A Badger Meter® Brand

# Water Quality Monitor

## Model Q46/88 Suspended Solids Monitor


Badger Meter

ATI-UM-04565-EN-02 (November 2024)

# User Manual

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# INTRODUCTION

## General

The Model Q46/88 is an online monitoring system designed for the continuous measurement of suspended solids in water. It is intended for continuous monitoring of aeration tank mixed liquor, clarifier effluent, industrial process water and other applications containing relatively high levels of suspended solids.

The system provides measurement over one of 3 selectable operating ranges: 0…100.0 mg/L, 0…1000 mg/L or 0…10.00 mg/L. The sensing element used for suspended solids measurement is an optical sensor measuring infrared "backscatter", a method suitable for high solids levels. For applications where sensor fouling is frequent, and Auto-Clean version of the system is available that uses Badger Meter's Q-Blast air cleaner assembly.

Q46/88 monitors are available in two electronic versions: an AC powered monitor with integral alarm relays and dual 4…20 mA output capability, and a 12…24V DC unit with dual output and relays. Options are available to add either a third 4…20 mA output or 3 additional low power SPST relays (required for Auto-Clean systems). In addition, digital output options are available for Profibus-DP, Modbus RTU, TCP/IP or Ethernet-IP.

## Standard System

Q46/88 systems include two components: the Q46 analyzer and an optical sensor with 30 ft cable. Sensor mounting options include submersion, submersion with Auto-Clean holder, 1-1/2 in. flow tee or flowcell. If possible, the flowcell or flow tee should be used if expected suspended solids levels are always below 10 mg/L.

For connection of the sensor to the electronics, a 30 ft cable is supplied. Up to an additional 400 ft of interconnect cable may be added using part number 07-0100 junction box.

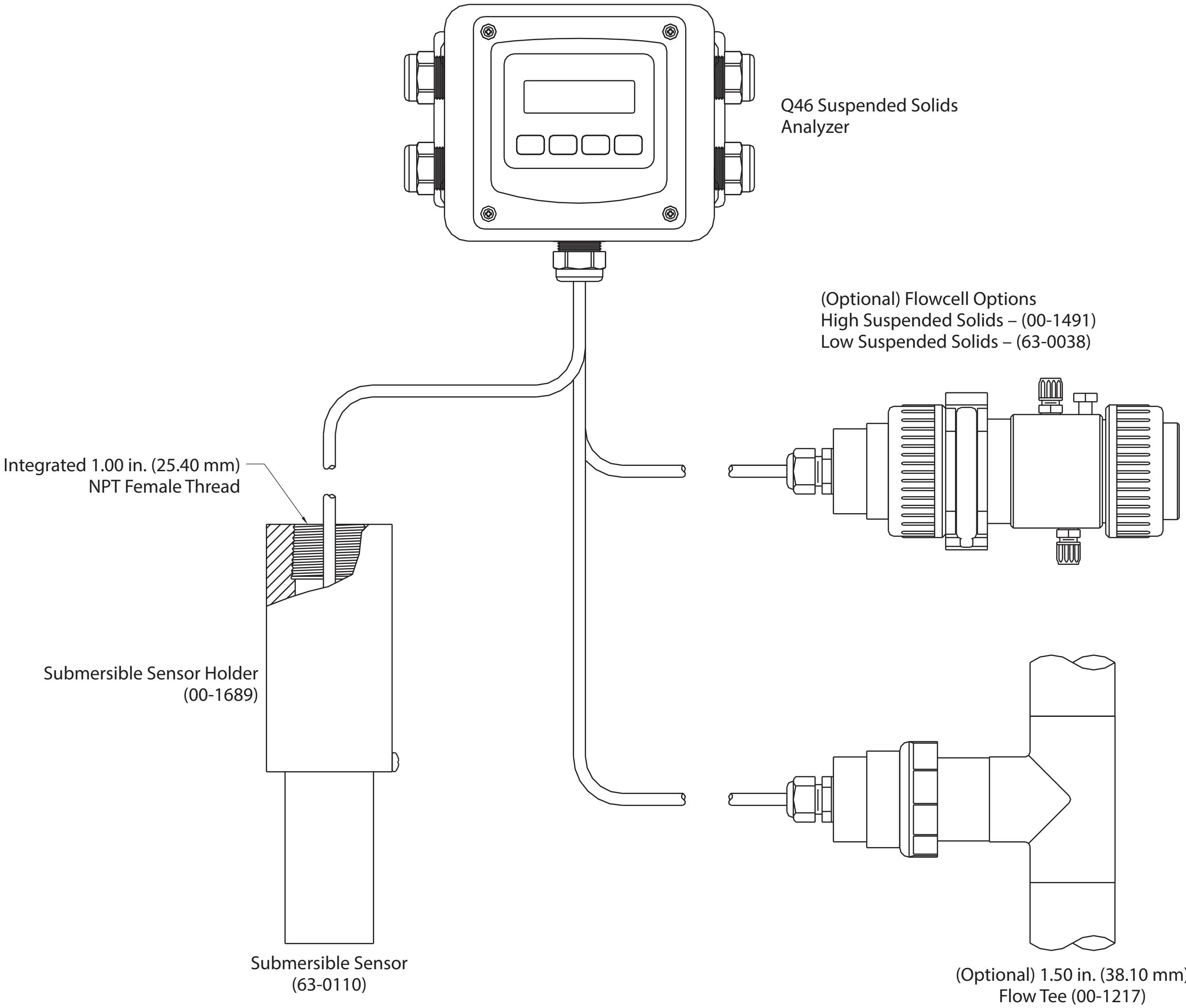



*Figure 1: System options*

## Features

- Q46 electronic transmitters are designed to be a fully isolated instruments for operation from either 90…260V AC or 12…24V DC power supplies.
- Two 4…20 mA analog outputs are standard, and a third analog output is available as an option. Output #1 may be configured for PID control. Outputs 2 (and 3 if added) are programmable to track suspended solids, temperature or sensor signal strength.
- Selectable PID controller on main analog output.
- Communication options for Profibus-DP, Modbus-RTU, TCP/IP or Ethernet-IP.
- *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 SPDT relay outputs for on-off control. Software settings for relay control include setpoint, deadband, phase, delay and failsafe.
- Selectable *Output Fail Alarm* feature on Relay C allows system diagnostic failures to be sent to external monitoring systems.
- Large, high contrast, custom LCD display with LED back light provides excellent readability in any light conditions. The secondary line of display uses 5 × 7 dot matrix characters for clear message display. Two of four measured parameters may be on the display simultaneously.
- 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.
- 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.

## Q46/88 System Specifications

| | |
|---|---|
| **Displayed Parameters** | Main input, 0.1 mg/L…10.00 mg/L<br>Sensor temperature, –5.0…50.0° C (23…122° F)<br>Loop current, 4.00…20.00 mA<br>Sensor slope/offset<br>Check signal level<br>% light level<br>Model number and software version<br>PID controller status |
| **Main Parameter Ranges** | Manual selection of one of the following display ranges:<br>0…100.0 mg/L, 0…1000 mg/L or 0…10.00 mg/L. |
| **Power** | 90…260V AC, 50/60 Hz, 10 VA Maximum<br>12…24V DC, 500 mA max |
| **Display** | 0.75 in. (19.05 mm) high 4-digit main display with sign<br>12-digit secondary display, 0.30 in. (7.62 mm) 5 × 7 dot matrix<br>Integral LED back-light for visibility in the dark. |
| **Enclosure** | NEMA 4X, polycarbonate, stainless steel hardware |
| **Mounting Options** | Wall, pipe or panel mount standard. Wall bracket suitable for either 1.50 in. or 2 in. I.D. U-bolts for pipe mounting. |
| **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.<br>Software selection for setpoint, phase, delay, deadband, hi-lo alarm and failsafe.<br>A-B indicators on main LCD, and C indicator on lower display. |
| **Analog Outputs** | Two 4…20 mA outputs. Output 1 programmable for NTU Suspended Solids or PID. Output 2 programmable for NTU or Temperature. Max load 450 Ohms for output 1 and 1000 Ohms for output 2. Outputs ground isolated and isolated from each other. An additional 3rd analog option is available. |
| **Output Isolation** | 600V galvanic isolation |
| **Optional Relays** | Three SPST, 1 amp @ 24V DC. Software selection for setpoint, phase, delay, deadband, hi-lo alarm and failsafe. |
| **Ambient Temperature** | Analyzer Service, –20…60° C (–4…140° F)<br>Sensor Service, 0…55° C (23…131° F)<br>Storage, –30…70° C (–22…158° F) |
| **Ambient Humidity** | 0…95%, indoor/outdoor use, non-condensing to rated ambient temperature range |
| **Altitude** | Up to 2000 m (6562 ft) |
| **Electrical Certification** | Ordinary location, cCSAus (certified to both CSA and UL standards), pollution degree 2, installation category 2 |
| **EMI/RFI Influence** | Designed to EN 61326-1 |
| **Weight** | 2.4 lb (1.1 kg) |
| **Sensor** | Optical backscatter |
| **Sensor Materials** | PVC and acrylic |
| **Sensor Cable** | Submersible: 30 ft (10 m) |
| **Max. Sensor Cable Length** | 400 ft (123 m) with junction box |

## Q46/88 Performance Specifications

| | |
|---|---|
| **Accuracy** | 0.5% of range or 0.5 mg/L |
| **Repeatability** | 0.3% of range or 0.3 mg/L |
| **Sensitivity** | 0.1% of selected range |
| **Warm-Up Time** | 30 seconds to rated performance (electronics only) |
| **Supply Voltage Effects** | ±0.1% span |
| **Instrument Response Time** | 120 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. Choose a location that is readily accessible for calibrations and keep in mind that it is necessary to use solutions 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 ft (30 m). To maximize signal-to-noise ratio however, work with the shortest sensor cable possible. The standard cable length of the Suspended Solids sensor is 15 ft.

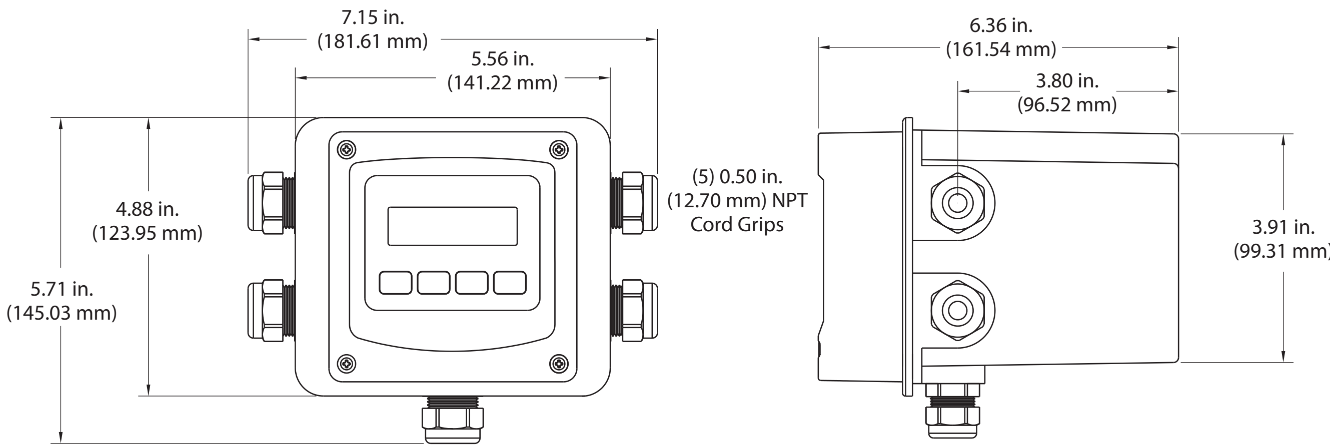



*Figure 2: Q46 Enclosure dimensions*

## Wall or Pipe Mount

A PVC mounting bracket with attachment screws is supplied with each transmitter (see *Figure 3* for dimensions). 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 3*.

**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).

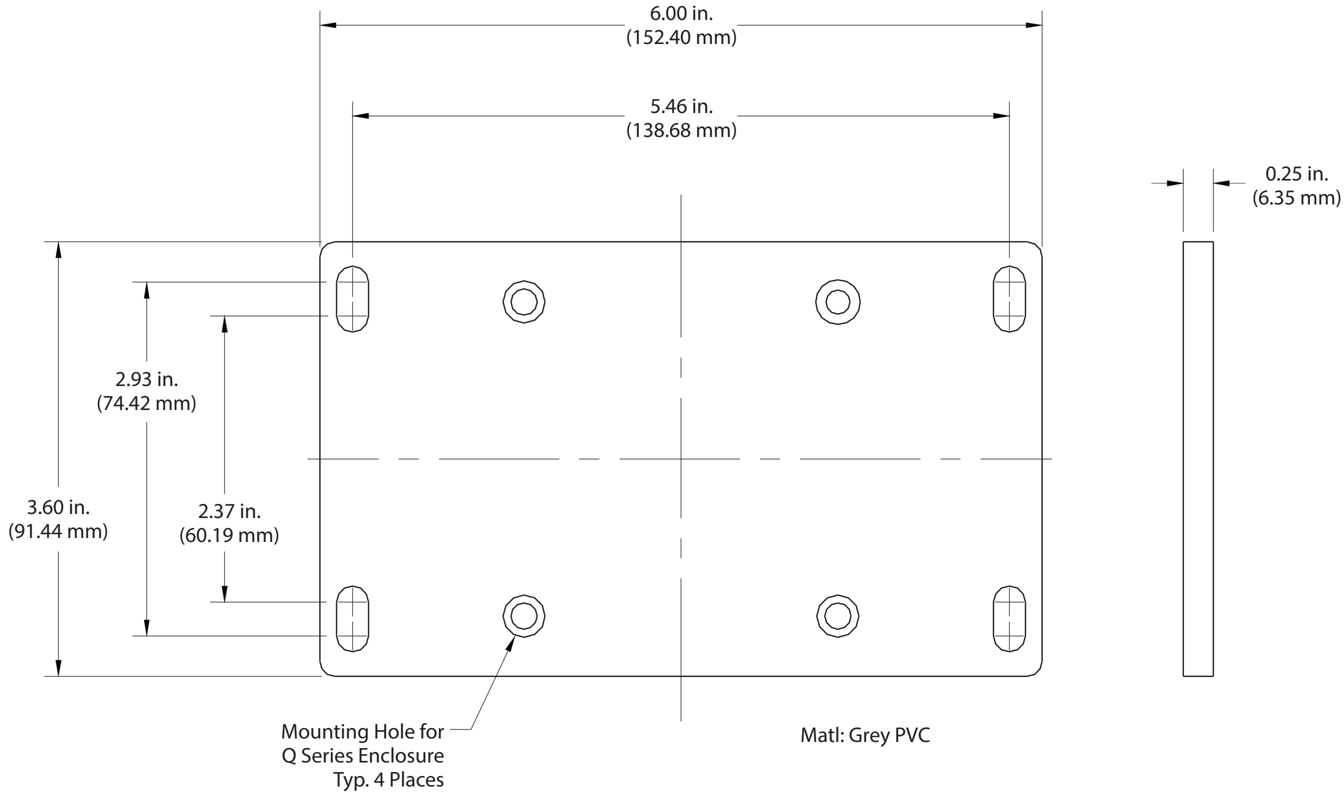



*Figure 3: Wall or pipe mount bracket*

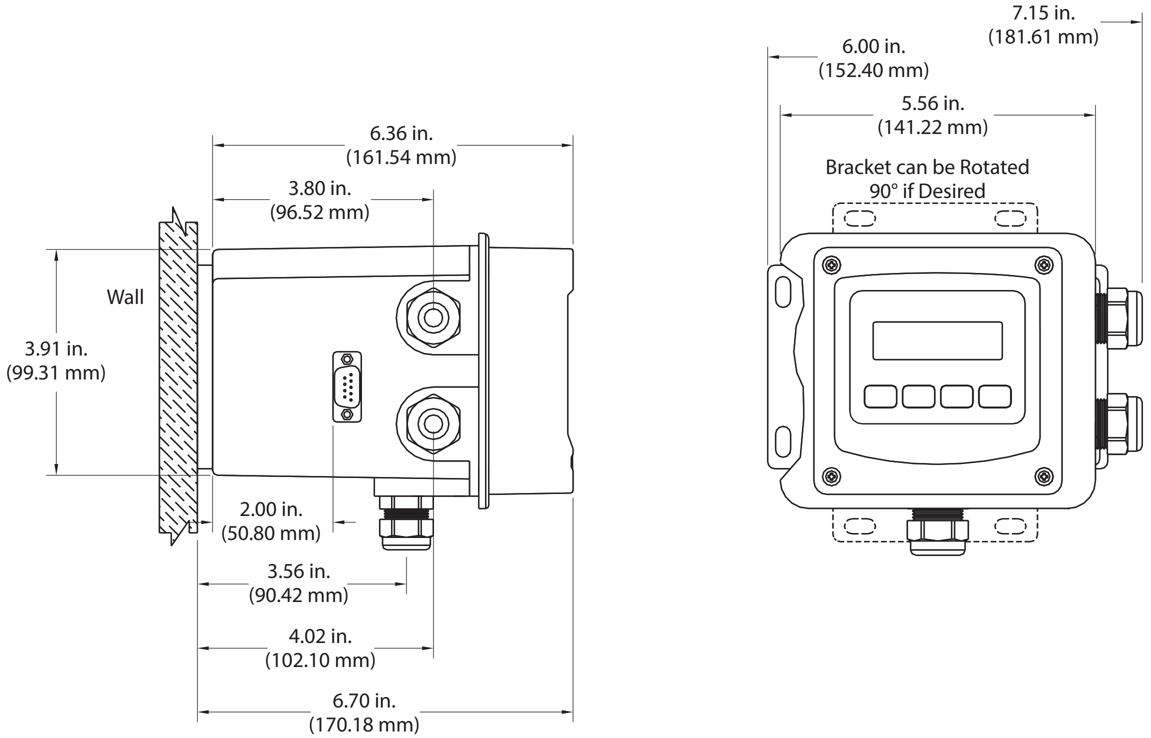
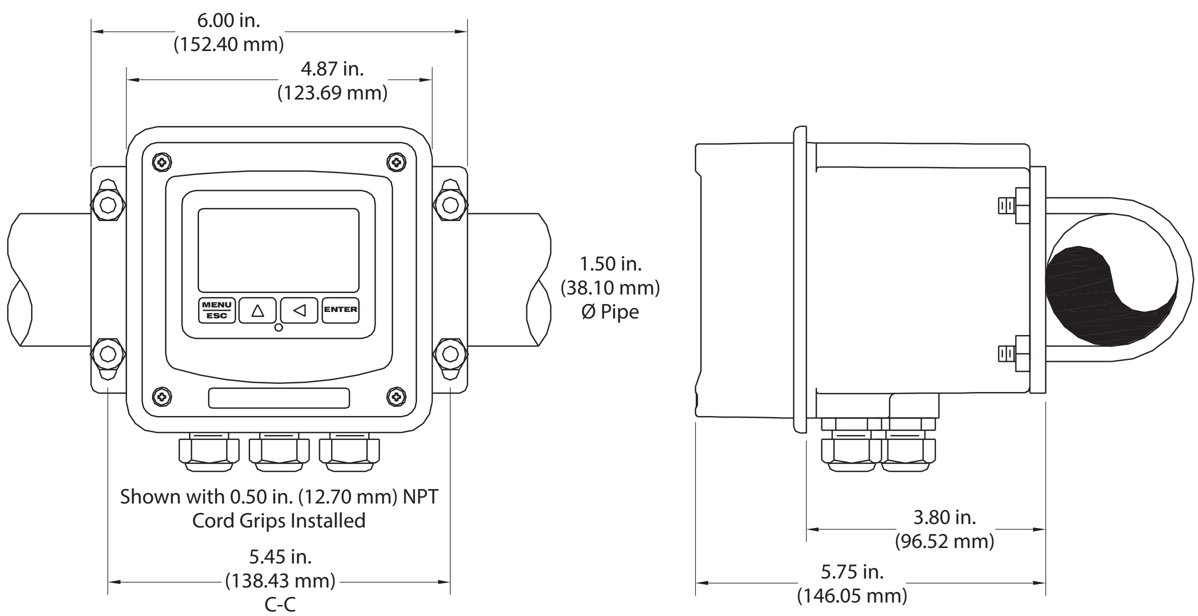



*Figure 4: Wall mounting diagram*




**NOTE:** Mounting plate hole spacing can support up to 2 in. Ø pipe max.

*Figure 5: Pipe mounting diagram*

## Panel Mount, AC Powered Monitor

Panel mounting of an AC powered monitor uses the panel mounting flange molded into the rear section of the enclosure.

*Figure 6* provides dimensions for the panel cutout required for mounting. The panel mounting bracket kit (05-0068) must be ordered separately. This kit contains a metal retainer bracket that attaches to the rear of the enclosure, 4 screws for attachment of this bracket and a sealing gasket to ensure that the monitor flange 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. 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 proceed to mount the monitor in the panel.

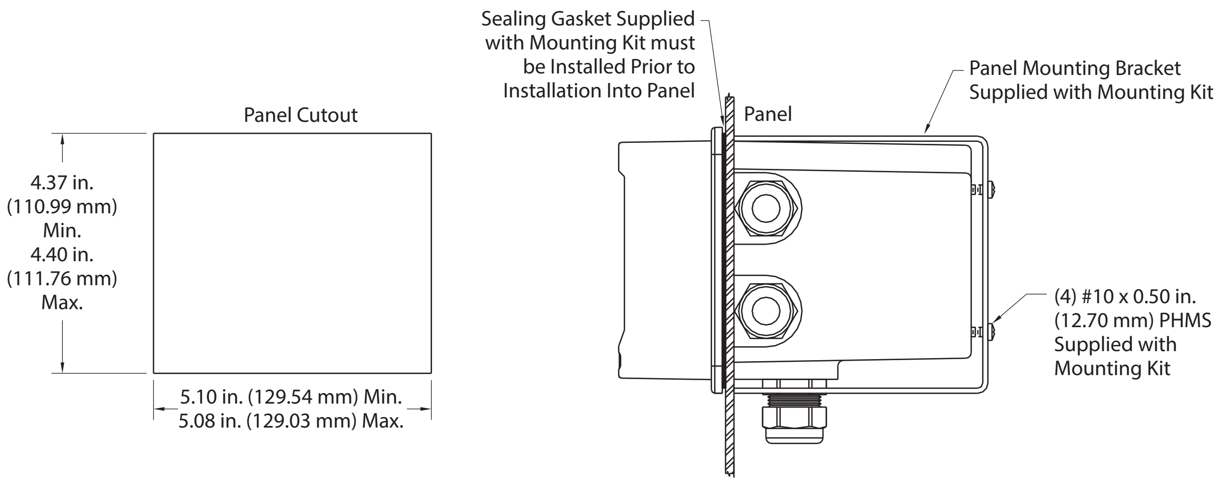



*Figure 6: Panel mount installation*

# SENSOR INSTALLATION

## General

The majority of suspended solids applications use a submersible sensor mounted on a pipe and submerged in aeration tanks, effluent channels or other open tanks. For monitoring very low suspended solids levels, it is often better to use a flowcell or flow tee for measurement, which means the sample must be pumped to the measuring point. A flowcell or flow tee eliminates all ambient light that might interfere at low solids levels. If a flowcell or tee is used, ensure that air is not entrained in the pumped sample. Air bubbles cause high SS values due to optical reflections off the bubbles.

## Submersible Installation

The standard suspended solids sensor may also be used for submersion installations. A special adapter is available for mounting the suspended solids sensor to a 1 in. pipe. *Figure 7* shows a typical submersion mounting using Badger Meter's submersion mounting kit (00-1690). This complete kit adapts to typical handrails. The pipe adapter only (00-1689) is available separately when the handrail mounting kit is not required.

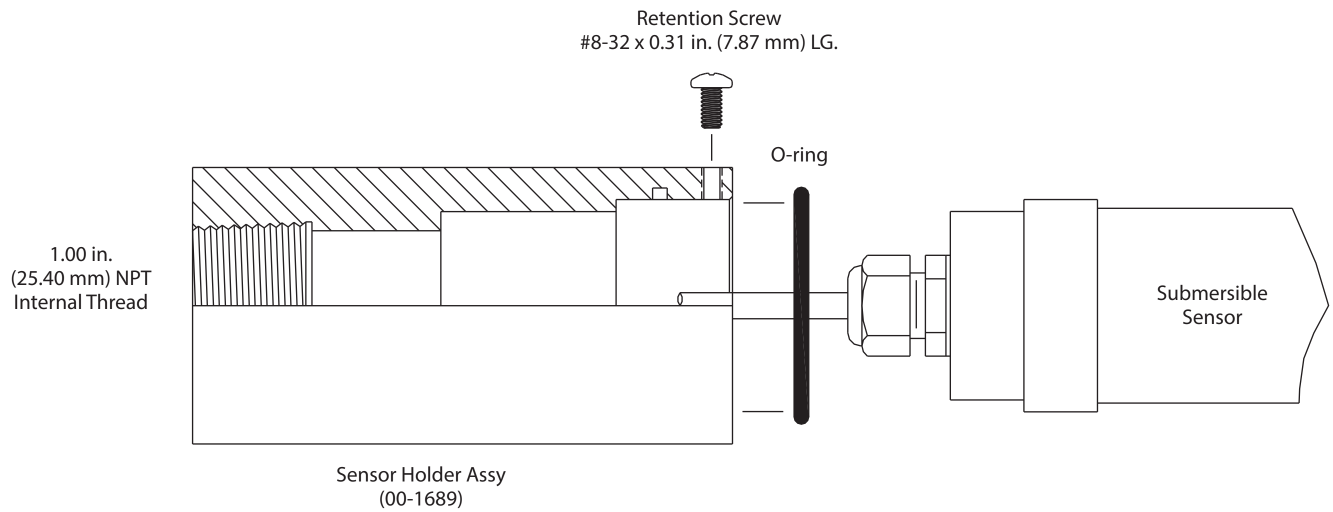



*Figure 7: Submersion mounting assembly*

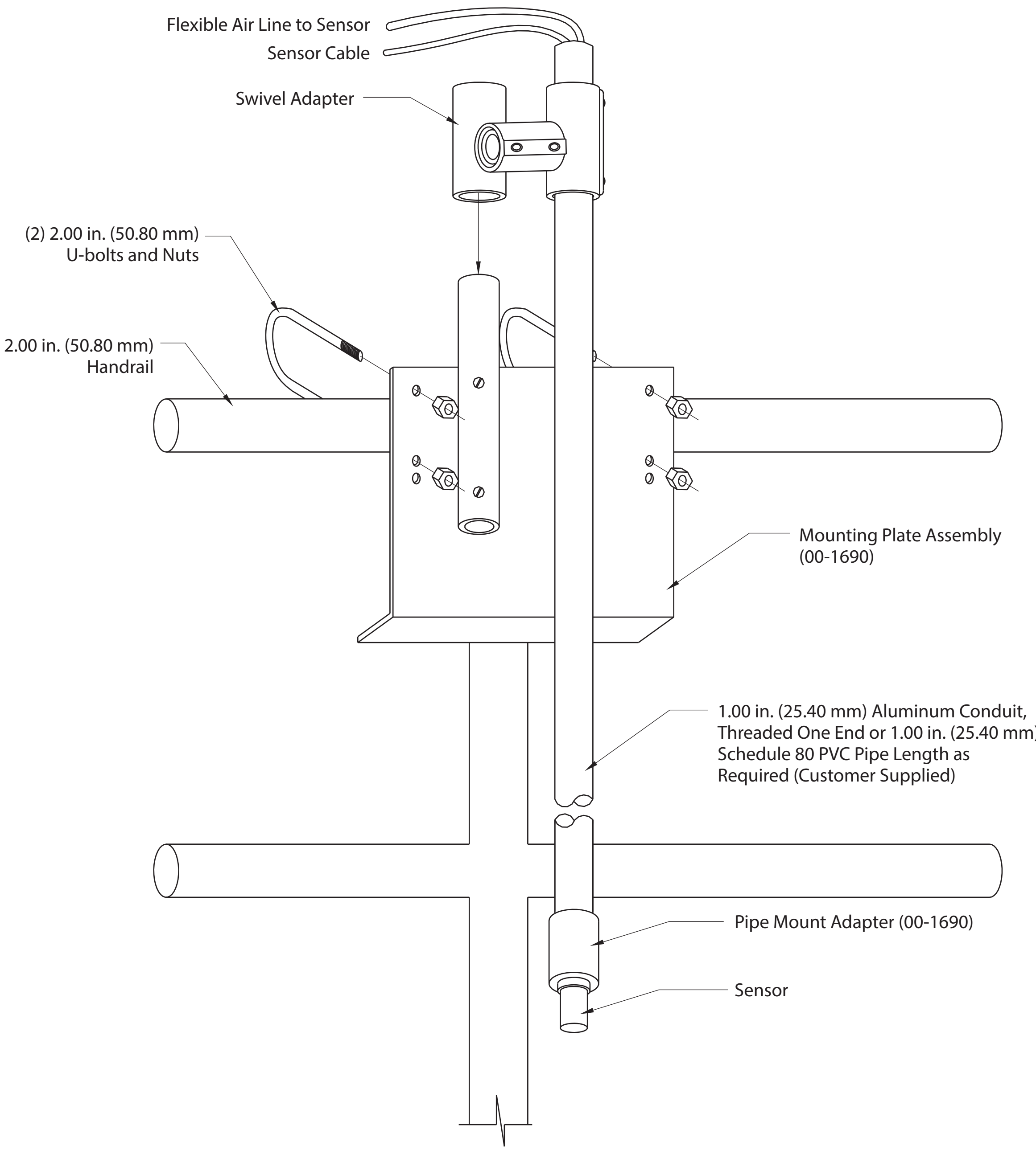



*Figure 8: Submersible sensor assembly*

## In-Line Installation

Suspended solids sensors may be installed directly into a flowing pipe system provided that the water does not contain a lot of entrained air. A 1-1/2 in. flow tee assembly is available for this purpose. It is best to install the sensor in a vertical pipe section with water flowing upward. This assures that air pockets cannot develop at the sensor. If installed in a horizontal run of pipe, place the sensor at the 3 or 9 o'clock position. Never mount the sensor on the top or bottom of the pipe. It is also good practice to install a bypass system around the sensor for maintenance and calibration purposes.

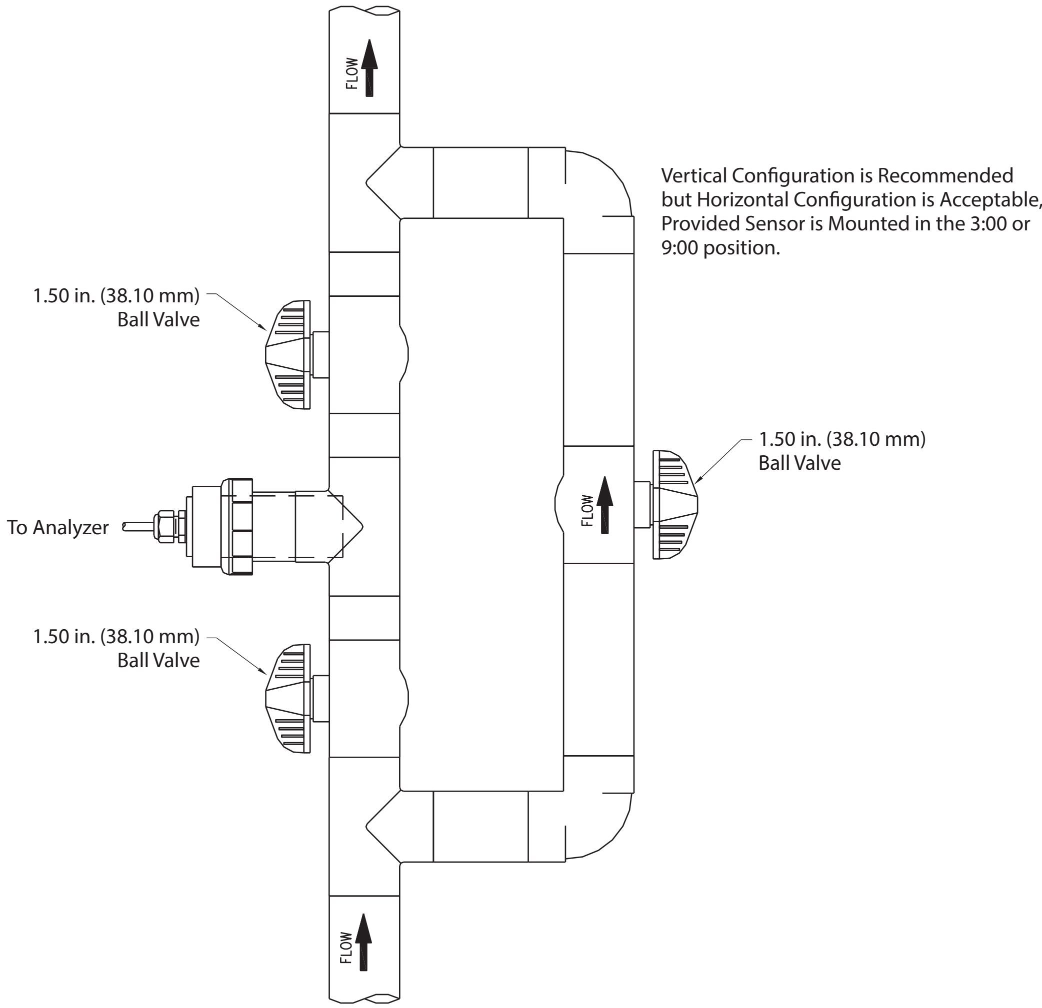



*Figure 9: 1-1/2 in. in-line installation*

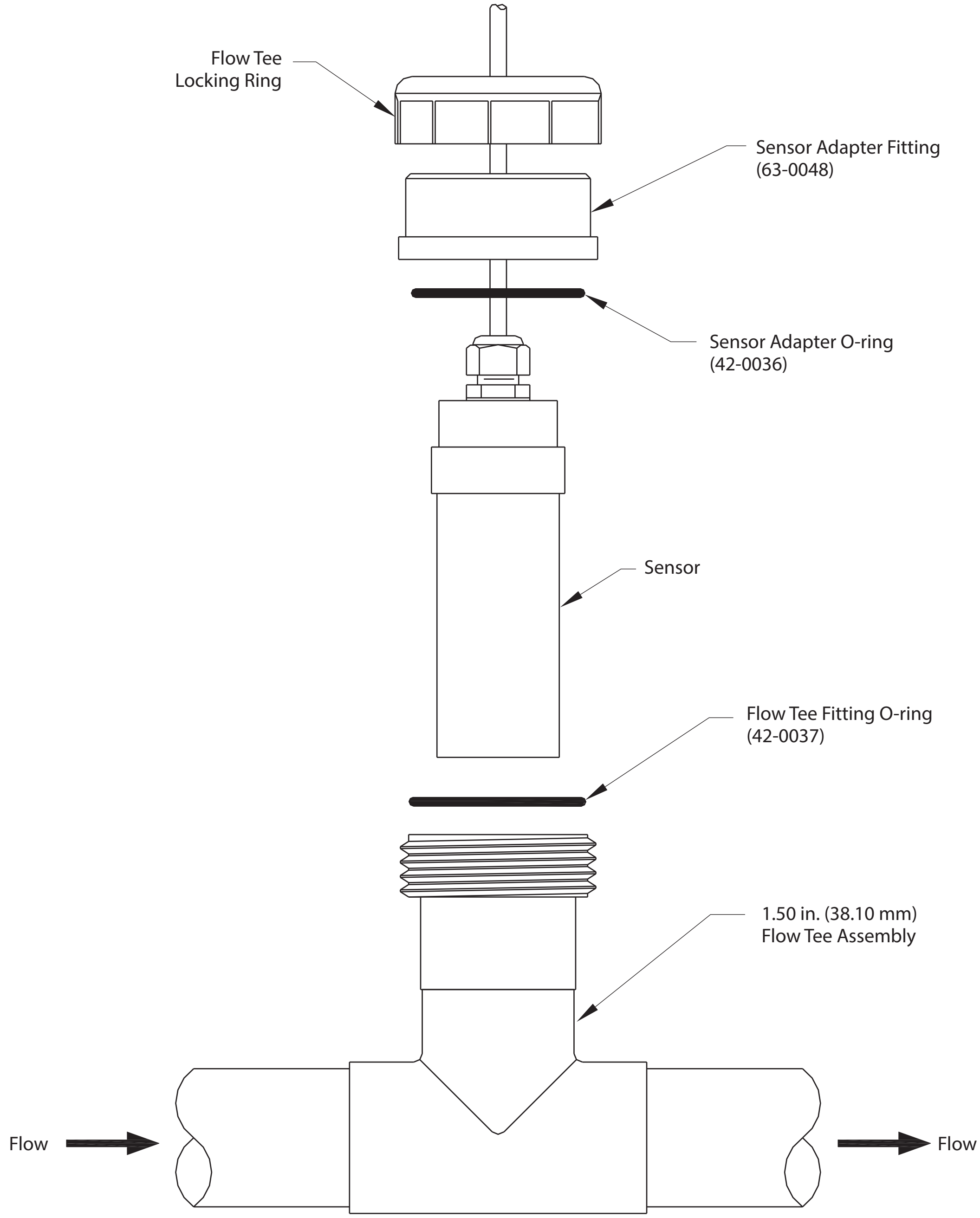


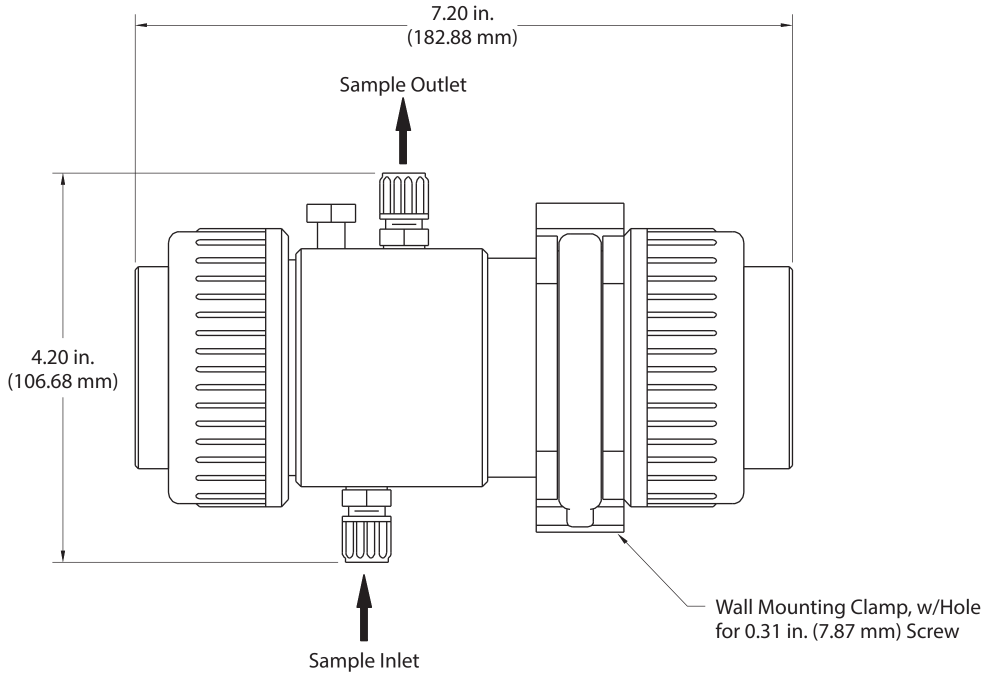

*Figure 10: Flow tee exploded view*

## Flowcell Mounting

Flowcells are used only for low suspended solids applications. The flowcell contains a needle valve for flow adjustment that can easily plug in high solids applications. Expected suspended solids are always below 10 mg/L, the flowcell is a good choice. *Figure 11* provides flowcell dimensions.

**NOTE:** The flowcell should always be mounted horizontally with the inlet on the bottom and outlet on the top.

Select a flowcell location with sufficient clearance below to allow installation of the inlet calibration valve to facilitate adjustment of the system after installation. See *Figure 8 on page 14* for the suggested tubing arrangement.




**NOTE:** Flowcell must be mounted horizontally with the outlet pointing up.

*Figure 11: Flowcell dimensions*

Figure 12 provides a detail of how the suspended solids sensor is installed in the flowcell assembly. During installation of the sensor, be sure that the O-ring is seated properly in the groove at the end of the flowcell assembly. Proper seating of that O-ring is critical to avoiding water leakage.

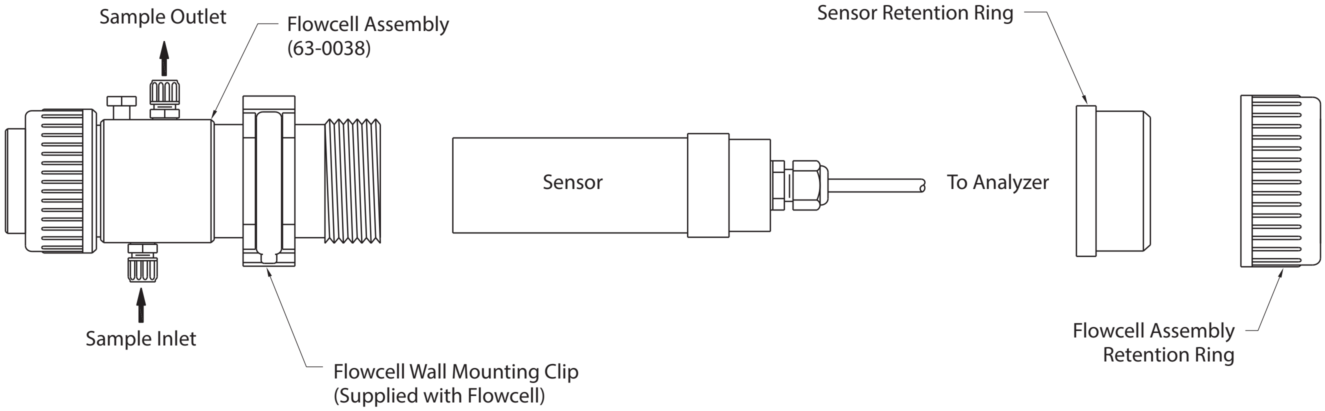



*Figure 12: Sensor/flowcell exploded view*

# 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 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 on TB7. The AC power supply in the transmitter 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 operating 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.
5. 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/88 should have the lowest possible impedance to ground.

## AC Wiring

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

Q46 systems are supplied with 5 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 TB5 OF THE POWER SUPPLY. THE POWER SUPPLY ACCEPTS ONLY STANDARD THREE-WIRE SINGLE PHASE POWER. THE POWER SUPPLY IS CONFIGURED FOR 115V AC OR 230V 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 analog outputs from the system are present at terminals TB1 and TB2. The loop-load limitation in this configuration is 450 Ohms maximum for output 1 and 1000 Ohms maximum for output 2.

**NOTE:** These two outputs are completely isolated from each other to ensure 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.

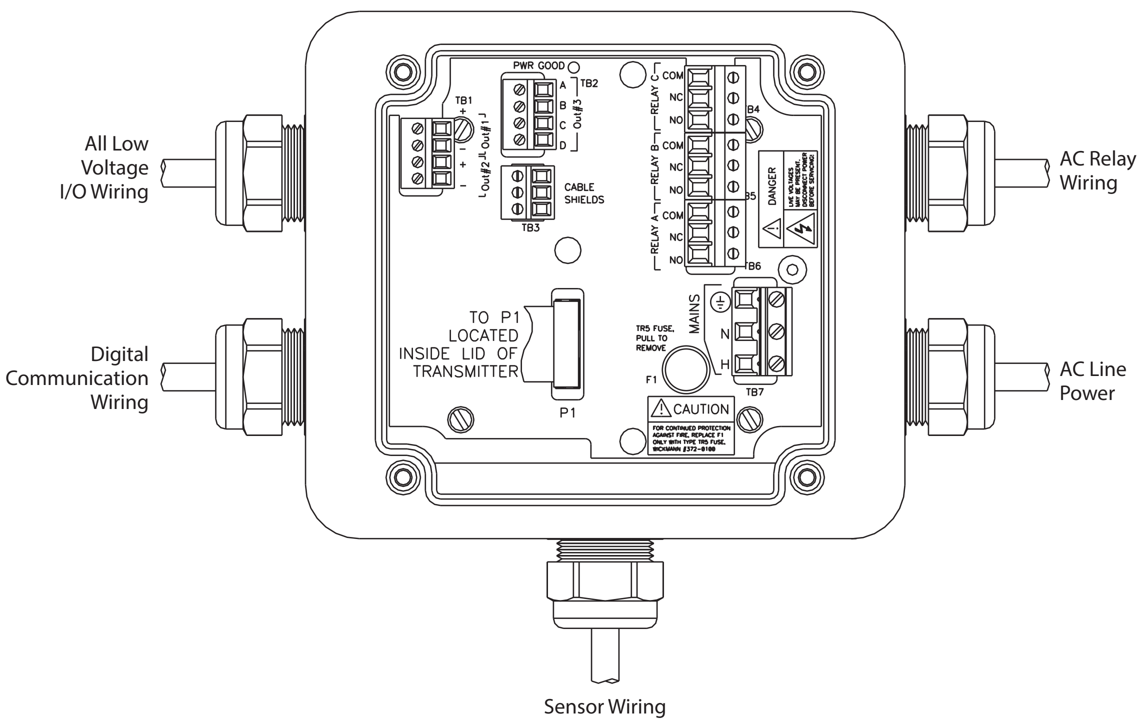



*Figure 13: AC power connections*

The power strip, TB5, 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 in. 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…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*.

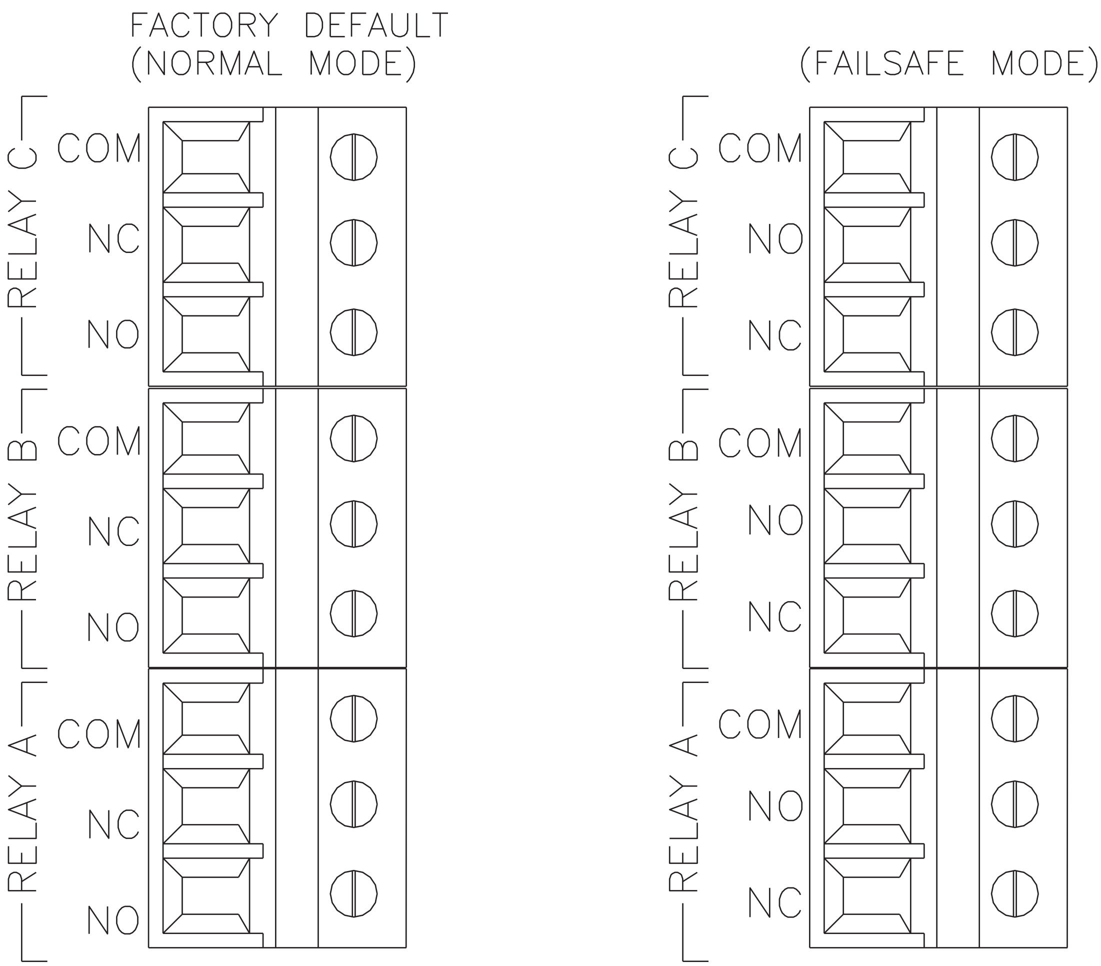



*Figure 14: Relay contacts*

## Optional Output/Relay Connection

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 features, and the hardware for either option must be factory installed.

**NOTE:** The optional 3 relays are for switching LOW POWER DC ONLY.

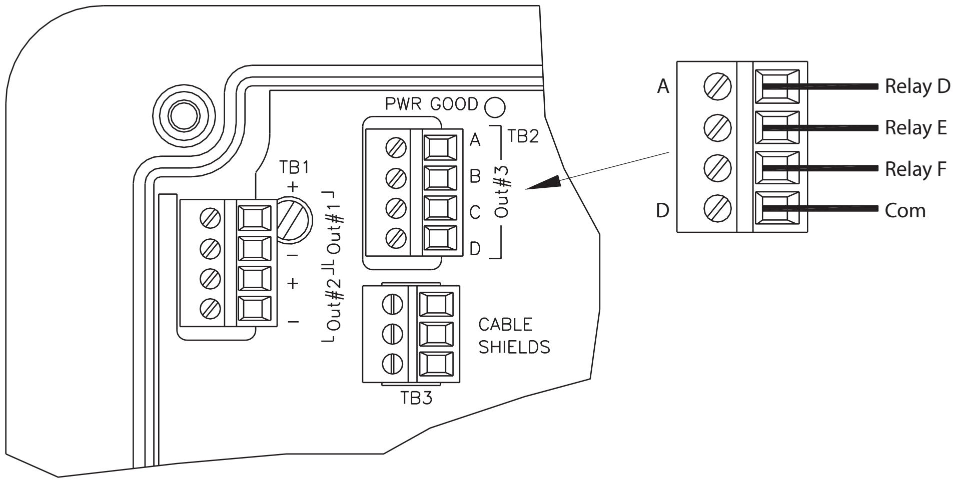



*Figure 15: Optional low power relay wiring*

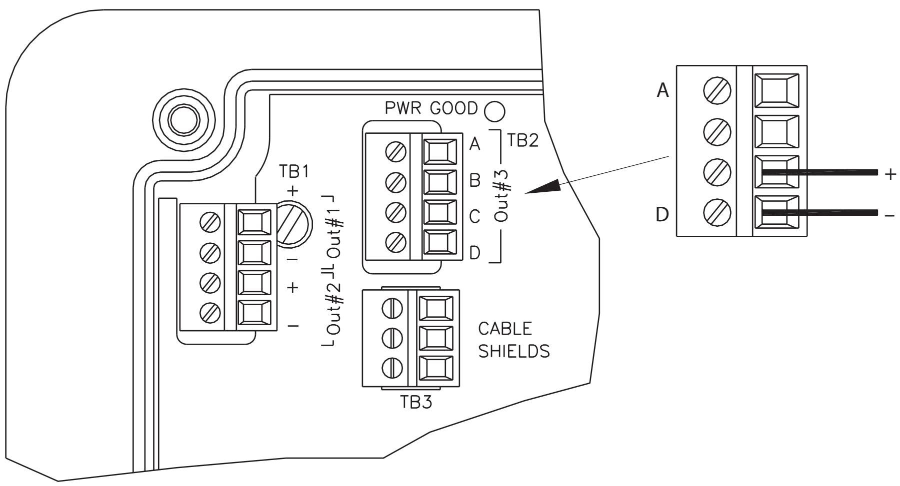



*Figure 16: Optional 3rd analog output wiring*

## Direct Sensor Wiring

Sensor connections are made to a terminal block mounted on the front section of the monitor. 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. 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.

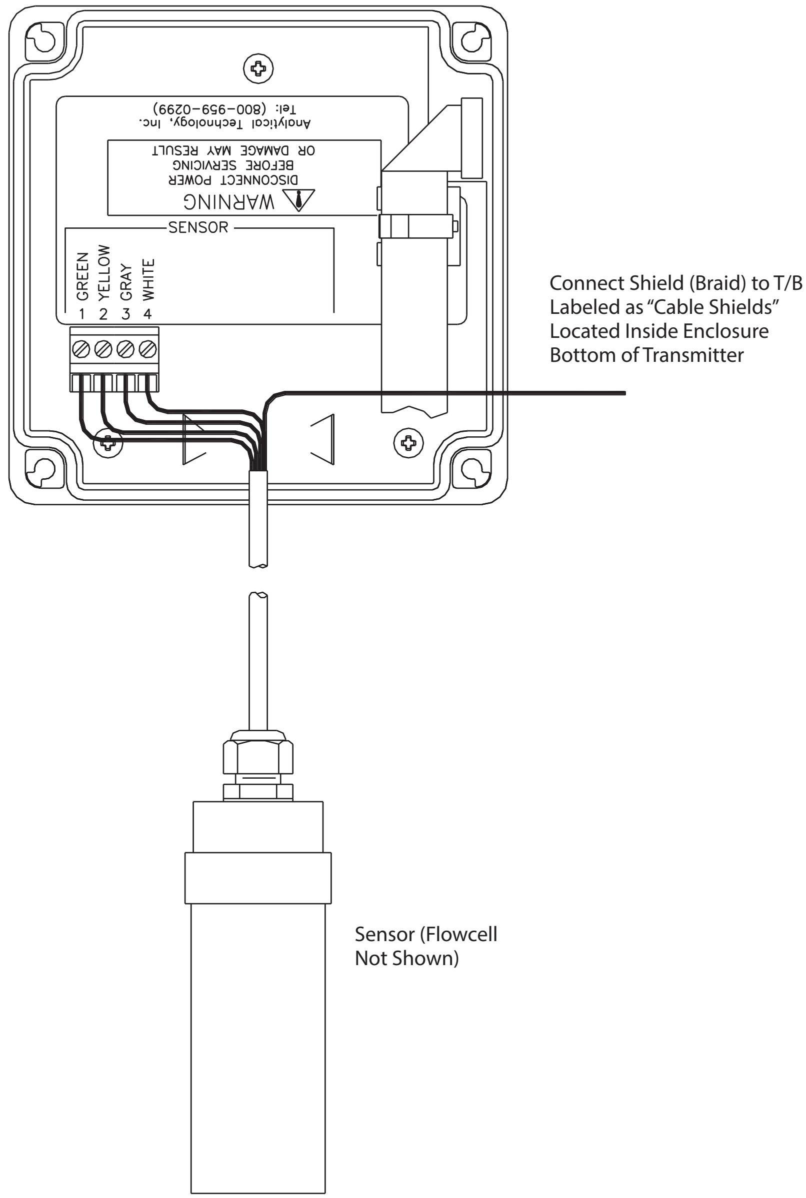



*Figure 17: Suspended solids sensor connection*

## Remote Sensor Wiring

Generally it is best to keep the sensor close to the monitor. However, it is possible to mount the sensor as much as 100 ft from the monitor using a junction box and additional interconnect cable.

**NOTE:** The wire used for remote sensor connection does not contain the same conductor colors as the sensor wire. *Figure 18* provides the information needed to connect a remote sensor using junction box (07-0100).

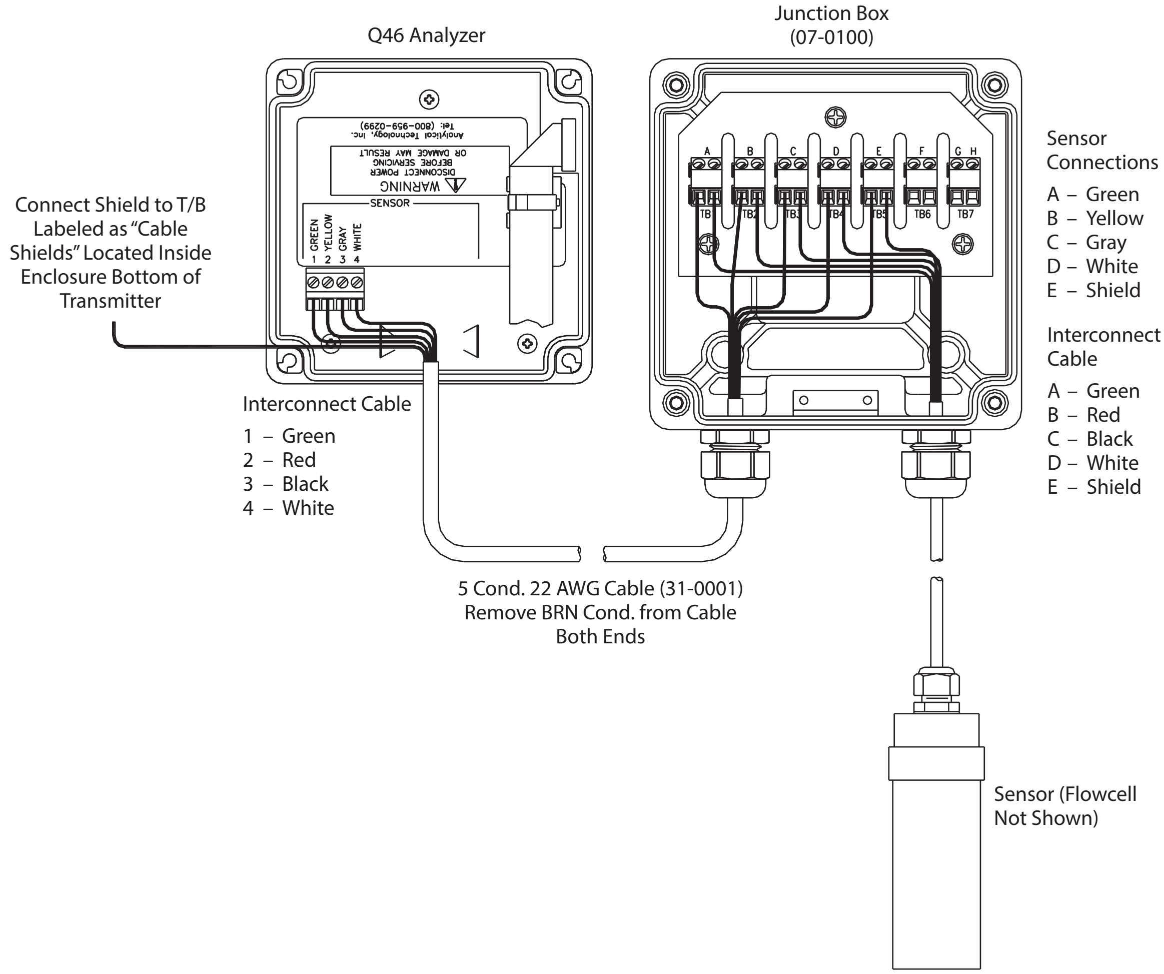



*Figure 18: Remote sensor wiring*

# 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 (for example, no internal jumpers or pots).

When power is first applied, you may notice that the display does not turn on immediately. This is normal. There is a 5 second start routine that runs before the display illuminates. In addition, you may notice an occasional "flicker" of the display, occurring about twice an hour. This is the result of a display processor refresh program that ensures long-term display integrity, and always occurs during normal operation of the instrument.

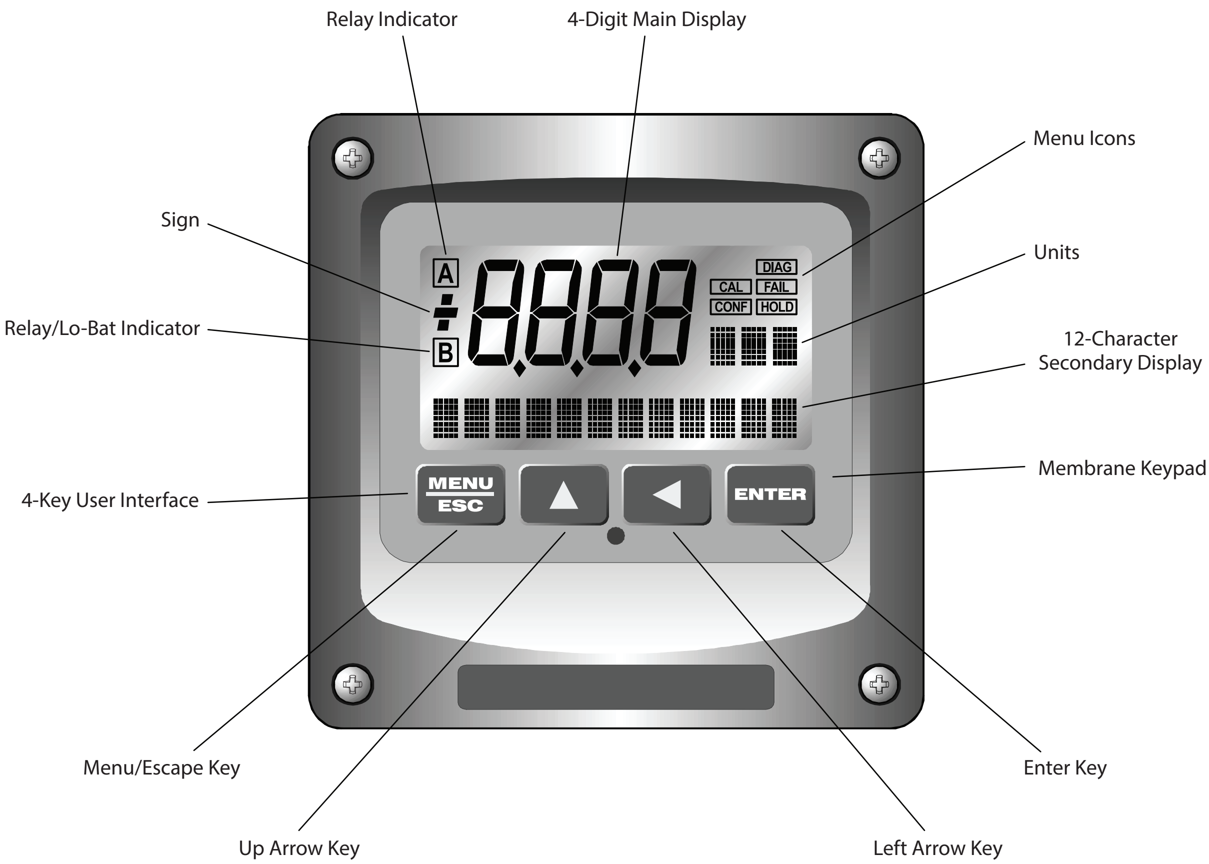



*Figure 19: User interface*

### Keys

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

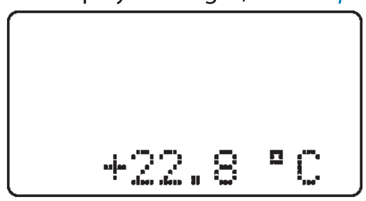
| | |
|---|---|
| **MENU/ESC** | To scroll through the menu section headers or to escape from anywhere in software. The escape sequence allows the user to back out of any changes in a logical manner. Using the ESC key aborts all changes to the current screen and backs the user out one level in the software 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

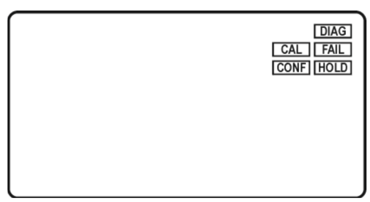
The large custom display provides clear information for general measurement use and user configuration. There are three main areas of the display: the main parameter display, the secondary message line and the icon area.

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


**Lower Line** During normal operation, the lower line of the display indicates user-selected secondary measurements that the system is making. This also includes calibration data from the last calibration sequence and the transmitter model number and software version. During configuration, the lower line displays menu items and set-up prompts to the user. Finally, the lower line displays error messages when necessary. For a description of all display messages, see *"Display Messages" on page 47*.



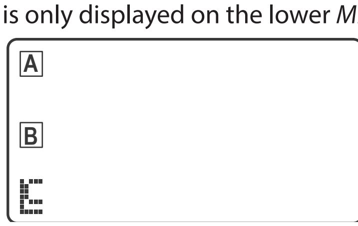

**Icon Area** The icon area contains display icons that assist the user in set-up and indicate important states of system functions. The *CAL*, *CONFIG* and *DIAG* icons are used to tell the user what branch of the software tree the user is in while scrolling through the menu items. This improves software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




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

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

**Relay Area A/B** The relay area contains two icons that indicate the state of the system relays. Relay C is normally configured for *FAIL* indication, so it is only displayed on the lower *MEASURE* display line.



## Software

The software of the Q46H 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. The list items can then be scrolled through using the **UP** arrow key. Once the last item is reached, the list wraps around and the first list item is shown again. The items in the menu sections are organized such that more frequently used functions are first, while more permanent function settings are later in the list. See *Figure 20 on page 28* 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 oxygen 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.

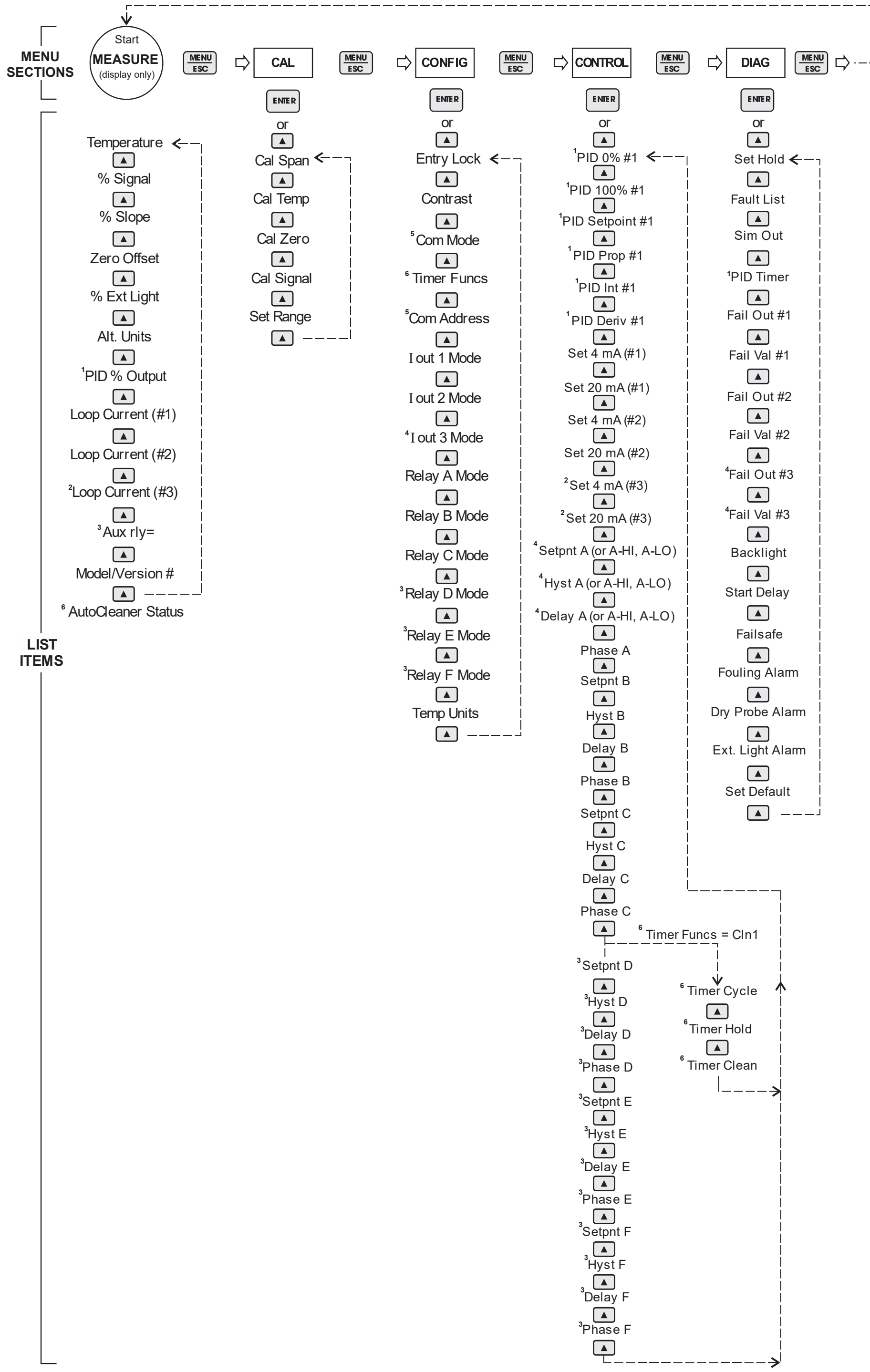
Any data that may be changed flashes. This flashing indicates *User Entry* mode and is initiated by pressing the **ENTER** key. The UP arrow key increases a flashing digit from 0…9. The LEFT arrow key moves the flashing digit from right to left. Once the change has been completed, pressing **ENTER** 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.




**NOTE:** (1) If Relay A, B, C, D, E, F is set to *FAIL* mode, relay settings are not displayed in menu.
(2) The annunciator for Relay C is shown in the *MEASURE*/temperature display.

1 PID is enabled.

2 Optional third 4…20 output installed.

3 Optional 3-relay card installed (D, E, F) not displayed if cleaner is enabled.

4 If Relay A is set to *ALARM* mode, the settings are divided into 2 groups of HI and LO points.

5 If *Comm* mode is set to a selection other than none, additional *Comm* menus show.

6 Future Cleaner Function.

*Figure 20: 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 key 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.

**% Signal** Indicates the general condition of the sensor optics. The nominal value is 100% but the value decreases if fouling of the sensor occurs. The value rises if the flowcell is no longer full of water.

**Slope = 100%** Sensor output response vs. ideal calibration. This value updates after each calibration. High or low slope can generally indicate problems with the sensor or problems with the standard being used for calibration.

**Zero Offset** Sensor zero signal at 0.000 NTU as compared to factory default electronic zero. This value updates after a zero-calibration has been performed.

**% Ext Light** Indicates the background ambient light level detected by the sensor. This value is not meaningful when the sensor is inside the flowcell, but is useful when submersible Suspended Solids sensors are used in open channels. Extremely high ambient light levels trigger an alarm if enabled in *DIAG* menu.

**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 (normally NTU).

**#2 12.00 mA** Analyzer output current # 2 (normally Temperature).

**#3 20.00 mA** Analyzer output current # 3 (if option included).

**Aux relay = D, E, F** Auxiliary relay annunciators (if option included).

**I/F v1.01** 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 five items in this list: *Cal Span, Cal Temp, Cal Zero, Cal Signal* and *Set Range*.

**Cal Span** Provides adjustment of the suspended solids value to match the standard being used for calibration. See *"Calibration" on page 38* 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.

**Cal Zero** Provides adjustment of the suspended solids value to 0 mg/L when filtered sample is running through the flowcell or the sensor is in clean water. See *"Calibration" on page 38* for more details.

**Cal Signal** Provides adjustment of the "signal strength" indicator to 100% after cleaning of sensor. See *"Calibration" on page 38* for more details.

**Set Range** Provides selection of the operating range. Ranges of 0…100.0 mg/L, 0…1000 mg/L or 0…10.00 mg/L can be selected. The default range is 0…10.00 mg/L, which is suitable for many suspended solids applications.

## 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 48* for the Q46 lock/unlock code. Press **ENTER** to toggle lock setting once code is correct. Incorrect codes do not change state of lock condition.

**Contrast** This function sets the contrast level for the display. The custom display is designed with a wide temperature range and contains an LED back light so that the display can be seen in the dark. In general, the contrast should be left at the default value of 8.

**Comp Table** The suspended solids monitor uses a lookup table to convert sensor signals to solids numbers. This is normally a linear function but the monitor allows you to modify the table to match applications where the sensor response is nonlinear. Changing the table values is described later in this manual.

**Timer Func** This function should be left in the OFF setting. It is used only for the Auto-Clean suspended solids system which is covered in another manual.

**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.

**Com Baud** Sets communications baud rate.

**Com Parity** Sets parity for the digital communications.

**Iout#1 Mode** This function sets analog output #1 to either track *NTU Suspended Solids* or enables the PID controller to operate on the Suspended Solids 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 – NTU turbidity or 2 – PID for PID control. Press **ENTER** to store the new value.

**Iout#2 Mode** This function sets analog output #2 for either temperature (default), NTU turbidity or for Aux Units (mg/L or PSL). 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 NTU or 3 – mg/L or PSL. Press **ENTER** to store the new value.

**Iout#3 Mode** **OPTIONAL.** This function sets analog output #3 for either temperature (default), NTU or Aux Units. 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 NTU or 3 – mg/L or PSL. 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 *CONTROL* menu automatically. See *Figure 21 on page 33* for further details.

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 22 on page 34* for further 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.

**Relay B Mode**
**Relay C Mode** Relays B and C can be used in two ways: as a setpoint control or as a fail alarm. The settings for Relays B and C mode are *CON*, *FAIL* and they are the same as those modes in Relay A.

***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 a fail alarm. The two settings for Relay D, E and F mode are *CON* and *FAIL*.

**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.

## Control Menu [CONTROL]

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

**NOTE:** PID menu items does not appear unless output 1 is configured for *PID* mode in the *CONFIG* menu.

**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 supress "second-order" effects from process variables. These variables may include items like pumps or mixers that may have minor impacts on the measured value. The derivative factor is rarely used in water treatment process, and therefore, it is best in most cases to leave it at the default value. Increasing this value makes the controller more responsive.

**Set 4 mA**
**Set 20 mA**
[Iout1=NTU]

These functions set the main 4 and 20 mA current loop output points for the transmitter. The units displayed depend on the selection made in the *CONFIG* menu for *Iout #1* mode. **Do not set the 20 mA setting above 400 NTU.**

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/D.O.]

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), NTU or the selected Aux Units of mg/L or PSL. 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 NTU. 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 value. Press **ENTER** to store the new value.

***Set 4 mA #3**
***Set 20 mA #3**
[temp/NTU/Aux]

**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), NTU or Aux Units. 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. 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 value. Press **ENTER** to store the new value.

***A Setpoint**

This function establishes the 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 value. Press **ENTER** to store the new value.

***A Delay**

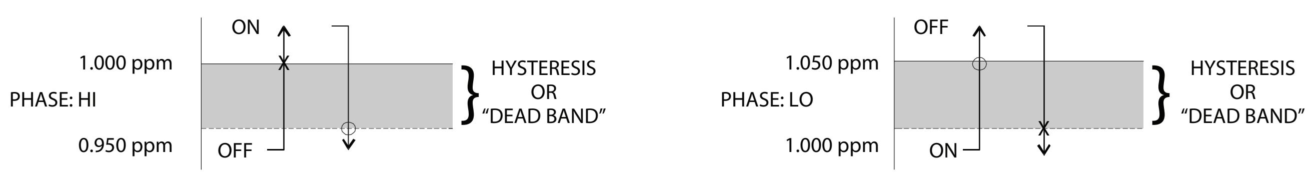
This function places an additional amount of time delay on the trip point for Relay A. This delay is in addition to the main delay setting for the controller. The entry value is limited to a value between 0…999 seconds. Press **ENTER** to initiate *User Entry* mode, and the value flashes. Use the arrow keys to modify 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 oxygen value **exceeds** the setpoint. When the phase is *LO*, the relay energizes and the LCD indicator illuminates when the oxygen 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. See *Figure 21* for a visual description of a typical control relay application.

When value rises to ≥ 1.000 ppm, relay closes.

When value rises to ≥ 1.050 ppm, relay opens.




When value falls to ≤ 0.950 ppm, relay opens.

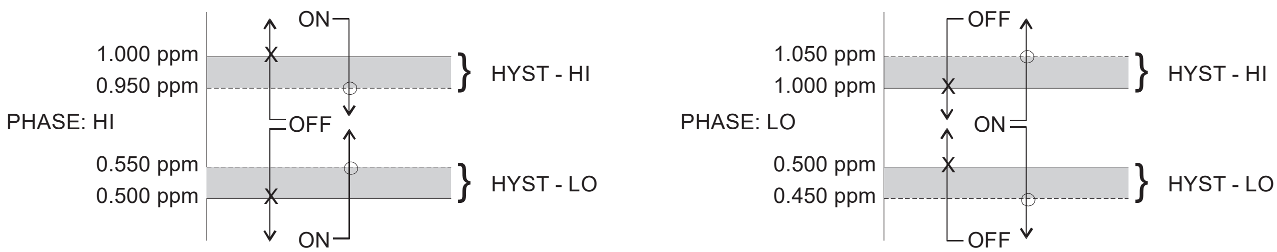
When value falls to ≤ 1.000 ppm, relay closes.

| | | |
|---|---|---|
| **Settings:** | Setpoint: | 1.000 ppm |
| | Hyst: | 0.050 |
| | Delay: | 000 |
| | Failsafe: | OFF |

*Figure 21: Control relay example, hysteresis and 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 22* 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 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 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 22: 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 31*), 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 31*), 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 31*), 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 holds relays in current status. 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.

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"*.

**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 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 oxygen 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 set-up 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.

**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.

***Failsafe** This function allows the user to set the optional system relays to a failsafe condition. In a failsafe condition, the relay logic is reversed so that the relay is electrically energized in a normal operating state. By doing this, the relay does not only change state when, for example, an oxygen 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 same contacts to open.

**Fouling Alarm** Activates or disables the fouled sensor detector. This circuit detects the buildup of solids on the face of the sensor that can degrade the Suspended Solids measurement. The options are *ON*–alarm is active or *OFF*–alarm is disabled. The default is ON.

**Dry Probe Alarm** Similar to the fouling alarm, this alarm is generated when the sensor is no longer in liquid. Loss of sample flow can cause this alarm to activate if the flowcell is drained of sample. The options are *ON*–alarm is active or *OFF*–alarm is disabled. The default is ON.

**Ext Light Alarm** The sensor can provide an alarm in the event that ambient light is high enough to cause measurement problems. This alarm is not useful for flowcell applications but can be of value if a submersible sensor is in use. Options are *ON*–alarm active or *OFF*–alarm disabled. The default is OFF.

**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 select either *CAL* or *ALL* with the **UP** arrow key. The default *CAL* routine resets the zero offset to 0.0 nA and reset the slope to 100%. The default *ALL* routine resets all program variables to factory default and should be used with care since it changes any user settings that were programmed in the field.

# CALIBRATION

## Suspended Solids Calibration

Suspended solids monitors start to measure aqueous samples as soon as power is applied and the sensor is in contact with sample. Calibration of a system is normally required at startup as factory calibration for suspended solids is not practical due to solids density variability. Calibration involves adjustment of both the zero and span of the instrument.

The SS sensor zero has been adjusted at the factory and user adjustment is normally not required for high solids applications. When operating in the lowest range of 0…100.0 mg/L, the zero should be check using clean tap water at startup.

### Cal Zero

If you are using a submersible SS sensor, remove the sensor from the process, wipe the sensing area clean and suspend the sensor in a bucket of clean tap water, distilled water or any solids free water. When cleaning, use only a soft cloth and detergent to clean the optical lens. **Do not sit the sensor on the bottom of your sample container.** You need at least 2 or 3 inches of water below the sensor in order for it to zero it properly.

If you are using either a flowcell or a flow tee, you can zero the sensor in place if you can fill the chamber with solids free water. If not, you may need to remove the sensor from the flowcell or flow tee in order to zero it.

**If your system is normally running on the high range of 0…10.00 mg/L, zeroing the sensor is normally not necessary.**

To zero the sensor, proceed as follows:

1. Immerse the sensor in solids free water and allow it to stabilize for 2 or 3 minutes. Press the **MENU** key to access the *CAL* menu. Press the **UP** arrow key until access to *Cal Zero*.
2. Press the **ENTER** key and the bottom line displays a message asking that the sensor be placed in zero sample. Zero sample is already flowing so just press **ENTER** again. The display flashes a "Wait" message.
3. After a short period, the monitor zeros the sensor and flash an "Accepted!" message indicating that the zero was successful. If the zero offset is too high, a "Cal Fail" message appears and the "FAIL" icon on the display lights up.
4. Once the zero adjustment is complete, remove the filter from the incoming sample line.

### Cal Span

Calibration of a Q46/88 suspended solids monitor is normally done by adjusting the displayed value to a lab measurement. Lab measurements of suspended solids take quite a long time so often an estimated value is used. If the application involves measurement of a known type of solids, it is sometimes possible to mix a standard for calibration. In many wastewater applications like raw sewage or mixed liquor suspended solids, it is often necessary to estimate the calibration value. Factory calibration is done using a formazin standard that may, or may not, have the same optical backscatter properties as the process in which the sensor is to be used.

To set the span of the SS monitor, follow the procedure below:

1. Submerge the sensor in the process tank or turn on the process water flow through the flowcell or flow tee. Allow the sensor to stabilize for 5…10 minutes. If possible, take a sample and get a measurement made as quickly as possible using an alternative method. If that is not possible, estimate the solids level based on experience with the process.
2. Press the **MENU** key to access the *CAL* menu. Press the **UP** arrow key to access *Cal Span*.
3. Press the **ENTER** key and you are prompted to place the sensor into a reference solution. Press **ENTER** again and the display flashes "Wait" while checking for the stability of the signal. After a few seconds, the display flashes, allowing adjustment of the value. Use the **UP** and **LEFT** arrow keys to adjust each digit of the display to the value of suspended solids determined previously.
4. After the proper value is entered, press the **ENTER** key and the display flashes "Accepted!". Should the sensor determine that the entered value is outside its normal offset limits, a "Cal Fail" message flashes. Should this occur, try to verify that the process value is correct. Also check the sensor optical surface and wipe with a clean cloth before attempting another span adjustment.

## 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 on line, or the sensor can be removed from the process and placed into a known solution temperature reference. In any case, it is critical that the sensor be allowed to reach temperature equilibrium with the solution in order to provide the highest accuracy. When moving the sensor between widely different temperature conditions, it may be necessary to allow the sensor to stabilize as much as one hour before the calibration sequence is initiated. If the sensor is 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, it is recommended to attempt the calibration again immediately.

## Check Signal Function

Suspended solids systems contain a sensor check system that is intended to give operators an indication of the operating condition of the optics. The scale of this function is somewhat arbitrary, going from 0…220%.

When a sensor is tested at the factory, the "check signal" value is set to 100% so a check signal value of 100% indicates optimum operation of the optical system. In an actual installation, conditions are never perfect so the check signal value is unlikely to be exactly 100% in normal operation, but that value is generally pretty close to 100% at startup.

The main purpose of this number is to indicate how much optical fouling is occurring over time. As the sensor runs for longer and longer periods of time, the check signal value often goes down slowly or up slowly, indicating that coatings on the optic lens is reflecting more and more of the LED emission. Oily organic coatings tend to increase the check signal value while inorganic coatings tend to decrease the value. A decreasing check signal value is the most common occurrence. Periodically checking the value of this variable on the lower line of the display alerts operators that maintenance is needed. In the *DIAG* menu, there is a "Foul Alarm" that can be turned on or off. If the *Foul Alarm* is turned on, the "FAIL" icon on the display and Relay C (if configured for fail) activates when the check signal value falls below 50%.

The check signal also can be used to indicate a "dry cell" when the sensor is used in a flowcell or flow tee. If sample flow is lost, the check signal value normally rises to 220%. There is a second alarm function in the *DIAG* menu called "Dry Alarm". Turning this alarm on actives the "FAIL" icon on the display and Relay C (if configured for fail) when signal value goes to 220%.

### Calibrate Check Signal

After startup of the SS monitor, you may set the check signal level to 100%. As mentioned above, the check signal value is different in different types of applications. The monitor allows you to set the check signal level to 100% when the sensor is operating in normal conditions and the sensor is clean. This can establish a good reference point so that the changes in the check signal value are related to your particular application.

Be sure that the sensor is in normal operation. You cannot complete this procedure with the sensor out of the sample. To calibrate the check signal value, proceed as follow:

1. Press the **MENU** key to go to the *CAL* menu. Press the **UP** arrow key until the lower line indicates "Cal Signal".
2. Press the **ENTER** key and the check signal value begins to flash. After the monitor evaluates the check signal value, you may see a "PASS" message and the check signal value is set to 100%.

## External Light Function

Optical suspended solids sensors can be sensitive to ambient light interference in unusual conditions. This is possible when sensors are submerged in flowing streams outdoors in bright sunlight. While it is not normally an issue, the Q46/88 contains a sensor diagnostic feature that measures the amount of ambient light and can provide an alarm in the event that ambient light levels are too high for reliable operation.

In dark conditions, the % light value is normally around 37%. That value increases with increasing ambient light and can go as high as about 70%. If values above 65% are observed in an application, investigate the possibility of locating the sensor in an area with less sunlight or adding a sun shield to the mounting assembly to reduce the % light value.

In the *DIAG* menu, you can configure an alarm for high ambient light conditions. If you program the *Ext Light Alarm* to ON, the monitor actives the "FAIL" icon on the display and Relay C (if configured for fail) when signal value goes above 70%.

# PID CONTROLLER DETAILS

## PID Description

PID control, like many other control schemes, is 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).

### ISA PID 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 32*, here are more general descriptions of what each of the PID elements contribute to the overall action of the controller.

**P** Proportional gain. With no *I* or *D* contribution, the controller output is simply a factor of the proportional gain multiplied by the input error (difference between the measured input and the controller setpoint). Because a typical chemical control loop cannot react instantaneously to a correction signal, proportional gain is typically not efficient by itself – it must be combined with some integral action to be useful. Set the *P* term to a number between 2…4 to start. Higher numbers 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 *P*s and low *I*s appear to operate the same as combinations of low *P*s and high *I*s, there is a difference in rate of recovery and stability. Because of the way the algorithm is structured, large *P*s can have a larger impact to instability, because the proportional gain term impacts all the other terms directly. Therefore, keep proportional gain lower to start and increase integral gain to achieve the effect required.

Many 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 Q46/88 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 41* 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 electronics are equipped designed to allow the user to take manual control of the PID output. 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 slow) can still provide substantial improvements to setpoint control. In fact, damaging oscillatory behavior is far more likely in tightly tuned controllers where the user attempted to increase response too much.

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

The easiest processes to control with closed-loop schemes are generally linear, and symmetrical, in nature. For example, controlling level in tank where the opening of valve for a fixed period of time corresponds linearly to the amount that flows into a tank. Chemical control processes can be more problematic when the nature of the setpoint value is nonlinear relative to the input of chemical added. For example, D.O. 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 Q46/88 Suspended Solids monitor 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 operating 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.

## Sensor Maintenance

Sensor maintenance is limited to simple cleaning of the optical surfaces. In general, wiping with a soft cloth is all that is needed. The optical surfaces can also be cleaned with a household glass cleaner or a surface cleaner. **Never use abrasive pads on the optical surfaces.**

In some applications, the sensor might accumulate iron and manganese deposits that precipitate from the water after chlorination. Should this occur, cleaning the sensor by soaking in solution of a commercial iron remover such as Red-B-Gone quickly removes deposits.

The lenses on the sensor are made of acrylic. Be careful not to scratch these surfaces when handling the sensor. Severe scratches can cause irreparable damage.

# 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. Use the special "shield terminal" stub on the power supply board for optimum sensor cable shield grounding.
2. Verify the proper power input is present. Check instrument label to verify your unit is either 100…240V AC or 12…24V 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 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 placing the sensor into a bucket of water.
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 for fouling. Look closely for signs of grease or oil which may be present. Sensor fouling can be corrected by cleaning optical surfaces with a soft cloth.

## 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. Verify proper voltage (115…230V AC) is present on the incoming power strip of the analyzer, and that the analyzer power label matches the proper voltage value.
2. If analyzer does not appear to power up (no display), remove power and check removable fuse for continuity with a DVM.
3. Using a DVM, check the voltage across the BLUE and WHITE wires coming from the power supply board in the base of the enclosure. FIRST, disconnect any wiring going to Iout#1. Then, verify voltage across these wires is about 16…18V DC when still connected to the terminal strip on the front half of the enclosure. If the BLUE and WHITE wires are not connected to the terminal strip on the front half of the enclosure, the voltage across them should measure about 29V DC.
4. If analyzer does power up with a display, use the "Simulate" feature to check operation of the analog outputs (and relays contacts with a DVM).
5. Check sensor power circuits. With a DVM, verify between –4.5…–5.5V DC from sensor connection terminals WHITE (+) to BLACK (–). Then verify between 4.5…5.5V DC from GREEN (+) to BLACK (–).
6. Check TC drive circuit. Place a wire-short between the RED and BLACK sensor terminals. With a DVM, measure the voltage between the BLACK (–) and BROWN (+) sensor terminals to verify that the TC drive circuit is producing about –4.6…–5.5V DC open-circuit. Remove DVM completely and connect a 1000 Ohms resistor across the BLACK to BROWN terminals. The temperature reading on the front LCD should display approximately 0° C and the dissolved oxygen 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 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. | Check wiring connections to sensor. Check optical surfaces for fouling. |
| 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. |
| Temp High | The temperature reading is > 55° C. | The temperature reading is over operating limits. |
| Temp Low | The temperature reading is < –10° C. | Same as "Temp High" above. |
| TC Error | TC may be open or shorted. | Check junction box connections if installed. |
| Cal Fail | Failure of SS calibration. FAIL icon does not extinguish until successful calibration has been performed, or 30 minutes passes with no keys being pressed. | Clean sensor and redo span calibration. If still failure, sensor slope may be less than 80% or greater than 120%. Replace sensor failure persists. |
| 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. 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. |

## SPARE PARTS

| Part No. | Description |
|---|---|
| * | AC Powered Monitor Electronics Assembly, 100…240V AC |
| * | DC Powered Monitor Electronics Assembly 12…24V DC |
| * | AC Powered Monitor Electronics Assembly w/Profibus, 100…240V AC |
| * | DC Powered Monitor Electronics Assembly w/Profibus, 12…24V DC |
| 03-0445 | Q46-88 Front Lid Electronics Assembly |
| 03-0407 | P/S Assy, 100…240V AC |
| 03-0408 | P/S Assy, 100…240V AC with 3rd 4…20 mA Output |
| 03-0409 | P/S Assy, 100…240V AC with 3 Relay Exp. Board |
| 03-0410 | P/S Assy, 12…24V DC |
| 03-0411 | P/S Assy, 12…24V DC with 3rd 4…20 mA Output |
| 03-0412 | P/S Assy, 12…24V DC with 3 Relay Exp. Board |
| 23-0029 | Fuse, 630 mA, 250V, TR-5 (for AC or DC Analyzers) |
| 63-0110 | Suspended Solids Sensor, Digital IR |
| 63-0038 | Sensor Flowcell Assembly |
| 42-0095 | Flowcell End Cap O-ring |
| 54-0036 | Flow Control Screw for Flowcell |
| 42-0104 | O-ring for 54-0036 Flow Control Screw |
| 07-0100 | Junction Box |
| 31-0001 | Interconnect cable for Junction Box to Monitor Wiring |
| 38-0072 | Terminal Block Plug, 3 Position (Relays) |
| 38-0073 | Terminal Block Plug, 4 Position (Outputs) |
| 38-0074 | Terminal Block Plug, 3 Position (Cable Shields) |
| 38-0081 | Terminal Block Plug, 3 Position (Power) |
| 38-0084 | Terminal Block Plug, 3 Position (Power) – V DC Version** |
| 63-0048 | 1-1/2 in. Pipe Tee Adapter |
| 42-0036 | O-ring for 63-0048 Tee Adapter |

* Please consult factory for electronic assemblies part numbers.

** Prior to Dec 2018, V DC (power) Terminal Block used the (38-0081).

**Lock/Unlock Code: 1472**