



O & M Manual



Model Q45S/87 Wet Hydrogen Sulfide Monitor

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Part 1 - Introduction

1.1 General

The Q45S/87 Wet H₂S Transmitter is a microcomputer-based instrument for monitoring the concentration of a hydrogen sulfide gas in wet scrubber outlet vents or scrubber inlet ducts saturated with water vapor.

The system consists of three parts, a Monitor assembly containing an LCD display, analog outputs, and alarm functions; a special H₂S sensor with duct insertion holder designed for operation in condensing gas streams; and an optional air-purge system to periodically remove any water droplets that might accumulate on the sensor and cause slow response. When air-purge system is ordered a system mounting plate is provided for mounting both transmitter and air purge system in the same location.

The system requires AC power for operation of the monitor and purge pump assembly. Power for the purge pump is switched on and off through a relay in the monitor. The frequency with which the purge pump is activated is controlled by the user through a setup routine in the configuration menu. The purge pump assembly should normally be mounted next to the monitor and both should be located within 25 feet of the sensor assembly for best results. A 1/8" I.D. tube connects the outlet of the air-purge pump to the sensor assembly. The basic system is shown in Figure 1 below.

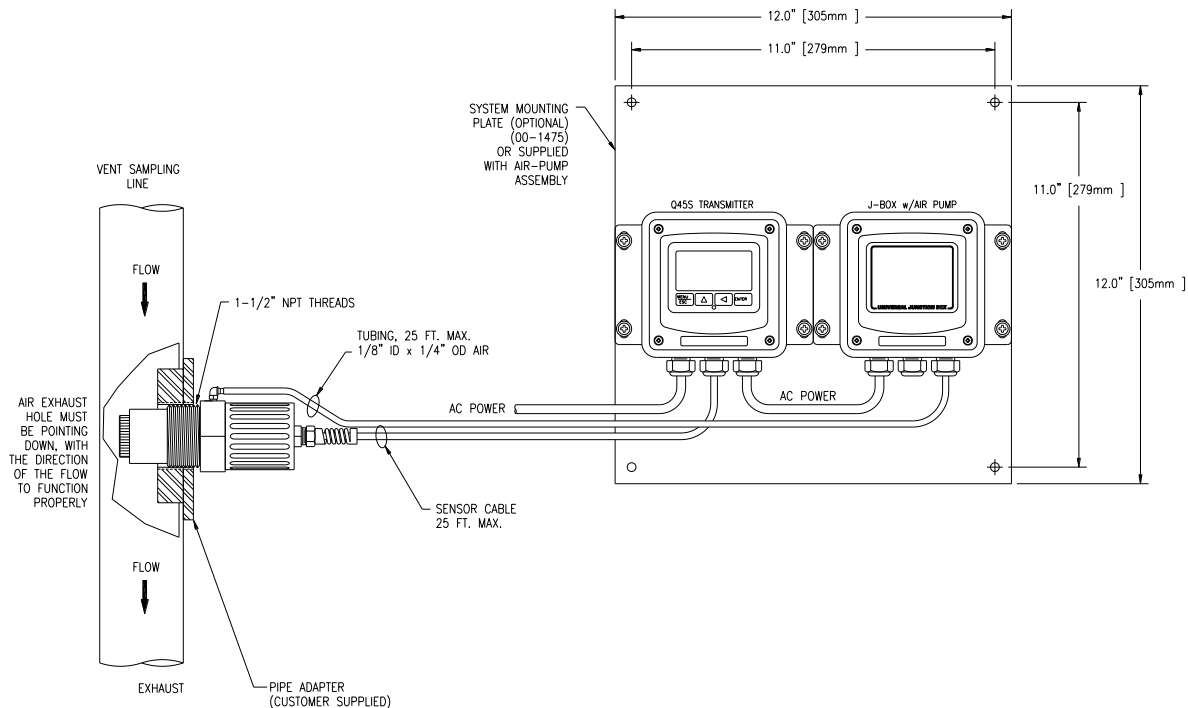


Figure 1 - Wet H₂S Typical System Diagram

1.2 Features

Standard Q45S/87 electronic transmitters are designed to be a fully isolated instrument for continuous operation from AC power. An optional battery powered version (without air-purge system) with an internal data logger is available for short term monitoring use.

High sensitivity system measures from 0.1 ppm to 200.0 ppm with 3 display ranges. User ranges of 2.000 ppm, 20.00 ppm, or 200.0 ppm may be selected, or the monitor may operate in Auto-Ranging mode, switching display sensitivity up and down depending on the measured value.

Output Hold, Output Simulate, Output Alarm, and Output Delay Functions. All forced changes in output condition include bumpless transfer to provide gradual return to on-line signal levels and to avoid system control shocks on both analog outputs.

Two SPDT relays are provided, one normally assigned to the control of the sensor air-purge pump and the other available for external alarming functions.

Two analog outputs may be configured to track H₂S concentration or temperature. Both analog outputs can be individually programmed to fail to specific values.

Selectable PID controller on main analog output. PID includes manual operation feature, and diagnostic “stuck-controller” timer feature for relay notification of control problems.

Large, high contrast, custom Super-Twist display provides excellent readability even in low light conditions. The secondary line of display utilizes 5x7 dot matrix characters for clear message display

Diagnostic messages provide a clear description of any problem with no confusing error codes to look up. Messages are also included for diagnosing calibration problems.

Quick and easy one-point calibration method and sensor zero-cal. To provide high accuracy, all calibration methods include stability monitors that check main parameter stability before accepting data.

Security lock feature to prevent unauthorized tampering with transmitter settings. All settings can be viewed while locked, but they cannot be changed.

1.4 Q45S/87 System Specifications

Displayed Parameters	Main input, 0.1 ppm to 200.0 ppm Sensor Current, 0.0 to 999.9 nA, 0.000 to 99.99 uA Sensor Temperature Loop current, 4.00 to 20.00 mA Sensor slope/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 0.00 to 200.0 ppm
Display	Large, high-contrast, Super-Twist (STN) LCD; 4-digit main display with sign, 0.75" (19.1 mm) seven-segment characters 12-digit secondary display, 0.3" (7.6 mm) 5x7 dot matrix characters
Keypad	4-key membrane type with tactile feedback, polycarbonate with UV coating
Weight	Line powered unit: 1.5 lb. (0.68 Kg) Battery power unit: 0.8 lbs. (0.36 Kg.)
Ambient Temperature	Analyzer Service, -20 to 60 °C (-4 to 140 °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	600 V galvanic isolation
Filter	Adjustable 0-9.9 minutes additional damping to 90% step input
Sensor	Electrochemical type for measurement of hydrogen sulfide gas
Sensor Materials	Noryl and PVC
Sensor Cable	25 ft. (7.5 meter) cable with 6-pin plug.
Max. Sensor-to-Analyzer Distance	100 feet (30.5 meters), with junction box
Sensor Holder	PVC duct insertion assembly with air-purge nozzle.

Power	90 – 130 VAC, 50/60 Hz or 180 – 260 VAC, 50/60 Hz
Enclosure, AC Powered	NEMA 4X, IP66, polycarbonate, stainless steel hardware, weatherproof and corrosion resistant, HWD: 4.9" (124 mm) x 4.9" (124 mm) x 5.5" (139 mm)
Mounting Options	Wall or pipe mount bracket standard. Bracket suitable for either 1.5" or 2" I.D. U-Bolts for pipe mounting. Panel mount adapter optional.
Conduit Openings	Three ½" NPT openings. Gland Seals installed
Relays, Electromechanical	Two SPDT, 6 amp @ 250 VAC, 5 amp @ 24 VDC contacts. Software selection for setpoint, phase, delay, deadband, hi-lo alarm, and failsafe. A-B indicators on main LCD.
Analog Outputs	Two 4-20 mA outputs. Output one programmable for PPM H ₂ S or PID. Output 2 programmable for PPM or temperature. Maximum load 500 Ohms for each output. Outputs ground isolated and isolated from each other.
<u>Battery Option:</u>	
Power:	Generic 9 VDC alkaline battery, low battery indication at 6.75 V DC. Lithium 9 VDC battery recommended for max performance.
Enclosure:	NEMA 4X, IP66, polycarbonate, stainless steel hardware, weatherproof and corrosion resistant, HWD: 4.4" (112 mm) x 4.4" (112 mm) x 3.5" (89 mm)
Mounting Options	Supplied with carrying handle and cable glands installed.
Outputs:	Two 0-2.5 VDC isolated outputs are provided on for connection to data recorders, etc.
Battery Life:	Approximately 100 hours with alkaline battery. Use of lithium cell increases life to approximately 250 hours.
Optional Datalogger	Removable data module holds 32,000 points from two user configured channels, time of logging is user configurable. Software supplied for data download and display.

1.5 Q45S/87 Performance Specifications

(Common to all variations)

Accuracy	1% of selected range or 0.2 PPM
Repeatability	0.5% of selected range or 0.1 PPM
Sensitivity	0.05% of selected range
Non-linearity	0.1% of selected range

Warm-up Time	3 seconds to rated performance (electronics only)
Supply Voltage Effects	± 0.05% span
Instrument Response Time	60 seconds to 90% of step input at lowest damping



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



Part 2 – Analyzer / Air Pump Mounting

2.1 General

All Q45 Series instruments offer maximum mounting flexibility. A bracket is included with each unit that allows mounting to walls or pipes. In all cases, choose a location that is readily accessible for calibrations. Also consider that it may be necessary to utilize a location where solutions can be used during the calibration process. To take full advantage of the high contrast display, mount the instrument in a location where the display can be viewed from various angles and long distances.

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

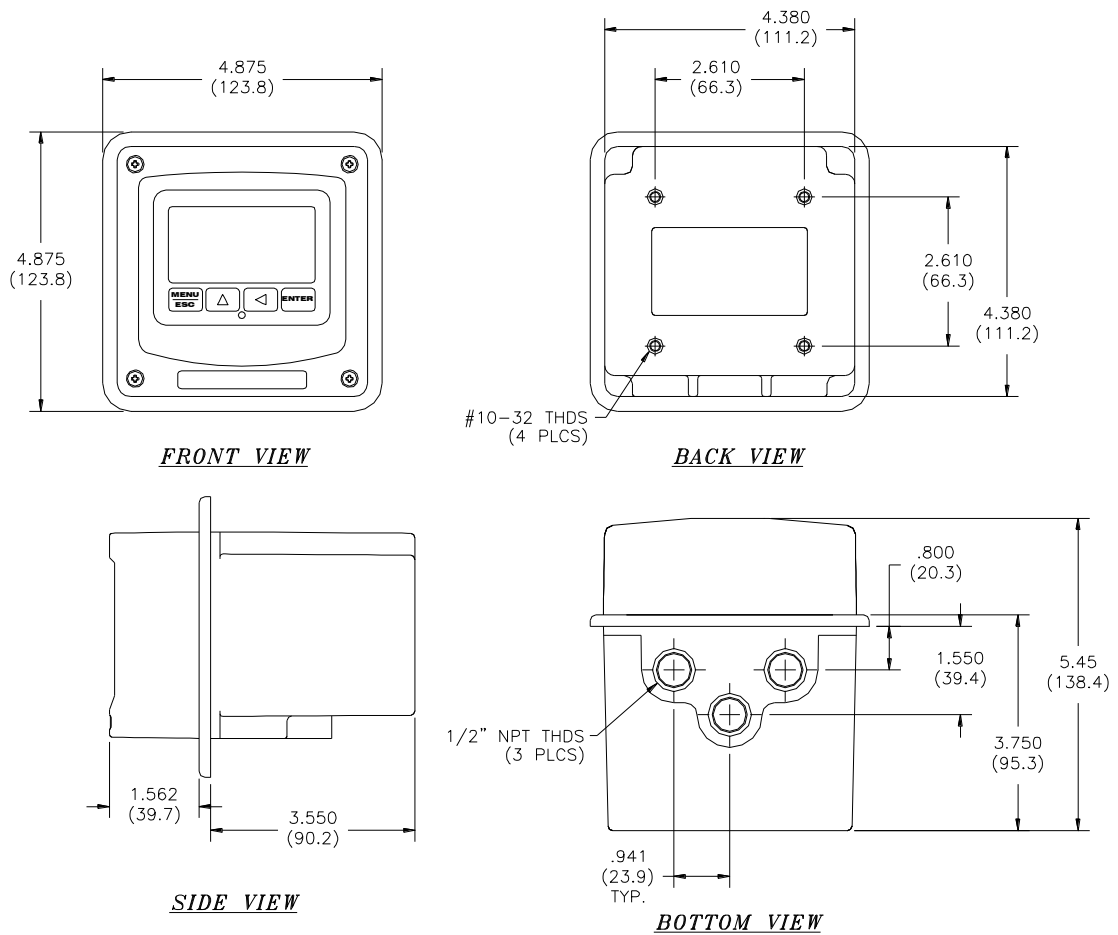


Figure 2 - Q45 Enclosure Dimensions, AC Power

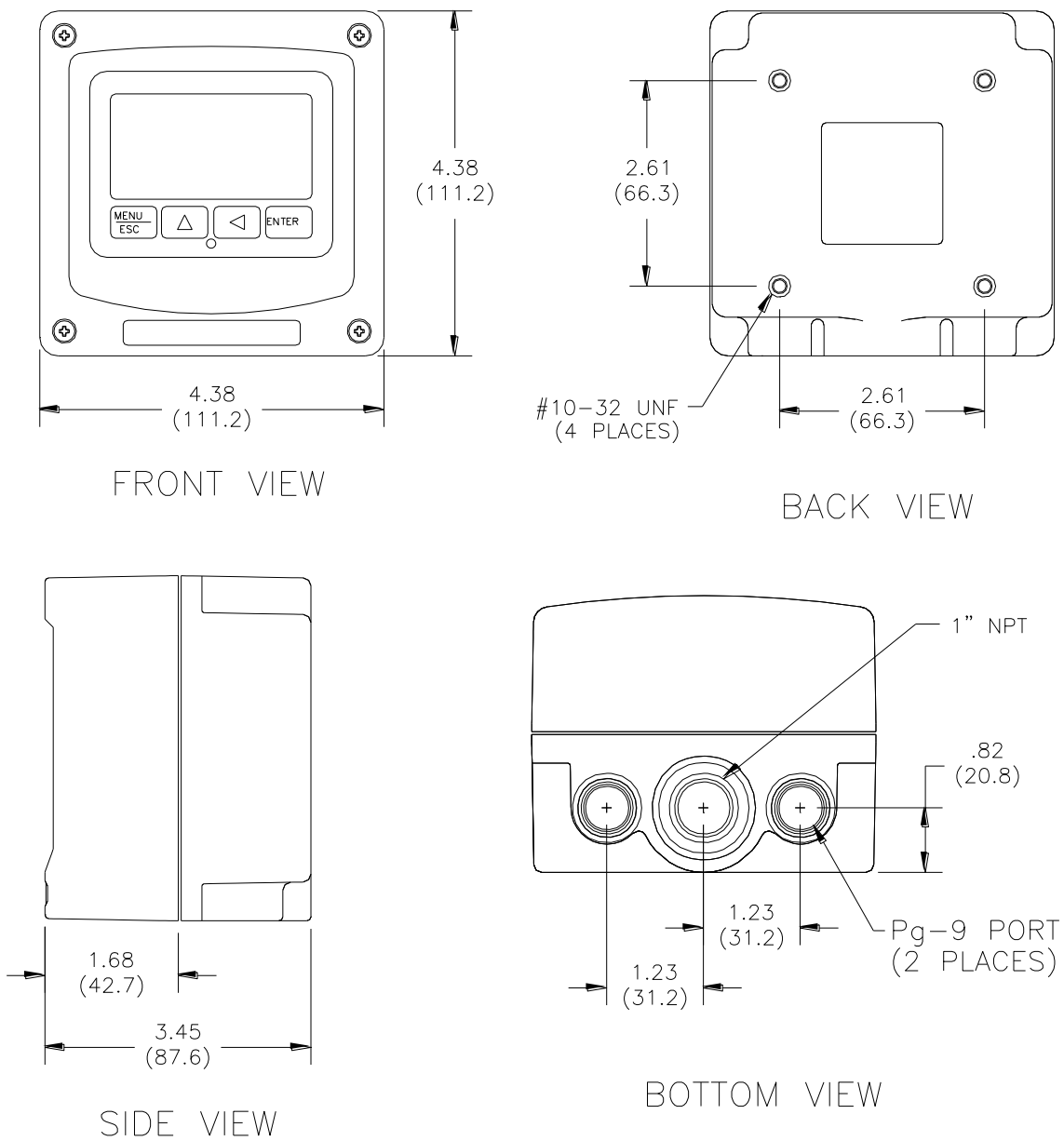


Figure 3 - Q45 Enclosure Dimensions, Battery Units

2.2 Wall or Pipe Mount

A PVC mounting bracket with attachment screws is supplied with each transmitter (see Figure 4 for dimensions). The multi-purpose 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 will accommodate u-bolts designed for 1½ "or 2" 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 ¼-20 threads. The 1½" pipe u-bolt (2" I.D. clearance) is available from ATI in type 304 stainless steel under part number 47-0005

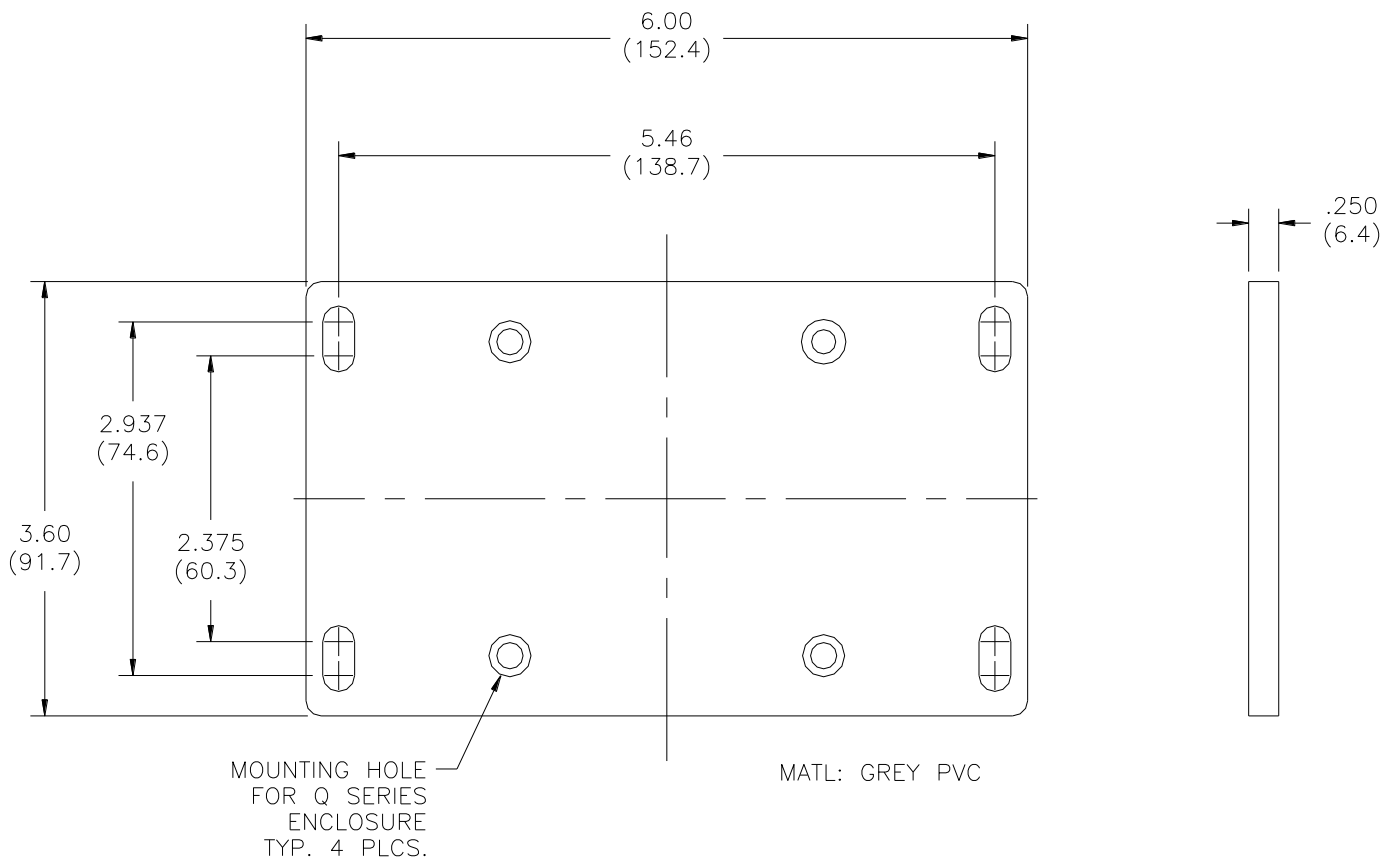


Figure 4 - Wall or Pipe mount Bracket

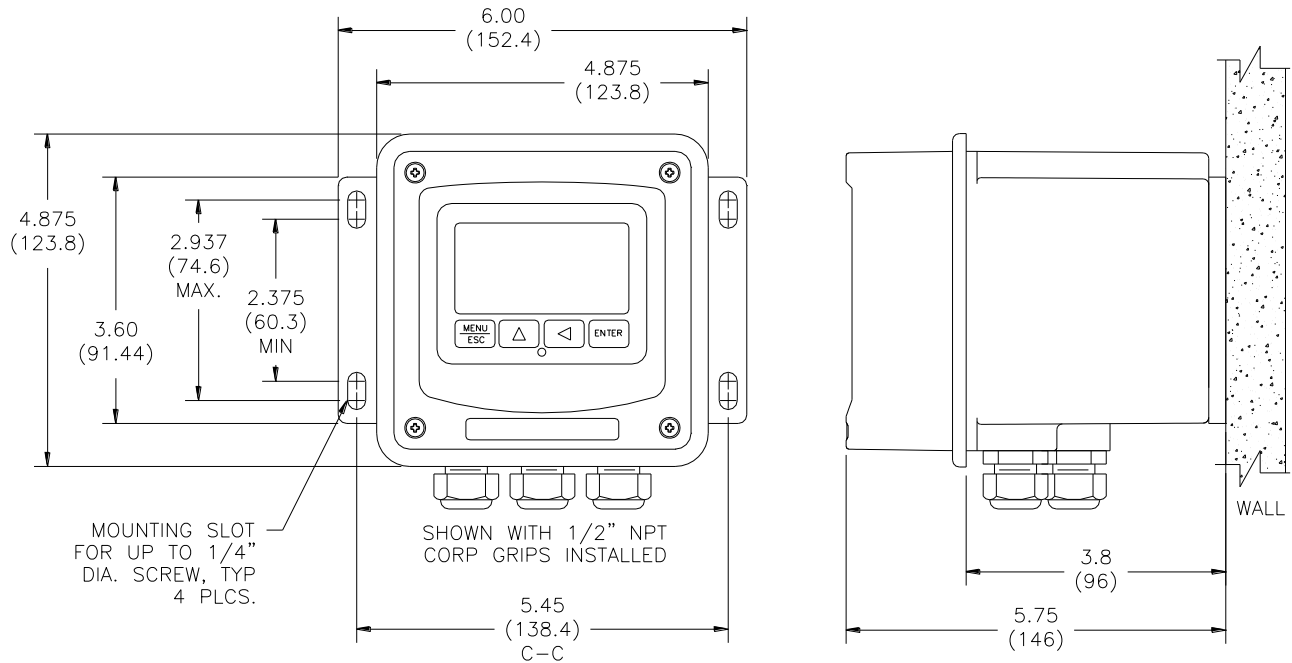


Figure 5 - Wall Mounting Diagram

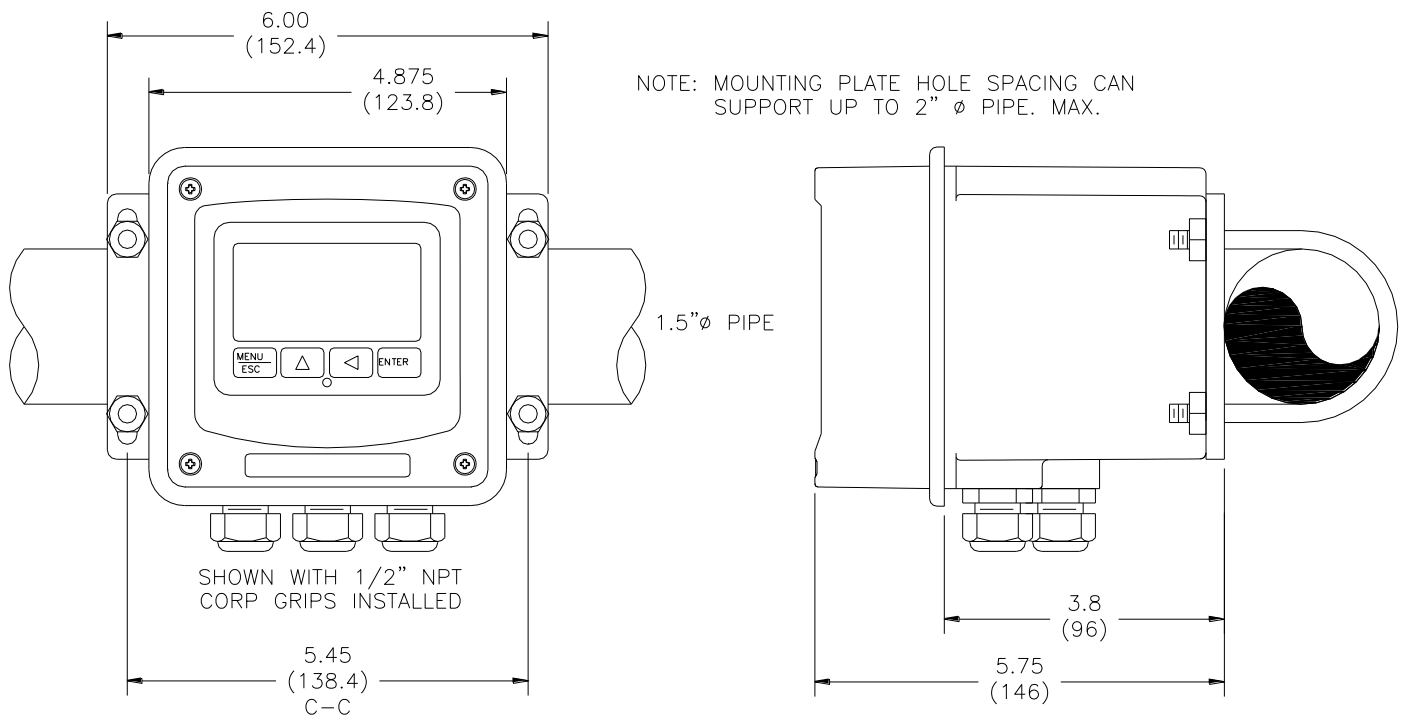


Figure 6 - Pipe Mounting Diagram

2.3 Panel Mount, AC Powered Monitor

Panel mounting of an AC powered monitor uses the panel mounting flange molded into the rear section of the enclosure. Figure 7 provides dimensions for the panel cutout required for mounting.

The panel mounting bracket kit must be ordered separately (part number 05-0068). 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 insure that the panel mounted monitor provides a water tight seal when mounted to a panel.

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

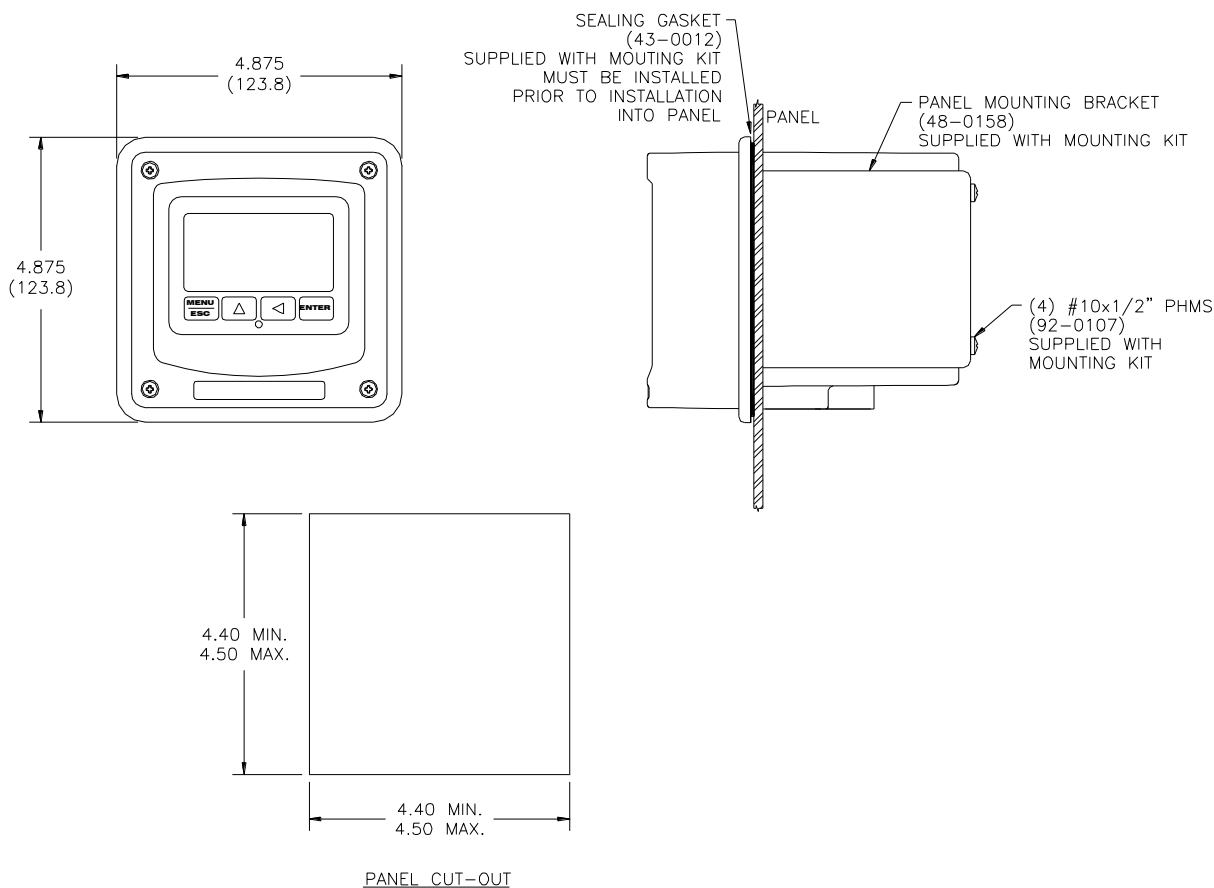


Figure 7 - Panel Mount Cut-Out

2.5 Air-Purge Pump Mounting

The Air Pump is mounted in a Junction Box, which is a NEMA 4X enclosure. The air pump comes with 25 ft. of tubing that should be cut to the desired length. A 5 ft. piece of 2 conductor cable is also supplied to interconnect the pump with the relay control in the Q45S/87 monitor.

See Figure 8 for Junction Box dimensions. The junction box comes complete with mounting hardware for pipe or wall mounting identical to that used for the monitor enclosure.

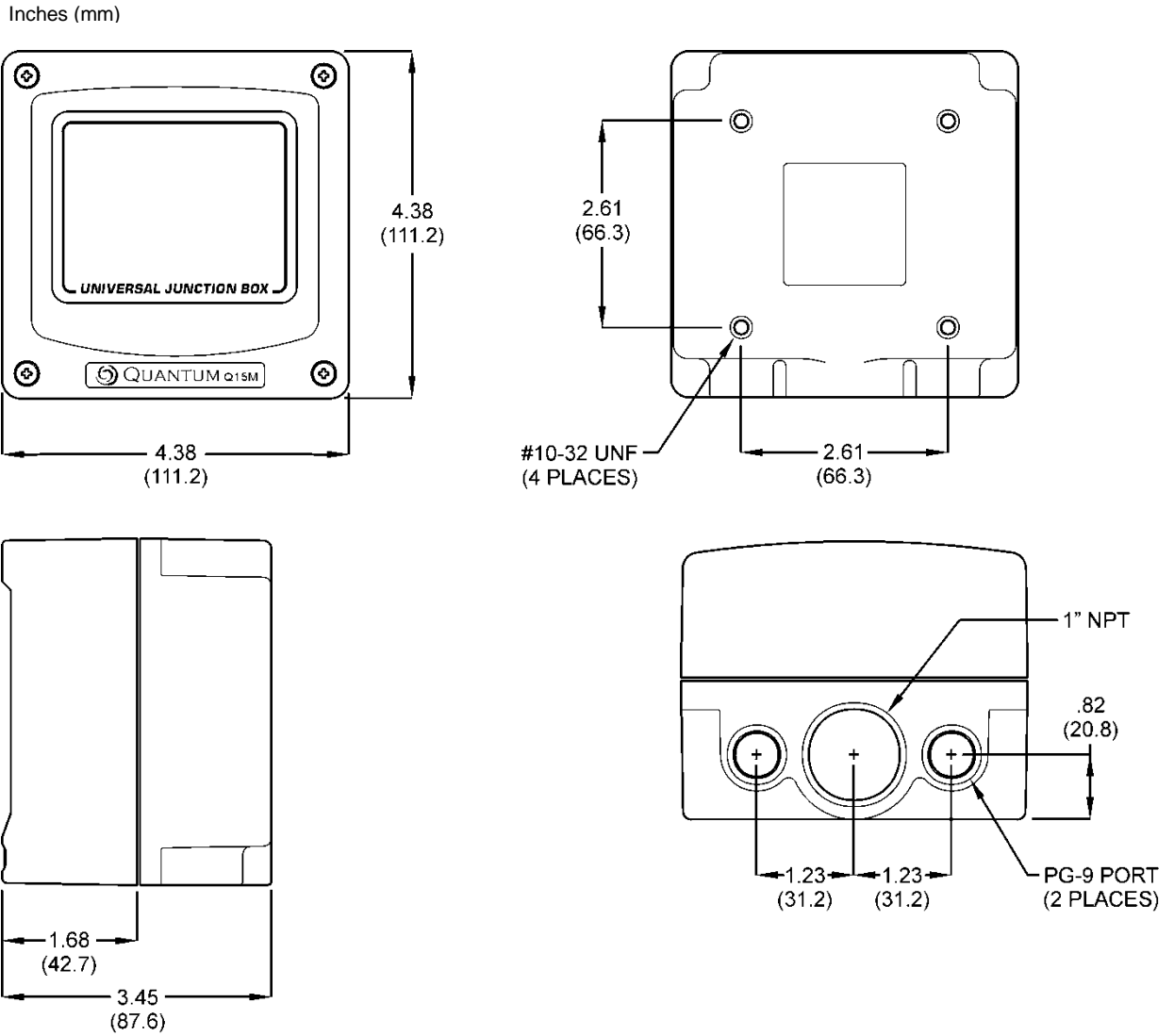


Figure 8 – Air Pump Enclosure Specifications

Part 3 – Sensor Mounting

3.1 General

Select a location for the sensor on the side of the scrubber inlet or outlet duct. Do not mount the sensor on the bottom of a horizontal duct section. If the duct is horizontal, mount the sensor at about 45-60 degrees off of vertical. **The preferred location for mounting the sensor is on a VERTICAL section of duct.** Always select a location that allows for easy access to the sensor for maintenance purposes. Placing the sensor in an inaccessible location generally leads to a lack of maintenance and ultimate failure of the system.

3.2 Sensor Duct Assembly

Figure 9 shows the dimensions of the duct mount assembly used to insert the wet hydrogen sulfide sensor into a scrubber duct. This assembly is designed to be screwed into a 1½" NPT female adapter on the duct. The female adapter attached to the duct must be supplied by the user.

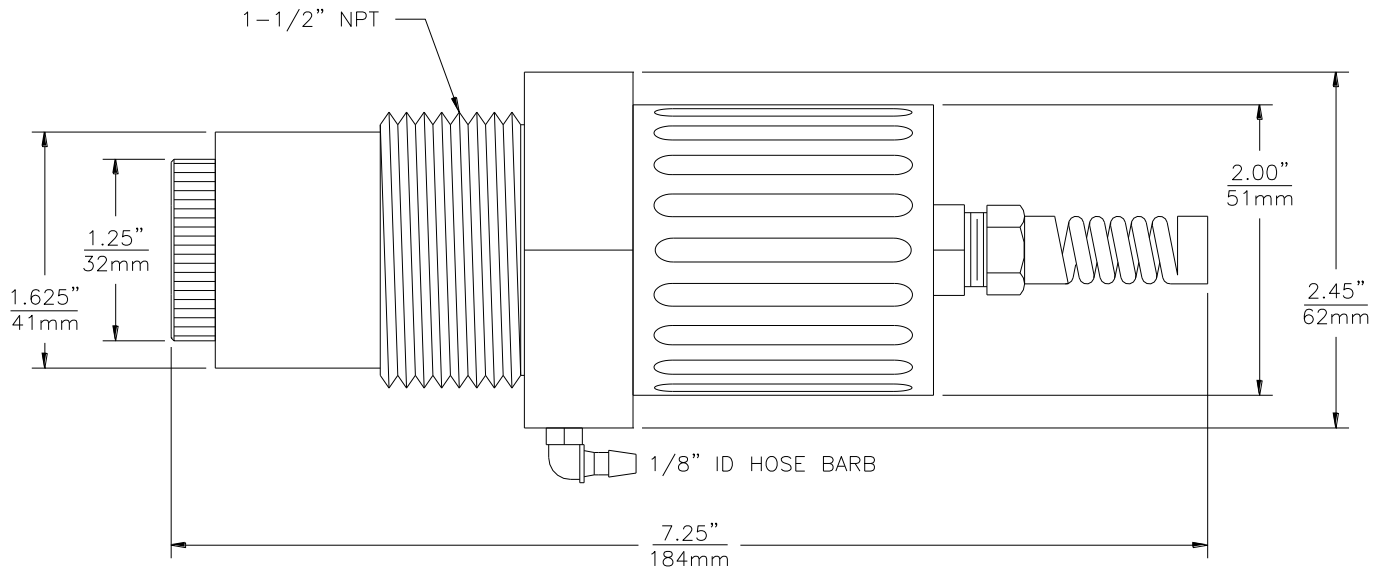


Figure 9 - Duct Insertion Sensor Holder Dimensions

Figure 10 shows an exploded view of the duct insertion assembly with the hydrogen sulfide sensor and cable assembly.

To facilitate installation, disassemble the sensor system so that the front half of the holder can be screwed into the duct separately. Note that the front section of the holder contains a small barb fitting on the side. This fitting is for connection of the optional air purge pump. The air purge system blows air through the sensing chamber to blow out accumulated water that may condense inside the air chamber. The outlet hole is 180 degrees opposite this barb fitting. **When installing the holder in the duct, align the air connection fitting to insure that water can be discharged from the chamber.** On a vertical duct mount, this means orienting the air connection barb so that it is on top of the holder.

The front section of the sensor holder assembly is screwed to the duct, and it will need to be removed periodically to replace the prefilter membrane. Apply teflon tape to the threads prior to installation and screw this part in “hand tight” to allow for easy removal.

When taking the sensor assembly apart, first loosen the cable gland at the back of the adapter so that cable can slide freely. Then unscrew the adapter from the front holder. The sensor can be pulled out from the holder using the cable. When inserting the sensor, connect the sensor cable first and use the connector to press the sensor firmly into place. An o-ring at the front of the holder seals the compartment. A small amount of o-ring lubricant on the side of the front section of the sensor will make insertion and removal much easier. Screw the adapter back in and then tighten the cable gland to seal the cable against water intrusion.

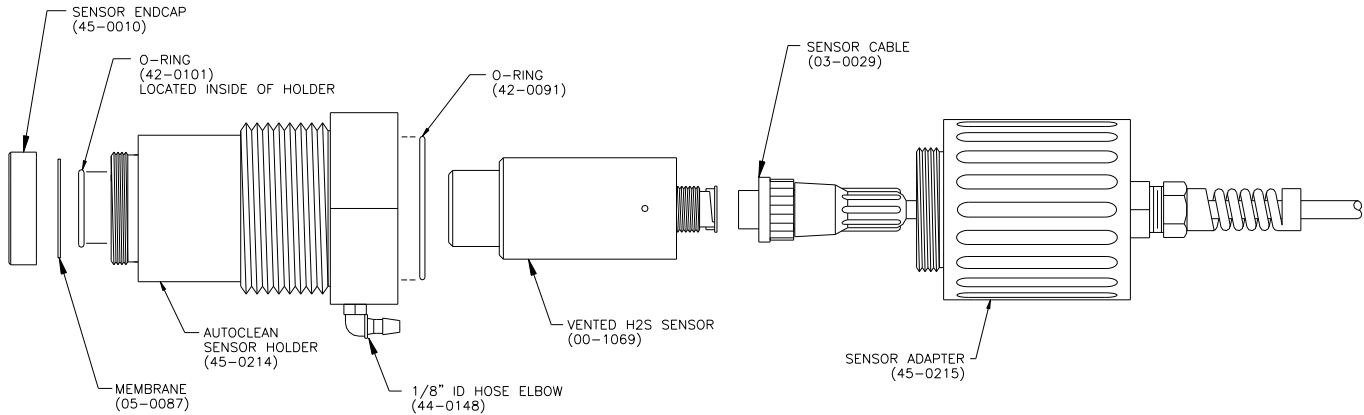


Figure 10 - Duct Insertion Sensor Holder Exploded View

3.3 Sensor Prefilter Membrane

On the front of the sensor holder is a membrane that serves as a sample prefilter to protect the sensor from deposits that could cause premature sensor failure. This membrane is held in place with a screw-on cap, and the membrane should be changed every 2 or 3 months to insure proper operation of the system. A package of 10 prefilter membranes are supplied with the unit.

The membrane material used as a prefilter IS NOT the same on both sides. Look carefully at one of the membrane disks and you will see a mesh pattern on one side. You can also feel the difference between the two sides. The mesh side is fairly smooth while the opposite side is slightly sticky, feeling a little like a latex glove. **When installing the prefilter on the sensor holder, the mesh side of the membrane must face out toward the measured air stream.**

Prefilters are available in packages of 10. The part number is listed on the spare parts page of this manual.

Part 4 – Electrical Installation

4.1 General

The Q45 is powered from either 115 or 230 VAC, 50/60 cycle power. Please verify the type of unit before connecting any power. The power supply voltage is marked on the circuit board near the AC power connection terminals. **Connection of 230 VAC power to a 115 VAC unit will result in damage to the power supply assembly.**

Important Notes:

1. Use wiring practices that conform to all national, state and local electrical codes. For proper safety as well as stable measuring performance, it is important that the earth ground connection be made to a solid ground point from terminal 12 (Figure 11). The AC power supply contains a single 100mA (115V) or 50mA (230V) slo-blo fuse. The fuse **F1** is located adjacent to **TB5** and is easily replaceable.
2. Do NOT run sensor cables or instrument 4-20 mA output wiring in the same conduit that contains AC power wiring. AC power wiring should be run in a dedicated conduit to prevent electrical noise from coupling with the instrumentation signals.

4.3 115/230 VAC w/Relays

In the 115/230 VAC configuration, a DC power supply is mounted into the inside rear of the enclosure. The power supply must be ordered with the proper operating voltage. Verify that the unit requires either 115 VAC or 230 VAC before installing. Also verify that power is fully disconnected before attempting to wire. Units marked for 115 VAC operation may be safely operated between 90 and 130 VAC. Units marked for 230 VAC operation may be safely operated with input voltages from 180 to 260 VAC.

AC powered Q45 systems are supplied with 3 cable gland fittings and two ½” conduit adapters. One of the cable glands has a larger hole in the rubber gland and should be used for the power cord entry if a flexible power cord will be used for installation. One of the cable glands with the smaller gland opening should normally be used for the sensor cable. Cable glands and conduit hubs will screw into any of the three threaded holes on the bottom of the enclosure.

Connect HOT, NEUTRAL, and GROUND to the matching designations on terminal strip **TB5**.

WARNING

Disconnect line power voltage BEFORE connecting line power wires to Terminal TB5 of the power supply. The power supply accepts only standard three-wire single phase power. The power supply is configured for 115 VAC or 230 VAC operation at the factory at time of order, and the power supply is labeled as such. Do NOT connect voltages other than the labeled requirement to the input.

The analog outputs from the system are present at terminals TB1 and TB2. The loop-load limitation in this configuration is 500 Ohms maximum for each output. Also note that these two outputs are completely isolated from each other to insure 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 removed during installation to facilitate wiring if desired. It is best to unplug only one end. The ribbon cable has a marking stripe on one edge that is used to indicate proper orientation. The indicator stripe should be on the bottom edge of the cable when installed as shown in Figure 11

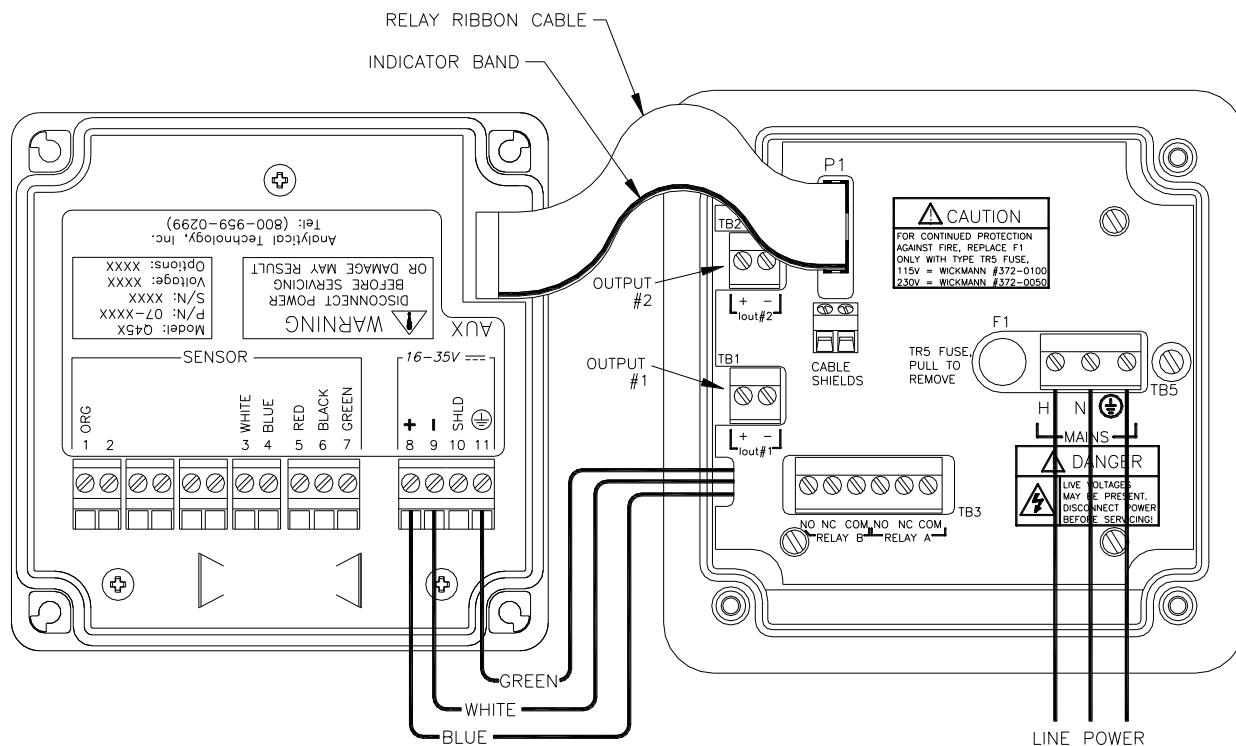


Figure 11 - Line Power Connection

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 M16 ports when wiring.

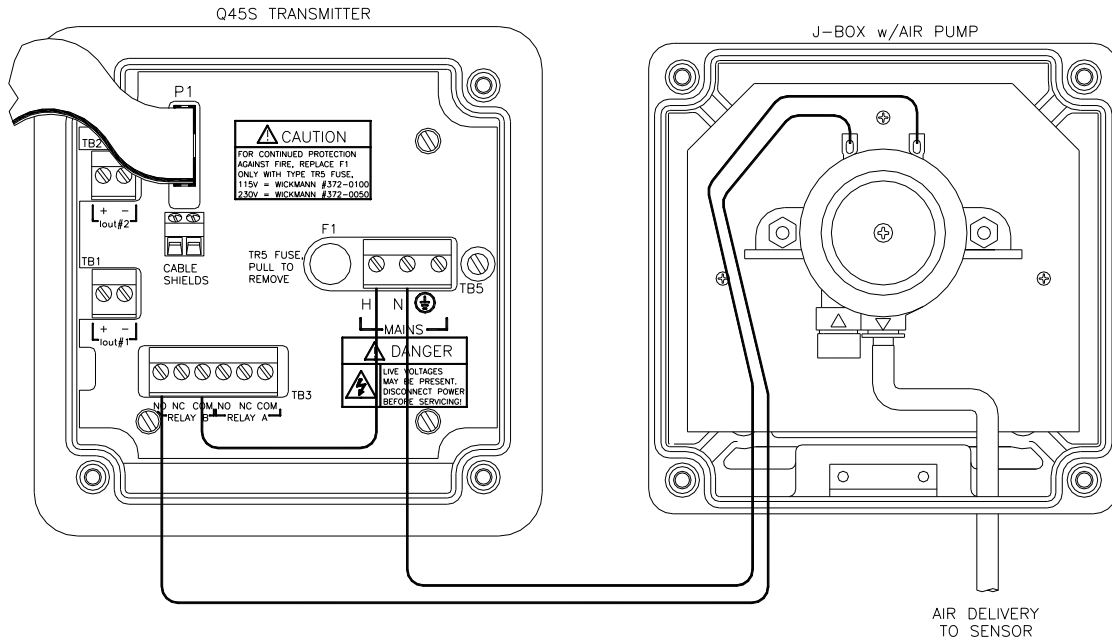


Figure 12 - Pump Interconnect Connection

Two sets of SPDT relay contacts are provided on the power supply board. None of the relay contacts are powered. The user must supply the proper power to the contacts. For applications that require the same switched operating voltage as the Q45 (115 or 230 V), power may be jumpered from the power input terminals at **TB5**. Relay wiring is connected at **TB3** as shown below. Note that the relay contact markings are shown in the NORMAL mode. Programming a relay for “Failsafe” operation reverses the NO and NC positions in this diagram.

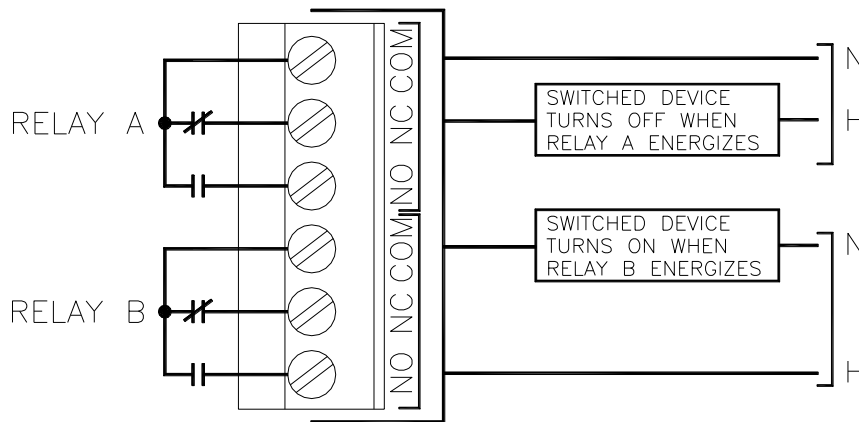


Figure 13 - Relay Contacts

4.4 Sensor Wiring

The sensor cable can be quickly connected to the Q45 terminal strip by matching the wire colors on the cable to the color designations on the label in the monitor. Route signal cable away from AC power lines, adjustable frequency drives, motors, or other noisy electrical signal lines. Do not run sensor or signal cables in conduit that contains AC power lines or motor leads.

Sensor connections are made in accordance with Figure 14. A 25 ft. sensor cable is supplied with the unit. The sensor cable can be routed into the enclosure through one of cord-grips supplied with the unit. The sensor cable can be cut to the length required for a particular installation if desired. Do not cut sensor cable too short, as some loose cable is needed near the installation point to facilitate sensor installation and removal.

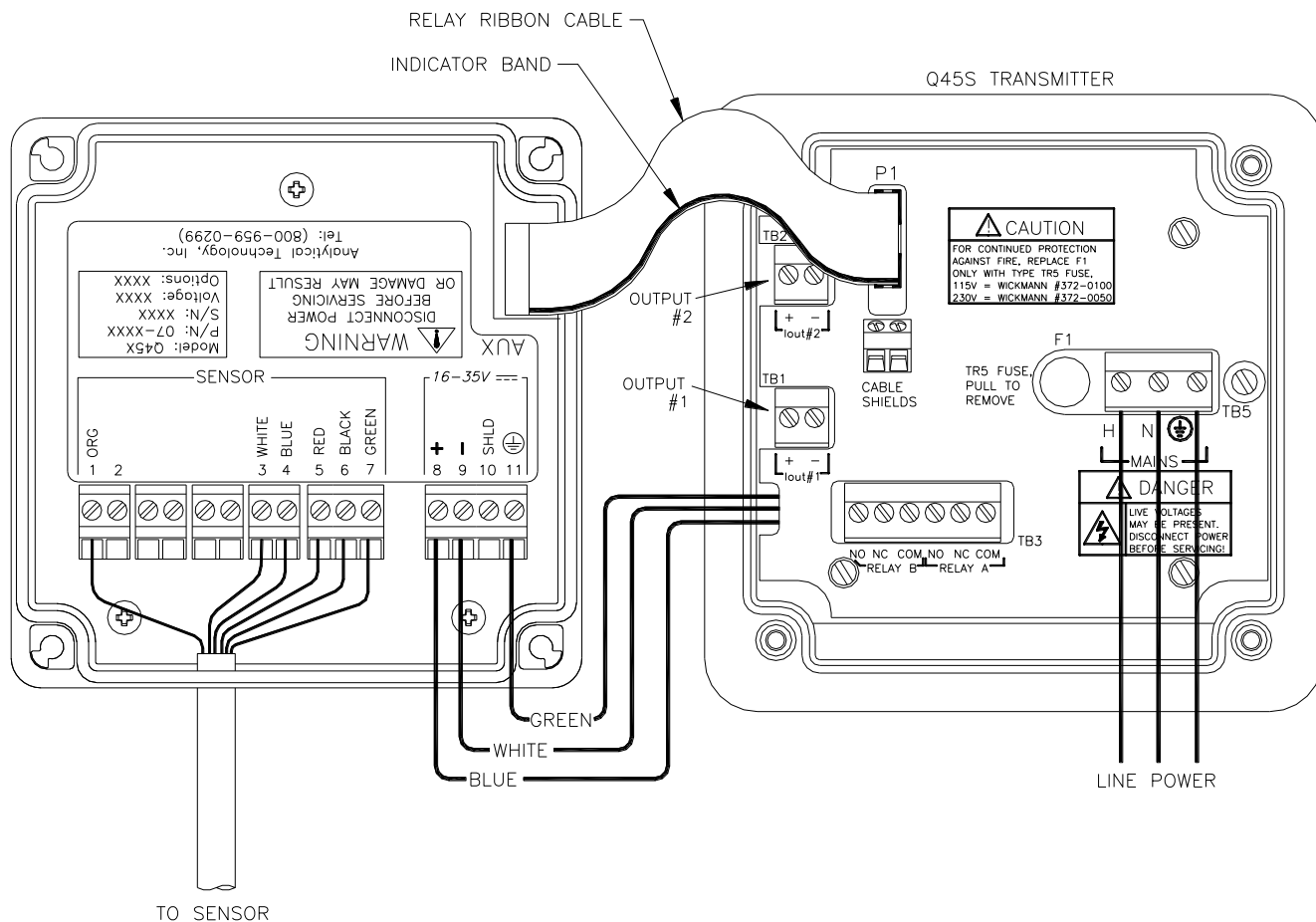


Figure 14 - Sensor Connection

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

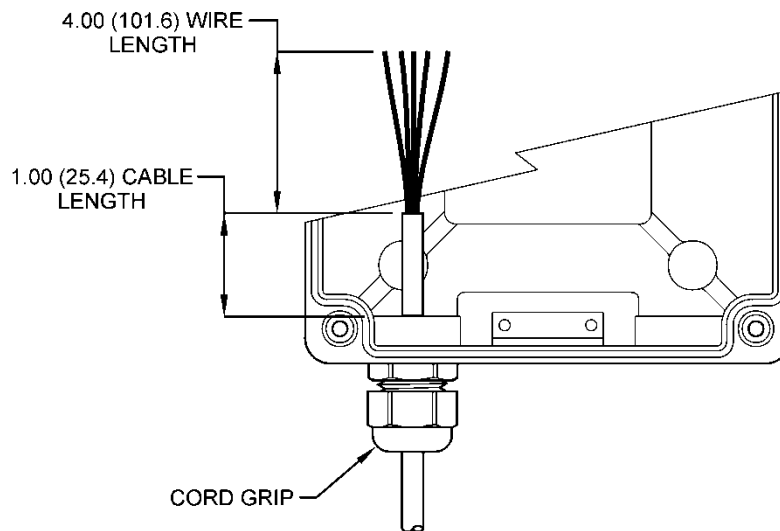


Figure 15 - Sensor Cable Preparation

Part 5 – Configuration

5.1 User Interface

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

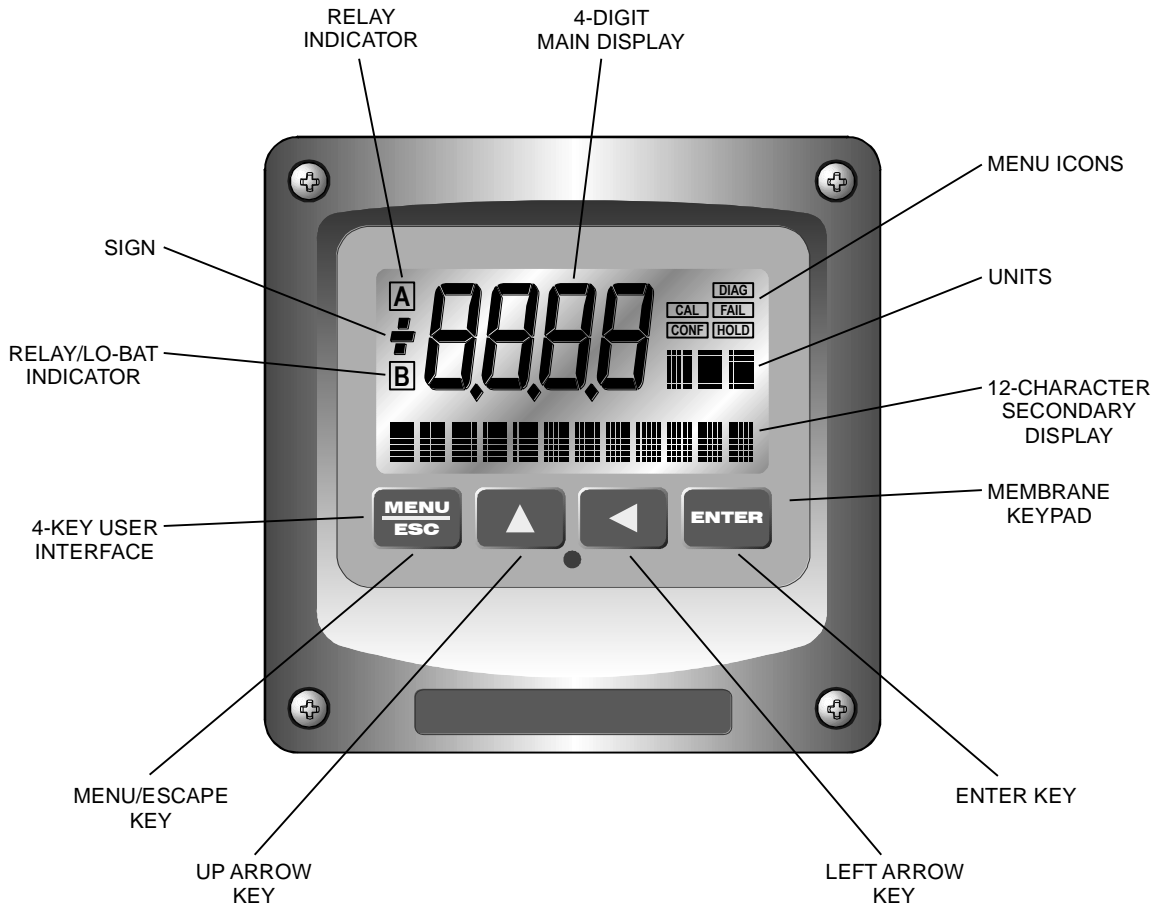


Figure 16 - User Interface

5.11 Keys

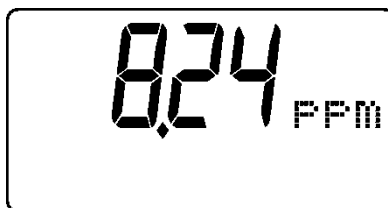
All user configurations occur through the use of four membrane keys. These keys are used as follows:

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

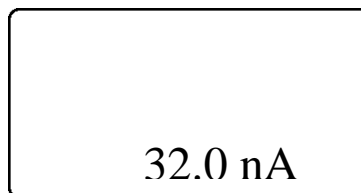
5.12 Display

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

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



Lower Line During normal operation, the lower line of the display indicates user-selected secondary measurements that the system is making. This also includes calibration data from the last calibration sequence and the transmitter model number and software version. During configuration, the lower line displays menu items and set-up prompts to the user. Finally, the lower line will display error messages when necessary. For a description of all display messages, refer to Section 9.31.



Icon Area

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

**HOLD**

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

FAIL

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

Relay Area A/B

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



5.2 Software

The software of the Q45H 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.

5.21 Software Navigation

Within the CAL, CONFIG, CONTROL, and DIAG menu sections is a list of selectable items. Once a menu section (such as CONFIG) has been selected with the MENU key, the user can access the item list in this section by pressing either the ENTER key or the UP arrow key. The list items can then be scrolled through using the UP arrow key. Once the last item is reached, the list wraps around and the first list item is shown again. The items in the menu sections are organized such that more frequently used functions are first, while more permanent function settings are later in the list. See Figure 17 for a visual description of the software.

Each list item allows a change to a stored system variable. List items are designed in one of two forms: simple single variable, or multiple variable sequences. In the single variable format, the user can quickly modify one parameter - for example, changing the display range from 2.000 to 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 will be flashing. This flashing indicates user entry mode and is initiated by pressing the ENTER key. The UP arrow key will increase a flashing digit from 0 to 9. The LEFT arrow key moves the flashing digit from right to left. Once the change has been completed, pressing ENTER again stores the variable and stops the flashing. Pressing ESC aborts the change and also exits user entry mode.

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

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

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

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

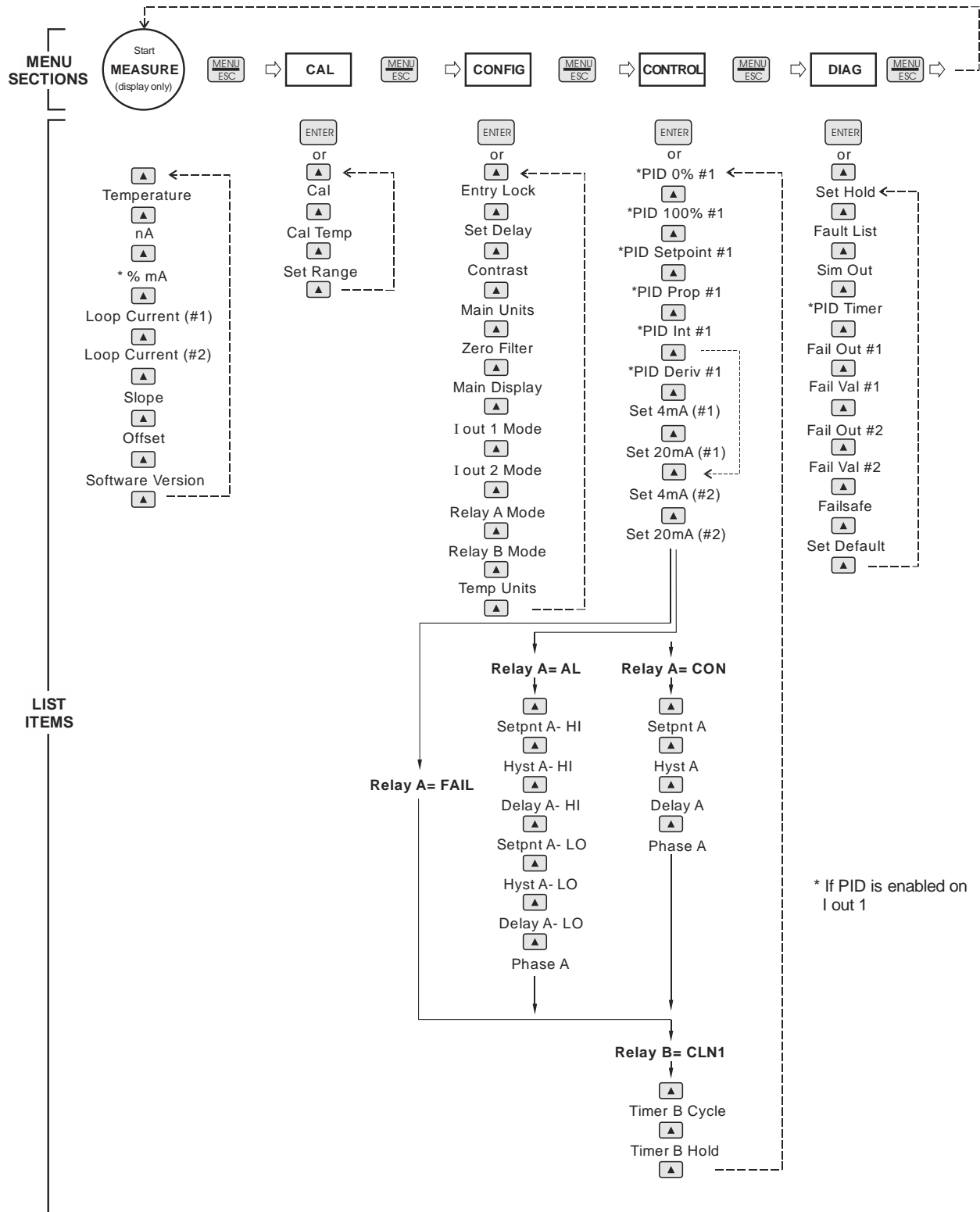


Figure 17 - Software Map

5.22 Measure Menu [MEASURE]

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

TRANSMITTER MEAS SCREENS:

25.7C	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 25C 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 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” will disappear.
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 will decay 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.
Q45H0 v4.01	Transmitter software version number.

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

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

5.23 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** The sulfide calibration function allows the user to adjust the transmitter span reading to match a reference solution, or to set the sensor zero point. See Part 6 - Calibration for more details.
- Cal Temp** The temperature calibration function allows the user to adjust the offset of the temperature response by a small factor of ± 5 °C. The temperature input is factory calibrated to very high accuracy. However, long cable lengths and junction boxes may degrade the accuracy of the temperature measurement in some extreme situations. Therefore, this feature is provided as an adjustment. See Part 6 - Calibration for more details.
- Set Range** This function allows the user to set the display range of the transmitter to a specific application. Once set, all output functions use this display range to establish configuration settings. Press ENTER to initiate user entry mode, and the value will flash. 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. The display range does not affect the internal auto ranging scaler that, therefore, sensitivity is to specification in any user selected range.

5.24 Configuration Menu [CONFIG]

The Configuration Menu contains all of the general user settings:

- Entry Lock** This function allows the user to lock out unauthorized tampering with instrument settings. All settings may be viewed while the instrument is locked, but they cannot be modified. The Entry Lock feature is a toggle-type setting; that is, entering the correct code will lock the transmitter and entering the correct code again will unlock it. The code is preset at a fixed value. Press ENTER to initiate user entry mode and the first digit will flash. Use arrow keys to modify value. **See Page 73 for the Q45H lock/unlock code.** Press ENTER to toggle lock setting once code is correct. Incorrect codes do not change state of lock condition.
- Set Delay** The delay function sets the amount of damping on the instrument. This function allows the user to apply a first order time delay function to the sulfide measurements being made. Both the display and the output value are affected by the degree of damping. Functions such as calibration are not affected by this parameter. The calibration routines contain their own filtering and stability monitoring functions to minimize the calibration timing. Press ENTER to initiate user entry mode, and the value will flash. Use the arrow keys to modify value; range is 0.1 to 9.9 minutes. Press ENTER to store the new value.
- Contrast** This function sets the contrast level for the display. The custom display is designed with a wide temperature range, Super-Twist Nematic (STN) fluid.

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

Main Units	This function allows the user to select either PPM or mg/l.
Zero Filter	This function forces the reading to zero when reading is below the entered value. For example, if the entered value were 0.0020 the display at 0-0019 would indicate 0.000. This feature is useful in blanking out zero noise.
Main Display	This function allows the user to change the measurement in the primary display area. The user may select between sulfide or output current. Using this function, the user may choose to put output current in the main display area and sulfide on the secondary, lower line of the display. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired display value. Press ENTER to store the new value.
lout#1 Mode	This function sets analog output #1 to either track sulfide (default) or enables the PID controller to operate on the sulfide input. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired value; selections include 1-ppm for sulfide tracking or 2-PID for sulfide PID control. Press ENTER to store the new value.
*lout#2 Mode	This function sets analog output #2 for either temperature or sulfide. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired value; selections include: 1-ppm for temperature, or 2-PPM for sulfide. Press ENTER to store the new value.
*Rly A Mode	<p>Relay A can be used in three different ways: as a setpoint control, as a fail alarm, or as a HI-LO alarm band. The three settings for Rly A Mode are CON, FAIL and AL.</p> <p>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 18 for further details.</p> <p>The FAIL setting enables the fail alarm mode for Relay A. Relay A will then trip on any condition that causes the FAIL icon to be displayed on the LCD. Using this mode allows the User to send alarm indications to other remote devices.</p> <p>The AL setting allows two setpoints to be selected for the same relay, producing a HI-LO alarm band. In this mode, Relay A will trip inside or outside of the band, depending upon the Phase selected. See Figure 19 for further details.</p>

***Relay B Mode**

Relay B in the Q45S is used to activate the air-wash system meant to remove condensation from the sensor. This relay is set to **CLn1** (factory default). Do not change the factory setting for this relay without first consulting ATI or your ATI representative.

The CLn mode of operation enables a timer feature for the automatic sensor air-purge system once enabled, a periodic automatic cycle will occur where a jet of air is blown past the sensor membrane to remove any large droplets of water which may have accumulated. During this cycle, the analog and relay outputs of the system are held. These outputs are released in a “bumpless” manner once the system automatically returns to the monitoring mode. The timer consists of two menu items which will appear in the CNTRL menu: Timer B CYCLE, and Timer B HOLD. The CLEAN function engages the relay B contact for a set time to operate the air-purge pump. The CYCLE function sets the time until the next CLEAN cycle. (Note: the CYCLE function is factory default (1 hr.). This can be customer adjusted from (1-999 hrs) depending on requirements. The HOLD setting sets the amount of delay that occurs after a cycle is completed, and should not be adjusted.

5.25 Control Menu [CONTROL]

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

Set 4 mA
Set 20 mA
[lout1=PPM]

These functions set the main 4 and 20 mA current loop output points for the transmitter. The units displayed depend on the selection made in the CONFIG menu for lout #1 Mode.

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

Set PID 0%
Set PID 100%
[lout1=PID]

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

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

	<p>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.</p>
PID Setpnt [Iout1=PID]	<p>The measured value which the controller is attempting to maintain by adjusting output value. It is the nature of the PID controller that it never actually gets to the exact value and stops. The controller is continually making smaller and smaller adjustments as the measured value gets near the setpoint.</p>
PID Prop [Iout1=PID]	<p>Proportional gain factor. The proportional gain value is a multiplier on the controller error (difference between measured value and setpoint value.) Increasing this value will make the controller more responsive.</p>
PID Int [Iout1=PID]	<p>Integral is the number of “repeats-per-minute” of the action of the controller. It is the number of times per minute that the controller acts on the input error. At a setting of 2.0 rpm, there are two repeats every minute. If the integral is set to zero, a fixed offset value is added to the controller (manual reset.) Increasing this value will make the controller more responsive.</p>
PID Deriv [Iout1=PID]	<p>Derivative is a second order implementation of Integral, used to suppress “second-order” effects from process variables. These variables may include items like pumps or mixers that may have minor impacts on the measured value. The derivative factor is rarely used in water treatment process, and therefore, it is best in most cases to leave it at the default value. Increasing this value will make the controller more responsive.</p>
*Set 4 mA #2 *Set 20 mA #2 [Temp / PPM]	<p>These functions set the second 4 mA and 20 mA current loop output points for the transmitter. The default setting for this output is temperature, but it may be set for PPM H₂S if preferred. The values stored for the 4 mA point may be higher or lower than the value stored for the 20 mA point.</p> <p>The entry value is limited to a value between 0 and 55 °C if it is set for temperature. The 4 mA and the 20 mA point must be at least 20 units away from each other. Press ENTER to initiate user entry mode, and the value will flash. Use arrow keys to modify value. Press ENTER to store the new value.</p> <p>NOTE: If the battery board option is installed, the menu will be shown as Set 0 V #2 – since the battery board has two 0-2.5Vdc voltage output signals instead of current outputs.</p>
*A Setpoint	<p>This function establishes the sulfide trip point for relay A. The entry value is limited to a value within the range specified in “Set Range”. Use the LEFT arrow key to select the first digit to be modified. Then use the UP and LEFT arrow keys to select the desired numerical value. Press ENTER to store the new value.</p>

- *A Hysteresis** This function establishes the hysteresis, or “deadband”, for Relay A. Hysteresis is most often used to control relay chattering; however, it may also be used in control schemes to separate the ON/OFF trip points of the relay. Press ENTER to initiate user entry mode, and the value will flash. Use the arrow keys to modify value. Press ENTER to store the new value.
- *A Delay** This function places an additional amount of time delay on the trip point for relay A. This delay is in addition to the main delay setting for the controller. The entry value is limited to a value between 0 and 999 seconds. Press ENTER to initiate user entry mode, and the value will flash. Use arrow keys to modify value; range is 0 to 999 seconds. Press ENTER to store the new value.
- *A Phasing** This function establishes the direction of the relay trip. When phase is HI, the relay operates in a direct mode. Therefore, the relay energizes and the LCD indicator illuminates when the sulfide value **exceeds** the setpoint. When the phase is LO, the relay energizes and the LCD indicator illuminates when the sulfide level drops **below** the setpoint. The failsafe setting does have an impact on this logic. The description here assumes the failsafe setting is OFF. Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify the desired value; selections include **HI** for direct operation or **LO** for reverse operation. Press ENTER to store the new value.

See Figure 18 below for a visual description of a typical control relay application.

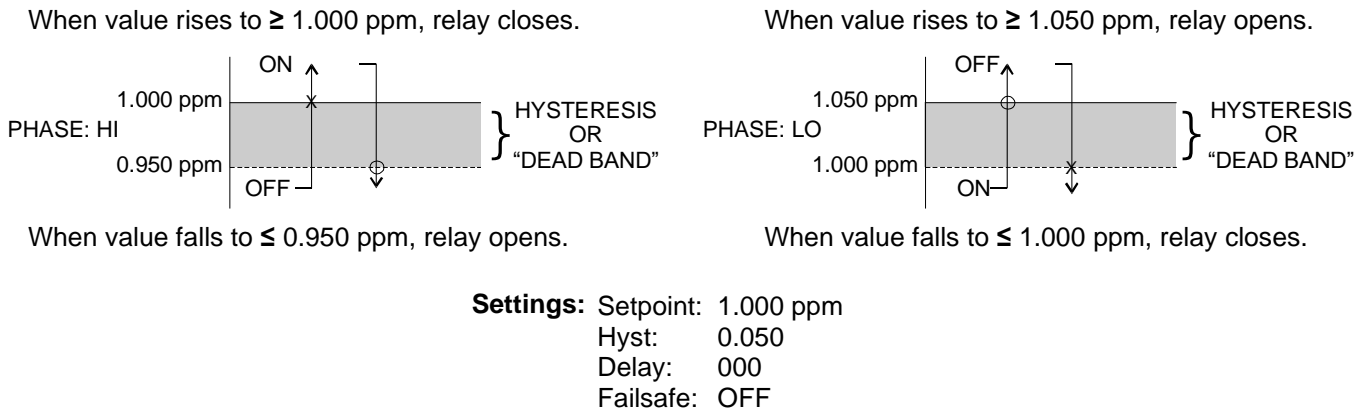
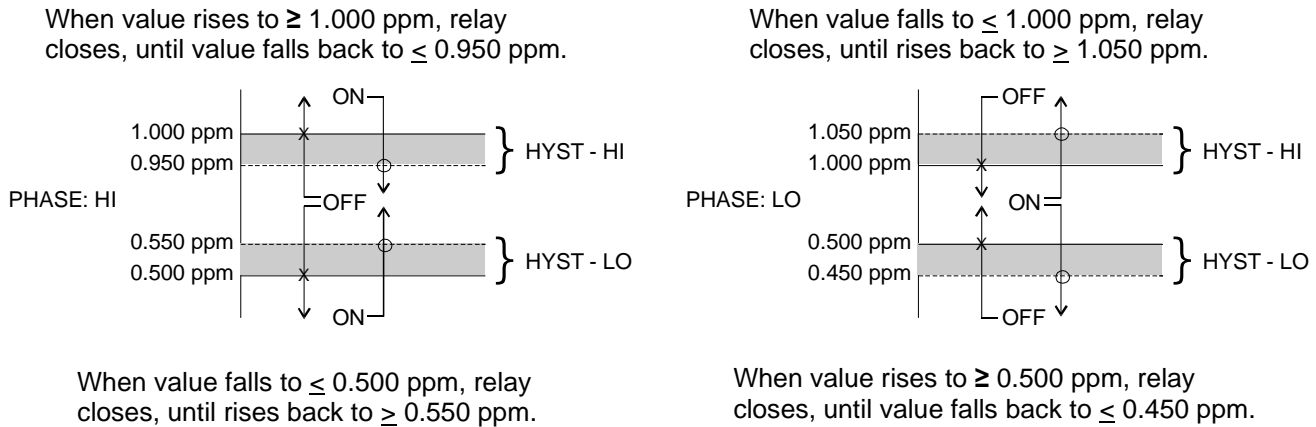


Figure 18 - Control Relay Example

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

Figure 19 is a visual description of a typical alarm relay application.



Settings: Setpoint A-HI: 1.000 ppm Setpoint A-LO: .500 ppm
 Hyst A-HI: 0.050 Hyst A-LO: .0050
 Delay A-HI: 000 Delay A-LO: 000

Figure 19 - Alarm Relay Example

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

If Relay B Mode is set to **CON** (see **Relay B Mode**, page 52), then Relay B will function identically to Relay A CON mode described earlier. Relay B settings appear in the CONFIG menu list automatically.

5.26 Diagnostics Menu [DIAG]

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

Set Hold

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

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

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

Fault List

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

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

After 30 minutes or if power to the transmitter is cycled, the failure for calibration will be cleared until calibration is attempted again. If the problem still exists, the calibration failure will re-occur. Press ENTER to initiate view of the highest priority failure. The display will automatically return to normal after a few seconds.

Sim Out

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

PID Timer

This function sets a timer to monitor the amount of time the PID controller remains at 0% or 100%. This function only appears if the PID controller is enabled. If the timer is set to 0000, the feature is effectively disabled. If the timer value is set to any number other zero, a FAIL condition will occur if the PID controller remains at 0% or 100% for the timer value. If one of the relays 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 will flash. Use the UP arrow key to modify desired value; range of value is 0-9999 seconds. Press ENTER to store the new value.

- Fail Out** This function enables the user to define a specified value that the main current output will go to under fault conditions. When the Relay Option Board is installed, the display will read **Fail Out #1**. When enabled to **ON**, the output may be forced to the current value set in **Fail Val** (next item.) With the Fail Out setting of ON, and a Fail Val setting of 6.5 mA, any alarm condition will cause the current loop output to drop outside the normal operating range to exactly 6.5 mA, indicating a system failure that requires attention.
- Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify desired value; selections are **ON**, **OFF**. Press ENTER to store the new value.
- Fail Val** Sets the output failure value for lout#1. When **Fail Out** above is set to **ON**, this function sets value of the current loop under a FAIL condition. When the Relay Option Board is installed, the display will read **Fail Out #1**. The output may be forced to any current value between 4-20 mA.
- Press ENTER to initiate user entry mode, and the entire value will flash. Use the UP arrow key to modify desired value; selections are between **4mA**, and **20mA**. Press ENTER to store the new value.
- Fail Out #2** This function sets the fail-mode of current loop output #2 under a FAIL condition. The settings and operation are identical to Fail Out for output #1.
- Fail Val #2** This function sets the value of current loop output #2 under a FAIL condition. The settings and operation are identical to Fail Out for output #1.
- *Failsafe** This function allows the user to set the optional system relays to a failsafe condition. In a failsafe condition, the relay logic is reversed so that the relay is electrically energized in a normal operating state. By doing this, the relay will not only change state when, for example, a sulfide limit is exceeded, but also when power is lost to the controller.
- When failsafe is selected to be ON, the normally-open contacts of the relay will be closed during normal operation. In an attempt to make this configuration less confusing, the LCD icon logic is reversed with this setting, and the icon is OFF under this normal condition. Therefore, when the trip condition occurs, the closed N.O. contacts will be opened (relay de-energized), and the LCD icon will illuminate. In addition, a power fail would also cause the same contacts to open.
- Set Default** The Set Default function allows the user to return the instrument back to factory default data for all user settings. It is intended to be used as a last resort troubleshooting procedure. All user settings are returned to the original factory values. Hidden factory calibration data remains unchanged. Press ENTER to initiate user entry mode and the value **NO** will flash. Use the UP arrow key to modify value to **YES** and press ENTER to reload defaults.

Part 6 – Calibration

6.1 Calibration

Once power is applied, the H₂S sensor must be given time to stabilize. This is best done by following the zeroing procedure below. Establishing a stable zero is critical to the proper operation of the monitor. A complete calibration will include zeroing and spanning the sensor.

6.11 Zero Cal

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 on scrubber outlets, zeroing the sensor in clean ambient air or bottled zero grade air is needed to correct for the sensor zero current, which is normally less than 0.5 PPM equivalent. An electronic zero can be set by disconnecting the sensor from the cable and performing steps 1-5 below.

The steps below assume that the sensor has been powered up for at least 8 hours prior to zeroing. It is preferable to allow the monitor to run for 24 hours prior to zeroing if possible to allow complete stabilization. If the unit has been running with the sensor connected, the sensor will normally return to a stable zero within 30 minutes.

1. Connect the sensor to the electronics by plugging the cable plug into the receptacle on the top of the sensor.
2. Remove the sensor from the holder if it is already installed in a duct adapter. Place the rubber sensor cap supplied with unit on the end of the sensor and allow it to sit for 30 minutes. If the sensor is outdoors, shade the sensor with a piece of cardboard or other material so it is not in direct sunlight.
3. Scroll to the CAL menu section using the MENU key and press ENTER or the UP arrow key. **Cal Sulfide** will then be displayed.
4. Press the ENTER key. The screen will display 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.

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

5. If accepted, the screen will display the message **PASS** with the new sensor zero reading (offset), then it will return to the main measurement display. If the calibration fails, a message indicating the cause of the failure will be displayed and the FAIL icon will be turned on. The range of acceptable value for sensor offset is -999 to +999 nA. Should a FAIL occur, carefully inspect the sensor for membrane fouling. Should the offset value remain high and result in calibration failures, review the Service section of this manual, and then contact the service dept. at ATI for further assistance.

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

6.12 Span Cal

Span calibration is done using compressed gas hydrogen sulfide standards. These standards are available from ATI or from a variety of specialty gas suppliers. These are the same types of standards used to calibrate hydrogen sulfide gas leak detectors and may already be available at the plant. If so, all that is needed is the sensor calibration adapter normally supplied with the system. If not, a calibration kit with the necessary span gas is available from ATI by ordering part number 00-0180.

To calibrate the system, follow the procedure below.

1. Place the previously zeroed sensor into the sensor calibration adapter and connect span gas to the inlet fitting on the adapter.
2. Turn on the flow of span gas. ATI calibration kits provide a fixed flow of gas at 500 cc/min. If using another source of gas, simply adjust the flow of gas for a flowrate between 250 and 750 cc/min.
3. Allow span gas to flow for 5 minutes.
4. Scroll to the CAL menu section using the MENU key and press ENTER or the UP arrow key. **Cal Sulf** then is displayed.
5. Press the ENTER key. The screen will display 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.
6. 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 will stop only when the data remains stable for a pre-determined amount of time. This can be overridden by pressing ENTER. If the data remains unstable for 10 minutes, the calibration will fail and the message **Cal Unstable** will be displayed.
7. The screen will display the last measured ppm value and a message will be displayed prompting the user for the span gas value. The user must then modify the screen value with the arrow keys and press ENTER. The system then performs the proper checks.
8. If accepted, the screen will display the message **PASS** with the new sensor slope reading, then it will return to the main measurement display. If the calibration fails, a message indicating the cause of the failure will be displayed and the FAIL icon will be turned on. The range of acceptable values for sensor slope is 25% to 300%.

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

6.2 Temperature Calibration

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

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

1. Scroll to the CAL menu section using the MENU key and press ENTER or the UP arrow key.
2. Press the UP arrow key until **Cal Temp** is displayed.
3. Press the ENTER key. The message **Place sensor in solution then press ENTER** will be displayed. Move the sensor into the calibration reference (if it hasn't been moved already) and wait for temperature equilibrium to be achieved. Press ENTER to begin the calibration sequence.
4. The calibration data gathering process will begin. The message **Wait** will flash as data is accumulated and analyzed. The °C or °F symbol may flash periodically if the reading is too unstable.
5. The message **Adjust value - press ENTER** will be displayed, and the right-most digit will begin to flash, indicating that the value can be modified. Using the UP and LEFT arrow keys, modify the value to the known ref solution temperature. Adjustments up to ± 5 °C from the factory calibrated temperature are allowed. Press ENTER.

Once completed, the display will indicate **PASS** or **FAIL**. If the unit fails, the temperature adjustment may be out of range, the sensor may not have achieved complete temperature equilibrium, or there may be a problem with the temperature element. In the event of calibration failure, it is recommended to attempt the calibration again immediately.

Part 7 – PID Controller Details

7.1 PID Description

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

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

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

7.2 PID Algorithm

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

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

Where:

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

Figure 20 - Q45H ISA PID Equation

The most notable feature of the algorithm is the fact the proportional gain term affects all components directly (unlike some other algorithms - like the “series” form.) If a pre-existing controller utilizes the same form of the algorithm shown above, it is likely similar settings can 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 (i.e. reps-per-min, sec-per-rep.)

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

Although the three components of the PID are described in the setting area (section 6.25), here are more general descriptions of what each of the PID elements contribute to the overall action of the controller.

- P Proportional gain. With no “I” or “D” contribution, the controller output is simply a factor of the proportional gain multiplied by the input error (difference between the measured input and the controller setpoint.) Because a typical chemical control loop cannot react instantaneously to a correction signal, proportional gain is typically not efficient by itself – it must be combined with some integral action to be useful. Set the P term to a number between 2-4 to start. Higher numbers will cause the controller action to be quicker.
- I Integral gain. Integral gain is what allows the controller to eventually drive the input error to zero – providing accuracy to the control loop. It must be used to affect the accuracy in the servo action of the controller. Like proportional gain, increasing integral gain results in the control action happening quicker. Set the I term to a number between 3-5 to start (1-2 more than P). Like proportional gain, increasing the integral term will cause the controller action to be quicker.
- D Derivative gain. The addition of derivative control can be problematic in many applications, because it greatly contributes to oscillatory behavior. In inherently slow chemical control processes, differential control is generally added in very small amounts to suppress erratic actions in the process that are non-continuous, such as pumps and valves clicking on and off. However, as a starting point for chemical process control, its best to leave the “D” term set to 0.

Based on these descriptions, the focus on tuning for chemical applications really only involves adjustment of “P” and “I” in most cases. However, increasing both increases the response of the controller. The difference is in the time of recovery. Although combinations of high “P’s” and low “I” will appear to operate the same as combinations of low “P’s” and high “I’s”, there will be a difference in rate of recovery and stability. Because of the way the algorithm is structured, large “P’s” can have a larger impact to instability, because the proportional gain term impacts all the other terms directly. Therefore, keep proportional gain lower to start and increase integral gain to achieve the effect required.

Many of the classical tuning techniques have the user start with all values at 0, and then increase the P term until oscillations occur. The P value is then reduced to ½ of the oscillatory value, and the I term is increased to give the desired response. This can be done with the Q45H controller, with the exception that the I term should start no lower than 1.0.

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

7.3 Classical PID Tuning

Unlike many high speed position applications where PID loops are commonly used, the chemical feed application employed by this instrument does not require intense mathematical exercise to determine tuning parameters for the PID. In fact, the risk of instability is far greater with overly tuned PID control schemes. In addition, many of the classical mathematical exercises can be damaging or wasteful in the use of chemicals when the process is bumped with large amounts of input error to seek a response curve. Because of this, the general adjustment guidelines described in section 8.2 are sufficient for almost all application tuning for this instrument. Beyond this, many sources are available for classical tuning methods.

7.4 Manual PID Override Control

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

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

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

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

7.5 Common PID Pitfalls

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

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

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

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

Part 8 – System Maintenance

8.1 General

The Q45S/87 Wet Hydrogen Sulfide System will generally provide unattended operation over long periods of time. With proper care, the system should continue to provide measurements indefinitely. For reliable operation, maintenance on the system must be done on a regular schedule. Keep in mind that preventive maintenance on a regular schedule is much less troublesome than emergency maintenance that always seems to come at the wrong time.

8.2 Analyzer Maintenance

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

8.3 Sensor Maintenance

Sensor maintenance is required for accurate measurements. The primary requirement is simply to keep the sensor clean. The air-purge system is designed to remove normal water droplet buildup that can cause slow sensor response, but a periodic wash with distilled water will remove particulates that might accumulate on the sensor face.

The frequency of cleaning depends on the conditions of any given installation and are difficult to predict with certainty. Start by inspecting the sensor weekly. If no buildup occurs in a week, then move to biweekly inspection. If that proves unnecessary, then move to monthly inspection. Inspection should be done at least once a month, and calibration should be checked once a month.

Cleaning accumulated deposits should only be done with distilled water. Using a “squirt bottle” such as that used in a laboratory, simply wash the tip of the sensor with a stream of water. NEVER use detergents on this sensor or it will be destroyed. Always check the calibration of the system after cleaning and recalibrate if necessary.

After calibration, check the lower line of the MEASURE screen to see what the new slope value is. The sensor output will decrease over time as the membrane becomes fouled. This reduction indicates that the sensor is losing sensitivity to H₂S. When the slope value falls below 50%, be prepared to replace the sensor within the next few months.

Part 9 – Troubleshooting

9.1 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 will save 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 will be very helpful when discussing the problem with the factory technical support group.

9.2 External Sources of Problems

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

1. Verify the analyzer is earth grounded. For all configurations of the analyzer, an earth ground connection **MUST** be present for the shielding systems in the electronics to be active. Grounded conduit provides no earth connection to the plastic enclosure, so an earth ground wiring connection must be made at the power input terminal strip. Verify metal shield is present over incoming power connections. This shield is for safety purposes, but also blocks electrical spikes from relay and power wiring.
2. Verify the proper power input is present (115/230 VAC).
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 Q45 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 relay based systems, check the load that is connected to the relay contacts. Verify the load is within the contact rating of the relays. Relay contacts which have been used for higher power AC current loads may become unsuitable for very low signal DC loads later on because a small amount of pitting can form on the contacts. If the load is highly inductive (solenoids, motor starters, large aux relays), note that the contact rating will be de-rated to a lower level. Also, due to the large amount of energy present in circuits driving these types of loads when they are switched on or off, the relay wiring placement can result in electrical interference for other devices. This can be quickly resolved by moving wiring, or by adding very inexpensive snubbers (such as Quencharcs) to the load.
8. Check sensor membrane for fouling. Look closely for signs of grease or oil which may be present. Replace the sensor if necessary. Sensor condition can only be determined by the use of a suitable span gas.

9.3 Analyzer Tests

1. Disconnect power and completely disconnect all output wiring coming from the analyzer. Remove sensor wiring, relay wiring, and analog output wiring. Re-apply power to the analyzer.
2. Using the Simulate feature, check operation of analog outputs and relays with a DMM.
3. Check cell drive circuit. With a digital voltmeter (DVM), measure the voltage between 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 4.8-5.1 Vdc open circuit. Remove DVM completely and connect a 100 Ohm resistor from the BLACK to RED terminals. The temperature reading should display approximately 0°C and the sulfide reading should display approximately 0 ppm.

9.4 Display Messages

The Q45 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 200	Entry failed, minimum value allowed is 200.	Increase value to ≥ 200
Cal Unstable	Calibration problem, data too unstable to calibrate. Icons will not stop flashing if data is too unstable. User can bypass by pressing ENTER.	Clean sensor, get fresh cal solutions, allow temperature and conductivity readings to fully stabilize, do not handle sensor or cable during calibration.
Out of Range	Input value is outside selected range of the specific list item being configured.	Check manual for limits of the function to be configured.
Locked!	Transmitter security setting is locked.	Enter security code to allow modifications to settings.
Unlocked!	Transmitter security has just been unlocked.	Displayed just after security code has been entered.
Offset High	The sensor zero offset point is out of the acceptable range of -999 to +999 nA.	Check wiring connections to sensor. Allow sensor to operate powered a minimum of 12 hours prior to first zero cal.
Sensor High	The raw signal from the sensor is too high and out of instrument range.	Check wiring connections to sensor.
Sensor Low	The raw signal from the sensor is too low.	Check wiring connections to sensor.
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.

Figure 21 - Q45H Display Messages

MESSAGE	DESCRIPTION	POSSIBLE CORRECTION
Cal Fail	Failure of sulfide calibration. FAIL icon will not extinguish until successful calibration has been performed, or 30 minutes passes with no keys being pressed.	Clean sensor redo zero and span calibration. If still failure, sensor slope may be less than 25% or greater than 300%. Perform sensor tests as described in section. Replace sensor if still failure.
EPROM 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.

Figure 22 - Q45H Display Messages (Cont'd)

Spare Parts

<u>Part No.</u>	<u>Description</u>
03-0342-1	Q45S front lid assembly
07-0134	115 VAC powered monitor electronics assembly
07-0135	230 VAC powered monitor electronics assembly
07-0136	9 VDC battery powered monitor electronics assembly
07-0137	9 VDC Battery powered monitor electronics assembly w/data logger
01-0242	Power supply circuit board assembly (specify 115 or 230 VAC)
00-1410	Sensor mounting assembly
00-1069	Hydrogen Sulfide Sensor
03-0029	Sensor interconnect cable with connector, 25 ft.
05-0087	Sensor prefilter membrane, package of 10
23-0018	Fuse, 100mA, 250V, (115VAC)
23-0019	Fuse, 50mA, 250V, (230VAC)
38-0063	Terminal block plug, 2 position (outputs)
38-0064	Terminal block plug, 6 position (relays)
38-0065	Terminal block plug, 3 position (power)
31-0168	Ribbon cable assembly for AC units
36-0023	Air pump
44-0148	Air purge tube fitting
44-0007	Air purge tubing
45-0214	Sensor holder
45-0215	Sensor adapter
45-0010	Prefilter end cap
42-0091	O-ring, sensor holder (rear)
42-0101	O-ring, sensor holder (front)

Lock/Unlock Code: 1456

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WATER QUALITY MONITORS

Dissolved Oxygen
Free Chlorine
Combined Chlorine
Total Chlorine
Residual Chlorine Dioxide
Potassium Permanganate
Dissolved Ozone
pH/ORP
Conductivity
Hydrogen Peroxide
Peracetic Acid
Dissolved Sulfide
Residual Sulfite
Fluoride
Dissolved Ammonia
Turbidity
Suspended Solids
Sludge Blanket Level
MetriNet Distribution Monitor

GAS DETECTION PRODUCTS

NH ₃	Ammonia
CO	Carbon Monoxide
H ₂	Hydrogen
NO	Nitric Oxide
O ₂	Oxygen
CO	Cl ₂ Phosgene
Br ₂	Bromine
Cl ₂	Chlorine
ClO ₂	Chlorine Dioxide
F ₂	Fluorine
I ₂	Iodine
H _x	Acid Gases
C ₂ H ₄ O	Ethylene Oxide
C ₂ H ₆ O	Alcohol
O ₃	Ozone
CH ₄	Methane (Combustible Gas)
H ₂ O ₂	Hydrogen Peroxide
HCl	Hydrogen Chloride
HCN	Hydrogen Cyanide
HF	Hydrogen Fluoride
H ₂ S	Hydrogen Sulfide
NO ₂	Nitrogen Dioxide
NO _x	Oxides of Nitrogen
SO ₂	Sulfur Dioxide
H ₂ Se	Hydrogen Selenide
B ₂ H ₆	Diborane
GeH ₄	Germane
AsH ₃	Arsine
PH ₃	Phosphine
SiH ₄	Silane
HCHO	Formaldehyde
C ₂ H ₄ O ₃	Peracetic Acid
DMA	Dimethylamine