

Model Q45R

Auto-Clean

ORP Monitor/Analyzer

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Gas sensors, except oxygen sensors, are covered by this warranty, but are subject to inspection for evidence of extended exposure to excessive gas concentrations. Should inspection indicate that sensors have been expended rather than failed prematurely, the warranty shall not apply.

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This warranty is void if the Manufacturer's product(s) has been subject to misuse or abuse, or has not been operated or stored in accordance with instructions, or if the serial number has been removed.

Analytical Technology, Inc. makes no other warranty expressed or implied except as stated above.

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Part 1 - Introduction

1.1 General

The Model Q45R ORP monitor/analyzer provides an extremely versatile measurement system for monitoring and control of ORP over the range of -1000 to +2000 mV. The system is 115/230 VAC powered, with dual relay outputs and two 4-20 mA outputs (one for ORP and one for temperature). The Q45R displays sensor temperature, sensor output millivolts, and output loop current on the secondary line of the custom display.



WARNING: Not following operating instructions may impair safety.

1.2 Standard System

The Model Q45R Auto-Clean system includes two main components, a NEMA 4X electronics unit and a submersible ORP sensor assembly with cleaner nozzle. For special applications, the cleaner system can be supplied separate from the ORP monitor electronics to allow the readout to be mounted remote from the sensor and cleaner. Submersible sensors are design for direct immersion in a tank or flowing stream. A 30 ft. cable is potted into the top section of the sensor assembly, and connects directly to the ORP monitor, or to an intermediate junction box if required. A separate tubing connection located at the top of the sensor assembly is provided for connection of a 25-foot length of plastic tubing (supplied with the unit) between the sensor and the monitor. A typical system is shown in Figure 1.

The ORP sensor assembly is mounted to a 1" pipe using a special mounting adapter supplied with the system. The 1" pipe is attached to the tank handrail with a bracket assembly that holds the sensor at a slight angle in the tank. Sensors should be checked for build-up periodically to verify that the cleaner is keeping the sensor clean. However, sensor maintenance intervals of 3 months or more are likely in most applications.

The sensor cleaning frequency is user programmable, and units are shipped with a default cleaning frequency of once every 24 hours. This frequency has proven sufficient for most applications, but can be increased if needed for a specific application.

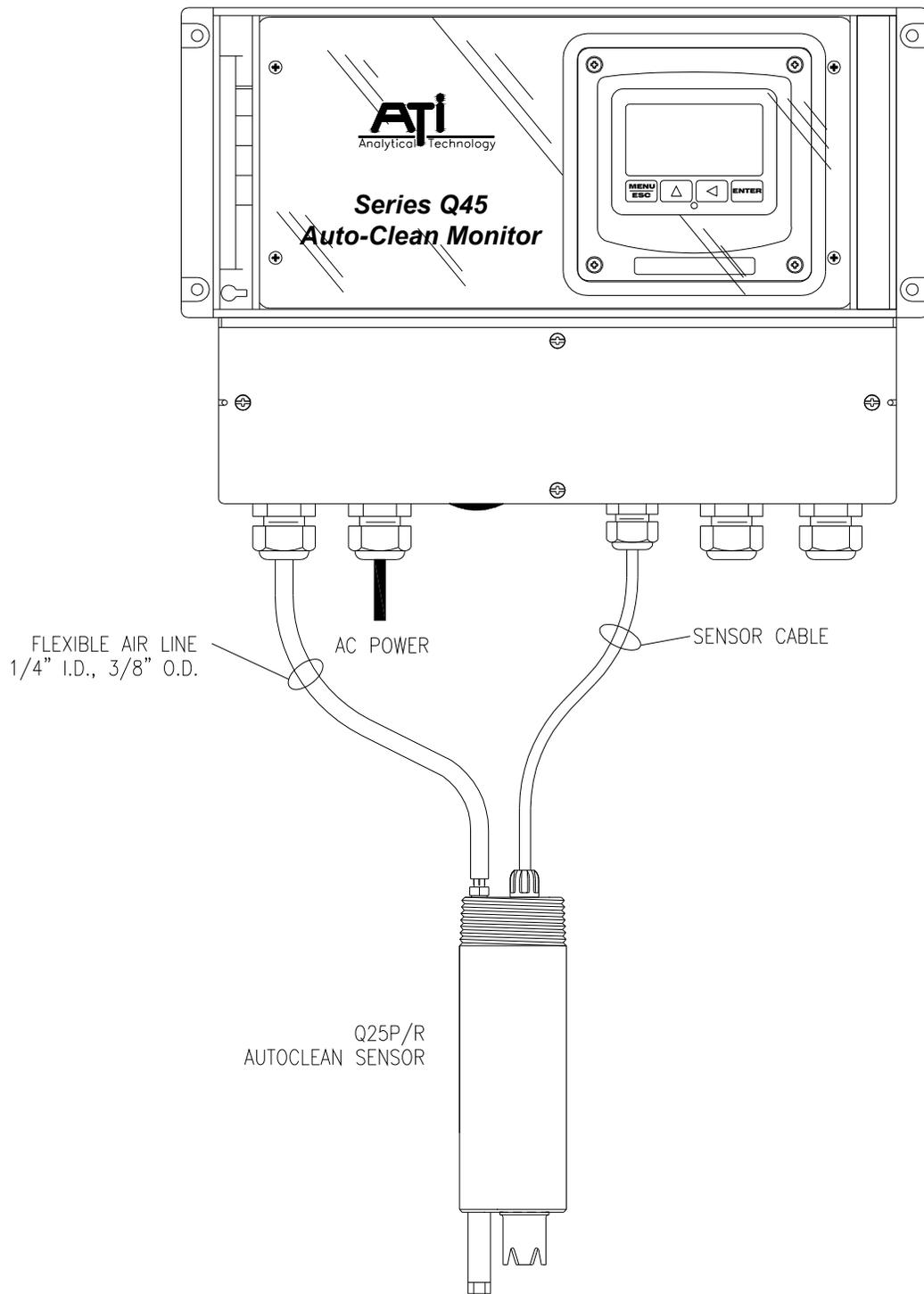


Figure 1 - ORP System with AutoClean Sensor

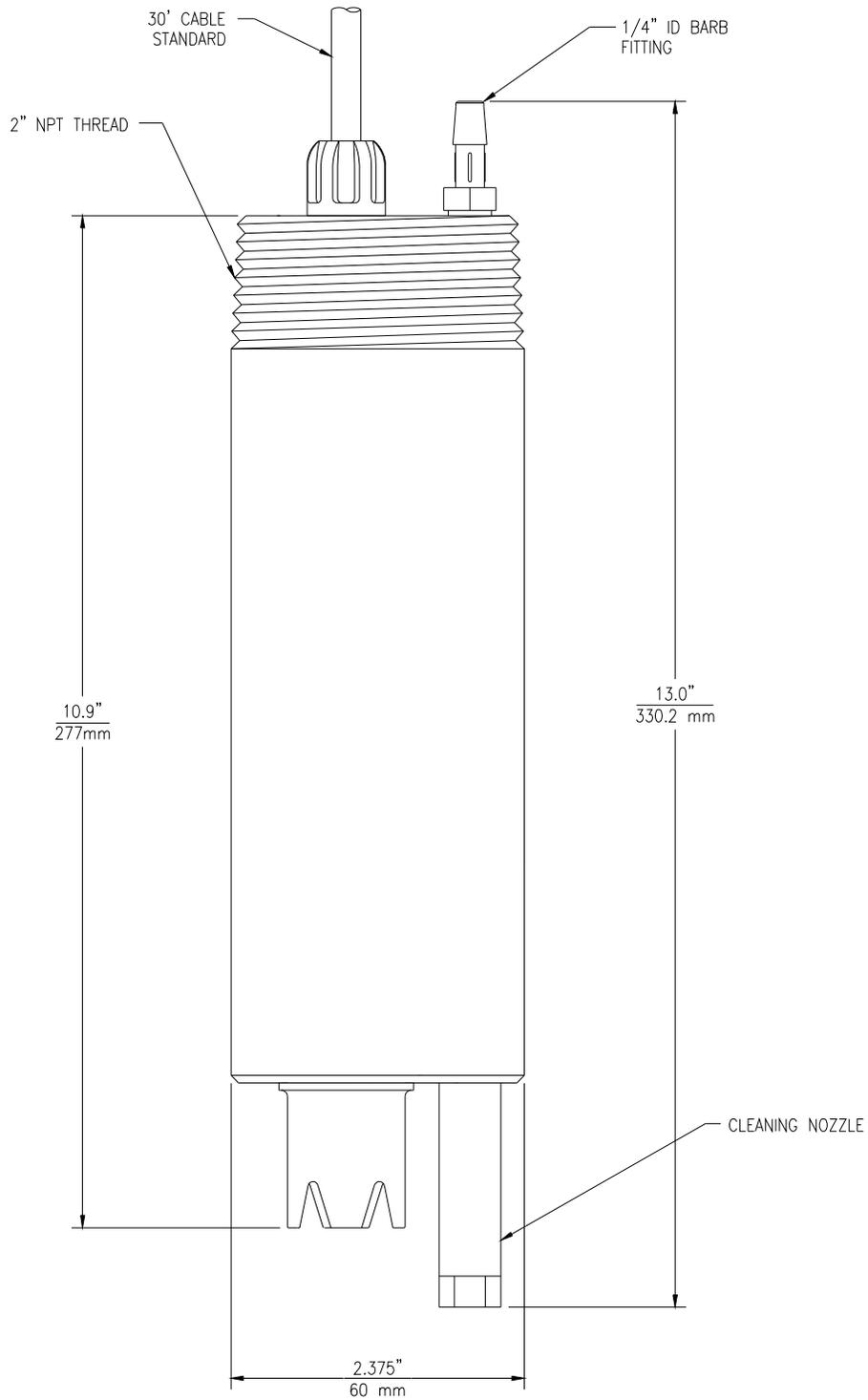


Figure 2 - ORP AutoClean Sensor

1.3 Features

- Output Hold, Output Simulate, Output Alarm, and Output Delay Functions. All forced changes in output condition include bumpless transfer to provide gradual return to on-line signal levels and to avoid system control shocks on both analog outputs.
- Single SPDT relay operation and two isolated analog output. Software settings for relay control include setpoint, deadband, phase, delay, and failsafe. Software controls automatically appear in menu list when hardware option card is plugged in and system power is applied.
- The analog outputs may be configured to track ORP and temperature. Both analog outputs can be individually programmed to fail to specific values.
- Selectable Output Fail Alarm feature allows system diagnostic failures to be sent to external monitoring systems.
- Large, high contrast, custom Super-Twist display provides excellent readability even in low light conditions. The secondary line of display utilizes 5x7 dot matrix characters for clear message display. Two of four measured parameters may be on the display simultaneously.
- Sensor diagnostics monitor glass breakage, sensor leaks, and RTD condition. Diagnostic messages provide a clear description of any problem with no confusing error codes to look up. Messages are also included for diagnosing calibration problems.
- Quick and easy two-point and sample calibration methods include auto-buffer recognition from 13 built-in buffer tables. To provide high accuracy, all calibration methods include stability monitors that check temperature and main parameter stability before accepting data.
- Selectable Pt1000 or Pt100 temperature inputs. Systems can also be hard-configured for three-wire elements. Temperature element can be user calibrated.
- Security lock feature to prevent unauthorized tampering with transmitter settings. All settings can be viewed while locked, but they cannot be changed.
- High reliability, microprocessor-based system with non-volatile memory back-up that utilizes no batteries. Low mass, surface mount PCB construction containing no adjustment potentiometers. All factory calibrations stored in non-volatile EEPROM.

1.4 Q45R Auto-Clean System Specifications

Mounting Options	Wall mounted electronic enclosure, Optional handrail mounting brackets.
Weight	Electronics Assembly: 15 lbs. (6.8 kg) Sensor Assembly: 3 lbs. (1.36 kg)
Display	Large, high-contrast, Super-Twist (STN) LCD; 4-digit main display with sign, 0.75" (19.1 mm) seven-segment characters; 12-digit secondary display, 0.3" (7.6 mm) 5×7 dot matrix characters
Keypad	4-key membrane type with tactile feedback, polycarbonate with UV coating, integral EMI/static shield and conductively coated window
Ambient Temperature	Service, -20 to 60 °C (-4 to 140 °F) Storage, -30 to 70 °C (-22 to 158 °F)
Ambient Humidity	0 to 95%, non-condensing
Altitude	Up to 2000 m (6562 Ft.)
Location	Designed for hazardous and non-hazardous areas
EMI/RFI Influence	Designed to EN 61326-1
Output Isolation	600 V galvanic isolation
Filter	Adjustable 0-9.9 minutes additional damping to 90% step input
Temperature Input	Selectable Pt1000 or Pt100 RTD with automatic compensation
Displayed Parameters	Main input, -1000 to +2000 mV Sensor temperature, -10.0 to 110.0 °C (14 to 230°F) Loop current, 4.00 to 20.00 mA PID controller status Sensor slope/offset Model number and software version
Main Parameter Ranges	-1000 to +2000 mV
Power	90 – 130 VAC, 50/60 Hz or 180 – 260 VAC, 50/60 Hz
Enclosure	NEMA 4X, IP66, polycarbonate, stainless steel hardware, weatherproof and corrosion resistant,

Fuse	Controller PCB – (6.3A, 250V) Transmitter – 115V (100mA, 250V), 230V (50mA, 250V)
Conduit Openings	Three ½” NPT openings. Gland seals plus two ½” conduit adapters supplied but not installed.
Relays, Electromechanical:	Two SPDT, 6 amp @ 250 VAC, 5 amp @ 24 VDC contacts. Software selection for setpoint, phase, delay, deadband, hi-lo alarm, and failsafe. A-B indicators on main LCD.
Analog Outputs	Two 4-20 mA outputs. Output one programmable for ORP. Output 2 programmable for Temperature or ORP. Max load 550 Ohms for each output. Outputs ground isolated and isolated from each other.

1.5 Q45R Performance Specifications

Input Impedance	Greater than 10 ¹³ Ohms
Accuracy	0.1% of span or better (± 2 mV)
Repeatability	0.1% of span or better (± 2 mV)
Sensitivity	0.05% of span (± 2 mV)
Stability	0.05% of span per 24 hours, non-cumulative (± 1 mV)
Warm-up Time	7 seconds to rated performance
Supply Voltage Effects	± 0.05% span
Instrument Response Time	6 seconds to 90% of step input at lowest setting
Temperature Drift	Span or zero, 0.02% of span/°C
Max. Sensor-Instrument Distance	3,000 ft. (914 meters) w/ preamp, 30 ft. (9.1 meters) w/o preamp
Sensor Types	Submersible ORP Sensor, w/cleaner nozzle



Equipment bearing this marking may not be discarded by traditional methods in the European community after August 12 2005 per EU Directive 2002/96/EC. End users must return old equipment to the manufacturer for proper disposal.

Part 2 – Analyzer Mounting

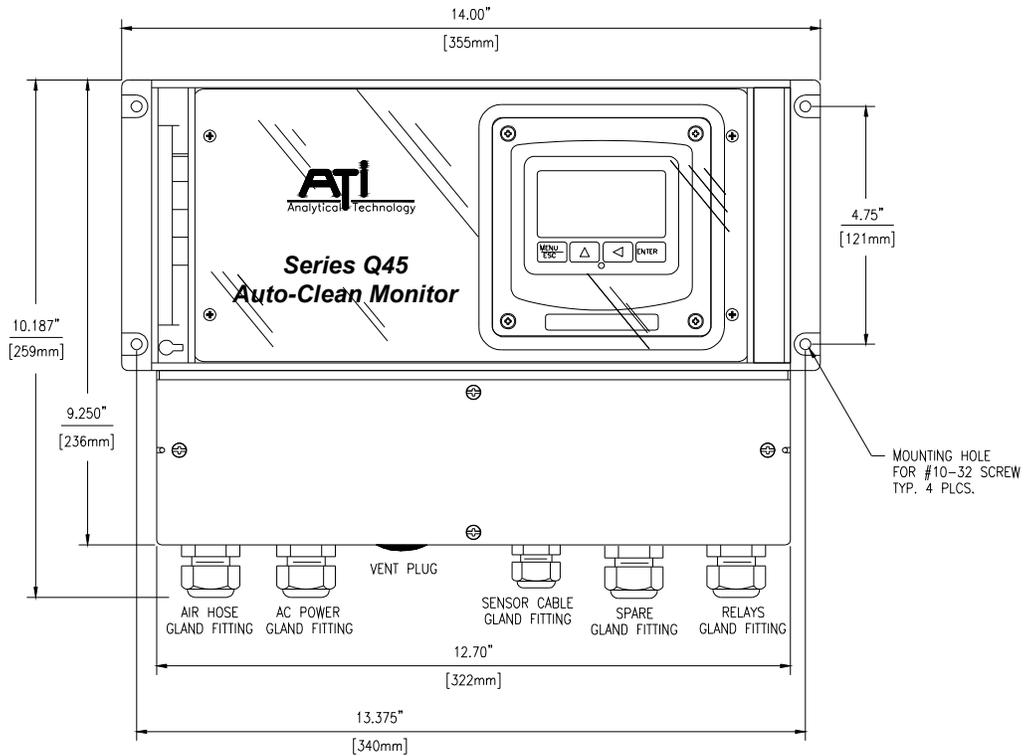
2.1 General

The Q45R Auto-Clean Monitor is housed in a Nema 4X (IP-65) enclosure. The monitor must be mounted near the measurement point, with a maximum of 60 feet between the monitor and the sensor. The standard system is supplied with a 30 ft. sensor cable and 30 feet of air line tubing.

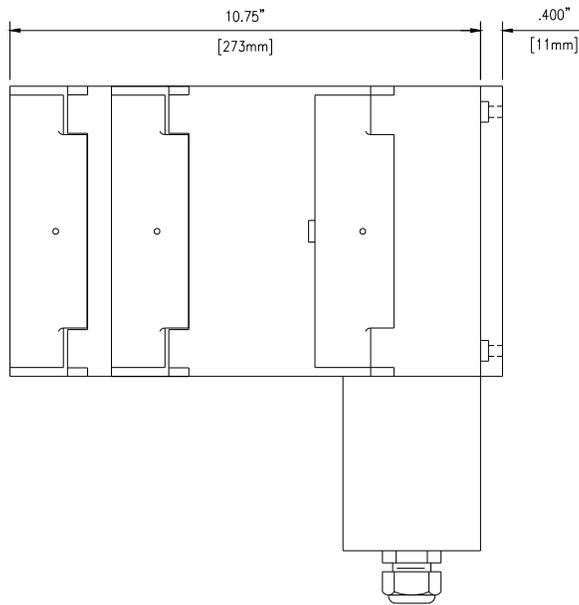
Monitor enclosure may be mounted to any flat surface like a wall or plate. A bracket assembly is available (#00-0930) for mounting the monitor enclosure to aeration handrail systems. This bracket locates the monitor at a convenient height for viewing the display and using the controls.

2.2 Wall Mount

Figure 2 shows the dimensions of the electronic assembly including the hole locations for the enclosure mounting ears. Note that the enclosure mounting brackets are not installed at the factory. They are supplied separately and must be attached using the screws provided. This is done to protect the brackets against shipping damage.



FRONT VIEW



SIDE VIEW

Figure 3 - Monitor Assembly Wall Mount Dimensions

2.3 Railing Mount

Figure 4 shows the mounting assembly used to mount the electronic monitor to a typical safety handrail that surrounds many aeration tanks. This bracket assembly consists of vertical channels attached to the handrail with u-bolts. The monitor screws to the channels with the 10-32 screws supplied as part of the kit. U-bolts for 2" diameter handrail pipe are also supplied.

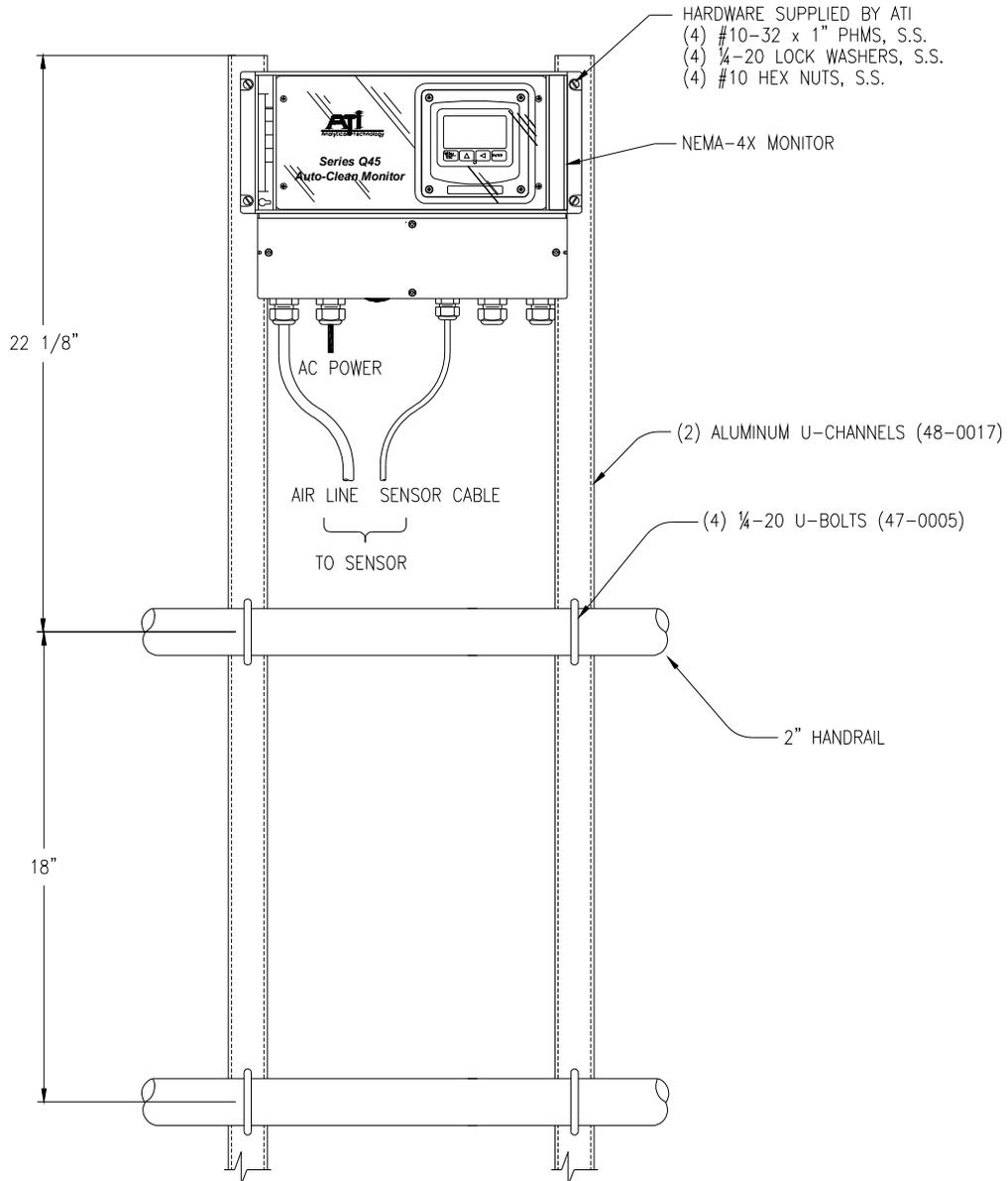


Figure 4 - Handrail Mounting Assembly

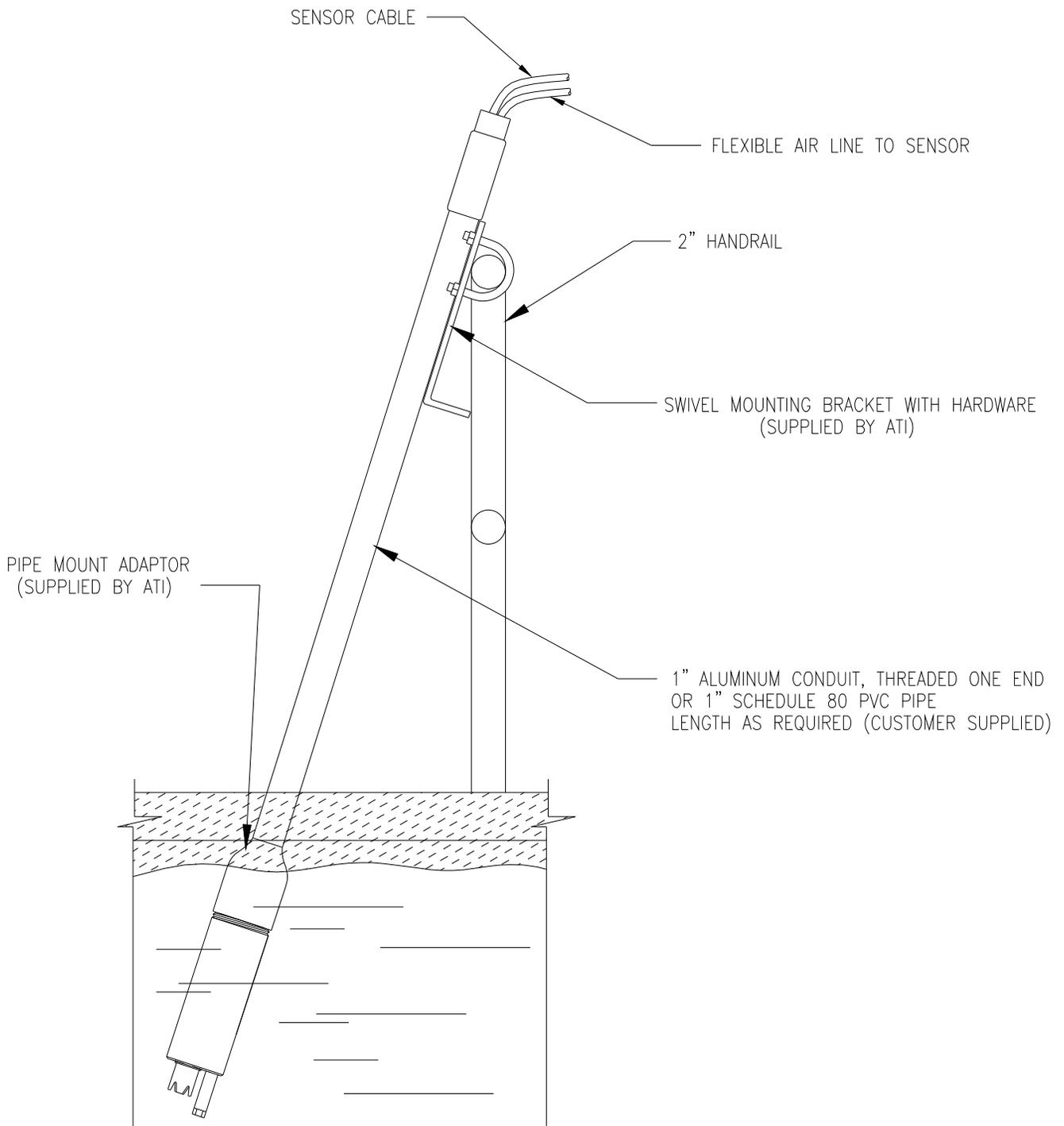


Figure 5 - Submersible Sensor Mounting Assembly

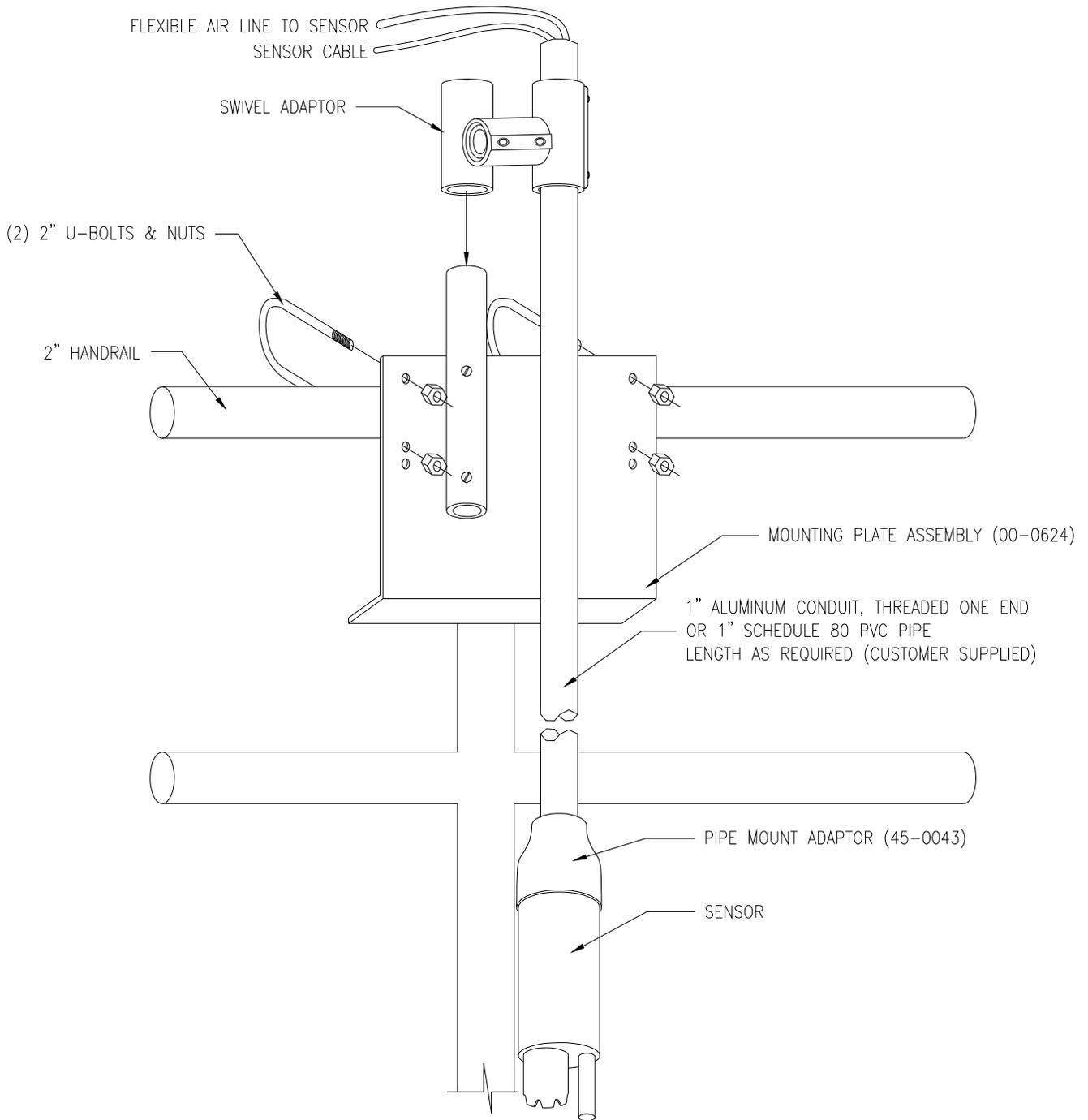


Figure 6 - Mounting Assembly Detail

Part 3 – Electrical Installation

3.1 General

Q45R Auto-Clean ORP monitors are powered from either 115 or 230 VAC, 50/60 Hz. Monitors can draw up to 3 amps when the internal air compressor activates as part of the sensor cleaning system. Normal current draw is less than 0.2 amps when the cleaner is off.

Important Notes:

1. Use wiring practices that conform to all national, state and local electrical codes. For proper safety as well as stable measuring performance, it is important that the earth ground connection be made to a solid ground point from TB1 located on the controller PCB. The AC power supply in the transmitter, contains a single 100mA (115V) or 50mA (230V) slo-blo fuse. The fuse **F1** is located adjacent to **TB5** and is easily replaceable.
2. Do NOT run sensor cables or instrument 4-20 mA output wiring in the same conduit that contains AC power wiring. AC power wiring should be run in a dedicated conduit to prevent electrical noise from coupling with the instrumentation signals.

3.2 Connections

All wiring connections are made in the terminal compartment at the bottom of the monitor. To access the terminal compartment, loosen the 4 screws holding the cover in place and set the cover aside. The screws are captive and should not come completely out of the plastic cover.

AC power should be brought into the enclosure through the second cordgrip from the left as shown in Figure 7. The left most cordgrip must remain open as this is the entry used for the cleaning system air line.

Sensor and 4-20 mA output connections are made to the terminals in the right side of the terminal compartment as shown..

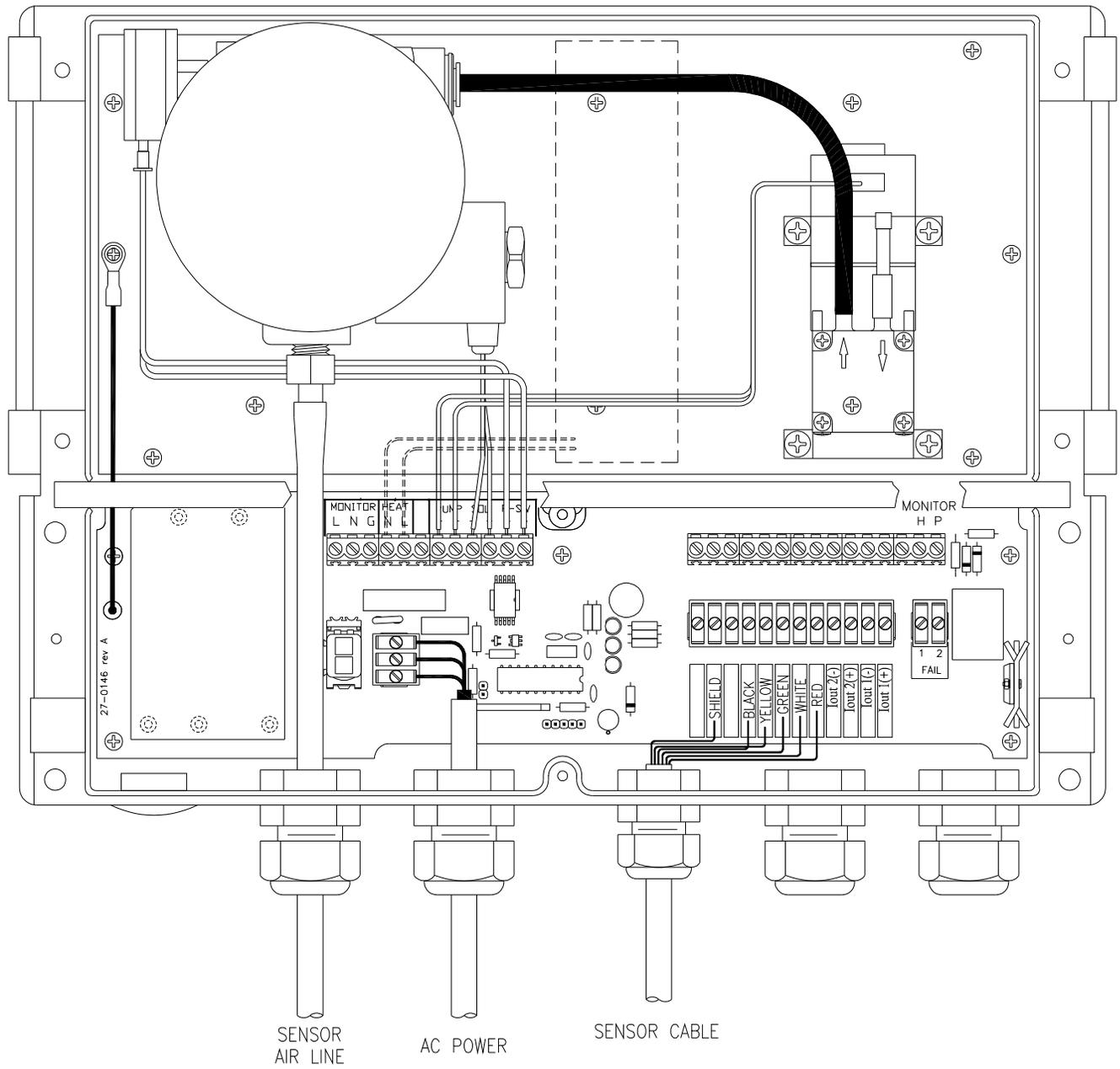


Figure 7 - OPR Monitor Electrical Connections

3.3 Relay Wiring

Relay wiring is done to terminal blocks inside the Q45R display assembly. This unit actually contains two SPDT relays, but one of the relays is used to control the activation of the sensor automatic cleaning system. Relay A is available for use as either a control relay, an alarm relay, or as a system failure alarm.

To access the terminals for Relay A, open the front protective cover of the analyzer. Loosen the 4 corner screws for the display unit and the front will hinge down. A terminal block labeled TB3 is accessible. The terminal block will unplug for wiring convenience, and the circuit board is screened to indicate the NO, NC and C contacts..

Part 4 – Operation

4.1 User Interface

The user interface for the Q45 Series instrument consists of a custom display and a membrane keypad. All functions are accessed from this user interface (no internal jumpers, pots, etc.).

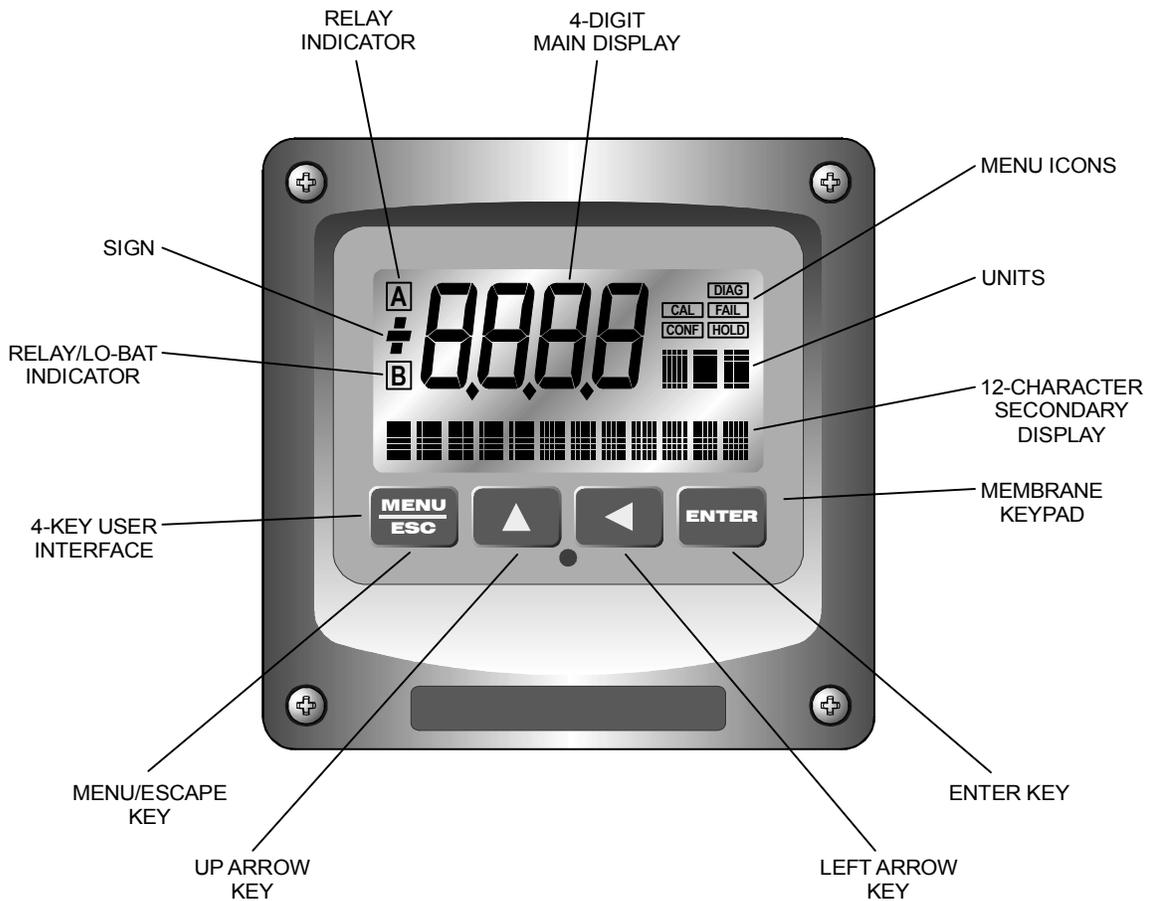


Figure 4-1 User Interface (ATI-0654)

4.11 Keys

All user configurations occur through the use of four membrane keys. These keys are used as follows:

- MENU/ESC** To scroll through the menu section headers or to escape from anywhere in software. The escape sequence allows the user to back out of any changes in a logical manner. Using the escape key aborts all changes to the current screen and backs the user out one level in the software tree. The manual will refer to this key as either MENU or ESC, depending upon its particular function. In the battery-powered version of the Q45, this is also the ON button.
- UP (arrow)** To scroll through individual list or display items and to change number values.
- LEFT (arrow)** To move the cursor from right to left during changes to a number value.
- ENTER** To select a menu section or list item for change and to store any change.

4.12 Display

The large custom display provides clear information for general measurement use and user configuration. There are three main areas of the display: the main parameter display, the secondary message line, and the icon area.

Main Parameter During normal operation, the main parameter display indicates the present process input with sign and units. This main display may be configured to display any of the main measurements that the system provides. During configuration, this area displays other useful set-up information to the user.

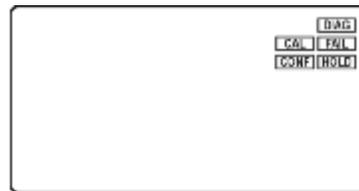


Lower Line

During normal operation, the lower line of the display indicates user-selected secondary measurements that the system is making. This also includes calibration data from the last calibration sequence and the transmitter model number and software version. During configuration, the lower line displays menu items and set-up prompts to the user. Finally, the lower line will display error messages when necessary. For a description of all display messages, refer to Section 8.3.

**Icon Area**

The icon area contains display icons that assist the user in set-up and indicate important states of system functions. The CAL, CONFIG, and DIAG icons are used to tell the user what branch of the software tree the user is in while scrolling through the menu items. This improves software map navigation dramatically. Upon entry into a menu, the title is displayed (such as CAL), and then the title disappears to make way for the actual menu item. However, the icon stays on.

**HOLD**

The HOLD icon indicates that the current output of the transmitter has been put into output hold. In this case, the output is locked to the last input value measured when the HOLD function was entered. HOLD values are retained even if the unit power is cycled.

FAIL

The FAIL icon indicates that the system diagnostic function has detected a problem that requires immediate attention. This icon is automatically cleared once the problem has been resolved.

Relay Area A/B

The relay area contains two icons that indicate the state of the system relays (if the relay card is installed). If the battery board is installed instead, the B icon indicates that the battery voltage is at a low level. The battery power option and the relay option cannot be installed together.



4.2 Software

The software of the Q45R is organized in an easy to follow menu-based system. All user settings are organized under five menu sections: Measure, Calibration [CAL], Configuration [CONFIG], Control [CONTROL] and Diagnostics [DIAG].

Note: The default Measure Menu is display-only and has no menu icon.

4.2.1 Software Navigation

Within the CAL, CONFIG, CONTROL, and DIAG menu sections is a list of selectable items. Once a menu section (such as CONFIG) has been selected with the MENU key, the user can access the item list in this section by pressing either the ENTER key or the UP arrow key. The list items can then be scrolled through using the UP arrow key. Once the last item is reached, the list wraps around and the first list item is shown again. The items in the menu sections are organized such that more frequently used functions are first, while more permanent function settings are later in the list. See Figure 8 for a visual description of the software.

Each list item allows a change to a stored system variable. List items are designed in one of two forms: simple single variable, or multiple variable sequences. In the single variable format, the user can quickly modify one parameter - for example, changing temperature display units from °F to °C. In the multiple variable sequence, variables are changed as the result of some process. For example, the calibration of ORP generally requires more than one piece of information to be entered. The majority of the menu items in the software consist of the single variable format type.

Any data that may be changed will be flashing. This flashing indicates user entry mode and is initiated by pressing the ENTER key. The UP arrow key will increase a flashing digit from 0 to 9. The LEFT arrow key moves the flashing digit from right to left. Once the change has been completed, pressing ENTER again stores the variable and stops the flashing. Pressing ESC aborts the change and also exits user entry mode.

The starting (default) screen is always the Measure Menu. The UP arrow key is used to select the desired display. From anywhere in this section the user can press the MENU key to select one of the four Menu Sections.

The UP arrow icon next to all list items on the display is a reminder to scroll through the list using the UP arrow key.

To select a list item for modification, first select the proper menu with the MENU key. Scroll to the list item with the UP arrow key and then press the ENTER key. This tells the system that the user wishes to perform a change on that item. For single item type screens, once the user presses the ENTER key, part or all of the variable will begin to flash, indicating that the user may modify that variable using the arrow keys. However, if the instrument is locked, the transmitter will display the message **Locked!** and will not enter user entry mode. The instrument must be unlocked by entering the proper code value to allow authorized changes to user entered values. Once the variable has been reset, pressing the ENTER key again causes the change to be stored and the flashing to stop. The message **Accepted!** will be displayed if the change is within pre-defined variable limits. If the user decides not to modify the value after it has already been partially changed, pressing the ESC key aborts the modification and returns the entry to its original stored value.

In a menu item which is a multiple variable sequence type, once the ENTER key is pressed there may be several prompts and sequences that are run to complete the modification. The ESC key can always be used to abort the sequence without changing any stored variables.

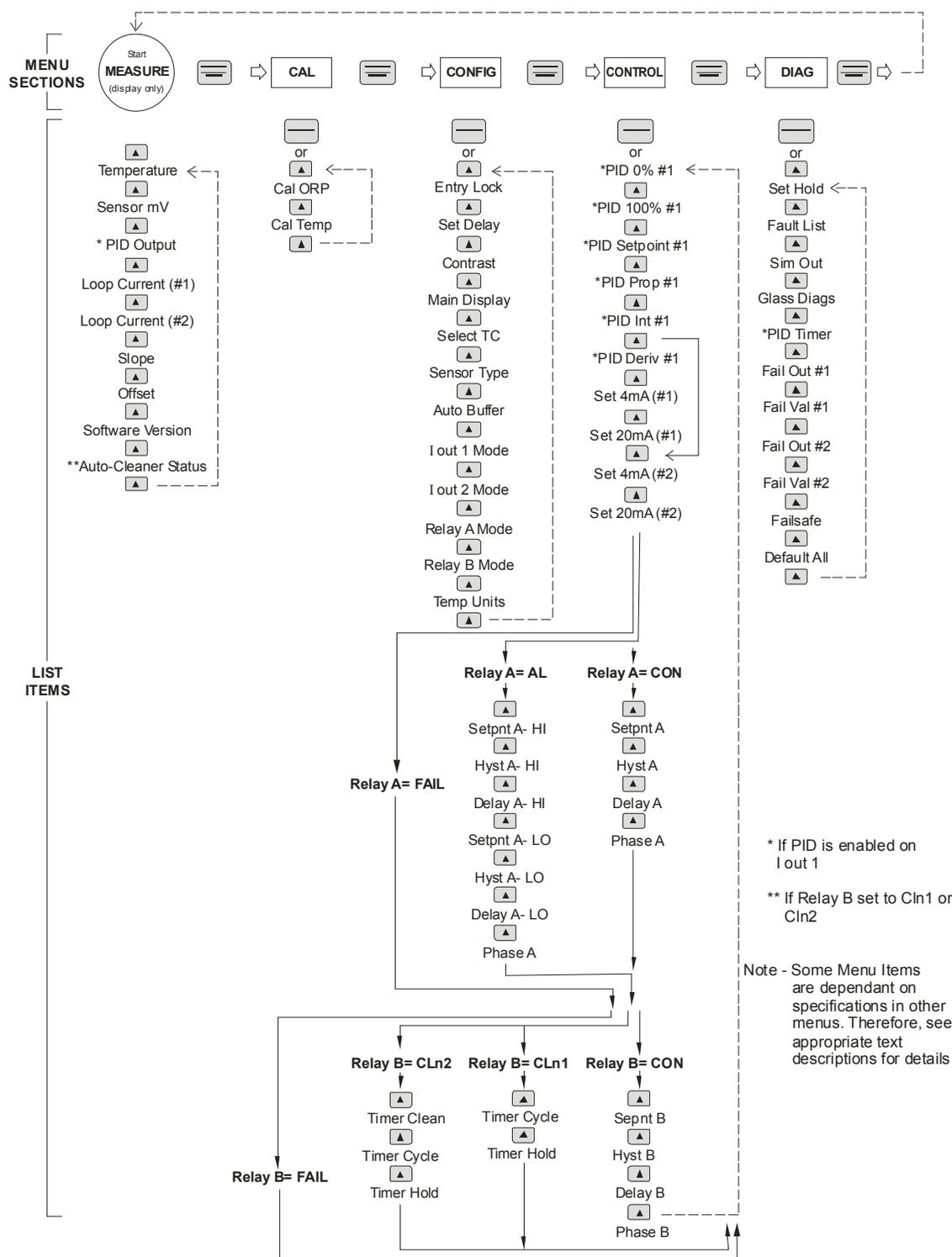


Figure 8 - Software Map

4.22 Measure Menu [MEASURE]

The default menu for the system is the display-only menu MEASURE. This menu is a display-only measurement menu, and has no changeable list items. When left alone, the instrument will automatically return to this menu after approximately 30 minutes. While in the default menu, the UP arrow allows the user to scroll through the secondary variables on the lower line of the display. A brief description of the fields in the basic transmitter version is as follows:

TRANSMITTER MEAS SCREENS:

25.7°C	Temperature display. Can be displayed in °C or °F, depending on user selection. A small “m” on the left side of the screen indicates the transmitter has automatically jumped to a manual 25°C setting due to a failure with the temperature signal input.
+132 mV	Raw sensor voltage. Useful for diagnosing problems.
20.00 mA	Transmitter output current.
Q45R v4.01	Transmitter software version number.
Tcyc 0.9mn	Auto-Clean status screen (if enabled on relay-based unit.)

Note: A display test (all segments ON) can be actuated by pressing and holding the ENTER key while viewing the model/version number on the lower line of the display.

For the relay-based analyzer version, or the portable battery powered version of the transmitter, the screens are basically the same, with additions to show two analog outputs instead of one (#1 and #2.)

The MEASURE screens are intended to be used as a very quick means of looking up critical values during operation or troubleshooting.

4.23 Calibration Menu [CAL]

The calibration menu contains items for frequent calibration of user parameters. There are three items in this list: Cal ORP, Cal Temp, and Cal TC Factor.

Cal ORP The ORP calibration function allows the user to adjust the transmitter offset and span reading to match reference buffers, or to adjust the sensor offset to match the sample reading. See Part 5 - Calibration for more details.

Cal Temp The temperature calibration function allows the user to adjust the offset of the temperature response by a small factor of ± 5 °C. The temperature input is factory calibrated to very high accuracy. However, long cable lengths and junction boxes may degrade the accuracy of the temperature measurement in some extreme situations. Therefore, this feature is provided as an adjustment. See Part 5 - Calibration for more details.

4.24 Configuration Menu [CONFIG]

The Configuration Menu contains all of the general user settings:

Entry Lock This function allows the user to lock out unauthorized tampering with instrument settings. All settings may be viewed while the instrument is locked, but they cannot be modified. The Entry Lock feature is a toggle-type setting; that is, entering the correct code will lock the transmitter and entering the correct code again will unlock it. The code is preset at a fixed value. Press ENTER to initiate user entry mode and the first digit will flash. Use arrow keys to modify value. **See end of manual for the Q45R lock/unlock code.** Press ENTER to toggle lock setting once code is correct. Incorrect codes do not change state of lock condition.

Set Delay The delay function sets the amount of damping on the instrument. This function allows the user to apply a first order time delay function to the ORP measurements being made. Both the display and the output value are affected by the degree of damping. Functions such as calibration are not affected by this parameter. The calibration routines contain their own filtering and stability monitoring functions to minimize the calibration timing. Press ENTER to initiate user entry mode, and the value will flash. Use the arrow keys to modify value; range is 0.1 to 9.9 minutes. Press ENTER to store the new value.

Contrast This function sets the contrast level for the display. The custom display is designed with a wide temperature range, Super-Twist Nematic (STN) fluid.

The STN display provides the highest possible contrast and widest viewing angle under all conditions. Contrast control of this type of display is generally not necessary, so contrast control is provided as a means for possible adjustment due to aging at extreme ranges. In addition, the display has an automatic temperature compensation network. Press ENTER to initiate user entry mode, and the value will flash. Use arrow keys to modify the value; range is 0 to 8 (0 being lightest). Press ENTER to update and store the new value.

Main Display

This function allows the user to change the measurement in the primary display area. The user may select between ORP, sensor temperature, or output current. Using this function, the user may choose to put temperature in the main display area and ORP on the secondary, lower line of the display. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired display value. Press ENTER to store the new value.

Select TC

This function allows the user to select either a Pt1000 or Pt100 platinum RTD temperature element. The Pt1000 element is the standard element in all high performance Q25 sensors; it is the recommended temperature sensing element for all measurements. The Pt100 selection is provided as an alternative for use with existing combination-style sensors. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired value. Press ENTER to store the new value.

Sensor Type

This function sets the sensor input type. This selection is critical for control of the internal diagnostics and compensation factors. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired value. Selections are **1** for Q25R sensor, **2** for combination electrode. Press ENTER to store the new value.

Iout#1 Mode

This function sets analog output #1 to either track ORP (default) or enables the PID controller to operate on the ORP input. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired value; selections include 1-ORP for ORP tracking or 2-PID for ORP PID control. Press ENTER to store the new value.

***Iout#2 Mode** This function sets analog output #2 for either temperature (default) or ORP. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired value; selections include 1-C/F for temperature or 2-ORP for ORP. Press ENTER to store the new value.

***Rly A Mode** Relay A can be used in three different ways: as a setpoint control, as a fail alarm, or as a HI-LO alarm band. The three settings for Rly A Mode are **CON**, **FAIL** and **AL**.

The **CON** setting enables normal control operation for Relay A, with settings for setpoint, hysteresis, delay and phasing appearing in the CONFIG menu automatically. See Figure 9 for further details.

The **FAIL** setting enables the fail alarm mode for Relay A. Relay A will then trip on any condition that causes the FAIL icon to be displayed on the LCD. Using this mode allows the User to send alarm indications to other remote devices.

The **AL** setting allows two setpoints to be selected for the same relay, producing a HI-LO alarm band. In this mode, Relay A will trip inside or outside of the band, depending upon the Phase selected. See Figure 10 for further details.

***Relay B Mode** Relay B in Auto-Clean Monitors is used to activate the air-wash cleaning system that keeps the sensor operating properly. This relay should normally be set to **CLn1** Mode for normal cleaning. Do not change the factory setting for this relay without first consulting ATI or your ATI representative

Temp Units This function sets the display units for temperature measurement. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired display value. The choices are °F and °C. Press ENTER to store the new value.

4.25 Control Menu [CONTROL]

The Control Menu contains all of the output control user settings:

Set PID 0%
Set PID 100%

[lout1=PID]

If the PID is enabled, this function sets the minimum and maximum controller end points. Unlike the standard 4-20 mA output, the controller does not “scale” output values across the endpoints. Rather, the endpoints determine where the controller would normally force minimum or maximum output in an attempt to recover the setpoint (even though the controller can achieve 0% or 100% anywhere within the range.)

If the 0% point is lower than the 100% point, then the controller action will be “reverse” acting. That is, the output of the controller will increase if the measured value is less than the setpoint, and the output will decrease if the measured value is larger than the setpoint. Flipping the stored values in these points will reverse the action of the controller to “direct” mode.

The entry value is limited to a value within the range specified in “Set Range”, and the 0% and the 100% point must be separated by at least 1% of this range Use the LEFT arrow key to select the first digit to be modified. Then use the UP and LEFT arrow keys to select the desired numerical value. Press ENTER to store the new value.

PID Setpnt

[lout1=PID]

The measured value which the controller is attempting to maintain by adjusting output value. It is the nature of the PID controller that it never actually gets to the exact value and stops. The controller is continually making smaller and smaller adjustments as the measured value gets near the setpoint.

PID Prop

[lout1=PID]

Proportional gain factor. The proportional gain value is a multiplier on the controller error (difference between measured value and setpoint value.) Increasing this value will make the controller more responsive.

PID Int

[lout1=PID]

Integral is the number of “repeats-per-minute” of the action of the controller. It is the number of times per minute that the controller acts on the input error. At a setting of 2.0 rpm, there are two repeats every minute. If the integral is set to zero, a fixed offset value is added to the controller (manual reset.) Increasing this value will make the controller more responsive.

PID Deriv
[lout1=PID]

Derivative is a second order implementation of Integral, used to suppress “second-order” effects from process variables. These variables may include items like pumps or mixers that may have minor impacts on the measured value. The derivative factor is rarely used in water treatment process, and therefore, it is best in most cases to leave it at the default value. Increasing this value will make the controller more responsive.

Set 4 mA
Set 20 mA
[lout1=ORP]

These functions set the main 4 and 20 mA current loop output points for the transmitter. The units displayed depend on the selection made in the CONFIG menu for lout #1 Mode. Also, when the Relay Option Board is installed, the units will also display **#1 or #2** – since there are actually two analog outputs present in this version.

The value stored for the 4 mA point may be higher or lower than the value stored for the 20 mA point. The entry values are limited to values within the range specified in “Set Range”, and the 4 mA and the 20 mA point must be separated by at least 1% of this range Use the LEFT arrow key to select the first digit to be modified. Then use the UP and LEFT arrow keys to select the desired numerical value. Press ENTER to store the new value.

***Set 4 mA #2**
***Set 20 mA #2**
[temp/ORP]

These functions set the second 4 mA and 20 mA current loop output points for the transmitter. The output may be set to track temperature (default) or ORP. The values stored for the 4 mA point may be higher or lower than the value stored for the 20 mA point.

The entry value is limited to a value between 0 and 55 °C if it is set for temperature and must be within -1000 to +2000 mV if set to track ORP. The 4 mA and the 20 mA point must be at least 20 units away from each other. Press ENTER to initiate user entry mode, and the value will flash. Use arrow keys to modify value. Press ENTER to store the new value.

NOTE: If the temperature units are changed between °C and °F (see Temp Units in this section), the default settings for this output will be stored (present data is not converted.)

NOTE: If the battery board option is installed, the menu will be shown as **Set 0 V #2** – since the battery board has two 0-2.5Vdc voltage output signals instead of current outputs.

***A Setpoint**

This function establishes the ORP trip point for relay A. The entry value is limited to a value within the range specified in “Set Range”. Use the LEFT arrow key to select the first digit to be modified. Then use the UP and LEFT arrow keys to select the desired numerical value. Press ENTER to store the new value.

***A Hysteresis**

This function establishes the hysteresis, or “deadband”, for Relay A. Hysteresis is most often used to control relay chattering; however, it may also be used in control schemes to separate the ON/OFF trip points of the relay. Press ENTER to initiate user entry mode, and the value will flash. Use the arrow keys to modify value. Press ENTER to store the new value.

***A Delay**

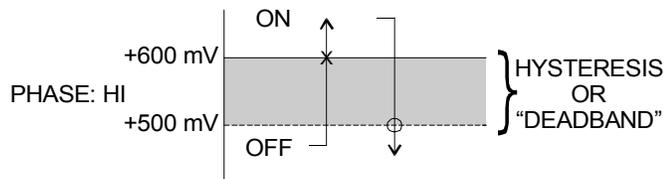
This function places an additional amount of time delay on the trip point for relay A. This delay is in addition to the main delay setting for the controller. The entry value is limited to a value between 0 and 999 seconds. Press ENTER to initiate user entry mode, and the value will flash. Use arrow keys to modify value; range is 0 to 999 seconds. Press ENTER to store the new value.

***A Phasing**

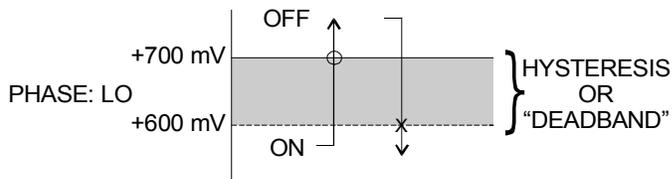
This function establishes the direction of the relay trip. When phase is HI, the relay operates in a direct mode. Therefore, the relay energizes and the LCD indicator illuminates when the ORP value **exceeds** the setpoint. When the phase is LO, the relay energizes and the LCD indicator illuminates when the ORP level drops **below** the setpoint. The failsafe setting does have an impact on this logic. The description here assumes the failsafe setting is OFF. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired value; selections include **HI** for direct operation or **LO** for reverse operation. Press ENTER to store the new value.

See Figure 9 for a visual description of a typical control relay application.

When value rises to $\geq +600$ mV, relay closes.



When value falls to $\leq +600$ mV, relay opens.



When value falls to $\leq +500$ mV, relay opens.

When value rises to $\geq +700$ mV, relay closes.

Setpoint: +600 mV
 Hyst: +100 mV
 Delay: 000
 Failsafe: OFF

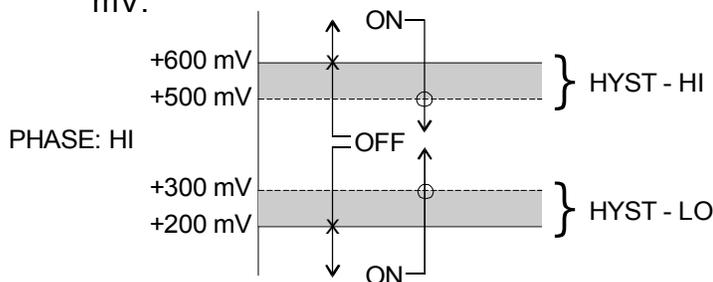
Figure 9 - Control Relay Example, Hysteresis & Two Opposite Phase Options

- *Setpnt A-HI
- *Hyst A-HI
- *Delay A-HI
- *Setpnt A-LO
- *Hyst A-LO
- *Delay A-LO

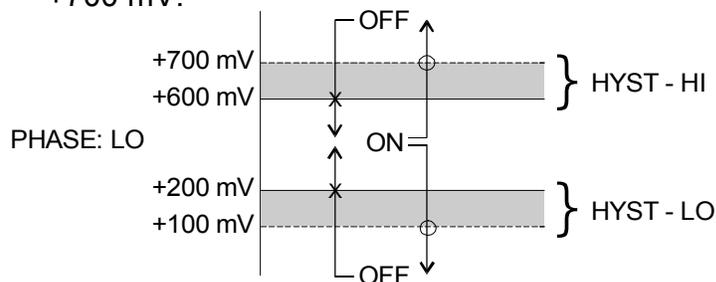
If Relay A Mode is set to Alarm Mode, **AL**, then the following settings will appear in the Config Menu list automatically. In this mode, two setpoints can be selected on the same relay, to create an alarm band. Phase HI selection causes the relay to energize outside of the band, and Phase LO causes the relay to energize inside of the band. This feature enables one relay to be used as a control relay while the other is used as a HI-LO Alarm relay at the same time. Setpoint A-LO must be set lower than Setpoint A-HI. When AL mode is first selected, Setpoint A-LO is defaulted to 0.

Figure 10 is a visual description of a typical alarm relay application.

When value rises to $\geq +600$ mV, relay closes, until value falls back to $\leq +500$ mV.



When value falls to $\leq +600$ mV, relay closes, until rises back to $\geq +700$ mV.



When value falls to $\leq +200$ mV, relay closes, until rises back to $\geq +300$ mV.

When value rises to $\geq +200$ mV, relay closes. until value falls back to $< +100$

Setpoint A-HI: +600 mV
 Hyst A-HI: +100 mV
 Delay A-HI: 000

Setpoint A-LO: +200 mV
 Hyst A-LO: +100 mV
 Delay A-LO: 000

Figure 10 - Alarm Relay Example

- *Timer B CLEAN
- *Timer B CYCLE
- *Timer B HOLD

When Relay B is set to **CLn1** mode (Factory Default), Submenu **Timer B CLEAN** is not active. When Relay B is set to **CLn2** (For Customer supplied Air Delivery Source) all three submenu Timer B settings appear in the CONTROL menu list.

Relay B will toggle open/closed based on the time settings entered by the user. The timer CLEAN setting controls the amount of time that Relay B is engaged (N.O. contact closed), and the timer CYCLE setting controls the amount of time that Relay B is released (N.O. contact open.)

The timer HOLD setting allows an output hold time to be entered into the cleaning cycle. This hold time allows the outputs to stabilize back to normal readings before the outputs are released from their “hold” state. Using this feature properly avoids disturbing any instruments connected to the outputs during the cleaning cycle – where ORP readings can fluctuate.

To change the values for Timer CLEAN, CYCLE, and HOLD, press ENTER to initiate user entry mode, and entire value will flash. Use the UP arrow key to modify the desired value. Selections for each variable are: CLEAN 1-10 minutes, CYCLE 1-999 hours, HOLD 0-999 minutes. Press ENTER to store the new value

Example: If the timer-CLEAN setting is 1 minute, the timer CYCLE setting is 24 hours, and the timer-HOLD setting is 3 minutes, the following sequence will occur: At the instant the timer is enabled (or data for the CLEAN/CYCLE/HOLD is modified) the “CYCLE” time period begins. Once the 24-hour CYCLE period ends, the outputs will be put in hold and relay B will engage for 1 minute (CLEAN time.) After the 1 minute has expired, relay B will be released but the hold will stay locked in for an additional 3 minutes (HOLD time), retaining the original output signals. Once the 3 minutes expire, the outputs will be released back to the normal monitoring state. Then, the entire cycle will repeat – approximately once per day.

Note: The sensor wash timer is not based on a “real-time” clock circuit. Therefore, the time accuracy is only within about 10 minutes per day.

Note: A timer wash cycle can be manually started by pressing and holding the ENTER key for a few seconds while viewing the timer status screen in the MEAS menu. The timer must be in the “Tcyc” state to allow a manual start. After this forced cycle, the system will return to normal.

If the B mode selection is changed while the sensor wash timer is in mid-cycle (and the HOLD is enabled), the HOLD must be turned off manually to return all of the outputs to normal operation. A flashing “T” will be seen on the lower line of the display next to temperature while the probe cleaner function is operating.

4.26 Diagnostics Menu [DIAG]

The diagnostics menu contains all of the user settings that are specific to the system diagnostic functions, as well as functions that aid in troubleshooting application problems.

Set Hold

The Set Hold function locks the current loop output values on the present process value. This function can be used prior to calibration, or when removing the sensor from the process, to hold the output in a known state. Once HOLD is released, the outputs return to their normal state of following the process input. The transfer out of HOLD is bumpless on the both analog outputs - that is, the transfer occurs in a smooth manner rather than as an abrupt change. An icon on the display indicates the HOLD state, and the HOLD state is retained even if power is cycled. Press ENTER to initiate user entry mode, and entire value will flash. Use the UP arrow key to modify the desired value, selections are **ON** for engaging the HOLD function, and **OFF** to disengage the function. Press ENTER to store the new value.

Note: When the Relay Option Board is installed, the Set Hold function holds BOTH current levels, as well as ALL relay settings.

The Set Hold function can also hold at an output value specified by the user. To customize the hold value, first turn the HOLD function on. Press the ESC key to go to the DIAG Menu and scroll to Sim Output using the UP arrow key. Press ENTER. Follow the instructions under Sim Output (see following page).

Fault List

The Fault List screen is a read-only screen that allows the user to display the cause of the highest priority failure. The screen indicates the number of faults present in the system and a message detailing the highest priority fault present. Note that some faults can result in multiple displayed failures due to the high number of internal tests occurring. As faults are corrected, they are immediately cleared.

Faults are not stored; therefore, they are immediately removed if power is cycled. If the problem causing the faults still exists, however, faults will be displayed again after power is re-applied and a period of time elapses during which the diagnostic system re-detects them. The exception to this rule is the calibration failure. When a calibration fails, no corrupt data is stored. Therefore, the system continues to function normally on the data that was present before the calibration was attempted.

After 30 minutes or if power to the transmitter is cycled, the failure for calibration will be cleared until calibration is

attempted again. If the problem still exists, the calibration failure will re-occur. Press ENTER to initiate view of the highest priority failure. The display will automatically return to normal after a few seconds.

Sim Out

The Sim Out function allows the user to simulate the ORP level of the instrument in the user selected display range. The user enters an ORP value directly onto the screen, and the output responds as if it were actually receiving the signal from the sensor. This allows the user to check the function of attached monitoring equipment during set-up or troubleshooting. Escaping this screen returns the unit to normal operation. Press ENTER to initiate the user entry mode, and the right-most digit of the value will flash. Use arrow keys to modify desired value.

The starting display value will be the last read value of the input. The output will be under control of the SIM screen until the ESC key is pressed.

Note: If the HOLD function is engaged before the Sim Output function is engaged, the simulated output will remain the same even when the ESC key is pressed. Disengage the HOLD function to return to normal output.



NOTE: If the HOLD function is engaged before the Sim Output function is engaged, the simulated output will remain the same even when the ESC key is pressed. Disengage the HOLD function to return to normal output.

Glass Diags

This function allows the user to shut off the glass breakage/leak diagnostics. It does not affect the state of the remaining system diagnostics. This capability is provided to eliminate nuisance trips in electrically noisy applications, such as some plating operations. If ON, Relay B is automatically configured as a fail alarm relay. The relay trips on any fail condition. Therefore, the normal settings for control Relay B will disappear from the CONFIG menu since they cannot be used.

Note that the probe timer function can also alter the operation of Relay B. If the electrode diagnostic function is enabled, that function takes precedence over the probe timer.

Note that the probe timer function can also alter the

operation of Relay B. If the electrode diagnostic function is enabled, that function takes precedence over the probe timer.

PID Timer

This function sets a timer to monitor the amount of time the PID controller remains at 0% or 100%. This function only appears if the PID controller is enabled. If the timer is set to 0000, the feature is effectively disabled. If the timer value is set to any number other zero, a FAIL condition will occur if the PID controller remains at 0% or 100% for the timer value. If one of the relays are set to FAIL mode, this failure condition can be signaled by a changing relay contact.

Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify desired value; range of value is 0-9999 seconds. Press ENTER to store the new value

Fail Out

This function enables the user to define a specified value that the main current output will go to under fault conditions. When the Relay Option Board is installed, the display will read **Fail Out #1**. When enabled to **ON**, the output may be forced to the current value set in **Fail Val** (next item.) With the Fail Out setting of ON, and a Fail Val setting of 6.5 mA, any alarm condition will cause the current loop output to drop outside the normal operating range to exactly 6.5 mA, indicating a system failure that requires attention.

Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify desired value; selections are **ON, OFF**. Press ENTER to store the new value.

Fail Val

Sets the output failure value for lout#1. When **Fail Out** above is set to **ON**, this function sets value of the current loop under a FAIL condition. When the Relay Option Board is installed, the display will read **Fail Out #1**. The output may be forced to any current value between 4-20 mA.

Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify desired value; selections are between **4mA**, and **20mA**. Press ENTER to store the new value.

- Fail Out #2** This function sets the fail-mode of current loop output #2 under a FAIL condition. The settings and operation are identical to Fail Out for output #1.
- Fail Val #2** This function sets the value of current loop output #2 under a FAIL condition. The settings and operation are identical to Fail Out for output #1.
- *Failsafe** This function allows the user to set the optional system relays to a failsafe condition. In a failsafe condition, the relay logic is reversed so that the relay is electrically energized in a normal operating state. By doing this, the relay will not only change state when, for example, an ORP limit is exceeded, but also when power is lost to the controller.
- When failsafe is selected to be ON, the normally-open contacts of the relay will be closed during normal operation. In an attempt to make this configuration less confusing, the LCD icon logic is reversed with this setting, and the icon is OFF under this normal condition. Therefore, when the trip condition occurs, the closed N.O. contacts will be opened (relay de-energized), and the LCD icon will illuminate. In addition, a power fail would also cause the same contacts to open.
- Set Default** The Set Default function allows the user to return the instrument back to factory default data for all user settings. It is intended to be used as a last resort troubleshooting procedure. All user settings are returned to the original factory values. Hidden factory calibration data remains unchanged. Press ENTER to initiate user entry mode and the value **NO** will flash. Use the UP arrow key to modify value to **YES** and press ENTER to reload defaults.

Part 5 – Calibration

5.1 Overview and Methods

The instrument must be calibrated periodically to maintain a high degree of measurement accuracy. Frequency of calibration must be determined by the application. High temperature applications or applications involving other extreme operating conditions may require more frequent calibration than those that operate at more ambient level temperatures. It is important for the user to establish a periodic cleaning and calibration schedule for sensor maintenance to maintain high system accuracy.

Before calibrating the instrument for the very first time after initial installation, it is important to select the proper operating parameters in the configuration menus for items like Sensor Type.

ORP calibration solutions can be one of two types: standard mV solutions, or standard pH buffers with quinhydrone powder added. For all 2-point calibrations, mV solutions must be at least 100 mV apart. When using quinhydrone powder, add slowly to the pH buffer until just after the quinhydrone ceases to dissolve (approximately 1 tsp. quinhydrone per pint of buffer). Use the following table as a guideline for reference mV values at nominal pH values:.

4 pH			7 pH		
20 °C	25 °C	30 °C	20 °C	25 °C	30 °C
+268 mV	+263 mV	+258 mV	+92 mV	+86 mV	+79 mV

CAUTION: Quinhydrone is highly acidic. Follow all safety instructions on Material Safety Data Sheets.

5.11 Sensor Slope

The sensor slope is a number (expressed as a percentage) which represents the current condition of the sensor electrodes. The slope display is updated after every calibration. When new, the sensor slope should be between 90% and 110%. A 100% slope represents an ideal sensor output of 1 mV/1 mV for displayed data vs. factory calibration data.

The slope of the ORP electrode does not degrade appreciably over the life of the sensor (as compared to a pH sensor), since the measuring element of the sensor is basically an exposed metal electrode. However, a very small slope degradation can occur over a long period of time as the glass reference electrode ages. Slope calibrations can remove this error along with very small inherent gain errors in the sensor preamp and electrodes. The transmitter will not allow calibrations on a sensor with a slope less than 60% or more than 140%. ORP sensor slope is only shown at the completion of a successful calibration.

5.12 Sensor Offset

Sensor offset is a number that indicates sensor output (expressed in mV) in a theoretical 0 mV solution at 25 °C. Ideally, the sensor will output 0 mV under these conditions. A sensor offset reading of +10 mV indicates that the sensor will output +10 mV when placed into a theoretically perfect 0 mV solution at 25 °C. In other words, sensor offset shifts the entire response curve up or down. Changes in sensor offset are generally produced by a small voltage drop at the sensor reference junction. Large offsets are most typically the result of foulants on the reference junction, an aged reference junction, or a weak reference fill solution. The instrument does not allow calibrations on a sensor with an offset greater than approximately +200 mV or less than –200 mV. Since sensor offset is considered an absolute value from the ideal 0 mV value, readings outside the range of –200 to +200 mV are considered “high offset” errors during calibration. Sensor offset information from the most recent calibration can be viewed at any time in the Default Menu (see Section 4.22).

The system provides two methods of ORP calibration: 2-point and 1-point. These two methods are significantly different. The following are brief explanations of their uses.

5.13 2-Point Calibration Explained

The 2-point calibration method involves the movement of the sensor through two known mV solution values. Therefore, the sensor must be removed from the application to utilize this method. Two-point calibration adjusts both the slope and the offset of the sensor. Although this method obtains the highest accuracy, it is not recommended for frequent calibrations as the slope of the ORP sensor does not degrade appreciably over time. In addition, problems can occur in some 2-point calibrations when two different mV solutions mix in the saltbridge of the sensor. A precipitant can be formed which can affect offset voltages in the reference junction.

5.14 1-Point Calibration Explained

The 1-point calibration method is generally known as the "grab sample" calibration method. In the 1-point calibration method, the sensor may be removed from the application and placed into one mV solution. It may also be left in the measurement process and calibrated by reference. 1-point calibration adjusts only the sensor offset. It is the recommended method for frequent ORP calibrations.

5.2 Performing a 2-Point Calibration

Two-point calibration adjusts both the slope and the offset of the sensor. Slope relates to how closely the system matches displayed mV with actual mV. Offset is the actual difference over the entire output curve between actual and displayed mV. Two point calibrations are not recommended for frequent calibrations as the slope of the ORP sensor does not degrade appreciably over time. However, two-point calibration does provide the highest level of accuracy.

Procedure

1. Remove sensor from application. Rinse and clean if necessary.
2. Allow sensor to temperature equilibrate with the buffer as best as possible. With the sensor coming from an application solution that differs greatly in temperature from the buffer, the user may have to wait as much as 20 minutes for this to occur.
3. Scroll to the CAL menu section using the MENU key and press ENTER or the UP arrow key. **Cal ORP** will then be displayed.
4. Press the ENTER key. The screen will display a flashing 1 for 1-point or a 2 for 2-point calibration. Using the UP arrow key, set for a 2-point calibration and press ENTER.



5. The display will prompt the user to place the sensor in the first buffer and press ENTER. If the sensor has been placed into this buffer already, once the temperature has stabilized, press ENTER to continue.
6. The present ORP value will be displayed and the secondary line of the display will flash **Wait** for approximately 10-15 seconds. At this time the system is attempting to recognize the first buffer value from the two values entered into the Set Buffers selection.
7. The screen will display the buffer value to be used for calibration. If the user chooses to change this value, the arrow keys can be used to modify the value. Any value between -1000 and +2000 mV can be entered. After adjusting this value, or to accept the automatic value, press ENTER.
8. The system now begins acquiring data for the calibration value of this buffer point. As data is gathered, the units for ORP and temperature may begin to flash. Flashing units indicates that this parameter is unstable. The data point acquisition will stop only when the data remains stable for a pre-determined amount of time. This can be overridden by pressing ENTER. If the data remains unstable for 10 minutes, the calibration will fail and the message **Cal Unstable** will be displayed.
9. Once the first calibration value has been established, the screen will prompt the user to move the sensor to the second buffer. At this point, rinse sensor with water and move the sensor into the second buffer solution. Allow temperature to stabilize, then press ENTER.
10. The present ORP value will be displayed and the secondary line of the display will flash **Wait** for approximately 10-15 seconds. At this time the system is attempting to recognize the second buffer value from the two values entered into the Set Buffers selection.
11. The screen will display the buffer value to be used for calibration. If the user chooses to change this value, the arrow keys can be used to modify the value. Any value between -1000 and +2000 mV can be entered. The second buffer must be at least 2 ORP units away from the first. After adjusting this value, or to accept the automatic value, press ENTER.
12. The system now begins acquiring data for the calibration value of this buffer point. As data is gathered, the units for ORP and/or temperature may again flash, indicating unstable parameters.
13. If accepted, the screen will display the message **PASS** with the new slope and offset readings, then it will return to the main measurement display. If the calibration fails, a message indicating the cause of the failure will be displayed and the FAIL icon will be turned on.

5.3 Performing a 1-Point Calibration

The 1-point, or sample calibration method is intended to be used as an on-line calibration method. However, the sensor can be removed and calibrated in a separate solution. During calibration, the system will display the current mV reading and the user can manually enter a reference value from a lab grab-sample or a comparative reference instrument.

Procedure

1. Determine whether the calibration will be done on-line or with the sensor removed and placed into a buffer. If the sensor is removed from the application, rinse and clean if necessary.
2. If the sensor has been removed and placed into a buffer, allow sensor to temperature equilibrate with the buffer as much as possible. With the sensor coming from an application which differs greatly in temperature difference, the user may have to wait as much as 20 minutes. If the sensor is on-line, the user may want to set the output HOLD feature prior to calibration to lock out any output fluctuations.
3. Scroll to the CAL menu section using the MENU key and press ENTER or the UP arrow key. **Cal ORP** will then be displayed.
4. Press the ENTER key. The screen will display a flashing 1 for 1-point or a 2 for 2-point calibration. Using the UP arrow key, set for a 1-point calibration and press ENTER.



5. The system now begins acquiring data for the calibration value. As data is gathered, the units for ORP and temperature may flash. Flashing units indicate that this parameter is unstable. The calibration data point acquisition will stop only when the data remains stable for a pre-determined amount of time. This can be overridden by pressing ENTER. If the data remains unstable for 10 minutes, the calibration will fail and the message **Cal Unstable** will be displayed.

6. The screen will display the last measured ORP value [or the auto buffer value, if activated] and a message will be displayed prompting the user for the lab value. The user must then modify the screen value with the arrow keys and press ENTER. The system then performs the proper checks.
7. If accepted, the screen will display the message **PASS** with the new offset reading, then it will return to the main measurement display. If the calibration fails, a message indicating the cause of the failure will be displayed and the FAIL icon will be turned on.

5.4 Temperature Calibration

The temperature input is factory calibrated for the highest accuracy. Temperature calibration is not recommended; however, it is provided for applications in which very long cable lengths are needed. For example, at 50 feet, readings may be off ± 0.2 °C.

The temperature calibration sequence is essentially a 1-point offset calibration that allows adjustments of approximately ± 5 °C.

The sensor temperature may be calibrated on line, or the sensor can be removed from the process and placed into a known solution temperature reference. In any case, it is critical that the sensor be allowed to reach temperature equilibrium with the solution in order to provide the highest accuracy. When moving the sensor between widely different temperature conditions, it may be necessary to allow the sensor to stabilize as much as one hour before the calibration sequence is initiated. If the sensor is on-line, the user may want to set the output HOLD (see section 4.26) feature prior to calibration to lock out any output fluctuations.

Procedure

1. Scroll to the CAL menu section using the MENU key and press ENTER or the UP arrow key.
2. Press the UP arrow key until **Cal Temp** is displayed.
3. Press the ENTER key. The message **Place sensor in solution then press ENTER** will be displayed. Move the sensor into the calibration reference (if it hasn't been moved already) and wait for temperature equilibrium to be achieved. Press ENTER to begin the calibration sequence.
4. The message **Adjust temp value then press ENTER** will be displayed, and the right-most digit will begin to flash, indicating that the

value can be modified. Using the UP and LEFT arrow keys, modify the value to the known ref solution temperature. Adjustments up to ± 5 °C from the factory calibrated temperature are allowed. Press ENTER.

5. The calibration data gathering process will begin. The message **Wait** will flash as data is accumulated and analyzed. The °C or °F symbol may flash periodically if the reading is too unstable.
6. Once completed, the display will indicate **PASS** or **FAIL**. If the unit fails, the temperature adjustment may be out of range, the sensor may not have achieved complete temperature equilibrium, or there may be a problem with the temperature element. In the event of calibration failure, it is recommended to attempt the calibration again immediately.

Part 6 – Sensor Cleaning System

6.1 General

The cleaner control system located in the ORP system enclosure contains a number of components designed to supply pulses of high pressure air to the tip of the sensor. The main components and their function are as follows:

Compressor: The air compressor is a small AC powered diaphragm type compressor that delivers air at up to 40 PSI to the accumulator cylinder which is part of the system. The compressor cannot provide an output above 40 PSI (2.6 Bar) so no special pressure relief is required in the system.

Accumulator: The accumulator is a 3 1/2" diameter stainless steel chamber that is pressurized with air from the compressor. The accumulator allows a relatively high volume of air to be delivered with each cleaning pulse, increasing the effectiveness of the cleaner.

Solenoid Valve: The solenoid valve on the outlet of the accumulator controls the flow of cleaning pulses to the nozzle located on the sensor assembly. The solenoid is opened and closed under the control of the sequencing module.

The operation of the cleaner control system is completely automatic. There are no customer adjustments required. The only requirement is that the ORP monitor be set for AUTO mode of operation and that the desired cleaning frequency be programmed.

6.2 Cleaner Sequence

The cleaner control system is designed to provide four 3-second pulses of pressurized air through a nozzle located within 1 inch of the sensor membrane. The nozzle directs the air blast at the center of the membrane, effectively blasting away accumulated coatings on the surface.

The cleaner sequence begins with the closure of relay B in the display module. This contact is connected to a sequence control circuit located in the terminal compartment of the monitor. The sequencing system contains a relay that turns on the compressor and releases air to the cleaner nozzle when the accumulator has been charged. The entire cycle takes about 90 seconds.

During the cycle, the compressor will run for 20 seconds to charge the accumulator. At this point, the sequencing system will open the solenoid valve for 3 seconds, discharging air through the solenoid valve and out to the cleaner nozzle at the sensor. This delivers a 3 second high velocity air blast across the membrane. After 3 seconds, the solenoid will close, allowing the accumulator to recharge for 20 seconds. This cycle repeats itself four times, after which the compressor shuts off. The solenoid will release the final air burst shortly after the compressor shuts off so that no pressure remains in the accumulator.

Once the air cleaning system has run through a cycle, it will remain in standby while waiting for the next activation signal from the ORP monitor. This will normally occur every 24 hours, but can be activated manually at any time as explained previously.

6.3 Cleaner Malfunction Alarm (Optional)

The Q45R can be supplied with an optional Clean Failure Detection alarm to indicate that the sensor cleaner system has failed to operate properly. This alarm circuit will indicate a failure condition if the Auto-Clean system fails to activate during a 24 hour period. The time period begins when power is applied to the unit.

The relay associated with this alarm is a SPST relay that can be configured with a jumper to operate either as a normally open (NO) or normally closed (NC) contact. The jumper is located inside the protective circuit cover in the terminal compartment of the monitor. Remove the cover of the compartment to access the jumper pins. The figure below indicates that the jumper needs to be removed to make the relay a Normally Open (NO) contact.

One method that can be used to remotely indicate a failure of the cleaner system is to use the fail relay to interrupt the 4-20 mA output wired to the central monitoring system. To do this, the relay must be configured for normally closed operation (Factory Default), as shown in the Figure below. The output signal is then wired through the normally closed relay as shown. A cleaner failure will result in the relay contacts opening, resulting in a loss of signal at the control system. A power failure at the ORP monitor would also result in a loss of this signal.

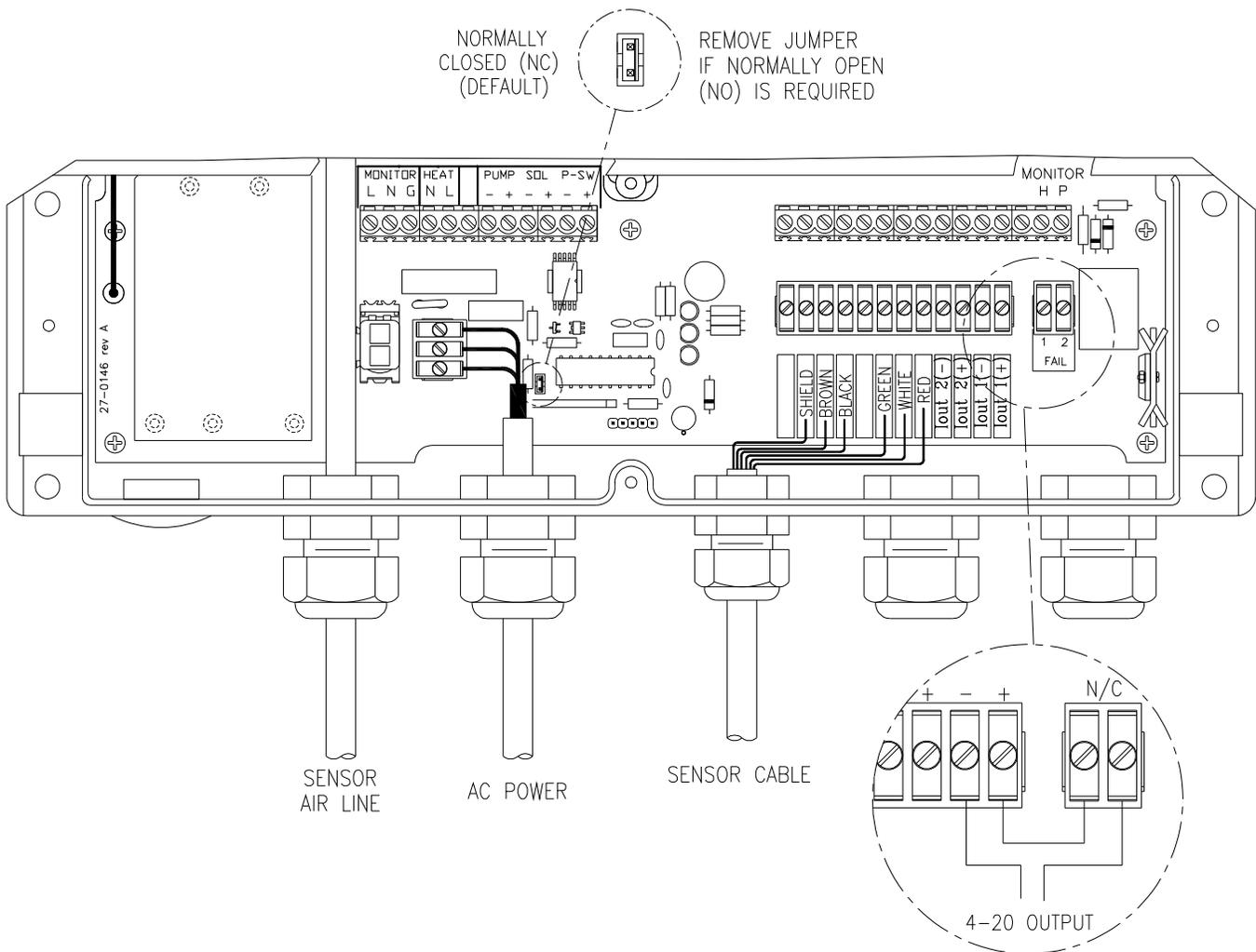


Figure 11 - Cleaner Failure 4-20 wiring & jumper map configuration

Part 7 – PID Controller Details

7.1 PID Description

PID control, like many other control schemes, are used in chemical control to improve the efficiency of chemical addition or control. By properly tuning the control loop that controls chemical addition, only the amount of chemical that is truly required is added to the system, saving money. The savings can be substantial when compared to a system which may be simply adding chemical at a constant rate to maintain some minimal addition under even the worst case conditions. The PID output controller is highly advantageous over simple control schemes that just utilize direct (proportional only) 4-20 mA output connections for control, since the PID controller can automatically adjust the “rate” of recovery based on the error between the setpoint and the measured value – which can be a substantial efficiency improvement..

The PID controller is basically designed to provide a “servo” action on the 4-20 mA output to control a process. If the user requires that a measured process stay as close as possible to a specific setpoint value, the controller output will change from 0% to 100% in an effort to keep the process at the setpoint. To affect this control, the controller must be used with properly selected control elements (valves, proper chemicals, etc.) that enable the controller to add or subtract chemical rapidly enough. This is not only specific to pumps and valves, but also to line sizes, delays in the system, etc.

This section is included to give a brief description of tuning details for the PID controller, and is not intended to be an exhaustive analysis of the complexities of PID loop tuning. Numerous sources are available for specialized methods of tuning that are appropriate for a specific application.

7.2 PID Algorithm

As most users of PID controllers realize, the terminology for the actual algorithm terms and even the algorithms themselves can vary between different manufacturers. This is important to recognize as early as possible, since just plugging in similar values from one controller into another can result in dramatically different results. There are various basic forms of PID algorithms that are commonly seen, and the implementation here is the most common version; The ISA algorithm (commonly referred to as the “ideal” algorithm.)

$$output = P \left[e(t) + \frac{1}{I} \int e(t) dt + D \frac{de(t)}{dt} \right]$$

Where:

output = controller output

P = proportional gain

I = integral gain

D = derivative gain

t = time

e(t) = controller error (e=measured variable – setpoint)

Figure 12 - Q45R ISA PID Equation

The most notable feature of the algorithm is the fact the proportional gain term affects all components directly (unlike some other algorithms - like the “series” form.) If a pre-existing controller utilizes the same form of the algorithm shown above, it is likely similar settings can for made if the units on the settings are exactly the same. Be careful of this, as many times the units are the reciprocals of each other (i.e. reps-per-min, sec-per-rep.)

PID stands for “proportional, integral, derivative.” These terms describe the three elements of the complete controller action, and each contributes a specific reaction in the control process. The PID controller is designed to be primarily used in a “closed-loop” control scheme, where the output of the controller directly affects the input through some control device, such as a pump, valve, etc.

Although the three components of the PID are described in the setting area (section 5.25), here are more general descriptions of what each of the PID elements contribute to the overall action of the controller.

P Proportional gain. With no “I” or “D” contribution, the controller output is simply a factor of the proportional gain multiplied by the input error (difference between the measured input and the controller setpoint.) Because a typical chemical control loop cannot react instantaneously to a correction signal, proportional gain is typically not efficient by itself – it must be combined with some integral action to be useful. Set the P term to a number between 2-4 to start. Higher numbers will cause the controller action to be quicker.

I Integral gain. Integral gain is what allows the controller to eventually drive the input error to zero – providing accuracy to the control loop. It must be used to affect the accuracy in the servo action of the controller. Like proportional gain, increasing integral gain results in the control action happening quicker. Set the I term to a number between 3-5 to start (1-2 more than P). Like proportional gain, increasing the integral term will cause the controller action to be quicker.

D Derivative gain. The addition of derivative control can be problematic in many applications, because it greatly contributes to oscillatory behavior. In inherently slow chemical control processes, differential control is generally added in very small amounts to suppress erratic actions in the process that are non-continuous, such as pumps and valves clicking on and off. However, as a starting point for chemical process control, it's best to leave the "D" term set to 0.

Therefore, based on these descriptions, the focus on tuning for chemical applications really only involves adjustment of "P" and "I" in most cases.

However, increasing both increases the response of the controller. The difference is in the time of recovery. Although combinations of high "P's" and low "I" will appear to operate the same as combinations of low "P's" and high "I's", there will be a difference in rate of recovery and stability. Because of the way the algorithm is structured, large "P's" can have a larger impact to instability, because the proportional gain term impacts all the other terms directly. Therefore, keep proportional gain lower to start and increase integral gain to achieve the effect required.

Many tuning techniques have the user start with all values at 0, and then increase the P term until oscillations occur. The P value is then reduced to $\frac{1}{2}$ of the oscillatory value, and the I term is increased to give the desired response. This can be done with the Q45D controller, with the exception that the I term should start no lower than 1.0.

If it appears that even large amounts of integral gain (>20) don't appreciably increase the desired response, drop I back to about 1.0, and increase P by 1.00, and start increasing I again. In most chemical control schemes, I will be approximately 3 times the value of P.

7.3 Classical PID Tuning

Unlike many high speed position applications where PID loops are commonly used, the chemical feed application employed by this instrument does not require intense mathematical exercise to determine tuning parameters for the PID. In fact, the risk of instability is far greater with overly tuned PID control schemes. In addition, many of the classical mathematical exercises can be damaging or wasteful in the use of chemicals when the process is bumped with large amounts of input error to seek a response curve. Because of this, the general adjustment guidelines described in section 7.2 are sufficient for almost all application tuning for this instrument. Beyond this, many sources are available for classical tuning methods.

7.4 Manual PID Override Control

The Q45 PID output function allows the user to take manual control of the PID control signal. This is often useful when starting up a control loop, or in the event that you wish to bump the system manually to measure system response time.

To access the manual PID control, you must be in the MEASURE mode of operation and you must have the PID output displayed on the lower line. This line will indicate “XX.X% XX.X mA” with the X values simply indicating the current values. With this display on the screen, press and hold the ENTER key for about 5 seconds. You will see a small “m” show up between the % value and the mA value. This indicates you are now in manual mode.

Once in manual, you may increase the PID output by pressing the UP arrow or you may decrease the output by pressing the LEFT arrow. This will allow you to drive the PID output to any desired setting.

To revert to normal PID control, press and hold the ENTER key again until the “m” indicator disappears.

7.5 Common PID Pitfalls

The most common problem occurring in PID control applications involves the false belief that proper settings on only the PID controller can balance any process to an efficient level.

Closed-loop control can only be effective if all elements in the loop are properly selected for the application, and the process behavior is properly understood. Luckily, the nature of simple chemical control process are generally slow in nature. Therefore, even a de-tuned controller (one that responds somewhat slow) can still provide substantial improvements to setpoint control. In fact, damaging oscillatory behavior is far more likely in tightly tuned controllers where the user attempted to increase response too much.

When deciding on a PID control scheme, it is important to initially review all elements of the process. Sticking valves, undersized pumps, or delays in reaction times associated with chemical addition can have a dramatic effect on the stability of the control loop. When controlling a chemical mix or reaction, the sensor should be placed in a location that ensures proper mixing or reaction time has occurred.

The easiest process' to control with closed-loop schemes are generally linear, and symmetrical, in nature. For example, controlling level in tank where the opening of valve for a fixed period of time corresponds linearly to the amount that flows into a tank. Chemical control process' can be more problematic when the nature of the setpoint value is non-linear relative to the input of chemical added. For example, pH control of a process may appear linear only in a certain range of operation, and become highly exponential at the extreme ranges of the measuring scale. In addition, if a chemical process is not symmetrical, that means it responds differently to the addition and subtraction of chemical. It is important in these applications to study steady-state impact as well as step-change impact to process changes. In other words, once the process has apparently been tuned under normal operating conditions, the user should attempt to force a dramatic change to the input to study how the output reacts. If this is difficult to do with the actual process input (the recommended method), the user can place the control in manual at an extreme control point such as 5% or 95%, and release it in manual. The recovery should not be overly oscillatory. If so, the loop needs to be de-tuned to deal with that condition (reduce P and/or I.)

Part 8– System Maintenance



WARNING: EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2.

8.1 System Checks

1. If the FAIL icon is flashing on the display, check the Fault List to determine the cause of the failure. To access the Fault List, press the MENU/ESC key until the DIAG menu appears. Then press the UP arrow key until the Fault List appears. Press the ENTER key to access the Fault List, and the highest priority fault message will be displayed. For a list of all messages and possible causes/solutions, refer to Section 6.3.
2. In **ALL** environments, connect an earth ground jumper to earth terminal connection on transmitter.
3. Perform a two-point calibration with two fresh buffers prior to sensor installation.
4. Check sensor cable color to terminal strip markings.
5. For highly unstable behavior, remove sensor from the process and measure the process solution in a plastic beaker. If the reading now stabilizes, place wire in beaker solution and actual process solution to determine if a ground loop exists.
6. Verify that the black rubber shipping boot has been removed from the end of the sensor prior to submersion. If the sensor has been left to dry out, allow sensor to be submerged in buffer or water to re-hydrate for at least 4 hours. The saltbridge may need replacement if the sensor has dried out for too long.
7. If the instrument 4-20 mA output is connected into other control systems, disconnect output loop from system load and run through a handheld DMM to monitor current. Verify that the system operates correctly in this mode first.

8.2 Instrument Checks

1. Remove sensor completely and connect 1100 Ohms from the yellow to black sensor input leads. Make sure the unit is configured for a Pt1000 thermal element and that the temperature is not in manual locked mode. Also, connect a wire jumper from the red cable lead input to the green cable lead input. The temperature reading should be approximately 25 °C, the ORP reading should be between -100 and +100 mV.
2. With a DMM, measure the DC voltage from the white sensor lead connection to the black sensor lead connection. With the positive DMM lead on the white wire, the meter should read between -4.5 and -5.5 VDC.
3. For the line powered version, verify the proper line voltage power. With power disconnected, verify continuity across the line fuse.
4. For the DC transmitter variation, verify that power supply has required voltage based on size of resistance in current loop. Large resistive loads can reduce available power for transmitter.

(NOTE: See sensor manual for specific sensor tests to be performed.)

8.3 Display Messages

The Q45 Series instruments provide a number of diagnostic messages that indicate problems during normal operation and calibration. These messages appear as prompts on the secondary line of the display or as items on the Fault List (see Section 4.25).

The following messages will appear as prompts:

MESSAGE	DESCRIPTION	POSSIBLE CORRECTION
Max is 200	Entry failed, maximum value allowed is 200.	Reduce value to ≤ 200
Min is 200	Entry failed, minimum value allowed is 200.	Increase value to ≥ 200
Cal Unstable	Calibration problem, data too unstable to calibrate.	Clean sensor, get fresh cal solutions, allow temperature and ORP readings to fully stabilize, do not handle sensor or cable during calibration.
Slope HIGH	Sensor slope from calibration is greater than 110%.	Get fresh cal solutions, allow temperature and ORP readings to fully stabilize, check for correct buffer values
Slope LOW	Sensor slope from calibration is less than 80%.	Clean sensor, get fresh cal solutions, allow temperature and ORP readings to fully stabilize, check for correct buffer values.
Offset HIGH	Sensor offset from calibration is less than -90 mV or greater than $+90$ mV	Clean or replace saltbridge, replace reference cell solution, clean sensor, get fresh cal solutions, allow temperature and ORP readings to fully stabilize, check for correct buffer values.
Out of Range	Input value is outside selected range of the specific list item being configured.	Check manual for limits of the function to be configured.
Locked!	Transmitter security setting is locked.	Enter security code to allow modifications to settings.
Unlocked!	Transmitter security has just been unlocked.	Displayed just after security code has been entered.
TC-F25 lock!	The TC selection is in F25 mode, locked at 25 °C	Calibration and TC adjustment cannot be performed while the TC is in F25 mode. To allow access to TC calibrations, change TC mode from F25 (fixed 25) to SENS (sensor).

Figure 13 - Diagnostic Messages

The following messages will appear as items on the Fault List:

MESSAGE	DESCRIPTION	POSSIBLE CORRECTION
Sensor High	The raw signal from the sensor is too high.	Check wiring connections to sensor.
Sensor Low	The raw signal from the sensor is too low.	Check wiring connections to sensor.
ORP too High	The ORP reading is > +2000 mV	The ORP reading is over operating limits.
ORP too Low	The ORP reading is < -1000 mV	The ORP reading is under operating limits.
Temp High	The temperature reading is > 110 °C.	The temperature reading is over operating limits. Check wiring and expected temp level. Perform RTD test as described in sensor manual. Recalibrate sensor temperature element if necessary.
Temp Low	The temperature reading is < -10 °C	The temperature reading is under operating limits. Check wiring and expected temp level. Perform RTD test as described in sensor manual. Recalibrate sensor temperature element if necessary.
TC Error	TC may be open or shorted.	Check sensor wiring and perform RTD test as described in sensor manual.
Meas Break	Leakage detected on measuring electrode of sensor.	Measuring electrode glass may be cracked or broken. Electrical noise may falsely trip this diagnostic. Turn off glass diagnostic feature and see if sensor operates correctly. If it does not, sensor must be replaced.
Ref Break	Leakage detected on reference electrode of sensor.	Reference glass electrode may be cracked or broken. Electrical noise may falsely trip this diagnostic. Turn off glass diagnostic feature and see if sensor operates correctly. If it does not, sensor must be replaced.

MESSAGE	DESCRIPTION	POSSIBLE CORRECTION
ORP Cal Fail	Failure of ORP calibration.	Clean sensor, get fresh cal solutions, regenerate sensor (if necessary) and redo calibration. If still failure, sensor slope may be less than 80% or offset may be out of range. Perform sensor tests as described in sensor manual. Replace sensor if still failure.
TC Cal Fail	Failure of temperature calibration.	Clean sensor, check cal solution temperature and repeat sensor temp calibration. TC calibration function only allows adjustments of +/- 6 °C. If still failure, perform sensor tests as described in sensor manual. Replace sensor if still failure. Note that TC offset may also be adjusted using the Cal TC Factor function (See Section 5.4) which involves no calibration reference solutions.
Eeprom Fail	Internal nonvolatile memory failure	System failure, consult factory.
Chcksum Fail	Internal software storage error.	System failure, consult factory.
Display Fail	Internal display driver fail.	System failure, consult factory.
mV Cal Fail	Failure of factory temperature calibration.	Consult factory.

8.4 Cleaning the Sensor

Keep the sensor as clean as possible for optimum measurement accuracy - this includes both the saltbridge and the measuring electrode. Frequency of cleaning depends upon the process solution.

Carefully wipe the measuring end of the sensor with a clean soft cloth. Then rinse with clean, warm water - use distilled or de-ionized water if possible. This should remove most contaminate buildup.

Prepare a mild solution of soap and warm water. Use a non-abrasive detergent (such as dishwashing liquid).



NOTE: DO NOT use a soap containing any oils (such as lanolin). Oils can coat the glass electrode and harm sensor performance.

Soak the sensor for several minutes in the soap solution.

Use a small, extra-soft bristle brush (such as a mushroom brush) to thoroughly clean the electrode and saltbridge surfaces. If surface deposits are not completely removed after performing this step, use a dilute acid to dissolve the deposits. After soaking, rinse the sensor thoroughly with clean, warm water. Placing the sensor in pH 7 buffer for about 10 minutes will help to neutralize any remaining acid.



NOTE: DO NOT soak the sensor in dilute acid solution for more than 5 minutes. This will help to prevent the acid from being absorbed into the saltbridge.



WARNING: ACIDS ARE HAZARDOUS. Always wear eye and skin protection when handling. Follow all Material Safety Data Sheet recommendations. A hazardous chemical reaction can be created when certain acids come in contact with process chemicals. Make this determination before cleaning with any acid, regardless of concentration.

8.5 Replacing the Saltbridge and Reference Buffer Solution

- Hold the sensor with the process electrode pointing up. Place a cloth or towel around the saltbridge. Turn the saltbridge counterclockwise (by hand) to loosen and remove the saltbridge. Do NOT use pliers
- Pour out the old reference buffer by inverting the sensor (process electrode pointing down). If the reference buffer does not run out, gently shake or tap the sensor.
- Rinse the reference chamber of the sensor with de-ionized water. Fill the reference chamber of the sensor with fresh Reference Cell Buffer. The chamber holds 6 to 7 mL of solution. MAKE SURE that 6 to 7 mL is used when refilling. The chamber should be FULL.
- Inspect the new saltbridge to verify that there are 2 o-rings inside the threaded section of the saltbridge
- Place the new saltbridge over the ground assembly of the sensor. Place a cloth or towel around the saltbridge and hand-tighten the saltbridge by turning it clockwise.



NOTE: Every ATI Q25R Sensor includes a spare bottle of Reference Buffer Solution, 7.0 pH. This is NOT typical pH 7 buffer, it is a special “high-capacity” buffer developed to ensure the highest possible stability of the reference portion of the pH measurement. No substitutions should be made.

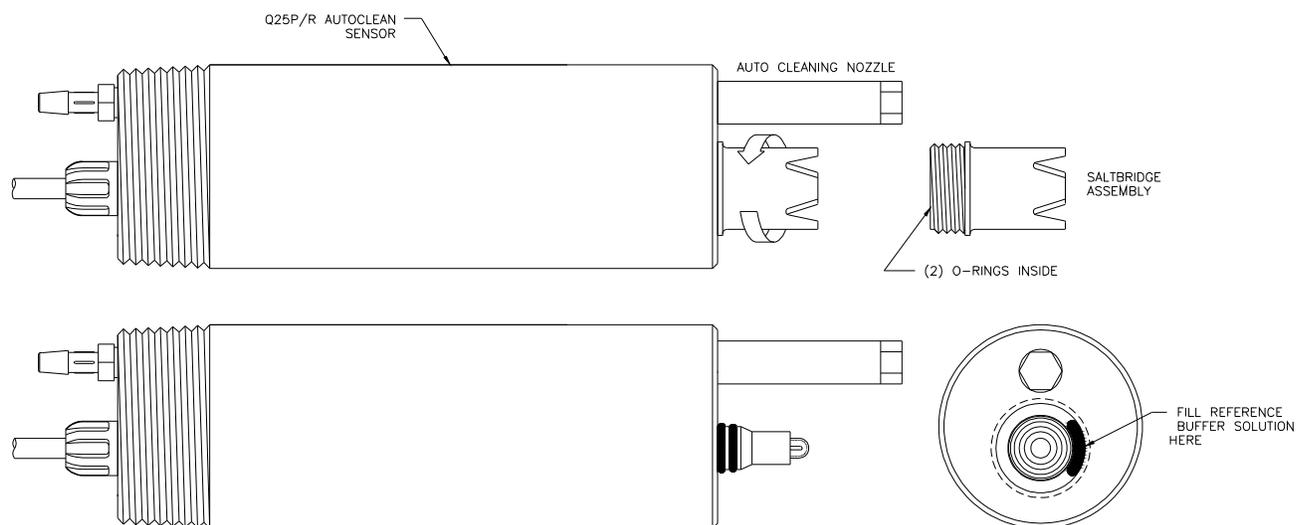


Figure 14 - Replacing the Saltbridge and Reference Buffer

8.6 Troubleshooting

The first step in resolving any measurement problem is to determine whether the trouble lies in the sensor or the transmitter. Since measurement problems can often be traced to dirty sensor electrode glass and/or saltbridge, cleaning the sensor using the method outlined in Section 9.1 should always be the first step in any troubleshooting.

If the sensor cannot be calibrated after cleaning, replace the saltbridge and reference cell buffer 7 pH as outlined in Section 9.2.

If the sensor still cannot be calibrated, perform the following test. A multimeter, 7 pH buffer and another buffer at least 2 pH units away will be needed.

1. With transmitter power on and sensor connected, place the multimeter's positive (+) lead on the white position of the transmitter terminal strip and the negative (-) lead on the black position. The multimeter should read between -4.2 and -6.5 VDC.
2. Disconnect the sensor's red, green, yellow, and white wires from the transmitter or junction box. Re-check Step 1.
3. Place the sensor in the first mV solution. As in calibration, allow the temperatures of the sensor and buffer to equilibrate at room temperature (approximately 25 °C).
4. Verify that the sensor's temperature element (Pt1000 RTD) is functioning properly by measuring the resistance between the sensor's yellow and black wires. The nominal resistance value at 25 °C is 1097 ohms. Use the following table as a guide to the approximate resistance value:

°C	RTD Ω
20	1078
25	1097
30	1117
35	1136

5. Reconnect the yellow and white wires.
6. Connect the multimeter's positive (+) lead to the red wire and its negative (-) lead to the green wire. With the sensor in the first mV solution at approximately 20-30 °C, measure the DC millivolts. The multimeter should display the value of the millivolt solution within -100 and +100 mV. If it is not, replace sensor reference solution and saltbridge (See Section 9.2) and re-test.
7. With the multimeter connected as in Step 5, rinse the sensor with clean water and place it in the second mV solution. Allow the temperatures to equilibrate as before. Check this solution as in Step 6.

Spare Parts

<u>Part No.</u>	<u>Description</u>
07-0001	Q45R ORP transmitter, 24 VDC
07-0007	Q45R ORP monitor, 115 VAC /Relays
07-0119	Q45R ORP monitor, 230 VAC / Relays
07-0100	Junction box
31-0057	Sensor interconnect cable
07-0129	Auto-Clean ORP sensor, 30' cable
07-0130	Auto-Clean ORP sensor, 60' cable
05-0060	Saltbridge Only
09-0033	Reference Solution (Q25 & Q22 Sensors)
05-0057	pH/ORP Sensor Regeneration Kit
36-0040	Compression Pump, 12VDC
36-0041	Pump Mounting Kit
36-0039	Solenoid Valve, 12VDC
01-0317	Universal Autoclean PCB Assy
00-0930	Monitor Handrail Mounting Kit
00-0624	Sensor mounting assembly
09-0034	pH4 Buffer, 5 packs (each pack makes 500 cc)
09-0035	pH7 Buffer, 5 packs (each pack makes 500 cc)
09-0042	200mV solution, 500mL
09-0043	600 mV solution, 500 mL
05-0056	5 grams Quinhydrone Powder
23-0003	Fuse, 6.3 A (Controller PCB)
23-0018	Fuse, 100mA, 250V (115VAC)
23-0019	Fuse, 50 mA, 250V (230VAC)
44-0276	Polyurethane Tubing, Black (sold / ft)
54-0014	Heater Strip
26-0020	Pressure Switch
44-0290	1/8" NPT x 1/4" OD Instant Fitting (Mounted in Air Distribution Block)

Lock/Unlock Code: 1451