does, however, accept a second input for pH when the main measurement is free chlorine.

4.2 DISPLAY

Figure 4-2 shows the main display.



4.3 KEY FUNCTIONS AND CONTROLS

The keys labeled F1, F2, F3, and F4 are multi-function. The function appears in the main display just above the key. For example, F1 is usually labeled Exit and F4 may be labeled Edit, Save, or Enter.

1. To enter the main menu, press any key.
2. Use the \uparrow and \downarrow keys to move the cursor to the desired sub-menu. The position of the cursor is shown in reverse video.

NOTE

When the last item of a menu has been reached, the cursor will be on the third line of the display. If the cursor is on the second line of the display more items remain. Continue pressing the \downarrow key.

3. Press Enter (F4) to access a sub-menu or an item in a sub-menu.

4. To change a number or a setting press Edit (F4). The display will change to show the cursor on the first digit or on a + or - sign. Use the \uparrow and \downarrow keys to increase or decrease a digit or to toggle the + and - signs. Use the \leftarrow and \rightarrow keys to move the cursor left and right.
5. If an entire number or a word is highlighted, use the \uparrow and \downarrow keys to scroll through the list of choices.
6. To store a number or setting in memory, press Save (F4).
7. To leave without storing changes, press Esc (F3).
8. To leave and return to the previous screen, press Exit (F1).
9. To end a calibration step and leave the previous calibration in place, press Abort (F1).
10. Occasionally, information screens will appear. To leave the information screen and move to the next screen press Cont (F3).

4.4 ALARM STATUS

Green LEDs (labeled 1, 2, and 3) indicate when alarm relays 1, 2, and 3 are energized. The fourth relay indicates a fault condition. When a fault occurs, the red LED (labeled FAIL) lights up, a descriptive error message appears, and the outputs and alarm relays act as programmed in Sections 5.5 and 5.6.

The red LED also indicates when the interval timer routine is activated and when the time limit has been reached on a feed limit timer. For more information on these subjects, see Section 5.6.

SECTION 5.0

PROGRAMMING THE ANALYZER

The Model 54eA analyzer can be used to measure dissolved oxygen, ozone, total chlorine, and monochloramine in addition to free chlorine. It is configured at the factory to measure dissolved oxygen. Before connecting the sensor to the cable, the analyzer must be configured to measure free chlorine. See section 5.4.

Figure 5-1 is an outline of the analyzer menu structure. Settings that do not apply to the measurement of free chlorine are grayed out. Settings that apply to PID and TPC control and HART digital communications, features not available in the analyzer option provided with the FCL, are also grayed out.

Table 5-1 list the default settings and the choices available for each setting. Only the choices available for free chlorine are shown.

TABLE 5-1. Program Settings List

ITEMS	CHOICES	FACTORY SETTINGS
A. Alarms setpoints (Section 5.1)		
1. Alarm 1 (low action)		
a. if chlorine	-9999 to 9999 ppm	0 ppm
b. if temperature	-5 to 130°C	0.1°C
2. Alarm 2 (high action)		
a. if chlorine	-9999 to 9999 ppm	20 ppm
b. if temperature	-5 to 130°C	130°C
3. Alarm 3	See alarm 2	See alarm 2
B. Output ranging (Section 5.2)		
1. Output 1 or 2: 4 mA setting		
a. if chlorine	-9999 to 9999 ppm	0 ppm
b. if temperature	-5 to 130°C	0.1°C
2. Output 1 or 2: 20 mA setting		
a. if chlorine	-9999 to 9999 ppm	20 ppm
b. if temperature	-5 to 130°C	130°C
C. Display options (Section 5.4)		
1. Measurement	Oxygen, ozone, free chlorine, total chlorine, monochloramine	Oxygen
2. Temperature units	°C or °F	°C
3. Output 1	mA or % of full scale	mA
4. Output 2	mA or % of full scale	mA
5. Language	English, Français, Español, Deutsch, Italiano	English
6. Main display left	See section 5.4	Sensor current
7. Main display right	See section 5.4	Output 1 current
8. Display contrast	00-99 (darkest)	50
9. Test timeout	On or off	On
10. Timeout value	1 to 60 min	10 min
D Output parameters (Section 5.5)		
1. Output 1 Control		
a. Measurement	Oxygen, chlorine, ozone, pH, or temperature	Oxygen
b. Control	Normal	Normal

Continued on the following page

TABLE 5-1. Program Settings List (continued)

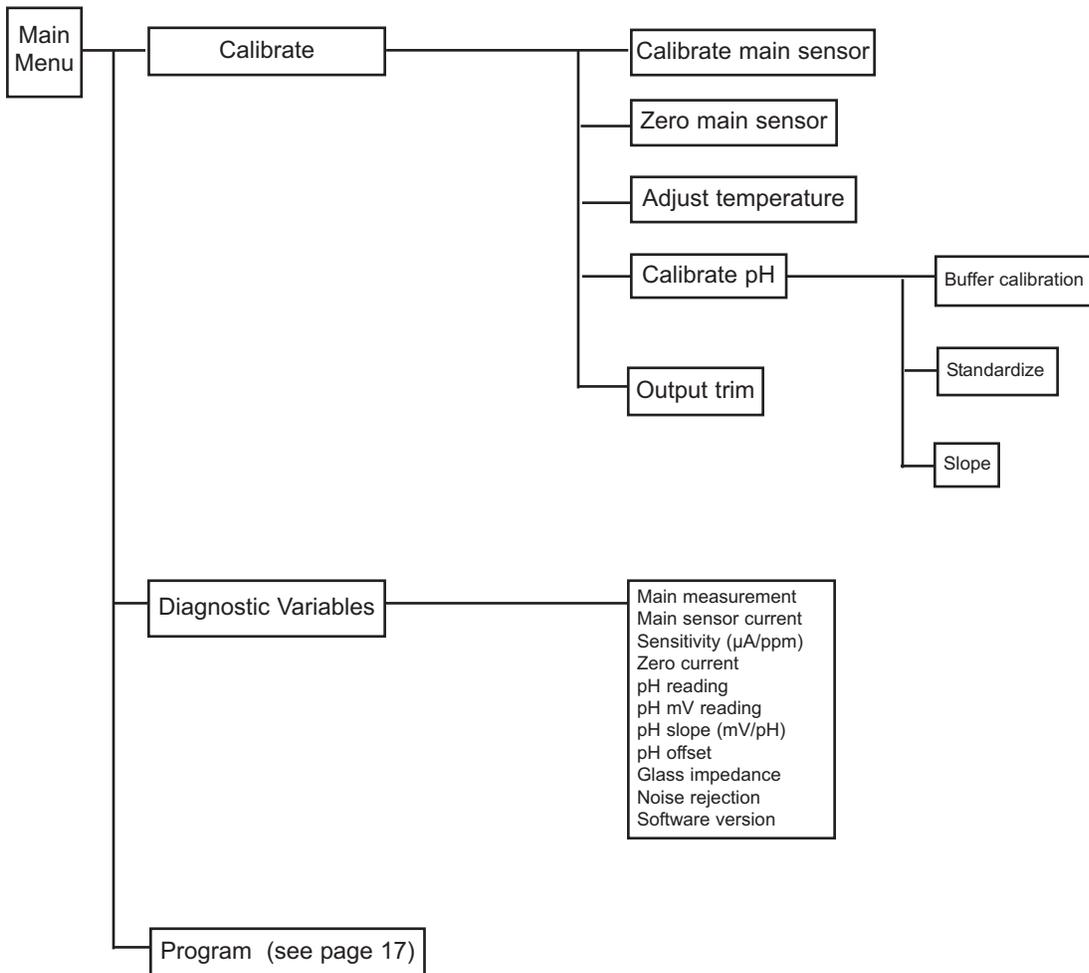
ITEMS	CHOICES	FACTORY SETTINGS
D. Outputs (Section 5.5) (continued)		
2. Output 1 Setup (normal)		
a. Current	4-20 mA or 0-20 mA*	4-20 mA
b. Dampening	0-299 sec	0 sec
c. Hold mode	Hold last value or go to fixed value	Hold last value
d. Fixed hold value	0-22 mA	21 mA
e. Fault value	0-22 mA	22 mA
3. Output 2	See output 1	See output 1
4. Hold feature	Enable, disable, or 20 min timeout	Disable
E. Alarms parameters (Section 5.6)		
1. Alarm 1 Control		
a. Activation method	Oxygen, chlorine, ozone, temperature, pH	Oxygen
b. Control mode	Normal	Normal
2. Alarm 1 setup (normal)		
a. Configuration	Low, high, or off	High
b. Hysteresis		
if chlorine	-9999 to 9999 ppm	0 ppm
if temperature	0 to 10°C	0.1°C
c. Delay time	0-99 sec	0 sec
d. Relay fault	none, open, closed	None
3. Alarm 2 Control		
a. Activation method	Oxygen, chlorine, monochloramine, ozone, temperature, pH	Oxygen
b. Control mode	Normal	Normal
4. Alarm 2 setup (normal)		
a. Configuration	Low, high, or off	Low
Rest of alarm 2 setup is the same as alarm 1		
5. Alarm 3 control and setup is the same as alarm 1		
6. Alarm 4 control		
Alarm	Fault or off	Fault
7. Feed limit timer		
a. Feed limit	Disable, alarm 1, alarm 2, or alarm 3	Disable
b. Timeout value	0 to 10,800 sec	600 sec
8. Interval timer		
a. Select alarm	Disable, alarm 1, alarm 2, or alarm 3	Disable
b. Interval time	0 to 999.9 hr	24.0 hr
c. Repeats	1 to 60	1
d. On time	0 to 2999 sec	120 sec
e. Off time	0 to 2999 sec	1 sec
f. Recovery time	0 to 999 sec	600 sec
F. Temperature compensation (Section 5.8)		
1. Temperature compensation	Auto or manual	Auto
2. Manual temperature	-15 to 130°C	25°C

Continued on the following page

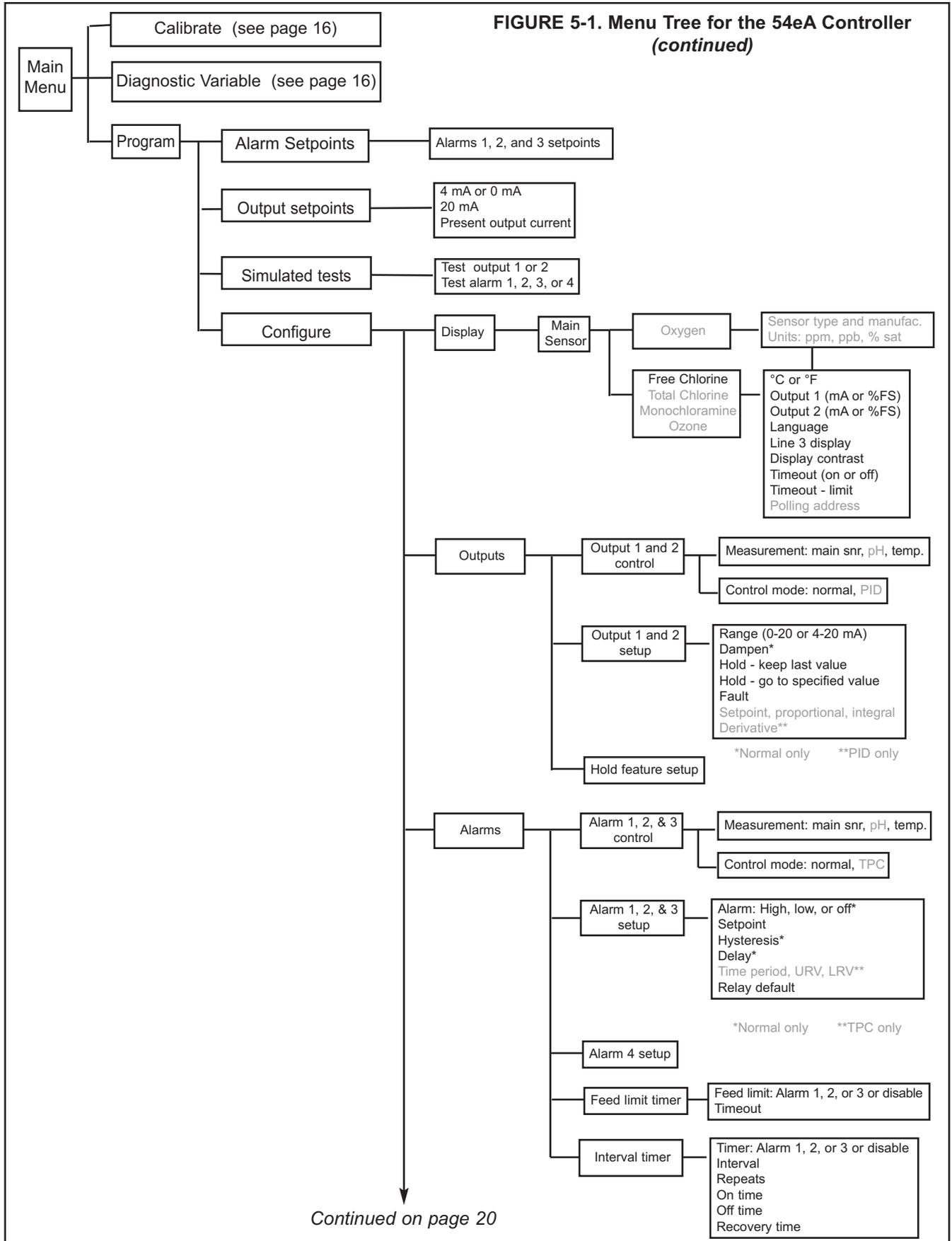
TABLE 5-1. Program Settings List (continued)

ITEMS	CHOICES	FACTORY SETTINGS
G. Noise Reduction (section 5.9)		
Noise rejection	50 or 60 Hz	60 Hz
H. Main sensor calibration (Section 5.10)		
1. Stabilize reading (Chlorine)	0 to 999 ppm	0.05 ppm
2. Stabilize time	0 - 30 sec	10 sec
3. Sensor zero stabilization value		
4. Dual range calibration	Enable or disable	disable
I. Security (Section 5.11)		
1. Lock all	000-999 (000 disables)	000
2. Lock program	000-999 (000 disables)	000
3. Lock configuration	000-999 (000 disables)	000

FIGURE 5-1. Menu Tree for the 54eA Controller

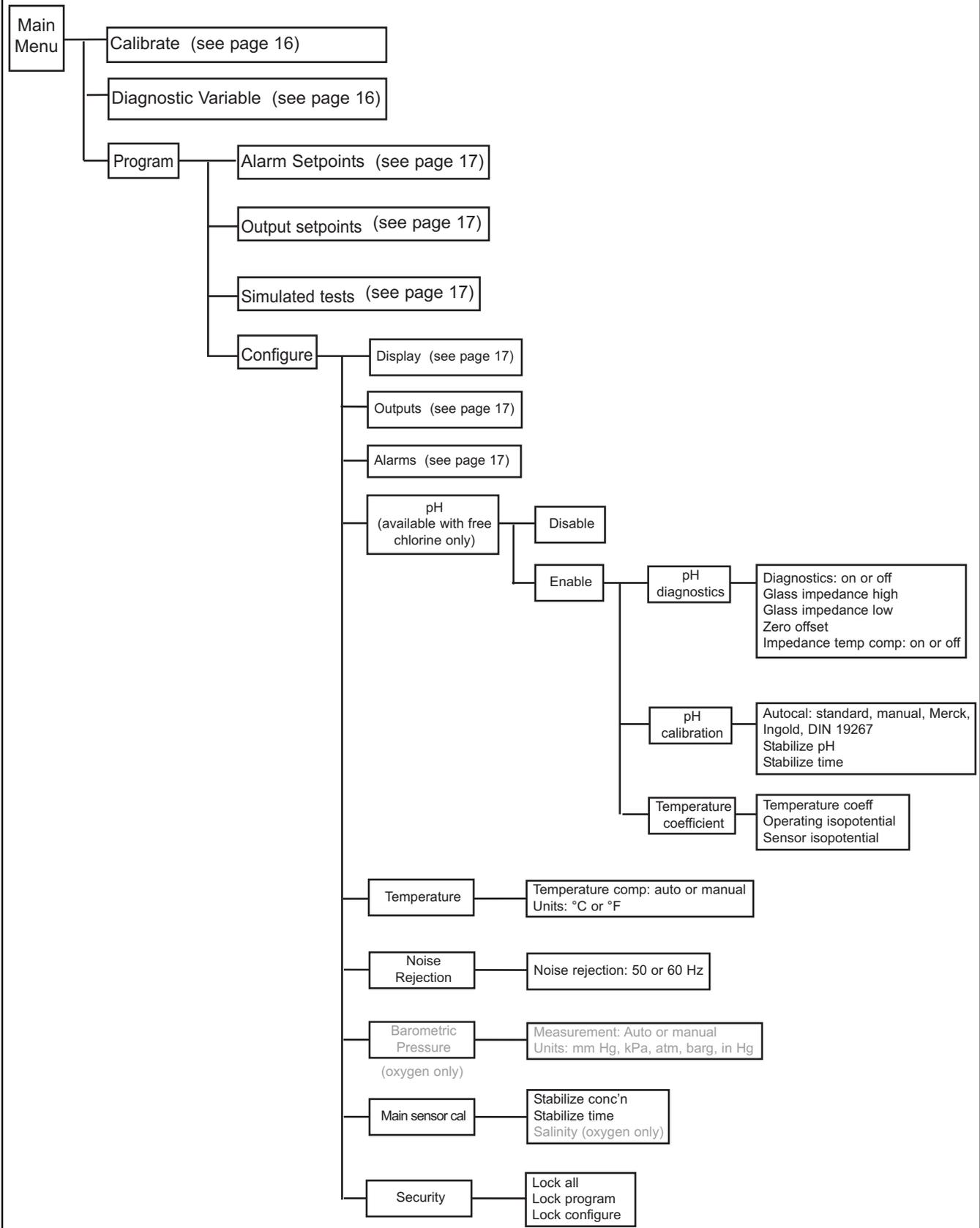


**FIGURE 5-1. Menu Tree for the 54eA Controller
(continued)**



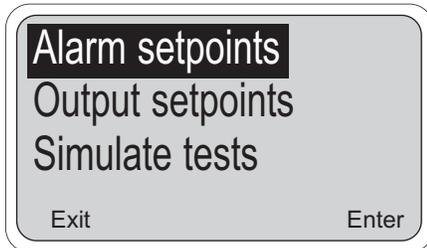
Continued on page 20

FIGURE 5-1. Menu Tree for the 54eA Controller (continued)



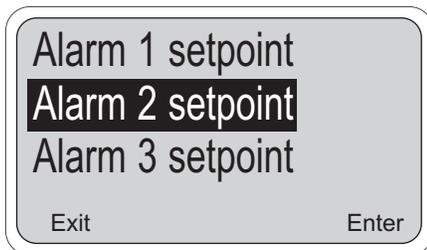
5.1 CHANGING ALARM SETPOINTS

1. Before changing alarm setpoints, be sure that alarms are properly configured. See Section 5.6.

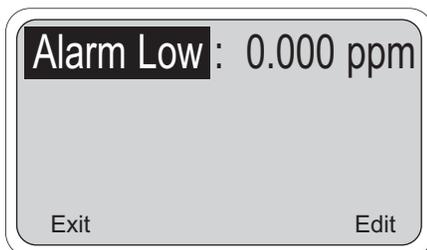


2. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).

3. Press Enter (F4).



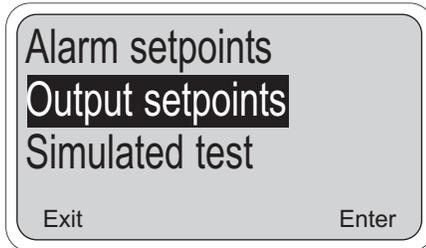
4. Move the cursor to the desired alarm and press Enter (F4).



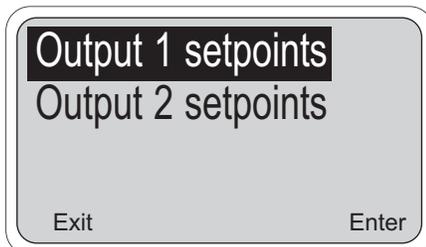
5. A screen like the one shown will appear. The alarm is a low alarm and the setpoint is 0.00 ppm. Press Edit (F4). Use the arrow keys to change the setpoint. Press Save (F4) to store the new value. Press Exit (F1) to return to the screen in step 4. Choose a new alarm.

5.2 RANGING THE OUTPUTS

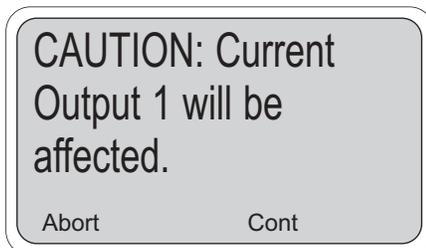
1. Ranging the outputs means assigning values to the low (0 or 4 mA) and high (20 mA) outputs. **Before ranging the outputs, be sure the outputs are properly configured. See Section 5.5.**



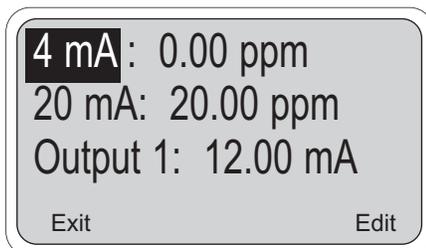
2. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).
3. Move the cursor to "Output setpoints" and press Enter (F4).



4. Move the cursor to the desired output and press Enter (F4).



5. This screen confirms that changes to output 1 are going to be made. Use caution. Changes may degrade process control. Press Cont (F3) to continue. Otherwise, press Abort (F1).



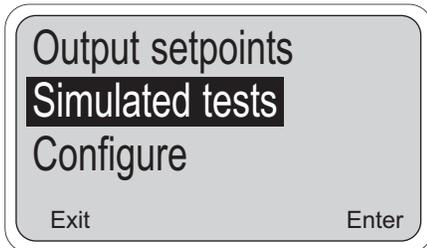
6. This screen shows the present settings for Output 1. If the output was configured to be 0-20 mA, the first line will show "0mA" instead of "4mA". The live current output is shown on the third line.

Move the cursor to the desired line and press Edit (F4). Use the arrow keys to change the setpoint. Press Save (F4) to store the new value.

Press Exit (F1) to return to the screen in step 4. Choose the other output and continue.

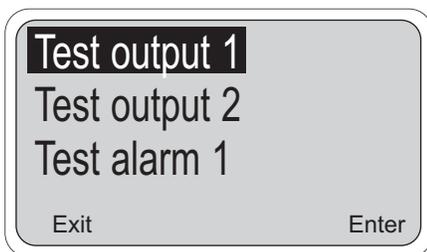
5.3 TESTING OUTPUTS AND ALARMS

1. For testing purposes, the analyzer can be programmed to generate simulated outputs and to activate and deactivate alarms.



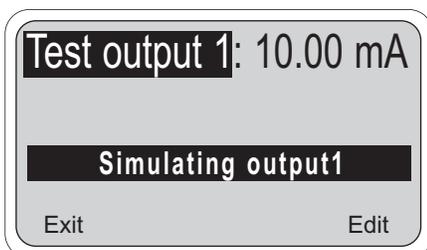
2. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).

3. Move the cursor to "Simulated tests" and press Enter (F4).



4. Move the cursor to the desired output or alarm. Both outputs and all four alarms can be tested. Press Enter (F4).

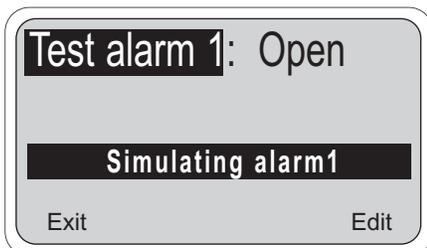
A screen will appear warning that the output or alarm will change. Press Cont (F3) to continue. Press Abort (F1) to cancel the simulation.



5. This screen appears when an output is being simulated. To change the simulation current, press Edit (F4). Use the arrow keys to change the current to the desired value. Press Test (F4), then Esc (F3).

The simulated current will be generated for 10 minutes, then the output returns to normal operation. To change the timeout to a different value see Section 5.4.

To end the simulation at any time, press Exit (F1).



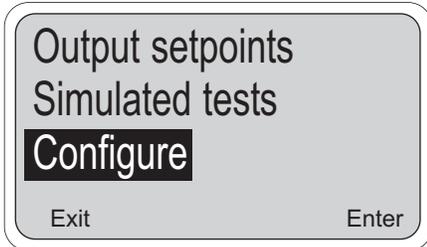
6. This screen appears when an alarm is being simulated. To change the state of the relay, press Edit (F4). Use the \uparrow or \downarrow keys to change from open to closed. Press Test (F4), then Esc (F3).

The alarm will be simulated for 10 minutes, then the alarm returns to normal operation. To change the timeout to a different value, see Section 5.4.

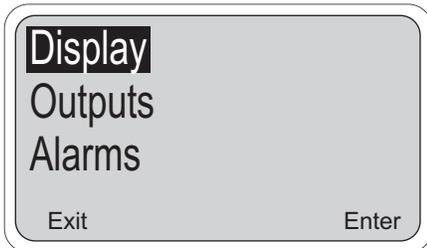
To end the simulation at any time, press Exit (F1).

5.4 CHOOSING DISPLAY OPTIONS

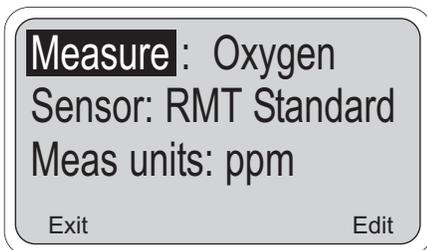
1. The Model 54eA analyzer is a versatile instrument that, in addition to free chlorine, can be used to measure oxygen, ozone, and other forms of chlorine. The default measurement is oxygen. Before connecting the sensor to the cable, the analyzer must be configured to measure free chlorine.
2. The display menu also lets the user customize the third line in the display, change timeout values, choose a language other than English, and change the display contrast.
3. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).



4. Move the cursor to "Configure" and press Enter (F4).

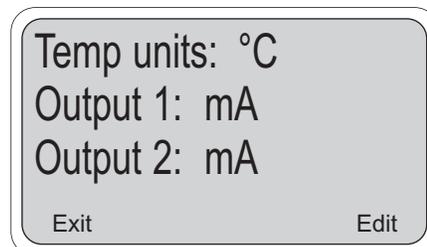


5. With the cursor on "Display", press Enter (F4).



6. A screen showing the present main measurement will appear. To change the measurement from oxygen to free chlorine, press Edit (F4), then use the \uparrow key to scroll through the choices until free chlorine is showing. Press Save (F4) to store the setting.

A screen will appear warning that if the measurement is changed, the analyzer will return to factory default settings. Press Cont (F3) to continue. Press Abort (F1) to cancel the change.



7. Set the remainder of the display parameters. Use the \uparrow and \downarrow keys to choose the desired parameter. Then press Edit (F4). Use the \uparrow key to move the cursor to the desired selection. Press Save (F4) to store.

5.4 CHOOSING DISPLAY OPTIONS (CONTINUED)

Language: English
 Display left: 1
 Display right: Out 2

Exit Edit

Display contrast: 40
 Timeout: On
 Timeout value: 10 min

Exit Edit

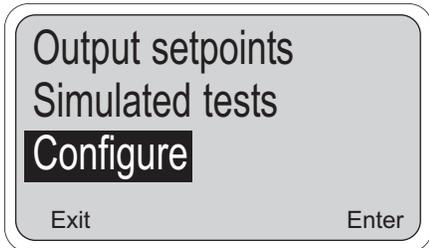
Temp units	°C or °F
Output 1	mA or % of full scale
Output 2	mA or % of full scale
Language	English, Français, Español, Deutsch, Italiano
Display left	sensor current (I), alarm 1 setpoint (no units), alarm 3 setpoint (no units), or blank
Display right	sensor current (I), alarm 2 setpoint (no units), alarm 3 setpoint (no units), output 2, or blank
Display Contrast	00 (lightest)-99 (darkest); the display contrast changes as the number changes
Timeout	Timeout returns the display from any other screen to the main display if no key is pressed before the timeout value is exceeded.
Timeout value	

SECURITY CAUTION

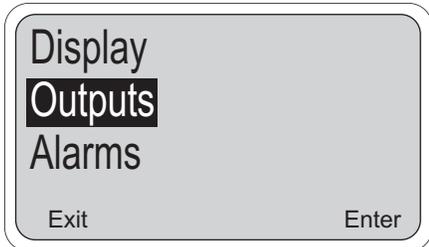
The analyzer uses the timeout value to activate security. Once the analyzer is unlocked by entering a security code, security will not re-activate until a display timeout occurs. If timeout has been turned off, security will never reactivate.

5.5 CHANGING OUTPUT PARAMETERS

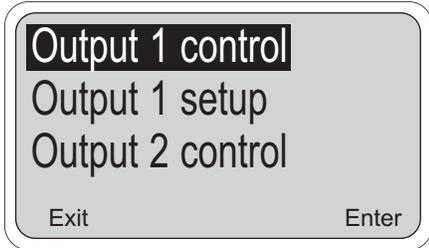
1. This section describes how to configure the analyzer outputs. Outputs can be configured to represent chlorine or temperature.
2. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).



3. Move the cursor to "Configure" and press Enter (F4).



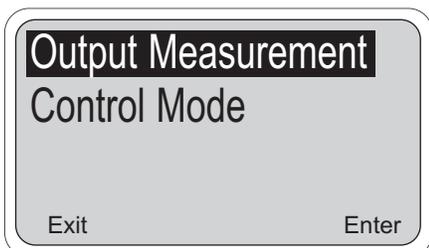
4. Move the cursor to "Outputs" and press Enter (F4).



5. Five menu headers relate to outputs. Each output has a control header and a setup header. The fifth header allows the output hold feature to be configured.

Always configure the control parameters BEFORE making changes in the output setup.

To access a header, move the cursor to the desired header and press Enter (F4).

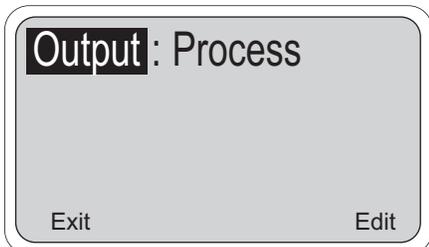


6. **Output Control Settings:**

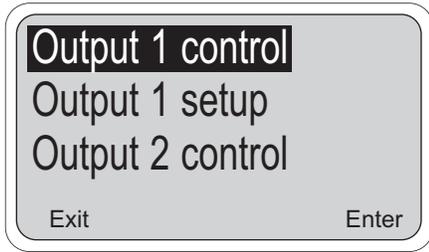
NOTE

There are no settings to make under "Control Mode." The 54eA analyzer supplied with the FCLi does not have control features.

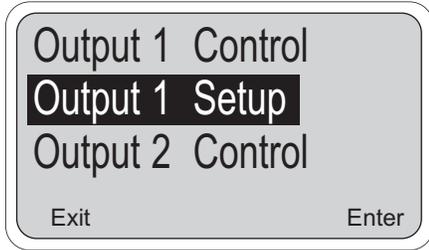
- a. The cursor is on "Output Measurement" press Enter (F4).
- b. Press Edit (F4).
- c. Use the **↑** key to scroll through the choices: "Process" or "Temperature". "Process" means free chlorine. Press Save (F4) to store the selection.



5.5 CHANGING OUTPUT PARAMETERS (continued)



- d. The display returns to the "Output: Process" screen. Press Exit (F1) twice. The display returns to the "Control/Setup" screen shown at left.



7. Output setup for normal outputs:

- a. Move the cursor to the desired output setup and press Enter (F4).



- b. Use the ↑ and ↓ arrow keys to move the cursor to the desired parameter. Press Edit (F4). Use the arrow keys to change the setting to the desired value and press Save(F4) to store the value.

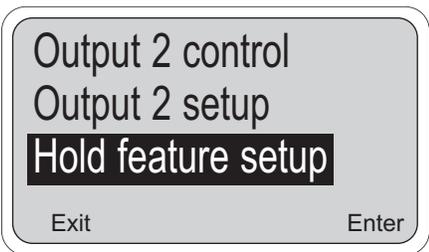
Range: Choose 4-20 mA or 0-20 mA.

Dampen: Dampening averages the output current, thus smoothing out a noisy reading. Higher values provide more smoothing but increase the response time of the output.

Hold and Fixed Hold: If the analyzer is placed in hold, the outputs will either remain at the last value or go to a fixed value selected by the user. The fixed value must be between 0 and 22.00 mA.

Fault: If the analyzer detects a fault, the output will signal the fault by going to a user-selected current between 0 and 22.00 mA.

For allowed values, see Table 5-1.



8. Hold setup.

- a. Move the cursor to "Hold feature setup" and press Enter (F4).
- b. Press Edit (F4). Use the ↑ to scroll through the choices: "Disable feature", "Enable feature", and "20 min timeout". If "20 min timeout" is selected, hold mode will automatically disengage after being on for 20 minutes.

NOTE

Selecting "Enable hold" or "20-min timeout" does not put the analyzer in hold. It only allows the user to put the analyzer in hold when the analyzer is in calibrate mode.

9. Using hold.

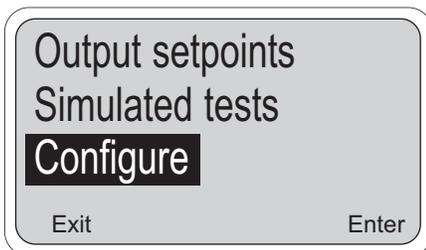
If hold was enabled in step 8 above, the hold screen will appear as soon as the user enters the Calibrate menu. To activate Hold, press Edit (F4). Use the ↑ key to change Off to On and press Save (F4). "Hold Mode Activated" will be displayed. Outputs and relays will go to the values programmed in step 7b.

5.5 CHANGING OUTPUT PARAMETERS (continued)

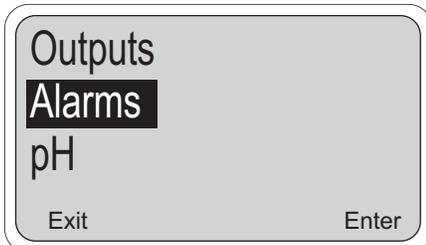
"Hold Mode Activated" will continue to flash in the main display even after the user has left the Calibrate menu. To deactivate hold, enter the Calibrate menu and press Edit (F4). Use the \uparrow key to change On to Off and press Save (F4). Press Exit (F1) twice to return to the main display.

5.6 CHANGING ALARM PARAMETERS

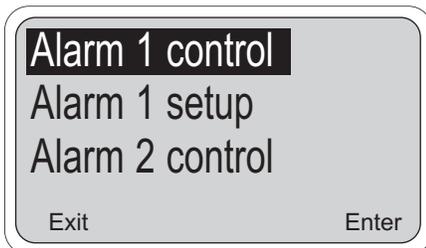
1. This section describes how to configure the analyzer alarms relays. Alarms 1, 2, and 3 can be assigned to chlorine or temperature. In addition, alarm 1, 2, or 3 can be configured as a feed limit timer or as an interval timer (see steps 9 and 10). Alarm 4 is always a fault alarm.
2. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).



3. Move the cursor to "Configure" and press Enter (F4).



4. Move the cursor to "Alarms" and press Enter (F4).

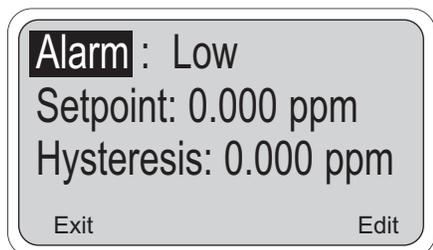
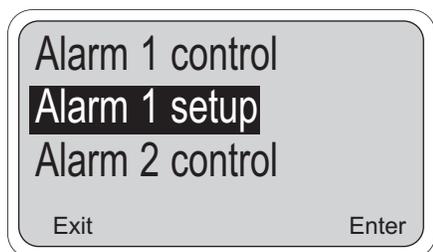
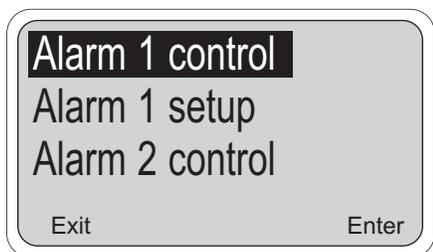
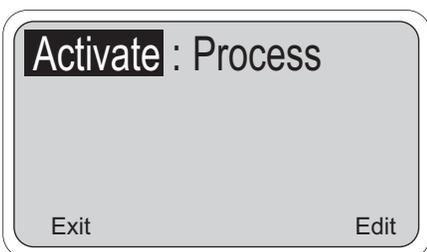
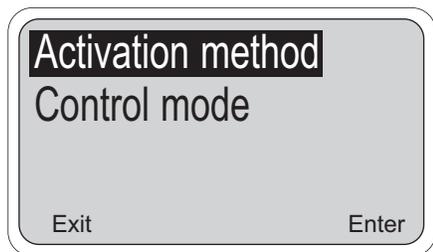


5. Nine menu headers relate to alarms. Alarms 1, 2 and 3, each have a control header and a setup header. Alarm 4 has only a setup header. The eighth menu header is for configuring the feed limit timer, and the ninth menu header is for configuring the interval timer.

Always configure the control parameters BEFORE making changes in the alarm setup.

To access a header, move the cursor to the desired header and press Enter (F4).

5.6 CHANGING ALARM PARAMETERS (continued)



6. Alarm Control Settings:

NOTE

There are no settings to make under "Control Mode." The 54eA analyzer supplied with the FCLi does not have control features.

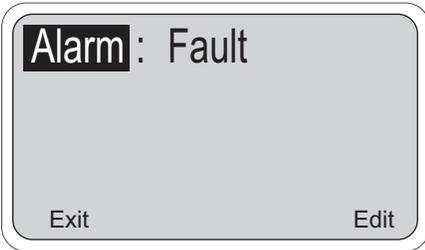
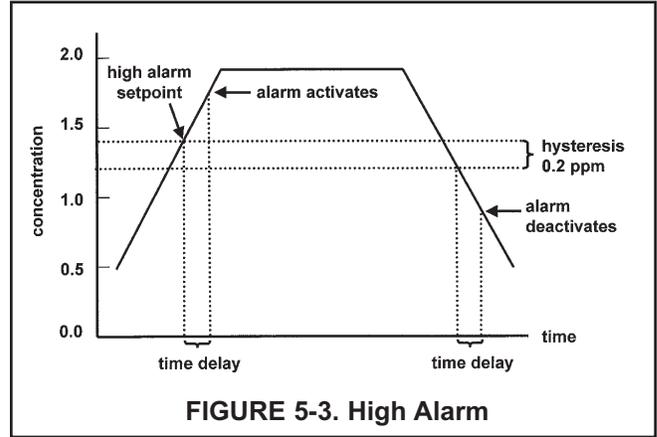
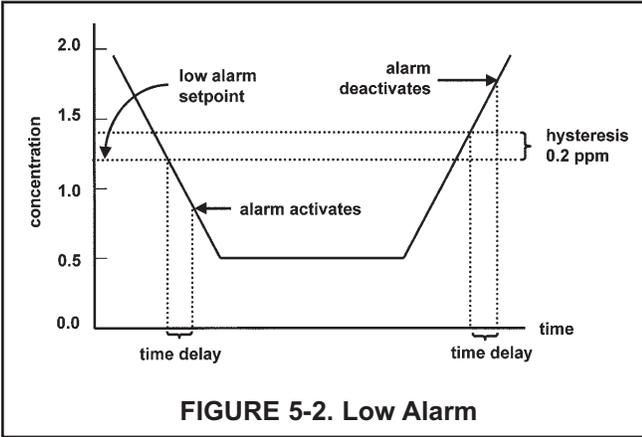
- a. With the cursor on "Activation method" press Enter (F4).
- b. To change the activation method, press Edit (F4). Use the \uparrow key to scroll through the choices: "Process" or "Temperature". "Process" means free chlorine. Press Save (F4) to store the selection.
- c. The display returns to the "Activate: Process" screen. Press Exit (F1) twice. The display returns to the Control/Setup screen shown at left.

7. Alarm setup for normal alarms:

- a. Move the cursor to the desired alarm setup and press Enter (F4).
- b. Use the \uparrow and \downarrow keys to move the cursor to the desired parameter. Press Edit (F4). Use the arrow keys to change the setting to the desired value and press Save (F4) to store the value. See the Figures 5-2 and 5-3 for an explanation of terms: **low alarm**, **high alarm**, **hysteresis**, and **delay**. See Table 5-1 for allowed values and limits.

Relay default determines how the relay will operate if there is a fault or the controller is in hold. Alarms can be forced on (Close), off (Open), or remain unchanged (None).

5.6 CHANGING ALARM PARAMETERS (continued)

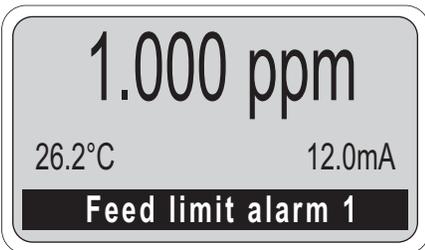
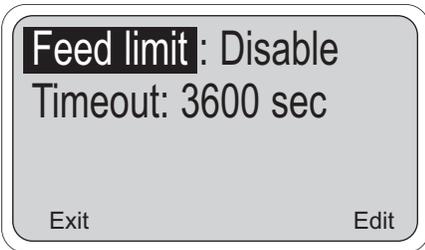


8. Alarm 4 setup:

- Alarm 4 is a dedicated fault alarm. When a fault condition exists, the red LED on the front display will light.
- From the menu header screen (step 6) move the cursor to "Alarm 4 setup."
 - To disable the alarm, press Edit (F4) and use the \uparrow key to change the "Fault" to "Off"

9. Feed limit timer setup:

- Alarm 1, 2, or 3 can be configured as a feed limit timer. The feed limit timer prevents overfeeding of treatment chemicals by automatically turning off the relay after a timeout period.
- From the menu header screen (step 6) move the cursor to "Feed limit timer." Press Enter (F4).
 - With the cursor on "Feed limit" press Edit. Use the \uparrow key to scroll through the choices: disable, AL 1, AL 2, and AL 3. Press Save (F4) to store the selection.
 - Move the cursor to "Timeout". Press Edit (F4) and use the arrow keys to change the timeout to the desired value. Press Save (F4) to store the setting.



Operation of the feed limit timer. When a feed limit alarm has timed out, "Feed limit alarm 1" (if alarm 1 was chosen) appears in the display. At the same time the red FAIL LED will light and alarm 4 will close (if not turned off), and the selected feed limit relay (alarm 1) will open (de-energize). All other alarms and current outputs will remain unchanged. The relays remain in the state described until the Ack (F2) key is pressed, at which time the controller returns to normal operation and the feed limit clock starts again.

NOTE

Pressing Ack (F2) acknowledges all conditions that turn on the red LED. If another event occurs after F2 is pressed, F2 must be pressed again to acknowledge the new event.

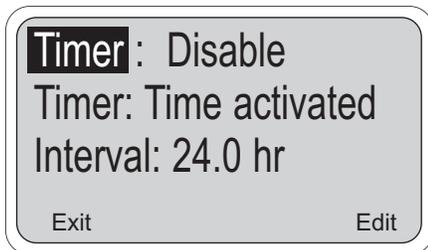
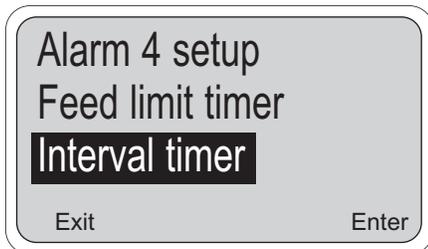
5.6 CHANGING ALARM PARAMETERS (continued)

10. Interval timer setup:

Alarm 1, 2, or 3 can be used as an interval timer. The selected relay will open and close at time intervals programmed by the user. The interval timer is useful for automatic cleaning of sensors.

NOTE

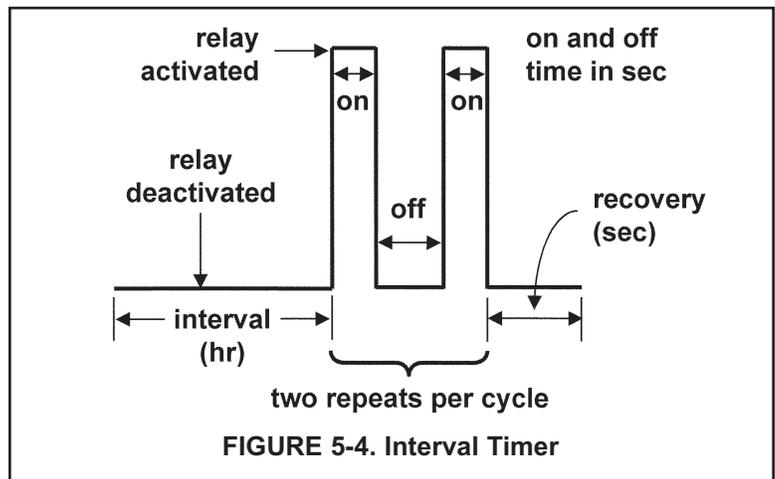
The alarm relay used for the interval timer cannot be used for other purposes. When a timer sequence is occurring, both current outputs are placed in hold (even if hold was not enabled) and the other two alarms will be placed in their default states.



- a. From the menu header screen (step 6c) move the cursor to "Interval timer."

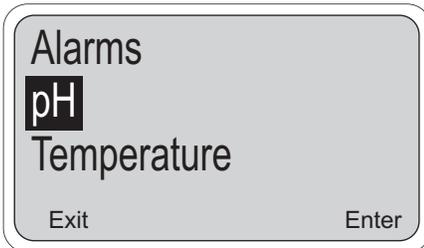
- b. With the cursor on "Interval timer", press Enter (F4). Use the ↓ key to scroll through the selections. Use the arrow keys to change settings. Press Save (F4) to store.

Refer to the diagram for definition of terms: **interval**, **repeats**, **on time**, **off time**, and **recovery**.



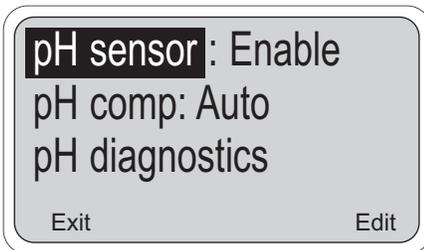
5.7 CONFIGURING THE pH MEASUREMENT

1. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).
2. Move the cursor to "Configure" and press Enter (F4).
3. Move the cursor to "pH" and press Enter (F4).

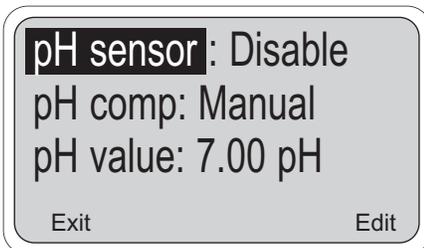


4. The default settings are "pH sensor: Enable" and "pH comp: Auto." Keeping these settings permits the analyzer to continuously correct raw chlorine readings for pH changes. Go to step 6.

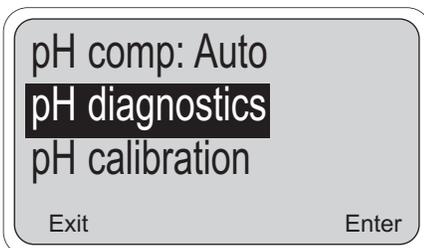
If continuous pH correction is not required, the analyzer must be configured for manual pH correction. Go to step 5.



5. For manual pH correction, press Edit (F4).
 - a. Use the ↑ key to change "Enable" to "Disable" and press Save (F4).
 - b. The screen at left appears. Use the ↓ key to move the cursor to "pH value." Press Edit (F4). Use the arrow keys to change the pH value to the desired number. The analyzer will use the value entered in **ALL** pH correction calculations no matter what the true pH is.



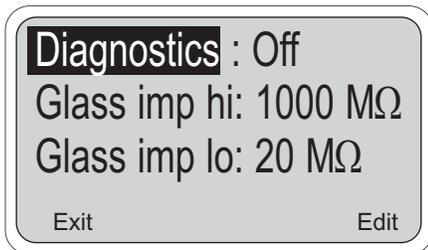
6. This screen appears if automatic pH correction for chlorine readings is being used. To enable diagnostic fault alarms and warning messages and to change pH diagnostic warning limits...
 - a. Move the cursor to "pH diagnostics" and press Enter (F4).
 - b. Move the cursor to "Diagnostics". Press Edit (F4) and use the ↑ key to change "Off" to "On". Press Save (F4).



NOTE

Choosing "On" means the controller will display pH diagnostic warning messages and fault alarms. Choosing "Off" means the messages and fault alarms will not be displayed. Diagnostic variables will still be measured and can be viewed under the Diagnostics menu.

5.7 CONFIGURING THE pH MEASUREMENT (continued)



- c. Use the \uparrow and \downarrow keys to move through the list of diagnostic measurements. To change a warning limit, press Edit (F4). Use the arrow keys to change the setting and press Save (F4) to store the change. For allowed ranges, see Table 5-1. Setting the limit to 0 disables the warning limit.

Glass imp hi: High glass impedance implies that the sensor may be nearing the end of its useful life. Set the warning limit about two times higher than the impedance of a new electrode. A typical glass electrode has an impedance of about 100 M Ω at 25°C.

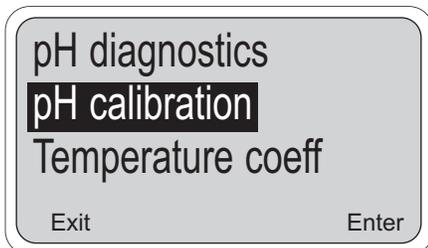
Glass imp lo: Low glass impedance warns of a broken electrode. A good setting is 20 M Ω .

Zero offset: pH measuring cells are designed to have a potential of 0 mV in pH 7 buffer. Zero offset is a measure of how far the true value is from 0.0 mV. Zero offset is calculated every time the sensor is calibrated. A good limit is 60 mV.

Imped comp: The impedance of a glass electrode is a strong function of temperature. For accurate comparison of impedances, readings must be temperature corrected. For best results, leave "Imped comp" on.

- d. Press Exit (F4) to return to the screen in step 6a.

7. To change calibration parameters...



- a. Move the cursor to pH calibration and press Enter (F4).



- b. Use the \uparrow and \downarrow keys to move through the list of items. To make a change press Edit (F4). Use the arrow keys to the setting to the desired value and press Save (F4). For allowed ranges see Table 5-1.

Autocal: To disable automatic calibration, choose "Manual". The other choices in the list ("Standard", "Merck", "Ingold", and "DIN 19267") refer to standard and technical buffers. Standard buffers are the NIST primary and secondary buffers: pH 1.68, 3.56, 3.78, 4.01, 4.64, 6.86, 7.41, 9.18, 10.01, and 12.45 as well as pH 7.00. Merck buffers are pH 2.00, 7.00, 9.00 and 12.00. Ingold buffers are pH 2.00, 4.01, 7.00, and 9.21. DIN 19267 buffers are pH 1.09, 3.06, 4.65, 6.79, 9.23, and 12.75.

Stabilize pH and Stabilize time: For the controller to accept calibration data, the pH must remain within a specified range for a specified period of time. The default values are 0.01 pH for 10 seconds. Using a small pH value and a large time provides the best protection against calibration while the reading is still changing.

5.7 CONFIGURING THE pH MEASUREMENT (continued)

8. In certain industries pH is used and reported at a reference temperature of 25°C. Correcting a pH reading to 25°C is often referred to as a solution temperature correction.

NOTE

IN THE MODEL FCL, pH IS MEASURED FOR THE SOLE PURPOSE OF CORRECTING THE FREE CHLORINE MEASUREMENT. FREE CHLORINE READINGS MUST BE CORRECTED USING THE pH AT THE ACTUAL SAMPLE TEMPERATURE. **DO NOT USE SOLUTION TEMPERATURE CORRECTION AND KEEP THE OPERATING AND SENSOR ISOPOTENTIAL pH VALUES AT 7.00**

- a. With the cursor on "Temperature coeff", press Enter (F4).
- b. Make the following settings:

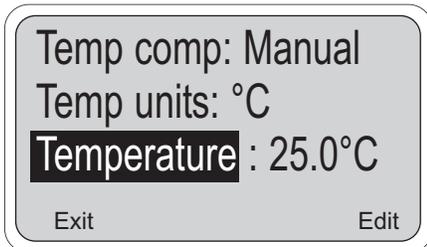
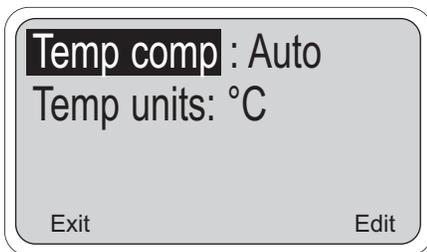
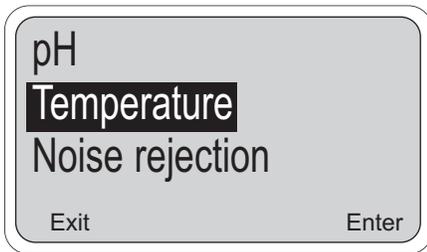
Temp coeff	0.000
Operate iso	7.00
Sensor iso	7.00

pH diagnostics
pH calibration
Temperature coeff
Exit Enter

Temp coeff: 0.000
Operate iso: 7.00 pH
Sensor iso: 7.00 pH
Exit Enter

5.8 TEMPERATURE COMPENSATION AND TEMPERATURE UNITS

1. Refer to Section 6.1 for a discussion of the ways in which temperature affects the chlorine measurement.
2. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).
3. Move the cursor to "Configure" and press Enter (F4).
4. Move the cursor to "Temperature" and press Enter (F4).



5. Use the ↑ and ↓ keys to move through the list of items. To make a change press Edit (F4). Use the arrow keys to change settings to the desired value. Press Save (F4) to store changes.

Auto: In automatic temperature compensation, the analyzer measures the temperature using an RTD (resistance temperature device) in the sensor. The analyzer then uses the measured temperature to calculate the membrane permeability correction.

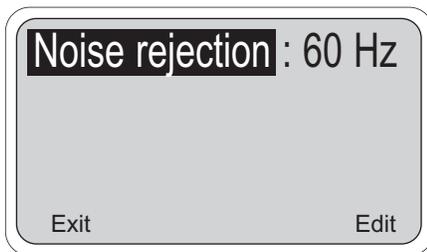
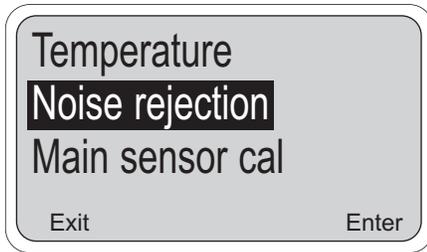
Manual: In manual temperature compensation, the analyzer uses the temperature entered by the user to calculate membrane permeability correction. It does **NOT** use the actual process temperature. Do **NOT** use manual temperature compensation unless the difference between the calibration and measurement temperatures is less than 2°C.

Manual temperature compensation is useful if the sensor RTD has failed and a replacement sensor is not available.

If Manual temperature compensation is selected, be sure to enter the desired temperature.

5.9 NOISE REDUCTION

1. For maximum noise reduction the frequency of the ac power must be entered into the analyzer.
 2. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).
 3. Move the cursor to "Configure" and press Enter (F4).
 4. Move the cursor to "Noise rejection" and press Enter (F4).



5. To change the frequency setting, press Edit (F4). Use the **↑** key to toggle between 50 and 60 Hz. Press Save (F4) to store the change.

5.10 MAIN SENSOR CALIBRATION PARAMETERS

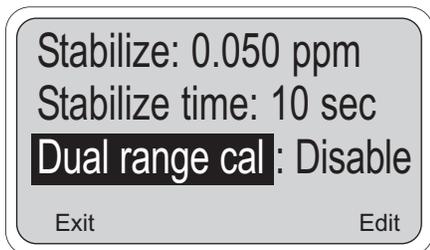
1. Main sensor refers to the chlorine sensor.

2. Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).

3. Move the cursor to "Configure" and press Enter (F4).

4. Move the cursor to "Main sensor cal" and press Enter (F4).

5. Use the \uparrow and \downarrow keys to move through the list of items. To make a change press Edit (F4). Use the arrow keys to change settings to the desired value and press Save (F4). For allowed ranges, see Table 5-1.



The choices depend on the measurement being made.

Stabilize and Stabilize time: For the analyzer to accept calibration data, the concentration must remain within a specified range for a specified period of time. The default values are 0.05 ppm and 10 seconds. Using a small stabilize value and a long stabilize time is the best protection against calibration while a reading is still changing.

Dual range cal: The response of the free chlorine sensor used with the FCL becomes slightly non-linear at high concentrations of chlorine. Dual range calibration allows the analyzer to correct for the non-linearity of the sensor. For more information see Section 7.4.

5.11 SECURITY

- The analyzer can be programmed to require a password for access to menus. There are three levels:

Level 1: A level 1 user can

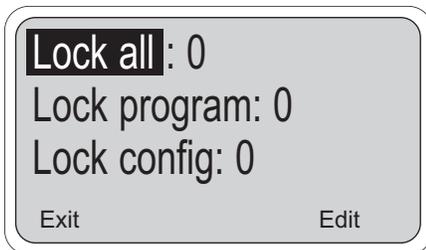
- Zero and calibrate the chlorine sensor
- Change temperature compensation from automatic to manual and enter a manual compensation temperature
- View diagnostic variables.

Level 2: A level 2 user can

- Do everything a level 1 user can do
- Change alarm setpoints
- Rerange the 4-20 mA outputs
- Manually test both outputs and all four alarm relays.

Level 3: A level 3 user has access to every menu item. Only a level 3 user can change passwords.

A person with no password can only view the main display.



- Press any key to enter the main menu. Move the cursor to "Program" and press Enter (F4).
- Move the cursor to "Configure" and press Enter (F4).
- Move the cursor to "Security" and press Enter (F4).

- Use the ↑ and ↓ keys to move through the list of items. To enter a password, press Edit (F4). Use the arrow keys to enter a three-digit password. Press Save (F4) to store the value.

Lock all: Until the user enters the "lock all" password, all he can do is view the main display. Entering the "lock all" password allows the user access to all Level 1 functions.

Lock program: Entering the "lock program" password allows the user access to all Level 2 functions.

Lock config: Entering the "lock config" password allows the user access to all Level 3 functions.

The controller will accept a higher level security code at a lower level security gate. For example, the controller will accept a level 2 password at a level 1 gate.

NOTES:

- A code of 000 disables security for that level.
- The security feature will not activate until after the timeout period has passed with no key presses.
- A hold condition will indefinitely prolong the timeout period.
- Security will activate immediately if power is removed and then restored.
- To recall a forgotten code, press and hold F4 for five seconds when the security screen appears. The code for that level will appear.

5.12 ANALYZER MODE PRIORITY

The Model 54eA analyzer can function in different modes depending on both how it is configured, what process conditions exist, and what actions an operator may have made. To reconcile these possible modes, there is a set priority that determines exactly what will happen to the two (2) current outputs and the four (4) alarm relays in the event of multiple modes occurring at the same time. See Table 5-2 below.

Priority is in the following order (from lowest to highest): normal, fault, timer, hold, feed limit, test. Each output or relay acts as if it is only in the state of highest priority.

NOTE

Some of these features may not be in use in the analyzer.

TABLE 5-2. Controller Mode Priority Chart

Condition	Priority	Current Output 1	Current Output 2	Alarm Relay 1	Alarm Relay 2	Alarm Relay 3	Alarm Relay 4
Normal	1	Normal	Normal	Normal	Normal	Normal	Open
Fault	2	Default	Default	Default	Default	Default	Closed
Interval Timer	3	Hold	Hold	Default/ Normal ¹	Default/ Normal ¹	Default/ Normal ¹	Prior
Hold Mode	4	Hold	Hold	Default	Default	Default	Prior
Feed Limit	5	Normal	Normal	Open ¹	Open ¹	Open ¹	Closed
Simulate tests	6	Test ¹	Test ¹	Test ¹	Test ¹	Test ¹	Test ¹

¹ Indicates the state **IF** that item has been configured or selected (i.e. if it is an interval timer or a feed limit timer or it is the one being tested). Unconfigured or unselected items are not affected by that mode.

Condition Definitions:

1. Normal refers to conditions when no other mode is present.
2. Fault means the instrument has diagnosed a fault condition. A fault message is displayed and the red LED is on.
3. Interval Timer means the timer sequence is occurring.
4. Hold Mode occurs when hold is activated by the operator (i.e. during calibration).
5. Feed Limit occurs when a feed limit timer has reached its limit and is turned off after being on for too long.
6. Simulate tests are described in Section 5.3.

Action Definitions:

1. Normal is determined by process conditions or how the item has been configured (Section 5.6)
2. Open is a deenergized alarm relay (alarm off).
3. Default is the setting configured for each item if there is a fault. (Section 5.6)
4. Closed is an energized alarm relay (alarm on).
5. Hold is the setting for the current output configured in Section 5.5 (fixed mA value or the last normal value).
6. Prior is the state the alarm had before that mode occurred.
7. Test is the value input by the operator (mA for current, on or off for a relay).

SECTION 6.0

CALIBRATION - TEMPERATURE

6.1 INTRODUCTION

The free chlorine sensor used in the FCL 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 chlorine diffuses through the membrane. The diffusion rate, in turn, depends on the concentration of chlorine and how easily it passes through the membrane (the membrane permeability). Because the membrane permeability is a function of temperature, the sensor current will change if the temperature changes. To correct for changes in sensor current caused by temperature, the analyzer automatically applies a membrane permeability correction. The correction is about 3%/°C at 25°C, so a 1°C error in temperature produces about a 3% error in the reading.

Without calibration the accuracy of the temperature measurement is about $\pm 0.4^\circ\text{C}$. Calibrate the analyzer if

1. $\pm 0.4^\circ\text{C}$ 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.

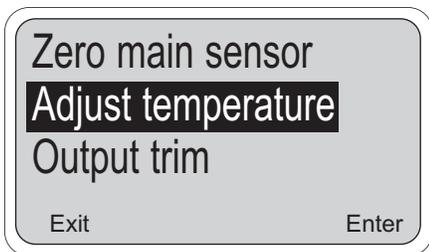
6.2 TEMPERATURE CALIBRATION

Place the sensor and a standard thermometer in a beaker of water. Allow the system to reach thermal equilibrium.

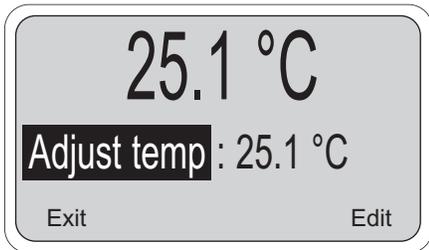
1. Check the temperature reading (main display) to make sure the sensor has stabilized. Compare the analyzer temperature reading with the standard thermometer. The readings should differ by at most 1°C. If the readings differ by a greater amount, refer to Section 11.8. Go to the next step if the reading requires adjustment.
2. From the main display, press any key. With the cursor on "Calibrate," press Enter (F4).

NOTE

If Hold was enabled in Section 5.5, the hold screen will appear. To activate hold, refer to Section 5.5, step 9.



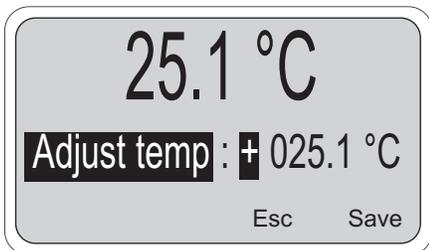
3. Press the ↓ key twice to move the cursor to "Adjust temperature," then press Enter (F4).



4. Press Edit (F4) to adjust the temperature. The screen below will then appear. Using the arrow keys, enter the correct temperature and press Save (F4). The controller will enter the value in memory. To abort the change, press Esc (F3). Press Exit (F1) three times for the main display.

NOTE

If Hold was activated during calibration, "Hold Mode Activated" will continue to flash in the main display. Return the sensor to normal and deactivate Hold. Refer to Section 5.5, step 9.



SECTION 7.0 CALIBRATION - CHLORINE

7.1 INTRODUCTION

As Figure 7-1 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 a few crystals of salt for every three ounces (90 mL) of water.
- 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 tap for the FCL.
- 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.

The Model 499ACL-01 free chlorine sensor loses sensitivity at high concentrations of chlorine. The 54eA 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.

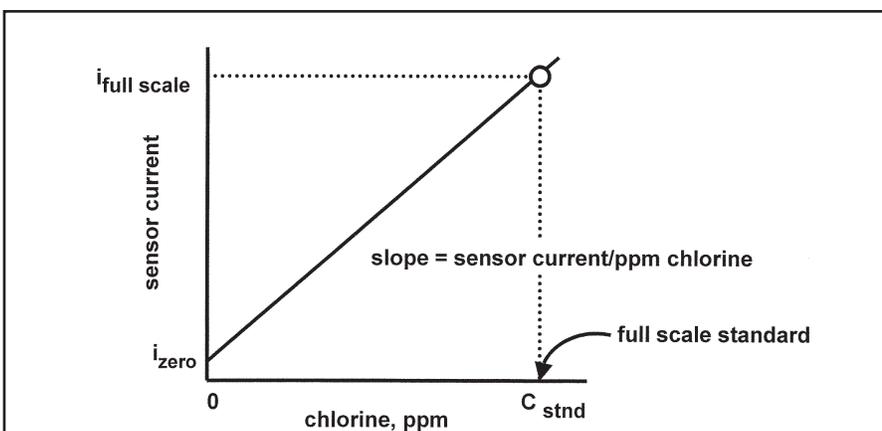
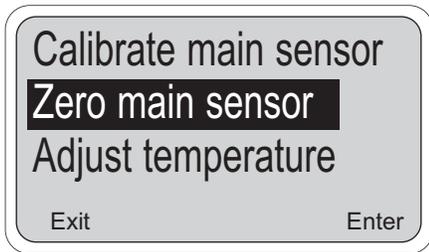


FIGURE 7-1. Sensor Current as a Function of Free Chlorine Concentration

7.2 ZEROING THE SENSOR

1. Remove the sensor from the flow cell and place it in the zero standard. See Section 7.1 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 any key to obtain the main menu. Press the ↓ key once to highlight “Diagnostic variables.” Press Enter (F4). The sensor current is the second item in the display. Note the units: nA is nanoamps, uA is microamps. To return to the main display, press exit (F1) twice. Typical zero current for the 499ACL-01 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. From the main display, press any key to obtain the main menu. With the cursor on “Calibrate,” press Enter (F4).

NOTE

If Hold was enabled in Section 5.5, the hold screen will appear. To activate hold, refer to Section 5.5, step 9.

Press the ↓ key once to move the cursor to “Zero main sensor.” Press Enter (F4).

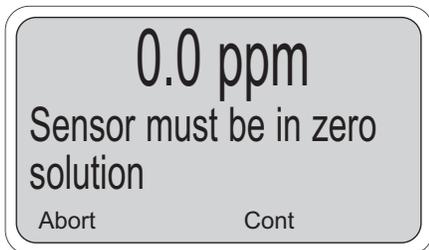
3. The screen at left appears. Press Cont (F3). “Wait” flashes until the sensor is stabilized. Once the zero step is complete, the message “Sensor zero done” appears.
4. Press Exit (F1) three times to return to the main display.

NOTE

If Hold was activated during calibration, “Hold Mode Activated” will continue to flash in the main display. Return the sensor to normal and deactivate Hold. Refer to Section 5.5, step 9.

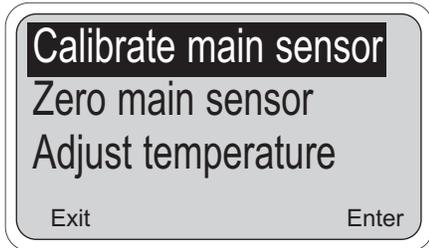
NOTE

During calibration, ERROR and WARNING messages may appear. If an ERROR message appears, press Exit (F1) to leave and return to the previous screen. If a WARNING message appears, press Cont (F3) to continue the calibration or press Abort (F1) to leave. Continuing the calibration after a warning message appears may cause substantial errors in the subsequent measurement. Refer to Section 11.0 for assistance.



7.3 FULL SCALE CALIBRATION

- Place the sensor in the flow cell. If automatic pH correction is being used, calibrate the pH sensor (section 8.0) and place it in the flow cell. If manual pH correction is being used, measure the pH of the sample and enter the value (section 5.7). Adjust the sample flow until water overflows the inside tube in the constant head flow controller.
- 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.

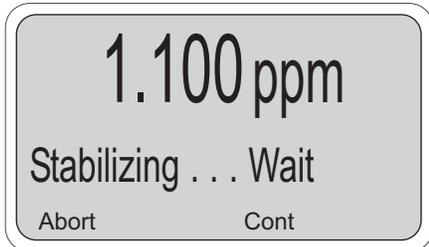


- From the main display, press any key to obtain the main menu. With the cursor on "Calibrate," press Enter (F4).

NOTE

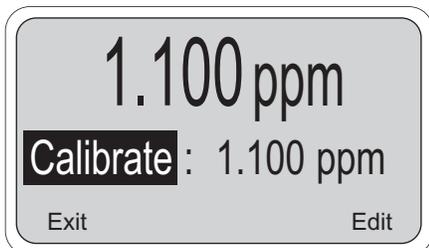
If Hold was enabled in Section 5.5, the hold screen will appear. To activate hold, refer to Section 5.5, step 9.

Press Enter (F4).



- Press Cont (F3). "Wait" flashes until the sensor is stabilized. If the analyzer appears locked, the reading is not stable enough. Wait until the process readings are stable before starting the calibration.

Alternatively, increase the stability concentration or reduce the stability time. See Section 5.9. Calibrating while readings are unstable may substantially reduce accuracy.



- Once the reading is stable, the screen at left appears. 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 measured in the grab sample.

Press Edit (F4). Use the arrow keys to change the concentration in the second line of the display to the desired value. Press Save (F4) to store the value.

- Press Exit (F1) four times to return to the main display.

NOTE

If Hold was activated during calibration, "Hold Mode Activated" will continue to flash in the main display. Return the sensor to normal and deactivate Hold. Refer to Section 5.5, step 9.

- During the calibration, the analyzer stores the measured current and calculates the sensitivity. Sensitivity is the sensor current in nA divided by the measured concentration. The sensitivity of the 499ACL-01 (free chlorine) sensor is 250-400 nA/ppm.

To view the sensitivity from the main display, press any key to enter the main menu. Press the ↓ key once. Then press Enter (F4) to display the diagnostic variables. The sensitivity is the third line on the screen. Note the units: nA is nanoamps, μA is microamps.

NOTE

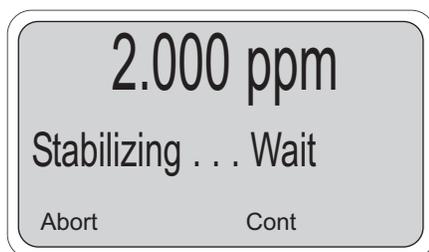
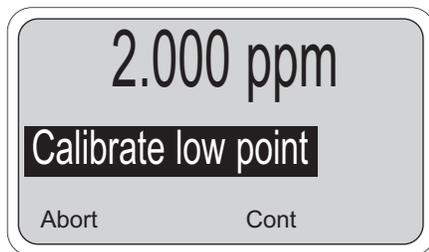
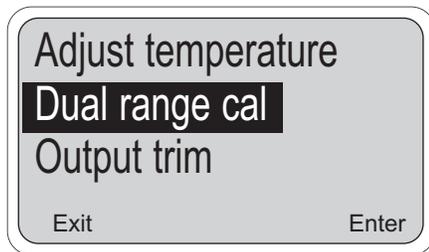
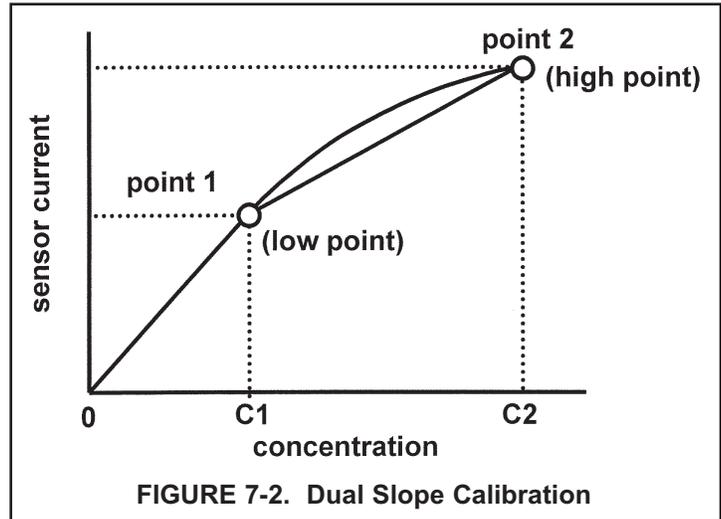
During calibration, ERROR and WARNING messages may appear. If an ERROR message appears, press Exit (F1) to leave and return to the previous screen. If a WARNING message appears, press Cont (F3) to continue the calibration or press Abort (F1) to leave. Continuing the calibration after a warning message appears may cause substantial errors in the subsequent measurement. Refer to Section 10.4 for assistance.

7.4 DUAL SLOPE CALIBRATION

Figure 7-2 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 might be needed if the chlorine concentration is greater than about 6 ppm.

1. Be sure the analyzer has been configured for dual slope calibration. See Section 5.10.
2. Zero the sensor. See Section 7.2.
3. Place the sensor in the flow cell. If automatic pH calibration is being used, calibrate the pH sensor (section 8.0) and place it in the flow cell. If manual pH correction is being used, measure the pH of the sample and enter the value (section 5.7). Adjust the sample flow until water overflows the inside tube in the constant head flow controller.



4. From the main display, press any key to obtain the main menu. With the cursor on "Calibrate," press Enter (F4).

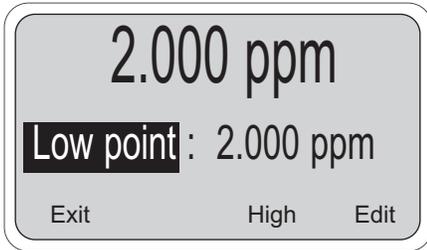
NOTE

If Hold was enabled in Section 5.5, the hold screen will appear. To activate hold, refer to Section 5.5, step 9.

Press the ↓ key three times to move the cursor to "Dual range cal." Press Enter (F4).

5. Adjust the concentration of chlorine in the process until it is near the upper end of the linear response range of the sensor, i.e., concentration near C1 as shown in Figure 7-2.

6. Press Cont (F3). "Wait" flashes until the sensor is stabilized. If the controller appears locked, the reading is not stable enough. Wait until the process readings are stable before starting the calibration.

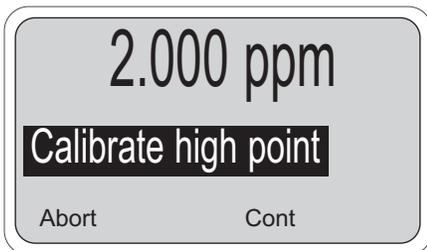


7. Once the reading is stable, the screen at left appears. Sample the process liquid. Make a note of the reading before taking the sample. Immediately determine free chlorine. Note the controller reading again. If the present reading (X) differs from the reading when the sample was taken (Y), calculate the value to enter (C) from the following formula:

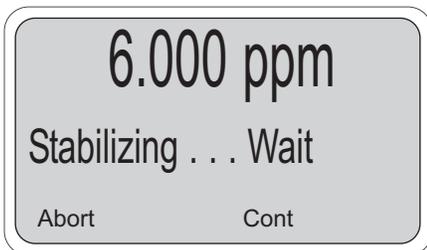
$$C = (X/Y) (A)$$

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

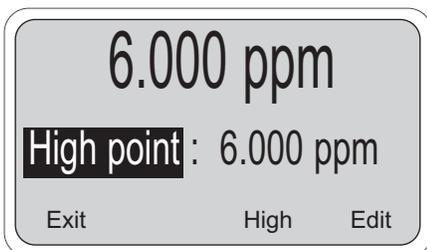
Press Edit (F4). Use the arrow keys to change the concentration in the second line of the display to the desired value. Press Save (F4) to store the value.



8. Press High (F3). Adjust the concentration of chlorine in the process until it is near the top end of the range, i.e., concentration near C2 as shown in Figure 7-2.



9. Press Cont (F3). "Wait" flashes until the sensor is stabilized.



10. Once the reading is stable, the screen at left appears. Following the procedure in step 7, determine chlorine in a sample of the process liquid.

Press Edit (F4). Use the arrow keys to change the concentration in the second line of the display to the desired value. Press Save (F4) to store the value.

11. Press Exit (F1) three times to return to the main display.

NOTE

If Hold was activated during calibration, "Hold Mode Activated" will continue to flash in the main display. Return the sensor to normal and deactivate Hold. Refer to Section 5.5, step 9.

NOTE

During calibration, ERROR and WARNING messages may appear. If an ERROR message appears, press Exit (F1) to leave and return to the previous screen. If a WARNING message appears, press Cont (F3) to continue the calibration or press Abort (F1) to leave. Continuing the calibration after a warning message appears may cause substantial errors in the subsequent measurement. Refer to Section 10.4 for assistance.

SECTION 8.0 CALIBRATION - pH

8.1 INTRODUCTION

A new pH sensor must be calibrated before use. Regular recalibration is also necessary.

A pH measurement cell (pH sensor and the solution to be measured) can be pictured as a battery with an extremely high internal resistance. The voltage of the battery depends on the pH of the solution. The pH meter, which is basically a voltmeter with a very high input impedance, measures the cell voltage and calculates pH using a conversion factor. The actual value of the voltage-to-pH conversion factor depends on the sensitivity of the pH sensing element (and the temperature). The sensing element is a thin, glass membrane at the end of the sensor. As the glass membrane ages, the sensitivity drops. Regular recalibration corrects for the loss of sensitivity. pH calibration standards, also called buffers, are readily available.

Two-point calibration is standard. Both automatic calibration and manual calibration are available. Auto calibration avoids common pitfalls and reduces errors. Its use is recommended.

In automatic calibration the controller recognizes the buffer and uses temperature-corrected pH values in the calibration. The table below lists the standard buffers the controller recognizes. The controller also recognizes several technical buffers: Merck, Ingold, and DIN 19267. Temperature-pH data stored in the controller are valid between at least 0 and 60°C.

pH of common buffers at 25°C (see note 1)			
Standard (NIST)	DIN 19267	Merck	Ingold
1.68	1.09	2.00	2.00
3.56	3.06	4.00	4.01
3.78	4.65	7.00	7.00
4.01	6.79	9.00	9.21
6.86	9.23	12.00	
7.00 (see note 2)	12.75		
7.41			
9.18			
10.01			
12.45			

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.

During automatic calibration, 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 the factory-set limits of 0.02 pH units for 10 seconds. The stability settings can be changed. See Section 5.10.

In manual calibration, the analyzer still monitors readings for stability; however, the buffer pH lookup feature is missing. The user has to enter the correct pH at the temperature the buffer is being used.

Once the analyzer completes the calibration, it calculates the calibration slope and offset. The slope is reported as the slope at 25°C. Figure 8-1 defines the terms.

The analyzer can also be standardized. Standardization is the process of forcing the analyzer reading to match the reading from a second pH instrument. Standardization is sometimes called a one-point calibration.

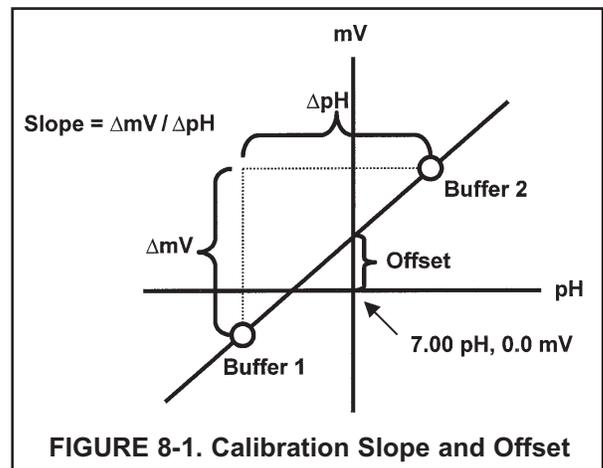


FIGURE 8-1. Calibration Slope and Offset

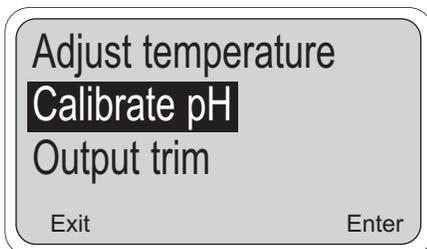
8.2 AUTOMATIC TWO-POINT CALIBRATION

1. Be sure the pH feature has been enabled. See Section 5.7.
2. Obtain two buffer solutions. Ideally the buffer pH values should bracket the range of pH values to be measured.
3. Remove the sensor from the process liquid. 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.

4. From the main display, press any key to obtain the main menu. With the cursor on "Calibrate" press Enter (F4).

NOTE

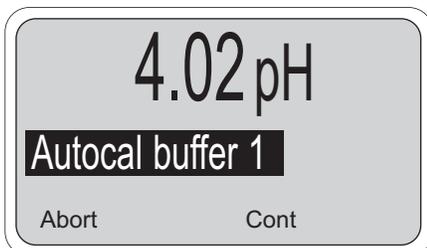
If Hold was enabled in Section 5.5, the hold screen will appear. To activate hold, refer to Section 5.5, step 9.



5. Press the ↓ key three times to move the cursor to "Calibrate pH". Press Enter (F4).

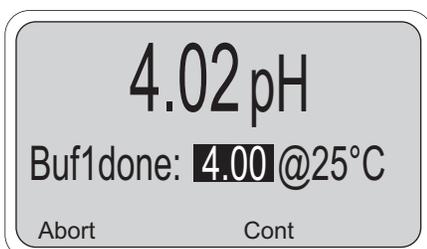


6. Press Enter (F4).

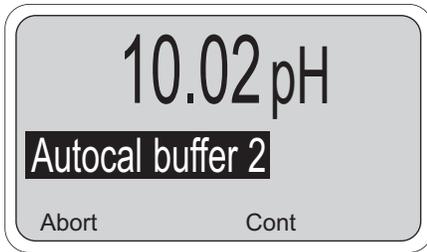


7. Rinse the sensor with water and place it in buffer 1. Be sure the glass bulb and reference junction are completely submerged. Swirl the sensor. Press Cont (F3). "Wait" flashes until the reading stabilizes.

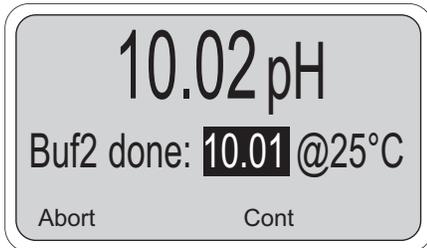
If the analyzer appears locked, the reading is not stable enough. Investigate and correct the cause of the noise or drift (see Section 11.5). Alternatively, change the stability limits (see Section 5.7) and repeat the calibration.



8. The screen at left appears once the reading is stable. Use the ↑ or ↓ key to change the reading to the nominal pH of the buffer. The nominal pH is the pH of the buffer at 25°C. Press Cont (F3).



9. Remove the sensor from buffer 1, rinse it with water, and place it in buffer 2. Swirl the sensor. Press Cont (F3). "Wait" flashes until the reading is stable.



10. The screen at left appears once the reading is stable. Use the \uparrow or \downarrow key to change the reading to the nominal pH of the buffer. The nominal pH is the pH of the buffer at 25°C. Press Cont (F3).

11. Press Exit (F1) four times to return to the main display.

NOTE

If Hold was activated during calibration, "Hold Mode Activated" will continue to flash in the main display. Return the sensor to normal and deactivate Hold. Refer to Section 5.5, step 9.

12. To view the slope and offset press any key to enter the main menu. Press the \downarrow key once to move the cursor to "Diagnostic variables". Press Enter (F4). Press the \downarrow key six times to scroll through the list of diagnostic variables. Note that the pH slope is at 25°C.

NOTE

During calibration, ERROR and WARNING messages may appear. If an ERROR message appears, press Exit (F1) to leave and return to the previous screen. If a WARNING message appears, press Cont (F3) to continue the calibration or press Abort (F1) to leave. Continuing the calibration after a warning message appears may cause substantial errors in the subsequent measurement. Refer to Section 11.5 for assistance.

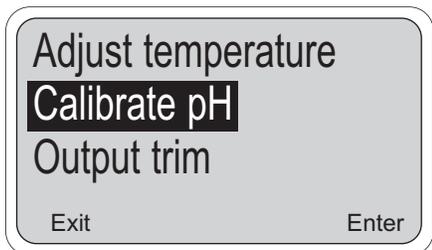
8.3 MANUAL TWO-POINT CALIBRATION

1. Be sure the pH feature has been enabled. See Section 5.7.
2. The controller comes from the factory set for automatic pH calibration. To do a manual calibration, the factory default setting must be changed. Refer to Section 5.7.
3. 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.
4. Remove the sensor from the process liquid. 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.

5. From the main display, press any key to obtain the main menu. With the cursor on "Calibrate" press Enter (F4).

NOTE

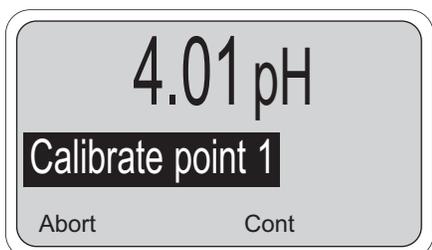
If Hold was enabled in Section 5.5, the hold screen will appear. To activate hold, refer to Section 5.5, step 9.



6. Press the ↓ arrow key three times to move the cursor to "Calibrate pH". Press Enter (F4).

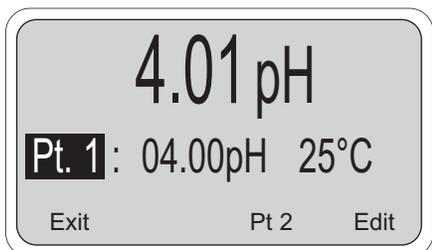


7. With the cursor on "2-pt calibration" press Enter (F4).

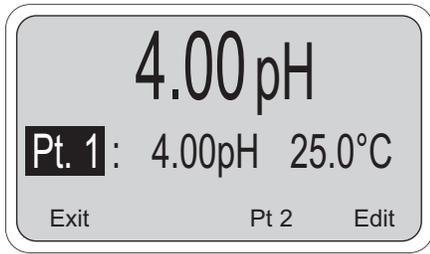


8. Rinse the sensor and thermometer with water and place them in buffer 1. Be sure the glass bulb and junction are completely submerged. Swirl the sensor. Press Cont (F3). "Wait" flashes until the reading stabilizes. The large number on the first line is the measured pH based on the previous calibration.

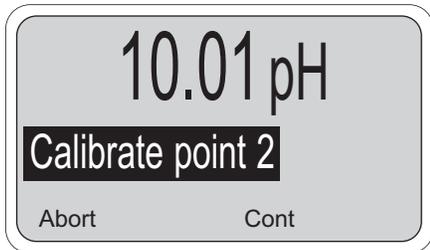
If the analyzer appears locked, the reading is not stable enough. Investigate and correct the cause of the noise or drift (see Section 11.5). Alternatively, change the stability limits (see Section 5.7) and repeat the calibration.



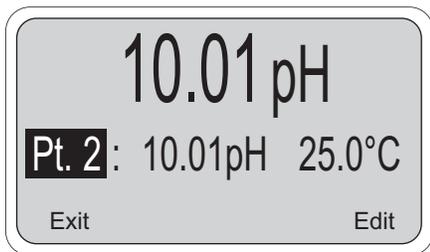
9. The screen at left appears once the reading is stable. Press Edit (F4) and use the arrow keys to change the reading to the pH of the buffer at the measured temperature. Most commercial buffers have a table of pH values as a function of temperature on the label. Press Save (F4) to store the value. If the pH value on the first line is correct, press Pt 2 (F3) and go to step 11.



10. The screen at left appears if the pH reading in step 9 was changed. Press Pt 2 (F3). Go to step 11.



11. Rinse the sensor and thermometer with water and place them in buffer 2. Be sure the glass bulb and junction are completely submerged. Swirl the sensor. Press Cont (F3). "Wait" flashes until the reading stabilizes.



12. The screen at left appears once the reading is stable. Press Edit (F4) and use the arrow keys to change the reading to the pH of the buffer at the measured temperature. Press Save (F4) to store the value.

Press Exit (F1) four times to return to the main display.

NOTE

If Hold was activated during calibration, "Hold Mode Activated" will continue to flash in the main display. Return the sensor to normal and deactivate Hold. Refer to Section 5.5, step 9.

13. To view the slope and offset press any key to enter the main menu. Press the ↓ key once to move the cursor to "Diagnostic variables". Press Enter (F4). Press the ↓ key six times to scroll through the list of diagnostic variables. Note that the pH slope is at 25°C.

NOTE

During calibration, ERROR and WARNING messages may appear. If an ERROR message appears, press Exit (F1) to leave and return to the previous screen. If a WARNING message appears, press Cont (F3) to continue the calibration or press Abort (F1) to leave. Continuing the calibration after a warning message appears may cause substantial errors in the subsequent measurement. Refer to Section 11.5 for assistance.

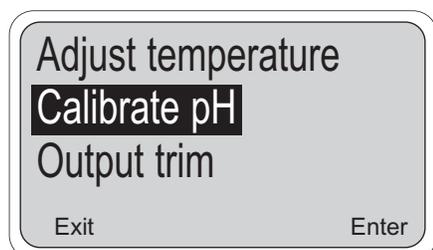
8.4 STANDARDIZATION (ONE-POINT CALIBRATION)

1. The pH measured by the analyzer can be changed to match the reading from a second or referee instrument. The process of making the two reading agree is called standardization, or one-point calibration.
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 sensor that has been calibrated with buffers is then standardized and placed back in a buffer, the measured pH will differ from the buffer pH by an amount equivalent to the standardization offset.
3. Install the sensor in the process liquid. Once readings are stable, measure the pH of the liquid using a referee instrument. Normally, it is acceptable to test a grab sample. Because the pH of the process liquid may change if the temperature changes, measure the pH immediately after taking the grab sample. 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 process sensor.

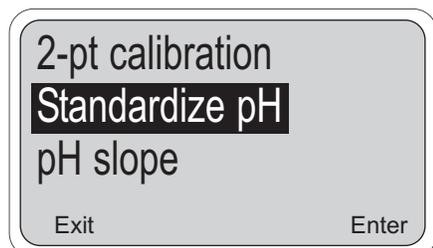
4. From the main display, press any key to obtain the main menu. With the cursor on "Calibrate" press Enter (F4).

NOTE

If Hold was enabled in Section 5.5, the hold screen will appear. To activate hold, refer to Section 5.5, step 9.



5. Press the ↓ key three times to move the cursor to "Calibrate pH". Press Enter (F4).



6. Press the ↓ key once to move the cursor to "Standardize pH". Press Enter (F4).



7. The pH reading in large numbers is the current process reading. Press Edit (F4). Use the arrow keys to change the reading in the second line to match the referee instrument. Press Save (F4).
8. Press Exit (F1) four times to return to the main display.

NOTE

If Hold was activated during calibration, "Hold Mode Activated" will continue to flash in the main display. Return the sensor to normal and deactivate Hold. Refer to Section 5.5, step 9.

NOTE

During calibration, ERROR and WARNING messages may appear. If an ERROR message appears, press Exit (F1) to leave and return to the previous screen. If a WARNING message appears, press Cont (F3) to continue the calibration or press Abort (F1) to leave. Continuing the calibration after a warning message appears may cause substantial errors in the subsequent measurement. Refer to Section 11.5 for assistance.

8.5 pH SLOPE ADJUSTMENT

1. If the electrode slope is known from other measurements, it can be entered directly into the 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:

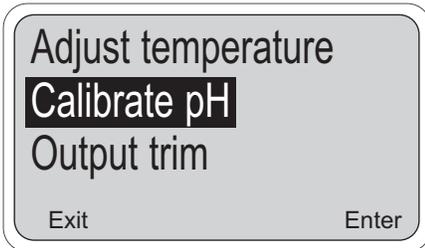
$$\text{slope at } 25^{\circ}\text{C} = (\text{slope at } t^{\circ}\text{C}) \frac{298}{t^{\circ}\text{C} + 273}$$

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

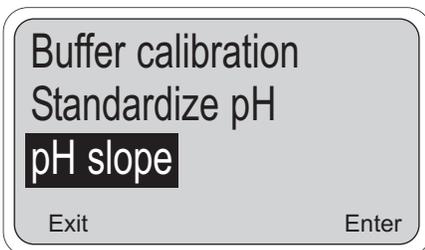
2. From the main display, press any key to obtain the main menu. With the cursor on "Calibrate" press Enter (F4).

NOTE

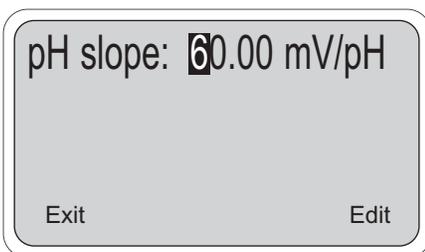
If Hold was enabled in Section 5.5, the hold screen will appear. To activate hold, refer to Section 5.5, step 9.



3. Press the ↓ key three times to move the cursor to "Calibrate pH". Press Enter (F4).



4. Press the ↓ key twice to move the cursor to "pH slope." Press Enter (F4).



5. Press Edit (F4). Use the arrow keys to change the slope to the desired value. The slope must be between 45 and 60 mV/pH. Press Save (F4).
6. Press Exit (F1) four times to return to the main display.

NOTE

If Hold was activated during calibration, "Hold Mode Activated" will continue to flash in the main display. Return the sensor to normal and deactivate Hold. Refer to Section 5.5, step 9.

NOTE

During calibration, ERROR and WARNING messages may appear. If an ERROR message appears, press Exit (F1) to leave and return to the previous screen. If a WARNING message appears, press Cont (F3) to continue the calibration or press Abort (F1) to leave. Continuing the calibration after a warning message appears may cause substantial errors in the subsequent measurement. Refer to Section 11.5 for assistance.

SECTION 9.0

CALIBRATION - CURRENT OUTPUTS

9.1 INTRODUCTION

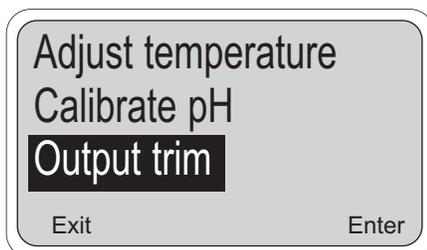
Although the analog outputs are calibrated at the factory, they can be trimmed in the field to match the reading from a standard milliammeter. Both the low output (0 or 4 mA) and the high output (20 mA) can be trimmed.

9.2 TRIMMING THE OUTPUTS

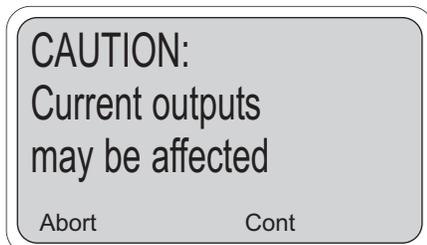
- From the main display, press any key to obtain the main menu. With the cursor on "Calibrate" press Enter (F4).

NOTE

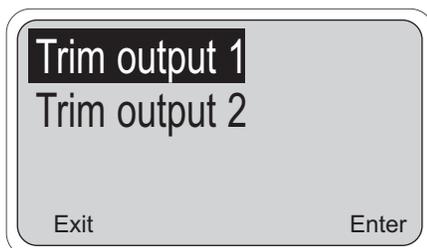
If Hold was enabled in Section 5.5, the hold screen will appear. To activate hold, refer to Section 5.5, step 9.



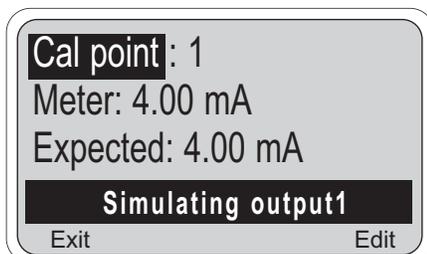
- Move the cursor to "Output trim" and press Enter (F4).



- The warning screen reminds the user that the output currents will be affected. Press Cont (F3) to continue.



- Use the \uparrow or \downarrow keys to move the cursor to the desired output and press Enter (F4).



- Select "Cal point 1" (0 or 4 mA) or "Cal point 2" (20 mA).
- Move the cursor to "Meter" and press Enter (F4). Measure the output current with a calibrated milliammeter. Use the \uparrow or \downarrow keys to change the display to match the milliammeter reading and press Save (F4).
- Move the cursor to the other "Cal point" and select it. Repeat step 6.

NOTE

If Hold was activated during calibration, "Hold Mode Activated" will continue to flash in the main display. Return the sensor to normal and deactivate Hold. Refer to Section 5.5, step 9.

SECTION 10.0 MAINTENANCE

10.1 ANALYZER

The analyzer used with the FCL 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 solvents, like alcohol, that might cause a buildup of static charge.

TABLE 10-1. Replacement parts

PART NUMBER	DESCRIPTION
23540-05	Enclosure, Front with Keyboard
23848-00	Power Supply Circuit Board Shield
23849-00	Half Shield, Power Supply
23969-02	PCB, CPU and power supply, calibrated, 115/230 Vac
23969-06	PCB, CPU and power supply, calibrated, 24 Vdc
33281-00	Hinge Pin
33286-00	Gasket, Front Panel
33293-00	Enclosure, Rear
9010377	Back-lit Display, LCD Dot Matrix
9510048	Enclosure Conduit Plug, 1/2 inch

NOTE: Individual printed circuit boards cannot be ordered for Model 54e. Replacement boards for Model 54e are assembled and calibrated as an integrated board stack.

10.2 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!

10.2.1 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 two to three months. In water containing large amounts of suspended solids, for example open recirculating cooling water, membrane cleaning or replacement will be more frequent.

10.2.2 Cleaning the membrane.

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

10.2.3 Replacing the electrolyte solution and membrane.

1. Unscrew the membrane retainer and remove the membrane assembly and O-ring. See Figure 10-2.
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. 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).
6. 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.
7. 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.
8. 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.
9. Insert a small **blunt** probe, like a toothpick with the end cut off, through the pressure equalizing port. See Figure 10-2.

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.

10. Place a drop of electrolyte solution on the cathode, then place the membrane assembly over the cathode. Screw the membrane retainer in place.
11. The sensor may require several hours operating at the polarizing voltage to equilibrate after the electrolyte solution has been replenished.

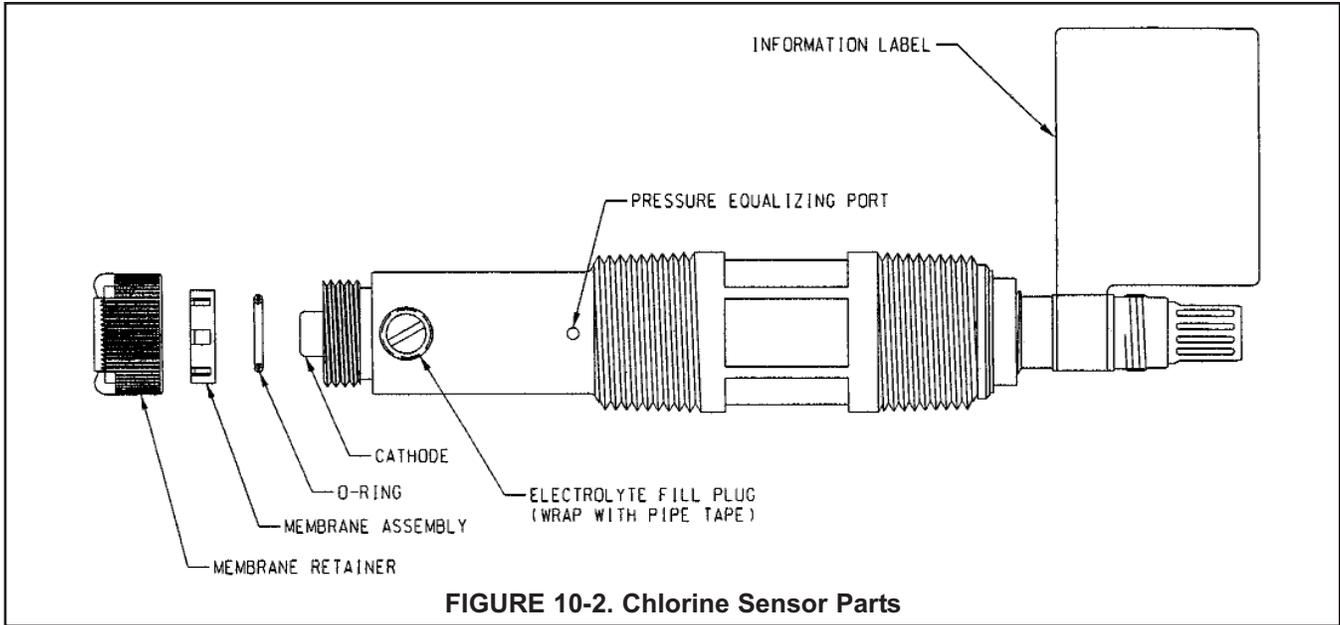


TABLE 10-2. Spare Parts

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)

10.3 pH SENSOR

10.3.1 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.

10.3.2 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.

10.3.3 Other Maintenance

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

10.4 CONSTANT HEAD FLOW CONTROLLER

10.4.1 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.

10.4.2 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.

10.4.3 Other Maintenance

Tables 10-3 and 10-4 and Figures 10-3 and 10-4 show the replacement parts for the flow controller assembly used in Models FCL-01 and FCL-02.

TABLE 10-3. Replacement parts for constant head flow controller assembly (Model FCL-01)

Location in Figure 10-3	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

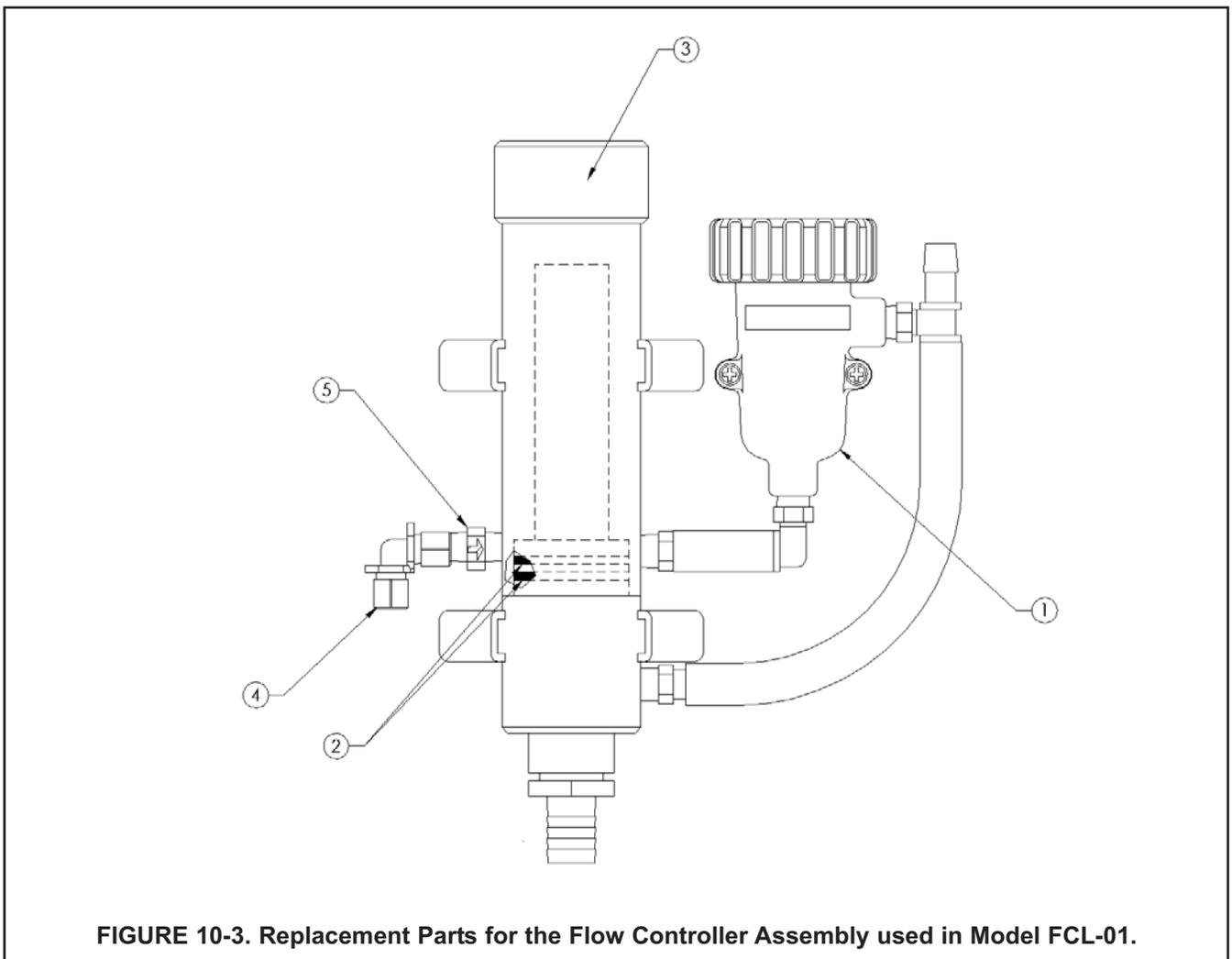


Table 10-4 and Figure 10-4 show the replacement parts for the flow controller assembly used in Model FCL-02.

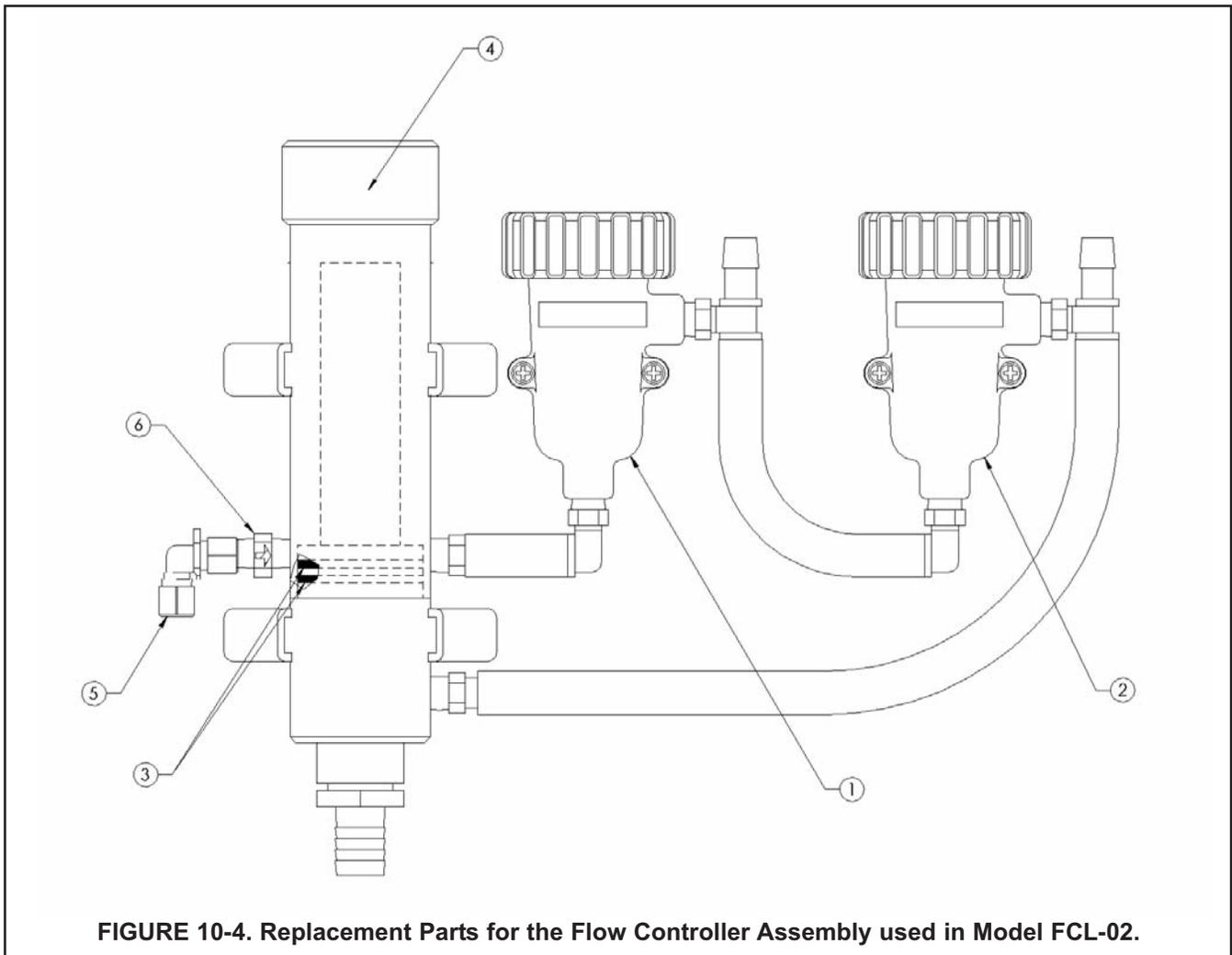


FIGURE 10-4. Replacement Parts for the Flow Controller Assembly used in Model FCL-02.

TABLE 10-4. Replacement parts for constant head flow controller assembly (Model FCL-02)

Location in Figure 10-4	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 11.0 TROUBLESHOOTING

11.1 OVERVIEW

The analyzer used with the FCL continuously monitors itself and the sensor for faults. When the controller detects a fault in the amperometric or pH sensor or in the instrument itself it displays a **fault message**. If alarm 4 was enabled, the red FAIL LED will also light and relay 4 will activate. The outputs will go to 22.00 mA or to the value programmed in Section 5.5.

Special rules apply to pH sensor diagnostics (high and low glass impedance). Alarm 4, the FAIL LED, and the output current failure mode will operate only if pH sensor diagnostics have been enabled. See Section 5.7.

See Section 11.2 for an explanation of fault messages and suggested corrective actions.

The controller also displays **error** and **warning messages** if a calibration is seriously in error. Refer to the section 11.3 -11.5 for assistance. Each section also contains hints for correcting **other measurement and calibration problems**.

For **troubleshooting not related to measurement** problems, see Section 11.7.

To view **diagnostic variables**, go to the main display and press any key. Move the cursor to “Diagnostic variables” and press Enter (F4). Use the **↑** or **↓** key to move up or down the list.

11.2 TROUBLESHOOTING WHEN A FAULT MESSAGE IS SHOWING

Fault message	Explanation	See Section
High input current	input current exceeds 210 uA	11.2.1
Check sensor zero	sensor current was too high when sensor was zeroed	11.2.2
pH low input voltage	input voltage is less than -1400 mV	11.2.3
pH high input voltage	input voltage exceeds 1400 mV	11.2.3
pH low reference voltage	input voltage is less than -1600 mV	11.2.4
pH high reference voltage	input voltage exceeds 1600 mV	11.2.4
Old glass warning	glass impedance exceeds high limit	11.2.5
Cracked glass failure	glass impedance is less than low limit	11.2.6
Temp error low	temperature less than -15°C	11.2.7
Temp error high	temperature greater than 130°C	11.2.7
Sense line open	RTD sense line is open	11.2.8
Failure factory	instrument needs factory calibration	11.2.9
Failure eeprom	write verify error has occurred	11.2.9

11.2.1 High input current

Excessive sensor current implies that the chlorine sensor is miswired or the sensor has failed. Verify that wiring is correct. See Section 3.3. If wiring is correct, try replacing the sensor.

11.2.2 Check sensor zero

The sensor current was extremely high when the sensor was zeroed. The zero current should be less than about 10 nA. Zeroing the sensor before the zero current has reached a stable minimum value will lead to low results. Allow adequate time, usually two or three hours but possibly as long as overnight, for the sensor to stabilize before starting the zero routine. Also see section 11.4 for more information.

11.2.3 pH low or high input voltage

The input voltage fault message usually means there is an open connection somewhere in the wiring between the pH sensor and analyzer. Check wiring connections. See Section 3.3. If wiring is correct, try replacing the sensor.

11.2.4 pH low or high reference voltage

The reference voltage fault message can mean several things: the pH sensor is no longer submerged in the sample, the sensor is coated or fouled, or there is an open connection between the sensor and analyzer. First, verify all electrical connections. Verify that the pH sensor is completely submerged in the process. Also, verify that the sensor is not coated with solids or oil. If the sensor looks dirty, clean it. Refer to section 10.3 for details. If cleaning the sensor fails to solve the problem, replace the sensor.

11.2.5 Old glass warning (pH sensor only)

Old glass warning means the pH sensor is no longer submerged in the process or the sensor is possibly nearing the end of its useful life. First, verify that the sensor is clean and submerged in the process liquid. Also verify that the sensor can still be calibrated in buffers. Make a note of the sensor slope. If the slope is between 54 and 60 mV/ unit pH, the sensor is good. If the slope is between 48 and 50 mV/unit pH, the sensor is near the end of its life. To make the warning message disappear, increase the warning limit (see Section 5.7).

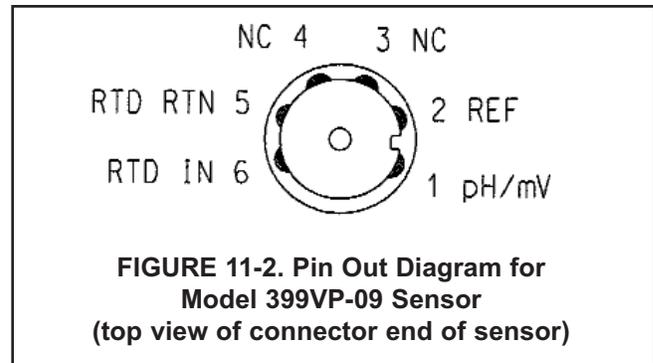
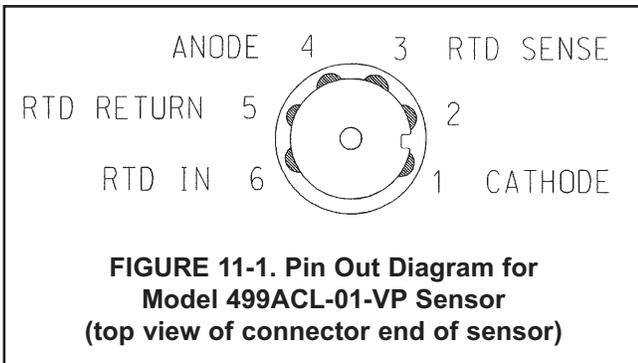
11.2.6 Cracked glass failure (pH sensor only)

This fault message almost always means the pH sensor has failed and must be replaced. Before discarding the sensor, try calibrating it in buffers. If the buffer calibration is successful, the sensor is okay, but the diagnostic limit is set too high. To make the fault message disappear, lower the glass failure limit (see Section 5.7). Do not lower the impedance below 10 M Ω .

11.2.7 Temperature error low or high

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 3.3.
- 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 11-1 or 11-2. 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 3.3 or Figure 3.4. 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 11.11.



11.2.8 Sense line open.

The analyzer measures temperature using a three-wire RTD. See Figure 11-4. 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.

11.2.9 Failure factory and Failure ecprom.

Turn the power off, wait about 30 sec, then turn the power back on. If the error message does not clear, call the factory.

11.3 TROUBLESHOOTING WHEN NO FAULT MESSAGE IS SHOWING - TEMPERATURE

11.3.1 Temperature measured by standard was more than 1°C different from analyzer.

- 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 sensor completely submerged in the liquid?
- C. Is the standard temperature sensor submerged to the correct level?

11.4 TROUBLESHOOTING WHEN NO FAULT MESSAGE IS SHOWING - FREE CHLORINE

Problem	See Section
Zero current was accepted, but the current is out of range	11.4.1
Error or warning message appears while zeroing the sensor (zero current is too high)	11.4.1
Zero current is unstable	11.4.2
Sensor can be calibrated, but sensitivity is out of range	11.4.3
Process readings are erratic	11.4.4
Readings drift	11.4.5
Sensor does not respond to changes in chlorine level	11.4.6
Chlorine reading spikes following rapid change in pH	11.4.7

11.4.1 Zero current is too high

- A. Is the sensor properly wired to the analyzer. See Section 3.3.
- 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.

11.4.2 Zero current is unstable

- A. Is the sensor properly wired to the analyzer? See Section 3.3. 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 about 50uS/cm. Use deionized water containing a small amount of sodium chloride approximately 0.5 grams per liter. **DO NOT USED DEIONIZED WATER ALONE.**
- 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. See section 10.2.

11.4.3 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 10.4.
- C. Low current can be caused by lack of electrolyte flow to the cathode and membrane. See step D in Section 11.4.2
- D. Is the membrane fouled or coated? A dirty membrane inhibits diffusion of free chlorine through the membrane, reducing the sensor current. Clean the membrane by rinsing it with a stream of water from a wash bottle. **DO NOT** use a 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 10.4 for details.

11.4.4 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 11.4.2.
- 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 11.5.7 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 10.2 for details.

11.4.5 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 10.4.
- 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.

11.4.6 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 10.4.
- 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.

11.4.7 Chlorine readings spike following sudden changes in pH.

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.

11.4.8 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 10.4.

11.5 TROUBLESHOOTING WHEN NO FAULT MESSAGE IS SHOWING - pH

Problem	See Section
Warning or error message during two-point calibration	11.5.1
Warning or error message during standardization	11.5.2
Analyzer will not accept manual slope	11.5.3
Sensor does not respond to known pH changes	11.5.4
Calibration was successful, but process pH is slightly different from expected value	11.5.5
Calibration was successful, but process pH is grossly wrong and/or noisy	11.5.6
Process reading is noisy	11.5.7

11.5.1 Warning or error message during two-point calibration.

Once the two-point (manual or automatic) calibration is complete, the analyzer automatically calculates the sensor slope (at 25°C). If the slope is less than 45 mV/pH, the analyzer displays a "Slope error low" message. If the slope is greater than 60 mV/pH, the analyzer displays a "Slope error high" message. The analyzer will 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 pH 7 buffer instead of pH 7 and pH 10 buffer.
- B. Was adequate time allowed for temperature equilibration? If the sensor was in a process liquid 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.
- C. Were correct pH values entered during manual calibration? Using auto calibration eliminates error caused by improperly entered values.
- D. Is the sensor properly wired to the analyzer? Check sensor wiring including any connections in a junction box. See Section 3.3.
- E. Is the sensor dirty or coated? See the sensor instruction sheet for cleaning instructions.
- F. Is the sensor faulty? Check the glass impedance. From the main display, press any key to enter the main menu. Move the cursor to "Diagnostic variables". Press Enter (F4). Press the ↓ key until "Glass impeded" is showing. Refer to the table for an interpretation of the glass impedance value.

less than 10 MΩ	Glass bulb is cracked or broken. Sensor has failed.
between 100 MΩ and 1000 MΩ	Normal reading
greater than 1000 MΩ	pH sensor may be nearing the end of its service life.

- G. Is the analyzer faulty? The best way to check for a faulty analyzer is to simulate pH inputs. See Section 11.10.

11.5.2 Warning or error message during standardization.

During standardization, the millivolt signal from the pH cell is increased or decreased until it agrees with the pH reading from a reference instrument. A unit change in pH requires an offset of about 59 mV. The controller 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 11.12.

11.5.3 Controller will not accept manual slope.

If the sensor slope is known from other sources, it can be entered directly into the controller. The controller will not accept a slope (at 25°) outside the range 45 to 60 mV/pH. If the user attempts to enter a slope less than 45 mV/pH, the controller will automatically change the entry to 45. If the user attempts to enter a slope greater than 60 mV/pH, the controller will change the entry to 60 mV/pH. See Section 11.5.1 for troubleshooting sensor slope problems.

11.5.4 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 the sensor properly wired to the analyzer?
- C. Is the glass bulb cracked or broken? Check the glass electrode impedance under diagnostic variables. See Section 11.1
- D. Is the analyzer working properly. Check the analyzer by simulating the pH input. See Section 11.10

11.5.5 Calibration was successful, but 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, standardize the sensor using the procedure in Section 8.4.

11.5.6 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. First, verify that pH sensor wiring is correct. Note that it is not necessary to jumper the solution ground and reference terminals.
 2. Disconnect all sensor wires at the analyzer except pH/mV IN, REFERENCE IN, RTD IN and RTD RETURN. See the wiring diagrams in Section 3.3. If the sensor is wired to the analyzer through a remote junction box containing a preamplifier, disconnect the wires at the sensor side of the junction box.
 3. Tape back the ends of the disconnected wires to keep them from making accidental connections with other wires or terminals.
 4. Connect a jumper wire between the RTD RETURN and RTD SENSE terminals (see wiring diagrams in Section 3.3).
 5. 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. If the sensor cable is run inside conduit, there may be a short between the cable and the conduit. Re-run the cable outside the conduit. If symptoms disappear, there is a short between the cable and the conduit. Likely a shield is exposed and touching the conduit. Repair the cable and reinstall it in the conduit.
 2. To avoid induced noise in the sensor cable, run it as far away as possible from power cables, relays, and electric motors. Keep sensor wiring out of crowded panels and cable trays.
 3. If ground loops persist, consult the factory. A visit from a technician may be required to solve the problem.

11.5.7 Process pH readings are noisy.

- A. Is the sensor dirty or fouled? Suspended solids in the sample can coat the reference junction and interfere with the electrical connection between the sensor and the process liquid. The result is often a noisy reading.
- B. Is the sensor properly wired to the analyzer? See Section 3.3.
- C. Is a ground loop present? Refer to Section 11.5.6.

11.7 TROUBLESHOOTING NOT RELATED TO MEASUREMENT PROBLEMS

Problem	Action
Display segments missing	Replace display board
Alarm relays are chattering	1. Check alarm setpoints. 2. Increase hysteresis time delay settings (see Section 5.6)
Incorrect current output	1. Verify that output load is less than 600 Ω. 2. For minor errors, trim outputs (see Section 8.0) 3. Replace power supply board
Display too light or too dark	Change contrast (see Section 5.4)
“Level 1, 2 or 3 security: Lock” shown in display	Analyzer has password protection (see Section 5.11)
“Hold mode activated” showing in display	Analyzer is in hold (see Section 5.5, steps 8 and 9)
“Simulating output 1 or 2” showing in display	Analyzer is simulating outputs (see Section 5.3)
“Simulating alarm 1, 2, 3 or 4” showing in display	Analyzer is simulating alarms (see Section 5.3)

11.8 TROUBLESHOOTING WHEN NO ERROR MESSAGE IS SHOWING—TEMPERATURE

11.8.1 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.

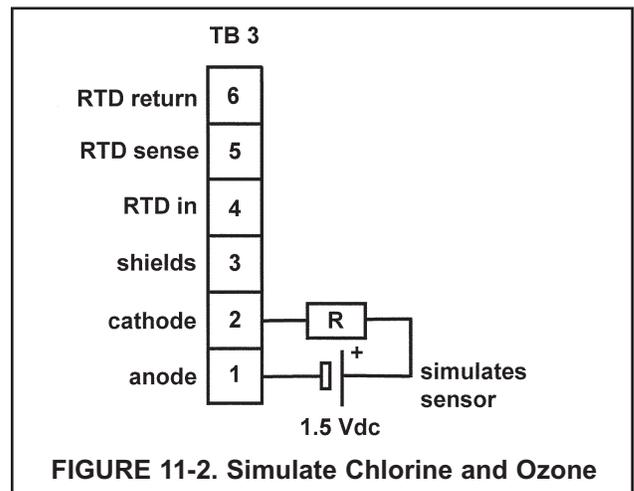
11.9 SIMULATING INPUTS - FREE CHLORINE

To check the performance of the analyzer use a decade box and a 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 11-2. It is not necessary to disconnect the RTD leads.
- B. Set the decade box to the 2.8 MΩ.
- C. Note the sensor current. It should about 500 nA. The actual value depends of the voltage of the battery. To view the sensor current from the main display, press any key to enter the main menu. Move the cursor to "Diagnostics" and press Enter (F4). The sensor current is the second line in the display. Note the units: μA is microamps, nA is nanoamps.
- D. Change the decade box resistance and verify that the correct current is shown. Calculate expected current from the equation:

$$\text{current (nA)} = \frac{V_{\text{battery}} - V_{\text{polarizing (mV)}}}{\text{resistance (M}\Omega\text{)}}$$

The voltage of a fresh 1.5 volt battery is about 1.6 volt (1600 mV).The polarizing voltage is 0.2 volt (200 mV)



11.10 SIMULATING INPUTS - pH

11.10.1 General

This section describes how to simulate a pH input into the 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.

11.10.2 Simulating pH input.

1. Turn off automatic temperature correction (Section 5.8) and set the manual temperature to 25°C.
2. Disconnect the sensor, including the jumper between the ANODE and REFERENCE IN terminals, and connect a jumper wire between the pH IN and the REFERENCE IN terminals.
3. From the Diagnostics menu scroll down until the "pH input" line is showing. The pH input is the raw voltage signal in mV. 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.
4. If a standard millivolt source is available, disconnect the jumper wire between the pH IN and the REFERENCE IN terminals and connect the voltage source as shown in Figure 11-3.
5. Calibrate the analyzer using the procedure in Section 8.2. 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, 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°C)
295.8	2.00
177.5	4.00
59.2	6.00
-59.2	8.00
-177.5	10.00
-295.8	12.00

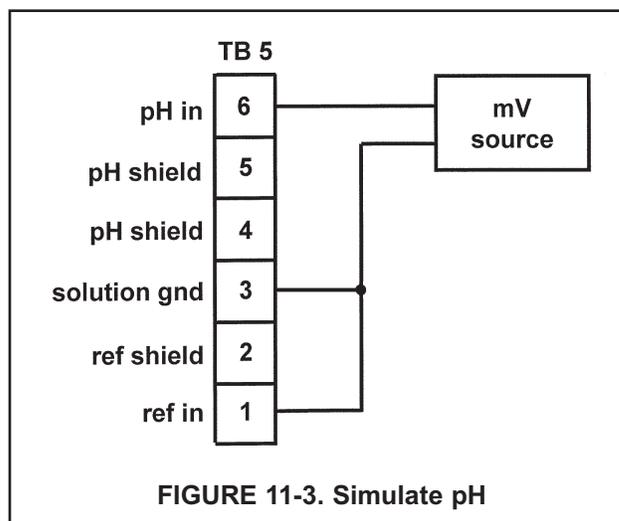


FIGURE 11-3. Simulate pH

11.11 SIMULATING TEMPERATURE

11.11.1 General.

The free chlorine sensor used in the FCL uses a Pt100 RTD in a three-wire configuration. See Figure 11-4.

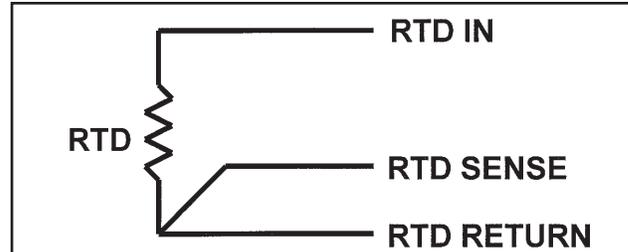


FIGURE 11-4. Three-Wire RTD Configuration.

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 caused by changes in ambient temperature.

11.11.2 Simulating temperature

To simulate the temperature input, wire a decade box to the analyzer or junction box as shown in Figure 11-5.

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 controller is measuring temperature correctly if the difference between measured temperatures equals the difference between the values in the table to within $\pm 0.1^\circ\text{C}$.

For example, start with a simulated resistance of $103.9\ \Omega$, which corresponds to 10.0°C . Assume the offset from the sensor calibration was $-0.3\ \Omega$. Because of the offset, the analyzer calculates temperature using $103.6\ \Omega$. The result is 9.2°C . Now change the resistance to $107.8\ \Omega$, which corresponds to 20.0°C . The analyzer uses $107.5\ \Omega$ 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.

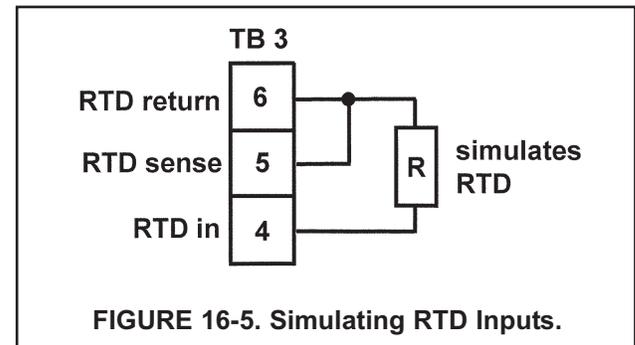
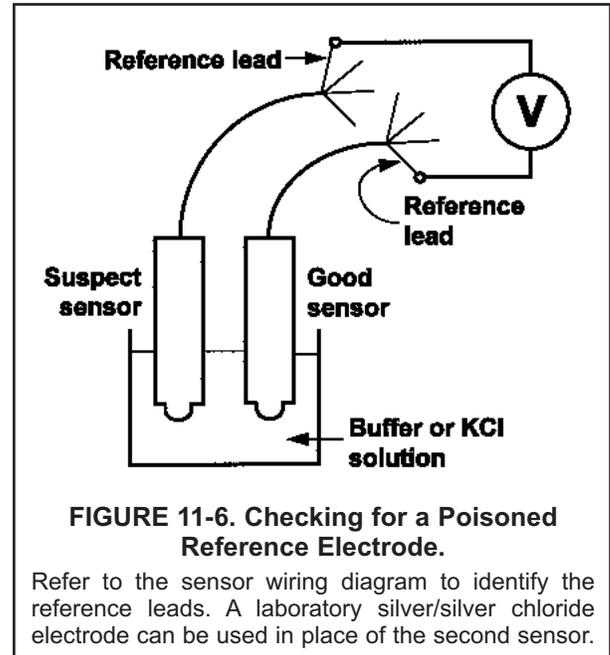


FIGURE 16-5. Simulating RTD Inputs.

Temp. ($^\circ\text{C}$)	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

11.12 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 11-6. If the reference electrode is good, the voltage difference should be no more than about 20 mV. A poisoned reference electrode usually requires replacement.



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THE AMERICAS - HEADQUARTERS

Emerson Process Management
Rosemount Analytical Inc.
Liquid Center of Excellence
2400 Barranca Parkway
Irvine, CA 92606
Phone: +1.949.757.8500
Toll Free: +1.800.854.8257
Fax: +1.949.474.7250

GERMANY

Emerson Process Management Process
Gas Analyzer Center of Excellence
GmbH & Co. OHG
Industriestrasse 1
63594 Hasselroth
Germany
T 49.6055.884.0
F 49.6055.884.20

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

LATIN AMERICA

Emerson Process Management
Rosemount Analytical
10241 West Little York, Suite #200
Houston, TX 77040 USA
T 713.467.6000
F 713.827.3328

EUROPE

Emerson Process Management AG
Blegistrasse 21
CH-6341 Baar-Walterswil
Switzerland
T 41.41.768.6111
T 41.41.761.8740

MIDDLE EAST AND AFRICA

Emerson Process Management
EPM Building
P. O. Box 17033
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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.**

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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
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.

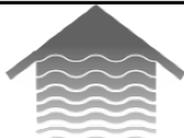
Adherence to these procedures will expedite handling of the returned material and will prevent unnecessary additional charges for inspection and testing to determine the problem with the device.

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



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