A Badger Meter® Brand

Water Quality Monitor

Model Q46-85 Peracetic Acid Monitor



Badger Meter

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User Manual

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INTRODUCTION

General

The Model Q46/85 is an online monitoring system designed for the continuous measurement of Peracetic Acid (PAA) concentration in solution. The full scale operating range of the system may be selected by the user for 0…20.00 ppm, 0…200.0 ppm or 0…2000 ppm, and the sensing system operates on water streams with temperatures ranging from 0…50° C. The Q46/85 PAA Measurement System is engineered for applications in which PAA is applied to water for sterilization purposes.

The basic sensing element used in the PAA monitor is a polarographic membrane sensor that measures PAA directly. Water simply flows past the sensor and directly to drain, with the flow rate and pressure across the sensor controlled by a constant-head flowcell assembly. The PAA measurement does not alter the sample or add any chemicals to the sample stream, so the water flow can return to the system if desired.

Q46/85 monitors are available in two basic electronic versions: a 90…260V AC powered monitor or a 12…24V DC powered monitor—both with three relays and two 4…20 mA analog outputs. Both versions allow flexible output options that include additional 4…20 mA current outputs, additional 0…30V DC signal relays, PID control and digital communication cards.

Standard System

The standard model Q46/85 system includes three main components: the Q46 analyzer, a constant-head flowcell and a PAA sensor. A low-volume flowcell is also available for applications where sample flow rate and pressure can be carefully controlled. *Figure 1* shows a typical installation including the optional pH sensor.

For connection of the sensor to the electronics, a 25 foot cable is supplied. An additional 100 feet of interconnect cable may be added using part number 07-0100 junction box. All required spare parts are provided with the basic system, including spare membranes, electrolyte, O-rings and any special hardware.

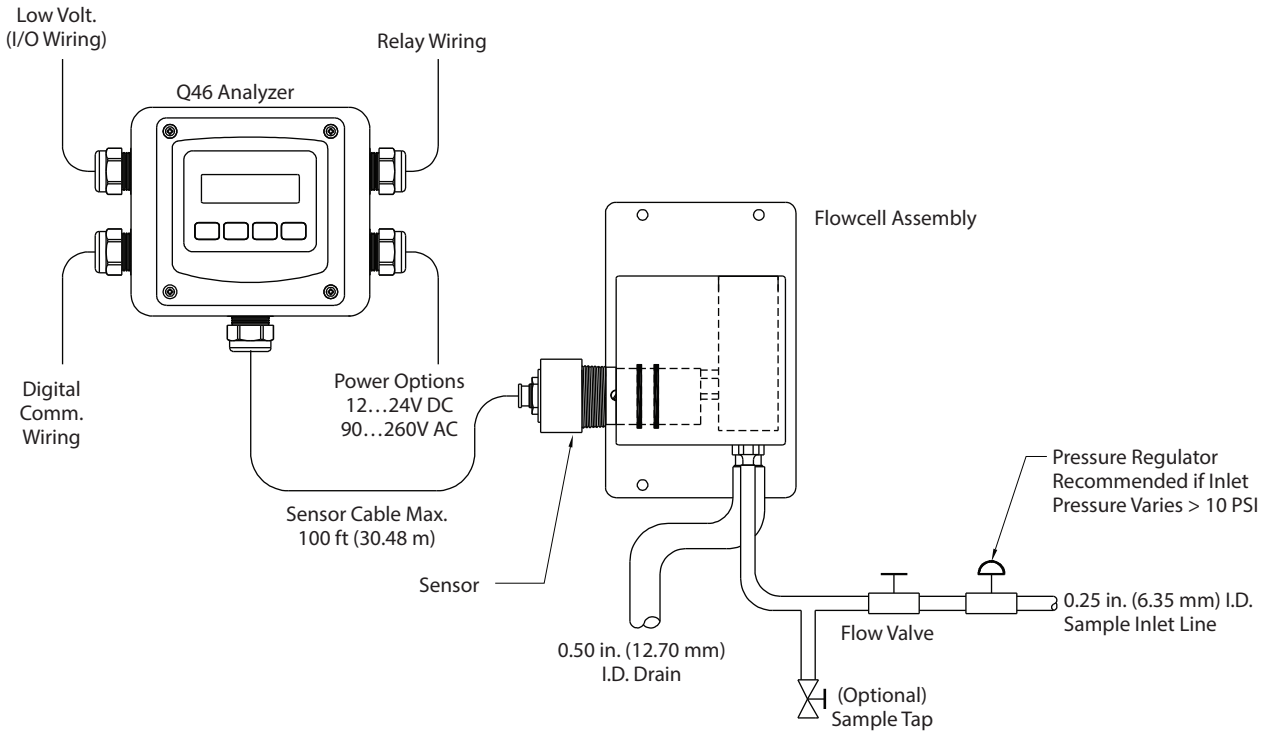


Figure 1: Typical system diagram

Figure 2 shows the same standard flowcell assembly and PAA sensor along with the conventional type pH sensor. A special adapter is required to hold the pH sensor in its proper location in the flowcell inlet chamber.

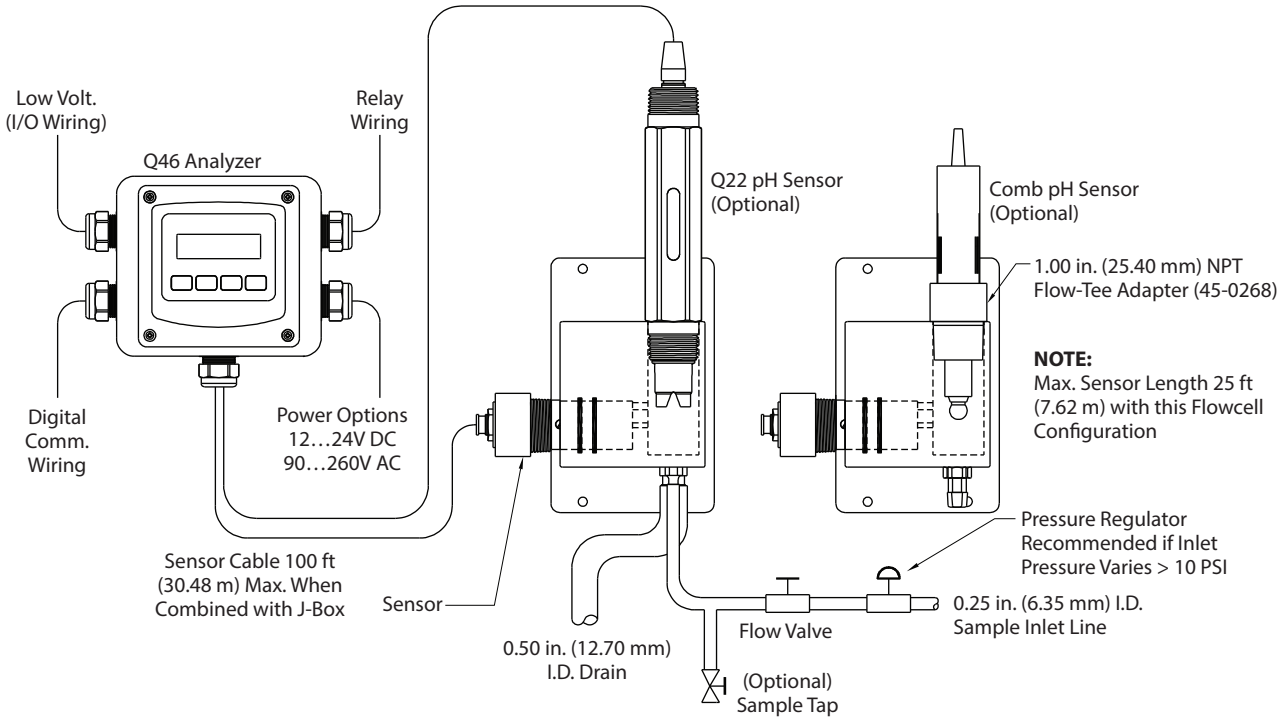


Figure 2: Monitoring system w/bayonet style pH sensor

Figure 3 shows an installation using a (00-1522) sealed flowcell for the PAA sensor and a (00-1527) sealed flowcell for the pH sensor. This type of installation requires careful flow control. We recommend the use of our (03-0371) flow control assembly when using sealed flowcells. This assembly consists of an inline filter and a fixed-flow regulator that maintains a constant 400 cc/min flow rate through the system. This flow is maintained so long as inlet pressures are between 5…125 PSIG. The inline filter is used mainly to protect the flow control element against larger particles that might cause plugging of the device.

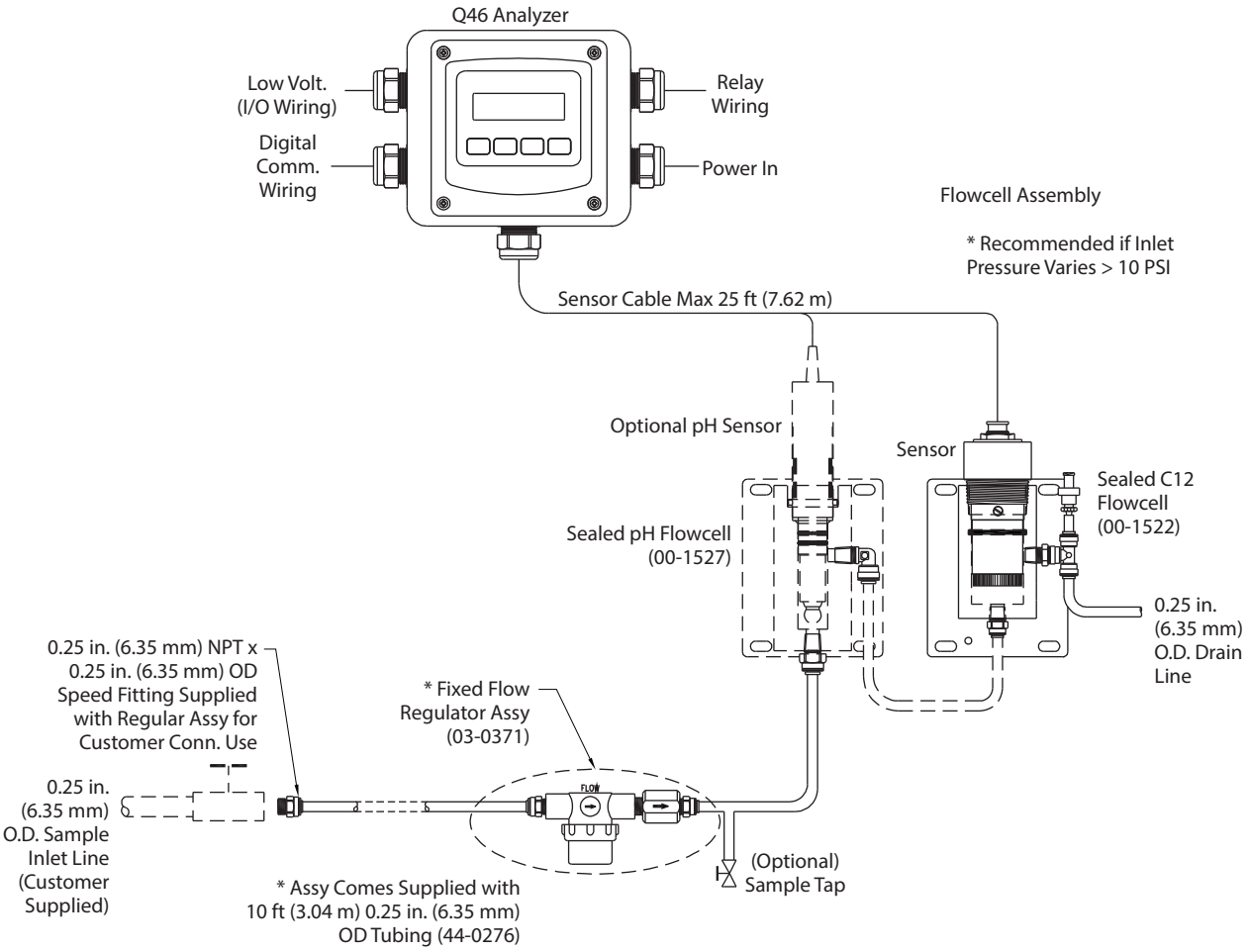


Figure 3: Sealed flowcell assemblies w/flow control

Features

- Standard Q46H Analyzers have fully isolated inputs and outputs. Analog outputs are additionally completely isolated from each other.
- Available in either 90…260V AC or 12…24V DC power supply systems. All features remain the same in both variations.
- *Output Hold, Output Simulate, Output Alarm* and *Output Delay* Functions. All forced changes in output condition include bumpless transfer to provide gradual return to online signal levels and to avoid system control shocks on both analog outputs.
- Three 6 amp SPDT relay outputs and two analog 4…20 mA outputs are standard. Software settings for relay control include setpoint, deadband, phase, delay and failsafe. An optional 3-relay card for low voltage signals is available to bring the total to 6 relays.
- Selectable PID controller on main analog output. PID controller can operate with instrument configured as loop-power transmitter, or as one of the two outputs on the AC powered instrument. PID includes manual operation feature and diagnostic "stuck-controller" timer feature for relay notification of control problems.
- Two analog outputs on the relay version may be configured to track PAA and temperature, PAA and PAA, or PAA and pH. Both analog outputs can be individually programmed to fail to specific values.
- Digital communication option for Profibus-DP, Modbus-RTU or Ethernet-IP. Consult the specific Communications Manual for specifications.
- 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 one-point calibration method and sensor zero-cal. To provide high accuracy, all calibration methods include stability monitors that check temperature and main parameter stability before accepting data.
- Security lock feature to prevent unauthorized tampering with transmitter settings. All settings can be viewed while locked, but they cannot be changed.



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.

Q46/85 System Specifications

Displayed Parameters	Main input, 0.01 ppm…2000 ppm Sensor temperature, –10.0…55.0° C (23…131° F) Sensor Current, 0.0…999.9 nA, 0.000…99.99 uA Loop current, 4.00…20.00 mA Sensor slope/offset Model number and software version PID Controller Status Optional pH Input value 0.00…14.00 pH
Main Parameter Ranges	Manual selection of one of the following ranges: 0.00…20.00 ppm 0.0…200.0 ppm 0…2000 ppm
Display	0.75 in. (19.05 mm) high 4-digit main display with sign 12-digit secondary display, 0.30 in. (7.62 mm) 5 × 7 dot matrix Integral LED back-light for visibility in the dark.
Weight	Approximately 5 lbs (2.3 kg) with sensor and flowcell
Ambient Temperature	Analyzer Service, –20…60° C (–4…140° F) Sensor Service, –5…55° C (23…131° F) Storage, -5…70° C (–22…158° F)
Ambient Humidity	0…95%, non-condensing
EMI/RFI Influence	Designed to EN 61326-1, CE Marked
Output Isolation	600V galvanic isolation
Filter	Adjustable 0…9.9 minutes additional damping to 90% step input
Temperature Input	Pt100 RTD with automatic compensation
Sensor	2-electrode polarographic membrane sensor for direct measurement of PAA
Sensor Materials	PVC and PEEK
Electrical Certification	Ordinary location, cCSAus (CSA and UL standards - both CSA approved), pollution degree 2, installation category 2
Sensor Cable	25 ft (7.5 m) cable with 6-pin plug
Max. Sensor-to-Analyzer Distance	100 ft (30.5 m), with junction box
Flowcell	Constant-head overflow, clear cast acrylic, 7…30 GPH, 15 GPH recommended, inlet is 1/4 in. hose barb at 1/8 in. MNPT, outlet is 1/2 in. hose barb at 3/8 in. MNPT
Power	90…260V AC, 50…60 Hz, 10 VA max or 12…24V DC, 500 mA max
Enclosure	NEMA 4X (IP-66), polycarbonate, stainless steel hardware, weatherproof and corrosion resistant
Mounting Options	Wall or pipe mount bracket standard. Bracket suitable for either 1.50 in. or 2 in. I.D. U-bolts for pipe mounting. Panel mount adapter optional.
Conduit Openings	Five 1/2 in. NPT openings. Adapter can be removed to provide a 1 in. NPT opening in the bottom of the enclosure. Gland seals provided but not installed.
Relays, Electromechanical	Three SPDT, 6 amp @ 250V AC, 5 amp @ 24V DC contacts. Software selection for setpoint, phase, delay, deadband, hi-lo alarm and failsafe. A-B indicators on main LCD, and C indicator on lower display.
Optional Relays	Three additional non-isolated low power relays available. SPST, 1 Amp @ 30V DC.
Analog Outputs	Two 4…20 mA outputs. Output 1 programmable for PPM, PAA or PID. Output 2 programmable for PPM, PAA or Temperature. Max load 500 Ohms for each output. Outputs ground isolated and isolated from each other. An additional 3rd analog option is available.

Q46H Performance Specifications

Accuracy	0.5% of selected range or 0.02 PPM
Repeatability	0.3% of selected range or 0.01 PPM
Sensitivity	0.05% of selected range
Non-Linearity	0.1% of selected range
Warm-Up Time	3 seconds to rated performance (electronics only)
Supply Voltage Effects	±0.05% span
Instrument Response Time	60 seconds to 90% of step input at lowest damping

ANALYZER MOUNTING

General

All Q46 Series instruments offer maximum mounting flexibility. A bracket is included with each unit that allows mounting to walls or pipes. In all cases, choose a location that is readily accessible for calibrations. Also consider that it may be necessary to use a location where solutions can be used during the calibration process. To take full advantage of the high contrast display, mount the instrument in a location where the display can be viewed from various angles and long distances.

Locate the instrument in close proximity to the point of sensor installation - this allows easy access during calibration. The sensor-to-instrument distance should not exceed 100 feet. To maximize signal-to-noise ratio however, work with the shortest sensor cable possible. The standard cable length of the PAA sensor is 25 feet.

Due to the flexibility of the instrument design, some of the mounting features change based on the configuration that was ordered. For example, the 2-wire transmitter version is different for the 115…230V AC controller because the rear of the enclosure is much deeper when the AC powered unit is used. In addition, the AC powered unit has an integrated panel mount flange requiring a single cutout for flush mounting.

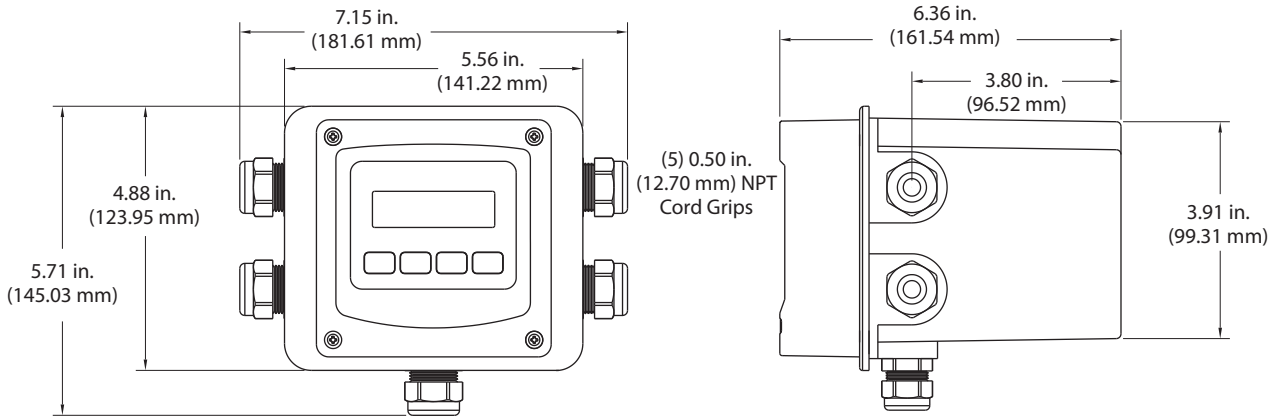


Figure 4: Q46 enclosure dimensions

Wall or Pipe Mount

A PVC mounting bracket with attachment screws is supplied with each transmitter as shown in *Figure 5*. The multipurpose bracket is attached to the rear of the enclosure using the four flat head screws. The instrument is then attached to the wall using the four outer mounting holes in the bracket. These holes are slotted to accommodate two sizes of U-bolts that may be used to pipe mount the unit. Slots accommodate U-bolts designed for 1-1/2 in. or 2 in. pipe. The actual center-to-center dimensions for the U-bolts are shown in *Figure 5*.

NOTE: These slots are for U-bolts with 1/4-20 threads. The 1-1/2 in. pipe U-bolt (2 in. I.D. clearance) is available from Badger Meter in type 304 stainless steel under part number 47-0005.

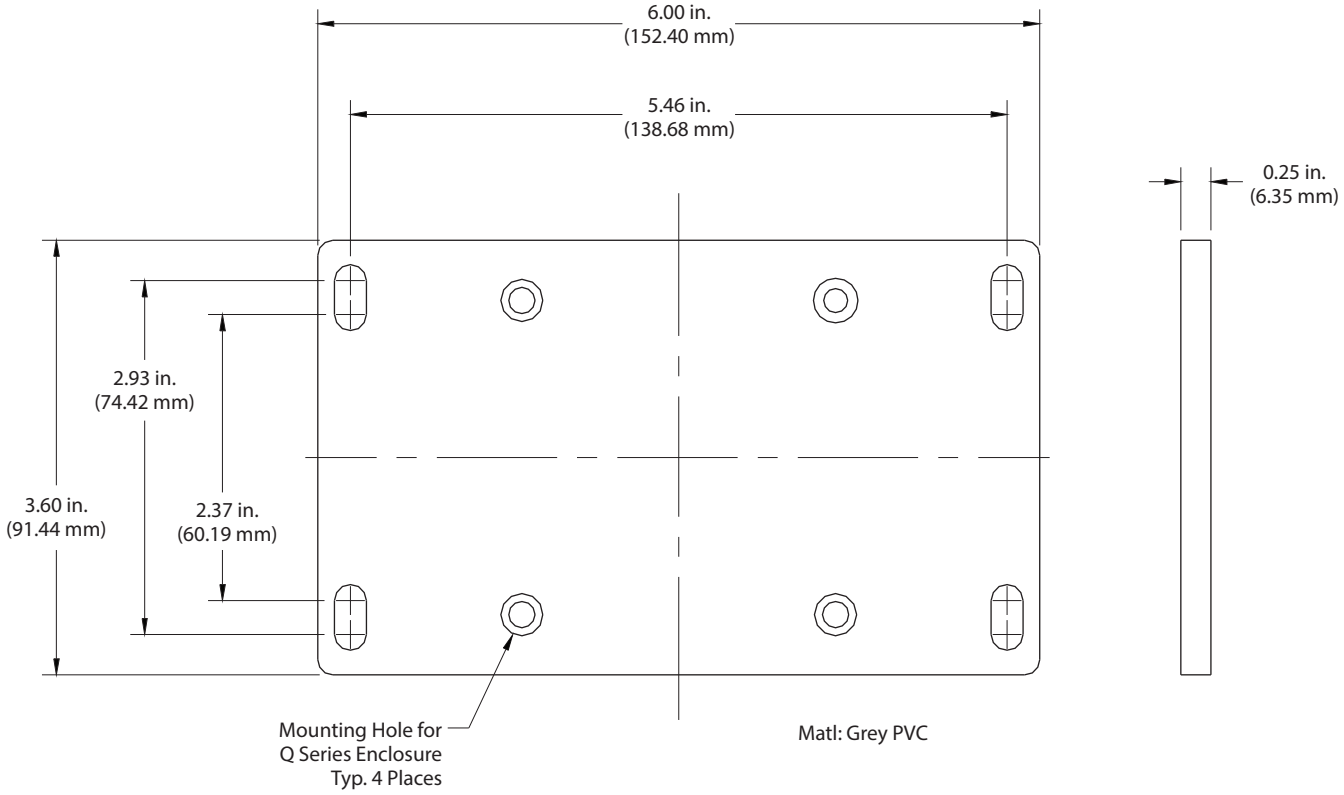


Figure 5: Wall or pipe mount bracket

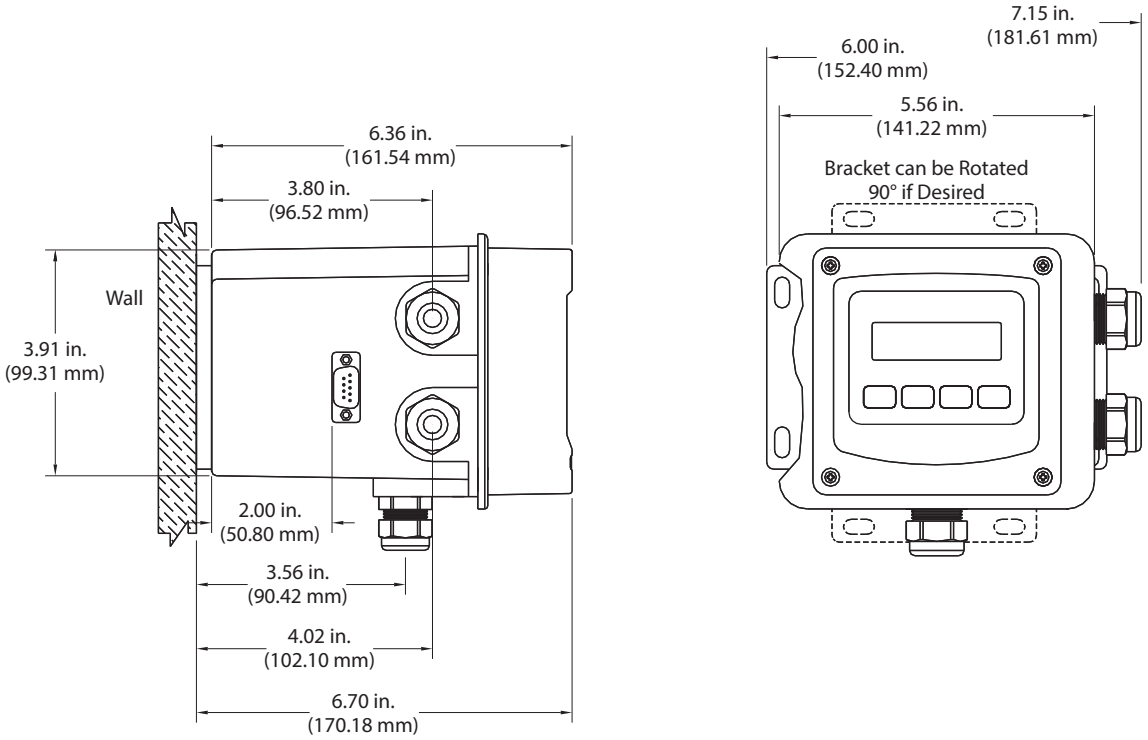


Figure 6: Wall mounting diagram

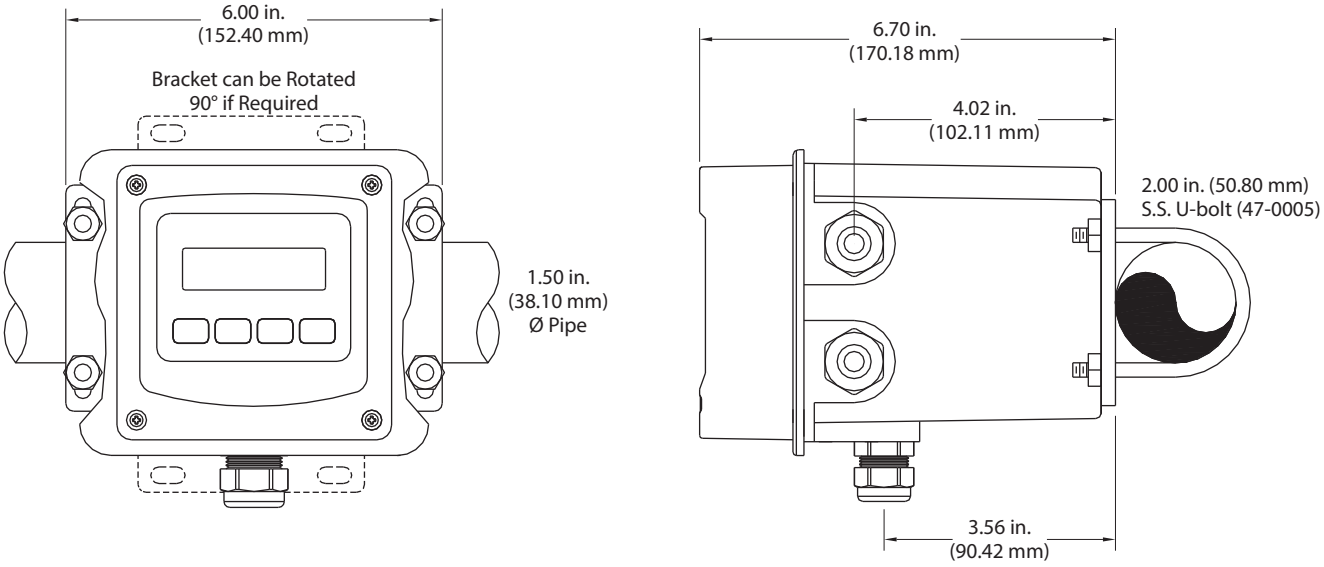


Figure 7: Pipe mounting diagram

Panel Mounting

Panel mounting uses the panel mounting flange molded into the rear section of the enclosure. *Figure 8* provides dimensions for the panel cutout required for mounting.

The panel mounting bracket kit must be ordered separately (part number 05-0094). This kit contains a metal retainer bracket that attaches to the rear of the enclosure, four (4) screws for attachment of this bracket and a sealing gasket to make sure that the panel mounted monitor provides a water tight seal when mounted to a panel.

The sealing gasket must first be attached to the enclosure. The gasket contains an adhesive on one side so that it remains in place on the enclosure. Remove the protective paper from the adhesive side of the gasket and slide the gasket over the back of the enclosure so that the adhesive side lines up with the back of the enclosure flange. Once in place, you can mount the monitor in the panel.

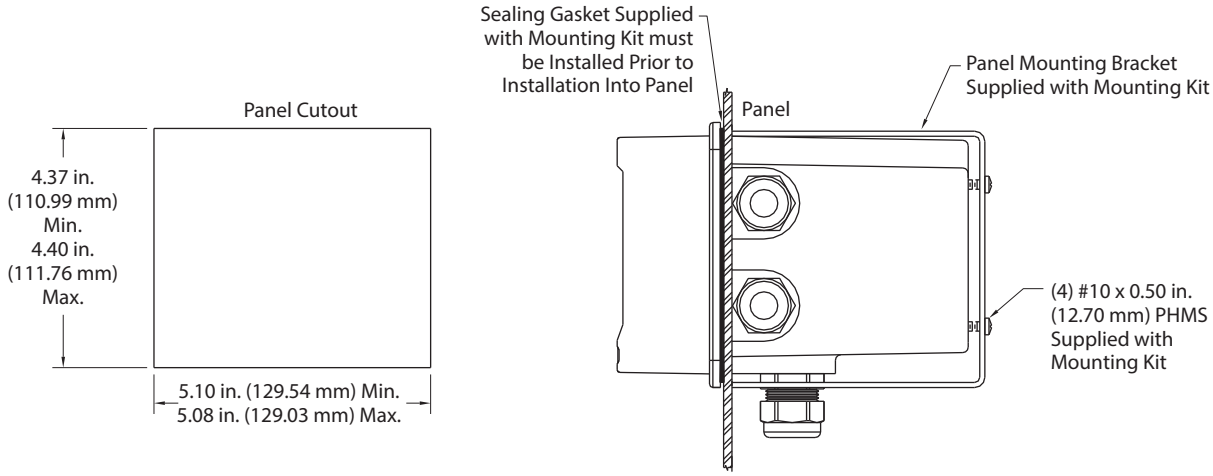


Figure 8: Panel mount cutout

SENSOR/FLOWCELL MOUNTING

General

Select a location within the maximum sensor cable length for mounting of the sensor flowcell.

Constant-Head Flowcell

PAA sensors are best used in a constant-head overflow chamber because variations in sample flow rate and pressure can cause unstable readings. When monitoring low concentrations (below 0.5 PPM), this method should always be used. Mechanical installation of the flowcell requires that it be mounted to a wall or other convenient flat surface. Alternatively, the mounting holes on the plate accommodate a 2 inch U-bolt for mounting the plate to a 2 inch pipe. *Figure 9* shows the dimensions and mounting hole locations for the flowcell. Be sure to allow enough clearance on the left side of the flowcell for insertion and removal of the sensor. About 12 inch clearance is recommended.

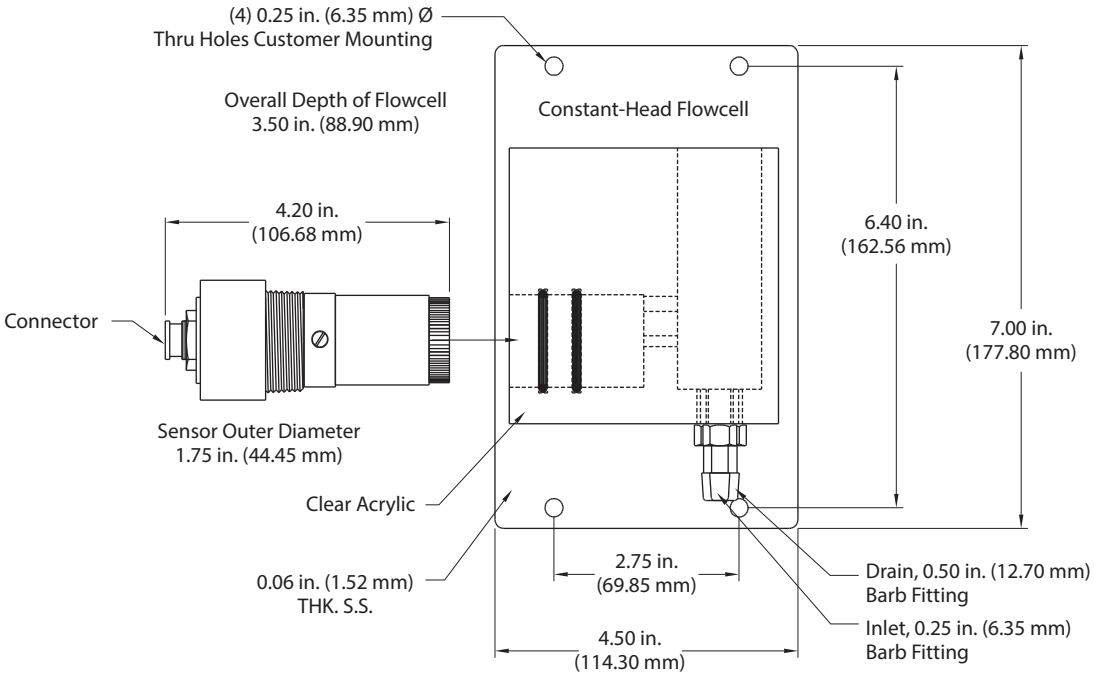


Figure 9: Constant-head flowcell details

Once mounted, inlet and drain connections must be made. The flowcell contains a 1/8 inch MNPT inlet connection and a 3/8 inch MNPT drain connection. Hose barbs for the inlet and drain connections are supplied with the flowcell for use with flexible tubing. The inlet hose barb is used with 1/4 inch I.D. tubing and the drain hose barb is used with 1/2 inch I.D. tubing.

Sealed Flowcell

Applications where the sample inlet flow is well controlled can use a simpler sealed flowcell. Using this flowcell requires that flow be controlled externally to about 400 cc/min. Variable flow rate or variable pressure causes unstable readings in this flowcell. Badger Meter offers a special flow control element that can be used ahead of this flowcell on the incoming sample line. The flow control is part number (55-0048). It controls the inlet flowrate at 400 cc/min. with inlet pressure variations from 5…150 PSIG. A 50 micron y-strainer ahead of the flow control element is recommended. The sealed flowcell provides a drain vent with check valve to avoid pulling a vacuum on the flow chamber.

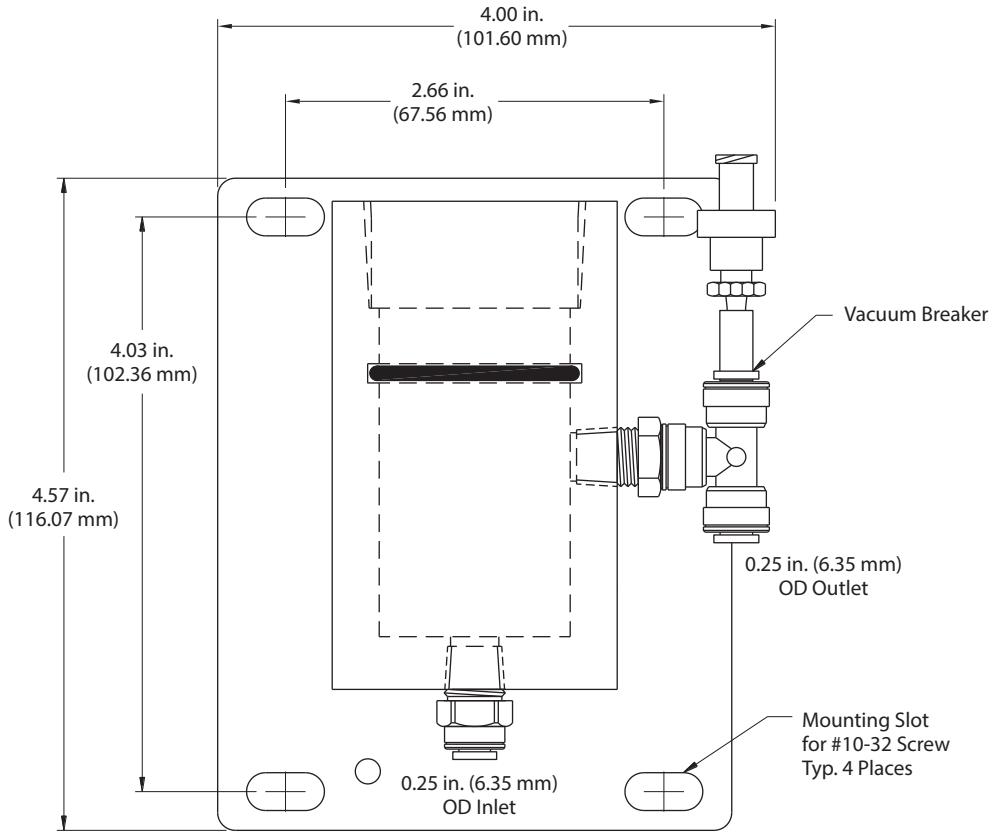


Figure 10: Sealed flowcell details

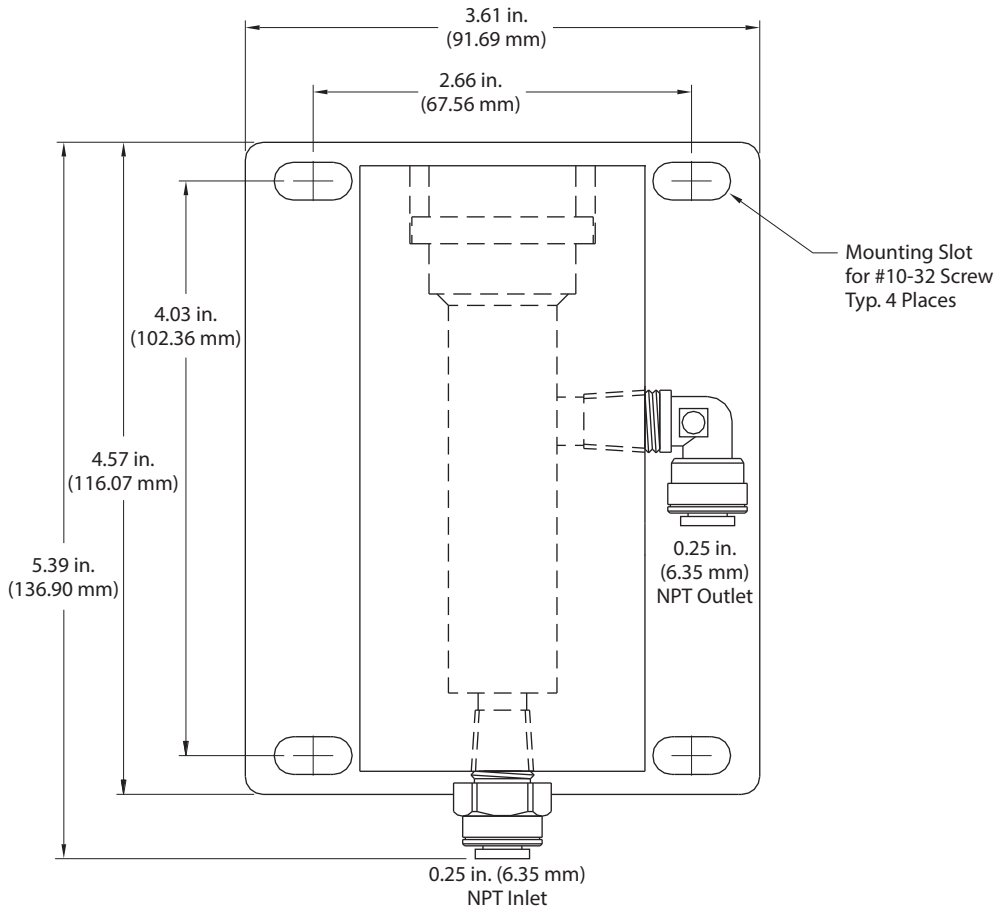


Figure 11: Sealed pH flowcell details

Submersion Mounting

Some applications are much easier done using the submersible sensor. This method can sometimes be used where flow is reasonably constant and hydraulic head does not vary appreciably. PAA sensors can never be used in completely stagnant conditions. A flow velocity of at least 0.3 feet per second is normally required for measurement. Any applications for a submersible PAA sensor should first be discussed with Badger Meter. A trial of such installations may be necessary.

Submersible sensors are mounted to a 1 inch pipe using a standard 1 inch PVC thread by thread pipe coupling. The mounting pipe can be secured to standard 1-1/2 inch pipe rail using a mounting bracket kit available from Badger Meter (part number 00-0628) as shown in *Figure 12*.

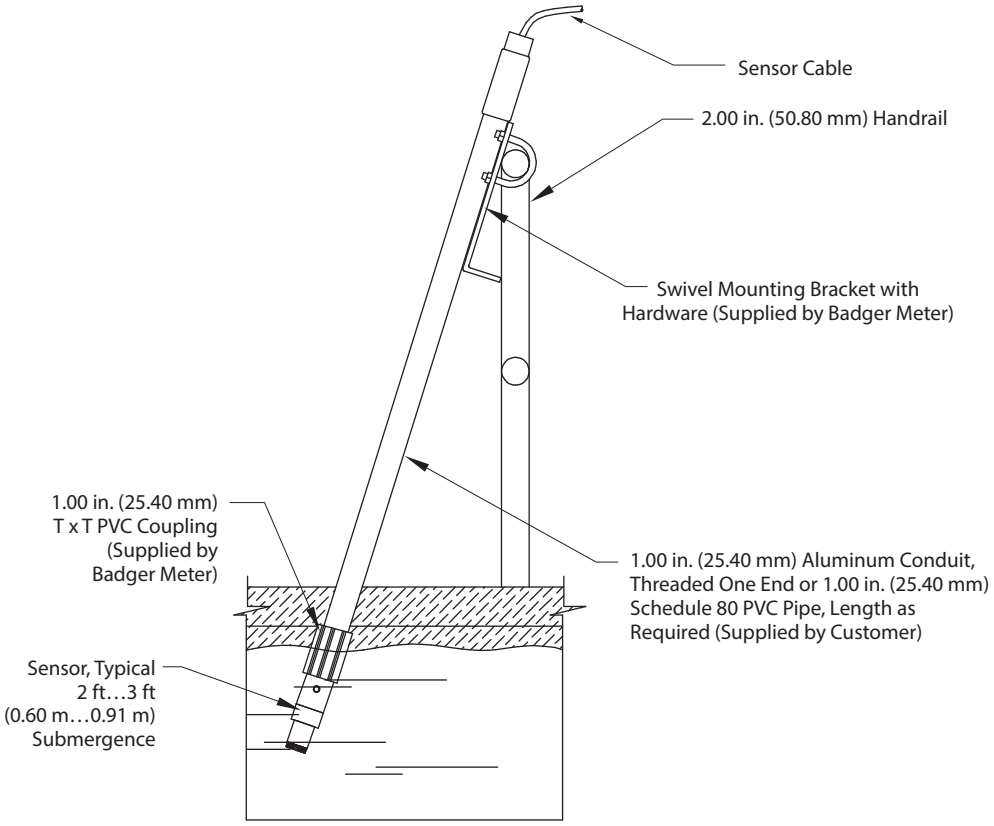


Figure 12: Submersible sensor mounting assembly

ELECTRICAL INSTALLATION

General

The Q46 is powered in one of two ways, depending on the version purchased. The 12…24V DC powered analyzer requires a customer supplied DC power supply. The 90…260V AC version requires line power. Please verify the type of unit before connecting any power.

⚠ WARNING

DO NOT CONNECT AC LINE POWER TO THE DC VERSION. SEVERE DAMAGE COULD RESULT.

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 TB7. The AC power supply contains a single 630 mA slo-blo fuse (Wickmann/Littlefuse part number 372-0630). The fuse **F1** is located adjacent to **TB7** 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. This analyzer must be installed by specifically trained personnel in accordance with relevant local codes and instructions contained in this user manual. Observe the analyzer's technical specifications and input ratings. Proper electrical disconnection means must be provided prior to the electrical power connected to this instrument, such as a circuit breaker - rated 250V AC, 2 A minimum. If one line of the line power mains is not neutral, use a double-pole main switch to disconnect the analyzer.
4. Repeated problems with lightning strikes damaging sensitive instrumentation are often attributed to poorly bonded earth grounds in the instrument power source. The protection schemes incorporated into this analyzer cannot operate to maximum efficiency unless the ground connection is at its absolute lowest impedance.

There is no standard ground resistance universally recognized. Many agencies recommend a ground resistance value of 5 Ohms or less. The NEC recommends an impedance to ground of less than 25 Ohms, and less than 5 Ohms where sensitive equipment is installed. Power sources feeding sensitive instruments like the Q46H/79PR should have the lowest possible impedance to ground.

Power Connection

Verify the AC power supply requirement before installing. Also verify that power is fully disconnected before attempting to wire.

Q46 systems are supplied with five cable gland fittings for sealing cable entries. Connect HOT, NEUTRAL and GROUND to the matching designations on terminal strip **TB7**.

⚠ WARNING

DISCONNECT LINE POWER VOLTAGE BEFORE CONNECTING LINE POWER WIRES TO TERMINAL TB7 OF THE POWER SUPPLY. THE POWER SUPPLY ACCEPTS ONLY STANDARD THREE-WIRE SINGLE PHASE POWER. AC POWER SUPPLIES ARE CONFIGURED FOR 90…260V AC OPERATION AT THE FACTORY AT TIME OF ORDER, AND THE POWER SUPPLY IS LABELED AS SUCH. DO NOT CONNECT VOLTAGES OTHER THAN THE LABELED REQUIREMENT TO THE INPUT.

The two analog outputs for the standard system are present at terminal TB1. The loop-load limitation in this configuration is 500 Ohms maximum for each output.

NOTE: These two outputs are completely isolated from each other to make sure that ground loops do not result from the connection of both outputs to the same device, such as a PLC or DCS.

A ribbon cable connects the power supply assembly with the microprocessor assembly located in the front section of the enclosure. This cable may be unplugged from the front section of the monitor if service is needed, but should normally be left in place during installation.

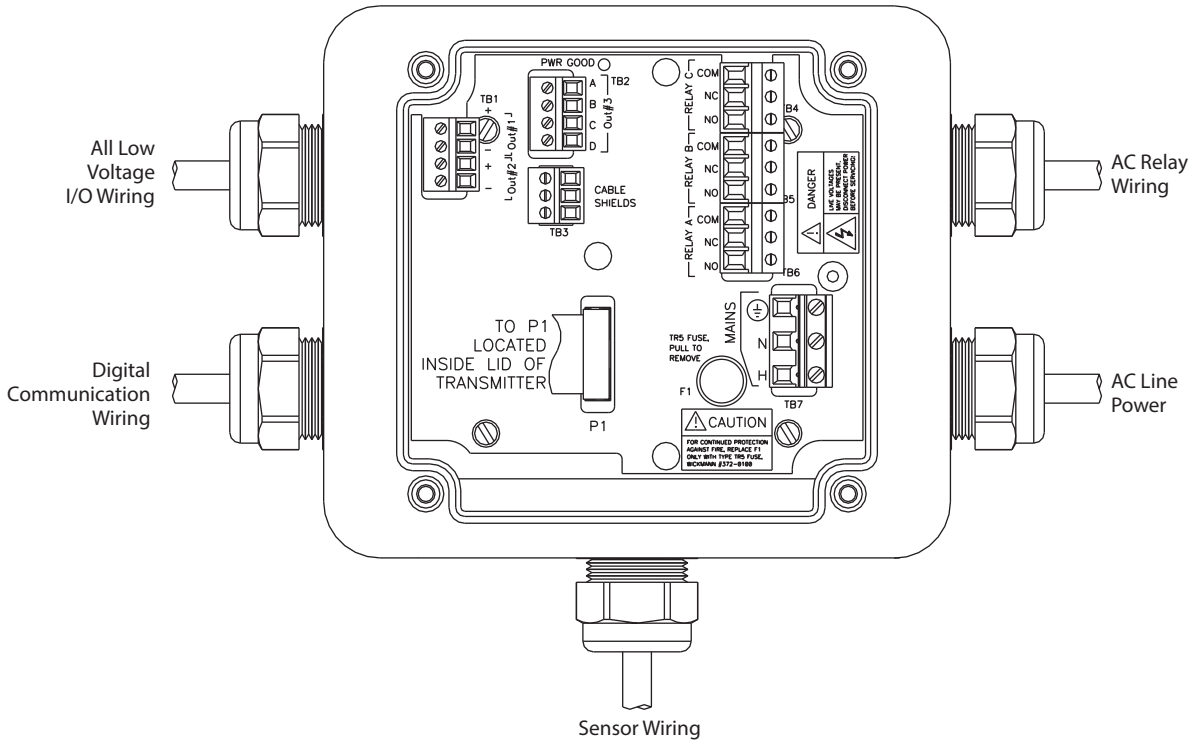


Figure 13: Line power connection

The power strip, **TB7**, allows up to 12 AWG wire. A wire gauge of 16 AWG is recommended to allow for an easy pass-through into the 1/2 inch NPT ports when wiring.

Relay Connection

Three SPDT relays are provided on the power supply board. None of the relay contacts are powered. The user must supply the proper power to the contacts. For applications that require the same switched operating voltage as the Q46 (115 or 230V), power may be jumped from the power input terminals at **TB7**. Relay wiring is connected at **TB4**, **TB5** and **TB6** as shown in *Figure 14*.

NOTE: The relay contact markings are shown in the *NORMAL* mode. Programming a relay for "Failsafe" operation reverses the NO and NC positions in *Figure 14*.

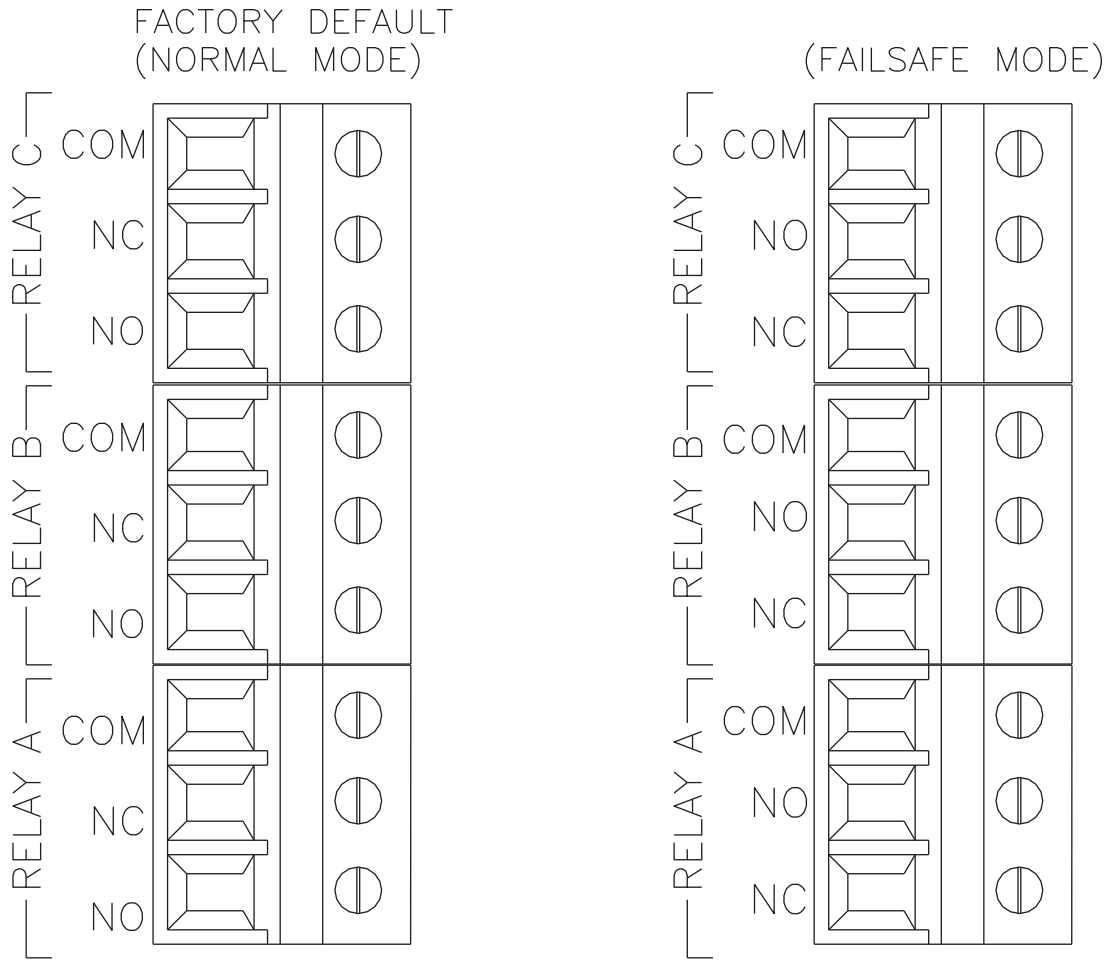


Figure 14: Optional relay board wiring

TB2 is used to connect the optional 3-relay card (see *Figure 15*) **OR** the optional third analog output, Out#3 (see *Figure 16*). The Q46 can be configured for only one of these optional features, and the hardware for either option must be factory installed.

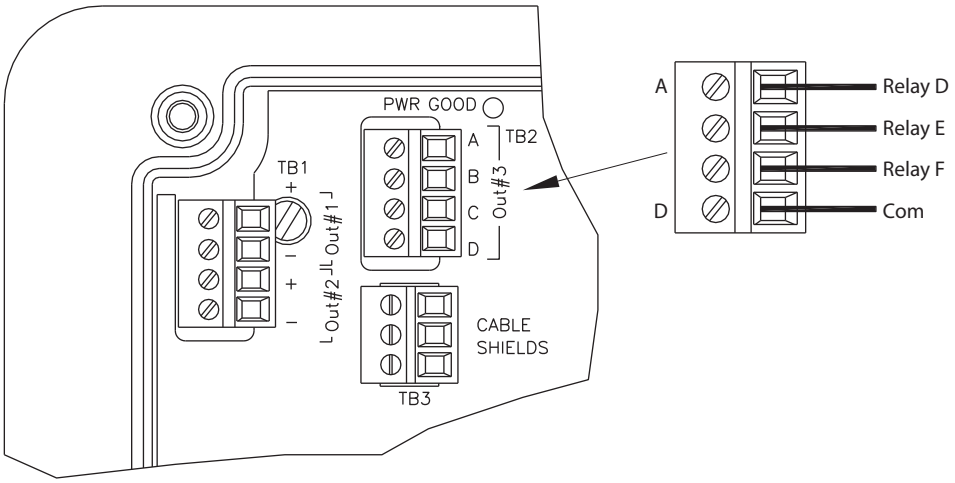


Figure 15: Optional relay board wiring

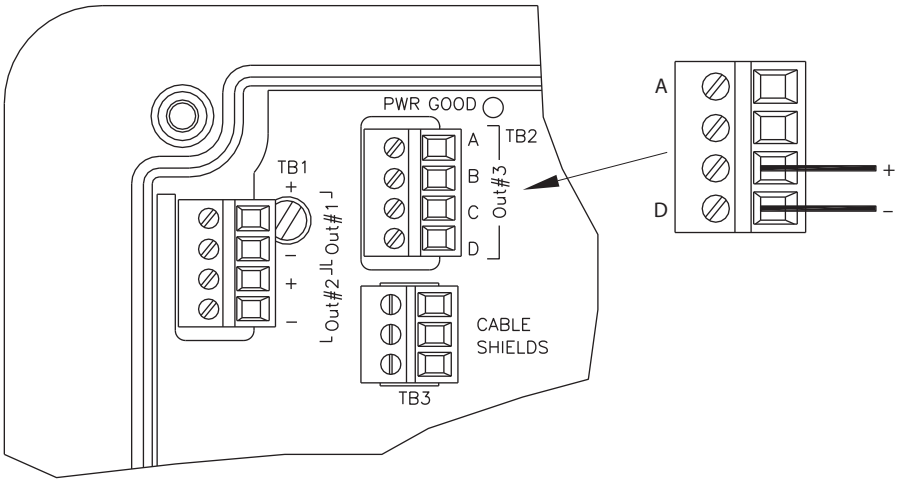


Figure 16: Optional analog output wiring

Direct Sensor Connection

The sensor cable can be routed into the enclosure through one of the cord grips supplied with the unit. Routing sensor wiring through conduit is only recommended if a junction box is to be used. Some loose cable is needed near the installation point so that the sensor can be inserted and removed easily from the flowcell.

Cord grips used for sealing the cable should be snugly tightened after electrical connections have been made to prevent moisture incursion. When stripping cables, leave adequate length for connections in the analyzer enclosure as shown in *Figure 17*. The standard 25 foot sensor cable normally supplied with the system is already stripped and ready for wiring. This cable can be cut to a shorter length if desired to remove extra cable in a given installation. Do not cut the cable so short as to make installation and removal of the sensor difficult.

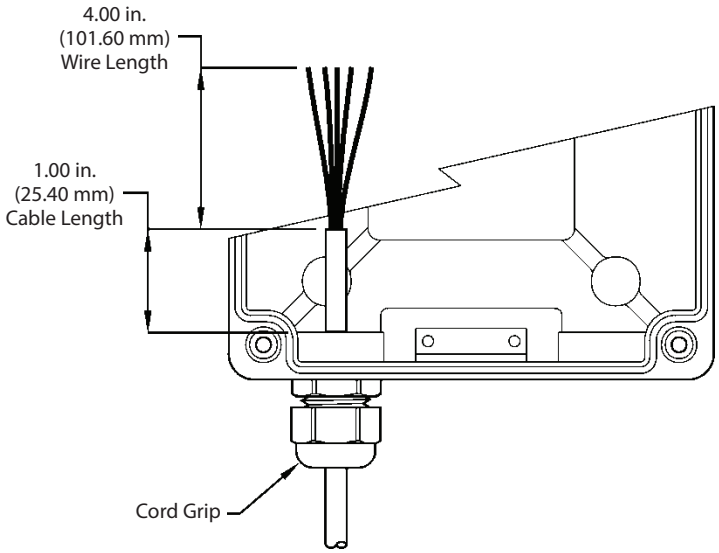


Figure 17: Sensor cable preparation

Sensor Wiring

The sensor cable can be quickly connected to the Q46 terminal strip by matching the wire colors on the cable to the color designations on the label in the monitor. A junction box is also available to provide a break point for long sensor cable runs. Route signal cable away from AC power lines, adjustable frequency drives, motors or other noisy electrical signal lines. Do not run sensor or signal cables in conduit that contains AC power lines or motor leads.

NOTE: If sensor is experiencing Low-Slope or Low-Output conditions due to poor earth ground connections, move the shield connection from P/S board to alternate location on lid, where indicated with an "S".

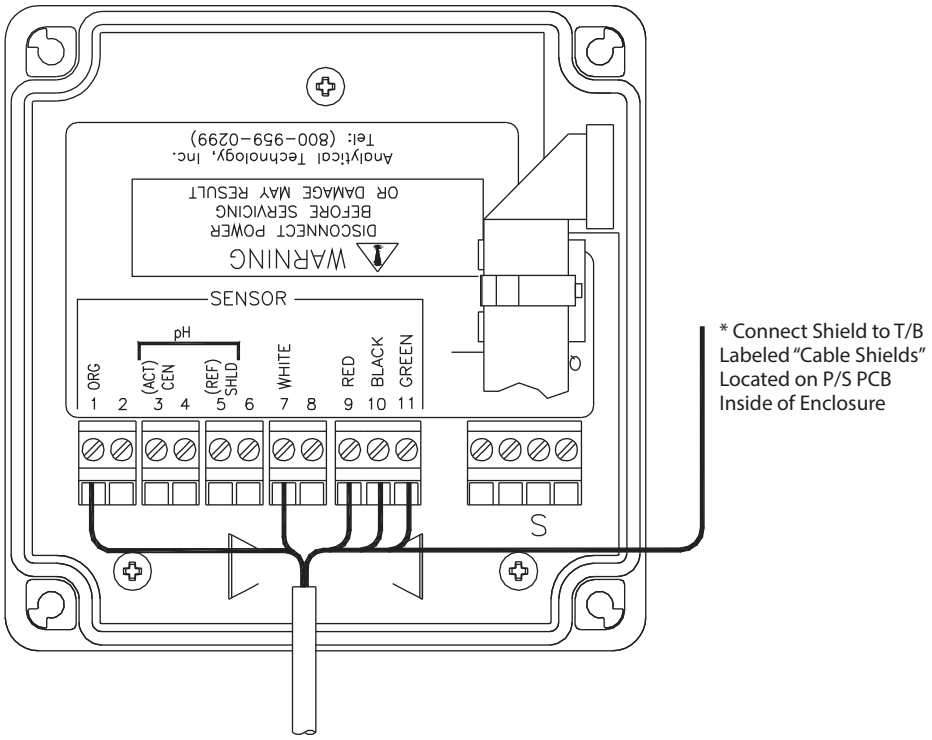
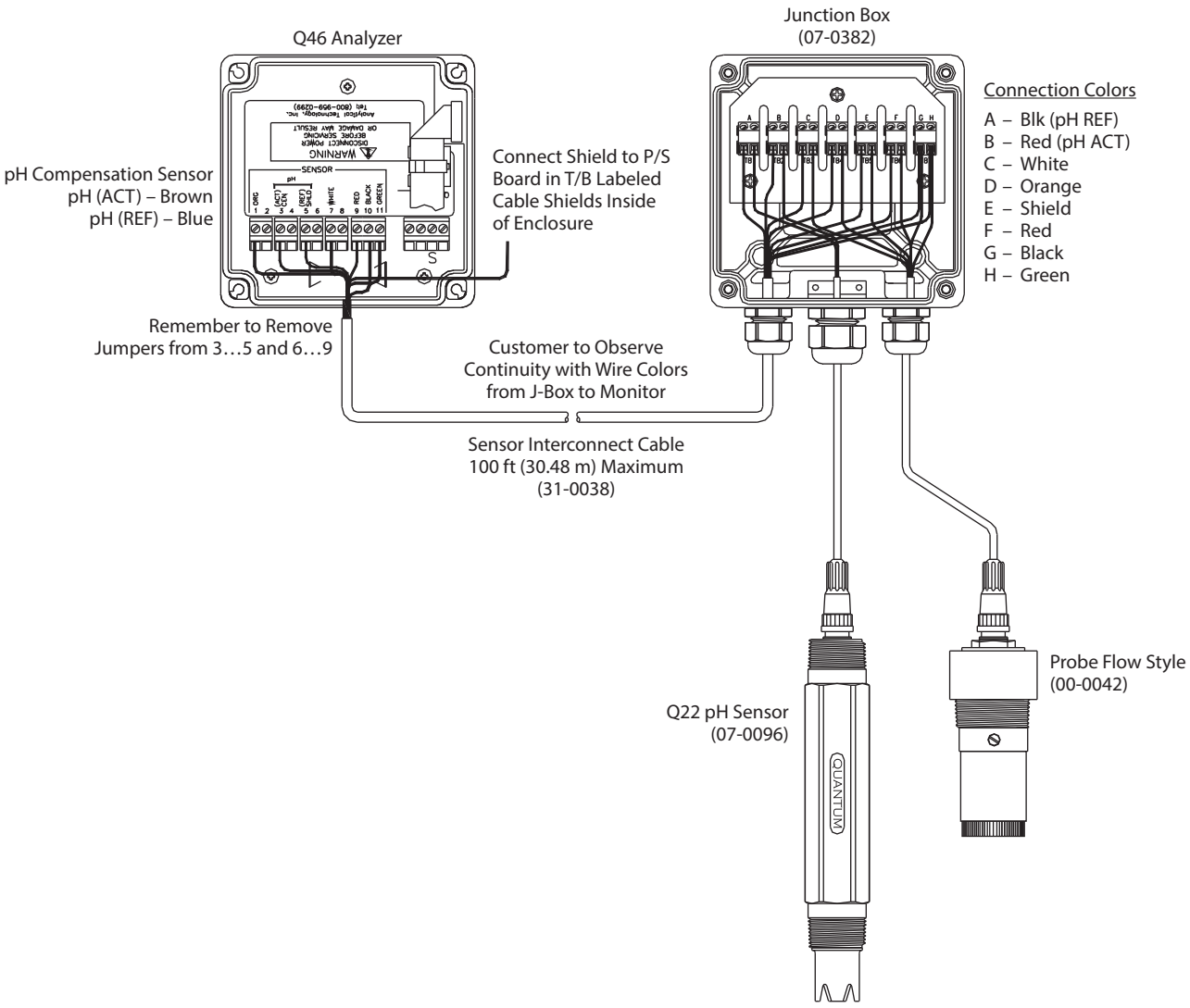


Figure 18: Sensor wiring

Junction Box Connection

For installations where the sensor is to be located more than 25 feet from the monitor (max. 100 feet), a junction box must be used. The junction box is shown in *Figure 19* and is supplied with a 1/2 inch conduit hub on one end and a sensor cable gland on the other end. Wiring shown below is with optional pH sensor installed requiring (07-0382) junction box.

NOTE: If sensor is experiencing Low-Slope or Low-Output conditions due to poor earth ground connections, move the shield connection from P/S board to alternate location on lid, where indicated with an "S."



NOTE: When connecting junction box to transmitter using the interconnect cable specified above, connect the blue wire to "A" and the brown wire to "B" in the junction box. In the transmitter end, connect the blue wire to "pH (REF)" and the brown wire to "pH (ACT)."

Figure 19: Junction box interconnect wiring

SENSOR ASSEMBLY

PAA Sensor Preparation

The PAA sensor supplied with the Q46 is shipped dry. It does not operate until it is prepared by adding electrolyte and a membrane. Preparation of the sensor for operation must be done carefully. The procedure should be done by a qualified technician, and it should only be done when the system is ready for operation. Until then, it is best to leave the sensor in the condition in which it is received.

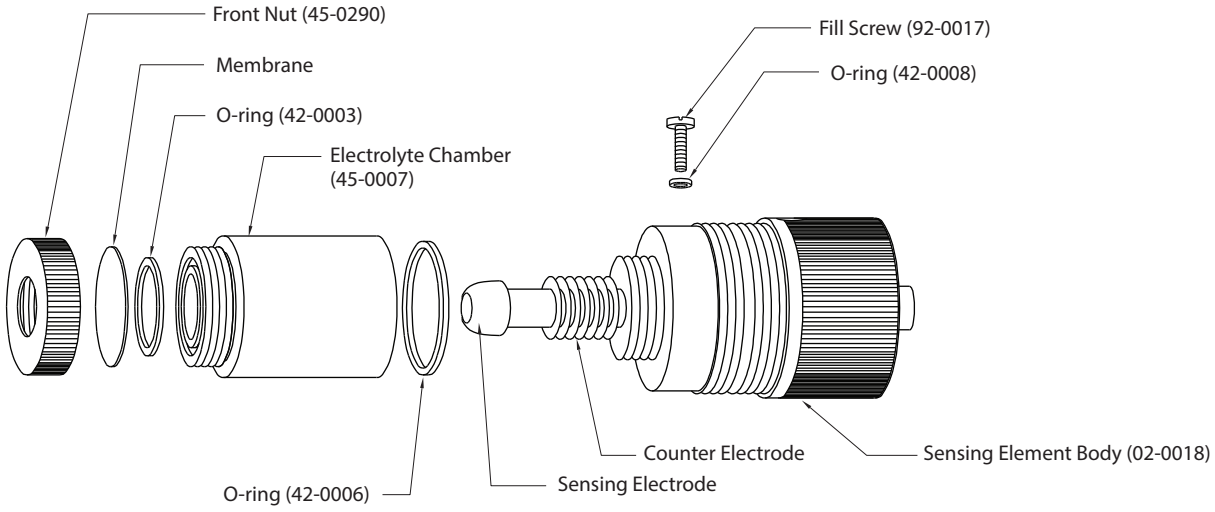


Figure 20: PAA sensor assembly

Submersible PAA sensors are made up of two separate parts: a submersion holder that also contains the temperature compensating element and a sensing module. The sensing module screws into the holder with an O-ring providing a water tight connection.

Follow the procedure below to prepare the PAA sensor for operation:

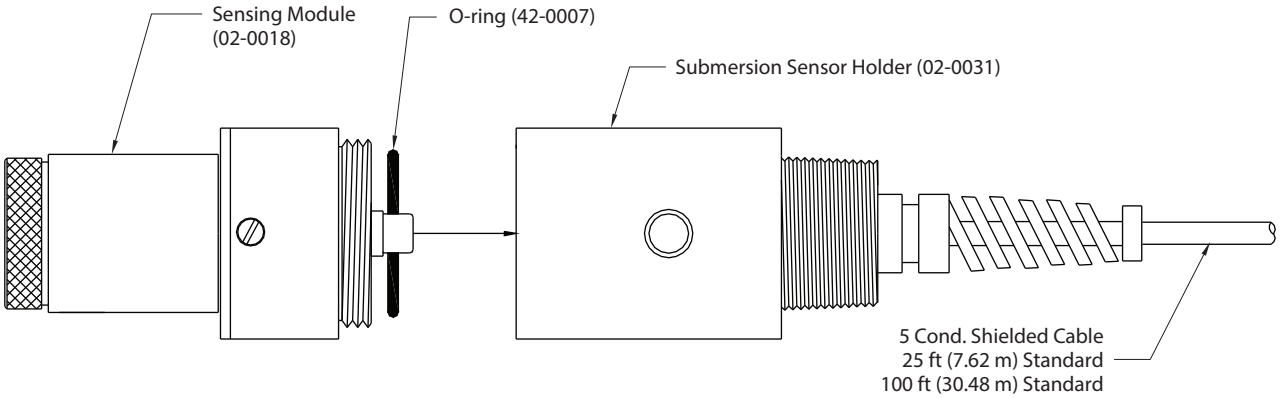


Figure 21: Submersible PAA sensor assembly

1. Unscrew the electrolyte chamber from the assembled sensor and also remove the fill screw from the side of the sensor body.
2. Remove the front nut from the bottom of the chamber and discard the protective membrane. O-rings are contained in grooves on both the bottom and top of the chamber. Be sure that these O-rings remain in place.
3. From the package of membranes supplied with the sensor, place a new membrane into the front nut. **The membrane is white in color and is separated from other membranes by a light blue paper spacer.**
4. Screw the front nut on to the chamber until you feel the O-ring compress. Hand-tight compression is all that is needed. Do not use tools to tighten. The membrane should be flat across the bottom of the chamber without wrinkles.
5. Fill the chamber with electrolyte until the level reaches the bottom of the internal threads.
6. Slowly screw the chamber onto the sensor body. A small amount of electrolyte runs out of the hole from which the fill screw was removed. Place a paper towel around the sensor to absorb the electrolyte overflow. The electrolyte is harmless and does not irritate skin. Tighten the chamber until the O-ring at the top of the chamber is compressed. Once again, do not use tools to tighten.
7. Shake excess electrolyte from the fill hole on the side of the sensor and replace the fill screw.

The sensor is now ready for operation. The membrane should be stretched tightly across the tip of the sensor.

⚠CAUTION

WHEN HANDLING THE ASSEMBLED SENSOR, DO NOT SET THE SENSOR ON ITS TIP OR DAMAGE TO THE MEMBRANE COULD RESULT. SEVERE IMPACTS ON THE TIP OF THE SENSOR FROM DROPPING OR OTHER MISUSE MAY CAUSE PERMANENT DAMAGE TO THE SENSOR.

Optional pH Sensor

An optional pH battery powered sensor is available for use with the Q46 system that outputs a nominal signal of 0.3…1.5V DC proportional to pH over a range of 0…14 pH units. The Q22P is also available and outputs a standard 4…20 mA analog signal. Both sensors are shipped with a protective rubber boot containing a small amount of salt solution to keep the glass elements in good condition and ready for use.

No special preparations are required for use of this electrode. The protective boot should remain in place until the system is to be placed into continuous service. **Do not remove the protective boot and allow the sensor to sit in the air for an extended period of time. The pH electrodes MUST stay wet.**

When ready for operation, simply remove the rubber boot from the end of the sensor and place the sensor into the inlet chamber of the PAA over flowcell. It is placed directly above the sample inlet tube. You may need to slide the flowcell chamber cover out of the way to put the pH sensor in place.

CONFIGURATION

User Interface

The user interface for the Q46 Series instrument consists of a custom display and a membrane keypad. All functions are accessed from this user interface (no internal jumpers or pots, for example).

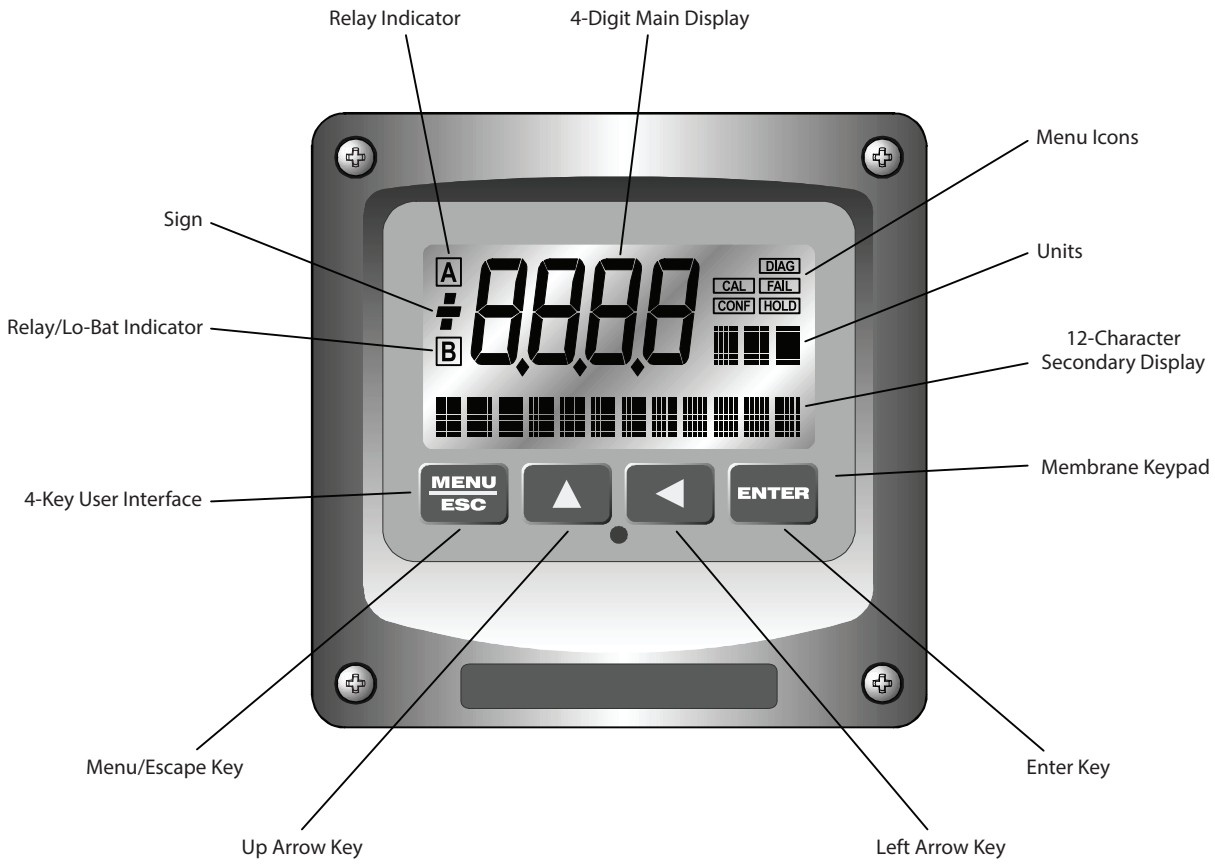


Figure 22: User interface

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 refers to this key as either MENU or ESC, depending upon its particular function. In the battery-powered version of the Q46, 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.

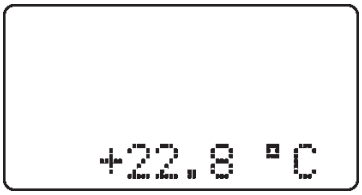
Display

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

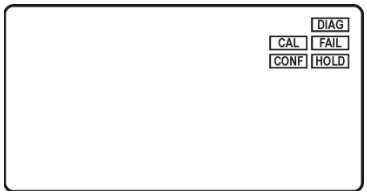
Main Parameter During normal operation, the main parameter display indicates the present process input with sign and units. This main display may be configured to display any of the main measurements the system provides. During configuration, this area displays other useful setup information to the user.



Lower Line During normal operation, the lower line of the display indicates user-selected secondary measurements 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 setup prompts to the user. Finally, the lower line displays error messages when necessary. For a description of all display messages, see *"Display Messages" on page 54*.



Icon Area The icon area contains display icons that assist the user in setup 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). Relay C is normally configured for *FAIL* indication, so it is only displayed on the lower *MEASURE* display line.



Software

The software of the Q46 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.

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. To scroll through the list items, use 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 23 on page 31* 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 sequence. 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 PAA 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 flashes. This flashing indicates *User Entry* mode and is initiated by pressing the **ENTER** key. The **UP** arrow key increases a flashing digit from 0…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 begins to flash, indicating that the user may modify that variable using the arrow keys. However, if the instrument is locked, the transmitter displays the message "Locked!" and does 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!" displays 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.

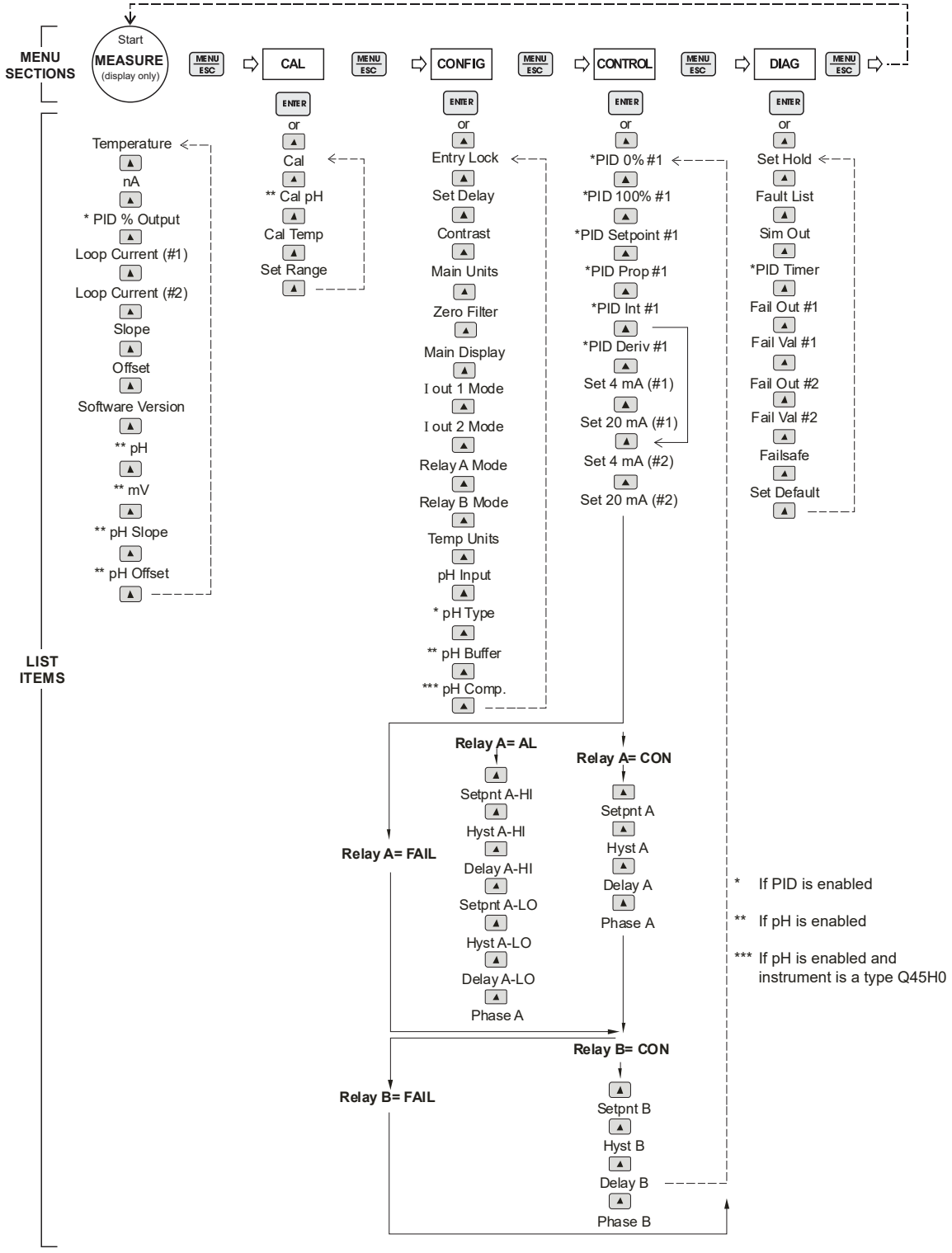


Figure 23: Software map

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 automatically returns 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 Measure 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.
32.0 nA	Raw sensor current. Useful for diagnosing problems.
100% 20.00 mA	*PID Status* screen (if enabled) shows the present controller output level on the left, and actual transmitter current on the right. The controller can be placed in manual while viewing this screen by pressing and holding the **ENTER** key for 5 seconds until a small flashing "m" appears on the screen. At that point the controller output can be adjusted up or down using the **UP** and **LEFT** arrow keys. To return to automatic operation, press and hold the **ENTER** key for 5 seconds and the "m" disappears.
#1 4.00 mA	Analyzer output current # 1.
#2 12.00 mA	Analyzer output current # 2.
#3 20.00 mA	Analyzer output current # 3 (if option included).
Aux relay = D,E,F	Auxiliary relay annunciators (if option included).
Slope = 100%	Sensor output response vs. ideal calibration. This value updates after each calibration. As the sensor ages, the slope reading decays indicating sensor aging. Useful for resolving sensor problems.
Offset = 0.0 nA	Sensor output current at a zero ppm input. This value updates after a zero-calibration has been performed. Useful for resolving sensor problems.
Q46S6 v 4.02	Transmitter software version number.

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.

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

Calibration Menu [CAL]

The calibration menu contains items for frequent calibration of user parameters. There are four items in this list: *Cal PAA*, *Cal pH*, *Cal Temp* and *Set Range*.

Cal PAA The PAA calibration function allows the user to adjust the transmitter span reading to match a reference solution, or to set the sensor zero point. See *"Calibration" on page 43* for more details.

Cal pH (if enabled) The pH calibration function allows the user to adjust the transmitter offset and span to match the sample or reference buffers. See *"Calibration" on page 43*. 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 *"Calibration" on page 43* 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 *"Calibration" on page 43* for more details.

Set Range This function allows the user to set the display range of the transmitter to a specific application. Once set, all output functions use this display range to establish configuration settings. Press **ENTER** to initiate *User Entry* mode and the value flashes. Use the arrow keys to modify value. Available ranges include 20.00 ppm, 200.0 ppm and 2000 ppm. Press **ENTER** to store the new value. The display range does not affect the internal auto ranging scaler which, therefore, sensitivity is to specification in any user selected range.

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 locks the transmitter and entering the correct code again unlocks it. The code is preset at a fixed value. Press **ENTER** to initiate *User Entry* mode and the first digit flashes. Use the arrow keys to modify value. See *page 57* for the Q46H 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 PAA 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 flashes. Use the arrow keys to modify the value. Range is 0.1…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 flashes. Use the arrow keys to modify the value. Range is 0…8 (0 being lightest). Press **ENTER** to update and store the new value.

Main Units This function allows the user to select either PPM or mg/l for the PAA measurement.

Zero Filter This function forces the reading to zero when reading is below the entered value. For example, if the entered value were 0.0020, the display at 0.0019 would indicate 0.000. This feature is useful in blanking out zero noise.

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

Com Mode Sets digital communication mode of analyzer. Optional digital communication card must be plugged into the power supply slot for this function to work. Press **ENTER** to initiate *User Entry* mode and the entire value flashes. Use the **UP** arrow key to modify the desired value. Selections include 1 – None; 2 – P-DP for Profibus DP; 3 – Modbus; 4 – Ethernet IP. Press **ENTER** to store the new value.

Com Address Sets bus address for digital communication mode of analyzer. Optional digital communication card must be plugged into the power supply slot for this function to work.

Press **ENTER** to initiate *User Entry* mode and the entire value flashes. Use the **UP** arrow key to modify the desired value. Range is 1…125. Press **ENTER** to store the new value.

Iout#1 Mode This function sets analog output #1 to either track PAA (default) or enables the PID controller to operate on the PAA input. Press **ENTER** to initiate *User Entry* mode and the entire value flashes. Use the **UP** arrow key to modify the desired value. Selections include 1-ppm for PAA tracking or 2-PID for PAA PID control. Press **ENTER** to store the new value.

***Iout#2 Mode** This function sets analog output #2 for temperature (default), PAA or pH. Press **ENTER** to initiate *User Entry* mode and the entire value flashes. Use the **UP** arrow key to modify the desired value. Selections include 1-°C/°F for temperature; 2-ppm for PAA; or 3-pH for pH. Press **ENTER** to store the new value.

***Iout#3 Mode** **OPTIONAL.** This function sets analog output #3 for temperature (default) or PAA. Press **ENTER** to initiate *User Entry* mode and the entire value flashes. Use the **UP** arrow key to modify the desired value. Selections include 1-°C/°F for temperature or 2-ppm for PPA. Press **ENTER** to store the new value.

***Relay 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 Relay 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 24 on page 39* for details.

The *FAIL* setting enables the fail alarm mode for Relay A. Relay A then trips 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 trips inside or outside of the band, depending upon the phase selected. See *Figure 25 on page 39* for details.

Relay B Mode
Relay C Mode Relay B and C can be used in two ways: as a setpoint control or as an alarm. The two settings for Relay B mode are *CON* and *FAIL*.

The *CON* setting enables normal setpoint operation for Relay B. Relay B then operates identically to Relay A, with settings for setpoint, hysteresis, delay and phasing appearing in the *CONFIG* menu automatically. See *Figure 25 on page 39* for details.

***Relay D Mode**
***Relay E Mode**
***Relay F Mode** **OPTIONAL.** Relays D, E and F can be used in two ways: as a setpoint control or as an alarm. The two settings for Relay B mode are *CON* and *FAIL*.

The *CON* setting enables normal setpoint operation for Relays D, E and F. The Relay then operates identically to Relay A, with settings for setpoint, hysteresis, delay and phasing appearing in the *CONFIG* menu automatically. See *Figure 24 on page 39* for details.

The *FAIL* setting enables the fail alarm mode for Relays D, E and F. The Relay then trips 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. See *Figure 25 on page 39* for details.

Temp Units This function sets the display units for temperature measurement. Press **ENTER** to initiate *User Entry* mode and the entire value flashes. Use the **UP** arrow key to modify the desired display value. The choices are **°F** and **°C**. Press **ENTER** to store the new value.

pH Input Enables the auxiliary pH input on the instrument. Once enabled, an optional pH sensor can be added to the instrument to provide for additional monitoring of pH (dual instrument, PAA + pH output.)

For the relay-based analyzer with two analog outputs, the pH signal can also be sent to one of the analog outputs for monitoring of pH. Once enabled, the pH input value is displayed on the lower line of the *MEASURE* screens. Press **ENTER** to initiate *User Entry* mode and the entire value flashes. Use the **UP** arrow key to modify the desired display value. The choices are **OFF** and **ON**. Press **ENTER** to store the new value.

pH Type Allows the user to select either 1-Comb or 2-Q22P. The 1-Comb selection configures the monitor for a standard pH electrode without using its temperature compensation but in turn, uses the temperature compensator from the PAA sensor. The 2-Q22P selection configures the monitor for use with the Q22P sensor or for the 4…20 mA input from any other pH monitor.

pH Buffer This is a multiple variable function that allows the user to choose which pH buffer sets that are used in the 2-point calibration mode. The Q46H contains 3 sets of built-in buffer tables with compensation values ranging from 0…95° C. During 2-point calibration, the instrument automatically identifies which buffer is being used and compensates for the value based on the built-in tables. This allows very quick, highly accurate calibrations by the user. The order in which the buffers are used during calibration is unimportant, since the system automatically chooses the correct buffer.

The default setting for this feature is **OFF**, which disables the auto-recognition function. Press **ENTER** to change this setting. The buffer table set options are: 1: [4/7/10], 2: [4/7/9.18] and 3: [4.65/6.79/9.23]. See *"Automatic pH Buffer Tables" on page 36*. Once the buffer set is selected, press **ENTER** and the message "Accepted!" displays on the lower line.

Automatic pH Buffer Tables

Table 1

4.00 pH		7.00 pH		10.00 pH	
°C	pH	°C	pH	°C	pH
0	4.00	0	7.10	0	10.27
10	3.99	10	7.06	10	10.15
20	4.00	20	7.02	20	10.05
30	4.01	30	6.99	30	9.95
40	4.03	40	6.97	40	9.87
50	4.05	50	6.98	50	9.80
60	4.08	60	6.98	60	9.75
70	4.12	70	6.97	70	9.73
80	4.16	80	6.99	80	9.73
90	4.21	90	7.01	90	9.75
95	4.24	95	7.01	95	9.77

Table 2

4.00 pH		7.00 pH		9.18 pH	
°C	pH	°C	pH	°C	pH
0	4.00	0	7.10	0	9.46
10	3.99	10	7.06	10	9.33
20	4.00	20	7.02	20	9.23
30	4.01	30	6.99	30	9.14
40	4.03	40	6.97	40	9.07
50	4.05	50	6.98	50	9.01
60	4.08	60	6.98	60	8.96
70	4.12	70	6.97	70	8.92
80	4.16	80	6.99	80	8.89
90	4.21	90	7.01	90	8.85
95	4.24	95	7.01	95	8.83

Table 3

4.65 pH		6.79 pH		9.23 pH	
°C	pH	°C	pH	°C	pH
0	4.67	0	6.89	0	9.48
10	4.66	10	6.84	10	9.37
20	4.65	20	6.80	20	9.27
30	4.65	30	6.78	30	9.18
40	4.66	40	6.76	40	9.09
50	4.68	50	6.76	50	9.00
60	4.70	60	6.76	60	8.92
70	4.72	70	6.76	70	8.88
80	4.75	80	6.78	80	8.85
90	4.79	90	6.80	90	8.82
95	4.79	95	6.80	95	8.82

Control Menu [CONTROL]

The *Control* menu contains all of the output control user settings.

Set 4 mA
Set 20 mA
[Iout1=PAA]

These functions set the main 4 and 20 mA current loop transmitter. The units displayed depend on the selection made in the *CONFIG* menu for *Iout #1* mode. Also, when the Relay Option Board is installed, the units 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 PID 0%
Set PID 100%
[Iout1=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 "reverse" acts. That is, the output of the controller increases if the measured value is less than the setpoint, and the output decreases if the measured value is larger than the setpoint. Flipping the stored values in these points reverses 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
[Iout1=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
[Iout1=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 makes the controller more responsive.

PID Int
[Iout1=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 makes the controller more responsive.

PID Deriv
[Iout1=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 the water treatment process, and therefore, it is best in most cases to leave it at the default value. Increasing this value makes the controller more responsive.

Set 4 mA
Set 20 mA
[Iout1= PAA]

These functions set the main 4 and 20 mA current loop #1 output points for the analyzer when output 1 is in normal, non-PID, mode of operation.

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/PAA/pH]

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), pH or PAA. 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…55° C if it is set for temperature, within the range specified in "Set Range" if the output is set to track PAA, and must be within 0…14 pH if set to track pH. 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 flashes. Use the arrow keys to modify the value. Press **ENTER** to store the new value.

NOTE: If the temperature units are changed between °C and °F (see *"Temp Units" on page 34*), the default settings for this output are stored (present data is not converted).

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

***Set 4 mA #3**
***Set 20 mA #3**
[temp/H_2O_2]

OPTIONAL. These functions set the optional third 4 mA and 20 mA current loop output points for the analyzer. The output may be set to track temperature (default) or PAA. 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…55° C if it is set for temperature, within the range specified in "Set Range" if the output is set to track PAA. The 4 mA and the 20 mA point must be at least 2 units away from each other. Press **ENTER** to initiate *User Entry* mode and the value flashes. Use the 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" on page 34*), the default settings for this output are stored (present data is not converted).

***A Setpoint**

This function establishes the PAA 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 flashes. Use the arrow keys to modify the 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…999 seconds. Press **ENTER** to initiate *User Entry* mode and the value flashes. Use the arrow keys to modify the value. Range is 0…999 seconds. Press **ENTER** to store the new value.

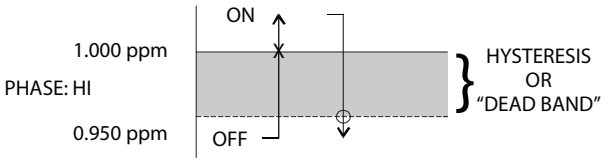
***A Phasing**

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 PAA value **exceeds** the setpoint. When the phase is LO, the relay energizes and the LCD indicator illuminates when the PAA 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 flashes. 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.

NOTE: If the temperature units are changed between °C and °F (see *"Temp Units" on page 34*), the default setting for this output changes between 100° C and 212° F accordingly.

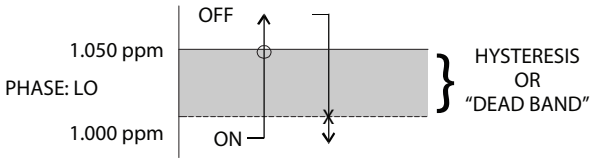
See *Figure 24 on page 39* for a visual description of a typical control relay application.

When value rises to ≥ 1.000 ppm, relay closes.



When value falls to ≤ 0.950 ppm, relay opens.

When value rises to ≥ 1.050 ppm, relay opens.



When value falls to ≤ 1.000 ppm, relay closes.

Settings:

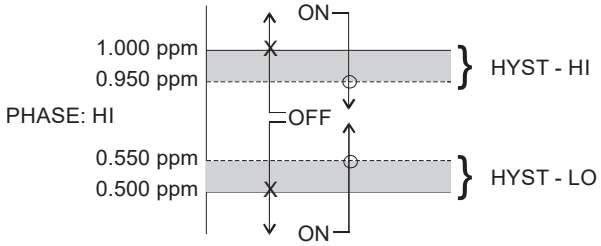
Setpoint: 1.000 ppm
Hyst: 0.050
Delay: 000
Failsafe: OFF

Figure 24: Control relay example, hysteresis and two opposite phase options

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

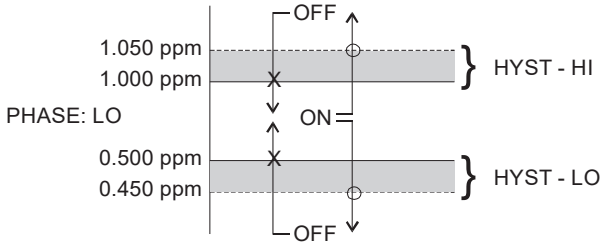
If Relay A mode is set to *Alarm* mode, *AL*, then the following settings appear in the *CONFIG* menu list automatically. In this mode, two setpoints can be selected on the same relay to create an alarm band. *Phase HI* selection causes the relay to energize outside of the band, and *Phase LO* causes 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 25* is a visual description of a typical alarm relay application.

When value rises to ≥ 1.000 ppm, relay closes, until value falls back to ≤ 0.950 ppm.



When value falls to ≤ 0.500 ppm, relay closes, until value rises back to ≥ 0.550 ppm.

When value falls to ≤ 1.000 ppm, relay closes, until value rises back to ≥ 1.050 ppm.



When value rises to ≥ 0.500 ppm, relay closes, until value falls back to ≤ 0.450 ppm.

Settings:

Setpoint	A-HI:	1.000 ppm	Setpoint	A-LO:	0.500 ppm
Hyst	A-HI:	0.050	Hyst	A-LO:	0.050
Delay	A-HI:	000	Delay	A-LO:	000

Figure 25: Alarm relay example

***B Setpoint**
***B Hysteresis**
***B Delay**
***B Phasing**

If Relay B mode is set to *CON* (see **Relay B Mode** on *page 34*), then Relay B functions identically to Relay A. Relay B settings appear in the *CONFIG* menu list automatically.

C Setpoint
C Hysteresis
C Delay
C Phasing

If Relay C mode is set to *CON* (see **Relay C Mode** on *page 34*), then Relay C functions identically to Relay A. Relay C settings appear in the *CONFIG* menu list automatically.

D, E, F Setpoint
D, E, F Hyster
D, E, F Delay
D, E, F Phasing

If Relay D, E or F mode is set to *CON* (see **Relay D, E, F Modes on** *page 34*), then the Relay functions identically to Relay A. Relay settings appear in the *CONFIG* menu list automatically.

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 and halts operation of the PID controller. 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 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 the entire value flashes. 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 Out"*.

CAUTION:
THERE IS NO TIME-OUT ON THE HOLD FEATURE. ONCE PLACED INTO HOLD MODE, RETURNING TO NORMAL OPERATION MUST BE DONE MANUALLY.

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: 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 display 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 clears until calibration is attempted again. If the problem still exists, the calibration failure reoccurs. Press **ENTER** to initiate view of the highest priority failure. The display automatically returns to normal after a few seconds.

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 than zero, a *FAIL* condition occurs if the PID controller remains at 0% or 100% for the timer value. If one of the relays is 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 flashes. Use the **UP** arrow key to modify desired value. Range of value is 0…9999 seconds. Press **ENTER** to store the new value.

Sim Out

The *Sim Out* function allows the user to simulate the PAA level of the instrument in the user selected display range. The user enters a ppm 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 setup or troubleshooting. Escaping this screen returns the unit to normal operation. Press **ENTER** to initiate the *User Entry* mode and the rightmost digit of the value flashes. Use the arrow keys to modify desired value.

The starting display value is the last read value of the input. The output is 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 remains the same even when the **ESC** key is pressed. Disengage the *HOLD* function to return to normal output.

Fail Out #1 This function enables the user to define a specified value that the main current output goes to under fault conditions. When the Relay Option Board is installed, the display reads "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 causes 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 flashes. Use the **UP** arrow key to modify desired value. Selections are **ON**, **OFF**. Press **ENTER** to store the new value.

Fail Val #1 Sets the output failure value for Iout#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 reads "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 flashes. Use the **UP** arrow key to modify desired value; selections are between **4 mA**…**20 mA**. 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.

***Fail Out #3** **OPTIONAL.** This function sets the fail-mode of current loop output #3 under a *FAIL* condition. The settings and operation are identical to *Fail Out* for output #1.

***Fail Val #3** **OPTIONAL.** This function sets the value of current loop output #3 under a *FAIL* condition. The settings and operation are identical to *Fail Out* for output #1.

Backlight This function has three options: **ON** – On all the time, **OFF** – Off all the time, **AL** – Alarm (Default). This function flashes the backlight on and off whenever the "Fail" icon is displayed.

Failsafe This function allows for setting 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 does not change state when, for example, a PAA 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 close 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 open (relay de-energized) and the LCD icon illuminates. In addition, a power fail would also cause the contacts to open.

Start Delay This function is designed to minimize control or alarm issues arising from temporary power loss. When power goes down, the monitor records the analog output values and the status of relays and PID functions. When power is restored, the analog values and relays are held at the pre-power loss values for a defined period of time. This "start delay" may be programmed for periods from 0…9.9 minutes. This function is set to 0.0 minutes by default and must be activated by the user if desired by setting a positive time value.

Set Default The *Set Default* function allows the user to return the instrument back to factory default data for all user settings or for just the calibration default. It is intended to be used as a last resort troubleshooting procedure. All user settings or the calibration 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" flashes. Use the **UP** arrow key to modify value to *YES* and press **ENTER** to reload defaults.

CALIBRATION

PAA Calibration

Once power is applied, the sensor must be given time to stabilize. This is best done by following the zeroing procedure below. Establishing a stable zero is critical to the proper operation of the monitor. A complete calibration includes zeroing and spanning the sensor. It is generally unnecessary to set the zero at every calibration, however, it should be done during the initial installation.

PAA Zero Cal

PAA sensors have extremely low offset currents at zero. For this reason, it is normally sufficient to simply leave the zero at the factory default of 0.0 nA. As an alternative, an electronic zero can be set by disconnecting the sensor from the cable and performing steps 3…5 below.

The steps below assume that the sensor has been prepared in accordance with *"Sensor Assembly" on page 26*.

NOTE: The 8 hour waiting time in step 2 below is not required if the monitor has been running for 24 hours prior to zeroing. If the unit has been running with the sensor connected, the sensor normally returns to a stable zero within 15 minutes.

1. Connect the sensor to the electronics by plugging the cable plug into the receptacle on the top of the sensor.
2. Place about an inch of water in a small beaker or other convenient container and immerse the tip of the sensor. The water used need not be distilled, but it must not contain PAA. For submersible sensors, submerge the entire sensor in a bucket of PAA free water. Allow the sensor to sit undisturbed for at least 8 hours.
3. Scroll to the *CAL* menu section using the *MENU* key and press **ENTER** or the **UP** arrow key. "Cal PAA" displays.
4. Press the **ENTER** key. The screen displays a flashing "1-Ref" for span calibration or a "2-Zer" for zero calibration. Using the **UP** arrow key, set for a 2-Zer zero calibration and press **ENTER**.
5. The system now begins acquiring data for the sensor zero calibration value. As data is gathered, the units for sensor current in nanoamps (nA) and temperature may flash. Flashing units indicate that this parameter is unstable. The calibration data point acquisition stops 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 fails and the message "Cal Unstable" displays.
6. If accepted, the screen displays the message "PASS" with the new sensor zero reading (offset), then it returns to the main measurement display. If the calibration fails, a message indicating the cause of the failure displays and the *FAIL* icon turns on. The range of acceptable value for sensor offset is -25 nA…+25 nA. Should a *FAIL* occur, carefully inspect the sensor for a tear in the membrane. It is probably necessary to rebuild the sensor as described in *"Sensor Assembly" on page 26*. Should the offset value remain high and result in calibration failures, review the *"System Maintenance" on page 50*, and then contact the service dept. at Badger Meter for further assistance.

The sensor zero offset value in nA from the last zero calibration is displayed on the lower line of the *Default* menus for information purposes.

PAA Span Cal

Span calibration of the system must be done against a laboratory measurement on the same sample that the sensor is measuring. A sample should be collected from the inlet line feeding the flowcell and quickly analyzed for PAA. When calibrating, it is best to have a reasonably high concentration of PAA in the system. The higher the value, the smaller are the calibration errors caused by errors in the laboratory analytical procedure. It is generally preferable to calibrate at values above 10 PPM to reduce calibration errors.

Start flowcell and calibrate system as follows:

1. Place the previously zeroed sensor into the sensor chamber of the flowcell assembly. The sensor is inserted into the side of the flowcell and is sealed in place with a double O-ring. The O-rings are lubricated at the factory to allow the sensor to slide smoothly into place. If insertion becomes difficult, use a small amount of silicon grease to lubricate the O-rings. If the low-volume flowcell is used, screw the sensor into the flowcell until the membrane cap bottoms out on the acrylic flowcell. Do not over-tighten.
2. Turn on the inlet water flow to the flowcell and adjust the inlet flow rate so that water is overflowing from the inlet chamber. The best performance is obtained when some water is always overflowing. This maintains constant flow and pressure on the sensor at all times.
3. Allow the system to operate undisturbed for 30…60 minutes. Assuming the water contains PAA, the display reads positive sensor current values. If the system is stable, the value on the display increases to some PPM value and remain at that level. At that point, calibration can continue.
4. If the sensor is online, the user may want to set the output *HOLD* feature prior to calibration to lock out any output fluctuations.
5. Scroll to the *CAL* menu section using the **MENU** key and press **ENTER** or the **UP** arrow key. "Cal PAA" displays.
6. Press the **ENTER** key. The screen displays a flashing "1-Ref" for span calibration or a "2-Zer" for zero calibration. Using the **UP** arrow key, set for a 1-Ref span calibration and press **ENTER**.
7. The system now begins acquiring data for the calibration value. As data is gathered, the units for ppm and temperature may flash. Flashing units indicate that this parameter is unstable. The calibration data point acquisition stops 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 fails and the message "Cal Unstable" displays.
8. The screen displays the last measured ppm value and a message displays 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.
9. If accepted, the screen displays the message "PASS" with the new sensor slope reading, then it returns to the main measurement display. If the calibration fails, a message indicating the cause of the failure displays and the "FAIL" icon turns on. The range of acceptable values for sensor slope is 20…250%. It may be necessary to rebuild the sensor as described in *"Sensor Assembly" on page 26*. Should the slope value remain out of range and result in calibration failures, review the *"System Maintenance" on page 50*, then contact the service dept. at Badger Meter for further assistance.

The sensor offset value in % from the last span calibration is displayed on the lower line of the *Default* menus for information purposes.

Temperature Calibration

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

The sensor temperature may be calibrated online, 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 online, the user may want to set the output *HOLD* feature prior to calibration to lock out any output fluctuations.

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" displays. 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 calibration data gathering process begins. The message "Wait" flashes as data is accumulated and analyzed. The "°C" or "°F" symbol may flash periodically if the reading is too unstable.
5. The message "Adjust value - press ENTER" displays, and the rightmost digit begins 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**.

Once completed, the display indicates "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, attempt the calibration again immediately (recommended).

pH Calibration

The pH calibration menus are not seen unless the optional pH sensor input is turned ON and a special pH sensor is connected to the input of the instrument. See *"Configuration Menu [CONFIG]" on page 33* for more details.

The pH calibration functions appear in the *CAL* menu listing when the optional pH input is enabled in the *CONFIG* menu. When enabled, the pH input signal is used to compensate the PAA signal. Calibration of pH is performed in one of two methods: one-point or two-point. For new sensors or for calibration in two different pH buffers with the sensor removed from the process, choose a two-point calibration. For online calibrations with the sensor still mounted in the process, choose a one-point calibration. For two-point calibrations, it is highly recommended to use fresh pH buffers of 7 pH and 9.18 pH.

Two-Point pH Cal

1. Thoroughly clean the pH sensor and place it into the first pH calibration buffer, stirring it several times before letting it rest in the beaker. Allow sensor to sit in solution long enough to achieve temperature equilibrium with the pH buffer (about 5 minutes.) It is important that both pH buffers be fresh and at room temperature.
2. Scroll to the *CAL* menu section using the **MENU** key and press **ENTER** or the **UP** arrow key.
3. Press the **UP** arrow key until "Cal pH Type" is displayed.
4. Press the **ENTER** key. The display begins to flash. Using the **UP** arrow key, adjust the displayed number to a **2** pt calibration type. This allows the user to offset+slope adjust the sensor input for two separate pH point. Once value has been adjusted, press the **ENTER** key and the message "Accepted!" displays.
5. Scroll to the next menu item by pressing the **UP** arrow key once. The menu item "Cal pH buf1" displays.
6. Press the **ENTER** key. The display begins to flash. Using the **UP** and **LEFT** arrow keys, adjust the displayed number to the known value of the pH buffer. The exact temperature compensated number for pH buffers is typically written on the side of the buffers shipping container. Once value has been adjusted, press the **ENTER** key.
7. The message "Accepted!" displays or an error describing the cause of the failure. If the cal point was accepted, rinse the sensor in distilled or deionized water and move it into the second pH buffer. Stir it slightly several times and let the sensor rest in the beaker.
8. Scroll to the next menu item by pressing the **UP** arrow key once. The menu item "Cal pH buf2" displays.
9. Press the **ENTER** key. The display begins to flash. Using the **UP** and **LEFT** arrow keys, adjust the displayed number to the known value of the second (higher or lower value) pH buffer. Once value has been adjusted, press the **ENTER** key.
10. The message "Accepted!" displays, or an error describing the cause of failure. The system is now two-point calibrated for pH.

One-Point pH Cal

1. For this calibration method, the sensor may be removed, cleaned and placed into a known pH buffer, or it may be calibrated online against a known reference value. If the sensor is removed, thoroughly clean the pH sensor and place it into the pH calibration buffer, stirring it several times before letting it rest in the beaker. Allow sensor to sit in solution long enough to achieve temperature equilibrium with the pH buffer (about 5 minutes.) It is important that the pH buffer be fresh and at room temperature.
2. Scroll to the *CAL* menu section using the **MENU** key and press **ENTER** or the **UP** arrow key.
3. Press the **UP** arrow key until "Cal pH Type" is displayed.
4. Press the **ENTER** key. The display begins to flash. Using the **UP** arrow key, adjust the displayed number to a **1** pt calibration type. This allows the user to offset-adjust the sensor input for one pH point. Once value has been adjusted, press the **ENTER** key and the message "Accepted!" displays.
5. Scroll to the next menu item by pressing the **UP** arrow key once. The menu item "Cal pH buf1" displays.
6. Press the **ENTER** key. The display begins to flash. Using the **UP** and **LEFT** arrow keys, adjust the displayed number to the known value of the pH buffer. If the sensor is still mounted in the process, enter the known reference value. The exact temperature compensated number for pH buffers is typically written on the side of the buffers shipping container. Once value has been adjusted, press the **ENTER** key.
7. The message "Accepted!" displays, or an error describing the cause of failure. The system is now two-point calibrated for pH.

PID CONTROLLER DETAILS

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 use 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 changes from 0…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 or proper chemicals, for example) 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, for example.

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.

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. The implementation here is the most common version (the ISA algorithm, commonly referred to as the "ideal" algorithm).

Q46H ISA (Ideal) Equation

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

Where:

output =	controller output
P =	proportional gain
I =	integral gain
D =	derivative gain
t =	time
e(t) =	controller error (e=measured variable – setpoint)

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 uses the same form of the algorithm shown above, it is likely similar settings can be 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 (that is, reps-per-min or 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 or valve, for example.

Although the three components of the PID are described in the setting area *"Control Menu [CONTROL]" on page 37*, here are more general descriptions of what each of the PID elements contributes 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 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 causes 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, its best to leave the "D" term set to 0.

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 "Ps" and low "Is" appear to operate the same as combinations of low "Ps" and high "Is", there is a difference in rate of recovery and stability. Because of the way the algorithm is structured, large "Ps" 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 of the classical 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 1/2 of the oscillatory value, and the "I" term is increased to give the desired response. This can be done with the Q46 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) do not 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" is approximately 3 times the value of "P".

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 *"PID Algorithm" on page 47* are sufficient for almost all application tuning for this instrument. Beyond this, many sources are available for classical tuning methods.

Manual PID Override Control

The Q46 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 indicates "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. A small "m" shows 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 key or you may decrease the output by pressing the **LEFT** arrow key. This allows 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.

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.

Close-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 processes are generally slow in nature. Therefore, even a de-tuned controller (one that responds somewhat slowly) 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 makes sure proper mixing or reaction time has occurred.

The easiest processes to control with closed-loop schemes are generally linear and symmetrical in nature. For example, controlling the level in a tank where the opening of a valve for a fixed period of time corresponds linearly to the amount that flows into a tank. Chemical control processes can be more problematic when the nature of the setpoint value is nonlinear 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 differentially 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").

SYSTEM MAINTENANCE

General

The Q46/85 PAA System generally provides unattended operation over long periods of time. With proper care, the system should continue to provide measurements indefinitely. For reliable operation, maintenance on the system must be done on a regular schedule. Keep in mind that preventive maintenance on a regular schedule is much less troublesome than emergency maintenance that always seems to come at the wrong time.

Analyzer Maintenance

No unusual maintenance of the analyzer is required if installed according to the guidelines of this manual. If the enclosure door is frequently opened and closed, it would be wise to periodically inspect the enclosure sealing gasket for breaks or tears.

PAA Sensor Maintenance

Sensor maintenance is required for accurate measurements. The primary requirement is simply to keep the sensor membrane clean. The membrane is a micro-porous polymer that is resistant to anything that is encountered in water streams. However, deposits can form on the surface or in the pores of the membrane, and these deposits reduce the sensitivity. Certain constituents in water, mainly iron and manganese, form precipitates. These precipitates can sometimes form a coating on the membrane.

Because membranes are micro-porous, they can be relatively difficult to clean effectively. Immersing the tip of the sensor in 1N nitric acid solution sometimes remove deposits that cause low sensitivity, but this is not always the case. The recommended practice is to simply replace the membrane when it becomes fouled. To change a membrane, follow the procedure (*"Sensor Assembly" on page 26*). Do not reuse the electrolyte from the sensor when changing a membrane. Always refill with fresh electrolyte. The electrolyte is stable and does not have a limited shelf life.

Refer again to the explanation of the sensor slope number after an accepted span calibration on the lower *MEASURE* screen. In normal operation, the slope of the sensor output decreases over time as the membrane becomes fouled. This reduction indicates that the sensor is losing sensitivity to PAA. It is good practice to replace the membrane if the slope number falls to 30…40%. The value does not go below 20%.

Even if no buildup is apparent on the membrane, it should be changed on a regular schedule. The recommended membrane change interval is every 3 months. For high purity water applications, this can probably be extended if desired, but a more frequent changing interval is a small price to pay for avoiding membrane failure at the wrong time.

While the sensor is disassembled for membrane changing, examine the condition of the O-rings on both ends of the electrolyte chamber. If the O-rings show any signs of damage, replace them with new ones from the spare parts kit. It is good practice to change these O-rings once a year, regardless of their condition.

Sensor Acid Cleaning

Over an extended operating period, PAA sensors can slowly accumulate deposits on the surface of the gold electrode. Typically, this type of buildup occurs over years of operation, but can sometimes occur more quickly in high levels of manganese, iron or other metals that are dissolved in the water. The platinum electrode can be "acid cleaned" using nitric acid solutions.

⚠ WARNING

THIS ACID CLEANING PROCEDURE INVOLVES THE USE OF HIGHLY CORROSIVE ACID SOLUTIONS. IT SHOULD ONLY BE COMPLETED BY TRAINED PERSONNEL USING PROTECTIVE EYEWEAR AND GLOVES. IF THERE IS ANY DOUBT ABOUT YOUR ABILITY TO SAFELY ACCOMPLISH THIS PROCEDURE, RETURN THE SENSOR TO BADGER METER FOR FACTORY CLEANING!

To acid clean the electrode assembly, remove the electrolyte chamber from the sensor so that both electrodes are exposed. Then follow the procedure below:

1. Place a small amount of 50% nitric acid solution in a beaker. Put in just enough so that the gold tip of the sensor can be submerged without any contact with the silver coil.
2. Allow the sensor to soak in this acid solution for 2 minutes. Remove the sensor body and rinse the platinum tip thoroughly with distilled water. Discard the nitric acid safely and according to all environmental regulations.
3. Fill the beaker with distilled water to the level sufficient to submerge both the tip and the silver coil. Do not allow the connector at the back of the sensor to be submerged. Allow the electrodes to soak in distilled water for 30 minutes.
4. Put a new membrane and fresh electrolyte in the electrolyte chamber and reassemble the sensor. Connect to the PAA monitor electronics and allow the sensor to stabilize for at least 24 hours. The sensor can be placed in the flowcell with ozonated water running through it during stabilization. However, the readings are not useful for 24 hours.

Flowcell Maintenance

The maintenance on the flowcell is simple cleaning. The flowcell is clear to make examination of the condition of the sensor easier without interfering with operations. The flowcell may be cleaned by wiping or by washing with detergents or dilute acids. Do not try to clean with solvents as the acrylic may craze or crack.

Change the O-ring in the flowcell yearly or if any damage is observed. If insertion of the sensor into the flowcell becomes difficult, use silicon grease to lubricate the O-rings that hold the sensor in place. Use only enough grease to provide surface lubrication. Excess grease could foul the sensor membrane.

TROUBLESHOOTING

General

The information included in this section is intended to be used in an attempt to quickly resolve an operational problem with the system. During any troubleshooting process, it saves the most time if the operator can first determine if the problem is related to the analyzer, sensor or some external source. Therefore, this section is organized from the approach of excluding any likely external sources, isolating the analyzer and finally isolating the sensor. If these procedures still do not resolve the operational problems, any results the operator may have noted here are very helpful when discussing the problem with the factory technical support group.

External Sources of Problems

To begin this process, review the connections of the system to all external connections.

1. Verify the analyzer is earth grounded. For all configurations of the analyzer, an earth ground connection MUST be present for the shielding systems in the electronics to be active. Grounded conduit provides no earth connection to the plastic enclosure, so an earth ground wiring connection must be made at the power input terminal strip. Verify metal shield is present over incoming power connections. This shield is for safety purposes, but also blocks electrical spikes from relay and power wiring.
2. Verify the proper power input is present (115…230V AC or 16…35V DC).
3. Verify the loads on any 4…20 mA outputs do not exceed the limits in the Instrument Specifications. During troubleshooting, it is many times helpful to disconnect all these outputs and place wire-shorts across the terminals in the instrument to isolate the system and evaluate any problems which may be coming down the analog output connections.
4. Do not run sensor cables or analog output wiring in the same conduits as power wiring. If low voltage signal cables must come near power wiring, cross them at 90° to minimize coupling.
5. If rigid conduit has been run directly to the Q46 enclosure, check for signs that moisture has followed conduit into the enclosure.
6. Check for ground loops. Although the membrane sensor is electrically isolated from the process water, high frequency sources of electrical noise may still cause erratic behavior in extreme conditions. If readings are very erratic after wiring has been checked, check for a possible AC ground loop by temporarily disconnecting feed and drain lines from the flowcell while there is still water on the inside. The reading should be initially stable and then fall very slowly in a smooth fashion as PAA is depleted in the static sample.
7. On relay based systems, check the load that is connected to the relay contacts. Verify the load is within the contact rating of the relays. Relay contacts which have been used for higher power AC current loads may become unsuitable for very low signal DC loads later on because a small amount of pitting can form on the contacts.

   NOTE: If the load is highly inductive (solenoids, motor starters, large aux relays), the contact rating is de-rated to a lower level. Also, due to the large amount of energy present in circuits driving these types of loads when they are switched on and off, the relay wiring placement can result in electrical interference for other devices. This can be quickly resolved by moving wiring, or by adding very inexpensive snubbers (such as Quencharcs) to the load.
8. Carefully examine any junction box connections for loose wiring or bad wire stripping. If possible, connect the sensor directly to the analyzer for testing.
9. Check sensor membrane for fouling. Look closely for signs of grease or oil that may be present. Replace membrane and electrolyte, allow to stabilize and re-check. The procedure in *"Sensor Assembly" on page 26*, must be followed when replacing the membrane.

Analyzer Tests

1. Disconnect power and completely disconnect all output wiring coming from the analyzer. Remove sensor wiring, relay wiring and analog output wiring. Re-apply power to the analyzer.
2. Using the *Simulate* feature, check operation of analog outputs and relays with a DMM.
3. Check cell drive circuit. With a digital voltmeter (DVM), measure the voltage between ORANGE (–) terminal and WHITE (+) terminals. Verify that the millivolt value is actually –400 mV.
4. Check TC drive circuit. Place a wire-short between the GREEN and BLACK terminals. With a digital voltmeter (DVM), measure the voltage between the BLACK and RED terminals on the back of the monitor to verify that the TC drive circuit is producing about 4.8…5.1V DC open circuit. Remove DVM completely and connect a 100 Ohms resistor from the BLACK to RED terminals. The temperature reading should display approximately 0° C and the PAA reading should display approximately 0 ppm.

Display Messages

The Q46 Series instruments provide a number of diagnostic messages which 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*.

The following messages appear as prompts:

Message	Description	Possible Correction
Max is 200	Entry failed, maximum user value allowed is 200.	Reduce value to ≤ 200.
Min is 20	Entry failed, minimum value allowed is 20.	Increase value to ≥ 20.
Cal Unstable	Calibration problem, data too unstable to calibrate. Icons do not stop flashing if data is too unstable. User can bypass by pressing **ENTER**.	Clean sensor, get fresh cal solutions, allow temperature and conductivity readings to fully stabilize. Do not handle sensor or cable during calibration.
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.
Offset High	The sensor zero offset point is out of the acceptable range of –20…+20 nA.	Check wiring connections to sensor. Allow sensor to operate powered a minimum of 12 hours prior to first zero cal.
Sensor High	The raw signal from the sensor is too high and out of instrument range.	Check wiring connections to sensor.
Sensor Low	The raw signal from the sensor is too low.	Check wiring connections to sensor.
PAA High	The PAA reading is greater than the maximum of the user-selected range.	The PAA reading is over operating limits. Set measuring range to the next highest level.
Temp High	The temperature reading is > 55° 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.	Same as "Temp High" above.
TC Error	TC may be open or shorted.	Check sensor wiring and perform RTD test as described in sensor manual. Check j-box connections.
PAA Cal Fail	Failure of PAA calibration. *FAIL* icon does not extinguish until successful calibration has been performed, or 30 minutes passes with no keys being pressed.	Clean sensor, redo zero and span calibration. If still failure, sensor slope may be less than 25% or greater than 250%. Perform sensor tests as described in *"Sensor Tests" on page 55*. Replace sensor if still failure.
TC Cal Fail	Failure of temperature calibration. *FAIL* icon does not extinguish until successful calibration has been performed, or 30 minutes passes with no keys being pressed.	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 Tests" on page 55*. Replace sensor if still failure.
EEPROM Fail	Internal non-volatile 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.
Range Cal Fail	Failure of factory temperature calibration.	Consult factory.

Sensor Tests

1. Check the membrane condition. A membrane that is not stretched smoothly across the tip of the sensor causes unstable measurements. If necessary, change membrane and electrolyte.
2. Residual PAA sensors can be tested with a digital voltmeter (DVM) to determine if a major sensor problem exists. Follow the steps below to verify sensor integrity:
    a. Disconnect the five sensor wires from the back of the PAA monitor. Those wires are color coded white, brown, red, black and green.

    NOTE: The brown wire may be replaced with an orange wire in some cables.

    b. Remove the electrolyte chamber from the sensor and dry the electrodes with a paper towel.
    c. Connect a DVM between the white and brown (or orange) wires. Reading resistance, you should find an open circuit value of infinite resistance. There must be no measurable resistance at all between these wires. Any resistance at all indicates either water in the cable connector or the breakdown in an electrode seal.
    d. Connect a DVM between the red and white wires. The red wire is part of the RTD circuit and the white wire is part of the measuring cell. There should be no connection. Reading resistance, you should find an open circuit value of infinite resistance. Any resistance at all indicates either water in the cable connector or the breakdown in an electrode seal.
    e. Connect the DVM between the red and black wires. These are the RTD leads, and you should find a resistance value that depends on the temperature. Reading resistance between the red and green wires should give exactly the same values as between red and black. The table below lists the resistance values for various temperatures:

Temperature	Resistance
0° C	100.0 Ω
5° C	101.9 Ω
10° C	103.9 Ω
15° C	105.8 Ω
20° C	107.8 Ω
25° C	109.7 Ω
30° C	111.7 Ω
35° C	113.6 Ω
40° C	115.5 Ω
45° C	117.5 Ω
50° C	119.4 Ω

    If you suspect that water has gotten into a cable connection on a flow type sensor or into the plug connection of a submersible sensor, disconnect the cable and allow the parts of the sensor to sit in a warm place for 24 hours. If water in the connector is the problem, it should dry out sufficiently to allow normal sensor operation. However, steps 2c thru 2e above have to be repeated after drying to see if the problem is gone.
3. Acid clean the sensor electrodes in accordance with the procedure *"Sensor Acid Cleaning" on page 51*.

SPARE PARTS

Part No.	Description
Electronics	
03-0385	Q46/85 Front Lid Assembly (specify PAA when ordering)
*	Q46/85 Monitor, 100…240V AC
*	Q46/85 Monitor, 12…24V DC
*	Q46/85 Monitor, 100…240V AC, w/Profibus
*	Q46/85 Monitor, 12…24V DC, w/Profibus
23-0029	Fuse, T-Lag, 630 mA, 250V, TR-5 (for AC and DC Analyzers)
38-0072	Terminal block plug, 3 position (relays)
38-0073	Terminal block plug, 4 position (outputs)
38-0074	Terminal block plug, 3 position (shields)
38-0081	Terminal block plug, 3 position (power)
38-0084	Terminal block plug, 3 position (power) – V DC version**
NOTE: **Prior to Dec 2018, V DC (power) Terminal block used the (38-0081)	
03-0407	Q46 P/S Assy, 100…240V AC
03-0408	Q46 P/S Assy, 100…240V AC with 3rd 4…20 mA output
03-0409	Q46 P/S Assy, 100…240V AC with 3 relay exp. Board
03-0410	Q46 P/S Assy, 12…24V DC
03-0411	Q46 P/S Assy, 12…24V DC with 3rd 4…20 mA output
03-0412	Q46 P/S Assy, 12…24V DC with 3 relay exp. Board
Sensors	
00-1620	PAA sensor, flow type
07-0096	Q22 pH Sensor, no cable
63-0101	Conventional pH Sensor with solution ground, 25 ft cable
Sensor Components	
02-0018	Sensing element body, (for part number 00-1620)
03-0029	Sensor interconnect cable with connector, 25 ft
45-0007	Electrolyte chamber
45-0290	Membrane holder, type Kynar
05-0090*	Membranes, pkg. of 10
05-0004*	Spare Parts Kit, screw and O-ring
09-0060*	Peracetic acid electrolyte, 4 oz (120 cc)
Flowcells	
00-0043	Constant-Head flowcell assembly with mounting plate
00-1522	Sealed flowcell assembly with mounting plate
00-1527	Sealed pH flowcell assembly with mounting plate
42-0014	Flowcell O-ring (each)

Part No.	Description
Misc Components	
07-0100	Universal Junction Box, NEMA 4X
07-0382	Junction Box for 2nd Input Sensor
31-0038	Interconnect cable for junction box to monitor wiring
03-0371	Fixed Flow Regulator assy (w/25 ft tubing)
44-0276	Black Polyurethane tubing
05-0101	Vacuum Breaker Assy

NOTE: Instrument is supplied with sufficient spare parts for 6…12 months of operation. For 2 year spare parts inventory, 3 each of the items marked with an asterisk are required.

***** Please consult factory or item numbers of electronic assemblies

Lock/Unlock Code: 1461

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