



Catalog Number 6120118

Digital PC sc and RC sc $\frac{3}{4}$ -inch Combination pH/ORP Sensor

USER MANUAL

October 2005, Edition 4

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Section 1 Specifications

Specifications are subject to change without notice.

Table 1 Combination pH and ORP Sensor Specifications

Components	Corrosion-resistant materials, fully-immersible probe with 4.6 m (15 ft) cable
Measuring Range (pH)	0 to 14 pH
Measuring Range (ORP)	-2000 to +2000 mV
Measuring Range (Temperature)	0 to 105 °C (32 to 221 °F)
Probe Operating Temperature	0 to 105 °C (32 to 221 °F)
Probe Storage Temperature	-30 to 70 °C (-22 to 158 °F); 0 to 95% relative humidity, non-condensing
Temperature Compensation	pH: Pt 1000 ohm RTD ORP: N/A
Accuracy (Analyzer only)	pH: 0.1% of span ORP: Limited to calibration solution accuracy (± 20 mV)
Stability (Analyzer only)	0.05% or span per 24 hours, non-cumulative
Repeatability (Analyzer only)	0.1% of span or better
Temperature Accuracy (Analyzer only)	±0.5 °C (±0.9 °F)
Temperature Drift (Analyzer only)	Zero and Span: less than 0.03% of span per °C
Calibration Methods (Analyzer only)	Two point automatic, one point automatic, two point manual, one point manual
Maximum Probe Immersion Depth/ Pressure	Submersible to 107 m (350 ft)/1050 kPa (150 psi)
Sensor Interface	Modbus from digital gateway
Probe Cable Length	4.6 m (15 ft)
Probe Weight	Depends on selected sensor
Probe Dimensions	See Figure 1 on page 8 through Figure 4 on page 9 .

Table 2 Digital Gateway Specifications

Weight	145 g (5 oz)
Dimensions	17.5 x 3.4 cm (7 x 1 ³ / ₈ in.)
Operating Temperature	-20 to 60 °C (-4 to 140 °F)

Section 2 General Information

2.1 Safety Information

Please read this entire manual before unpacking, setting up, or operating this equipment. Pay attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

To ensure that the protection provided by this equipment is not impaired, do not use or install this equipment in any manner other than that specified in this manual.

This product is acceptable for use in a Hazardous Location when used with an sc100 Controller and installed per Control Drawing 58600-78 as described in the sc100 Controller Manual, Cat. No. 5860018.

2.1.1 Use of Hazard Information

DANGER

Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Indicates a potentially hazardous situation that may result in minor or moderate injury.

***Important Note:** Information that requires special emphasis.*

***Note:** Information that supplements points in the main text.*

2.1.2 Precautionary Labels

Read all labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed.

	This symbol, if noted on the instrument, references the instruction manual for operation and/or safety information.
	This symbol, when noted on a product enclosure or barrier, indicates that a risk of electrical shock and/or electrocution exists.
	This symbol, if noted on the product, indicates the need for protective eye wear.
	This symbol, when noted on the product, identifies the location of the connection for Protective Earth (ground).
	This symbol, when noted on the product, identifies the location of a fuse or current limiting device.

2.2 General Sensor Information

Optional equipment, such as mounting hardware for the probe, is supplied with instructions for all user installation tasks. Several mounting options are available, allowing the probe to be adapted for use in many different applications.

2.2.1 Sensor Body Styles

Combination pH and ORP sensors are available in three body styles:

- **Convertible Body Style (Figure 1 and Figure 2)**— has ¾-in. NPT threads at both ends of the body for mounting in any of the following configurations:
 - into a standard ¾-in. NPT pipe tee
 - onto the end of a pipe for immersion into a vessel
- **Insertion Body Style (Figure 3)**— for mounting into the pipe adapter of a ball valve hardware assembly. This hardware enables the sensor to be inserted into or retracted from the process without stopping the process flow.
- **Sanitary Body Style (Figure 4)**— features a built-in 2-in. flange for mounting into a 2-in. sanitary tee. Included with the sanitary-style sensor is a special cap and EDPM compound gasket for use with the sanitary hardware.

Figure 1 Convertible Style Sensor with Flat Electrode

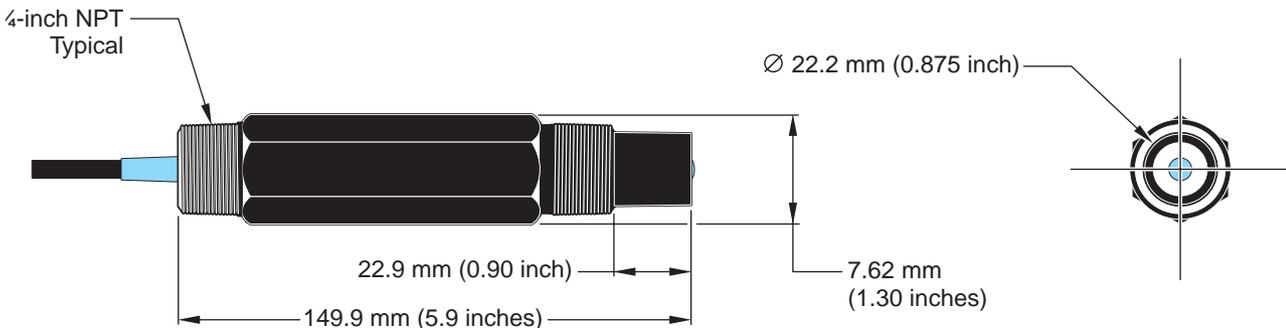


Figure 2 Convertible-style Sensor with Dome Electrode

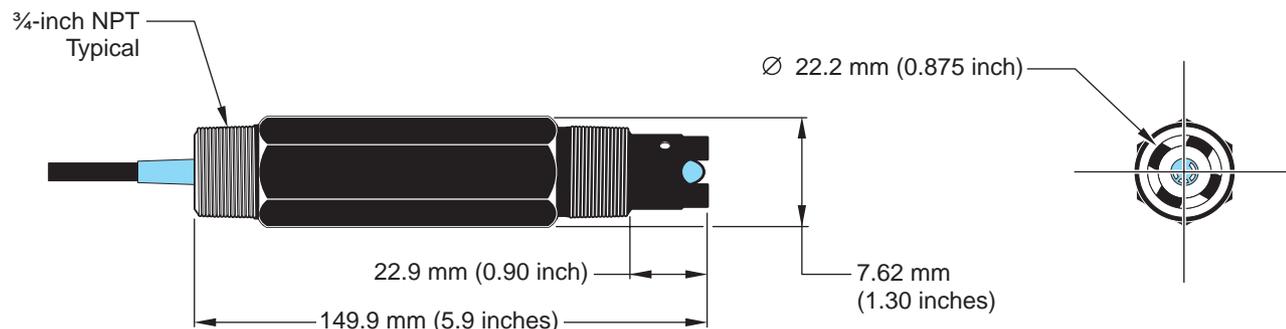
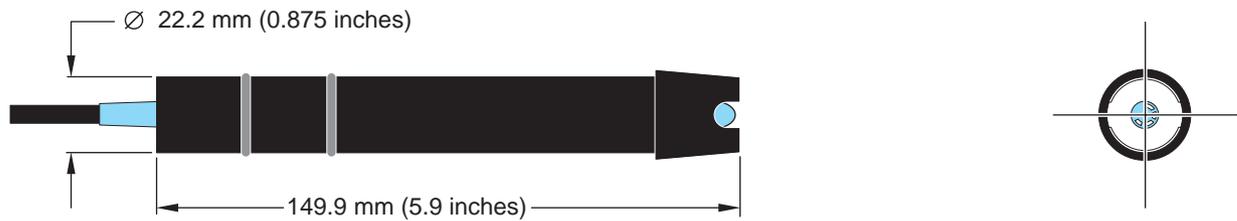
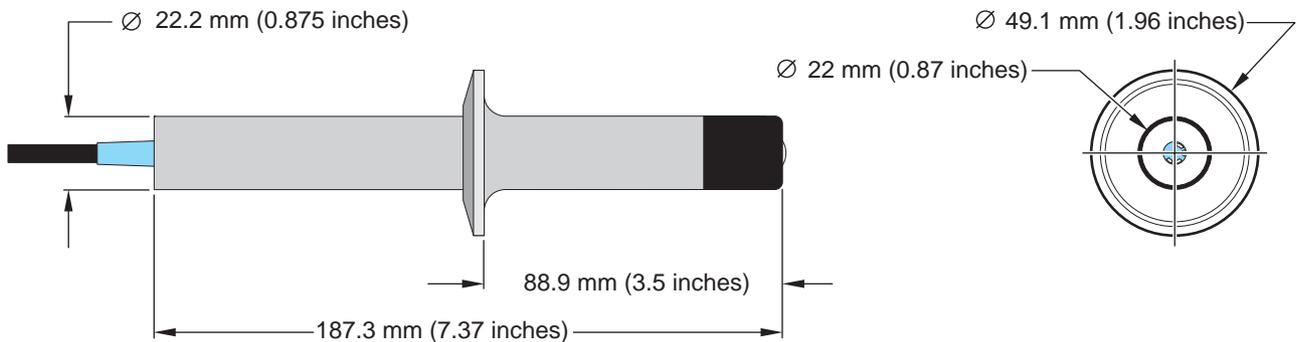


Figure 3 Insertion Style Sensor with Domed Electrode**Figure 4 Sanitary-style Sensor**

2.3 The Digital Gateway

The digital gateway was developed to provide a means to use existing analog sensors with the new digital controllers. The gateway contains all the necessary software and hardware to interface with the controller and output a digital signal.

2.4 Operating Precaution

Before placing the pH or ORP sensor into operation, remove the protective cap to expose the process electrode and reference junction. Save the protective cap for future use.

For short-term storage (when sensor is out of the process for more than one hour), fill the protective cap with pH 4 buffer or DI water and place the cap back on the sensor. Keeping the process electrode and reference junction moist will avoid slow response when the sensor is placed back in operation.

For extended storage, repeat the short-term storage procedure every 2 to 4 weeks, depending on the surrounding environmental conditions.

CAUTION

If the pH process electrode breaks, handle the sensor very carefully to prevent injury.

The process electrode at the pH sensor tip has a glass bulb, which can break. Do not subject this electrode to abrupt impact or other mechanical abuse.

The gold or platinum process electrode at the ORP sensor tip has a glass shank (hidden by the salt bridge) which can break. Do not subject this electrode to impact or other mechanical abuse.

DANGER

Only qualified personnel should conduct the tasks described in this section of the manual.

DANGER

Seul un technicien qualifié peut effectuer les tâches d'installation décrites dans cette section du manuel.

The Combination pH/ORP Sensor can be used with either an sc100 or sc1000 controller. Refer to [section 3.2 on page 13](#) for sc100 installation instructions and [section 3.3 on page 16](#) for sc1000 installation instructions.

The sc sensor should be wired to the digital gateway before connecting the digital gateway to the sc100 or sc1000 Controller. The digital gateway is designed to provide a digital interface to the appropriate digital controller. Refer to [section 3.1](#) for more information.

3.1 Wiring the sc Sensor to the Digital Gateway

DANGER

The sc100 and certain versions of the sensor are suitable for use in Class 1, Division 2, Groups A, B, C, D Hazardous Locations . See Control Drawing 58600-78 in the sc100 Controller Manual, Cat. No. 58600-18 for acceptable sensor versions and installation requirements.

DANGER

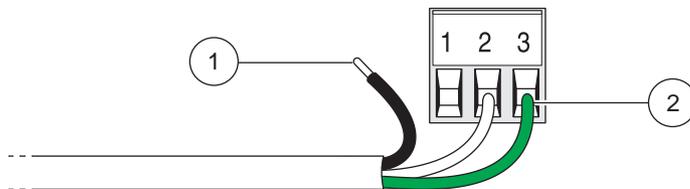
Le sc100 et certaines versions du capteur peuvent être utilisés dans des endroits dangereux de la Classe 1, Division 2, Groupes A, B, C, D. Reportez-vous au schéma de contrôle 58600-78 du Manuel du contrôleur sc100, Réf. 58600-18 pour connaître les versions des capteurs admises et les conditions d'installation.

1. Route the cable from the sensor through the strain relief in the digital gateway then properly terminate the wire ends (see [Figure 5](#)).

Note: *Do not tighten the strain relief until the digital gateway is wired and the two halves are threaded securely together.*

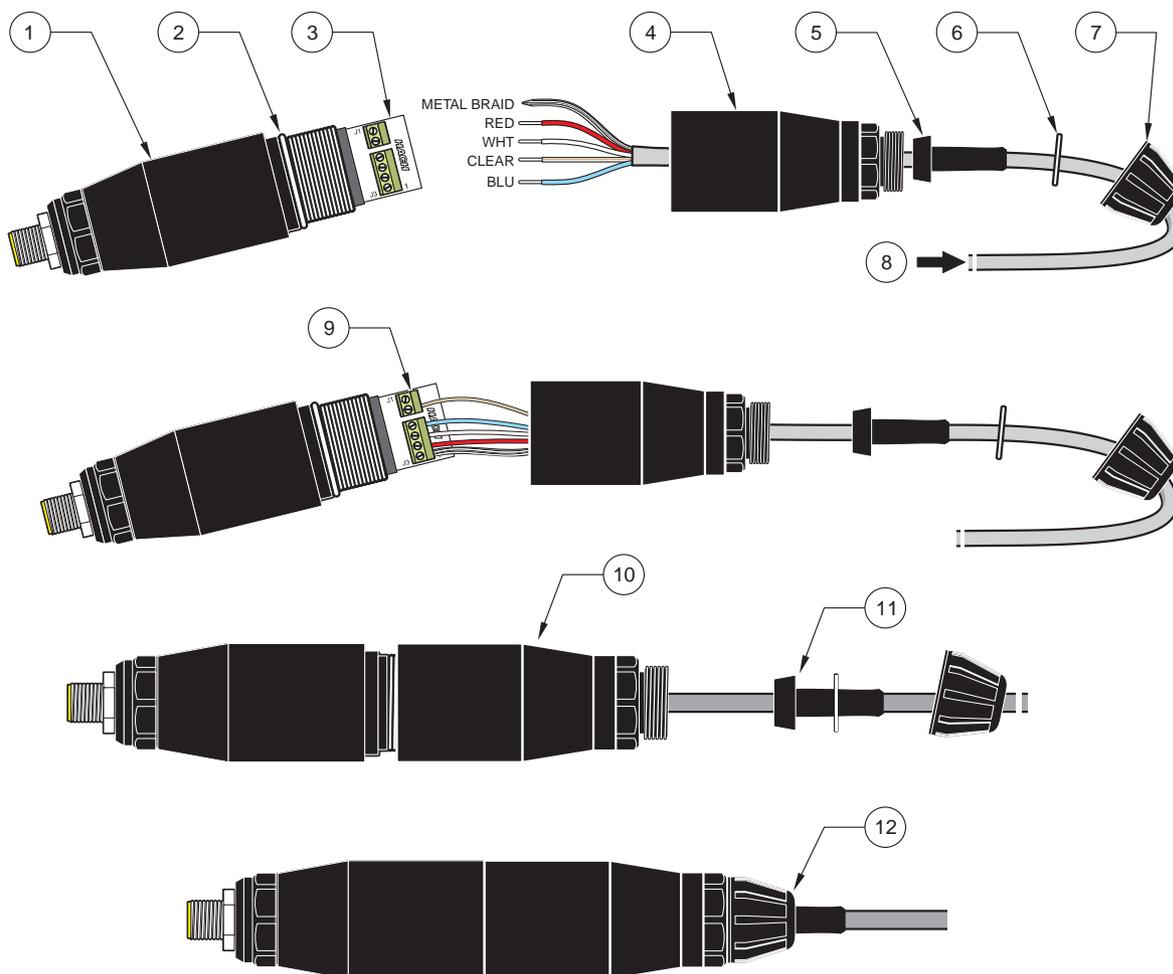
2. Insert the wires as shown in [Table 3](#) and [Figure 6](#).
3. Make sure the O-ring is properly installed between the two halves of the digital gateway and thread the two halves together. Hand tighten.
4. Tighten the strain relief to secure the sensor cable.
5. Connect the digital gateway to the controller.
 - sc100 Non-hazardous Location—[section 3.2.1.1 on page 13](#)
 - sc100 Hazardous Location—[section 3.2.2.1 on page 16](#)
 - sc1000 Connection Instructions—Refer to [section 3.3 on page 16](#).

Figure 5 Proper Wire Preparation and Insertion



- | | |
|----------------------------------|---|
| 1. Strip 1/4-inch of insulation. | 2. Seat insulation against connector with no bare wire exposed. |
|----------------------------------|---|

Figure 6 Wiring and Assembling the Digital Gateway



1. Digital gateway front	7. Cord grip
2. O-ring	8. From sensor
3. Sensor wire connector	9. Insert wires into connector according to Table 3 . Use the included 2 mm screwdriver (Cat. No. 6134300) to secure connections.
4. Digital gateway back	10. Screw back of digital gateway onto front.
5. Cable bushing	11. Push cable bushing and anti-rotation washer into back.
6. Anti-rotation washer	12. Fasten cord grip securely. Assembly is complete.

Table 3 Wiring the Digital Gateway (Cat. No. 6120800)

Sensor (wire color)	Sensor Signal without Ground Rod	Sensor Signal with Ground Rod ¹	Digital Gateway
Metal Braid ²	Jumper 2 from J3-1 to J3-3 ³	Ref	J3-1
White	Temp +	Temp +	J3-2
Red	Temp –	Temp –	J3-3
Blue	Ref	Solution Ground	J3-4
Clear	Active/Measuring	Active/Measuring	J1-5
not used	not used	not used	J1-6

¹ Some applications require the use of an external ground rod with the combination electrode. Use this wiring scheme for these applications.

² If Metal Braid is “tinned”, cut the tinned area off and twist the wire to insert into connector.

³ Customer-supplied (required)

3.2 Connecting/Wiring the Digital Gateway to the sc100 Controller

DANGER

The sc100 and certain versions of the sensor are suitable for use in Class 1, Division 2, Groups A, B, C, D Hazardous Locations . See Control Drawing 58600-78 in the sc100 Controller Manual, Cat. No. 58600-18 for acceptable sensor versions and installation requirements.

DANGER

Le sc100 et certaines versions du capteur peuvent être utilisés dans des endroits dangereux de la Classe 1, Division 2, Groupes A, B, C, D. Reportez-vous au schéma de contrôle 58600-78 du Manuel du contrôleur sc100, Réf. 58600-18 pour connaître les versions des capteurs admises et les conditions d'installation.

The digital gateway should be wired to the sensor before connecting to the controller.

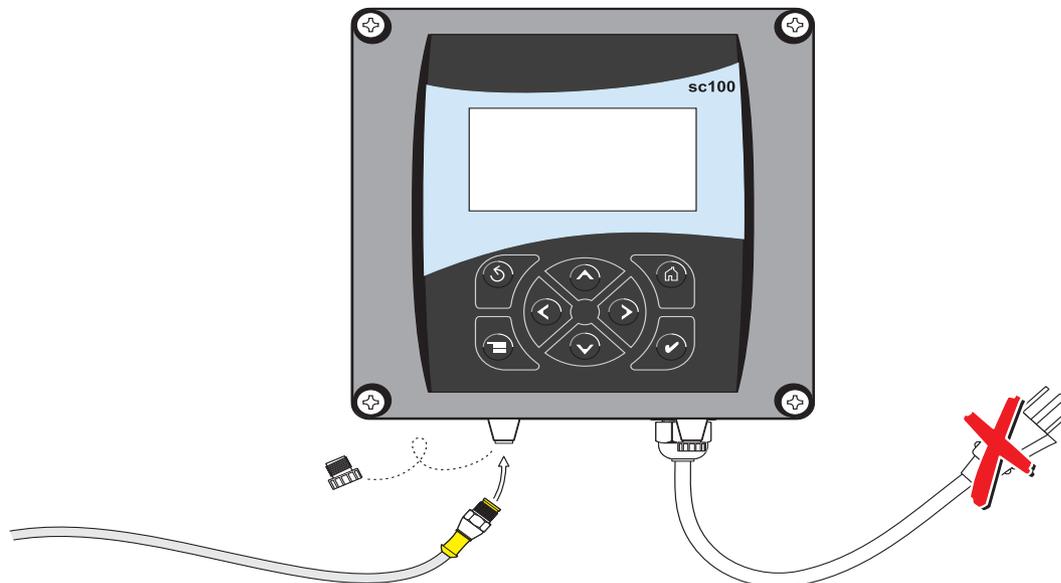
3.2.1 Connecting the Digital Gateway Sensor in a Non-hazardous Location

3.2.1.1 Attaching the Digital Gateway with a Quick-connect Fitting in a Non-hazardous Location

Important Note: *The standard quick-connect fitting is NOT suitable for Class 1, Division 2 Hazardous Location installations without the connector lock installed, see [section 3.2.1 on page 13](#) for more information.*

The digital gateway is supplied with a keyed quick-connect fitting for easy attachment to the controller, see [Figure 7](#). Retain the connector cap to seal the connector opening in case the sensor must be removed. Optional extension cables may be purchased to extend the sensor cable length. If the total cable length exceeds 100 m (328 ft), a termination box must be installed. See [Replacement Parts and Accessories on page 37](#).

Figure 7 Attaching the Digital Gateway using the Quick-connect Fittings



3.2.1.2 Hard-wiring the Digital Gateway to the sc100

Important Note: Hard-wiring the digital gateway to the sc100 is not an approved method for Class 1, Division 2 Hazardous Locations.

1. Disconnect power to the controller if powered.
2. Open the controller cover.
3. Disconnect and remove the existing wires between the quick-connect and terminal strip J5, see [Figure 8 on page 15](#).
4. Remove the quick-connect fitting and wires and install the threaded plug on the opening to maintain the environmental rating.
5. Cut the connector from the sensor cable.
6. Strip the insulation on the cable back 1-inch. Strip ¼-inch of each individual wire end.

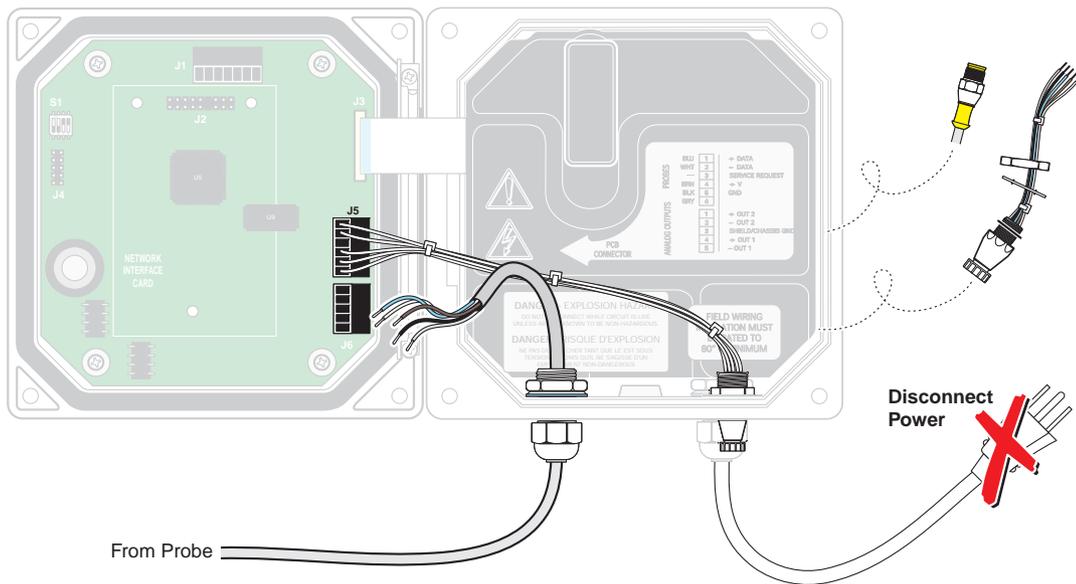
Note: Use of strain relief fitting other than Cat. No. 16664 may result in a hazard. Use only the recommended strain relief fitting.

7. Pass the cable through conduit and a conduit hub or a strain relief fitting (Cat. No. 16664) and an available access hole in the controller enclosure. Tighten the fitting.
8. Reinstall the plug on the sensor access opening to maintain the environmental rating.
9. Wire as shown in [Table 4](#) and [Figure 8](#).
10. Close and secure the cover.

Table 4 Wiring the Sensor at Terminal Block J5

Terminal Number	Terminal Designation	Wire Color
1	Data (+)	Blue
2	Data (-)	White
3	Service Request	No Connection
4	+12 V dc	Brown
5	Circuit Common	Black
6	Shield	Shield (grey wire in existing quick disconnect fitting)

Figure 8 Hard-wiring the Digital Gateway



3.2.2 Connecting the Digital Gateway to a sc100 Controller in a Hazardous Location

DANGER

The sc100 and certain versions of the sensor are suitable for use in Class 1, Division 2, Groups A, B, C, D Hazardous Locations. See Control Drawing 58600-78 in the sc100 Controller Manual, Cat. No. 58600-18 for acceptable sensor versions and installation requirements.

DANGER

Le sc100 et certaines versions du capteur peuvent être utilisés dans des endroits dangereux de la Classe 1, Division 2, Groupes A, B, C, D. Reportez-vous au schéma de contrôle 58600-78 du Manuel du contrôleur sc100, Réf. 58600-18 pour connaître les versions des capteurs admises et les conditions d'installation.

DANGER

Explosion hazard. Do not connect or disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

DANGER

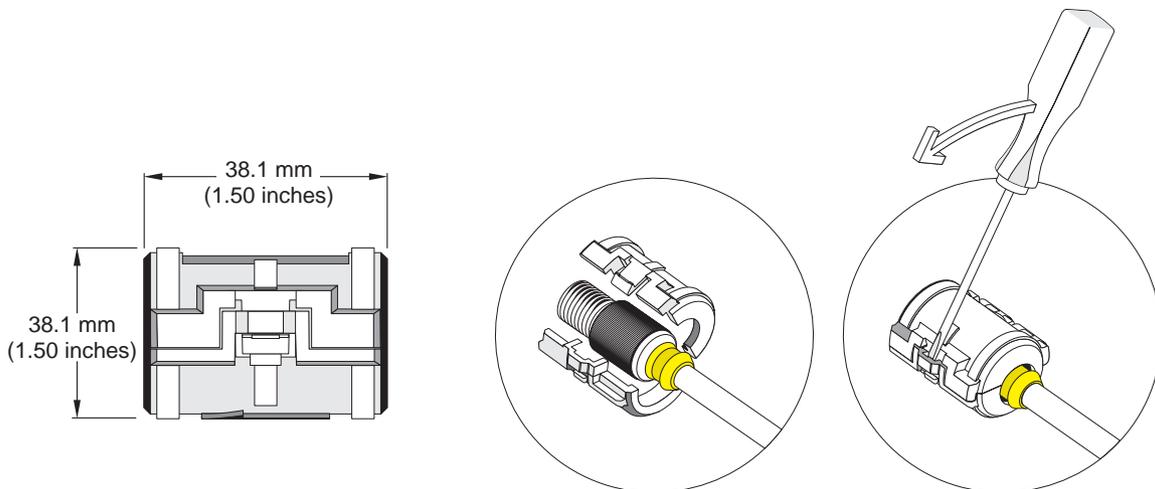
Risque d'explosion. Couper le courant ou s'assurer que l'emplacement est désigné non dangereux avant de remplacer le aucun composant.

3.2.2.1 Attaching the Digital Gateway with a Quick-Connect Fitting in a Hazardous Location

The digital gateway is supplied with a keyed quick-connect fitting for easy attachment to the controller, see [Figure 7 on page 14](#). For Hazardous Locations, a connector safety lock (Cat. No. 6139900) must be installed. Retain the connector cap to seal the connector opening in case the sensor must be removed.

1. Remove the connector cap from the sc100 controller. Retain the connector cap to seal the connector opening in case the sensor must be removed.
2. Connect the digital gateway connector to the sensor plug on the sc100.
3. Install the connector safety lock ([Figure 9](#)). Align the lock over the connector and squeeze the two halves together to lock. To remove the connector safety lock, insert a small flat-blade screwdriver into the locking groove. Pivot the screwdriver away from the groove and separate the two halves ([Figure 9](#)).

Figure 9 Installing the Connector Safety Lock



3.3 Connecting the Sensor to the sc1000

3.3.1 Connecting the Sensor using the Quick-connect Fittings

1. Unscrew the connector cap from the controller. Retain the connector cap to seal the connector opening in case the sensor must be removed.
2. Push the digital gateway connector into the socket.
3. Hand-tighten the union nut.

Note: Do not use the middle connection for the sensors as this is reserved for the display module.

3.4 Mounting the Digital Gateway

The digital gateway is supplied with a mounting clip for mounting to a wall or other flat surface. See [Figure 10](#) for dimensions. Use an appropriate fastener to secure it to the wall, see [Figure 11](#). After the sensor is wired to the digital gateway and the two halves are threaded together, place the mounting clip over the center of the digital gateway and squeeze the clip together to secure.

Figure 10 Digital Gateway Dimensions

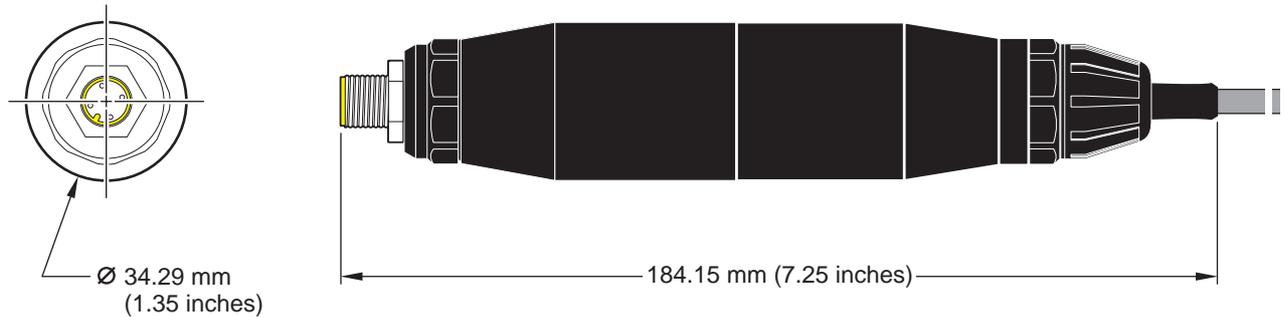
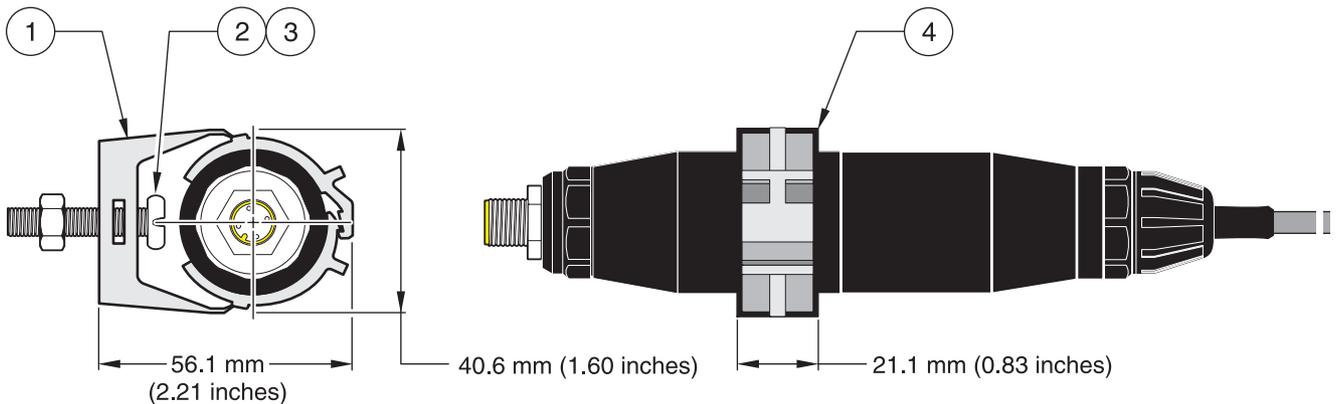


Figure 11 Mounting the Digital Gateway



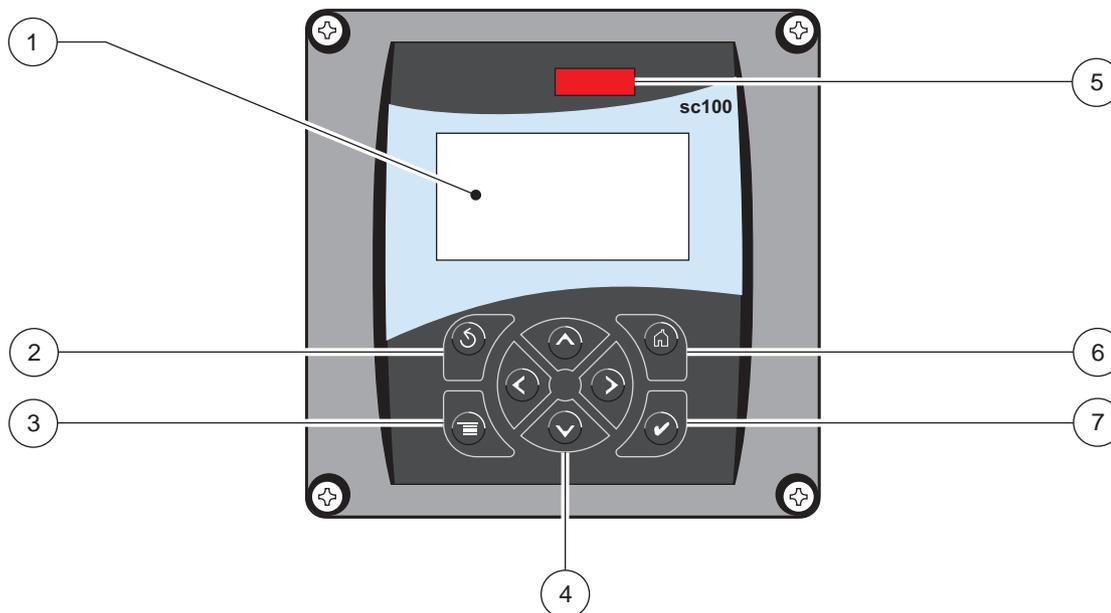
1. Mounting Clip	3. Hex Nut, 1/4-28
2. Screw, pan head, 1/4-28 x 1.25-in.	4. Mount clip, insert digital gateway, squeeze clip closed.

Section 4 User Interface and Navigation

4.1 Using the sc100 Controller

The front of the controller is shown in [Figure 12](#). The keypad consists of the eight keys described in [Table 5](#).

Figure 12 Front of the Controller



1. Instrument display	5. IrDA window
2. BACK key	6. HOME key
3. MENU key	7. ENTER key
4. RIGHT, LEFT, UP, and DOWN keys	

Table 5 Controller Key Functions/Features

Number	Key	Function
2		Moves back one level in the menu structure.
3		Moves to the main menu from other menus. This key is not active in menus where a selection or other input must be made.
4		Navigates through the menus, changes settings, and increments and decrements digits.
5		Moves to the Main Measurement screen from any other screen. This key is not active in menus where a selection or other input must be made.
6		Accepts an input value, updates, or accepts displayed menu options.

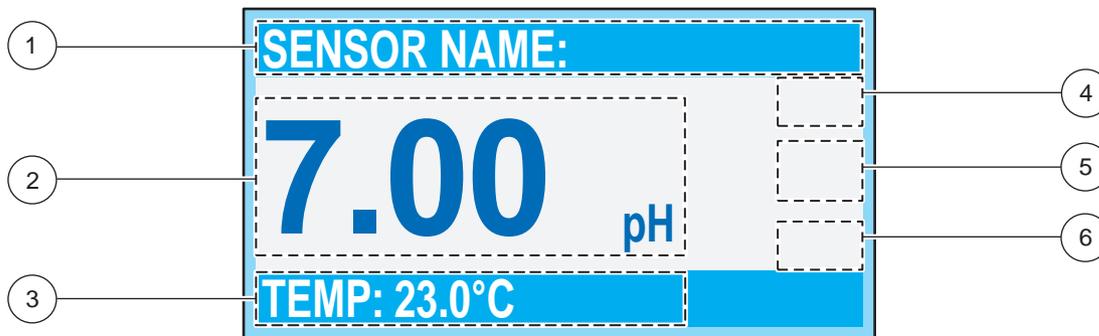
4.1.1 Controller Display Features

When a sensor is connected and the controller is in measurement mode, the controller automatically identifies the connected sensors and displays associated measurements.

The display will flash on startup, when a sensor error has occurred, and when a sensor is being calibrated.

An active system warning will cause the warning icon (a triangle with an exclamation point inside) to be displayed on the right side of the display. See [Figure 13](#).

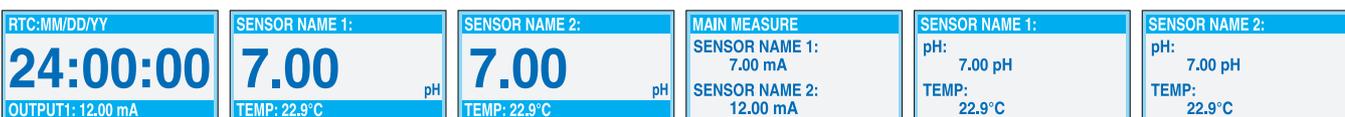
Figure 13 Display



1. Status bar. Indicates the sensor name and status of relays. The relay letter is displayed when the relay is energized.	4. Parameter
2. Main measurement	5. Warning icon area
3. Secondary measurement (if applicable)	6. Measurement units

4.1.2 Important Key Presses

- Press **HOME** then the **RIGHT** or **LEFT** key to display two readings when two sensors are connected. Continue to press the **RIGHT** or **LEFT** key to toggle through the available display options as shown below.



- Press the **UP** and **DOWN** keys to toggle the status bar at the bottom of the measurement display to display the secondary measurement (temperature) and output information.



- When in Menu mode, an arrow may appear on the right side of the display to indicate that more menus are available. Press the **UP** or **DOWN** key (corresponding to the arrow direction) to display additional menus.



4.2 Using the sc1000 Controller

The sc1000 is a touch screen application. Use your finger to touch keys and menu commands. In normal operation the touch screen displays the measured values for the sensors selected.

4.2.1 Display Features

4.2.1.1 Using the Pop-up Toolbar

The pop-up toolbar provides access to the controller and sensor settings. The toolbar is normally hidden from view. To view the toolbar, touch the bottom-left of the screen.

Figure 14 Pop-up Toolbar Functions



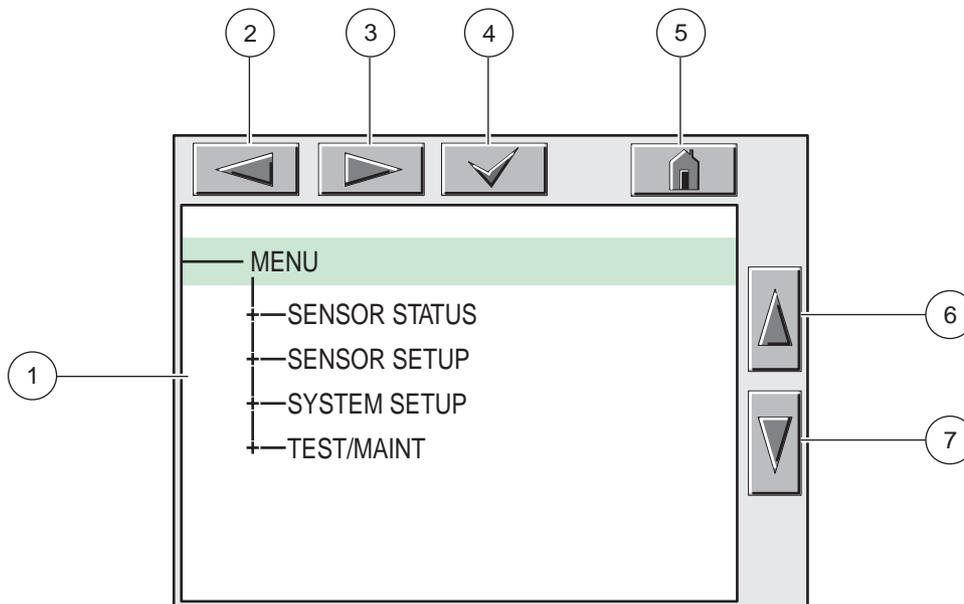
	MAIN MENU —displays the Main Menu Structure
	UP Arrow —scrolls up to the previous displayed value.
	Displays one value.
	Displays two values at the same time.
	Displays four values at the same time.
	LIST —displays the list of connected devices and sensors.
	DOWN Arrow —scrolls down to the next displayed value.

4.2.1.2 Using the Menu Windows

If the Menu button (from the pop-up toolbar) is selected, the Main Menu screen is opened. The Main Menu screen allows the user to view the sensor status, configure the sensor setup, system setup, and perform diagnostics.

The menu structure may vary depending on the configuration of the system.

Figure 15 Main Menu



1.	Display Area
2.	BACK
3.	FORWARD
4.	ENTER —confirms the entry or selection.
5.	HOME —changes to the display of measured values. The pop-up toolbar cannot open from the menu window. To view the Main Menu from this display, touch the Home button and then the bottom of the screen.
6.	UP —scrolls up
7.	DOWN —scrolls down

4.2.1.3 Navigating the Menu Windows

To view a menu item, touch the menu item or use the **UP** and **DOWN** keys to highlight the item. The menu item remains highlighted for approximately 4 seconds after it is selected. To view the highlighted command, select the area to the left of the menu item or select the **ENTER** button.

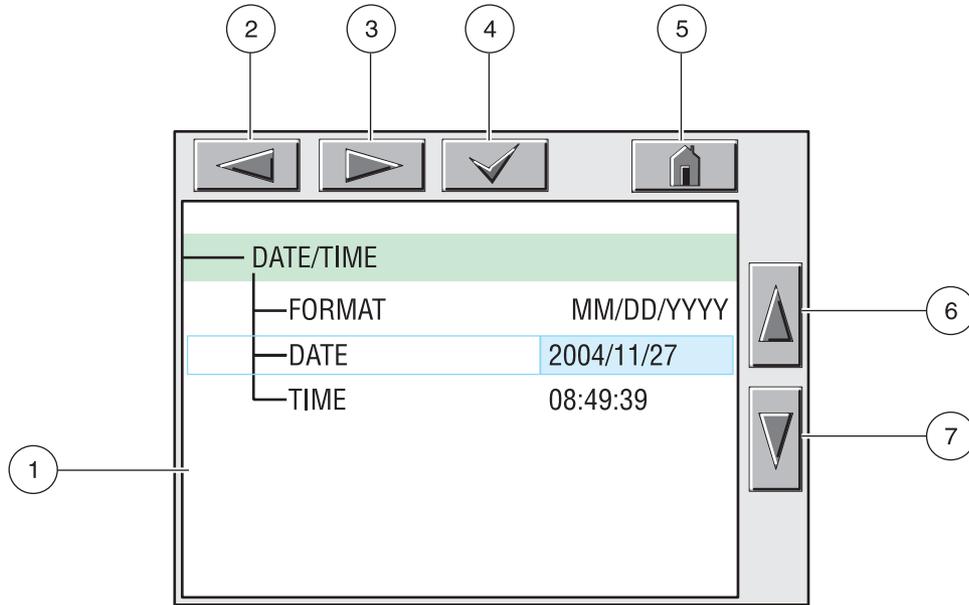
A “+” next to a menu command indicates there is a submenu. Touch the “+” to view the submenu. An “i” next to a menu command indicates it is information only.

If a menu item is editable, highlight the item and touch the far-left part of the menu item until it is highlighted and press **ENTER** or double-tap the highlighted item. A keypad will be displayed to change an entry (Figure 17 on page 23) or a list box will be displayed (Figure 18 on page 24).

Messages are displayed in the message window (Figure 19 on page 24).

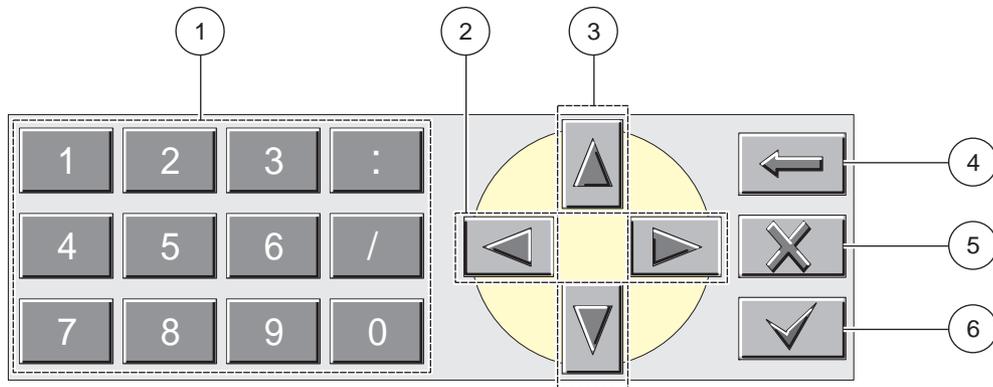
If an entry is incorrect, repeat the entry with the correct values. If the entry is outside the working range, a correction to the entry is made automatically.

Figure 16 Changing a Menu Item



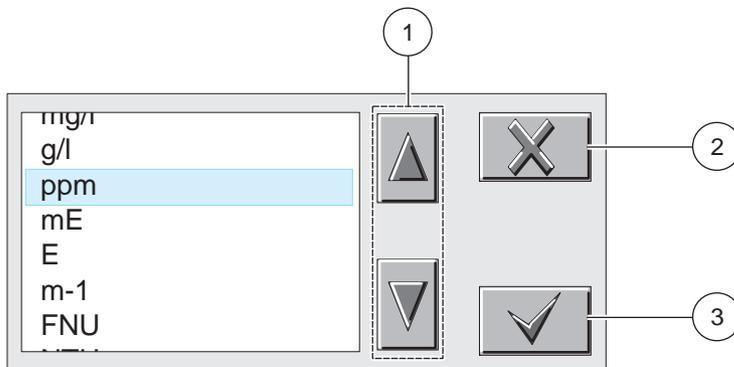
1. Display Area	5. HOME—changes to the display of measured values.
2. BACK	6. UP—scrolls up
3. FORWARD	7. DOWN—scrolls down
4. ENTER—confirms the entry or selection.	

Figure 17 Keypad



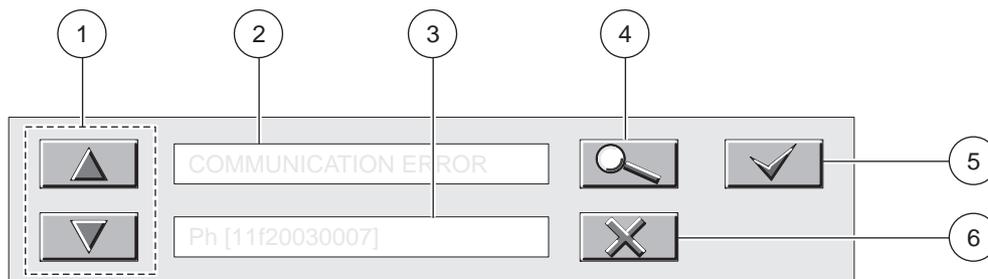
1. Enters numbers or the character as shown on the button.
2. Moves the cursor one position to the left or to the right.
3. Increase/Decrease a number or letter at the cursor position. Keep the button pressed to change the numbers/characters continuously.
4. Deletes the character to the left of the cursor.
5. CANCEL—cancels the entry.
6. ENTER—confirms the entry or selection.

Figure 18 List Box



- | |
|--|
| 1. Scrolls up or down |
| 2. CANCEL —cancels and entry. |
| 3. ENTER —confirms a selection. |

Figure 19 Message window



- | |
|--|
| 1. Scrolls up or down. |
| 2. Displays the messages or warnings. |
| 3. Displays details on the selected entry. |
| 4. This button changes back to the previous display. |
| 5. ENTER —confirms an entry. |
| 6. CANCEL —cancels an entry. |

Section 5 Operation

5.1 Sensor Setup

When a sensor is initially installed, the serial number of the Digital Gateway will be displayed as the sensor name. To change the sensor name refer to the following instructions:

1. Select Main Menu.
2. From the Main Menu, select SENSOR SETUP and confirm.
3. Highlight the appropriate sensor if more than one sensor is attached and confirm.
4. Select CONFIGURE and confirm.
5. Select EDIT NAME and edit the name. Confirm or cancel to return to the Sensor Setup menu.

5.2 Sensor Data Logging

The sc1000 controller provides a data log for each sensor.

The sc100 provides three data logs (one for each sensor and one for calculated values). The data logs store the measurement data at selected intervals. The event log stores a variety of events that occur on the devices such as configuration changes, alarms, and warning conditions. The data logs are stored in a packed binary format and the event logs are stored in a CSV format. The logs can be downloaded through the digital network port, service port, or the IrDA port. DataCom is needed for downloading logs to a computer.

5.3 Sensor Diagnostics Menu for pH and ORP

SELECT SENSOR (if more than one sensor is attached)

STATUS	
ERROR LIST	See section 7.1 on page 35 .
WARNING LIST	See section 7.2 on page 35 .

5.4 pH Sensor Setup Menu

SELECT SENSOR (if more than one sensor is attached)

CALIBRATE (Main Menu Item)	
1 POINT AUTO	Calibration with a single buffer — normally pH 7.
2 POINT AUTO	Calibration with two buffers — normally pH 7 and pH 4 or 10.
1 POINT MANUAL	Calibration against a single known sample.
2 POINT MANUAL	Calibration against two samples, both with a known pH.
TEMP ADJUST	Adjust the displayed temperature by up to ± 15 °C.
DEFAULT SETUP	Restores the system to the original factory calibration.
CONFIGURE	
EDIT NAME	Enter up to a 10-digit name in any combination of symbols and alpha or numeric characters.
SELECT MEASURE	Select the appropriate measurement units to display.
DISPLAY FORMAT	Select the measurement resolution (xx.xx pH or xx.x pH).
TEMP UNITS	Choose from the displayed options (°C or °F).
LOG SETUP	Choose SENSOR INTERVAL to set the sensor log interval or select TEMP INTERVAL to set the temperature log interval.

5.4 pH Sensor Setup Menu (continued)

CONFIGURE (continued)	
REJECT FREQ	Choose 50 or 60 Hz depending on the power line frequency for optimal noise rejection. Default is 60 Hz.
FILTER	Select 0–60 second signal averaging time.
TEMP ELEMENT	Select type of temperature element from the displayed choices.
SELECT BUFFER	Select the buffer type (standard 4, 7, 10 or DIN 19267) from the displayed choices.
PURE H2O COMP	Allows the user to specify that ammonia, morpholine, or other user-defined electrolyte is being used in the application, allowing a temperature-dependent linear slope factor to be applied to the measured pH.
CAL DAYS	Number of days since the last calibration. Default notification at 60 days.
SENSOR DAYS	Number of days the sensor has been in operation. Default notification at 365 days.
DEFAULT SETUP	Resets all user-editable options to their factory-defaults.
DIAG/TEST	
PROBE INFO	Display the sensor type, entered name of the sensor (Default: Digital Gateway serial number and name), the sensor serial number, the software version number, and the sensor driver version number.
CAL DATA	Displays the pH slope and the date of the last calibration.
SIGNALS	<p>SENSOR SIGNAL: Displays the sensor output in mV</p> <p>SENSOR ADC COUNTS: Displays the sensor ADC counts</p> <p>TEMP ADC COUNTS: Displays raw data for temperature ADC counts. ADC counts are comparable to A/D counts and are for sensor electronic diagnostic purposes only.</p> <p>ELECTRODE STATE: Identifies the state of the electrode (good or bad) depending on whether the impedance is within preset limits.</p> <p>ACTIVE ELECT: Displays the impedance (Mohms) of the active electrode if Imped Status is set to Enabled.</p> <p>IMPED STATUS: Sensor diagnostic. Choose Enabled or Disabled.</p>
COUNTERS	<p>SENSOR DAYS: Displays the cumulative days the sensor has been in use.</p> <p>RESET SENSOR: Allows the sensor counter to be reset to zero.</p> <p>ELECTRODE DAYS: Cumulative days the electrode has been in use.</p>

5.5 ORP Sensor Setup Menu

SELECT SENSOR (if more than one sensor is attached)

CALIBRATE (Main Menu Item)	
1 POINT MANUAL	Calibration against a single known sample.
TEMP ADJUST	Adjust the displayed temperature by up to ± 15 °C.
DEFAULT SETUP	Restores the system to the original factory calibration.
CONFIGURE	
EDIT NAME	Enter up to a 10-digit name in any combination of symbols and alpha or numeric characters.
SELECT SENSOR	Choose from the displayed sensor type (pH or ORP).
TEMP UNITS	Choose from the displayed options (°C or °F).
LOG SETUP	Choose SENSOR INTERVAL to set the sensor log interval or select TEMP INTERVAL to set the temperature log interval.
AC FREQUENCY	Choose 50 or 60 Hz depending on the power line frequency for optimal noise rejection. Default is 60 Hz.
FILTER	Select 0–60 second signal averaging time.
TEMP ELEMENT	Select type of temperature element from the displayed choices.
CAL DAYS	Number of days since the last calibration. Default notification at 60 days.
SENSOR DAYS	Number of days the sensor has been in operation. Default notification at 365 days.
IMPED LIMITS	Set min/max electrode sensor impedance limits.
DEFAULT SETUP	Resets all user-editable options to their factory-defaults.
DIAG/TEST	
PROBE INFO	Display the sensor type, entered name of the sensor (Default: Digital Gateway serial number and name), the sensor serial number, the software version number, and the sensor driver version number.
CAL DATA	Displays the slope and the date of the last calibration.
SIGNALS	<p>SENSOR SIGNAL: displays the sensor output in mV</p> <p>SENSOR ADC COUNTS: displays the sensor ADC counts</p> <p>TEMP ADC COUNTS: shows raw data for temperature ADC counts. ADC counts are comparable to A/D counts and are for sensor electronic diagnostic purposes only.</p> <p>ELECTRODE STATE: Identifies the state of the electrode (good or bad) depending on whether the impedance is within preset limits.</p> <p>ACTIVE ELECT: Shows the impedance (Mohms) of the active electrode if Imped Status is set to Enabled.</p> <p>IMPED STATUS: Sensor diagnostic. Choose Enabled or Disabled.</p>
COUNTERS	<p>SENSOR DAYS: displays the cumulative days the sensor has been in use.</p> <p>RESET SENSOR: allows the sensor counter to be reset to zero.</p> <p>ELECTRODE DAYS: Cumulative days the electrode has been in use.</p>

5.6 pH Calibration

The manufacturer offers one and two point automatic and manual calibrations for pH. An automatic calibration identifies the buffer table corresponding to the chosen buffer and automatically calibrates the probe after it stabilizes. A manual calibration is performed by placing the pH sensor in any buffer or sample with a known value and then entering that known value into the controller.

The value of the sample used in the manual calibration may be determined by laboratory analysis or comparison reading.

5.6.1 One Point Automatic Calibration

1. From the Main Menu, select SENSOR SETUP and confirm.
2. Select the appropriate sensor if more than one is attached and confirm.
3. Select CALIBRATE and confirm.
4. Select 1 POINT AUTO. Select the available Output Mode (Active, Hold, or Transfer) from the list box and confirm.
5. Move the clean probe to buffer and confirm to continue.
6. Confirm when stable. A screen will display 1 Point Auto Complete and the slope (XX.X mV/pH).
7. Return the probe to process.

5.6.2 Two Point Automatic Calibration

1. From the Main Menu, select SENSOR SETUP and confirm.
2. Select the appropriate sensor if more than one is attached and confirm.
3. Select CALIBRATE and confirm.
4. Select 2 POINT AUTO. Select the available Output Mode (Active, Hold, or Transfer) from the list box and confirm.
5. Move the clean probe to Buffer 1 and confirm.
6. Confirm when stable.
7. Move the clean probe to Buffer 2 and confirm.
8. Confirm when stable. A screen will display 2 Point Calibration Complete and the slope (XX.X mV/pH).
9. Return the probe to process.

5.6.3 One Point Manual Calibration

1. From the Main Menu, select SENSOR SETUP and confirm.
2. Select the appropriate sensor if more than one is attached and confirm.
3. Select CALIBRATE and confirm.
4. Select 1 POINT MANUAL. Select the available Output Mode (Active, Hold, or Transfer) from the list box and confirm.
5. Move the clean probe to solution and confirm to continue.
6. Confirm when stable. Edit the solution value using the keypad and confirm.
7. Confirm when stable. A screen will display 1 Point Manual Complete and the slope (XX.X mV/pH).
8. Return the probe to process.

5.6.4 Two Point Manual Calibration

1. From the Main Menu, select SENSOR SETUP and confirm.
2. Select the appropriate sensor if more than one is attached and confirm.
3. Select CALIBRATE and confirm.
4. Select 2 POINT MANUAL CAL. Select the available Output Mode (Active, Hold, or Transfer) from the list box and confirm.
5. Move the clean probe to Solution 1 and confirm.
6. Confirm when stable. Edit the solution value using the keypad and confirm.
7. Move probe to solution 1 and confirm.
8. Confirm when stable. Edit the solution value using the keypad and confirm.
9. A screen will display 2 Point Manual Cal Complete and the slope (XX.X mV/pH).
10. Return the probe to process.

5.7 ORP Calibration

5.7.1 One-point Manual Calibration

The manufacturer offers a one point manual calibration for ORP. The value of the sample used in the manual calibration may be determined by laboratory analysis or comparison reading.

1. From the Main Menu, select SENSOR SETUP and confirm.
2. Select the appropriate sensor if more than one is attached and confirm.
3. Select CALIBRATE and confirm.
4. Select 1 POINT MANUAL CAL. Select the available Output Mode (Active, Hold, or Transfer) from the list box and confirm.
5. Move the clean probe to Solution and confirm.
6. Confirm when stable. Edit the solution value using the keypad and confirm.
7. A screen will display 1 Point Manual Complete and the slope (XX.X mV).
8. Return the probe to process.

5.8 Concurrent Calibration of Two Sensors for pH and ORP

1. Begin a calibration on the first sensor and continue until "Wait to Stabilize" is displayed.
2. Select LEAVE and confirm. The display will return to the main measurement screen. The reading for the sensor currently being calibrated will flash.
3. Begin the calibration for the second sensor and continue until "Wait to Stabilize" is displayed.
4. Select LEAVE and confirm. The display will return to the main measurement screen and the reading for both sensors will flash. The calibration for both sensors are now running in the background.
5. To return to the calibration of either sensor select SENSOR SETUP from the Main Menu and confirm. Select the appropriate sensor and confirm.
6. The calibration in progress will be displayed. Continue with the calibration.

5.9 Adjusting the Temperature

View or change the temperature using the steps below:

1. From the Main Menu, select SENSOR SETUP and confirm.
2. Select the appropriate sensor if more than one is attached and confirm.
3. Select CALIBRATE and confirm.
4. Select TEMP ADJUST and confirm.
5. Select MEASURED TEMP and confirm.
6. The temperature will be displayed. Select the temperature to edit and confirm.

Section 6 Maintenance

DANGER

Only qualified personnel should conduct the tasks described in this section of the manual.

DANGER

Seul un technicien qualifié peut effectuer les tâches d'installation décrites dans cette section du manuel.



DANGER

Explosion hazard. Do not connect or disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

DANGER

Risque d'explosion. Couper le courant ou s'assurer que l'emplacement est désigné non dangereux avant de remplacer le aucun composant.

DANGER

Explosion hazard. Substitution of components may impair suitability for Class 1, Division 2.

DANGER

Risque d'explosion. La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe 1, Division 2.

6.1 Maintenance Schedule

Maintenance Task	90 days	Annually
Clean the sensor ¹	x	
Inspect sensor for damage	x	
Calibrate Sensor (if required by regulatory agency)	Per the schedule mandated by your regulatory agency.	

¹ Cleaning frequency is application dependent. More or less frequent cleaning will be appropriate in some applications.

6.2 Cleaning the Sensor

CAUTION

Before cleaning with acid, determine if the chemical reaction between the acid and the sample will create a hazardous chemical reaction. (For example, do not put a sensor that is used in a cyanide bath directly into a strong acid for cleaning because this chemical combination may produce poisonous cyanide gas.)

DANGER

Acids are hazardous. Always wear appropriate eye protection and clothing in accordance with material safety data sheet recommendations.

1. Clean the exterior of the sensor with a stream of water. If debris remains remove loose contaminate buildup by carefully wiping the entire measuring end of the sensor with a soft clean cloth. Rinse the sensor with clean, warm water.
2. Prepare a mild soap solution of warm water and dish detergent or other non-abrasive soap that does not contain lanolin.

Note: Lanolin will coat the glass process electrode and can adversely affect sensor performance.

3. Soak the sensor for 2 to 3 minutes in the soap solution.
4. Use a small soft-bristle brush and scrub the entire measuring end of the sensor, thoroughly cleaning the electrode and reference junction surfaces. If surface deposits cannot be removed by detergent solution cleaning, use muriatic acid (or other dilute acid) to dissolve them. The acid should be as dilute as possible, do not use stronger than 3% HCL. Experience will determine which acid to use and the appropriate dilution ratio. Some stubborn coatings may require a different cleaning agent. For assistance, contact [Technical and Customer Service \(U.S.A. only\) on page 39](#).
5. Soak the entire measuring end of the sensor in dilute acid for no more than 5 minutes. Rinse the sensor with clean, warm water then place the sensor back into the mild soap solution for 2 to 3 minutes to neutralize any remaining acid.
6. Remove the sensor from the soap solution, and rinse the sensor again in clean, warm water.
7. After cleaning, always calibrate the measurement system. Refer to [section 4.7 on page 25](#) or [section 4.8 on page 29](#).

Section 7 Troubleshooting

7.1 Error Codes

When a sensor is experiencing an error condition, the sensor reading on the measurement screen will flash and all relays and analog outputs associated with this sensor will be held. The following conditions will cause the sensor reading to flash:

- Sensor calibration
- Relay timer washing cycle
- Loss of communication

Highlight the Sensor Diag menu and press **ENTER**. Highlight Errors and press **ENTER** to determine the cause of the error. Errors are defined in [Table 6](#).

Table 6 Error Codes

Displayed Error	Definition	Resolution
ADC FAILURE	System measurement fails	Contact Technical Consulting Services.

7.2 Warnings

A sensor warning will leave all menus, relays, and outputs functioning normally, but will cause a warning icon to flash on the right side of the display. Highlight the Sensor Diag menu and press **ENTER** to determine the cause of the warning.

A warning may be used to trigger a relay and users can set warning levels to define the severity of the warning. Warnings are defined in [Table 7](#).

Table 7 Warning Codes

Displayed Warning	Definition	Resolution
PROBE OUT RANGE	Measured pH/ORP exceeds the expected value range.	Contact Technical Consulting Services.
TEMP OUT RANGE	Measured temperature exceeds the expected value range.	Contact Technical Consulting Services.
FLASH FAILURE	System flash memory write has failed.	Contact Technical Consulting Services.
REF ELECTRODE	Standard Electrode is not performing within the required specifications.	Contact Technical Consulting Services.

7.3 Troubleshooting the pH or ORP Sensor

Clean the sensor using the procedure described in [section 6.2 on page 34](#) and then calibrate the sensor as shown in [section 4.7 on page 25](#) or [section 4.8 on page 29](#). If the measuring system cannot be calibrated after cleaning, contact [Technical and Customer Service \(U.S.A. only\) on page 39](#).

Section 8 Replacement Parts and Accessories

8.1 Replacement Items, Accessories, and Reagent and Standards

Item Description	QTY	Catalog Number
Instruction manual, Combination pH System, English	each	6120118
Cable, sensor extension, 1 m (3 ft)	each	6122400
Cable, sensor extension, 7.7 m (25 ft)	each	5796000
Cable, sensor extension, 15 m (50 ft)	each	5796100
Cable, sensor extension, 31 m (100 ft)	each	5796200
Connector Safety Lock	each	6139900
Termination box	each	586700
Plug, sealing, conduit opening	each	5868700
Strain relief, Heyco	each	16664
Buffer, pH 7	500 mL (1 pint)	2283549
Buffer, pH 4	500 mL (1 pint)	2283449
Buffer, pH 10	500 mL (1 pint)	2283649
Buffer, pH 7	1 gallon	2283556
Buffer, pH 4	1 gallon	2283456
Buffer, pH 10	1 gallon	2283656
ORP Standard Solution, 200 mV	500 mL (1 pint)	25M2A1001-115
ORP Standard Solution, 600 mV	500 mL (1 pint)	25M2A1002-115
ORP Standard Solution, 200 mV	1 gallon	25M2A1001-123
ORP Standard Solution, 600 mV	1 gallon	25M2A1002-123

Section 9 How to Order

U.S.A. Customers

By Telephone:

6:30 a.m. to 5:00 p.m. MST
Monday through Friday
(800) 227-HACH (800-227-4224)

By Fax:

(970) 669-2932

By Mail:

Hach Company
P.O. Box 389
Loveland, Colorado 80539-0389 U.S.A.
Ordering information by e-mail: orders@hach.com

Information Required

- Hach account number (if available)
- Your name and phone number
- Purchase order number
- Brief description or model number
- Billing address
- Shipping address
- Catalog number
- Quantity

International Customers

Hach maintains a worldwide network of dealers and distributors. To locate the representative nearest you, send an e-mail to: intl@hach.com or contact:

Hach Company World Headquarters; Loveland, Colorado, U.S.A.
Telephone: (970) 669-3050; Fax: (970) 669-2932

Technical and Customer Service (U.S.A. only)

Hach Technical and Customer Service Department personnel are eager to answer questions about our products and their use. Specialists in analytical methods, they are happy to put their talents to work for you.

Call 1-800-227-4224 or e-mail techhelp@hach.com

Section 10 Repair Service

Authorization must be obtained from Hach Company before sending any items for repair. Please contact the Hach Service Center serving your location.

In the United States:

Hach Company
Ames Service
100 Dayton Avenue
Ames, Iowa 50010
(800) 227-4224 (U.S.A. only)
FAX: (515) 232-3835

In Canada:

Hach Sales & Service Canada Ltd.
1313 Border Street, Unit 34
Winnipeg, Manitoba
R3H 0X4
(800) 665-7635 (Canada only)
Telephone: (204) 632-5598
FAX: (204) 694-5134
E-mail: canada@hach.com

**In Latin America, the Caribbean, the Far East,
Indian Subcontinent, Africa, Europe, or the Middle East:**

Hach Company World Headquarters,
P.O. Box 389
Loveland, Colorado, 80539-0389 U.S.A.
Telephone: (970) 669-3050
FAX: (970) 669-2932
E-mail: intl@hach.com

Section 11 Limited Warranty

Hach Company warrants its products to the original purchaser against any defects that are due to faulty material or workmanship for a period of one year from date of shipment unless otherwise noted in the product manual.

In the event that a defect is discovered during the warranty period, Hach Company agrees that, at its option, it will repair or replace the defective product or refund the purchase price excluding original shipping and handling charges. Any product repaired or replaced under this warranty will be warranted only for the remainder of the original product warranty period.

This warranty does not apply to consumable products such as chemical reagents; or consumable components of a product, such as, but not limited to, lamps and tubing.

Contact Hach Company or your distributor to initiate warranty support. Products may not be returned without authorization from Hach Company.

Limitations

This warranty does not cover:

- Damage caused by acts of God, natural disaster, labor unrest, acts of war (declared or undeclared), terrorism, civil strife or acts of any governmental jurisdiction
- Damage caused by misuse, neglect, accident or improper application or installation
- Damage caused by any repair or attempted repair not authorized by Hach Company
- Any product not used in accordance with the instructions furnished by Hach Company
- Freight charges to return merchandise to Hach Company
- Freight charges on expedited or express shipment of warranted parts or product
- Travel fees associated with on-site warranty repair

This warranty contains the sole express warranty made by Hach Company in connection with its products. All implied warranties, including without limitation, the warranties of merchantability and fitness for a particular purpose, are expressly disclaimed.

Some states within the United States do not allow the disclaimer of implied warranties and if this is true in your state the above limitation may not apply to you. This warranty gives you specific rights, and you may also have other rights that vary from state to state.

This warranty constitutes the final, complete, and exclusive statement of warranty terms and no person is authorized to make any other warranties or representations on behalf of Hach Company.

Limitation of Remedies

The remedies of repair, replacement or refund of purchase price as stated above are the exclusive remedies for the breach of this warranty. On the basis of strict liability or under any other legal theory, in no event shall Hach Company be liable for any incidental or consequential damages of any kind for breach of warranty or negligence.

Section 12 Compliance Information

Hach Company certifies this instrument was tested thoroughly, inspected and found to meet its published specifications when it was shipped from the factory.

The **Model sc100 Controller/sc1000 Controller and the pH Combination sensor** has been tested and is certified as indicated to the following instrumentation standards:

Product Safety

UL 61010A-1 (ETL Listing # 65454)
CSA C22.2 No. 1010.1 (ETLc Certification # 65454)
Certified by Hach Co. to EN 61010-1 Amds. 1 & 2 (IEC1010-1) per 73/23/EEC, supporting test records by Intertek Testing Services.

Immunity

This equipment was tested for industrial level EMC per:

EN 61326 (EMC Requirements for Electrical Equipment for Measurement, Control and Laboratory Use) **per 89/336/EEC EMC:** Supporting test records by Hach Company, certified compliance by Hach Company.

Standards include:

IEC 1000-4-2:1995 (EN 61000-4-2:1995) Electrostatic Discharge Immunity (Criteria B)
IEC 1000-4-3:1995 (EN 61000-4-3:1996) Radiated RF Electromagnetic Field Immunity (Criteria A)
IEC 1000-4-4:1995 (EN 61000-4-4:1995) Electrical Fast Transients/Burst (Criteria B)
IEC 1000-4-5:1995 (EN 61000-4-5:1995) Surge (Criteria B)
IEC 1000-4-6:1996 (EN 61000-4-6:1996) Conducted Disturbances Induced by RF Fields (Criteria A)
IEC 1000-4-11:1994 (EN 61000-4-11:1994) Voltage Dip/Short Interruptions (Criteria B)

Additional Immunity Standard/s include:

ENV 50204:1996 Radiated Electromagnetic Field from Digital Telephones (Criteria A)

Emissions

This equipment was tested for Radio Frequency Emissions as follows:

Per **89/336/EEC EMC: EN 61326:1998** (Electrical Equipment for measurement, control and laboratory use—EMC requirements) Class “A” emission limits. Supporting test records by Hewlett Packard, Fort Collins, Colorado Hardware Test Center (A2LA # 0905-01) and certified compliance by Hach Company.

Standards include:

EN 61000-3-2 Harmonic Disturbances Caused by Electrical Equipment
EN 61000-3-3 Voltage Fluctuation (Flicker) Disturbances Caused by Electrical Equipment

Additional Emissions Standard/s include:

EN 55011 (CISPR 11), Class “A” emission limits

Canadian Interference-causing Equipment Regulation, IECS-003, Class A

Supporting test records by Hewlett Packard, Fort Collins, Colorado Hardware Test Center (A2LA # 0905-01) and certified compliance by Hach Company.

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

FCC PART 15, Class "A" Limits

Supporting test records by Hewlett Packard, Fort Collins, Colorado Hardware Test Center (A2LA # 0905-01) and certified compliance by Hach Company.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense. The following techniques of reducing the interference problems are applied easily.

1. Disconnect the Controller from its power source to verify that it is or is not the source of the interference.
2. If the Controller is connected into the same outlet as the device with which it is interfering, try another outlet.
3. Move the Controller away from the device receiving the interference.
4. Reposition the receiving antenna for the device receiving the interference.
5. Try combinations of the above.

Appendix A Modbus Register Information

Table 8 Sensor Modbus Registers

Group Name	Tag Name	Register #	Data Type	Length	R/W	Description
Tags	SensorMeasTag	40001	Integer	1	R	Sensor measurement tag
Measurements	pHMeas	40002	Float	2	R	pH /ORP measurement
Tags	TempMeasTag	40004	Integer	1	R	Temperature measurement tag
Measurements	TempDegCMeas	40005	Float	2	R	Temperature measurement
Configuration	SensorName	40007	String	6	R/W	Sensor name
Tags	FuncCode	40013	Integer	1	R/W	Function code tag
Tags	NextState	40014	Integer	1	R/W	Next state tag
Configuration	MeasType	40015	Integer	1	R/W	Measurement type—pH or ORP
Configuration	TempUnits	40016	Integer	1	R/W	Temperature units—C or F
Configuration	pHFormat	40017	Integer	1	R/W	pH display format
Configuration	TaggedPhFormat	40018	Long	2	R	pH display tagged format
Configuration	Filter	40020	Integer	1	R/W	Sensor filter
Configuration	TempElementType	40021	Integer	1	R/W	Temperature element type
Tags	TempUserValueTag	40022	Integer	1	R	Temperature user value tag
Configuration	TempUserDegCValue	40023	Float	2	R/W	Temperature user value
Configuration	pHBuffer	40025	Integer	1	R/W	pH buffer type
Configuration	PureWaterCompType	40026	Integer	1	R/W	Pure H ₂ O compensation type
Configuration	PureWaterCompUser	40027	Float	2	R/W	Pure H ₂ O compensation user val
Calibration	OutputMode	40029	Integer	1	R/W	Output mode
Calibration	CalLeave	40030	Integer	1	R/W	Cal leave mode
Calibration	CalAbort	40031	Integer	1	R/W	Cal abort mode
Tags	CalEditValueTag	40032	Integer	1	R	Cal edit value tag
Calibration	CalEditPhValue	40033	Float	2	R/W	Cal edit value
Diagnostics	pHSlope	40035	Float	2	R	pH slope
Diagnostics	SoftwareVersion	40037	String	6	R	Software version
Diagnostics	SerialNumber	40043	String	6	R	Serial number
Diagnostics	pHOffset	40049	Float	2	R	pH offset
Diagnostics	OrpOffset	40051	Float	2	R	Orp offset
Calibration	CalCode	40053	Integer	1	R	Cal code
Configuration	SensorLogInterval	40054	Integer	1	R/W	Sensor data log interval
Configuration	TempLogInterval	40055	Integer	1	R/W	Temperature data log interval
Diagnostics	pHmV	40056	Float	2	R	pH mV
Diagnostics	ProdDate	40058	Date	2	R/W	Production date
Diagnostics	StdElectrode	40060	Float	2	R	Standard electrode impedance
Diagnostics	RefElectrode	40062	Float	2	R	Reference electrode impedance
Diagnostics	LastCalDate	40064	Date	2	R	Last calibration date
Diagnostics	SensorDays	40066	Integer	1	R	Sensor running days
Diagnostics	ElectrodeDays	40067	Integer	1	R	Electrode running days
Diagnostics	ElectrodeStatus	40068	Integer	1	R	Electrode status
Diagnostics	SensorType	40069	Integer	1	R	Sensor type
Configuration	RejectFrequency	40070	Integer	1	R/W	Reject frequency
Diagnostics	DeviceDriver	40071	String	5	R	Device driver

Modbus Register Information

Table 8 Sensor Modbus Registers

Group Name	Tag Name	Register #	Data Type	Length	R/W	Description
Configuration	CalWarningDays	40076	Integer	1	R/W	Calibration warning days
Configuration	SensorWarningDays	40077	Integer	1	R/W	Sensor warning days

Appendix B General pH Information

B.1 pH Measurement Theory

pH is the negative logarithm of the hydrogen ion activity and a measure of the acidity or alkalinity of a solution.

$$\text{pH} = -\log A[\text{H}^+]$$

pH is normally measured using a glass electrode and a reference electrode.

The glass electrode acts as a transducer, converting chemical energy (the hydrogen ion activity) into an electrical energy (measured in millivolts). The reaction is balanced and the electrical circuit is completed by the flow of ions from the reference solution to the solution under test.

The electrode and reference solution together develop a voltage (emf) whose magnitude depends on the type of reference electrode, the internal construction of the glass electrode, the pH of the solution and the temperature of the solution. This voltage is expressed by the Nernst Equation:

$$E = E_o - (2.3 RT/F) \times \log A[\text{H}^+]$$

$$E = E_o - (\text{slope}) \times \log A[\text{H}^+]$$

where:

E = the emf of the cell

E_o = the zero potential (isopotential) of the system. It depends on the internal construction of the glass and reference electrodes.

R = gas constant

T = temperature in Kelvin

$A[\text{H}^+]$ = activity of the hydrogen ion (assumed to be equivalent to the concentration of hydrogen ions)

F = Faraday constant

For every unit change in pH (or decade change in ion concentration) the emf of the electrode pair changes by 59.16 mV at 25 °C. This value is known as the Nernstian Slope of the electrode.

The pH electrode pair is calibrated using solutions of known and constant hydrogen ion concentration, called buffer solutions. The buffer solutions are used to calibrate both the electrode isopotential and slope.

B.2 PID Controller Basics

A pH control loop operates as follows: The pH meter measures the value of the pH in the effluent, and, if the pH is different from the setpoint, the controller actuates the reagent pump (or valve) that adds reagent to a mixing tank. The added reagent adjusts the pH value of the process.

The physical layout of the loop, the sizing of the pump (valve), type of mixing tank, and location of the pH electrodes all have a major impact on the ultimate performance of the loop, after the controller is tuned for optimal performance. The largest single performance factor is the delay time around the loop. This includes the response time of the electrode/meter, time required to deliver the reagent to the process water, time required for the reagent to mix with and react with the process water, and the time required to deliver the completely mixed water to the electrode. If the delay times are too long or the mixing is not complete, the control will be poor regardless of how well the controller is tuned.

The Process pH Meter uses a PID (proportional, integral (reset), derivative (rate) control) control algorithm. Each of the instrument settings along with their effects on the control loop, are described below.

Mode

Manual: The manual output is specified in percent of full-scale PID output (4–20 mA) and is commonly used for testing the output device.

Auto: Allows the process to be controlled automatically using information specified in the Phase, Setpoint, Proportional Band, Integral, and Derivative menus as follows:

Phase

Direct: The control output action will cause the process value to increase.

Reverse: The control output action will cause the process value to decrease.

Setpoint

The setpoint is defined as the desired process value in pH

Proportional Band

The proportional band is the range in pH from the setpoint value where the controller provides proportional control. For example, the desired setpoint for the process is pH 7.0 and the process requires that a reagent must be added to the process water to bring it up to pH 7.0. If the proportional band is set to pH 1.0, the controller will provide proportional output control over the range of pH 6.0 to 8.0. When the process is at pH 6.0, the controller will provide a 100% control output level (assuming that Phase is set to Direct). When the process is at pH 7.0, the proportional control will provide a 0% control output level. When the process is at pH 6.5 the proportional control will provide a 50% output. The output action is equal to the difference between the setpoint and the process value, divided by the proportional band value.

Integral

The integral value is used to reduce the steady state error, between the process value and the setpoint, to zero. For example, assume a process can be manually controlled at a level of pH 8.0 by sending a 35% control output level to a reagent pump. Now, say that the system is set up for the controller to provide proportional only control, with the controller setpoint set to pH 8.0 and the proportional band set to pH 1.0. Note that the nearer the process gets to the pH 8.0 setpoint, the lower the control output level is. In fact, when the process is at pH 8.0, the output level will be 0%. Since the process requires that the pump be operated at 35% for the process to reach pH 8.0, its apparent that proportional-only control will never quite reach the desired setpoint of pH 8.0. This is where the integral control comes in.

Integral control can be thought of as adding up the output action from the proportional control over time. For example, the proportional control output reaches a steady state level of 5%. If the integral time is set to five minutes, the integral action of the controller will add an additional 5% to the controller output level over a 5-minute interval. The integral action is additive, so for every 5-minute interval an additional 5% is added to the controller's output level. This will allow the controller to bring the process to the desired setpoint level. Note that the longer the integral time setting, the longer it takes for the integral action to affect the process. The integral control action is disabled by setting it to zero. Note that the integral time is in minutes.

Derivative

Derivative control is used to adjust the control output level based upon the rate at which the process value is approaching or passing the setpoint. Derivative control action would be used in cases where the process value can rapidly ramp up and overshoot the setpoint. The derivative setting is in minutes. The output action of the derivative control is equal to the rate of change of the process (in pH units per minute) times the derivative time, divided by the proportional band, times negative one. For example, if the process pH is changing at a rate of pH 0.20 per minute, the derivative time is set to 3.0 minutes, the proportional band is set to pH 0.80, and the action is "direct" the derivative control output action will be approximately equal to: $(-0.20 \text{ pH/minute} \times 3.0 \text{ minute}) / 0.80 \text{ pH} = -75\%$.

During calibration, the analog outputs can remain active, be held, or be transferred to a preset mA value.

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