A Badger Meter® Brand

Water Quality Monitor

Q46S/81 Auto-Chem Sulfide Monitor



Badger Meter

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User Manual

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INTRODUCTION

General

The Q46S/81 is an online monitoring system designed for the continuous measurement of sulfide in solution. The full -operating range of the system may be selected for 0–2.000 PPM or 0–20.00 PPM and the sensing system operates on water streams with temperatures from 0 to 50 °C.

Sulfide ion measurement is made in the Q46S system by pumping a small amount of sample out of the inlet overflow assembly, mixing the sample with acid to convert any HS- or S= ions to hydrogen sulfide gas and then air stripping the H2S for measurement in the gas phase. A hydrogen sulfide gas sensor located in the flow block next to the sample conditioning module measures the concentration of H_2S in the gas stream and is connected to an electronic module that converts sensor signals to a direct concentration display.

The measured sulfide concentration is displayed on a backlit LCD on the front of the instrument. Depending on the full-scale operating range selected, the unit displays sulfide with a resolution of either 0.01 PPM (10 PPB) or 0.001 (1 PPB). A 4–20 mA output is provided for recording or data logging. The output can be programmed for a variety of ranges with a minimum range of 0–0.1 PPM and a maximum range of 0–20 PPM. Alarm contacts are also standard in the electronic package and may be used either for simple control schemes or for signaling operators of abnormal operating conditions.

The typical system is shown in *Figure 1*.

NOTE: The Auto-Chem chemistry module is designed for use in protected environments. It is not suitable for use outdoors without the addition of another enclosure that is temperature controlled.

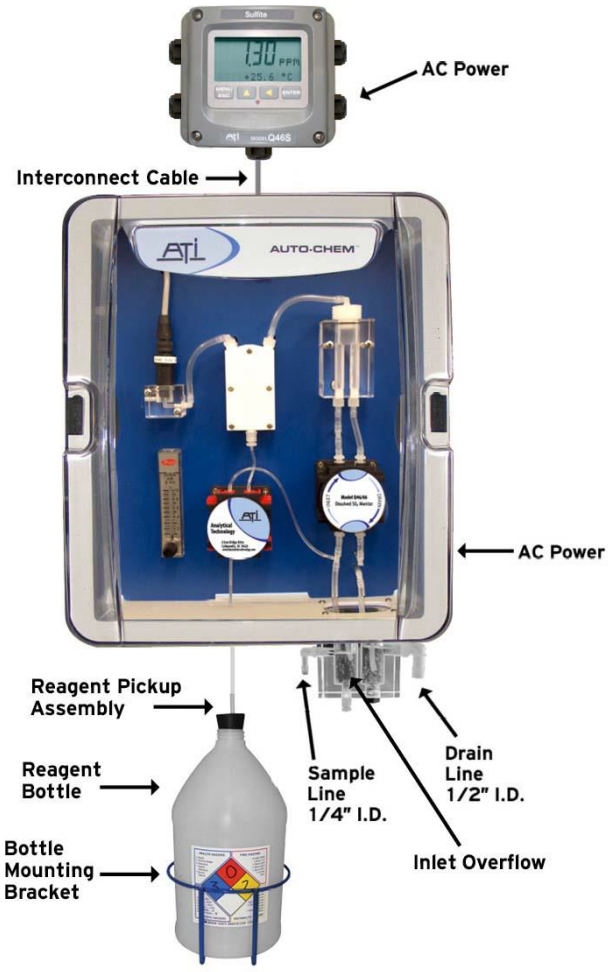


Figure 1: Dissolved sulfide typical system

Q46S/81 System Specifications

Displayed Parameters	Main input: 0.001 ppm to 20.00 ppm dissolved sulfide Sensor current: 0.0 to 999.9 nA, 0.000 to 99.99 uA Sample Temperature Loop current: 4.00 to 20.00 mA Sensor slope & zero offset Model number and software version PID Controller Status
Main Parameter Ranges	Manual selection of one of the following ranges: 0.0 to 2.000 ppm 0.00 to 20.00 ppm
Display	0.75 in. (19.1 mm) high 4-digit main display with sign 12-digit secondary display, 0.3 in. (7.6 mm) 5×7 dot matrix Integral LED backlight for visibility in the dark.
Ambient Temperature	Analyzer Service: 5 to 40 °C (41 to 104 °F) Storage, –5 to 70 °C (–22 to 158 °F)
Ambient Humidity	0 to 95%, non-condensing.
EMI/RFI Influence	Designed to EN 61326-1
Output Isolation	600V galvanic isolation
Filter	Adjustable 0–9.9 minutes additional damping to 90% step input
Sensor	Electrochemical type for hydrogen sulfide gas
Sensor Materials	Noryl and PVC
Interconnect Cable	20 ft (6.15 m) standard, 100 ft (30 m) maximum
Q46S Power	100–240V AC ±10%, 50/60 Hz
Auto-Chem Power	115 or 230V AC, 50/60 Hz
Q46S Enclosure	NEMA 4X, IP66, polycarbonate, stainless steel hardware HWD: 4.9 in. (124 mm) × 4. in. (124 mm) × 5.5 in. (139 mm) Flammability rating: UL 94 V-0
Auto-Chem Enclosure	NEMA 1, IP11, Kydex with polycarbonate clear lid HWD: 4.9 in. (124 mm) × 4.9 in. (124 mm) × 5.5 in. (139 mm) Flammability rating: UL 94 V-0
Mounting Options	Wall mount bracket standard Panel mount adapter optional for Q46S Only
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
Analog Outputs	Two 4–20 mA outputs: Output one programmable for PPM H2S or PID; Output 2 programmable for PPM or temperature ; Maximum load 500 Ohms for each output. Outputs ground isolated and isolated from each other
Digital Communications (Optional)	Profibus-DP, Modbus-RTU
Sample Flow Rate	5 GPH Minimum (315 cc/min); 25 GPH Maximum (1.5 LPM)
Weight	20 lb (9 kg)

Q46S/81 Performance Specifications

Accuracy	1% of selected range or 0.05 PPM
Repeatability	0.5% of selected range or 0.05 PPM
Sensitivity	0.005 PPM
Non-linearity	0.1% of selected range
Warm-up Time	3 seconds to rated performance (electronics only) Sensor requires 8 hour stabilization at startup
Supply Voltage Effects	± 0.05% span
Instrument Response Time	60 seconds to 90% of step input at lowest damping



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.

MECHANICAL INSTALLATION

General

Mechanical installation of a Q46S/81 sulfide system involves mounting of the Q46S electronic assembly, mounting of the Auto-Chem chemistry module and mounting of the reagent bottle bracket.

Proper planning of the installation benefits operation and maintenance of the system. Here are a few considerations.

1. Locate the Q46S electronics where personnel can easily access the front panel control keys. Calibration of the system requires access to these controls.
2. Locate the chemistry module high enough above the floor so that servicing of the pumps is not difficult. Pump tubing must be replaced every 6 months so access to the chemistry system is required.
3. Do not mount the reagent bottle closer than about 18 inches from the bottom of the chemistry module. Mounting too close makes removal of the bottle difficult.
4. Water sample and drain lines connect to an inlet overflow assembly at the bottom of the chemistry module. Locate the chemistry module so that the drain line is short and can flow freely.

The Q46S electronics is wall mounted using a PVC plate supplied with the unit. The bracket kit contains 4 screws for attaching the plate to the back of the enclosure. A paper template is supplied to ease of locating anchors in the wall.

The Auto-Chem chemistry module is supplied with 4 stainless steel mounting feet and 8 attachment screws (10-32 × 1/4 in. long). Inserts in the back of the enclosure provide for attachment of the mounting feet.

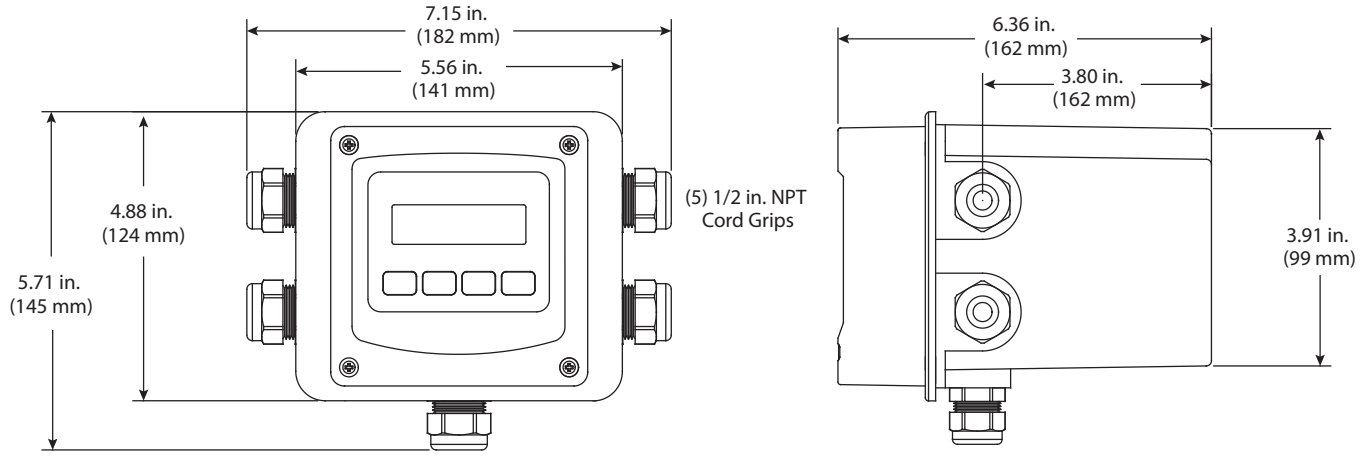


Figure 2: Q46S enclosure dimensions

Wall Mount Bracket

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-bolt that may be used to pipe mount the unit. Slots accommodate U-bolts designed for 1-1/2 inch or 2 inch pipe. The actual center-to-center dimensions for the U-bolts are shown in the drawing. Note that these slots are for U-bolts with 1/4-20 threads. The 1-1/2 inch pipe U-bolt (2 inch I.D. clearance) is available from Badger Meter in type 304 stainless steel, part number 47-0005.

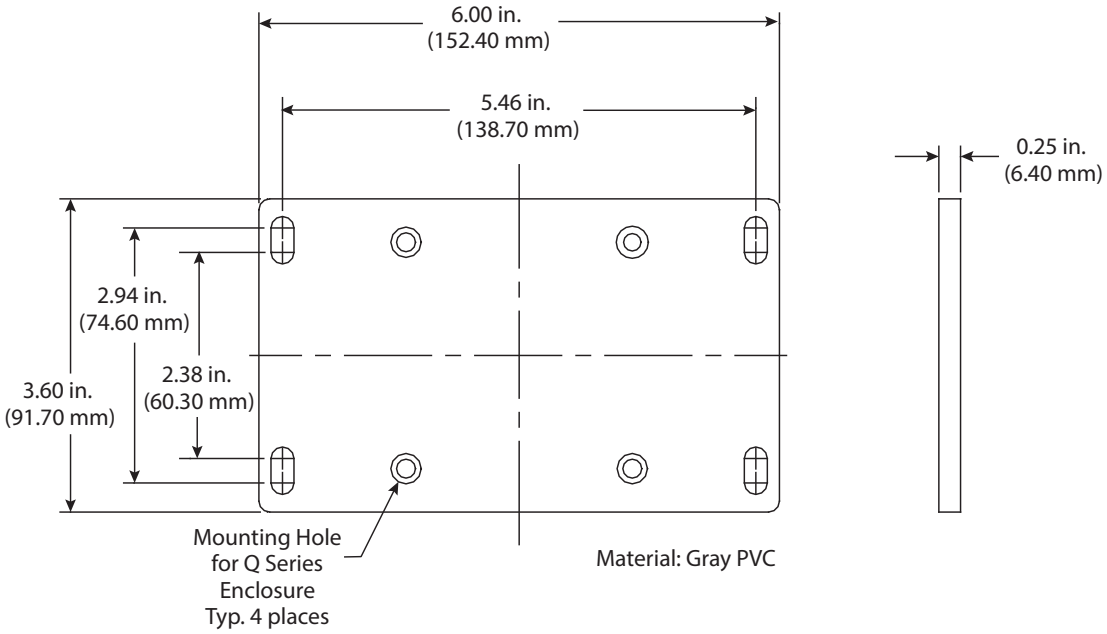


Figure 3: Wall or pipe mount bracket

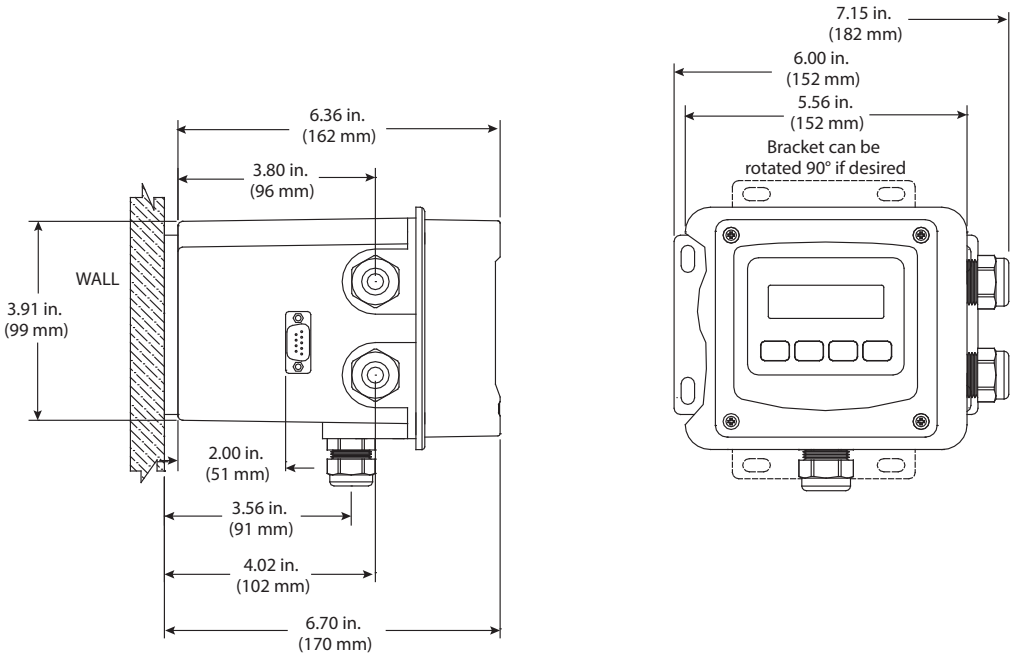


Figure 4: Wall mounting diagram

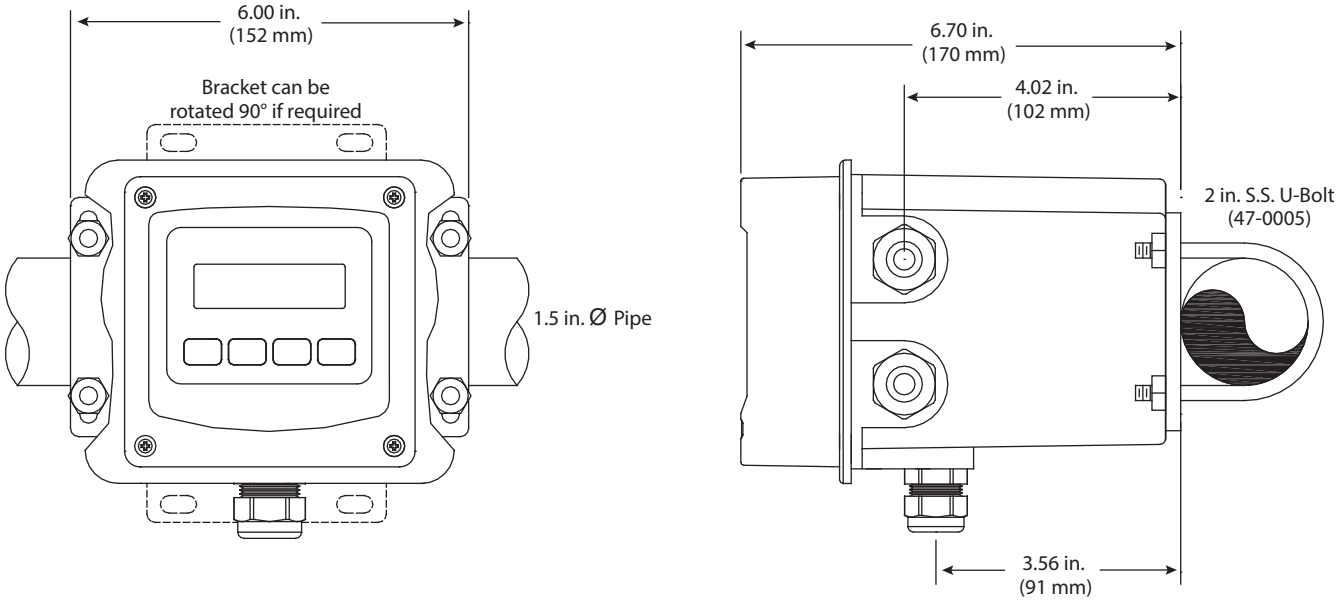


Figure 5: Pipe mounting diagram

Panel Mount, AC Powered Monitor

Panel mounting of the Q46 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 must be ordered separately (05-0094). 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 make certain that the panel mounted monitor provides a watertight seal when mounted to a panel.

1. Attach the sealing gasket to the enclosure. The gasket contains an adhesive on one side so that it remains in place on the enclosure.
2. 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.
3. Mount the monitor in the panel.

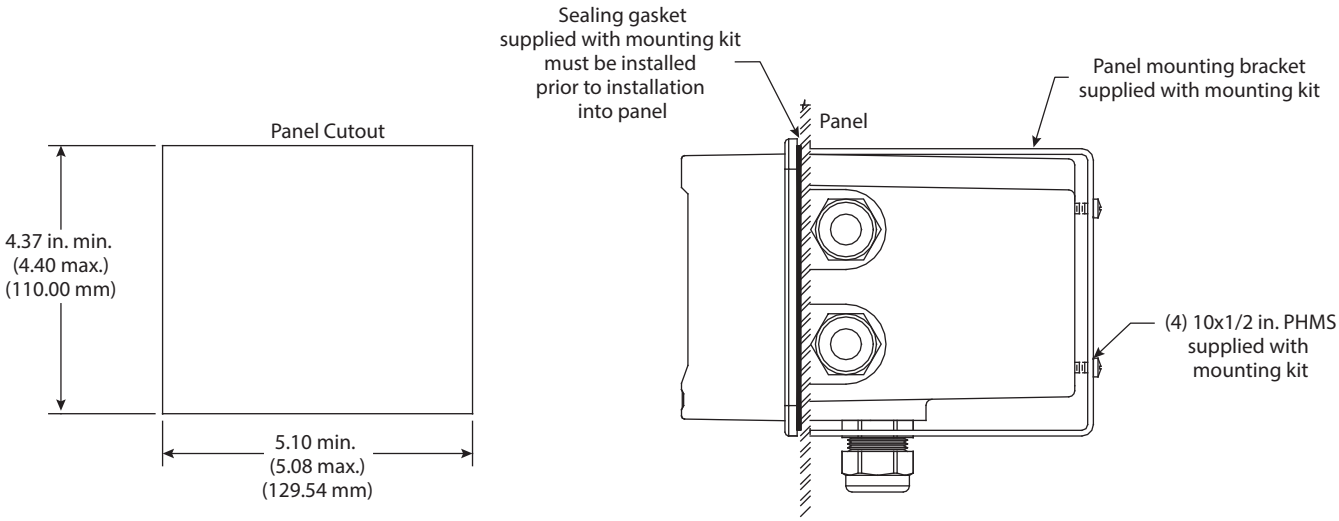


Figure 6: Panel mount cutout

Auto-Chem Mounting

Mount the chemistry module on a wall or flat plate.

1. Tape the mounting template to the wall and mark the four screw locations.
2. Mount any wall anchors first and then screw in the two bottom mounting screws about half way.
3. Screw the stainless steel mounting feet to the back of the enclosure using the screws supplied.
4. Place the two bottom mounting feet of the enclosure on to the screws and tilt the enclosure into place. Install the two top screws to secure the enclosure and then tighten the bottom screws.



Figure 7: Auto-Chem enclosure mounting feet

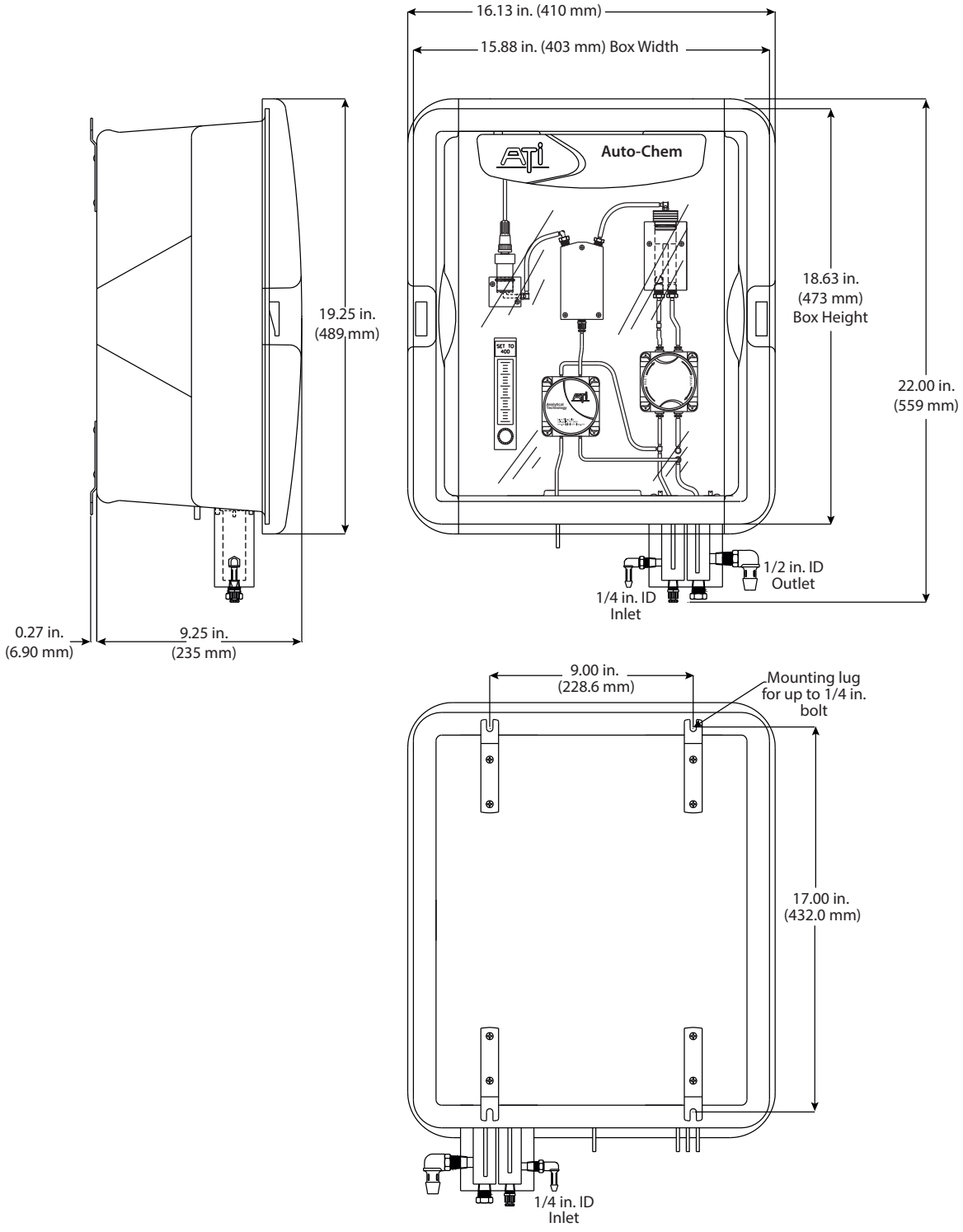


Figure 8: Auto-Chem dimensional drawing

Reagent Bottle Bracket and Pickup Assembly

The Auto-Chem system requires approximately one gallon of reagent every 25 days. A one gallon bottle holder is supplied and mounts to the wall. It is sufficient to mount the bracket using only the upper two mounting holes. A reagent pickup assembly is supplied that fits into the mouth of the bottle and keeps the pickup tubing from floating to the top of the liquid.

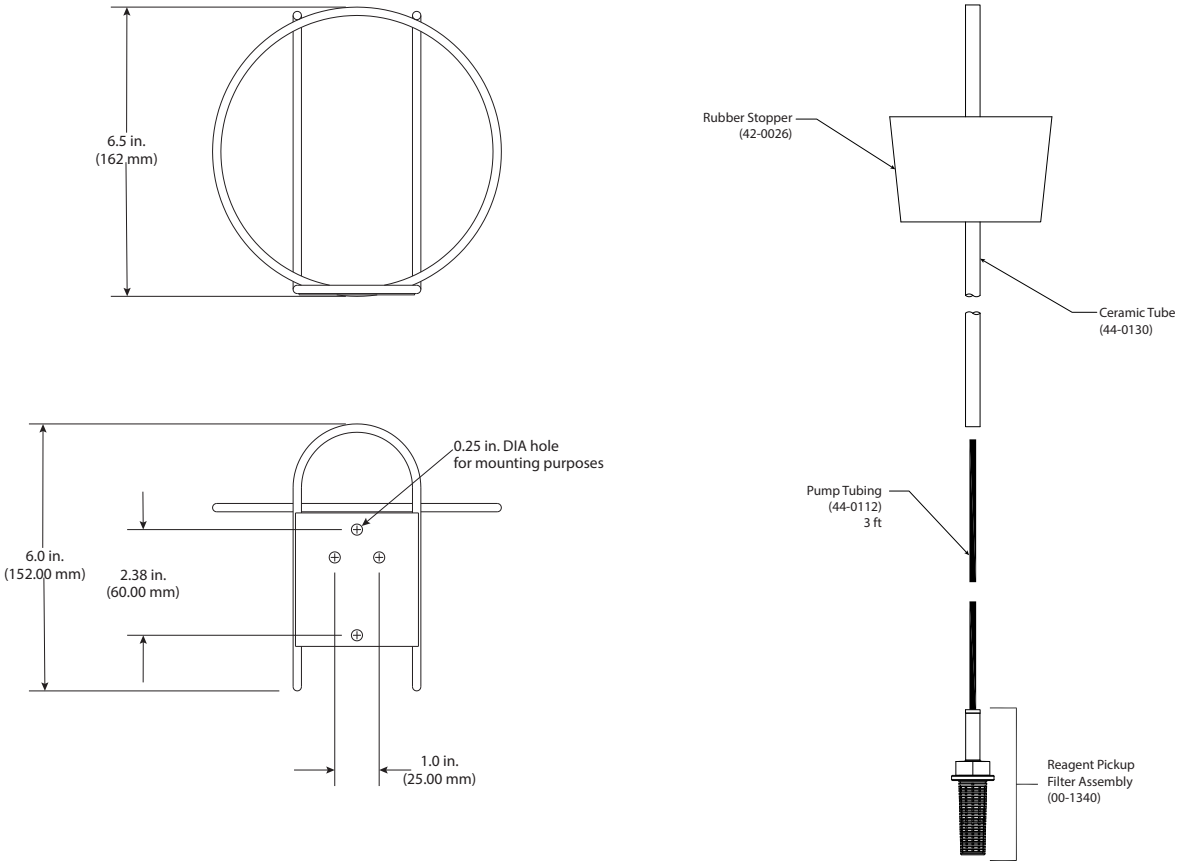


Figure 9: Bottle bracket and reagent feed assembly

Inlet and Drain Connections

NOTE: To avoid shipping damage, the inlet assembly is shipped separately and must be installed on the bottom of the chemistry module after the enclosure has been mounted to the wall. The inlet assembly is supplied with 4 mounting screws for attachment to the enclosure. The photo below shows the inlet assembly attached to the enclosure.

The sample inlet is connected to the inlet overflow assembly mounted on the bottom of the chemistry module. For convenience, a 10-foot piece of 1/4 inch I.D. PVC tubing is supplied. This tubing mates with the inlet hose barb located on the bottom of the inlet assembly.

The drain connection is a 1/2 inch I.D. hose barb on the bottom of the overflow assembly. A 5-foot length of PVC drain tubing is also supplied. The drain should be a free flowing gravity drain. No backpressure is allowed on the drain line.

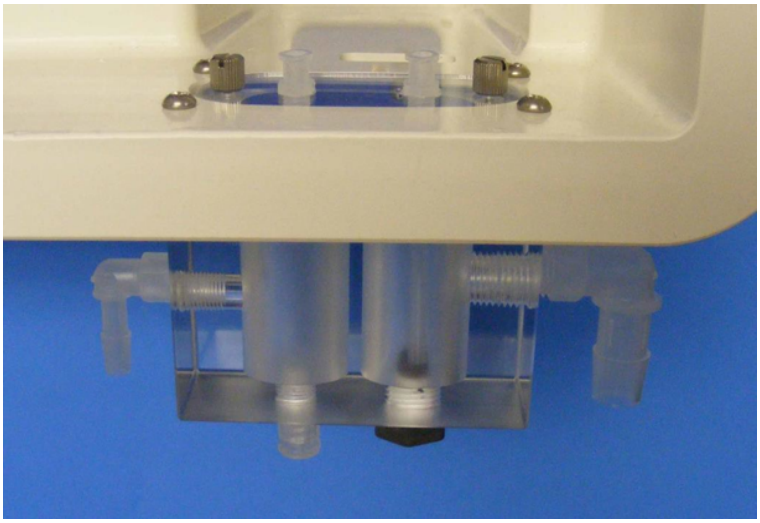


Figure 10: Inlet and drain connections

ELECTRICAL INSTALLATION

General

IMPORTANT

The Q46 electronics contains a universal power supply operating on voltages between 90 and 265V AC, 50/60 cycle. Auto-Chem chemistry modules are not universal and must be ordered for operation from EITHER 115V AC or 230V AC. Please verify the type of unit before connecting any power. The Auto-Chem assembly contains two DIN rail mounted power supplies, one of which is AC power dependent. The 24V AC supply located next to the AC power input terminals is the power supply that must be compatible with the installation site. If there is any question, remove the power supply from the DIN rail and check the label on the bottom of the supply. **Connection of 230V AC power to a 115V AC unit results in damage to the power supply assembly.**

NOTE: 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 terminal 12 (*Figure 10 on page 13*).

NOTE: 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.

NOTE: 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, 2A minimum. If one line of the line power mains is not neutral, use a double-pole mains switch to disconnect the analyzer.

NOTE: 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.

Q46 electronic units are supplied with five 1/2-inch NPT ports, two on each side and one on the bottom. Red plugs are provided for each port. Five cord grips are supplied separately for use during installation. Install a cord grip in the bottom port for sealing the sensor cable connection to the Auto-Chem unit. AC power should enter through the lower right port as the AC terminals are closest to this entry.

⚠ 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. THE POWER SUPPLY IS CONFIGURED FOR 100–240V AC ±10% OPERATION. DO NOT CONNECT VOLTAGES OTHER THAN THE LABELED REQUIREMENT TO THE INPUT.

Connect HOT, NEUTRAL and GROUND to the matching designations on terminal strip **TB7**.

The analog outputs from the system are present at terminal TB1 and TB2. The loop-load limitation in this configuration is 500 Ohms maximum for each output. These three outputs are completely isolated from each other to make certain 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 can be disconnected from the front section during installation to facilitate wiring. The ribbon cable has a marking stripe on one edge that indicates proper orientation.

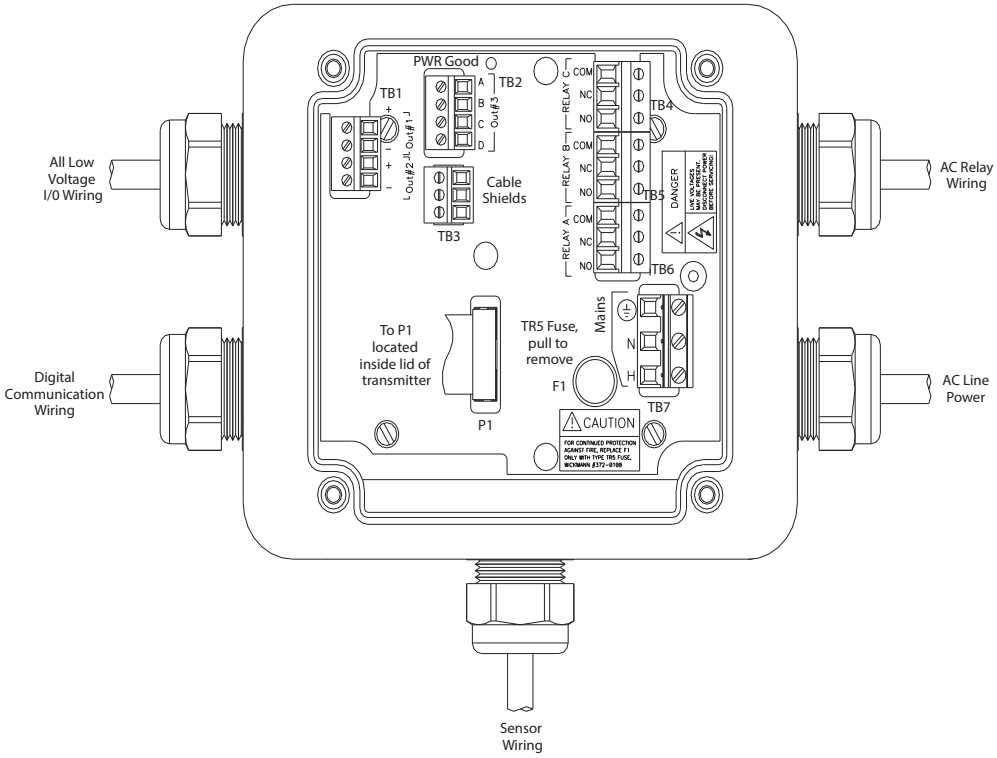


Figure 11: Line power connection

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-inch NPT ports when wiring.

Auto-Chem Power Panel

The chemistry module contains terminals and power supplies on a DIN rail located behind the front panel. During installation, it is often convenient to completely remove the front panel, allowing access to terminals inside. Disconnect the inlet and outlet fittings at the top of the inlet overflow assembly. To remove the front panel, open the latch at the top of the panel and allow the panel to hinge forward. A retaining strap stops the panel from moving too far.

The two pumps are plugged into the 24V AC power supply on the right. The sample conditioner cooling element is plugged into the 6V DC power supply on the left. It is easiest to unplug all 4 items at the power supplies. The RTD temperature element wires have a molex connector that can be unplugged. Also, remove the air line from the lower fitting of the rotameter.

Once everything is disconnected, open the Velcro on the retaining strap and slide the strap through the slots on the front panel. At this point, the entire front panel can be removed from the enclosure. *Figure 12* is a photo of the interior showing power supplies and terminals.

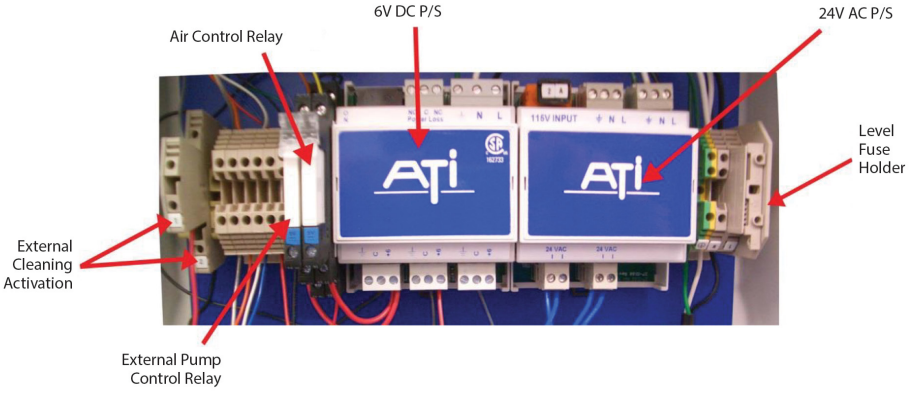


Figure 12: Auto-chem power panel

Q46S to Auto-Chem Connection

A 10-conductor cable connects the chemistry module to the Q46 monitor and includes 6 conductors for the sensor and 4 for the automated sample line cleaning function. The chemistry module connections for this cable are done at the factory and 10-foot length of cable is supplied for routing to the monitor. This cable can be cut to the length required by a particular installation. Eliminating excess cable can reduce the potential for electrical interference. When stripping cables, leave adequate lead lengths for connection in the transmitter enclosure.

Figure 13 provides detail of the internal connections and the location of the AC power connection for the Auto-Chem Module. *Figure 14 on page 17* shows the interconnecting wiring between the Auto-Chem and Q46 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.

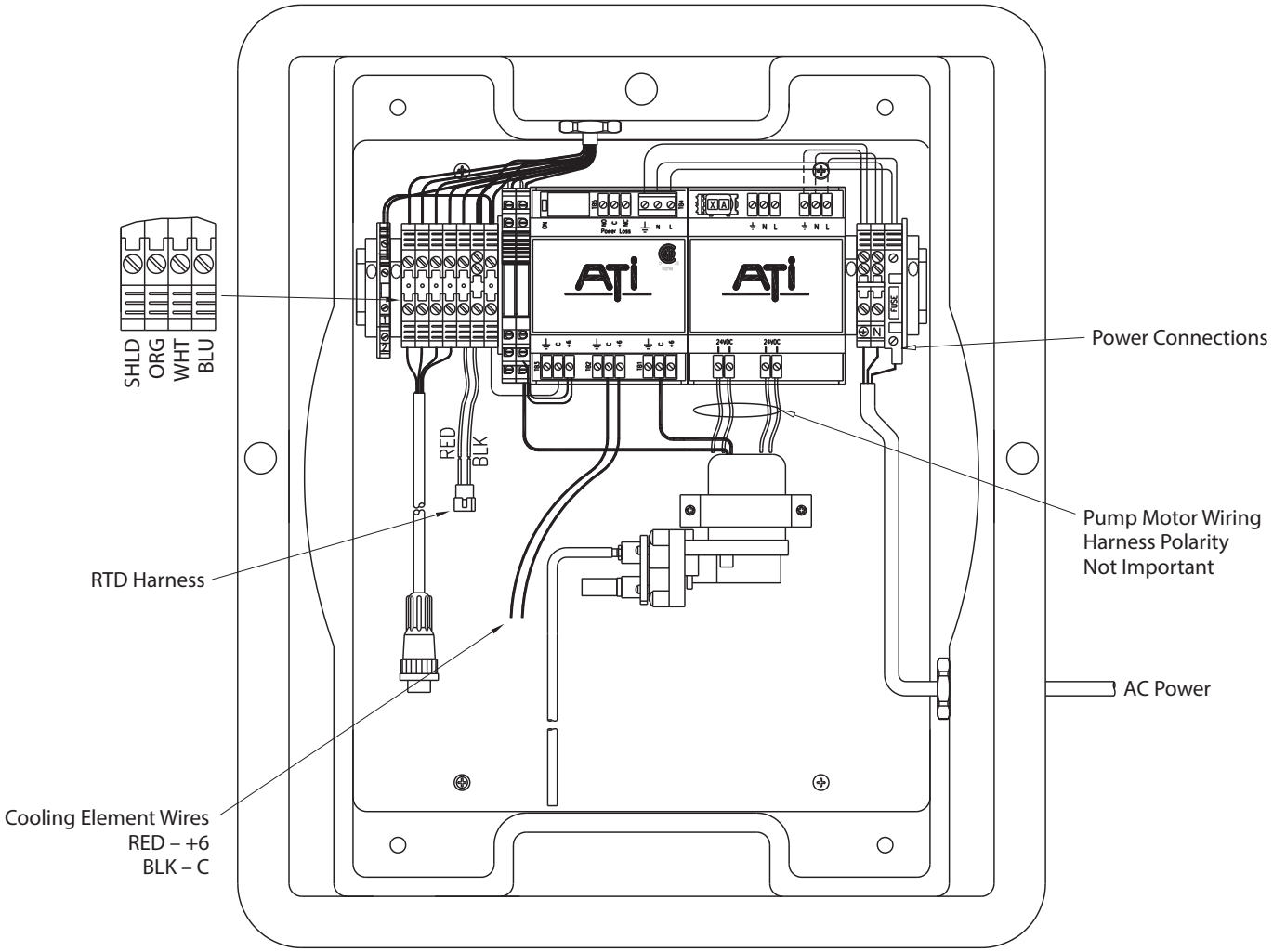


Figure 13: Auto-chem system wiring

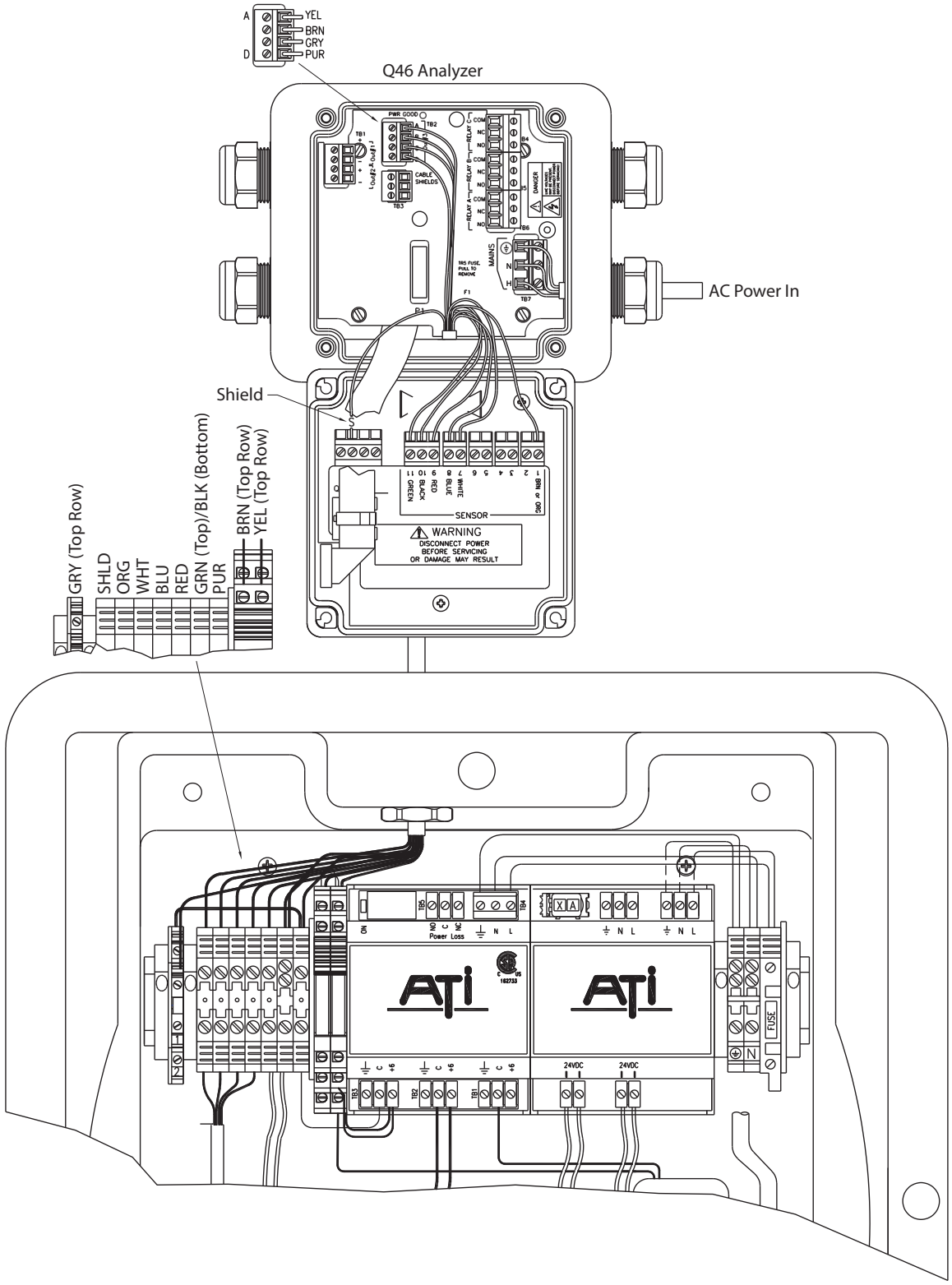


Figure 14: Analyzer connection from Auto-Chem

Relay Wiring

Three SPDT relays are provided on the power supply board. None of the relay contacts are powered. You 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 jumpered from the power input terminals at TB7. Relay wiring is connected at TB4, TB5, and TB6 as shown *Figure 15*. The relay contact markings are shown in the NORMAL mode. Programming a relay for "Failsafe" operation reverses the NO and NC positions in *Figure 15*.

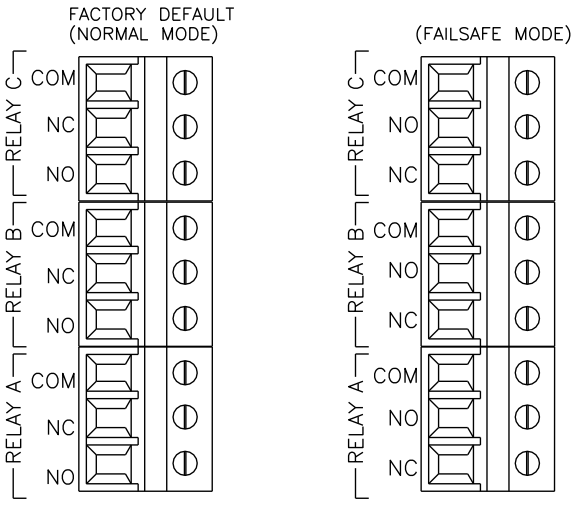


Figure 15: Relay contacts

External Line Cleaning Control

The Auto-Chem chemistry unit contains a relay you can use to control an external chemical feed system for automating sample line cleaning. The relay is mounted on the power panel and wiring is shown in *Figure 16*.

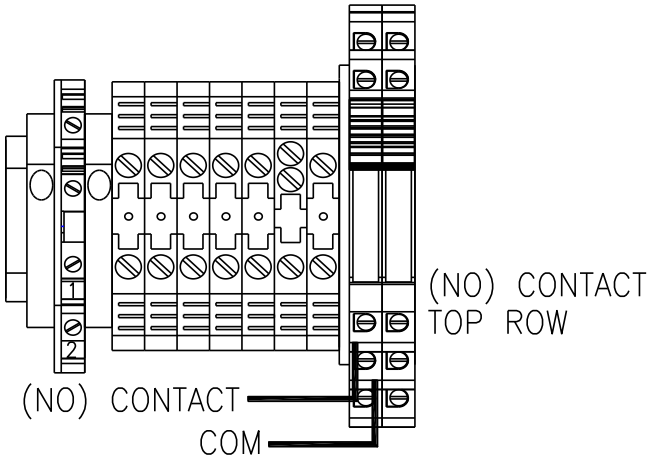


Figure 16: Sample line cleaning control contacts

AUTO-CHEM STARTUP

General

Prior to operating the chemistry module, connect inlet sample and drain tubing to the hose barbs provided on inlet overflow assembly. Remove the clear cover from the chemistry module and check the inlet and outlet tube connections on the inside cover of the overflow assembly. Also, check to be sure that the reagent pickup tube is connected to the inlet fitting of the regent pump.

Two sensors for the system are shipped in a separate container. One of these sensors contains a keeper plug on the end and the other does not. The keeper plug maintains the sensor in stable condition ready for immediate use. Disconnect the keeper plug and plug the sensor cable into the back of the sensor. Remove the protective cap from the end of the sensor and slide it into the sensor flow block. Plug the keeper into the spare sensor and store it in a convenient place. Store in a sealed container in a cool location.

Reagent

Q45S/81 Sulfide systems require acid to convert all sulfides to H_2S. You must supply the acid required for operation. Either sulfuric acid or acetic acid is generally suitable for use in this analyzer. A one-gallon container with marking placard is supplied along with a bottle holder.

Use the following solutions. Acetic acid is not as strong an acid as sulfuric acid, but it is safer to use. If using vinegar (5% acetic acid), verify that the water coming from the sample pump drain tube has a pH below 5.

Sulfuric Acid: Use a 5% solution

Acetic Acid: Use a 5% solution (vinegar is 5% acetic acid)

Reagent Pump Priming

Acid is pulled from the gallon container by a peristaltic pump in the Auto-Chem. The pump rate for chemical feed is about 0.1 cc/min. It can take up to 20 minutes for acid to reach the sample injection point when power is first turned on.

If desired, the acid feed tube can be manually filled to reduce the waiting time. A 10 cc syringe with plastic tip is supplied for this purpose. To fill the feed tube, release the pressure on the reagent pump tube by loosening the clamp plate on the left side of the pump. Then disconnect the 1/16-inch I.D. tube from the injection tee below the sample pump. Insert the tip of the syringe into the tube and use the syringe to draw reagent from the bottle into the syringe. When reagent has reached the syringe, replace the pressure plate on the reagent pump. Once the pressure plate is properly seated, disconnect the syringe and connect the tubing to the injection tee. Carefully discard any acid in the syringe and rinse.

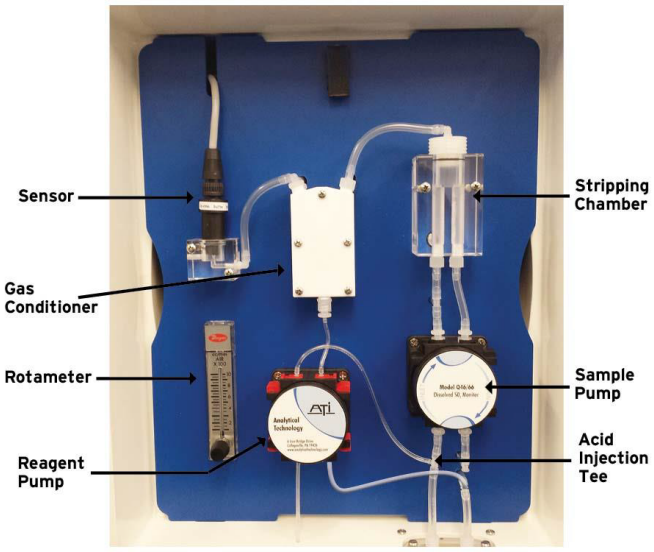


Figure 17: Auto-chem panel components

Operation

The chemistry module contains a lever fuse holder that can be used to turn the chemistry system on and off. Once the steps outlined earlier in this section are complete and power has been connected to the proper terminals, simply close the lever fuse to activate the chemistry module.

Once power is applied, the two peristaltic pumps start to turn and the rotameter on the panel begins to indicate the air flow rate. Use the air flow control valve to adjust the rotameter to 400 cc per minute. The air is discharged into the reactor and there is bubbling in that chamber. The final discharge of the air is into the drain chamber of the inlet overflow assembly and the drain chamber bubbles.

Assuming that sample is flowing to the overflow assembly, sample reaches the reactor in just a few seconds. If the reagent feed has been manually primed, the system begins to function almost immediately. Let the system to run undisturbed for 1 hour after initial startup. Power up the electronics module at this time. The sensor does not stabilize unless the power to the monitor is turned on.

Internal Gas & Liquid Flow

In the Auto-Chem chemistry module, there are two flow paths—one for gas and one for liquid. Understanding how these two flow paths function allows you to quickly verify that the system is operating normally.

The gas flow is used to strip hydrogen sulfide gas from the acidified sample and carry it to the sensor. An air pump behind the front panel pulls ambient air from inside the enclosure and pumps it through the rotameter and into the clear acrylic stripping chamber. The air exits the stripping chamber through the chamber plug at the top and flows through the Teflon gas conditioning block where excess moisture is removed. From the conditioning block, the air flows through the sensor chamber and then out through a tube connected to the drain chamber of the inlet overflow at the bottom of the enclosure. During normal operation, bubbling occurs in both the stripping chamber and in the overflow outlet chamber.

The liquid flow originates in the inlet chamber of the overflow block. Sample is pulled up from that chamber by vacuum and reagent is injected into the sample just below the sample pump. The treated water is pumped into the stripping chamber where it is stripped of hydrogen sulfide. The water overflows into the drain side of the stripping chamber where it is pumped out. The water from the drain side is then pumped into the rear chamber of the gas conditioning block and from there it flows to the drain chamber of the overflow assembly.

One other liquid flow path exists but does not carry much flow. One channel of the reagent pump is connected to the bottom of the gas conditioning block and pumps condensate out of the block and into the main drain line.

Sample Line Considerations

Sulfide monitor sampling systems can suffer from biological contamination that changes the sulfide concentration in the sample during transport to the monitor. This occurs because sulfur-reducing bacteria grow in the sample lines. When the amount of bacterial fouling is high, the sulfide in the sample is consumed by the bacteria during the time it is flowing through the system.

To eliminate this problem, periodically lean sample lines with high levels of chlorine. Injecting sodium hypochlorite solution to provide 50–100 PPM of chlorine in the sample line for a few minutes every few days usually controls growth in the system. The Q46S/81 monitor provides software to automate this cleaning procedure. To implement this function, provide a chemical feed pump that injects the required hypochlorite solution. Starting and stopping of that pump is controlled by the monitor.

The Auto-Chem chemistry module contains two relays that are controlled by the Q46 monitor. One of these relays is used to turn the internal air pump on and off during sample line cleaning. The other is an unpowered contact used to signal a chemical feed pump to start and stop. Use the relay in the chemistry module as a pilot relay to signal a power relay to switch the pump on and off. Switching inductive electrical loads inside the chemistry module can result in interference with the sulfide measurement and should be avoided.

Details on programming the cleaning function are found later in this manual. *Figure 18 on page 21* is a schematic of how a typical line cleaning system might be configured.

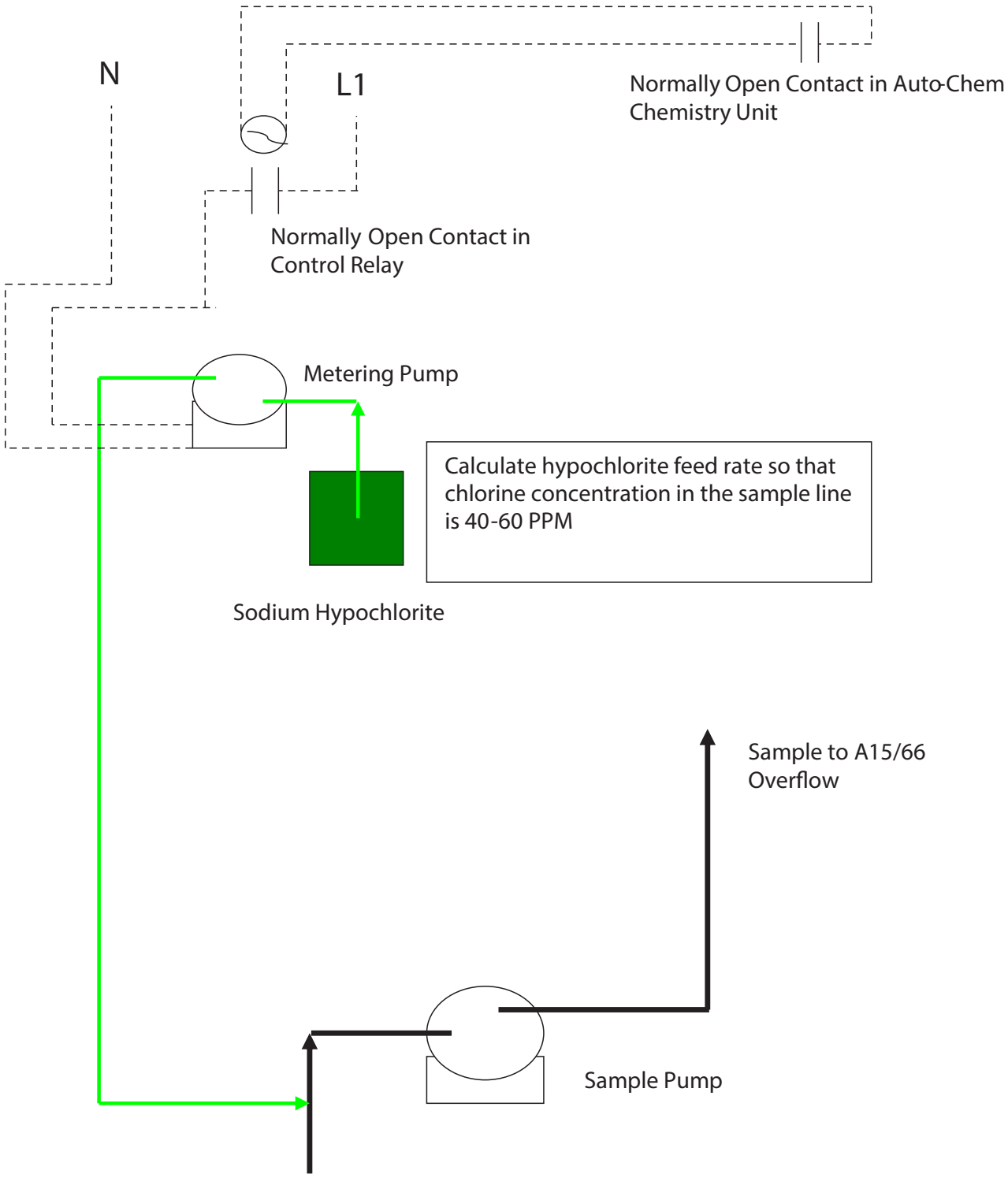


Figure 18: Sample line cleaning system

Cleaning System Remote Activation

The automatic sample line cleaning function is not required for operation of the sulfide monitor but can be useful in reducing manual cleaning. This function can be activated in one of two ways, either with the internal timer in the Q46 or by a contact closure input controlled remotely. If the internal Q46 timer is used, the cleaning cycle occurs at whatever preset interval is desired. The interval is programmed in the *Control Menu* of the Q46. Timer function **T1** is selected when the Q46 monitor controls the start of the cleaning cycle.

Activating the cleaning cycle remotely requires a user-controlled normally open contact input. The contact input must be a dry contact and must close for a minimum of 2 seconds. There can be no power on the contacts used to start the cycle. **A contact input carrying voltage is likely to cause severe damage to the Q46**. The contact input is wired to a terminal block located in the chemistry module. That terminal block contains terminals marked **1** and **2** as shown in *Figure 19*. When programming the Q46 Timer Functions, be sure that the timer function **T2** is selected.

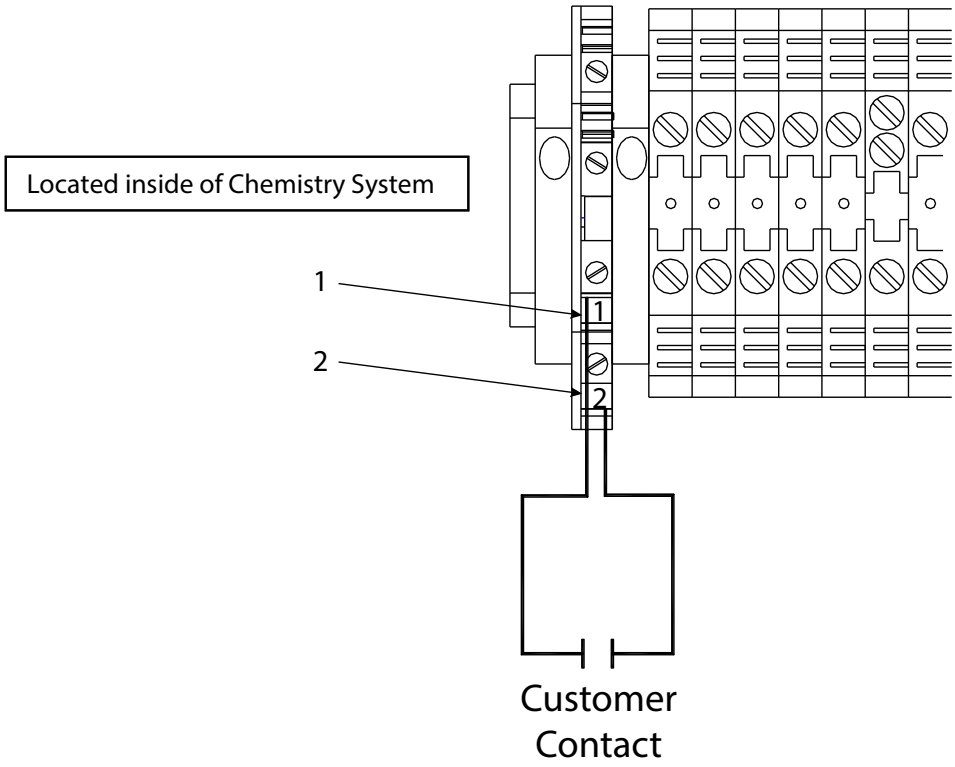


Figure 19: Terminals 1 and 2

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).

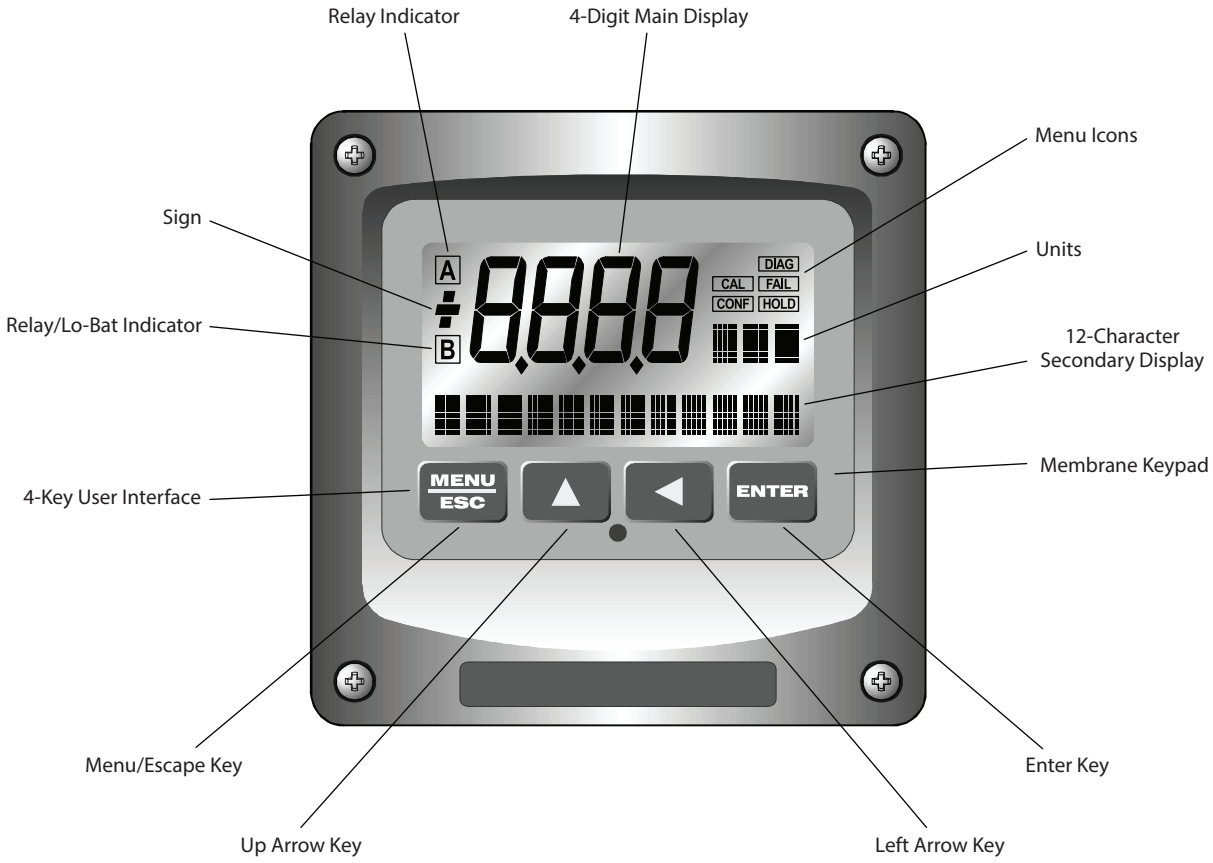


Figure 20: User interface

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 you to back out of any changes in a logical manner. Using the escape key aborts all changes to the current screen and backs you out one level in the software tree. The manual refers to this key as either *MENU* or *ESC*, depending upon its particular function.
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.

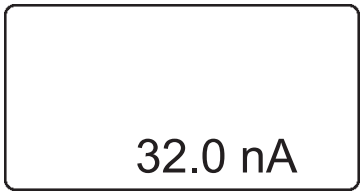
Display

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.

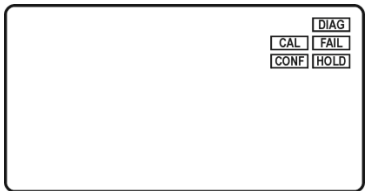
Main Parameter During normal operation, the main parameter display indicates the present process input with sign and units. This main display may be configured to display any of the main measurements that the system provides. During configuration, this area displays other useful setup information to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



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 setup prompts to you. Finally, the lower line displays error messages when necessary. For a description of all display messages, see *"Display Messages" on page 44*.



Icon Area The icon area contains display icons that assist you in setup and indicate important states of system functions. The *CAL*, *CONFIG* and *DIAG* icons are used to tell you what branch of the software tree you are 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*, so it is only displayed on the lower *MEASURE* display line.



Software

The software of the Q46S 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, you 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 21 on page 26* 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, you can quickly modify one parameter. For example, changing the display range from 2.000–20.00. In the multiple variable sequence, variables are changed as the result of some process. For example, the calibration of hydrogen sulfide 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, you 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 you want to perform a change on that item. For single item type screens, once you press the **ENTER** key, part or all of the variable begins to flash, indicating that you 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, press the **ENTER** key again to store the value and stop the flashing. The message "Accepted!" displays if the change is within pre-defined variable limits. If you decide not to modify the value after it has already been partially changed, press the **ESC** key to abort the modification and return the entry to its original stored value.

In a menu item that 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.

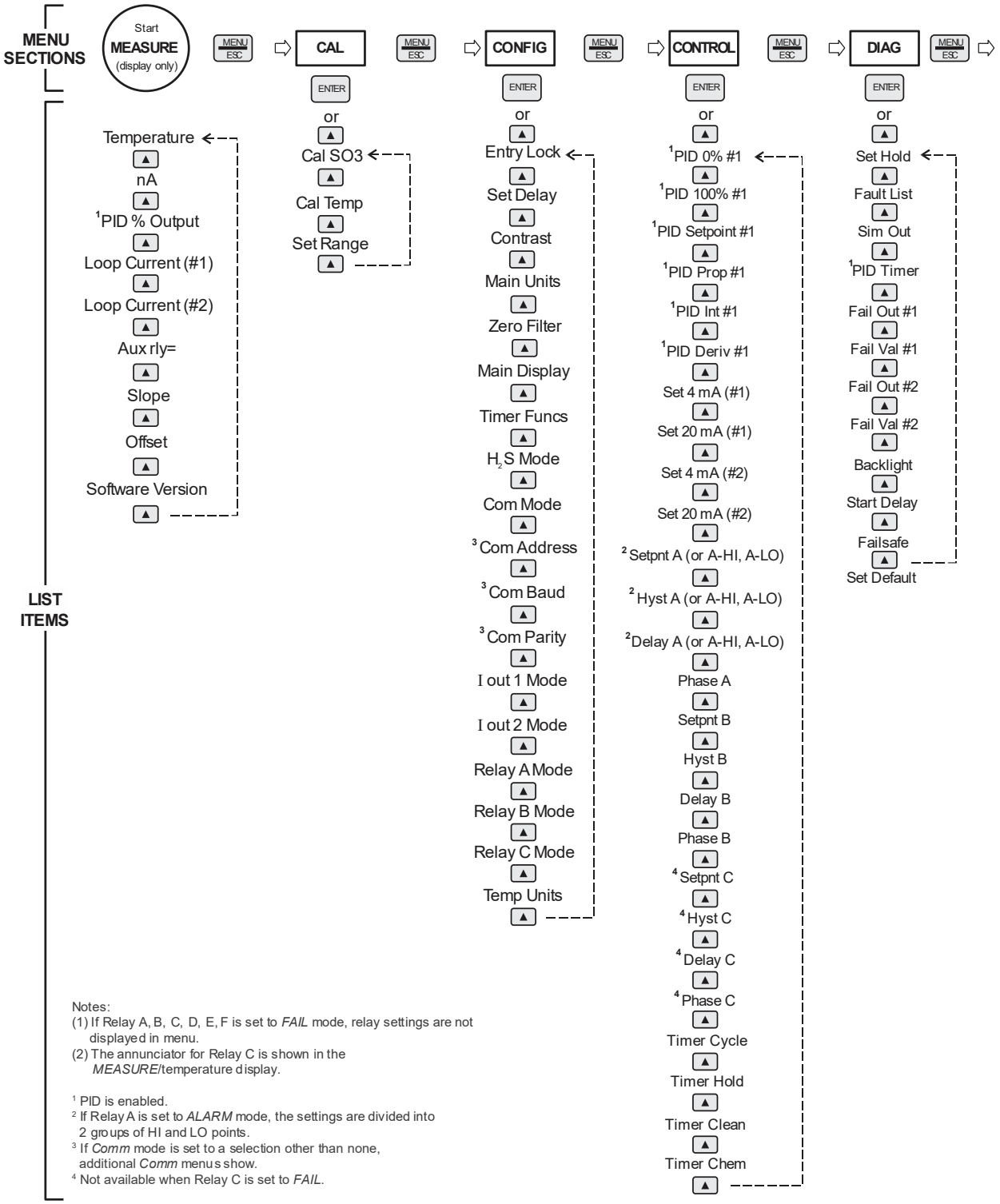


Figure 21: Software map

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 you 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.
4.00 mA	Transmitter output current # 1.
20.00 mA	Transmitter output current # 2.
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.
Q46S VX.XX	Transmitter software version number.
T1-cyc 24.0h	Time remaining until next cleaning cycle. Appears only if the T1 timer is enabled.
T2-wait–	Indicates that the timer function is waiting for a contact input. Appears only if the T2 timer is enabled.

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 three items in this list: *Cal Sulfide, Cal Temp* and *Set Range*.

Cal Sulfide Allows you to adjust the transmitter span reading to match a reference solution, or to set the sensor zero point. See *"Calibration" on page 35* for more details.

Cal Temp Allows you to adjust the offset of the temperature response by a small factor of ±5 °C. The temperature input is factory calibrated. Long cable lengths and junction boxes may degrade the accuracy in some extreme situations. See *"Calibration" on page 35* for more details.

Set Range Provides for user selection of the display range. 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 2.000 ppm, 20.00 ppm and 200.0 ppm. Press **ENTER** to store the new value.

Configuration Menu [CONFIG]

The *Configuration* menu contains all of the general user settings:

Entry Lock Used to inhibit unauthorized tampering. All settings may be viewed while the instrument is locked but cannot be modified. The *Entry Lock* 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. Press **ENTER** to initiate *User Entry* mode and the first digit flashes. The lock/unlock code is 1417.

Set Delay Sets the amount of damping on the instrument. 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 value; range is 0.2–9.9 minutes. Press **ENTER** to store the new value. **Default is 0.2.**

Contrast Sets the contrast level for the display. The STN display provides the highest possible contrast and widest viewing angle under all conditions. Contrast control rarely adjusts, but extreme operating conditions could result in the need for a small change. 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. **Default is 8.**

Main Units This function allows you to select either PPM or mg/L. **Default is PPM.**

Zero Filter This function forces the reading to zero when reading is below the entered value. For example, if the entered value were 0.020, the display at 0.019 would indicate 0.000. This feature is useful in blanking out zero noise. **Default is 0.**

Main Display Allows you to change the primary display. The selection is either sulfide concentration or output current. Press **ENTER** and the display flashes. Use the **UP** arrow key to modify the desired display value. Press **ENTER** to store the new value. **Default is sulfide concentration.**

Com Mode Sets digital communication mode. A digital communication card must be plugged into the power supply slot for this function to work. Press **ENTER** and display 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.

Timer Funcs Activates the automatic sample line cleaning feature and allows selection of either internal or remote activation. The choices are "OFF", "SENS T1" (for internal timing) or "SENS T2" (for remote activation). Default setting is OFF.

H_2S Mode This function is not used in the Q46S/81 Sulfide Monitor and must always remain OFF.

Com Mode Sets digital communication mode. A digital communication card must be plugged into the power supply slot for this function to work. Press **ENTER** and display 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. Press **ENTER** and the display flashes. Use the **UP** arrow key to modify the desired value. Range is 1–125. Press **ENTER** to store the value.

Com Baud Sets the data transmission speed. Press **ENTER** and the display flashes. Use the **UP** arrow key to modify the desired value. The selections are 300 Hz, 600 Hz, 900 Hz, 1.2 kHz, 2.4 kHz, 4.8 kHz, 9.6 kHz, 14.4 kHz, 19.2 kHz, 28.8 kHz, 38.4 kHz, 57.6 kHz and 115.2 kHz. Press **ENTER** to store the value.

Com Parity Sets data parity for digital communication. Press **ENTER** and the display flashes. Use the **UP** arrow key to modify the desired value. Selections are 1-None, 2-Odd or 3-Even. Press **ENTER** to store the value.

Iout#1 Mode Sets analog Output #1 for either sulfide concentration or PID control. Press **ENTER** and the display flashes. Use the **UP** arrow key to select. Selections include 1-ppm for sulfide concentration or 2-PID control. Press **ENTER** to store the new value. **Default is 1-Sulfide.**

Iout#2 Mode Sets analog Output #2 for either temperature or sulfide. Press **ENTER** and the display flashes. Use the **UP** arrow key to select. Selections include: 1-°C for temperature, or 2-PPM for sulfide. Press **ENTER** to store the new value. **Default is 1-°C.**

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 22 on page 31* 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 you 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 22 on page 31* for further 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/C. Relay B/C then operates identically to Relay A, with settings for setpoint, hysteresis, delay and phasing appearing in the *CONFIG* menu automatically.

The *FAIL* setting enables the fail alarm mode for Relay B/C. Relay B/C then trips on any condition that causes the *FAIL* icon to be displayed on the LCD.

NOTE: The Relay C indicator shows up only on the lower screen of the display next to the temperature reading. This is because the default setting for Relay C is the *FAIL* setting. Using this mode allows you to send alarm indications to other remote devices.

Control Menu [CONTROL]

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

Set 4 mA #1
Set 20 mA #1
[Iout1=PPM]

Allows adjustment of analog Output #1. The units displayed depend on the selection made in the *CONFIG* menu for *Iout #1* mode. 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" in the *CONFIG* menu, 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 PID is enabled on Output #1, 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.

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 value which the controller is attempting to maintain by adjusting output value.

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 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 #2
Set 20 mA #2
[Temp/PPM]

Sets the span of analog Output #2. The default setting for this output is temperature, but it may be set for PPM SO_3 if preferred. 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 to 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** and the display flashes. Use the arrow keys to modify value. Press **ENTER** to store the new value.

A Setpoint

Programs the setpoint 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.

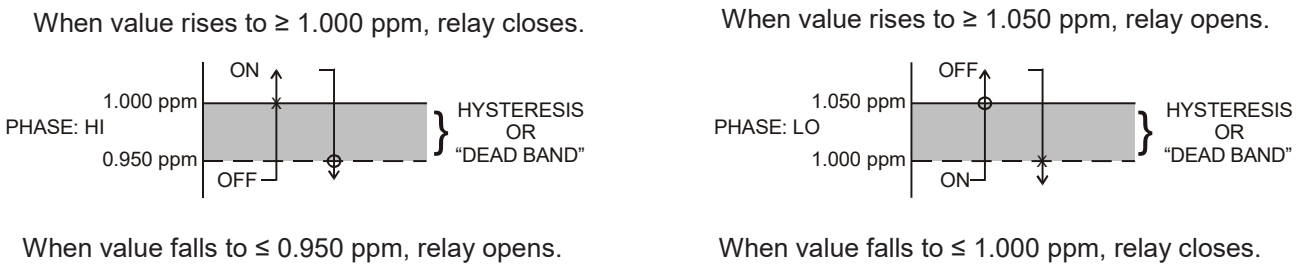
A Hysteresis

Programs 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** and the display flashes. Use the arrow keys to modify value. Press **ENTER** to store the new value.

A Delay Programs the amount of time delay on the trip point for Relay A. The entry value is limited to a value between 0–999 seconds. Press **ENTER** and the display flashes. Use the arrow keys to modify value; range is 0–999 seconds. Press **ENTER** to store the new value.

A Phasing Establishes the direction of the relay trip. When phase is HI, the relay activates when the measured value **exceeds** Setpoint A. When the phase is LO, the relay energizes and the LCD indicator illuminates when the measured value 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** and the display flashes. Use the **UP** arrow key to select either **HI** for direct operation or **LO** for reverse operation. Press **ENTER** to store the new value.

See *Figure 22* for a visual description of a typical control relay application.



Settings:

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

Figure 22: Control relay example

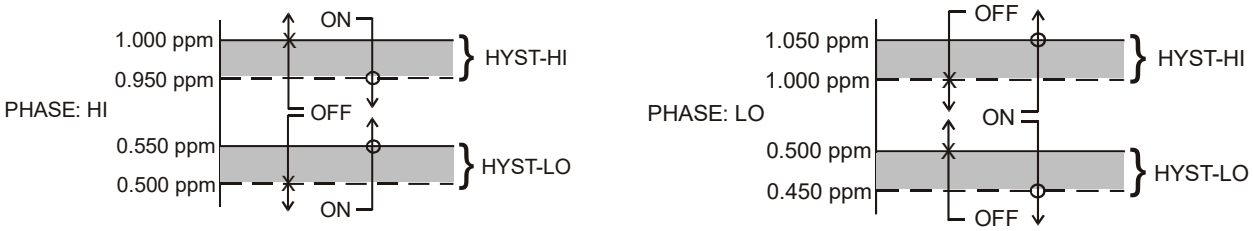
***Setpnt A-HI**
***Hyst A-HI**
***Delay A-HI**
***Setpnt A-LO**
***Hyst A-LO**
***Delay A-LO**

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 23 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 ≤ 1.000 ppm, relay closes, until value rises back to ≥ 1.050 ppm.



When value falls to ≤ 0.500 ppm, relay closes, until value rises back to ≥ 0.550 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 23: 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 29*), 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 29*), then Relay C functions identically to Relay A. Relay C settings appear in the *CONFIG* menu list automatically.

Timer Cycle Sets the frequency of the sample line cleaning function if enabled in *CONFIG* menu. Press **ENTER** to adjust the displayed interval to the desired number of hours between cleaning. Press **ENTER** again to accept the new setting. Do not set the interval for less than 12 hours.

Timer Hold Sets the output holding time after a cleaning cycle is complete. Recommended holding time is 2–4 minutes.

Timer Clean Sets the amount of time that the relay controlling an external chemical feed pump energizes. This is the amount of time that hypochlorite would be fed into the sample line to control biofouling. A period of 3–5 minutes is likely to be adequate, but experience determines actual requirement.

Timer Chem Sets the time period in which the Auto-Chem system is inhibited AFTER the cleaning period set in the previous step. During this period, the air pump in the system is shut off so that the sensor is not exposed to chlorine gas. A minimum of 3 minutes is recommended.

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

Locks the analog output values on the present 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. Once *HOLD* is released, the outputs return to their normal function. 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** and the display flashes. Use the **UP** arrow key to select. 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 you. 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"* below.

Fault List

The *Fault List* screen is a read-only screen that allows you 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 and are immediately removed if power is cycled. If the problem causing the faults still exists, faults display again after power is re-applied and a period of time elapses during which the diagnostic system detects them. The exception to this rule is the calibration failure. When a calibration fails, no corrupt data is stored. 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.

Sim Out

Allows you to simulate the ammonia level of the instrument in the user-selected range. Enter a ppm value directly onto the screen and the output responds as if it were actually receiving the signal from the sensor. This allows you to check the function of attached monitoring equipment. Escaping this screen returns 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.

PID Timer

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.

Fail Out #1

Enables you to define a specified value that the main current output goes to under fault conditions. 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. 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.

Backlight Selects the function of the LCD 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 Allows you to set the relays to a failsafe condition. In a failsafe condition, the relay logic is reversed so that the relay coil is electrically energized in a normal operating state. By doing this, the relay does not only change state when the concentration limit is exceeded, but also when power is lost to the controller.

Start Delay Minimizes control or alarm issues arising from temporary power loss. On power outage, the monitor records analog output values and relay status. 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.

Set Default Allows you to return the instrument to factory default data for all user settings (*ALL*) or for just the calibration default (*CAL*). It is intended 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 *ALL* or *CAL* with the **UP** arrow key.

CALIBRATION

Calibration

After the chemistry module has been running for an hour, zero the system using distilled water. To do this, disconnect the sample pickup line from the inlet overflow and connect the extension tube (supplied with the system). The extension tube is long enough to place into a bottle of distilled water placed near the unit.

Zero Cal

Allow the system to run for about 30 minutes on distilled water. By the end of that time, the sensor output is at its lowest value. On the bottom line of the display, you can see the actual sensor current if desired. This is the "nA" display. If you watch that display, you should see a current value that is normally below 50 nA. The value may be changing some up and down but is not trending in any one direction. If you look at the large numerical PPM display, you normally see a value below 0.3 PPM.

Hydrogen Sulfide sensors have fairly low offset currents at zero. In some cases, it is sufficient to simply leave the zero at the factory default of 0.0 nA. If measurements are being made that are normally above 5 PPM, leaving the unit at electronic zero is satisfactory. If the units is to be used for low level measurements, zero the sensor should be done at startup. An electronic zero can be set by disconnecting the sensor from the cable and performing steps 1–3 below.

The steps below assume that the system has been operating on distilled water for 30 minutes after the initial 8 hour stabilization time.

1. Scroll to the *CAL* menu section using the **MENU** key and press **ENTER** or the **UP** arrow key. "Cal H_2S" displays.
2. 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**.
3. The system now begins acquiring data for the sensor zero calibration value. As data is gathered, the units for sensor current in nanoamps (nA) displays. Once the software has identified a stable value, the zero offset current is automatically recorded. If you do not wish to wait for the monitor to analyze the data, you can override by pressing **ENTER**. If the data remains unstable for 10 minutes, the calibration fails and the message "Cal Unstable" displays.
4. 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 -999–+999 nA. If a *FAIL* occurs, carefully inspect the sensor for membrane fouling. If the offset value remain high and result in calibration failures, review *"Troubleshooting" on page 43* 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.

Span Cal

Calibration of the Sulfide Monitor can be done in one of two ways. If an accurate laboratory measurement can be made on the same sample that the sensor is measuring, the monitor can be adjusted to the laboratory result. A sulfide standard can also be prepared in accordance with the procedure on the following page, but the final value of the standard should be verified if possible by laboratory test. A sample should be collected from the inlet line feeding the flow cell and quickly analyzed for sulfide ion. When calibrating, it is best to have a reasonably high concentration of sulfide in the system. The higher the value, the smaller the calibration errors caused by errors in the laboratory analytical procedure. It is generally preferable to calibrate at values above 0.5 PPM to reduce calibration errors:

To calibrate the system, follow the procedure below:

1. If a mixed standard is to be used, place the sample pickup tube into the container of standard. If you plan to use an actual sample, collect this sample in a 500 cc container and have a portion of this sample tested for sulfide content.
2. Allow either the known sample or mixed sample flow for 5 minutes.
3. Scroll to the *CAL* menu section using the **MENU** key and press **ENTER** or the **UP** arrow key. "Cal H_2S" 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 1-Ref span calibration and press **ENTER**.
5. The system now begins acquiring data for the calibration value. As data is gathered, the units for ppm 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 stable, the screen displays the last measured ppm value and a message displays prompting you to adjust the value. Enter the sample or standard value depending on what you are using. Each digit must be adjusted separately using the **UP** arrow key. Move to the left using the **LEFT** arrow key. When adjusted, press **ENTER**.
7. If accepted, the screen displays the message "PASS" with the new sensor slope reading. 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 20–500%.

Mixing a Sulfide Standard

While calibration against a lab analysis is preferred, it is possible to mix a sulfide standard that can be used for calibration. The following procedure produces a standard of about 1.6 PPM. The actual value may be somewhat lower, but this procedure should be within about 10–15% of that value. Reagent grade sodium sulfide, analytical balance, volumetric flask and distilled water is required.

This standard requires 2 steps. First, accurately weight out 1.000 grams of sodium sulfide and place into a 1 liter volumetric flask. Fill to 1 liter with distilled water. This provides a concentrated standard of about 410 PPM and is stable for a few days. Use of a hydrated sulfide salt results in a different value that can be calculated using the formula weight for that salt.

The dilute standard is only stable for about an hour, so take this step just before use. Place 500 cc of water in a container and then add exactly 2 cc of concentrated standard using a pipette. Mix and feed into the sulfide monitor as a standard. The easiest way to feed this standard is through the inlet port normally used for distilled water. Simply use the same inlet tubing used for zeroing to introduce the mixed standard. Once the monitor has stabilized, adjust the display to 1.64 PPM using the calibration procedure in the previous sections.

Temperature Calibration

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

The temperature element is measuring the temperature of the sample inside the air stripping chamber. This temperature may, or may not, be close to the temperature of the water in the inlet overflow. Heat generated inside the chemistry module can sometimes cause the displayed temperature to be above the actual sample temperature. While temperature calibration is possible, it is not recommended. If you wish to calibrate the temperature system, proceed as follows:

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. 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 your measured value. 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.

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 you require that a measured process stay as close as possible to a specific setpoint value, the controller output changes from 0 to 100% in an effort to keep the process at the setpoint. To effect 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 or 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).

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

Where:

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

Figure 24: Q46S ISA PID equation

The most notable feature of the algorithm is the fact the proportional gain term affects all components directly (unlike some other algorithms - like the "series" form). If a pre-existing controller 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 30*, 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 "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 you 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 Q46S 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 38* 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 you 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 × 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 you 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, place the sensor in a location that provides proper mixing or reaction time.

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, 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, 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), 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, de-tun the loop to deal with that condition (reduce "P" and/or "I").

SYSTEM MAINTENANCE

General

The Q46S/81 Auto-Chem Sulfide System requires regular maintenance for reliable operation. 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 maintenance of the electronic monitor is required if installed according to the guidelines of this operating manual. During operation, it is best to use only your finger to operate front panel keys. Using tools, especially sharp objects, to press front panel keys results in damage to the panel keys.

Sensor Maintenance

Sensor maintenance is limited to periodic inspection to be sure that the membrane area is clean. It is unusual for contaminants to make it all the way through the air system and reach the sensor, but it is good practice to inspect the sensor every 2 or 3 months.

The sensor used in this system has an operational life that is dependent on the amount of SO_3 that is being routinely measured. Continuous operating below 1 PPM normally results in sensor life of 9–12 months. Constant operation above 10 PPM results in sensor life of about 6 months. After calibration, the "slope" value for a sensor is calculated. When you see a slope value below 40% after a calibration, the sensor is nearing the end of its life. It is good practice to always have a spare sensor on hand. Two sensors are supplied with the unit. When the first sensor is used up, it is best to order a replacement.

Sample Pump Tube Replacement

Peristaltic pump tubing replacement is the most common maintenance required for the Auto-Chem system. The sample pump used in this system contains two different tubes, one for the inlet (left) side of the pump and one for the outlet (right) side of the pump. **These tubes MUST be installed in the proper location or the system does not work.**

The inlet tube has a slightly smaller I.D. than the outlet tube. This is necessary so that the air stripping chamber does not fill with sample and force sample through the rest of the system.

Both inlet and outlet tubes are black. One spare tube of each size is provided in the spare parts kit. Spare tubing is available in packages of 5, and spare tubes are cut to the proper length at the factory. Be very careful to make sure that the I.D. of the tube used on the outlet is larger than the I.D. of the inlet tube. The difference is clear when comparing the two tubes side-by-side. Reversing the tube sizes on the pump results in sample water being pumped through the parts of the system that should only see gas.

NOTE: The tube fittings on the inlet side are smaller than those on the outlet side. The spare parts kit contains 2 of each size.

To replace the sample pump tubing, follow these steps:

1. Remove the reagent pickup assembly from the reagent bottle and place it in a container of tap water. Allow the monitor to run for 30 minutes so all the acid is out of the system prior to maintenance.
2. Release the front panel latch and tilt the front panel forward. Raise the lever on the fuse holder to turn off power to the chemistry system. Then, return the front panel to normal position.
3. Release the pressure plates on each side of the pump. This allows sample and drain tubes to drain into the overflow. Then disconnect the inlet and outlet tubing connections from both sides of the pump.
4. Slide the tube holders out of the pump body and then pull the old tubes from barb end of the luer fittings.
5. Place one inlet tube and one outlet tube onto the proper sized fittings. Place the tube holders with the inlet tube onto the left side of the pump and place the tube holders with the outlet tube on the right side.
6. Once tube holders are in place, replace the pressure plates on each side of the pump.

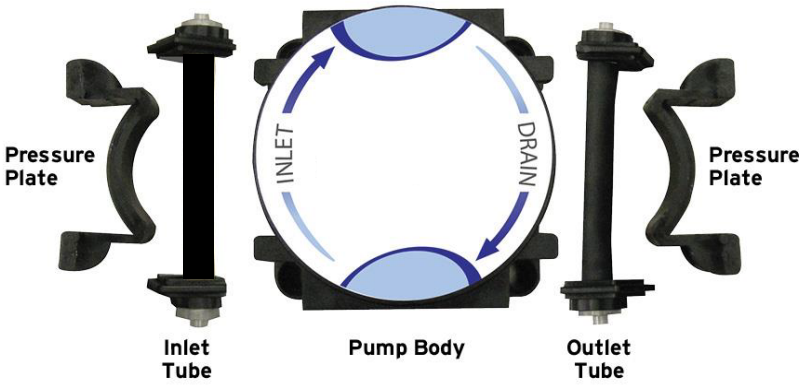


Figure 25: Sample pump exploded view

Reagent Pump Tube Replacement

Replacement of the reagent pump tubes is similar to the procedure used for the sample pump. However, the replacement reagent tubes are supplied with the plastic tube fittings already attached. Do not pull the microbore tubing off the fittings as it is difficult to put back on.

The reagent tubing assemblies snap into the tube holders at the middle of the plastic tube fittings. Observe the position of these assemblies prior to removing the old ones.

One tube assembly is required on the left side of the pump for delivery of acid into the sample. A second tube assembly is required on the right side of the pump to remove condensate from the gas sample conditioning module. The tubes assemblies are the same for both sides of the pump.

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. 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.
2. Verify the proper power input is present (115/230V AC).
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, high frequency sources of electrical noise may still cause erratic behavior in extreme conditions.
7. On systems where relays are in use, check the relay load to 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: The contact rating are de-rated to a lower level if the load is highly inductive (solenoids, motor starters, large aux relays). Also, due to the large amount of energy present in circuits driving these types of loads when they are switched on an 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.

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 analog outputs and relays with a DMM.
3. Check cell drive circuit. With a digital voltmeter (DVM), measure the voltage between the ORANGE and BLUE terminals with the BLUE jumpered to the WHITE on the monitor to verify that the millivolt value is actually 0 mV. **(REMOVE JUMPER AFTER VERIFICATION.)**
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 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.

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*.

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**.	Check to see that a stable standard is in use. If sample is stable, verify that sample from the drain tube is less than 4 pH. Replace sensor is necessary.
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 -999–+999 nA.	Check wiring connections to sensor. Allow sensor to operate powered a minimum of 4 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. Be sure that the blue and white wires are not reversed.
Sensor Low	The raw signal from the sensor is too low.	Check wiring connections to sensor.
Sulfide High	The sulfide reading is greater than the maximum of the user-selected range.	The reading is over operating limits. Set measuring range to the next highest level.
Cal Fail	Failure of sulfide 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 20% or greater than 500%. Replace sensor if failure recurs.
EEPROM Fail	Internal nonvolatile memory failure.	System failure, consult factory.
Chcksum Fail	Internal software storage error.	System failure, consult factory.
Display Fail	Internal display driver fail.	System failure, consult factory.
Range Cal Fail	Failure of factory temperature calibration.	Consult factory.

SPARE PARTS

Q46 Electronic Assembly

Part No.	Description
03-0431-2	Q46S front lid assembly
07-0365	100–240V AC monitor electronics assembly
07-0367	100–240V AC monitor electronics assembly with Profibus
03-0409	P/S Assy, 100–240V AC with 3-relay exp. board
23-0029	Fuse, 630 mA, 250V, TR-5
38-0072	Terminal block plug, 3-position (relays)
38-0073	Terminal block plug, 4-position (outputs)
38-0074	Terminal block plug, 3-position (ground)
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)	
44-0311	Conduit entry plug, red PE
44-0274	Cord grip, 1/2 in. NPT

Auto-Chem Assembly

Part No.	Description
00-1651	Hydrogen Sulfide Sensor
31-0177	Sensor cable with connector, 2 ft
00-1654	RTD Assembly, Pt100
03-0428	RTD wiring harness
23-0002	Fuse, 2A
03-0420	Thermoelectric cooler with cable
03-0421	Sample pump assembly (requires parameter label #34-0391)
34-0392	Sulfide label for sample pump
03-0422	Reagent pump assembly
36-0051	Sample pump motor, 24 RPM
36-0049	Reagent pump motor, 6 RPM
03-0427	Pump motor wiring harness
05-0103	Sample pump inlet tubing, pkg. of 5
05-0104	Sample pump drain tubing, pkg. of 5
05-0102	Reagent pump tubing assembly, pkg. of 10
00-1652	24V AC power supply, 115V AC input
00-1657	24V AC power supply, 230V AC input
00-1653	6V DC power supply, 100–240V AC Input
36-0053	Air pump assembly, 6V DC
55-0014	Rotameter
44-0116	Check valve, 1/8 in. I.D. tubing
45-0299	Air stripping chamber, Acrylic
45-0302	Air stripping chamber plug
42-0024	Stripping chamber plug O-ring
45-0304	Sensor flow block, Acrylic
42-0003	Sensor flow block O-ring
45-0317	Gas conditioner front block
45-0324	Gas conditioner rear block

Tube Fittings

Part No.	Description
44-0004	Plug, 1/8 in. NPT
44-0036	1/8 in. NPT × 1/8 in. I.D. right angle barb fitting
44-0090	1/8 in. NPT × 1/4 in. I.D. right angle barb fitting
44-0091	10-32 × 1/8 in. I.D. barb fitting
44-0148	10-32 × 1/8 in. I.D. right angle barb fitting
44-0159	Luer fitting, female, 1/8 in. barb
44-0164	Luer fitting, male, 1/8 in. barb
44-0167	1/8 in. NPT × 1/8 in. I.D. barb fitting
44-0168	1/8 in. I.D. tee fitting
44-0184	Luer adapter, 1/8 in. NPT × male luer
44-0185	Luer cap, female
44-0194	Luer adapter, female, 1/6 in. I.D. barb
44-0253	Luer adapter, female, panel mount, 1/4-28 × 1/8 in. barb
44-0336	1/8 in. I.D. tube "L" fitting
44-0337	3/8 in. NPT × 1/2 in. I.D. barb fitting
44-0338	3/8 in. NPT plug
44-0348	Luer adapter, 5/32 in. tubing, sample pump inlet
44-0394	Luer adapter, 3/16 in. tubing, sample pump outlet
00-1340	Reagent pickup tubing filter assy

Tubing

Part No.	Description
44-0334	Tygon tubing, 1/8 in. I.D. × 1/4 in. O.D.
44-0333	PVC tubing, 1/6 in. I.D. × 1/8 in. O.D.
03-0419	Reagent feed assembly
44-0114	Buffer pickup tubing connector
47-0022	Reagent bottle wall bracket

Lock/Unlock Code: 1471

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