INSTRUCTION MANUAL

MODEL 450H
OZONE MONITOR

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SAFETY MESSAGES

Your safety and the safety of others is very important. We have provided many important safety messages in this manual. Please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Each safety message is associated with a safety alert symbol. These symbols are found in the manual and inside the instrument. The definition of these symbols is described below:

General Warning/Caution: Refer to the instructions for details on the specific danger.

Caution: Hot Surface

Caution: Electrical Shock Hazard

Technician Symbol: All operations marked with this symbol are to be performed by qualified maintenance personnel only.

CAUTION

The monitor should only be used for the purpose and in the manner described in this manual.

If you use the monitor in a manner other than that for which it was intended, unpredictable behavior could ensue with possibly hazardous consequences.

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1.0 INTRODUCTION

1.1 Preface

Teledyne API is pleased that you have purchased the Model 450H. We offer a full one-year warranty (see Section 1.2) and we at Teledyne API will be pleased to provide you with any support required so that you may utilize our equipment to the fullest extent.

The Model 450H is a microprocessor based high concentration ozone monitor for monitoring process streams in water treatment, food processing, and research applications. The Model 450H has been designed to give accurate and stable readings over long time periods with little or no maintenance or calibration.

The flexibility of the software as well as the analog and digital I/O allow the Model 450H to interface with a broad range of devices for process control and data logging.

The Teledyne API Model 450H keyboard/operator interface with its "talking keys" makes the Teledyne API a very user-friendly system. We hope you will not experience any problems with the Teledyne API Model 450H but if you do, the built-in tests and diagnostics should allow you to quickly and easily find the problem. In addition, our full time customer service department is always available to answer your questions.

1.2 WARRANTY POLICY

ADVANCED POLLUTION INSTRUMENTATION DIVISION

02024c

Prior to shipment, Teledyne API equipment is thoroughly inspected and tested. Should equipment failure occur, Teledyne API assures its customers that prompt service and support will be available.

COVERAGE

After the warranty period and throughout the equipment lifetime, Teledyne API stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting are to be performed by the customer.

NON-API MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by Teledyne API is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturers warranty.

GENERAL

Teledyne API warrants each Product manufactured by Teledyne API to be free from defects in material and workmanship under normal use and service for a period of one year from the date of delivery. All replacement parts and repairs are warranted for 90 days after the purchase.

If a Product fails to conform to its specifications within the warranty period, Teledyne API shall correct such defect by, in API's discretion, repairing or replacing such defective Product or refunding the purchase price of such Product.

The warranties set forth in this section shall be of no force or effect with respect to any Product:
(i) that has been altered or subjected to misuse, negligence or accident, or (ii) that has been used in any manner other than in accordance with the instruction provided by API or (iii) not properly maintained.

THE WARRANTIES SET FORTH IN THIS SECTION AND THE REMEDIES THEREFORE ARE EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, WHETHER EXPRESSED OR IMPLIED. THE REMEDIES SET FORTH IN THIS SECTION ARE THE EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONTAINED HEREIN. TELEDYNE API SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATED TO THIS AGREEMENT OF API'S PERFORMANCE HEREUNDER, WHETHER FOR BREACH OF WARRANTY OR OTHERWISE.

TERMS AND CONDITIONS

All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.

1.3 Principle of Operation

The detection of ozone molecules is based on absorption of 254 nm UV light due to an internal electronic resonance of the O_3 molecule. The Model 450H uses a mercury lamp constructed so that a large majority of the light emitted is at the 254nm wavelength. Light from the lamp shines through an absorption cell through wich the sample gas being measured is passed. The ratio of the intensity of light passing through the gas to a reference measurement which does not pass through the gas forms the ratio I/I_O. This ratio forms the basis for the calculation of the ozone concentration.

The Beer-Lambert equation, shown below, calculates the concentration of ozone from the ratio of light intensities.

$$C_{O_3} = -\frac{10^6}{\alpha \times \ell} \times \frac{\mathrm{T}}{273^o \mathrm{K}} \times \frac{14.695 psi}{\mathrm{P}} \times \ell n \frac{\mathrm{I}}{\mathrm{I}_o}$$

Where:

I = Intensity of light passed through the sample
I_o = Intensity of light through sample free of ozone
α = absorption coefficient
ℓ = path length
C_{O_3} = concentration of ozone in parts per million
T = sample temperature in degrees Kelvin
P = pressure in pounds per square inch (absolute)

As can be seen the concentration of ozone depends on more than the intensity ratio. Temperature and pressure influence the density of the sample. The density changes the number of ozone molecules in the absorption cell which impacts the amount of light removed from the light beam. These effects are addressed by directly measuring temperature and pressure and including their actual values in the calculation. The absorption coefficient is a number that reflects the inherent ability of ozone to absorb 254 nm light. Most current measurements place this value at 308 cm^{-1} atm^{-1} at STP. The value of this number reflects the fact that ozone is a very efficient absorber of UV radiation which is why stratospheric ozone protects the life forms lower in the atmosphere from the harmful effects from solar UV radiation. Lastly, the absorption path length determines how many molecules are present in the column of gas in the absorption cell.

The intensity of light is converted into a voltage by the detector/preamp module. The voltage is converted into a number by a voltage-to-frequency (V/F) converter capable of 80,000 count resolution. The digitized signal, along with the other variables, are used by the CPU to compute the concentration using the above formula.

1.4 Specifications

Measurement Principle	UV Absorption (Beer Lambert Law)
Ranges	0-5%, 0-10%, 0-15% w/w 0-100 g/m^3, 0-200 g/m^3, 0-300 g/m^3
Measurement Units	wt%, g/m^3, g/Nm^3 (Operator selectable)
Precision/Repeatability	±0.5% of full scale range
Resolution	0.1 % w/w
Linearity	1%
Response Time (95%)	<5 sec to 95%
Compensation	Pressure, temperature, gas molecular weight
Gas Flow Rate	0.5 - 2 LPM
Temperature Range	5-45^{o}C
Alarm Relay Mode	Latching or Non-Latching (Operator selectable)
19” Rack Mount Enclosure	7" x 17" x 18.2"
Dimensions (H x W x D)	(178 mm x 432 mm x 463 mm)
NEMA 4X Enclosure	19.50” x 17.25” x 9.63”
Dimensions (H x W x D)	(495 mm x 438 mm x 245 mm)
Weight	28 lb. (12.7 kg) - 19” Rack Mount Enclosure 33 lb. (15 kg) - NEMA 4X Enclosure
Power	110V/60 Hz, 220V/50 Hz, 240V/50Hz 250 watts 230V~, 50Hz, 2.5A
Environmental Conditions	Installation Category (Overvoltage Category) II Pollution Degree 2
Maximum Operating Altitude	2000 meters
Analog Output Voltage Mode	100mV, 1V, 5V, 10V (User Selectable)
Isolated Analog Output 4-20mA Mode*	Maximum voltage between outputs and ground 60V peak
Degree of Protection (IP Code)	IPX0 (450 Rack Mount) IPX66 (450 Nema)

*Optional

1.5 Installation (19” Rack Mount Enclosure)

The Model 450H 19” Rack version is shipped with the following standard equipment:

1. Instruction manual.
2. Power Cord

CAUTION

To avoid personal injury, always use **two** persons to lift and carry the Model 450H.

Upon receiving the Model 450H please do the following:

1. Verify no apparent shipping damage. (If damage has occurred please advise shipper first, then Teledyne API.)
2. Before connecting power to the instrument, check the serial number tag to verify that the instrument has been configured for the correct line voltage and frequency connections.

CAUTION

Verify that the instrument is set up for proper line voltage and frequency.

3. Connect an exhaust line to the fitting labeled 'Exhaust.' If the M450H has been configured with the ozone killer option, this line should be vented to an outside area, since the exhaust gas may still contain trace levels of ozone. If the M450H has not been equipped with an ozone killer, this line should be vented to an ozone destruct unit or other appropriate device.

CAUTION

Exhaust gas from the M450H may contain dangerous levels of ozone!

4. Connect the ozone delivery line to the ¼" inlet fitting on the filter assembly on the rear panel. The ozone delivery pressure should be regulated to no more than 30psig. All tubing used should be made of ozone resistant material such as PTFE(Teflon™) or PFA. If new, unconditioned tubing is used for the ozone delivery line, the ozone concentration may be affected until the tubing becomes conditioned. Pre-conditioned ¼" tubing can be purchased from Teledyne API. Contact the Teledyne API sales department and reference part number 02639.

5. If the M450H has been configured with the auto-zero valve option, connect the oxygen or other zero gas source to the ¼" tube fitting labeled 'Zero Gas Inlet.' Do not exceed 30 psig in the zero air delivery line.

NOTE

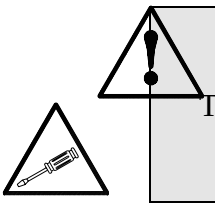
The zero gas used must be clean and free of particles. If the gas contains particulate contamination, install a particulate filter in the zero air line. You can purchase an appropriate filter from Teledyne API.

6. With the ozone delivery line pressurized, adjust the ozone flow rate using the needle valve mounted inside the front panel of of the monitor. To access the needle valve, pop out the two black plastic fasteners at the top of the front panel. The panel will now hinge down, allowing access to the needle valve. The flow-rate should be set from 0.5 to 2.0 liters/min. The flow-rate required will depend on your system. As a general guideline, the flow should be set to the lowest value that will still achieve an acceptable response time from the instrument. The lower the flow, the slower the response will be. If a long length of tubing is used for the ozone delivery line then the flow-rate may need to be increased so that the ozone concentration will not degrade in the sample line.
7. Turn on the M450H by switching the power switch on the front panel. The front panel display should light with a sequence of messages, -API - M450H - software version number, then a normal display as shown in Figure 2.2.
8. Allow about 10 minutes for the UV lamp temperature to come up to it's set-point then press the **TST>** button on the front keyboard to scroll through the TEST values. Compare these values to those noted during the final factory checkout listed in Table 1.3. The values observed should closely match the Table 1.3 values.

1.6 Installation (NEMA 4X Wall Mount Enclosure)

The Model 450H NEMA 4X is shipped with the following standard equipment:

1. Instruction manual.



CAUTION

To avoid personal injury, always use **two** persons to lift and carry the Model 450H.

Upon receiving the Model 450H please do the following:

2. Verify no apparent shipping damage. (If damage has occurred please advise shipper first, then Teledyne API.)
3. Mount the 450H to a vertical surface using four 5/16" bolts. See Figure 1.1 for mounting hole dimensions.
4. PVC piping of ½" or the metric equivalent must be placed on the bulkhead conduits.
   If a bulkhead conduit is not used it must be plugged to assure the watertight seal on the unit. If this is not done the protection rating of the unit will be greatly compromised
   If the fittings are not the correct type for your application consult an electrician to wire the unit according to the local electrical code.
5. Before connecting power to the instrument, check the serial number tag to verify that the instrument has been configured for the correct line voltage and frequency. The AC power line should be routed through one of the three ½" conduit bulkheads on the bottom face of the enclosure. A barrier strip inside the inside the enclosure is provided for wiring the AC line to the instrument. See Figure 1.2 for details on these connections.

CAUTION

Verify that the instrument is set up for proper line voltage and frequency.

6. Connect an exhaust line to the fitting labeled 'Exhaust.' If the M450H has been configured with the ozone killer option, this line should be vented to an outside area, since the exhaust gas may still contain trace levels of ozone. If the M450H has not been equipped with an ozone killer, this line should be vented to an ozone destruct unit or other appropriate device.

CAUTION

Exhaust gas from the M450H may contain dangerous levels of ozone!

7. Connect the ozone delivery line to the ¼" inlet fitting on the bottom of the filter assembly. This assembly is located on the bottom face of the enclosure (See Figure 1.3.) The ozone delivery pressure should be regulated to no more than 30psig. All tubing used should be made of ozone resistant material such as PTFE(Teflon™) or PFA. If new, unconditioned tubing is used for the ozone delivery line, the ozone concentration may be affected until the tubing becomes conditioned. Pre-conditioned ¼" tubing can be purchased from Teledyne API. Contact the API sales department and reference part number 02639.
8. If the M450H has been configured with the auto-zero valve option, connect the oxygen or other zero gas source to the ¼" tube fitting labeled 'Zero Gas Inlet.' Do not exceed 30 psig in the zero air delivery line.

NOTE

The zero gas used must be clean and free of particles. If the gas contains particulate contamination, install a particulate filter in the zero air line. You can purchase an appropriate filter from Teledyne API.

9. With the ozone delivery line pressurized, adjust the ozone flow rate using the needle valve mounted below the sensor inside the instrument. The flow-rate should be set from 0.5 to 2.0 liters/min. The flow-rate required will depend on your system. As a general guideline, the flow should be set to the lowest value that will still achieve an acceptable response time from the instrument. The lower the flow, the slower the response will be. If a long length of tubing is used for the ozone delivery line then the flow-rate may need to be increased so that the ozone concentration will not degrade in the sample line.
10. Turn on the M450H by switching the power switch on the front panel. The front panel display should light with a sequence of messages, -API - M450H - software version number, then a normal display as shown in Figure 2.2.
11. Allow about 10 minutes for the UV lamp temperature to come up to it's set-point then press the **TST>** button on the front keyboard to scroll through the TEST values. Compare these values to those noted during the final factory checkout listed in Table 1.3. The values observed should closely match the Table 1.3 values.

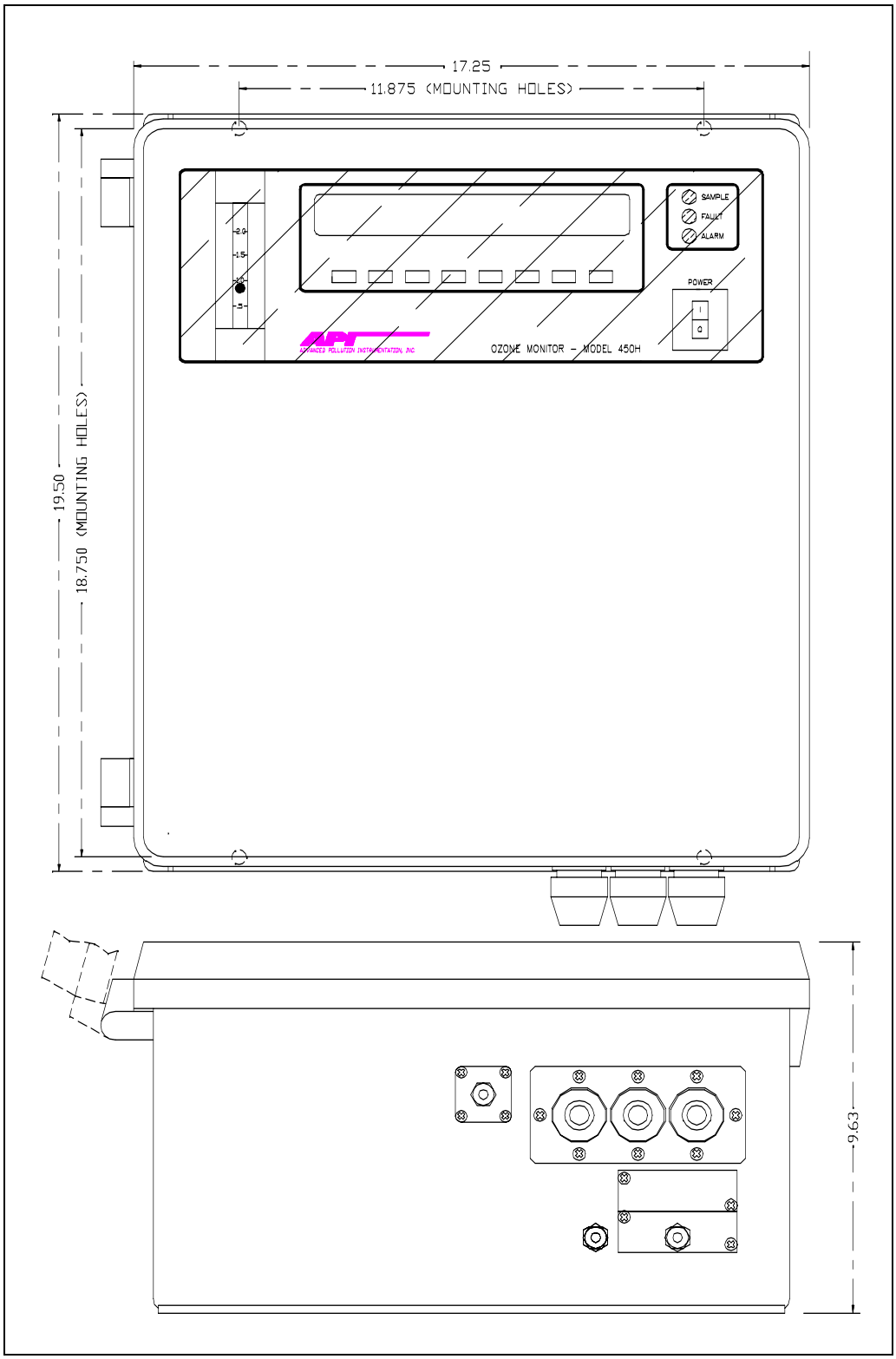


FIGURE 1.1 – NEMA 4X MOUNTING HOLE DIMENSIONS

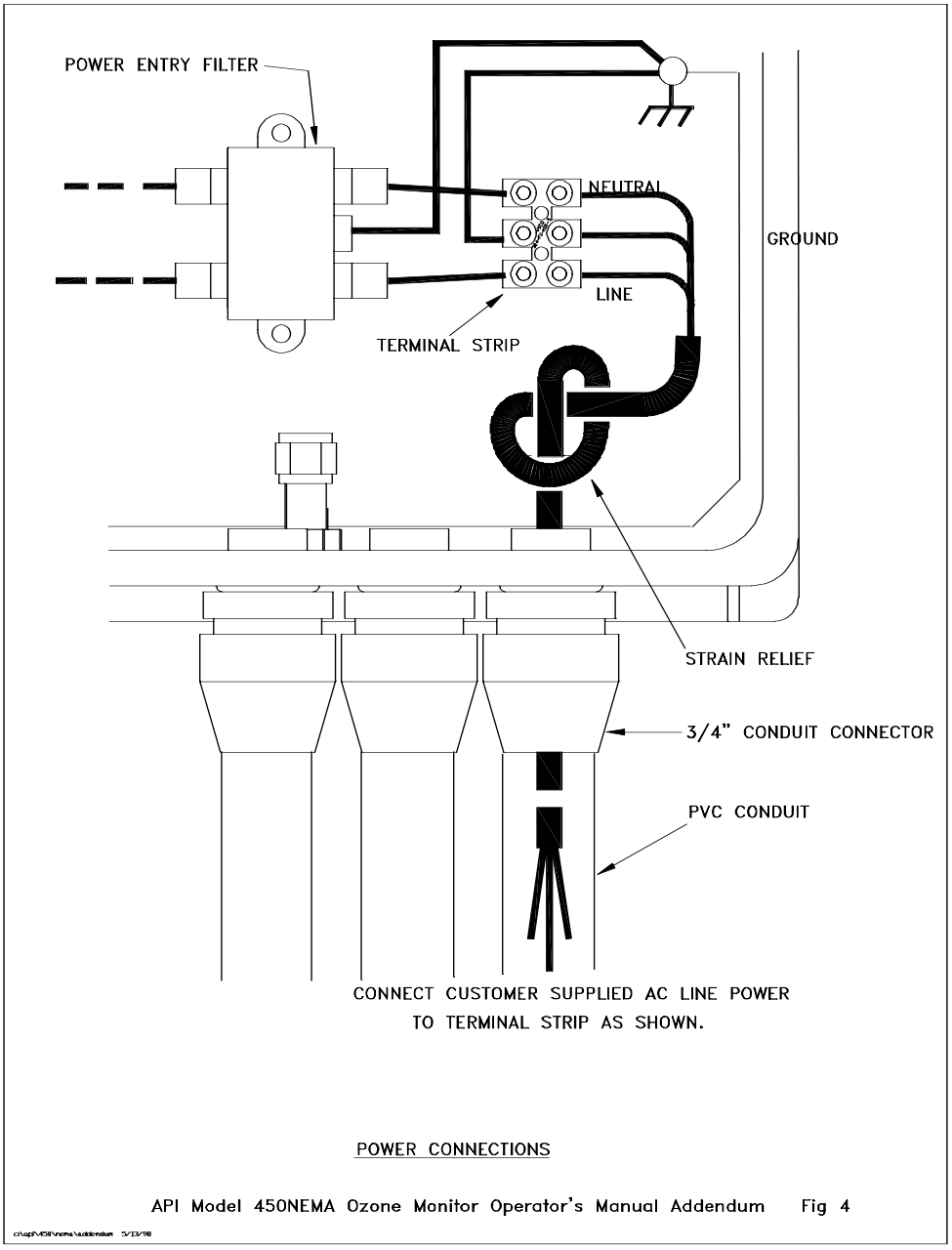


FIGURE 1.2 – NEMA 4X ELECTRICAL POWER CONNECTIONS

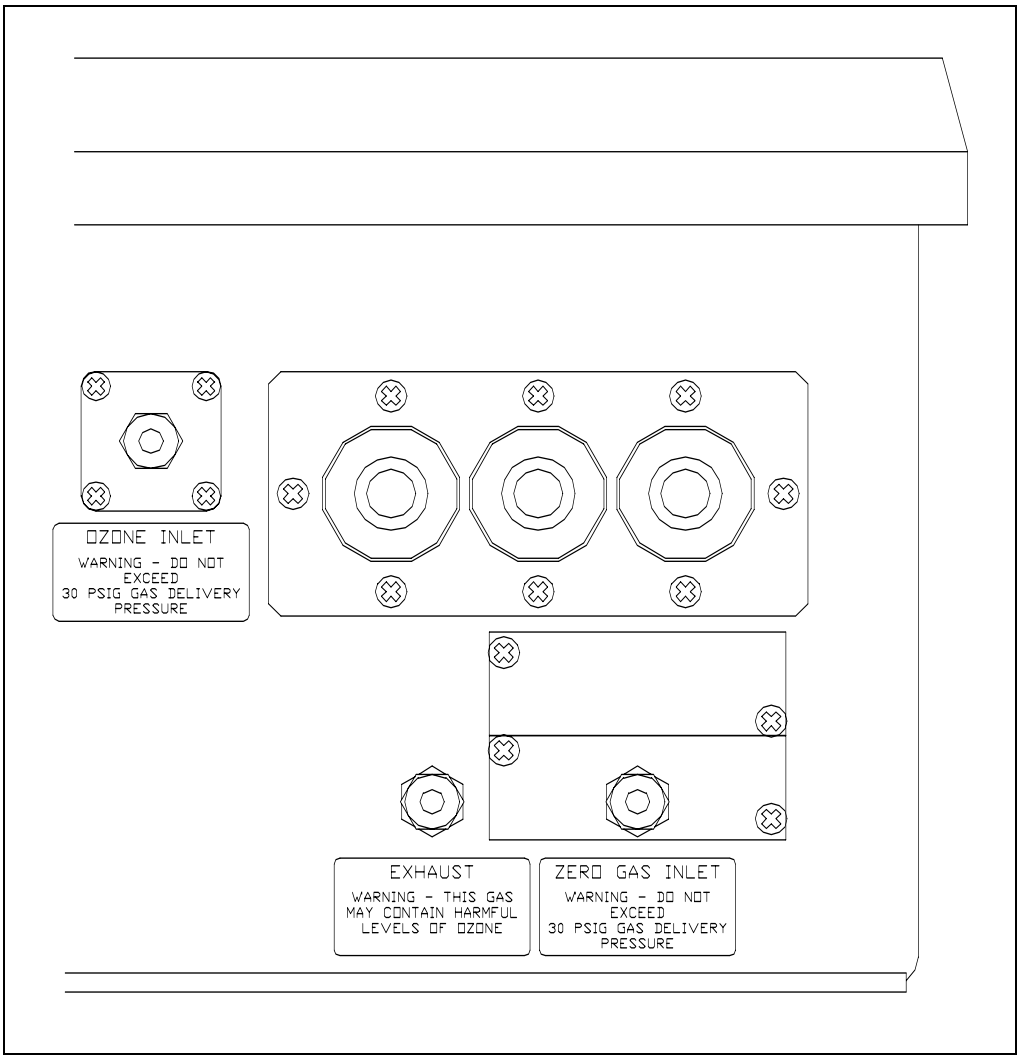


FIGURE 1.3 – NEMA 4X PNEUMATIC CONNECTIONS

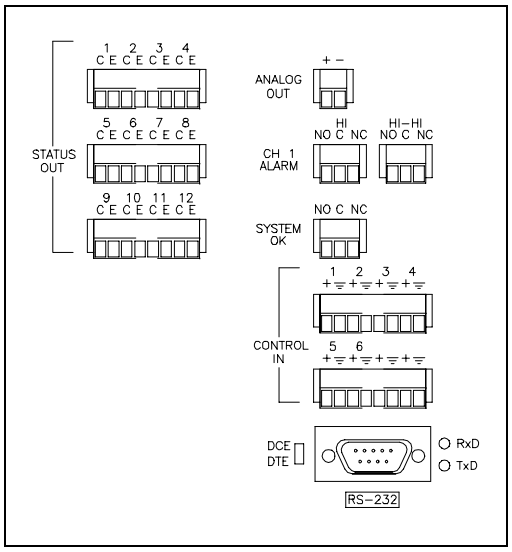


FIGURE 1.4 - ELECTRICAL SIGNAL I/O CONNECTIONS

1.6 Electrical I/O Connections

1.6.1 Analog Output

The analog output is a two pin connector (See Figure 1.4). The analog output can be configured for voltage or current output. The standard is a 0-5 volt output. 0-100mV, 0-1V, 0-10V, and 4-20 mA outputs are also available. See Section 5.2 for information on setting other output ranges.

1.6.2 Relay Outputs

Three form C relay outputs are provided on three pin connectors (See Figure 1.1). These outputs correspond to the 'HI' and 'HI-HI' concentration alarms and a System OK status output that is used to indicate a fault or error condition in the instrument. The relay contacts are rated to 3A at 240VAC. Do not exceed these ratings when connecting equipment to the instrument.

1.6.3 Digital Outputs

There are 12 digital output. These outputs are optically isolated NPN transistors which can pass 50 mA of DC current. These outputs can be used to interface to devices that accept logic-level digital inputs, such as Programmable Logic Controllers(PLC's).

The outputs labeled 'STATUS OUT' are used to indicate instrument operational status and fault conditions. Table 1.1 below summarizes the functions of all the digital outputs.

Output	Description	Normal Operating State
1	Power OK	ON
2	Diagnostics Mode(Instrument not monitoring)	OFF
3	Temperature Fault	OFF
4	Pressure Fault	OFF
5	UV Lamp Fault	OFF
6	Flow Fault	OFF
7	Performing Auto-Zero Calibration	OFF
8-11	Not Used	N/A
12	System OK(no faults)	ON

TABLE 1.1 DIGITAL OUTPUTS

Each digital output is configured as a Collector/Emitter pair. The labels are 'C' and 'E' for these contacts, respectively. Figure 1.2 below shows the most common way of connecting the digital outputs to an external device such as PLC. Note: Most devices, such as PLC's, have internal provision for limiting the current that the input will draw from an external device. When connecting to a unit that does not have this feature, external dropping resistors must be used to limit the current through the transistor output to 50mA or less.

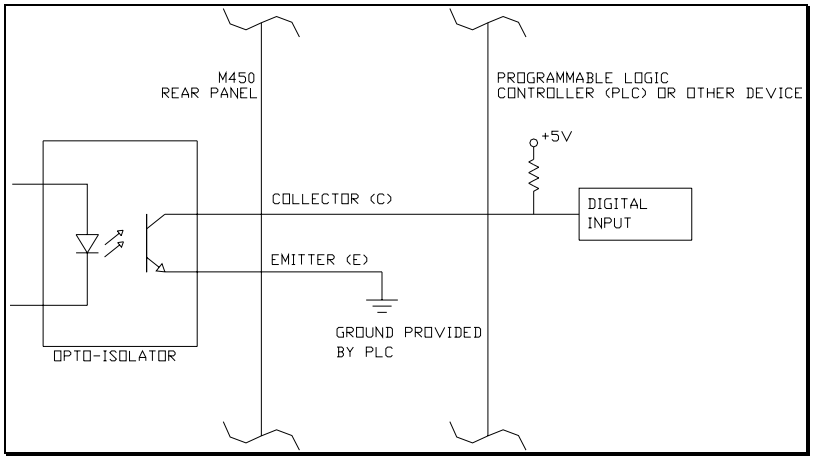


FIGURE 1.5 - CONNECTING DIGITAL OUTPUTS

1.6.4 Control Inputs

There are 6 digital control inputs on the rear panel; they are labeled 'CONTROL IN' (See Figure 1.4.) The control inputs are used for remote control of the M450H by a device such as a PLC. These inputs are triggered by providing a contact closure or low impedance current path between the + and ground contacts. This can be done by using a mechanical switch or isolated transistor type output from another device, such as a PLC. Never connect a voltage level output from another device to these contacts. The functions of the control inputs is summarized below in Table 1.2:

Input	Description
1	Zero Calibrate
2	Undefined (Spare)
3	Undefined (Spare)
4	Undefined (Spare)
5	Undefined (Spare)
6	Undefined (Spare)

TABLE 1.2 CONTROL INPUTS

Zero Calibrate:
The zero calibration input is used to initiate zero calibration from an external device. This control input only functions when the instrument has been configured with the Auto-Zero option. To perform the Auto-Zero calibration using the control input, this input should be closed for at least 2 seconds and released. The instrument will then automaticall perform the zero calibration and return to normal monitoring afterwards.

See Section 3.5 for details on configuring the Auto-Zero feature.

1.6.5 RS232 Output

The RS232 output is provided on the 9-pin D-Sub connector shown in Figure 1.4. The RS232 output can be connected to a computer or serial printer. The RS232 output can be used to record alarm events with a time and date stamp or can be used to control the instrument's operation remotely using a computer. Almost any function that can be done through the front panel interface can also be done remotely through the RS232 interface.

To use the RS232 for instrument control, all that is needed is a PC(personal computer) with an available serial communications port(COM port), a serial cable, and terminal emulation software. The serial cable must have a female DB-9 connector on one end and an appropriate connector on the other end to interface with the COM port on a PC.

For more details on the use of the RS232 interface, please contact Teledyne API and request document number 01350.

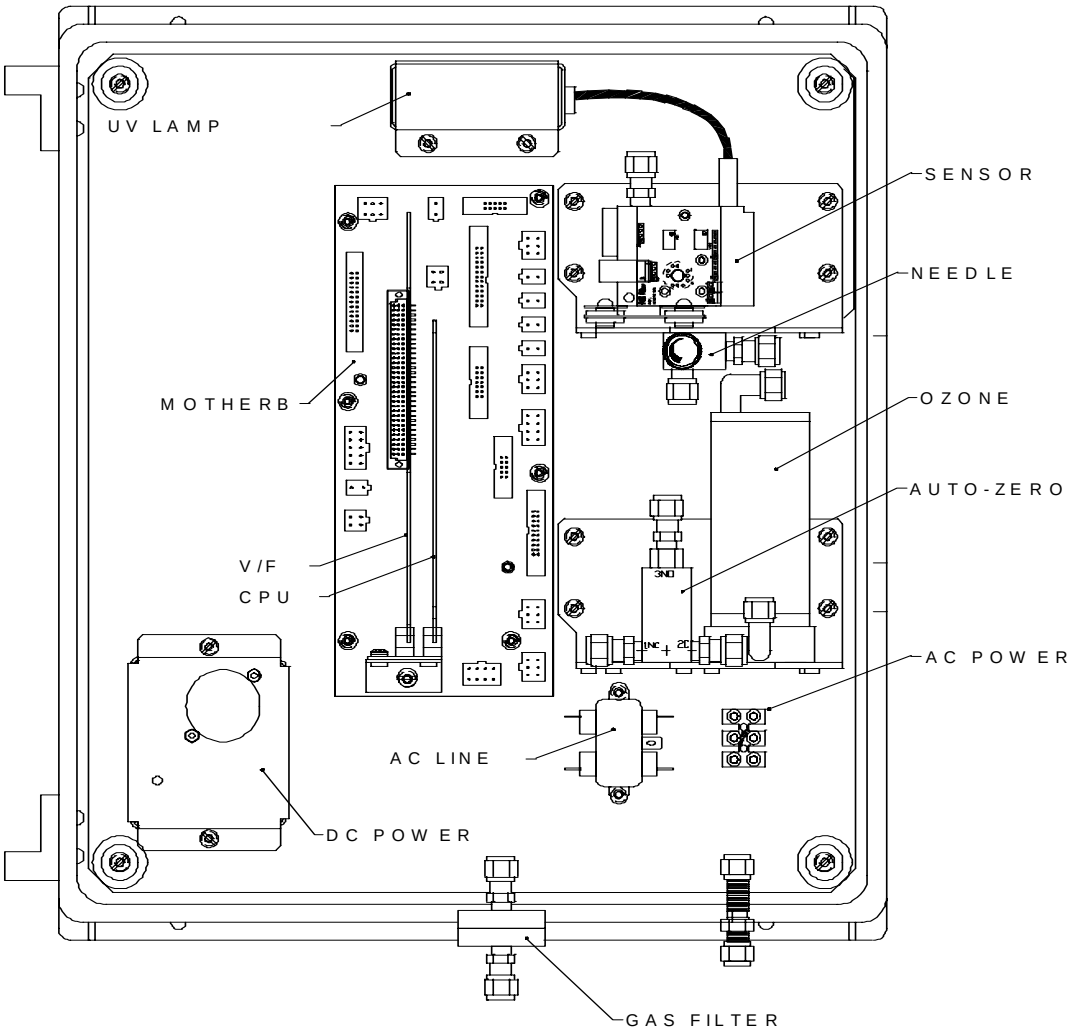


FIGURE 1.6 – NEMA4X ASSEMBLY LAYOUT

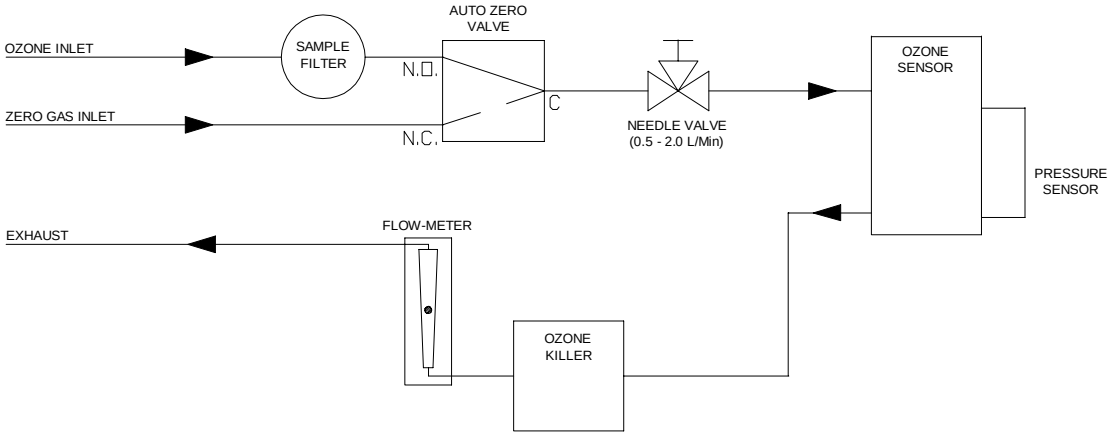


FIGURE 1.7 - M450H PNEUMATIC BLOCK DIAGRAM

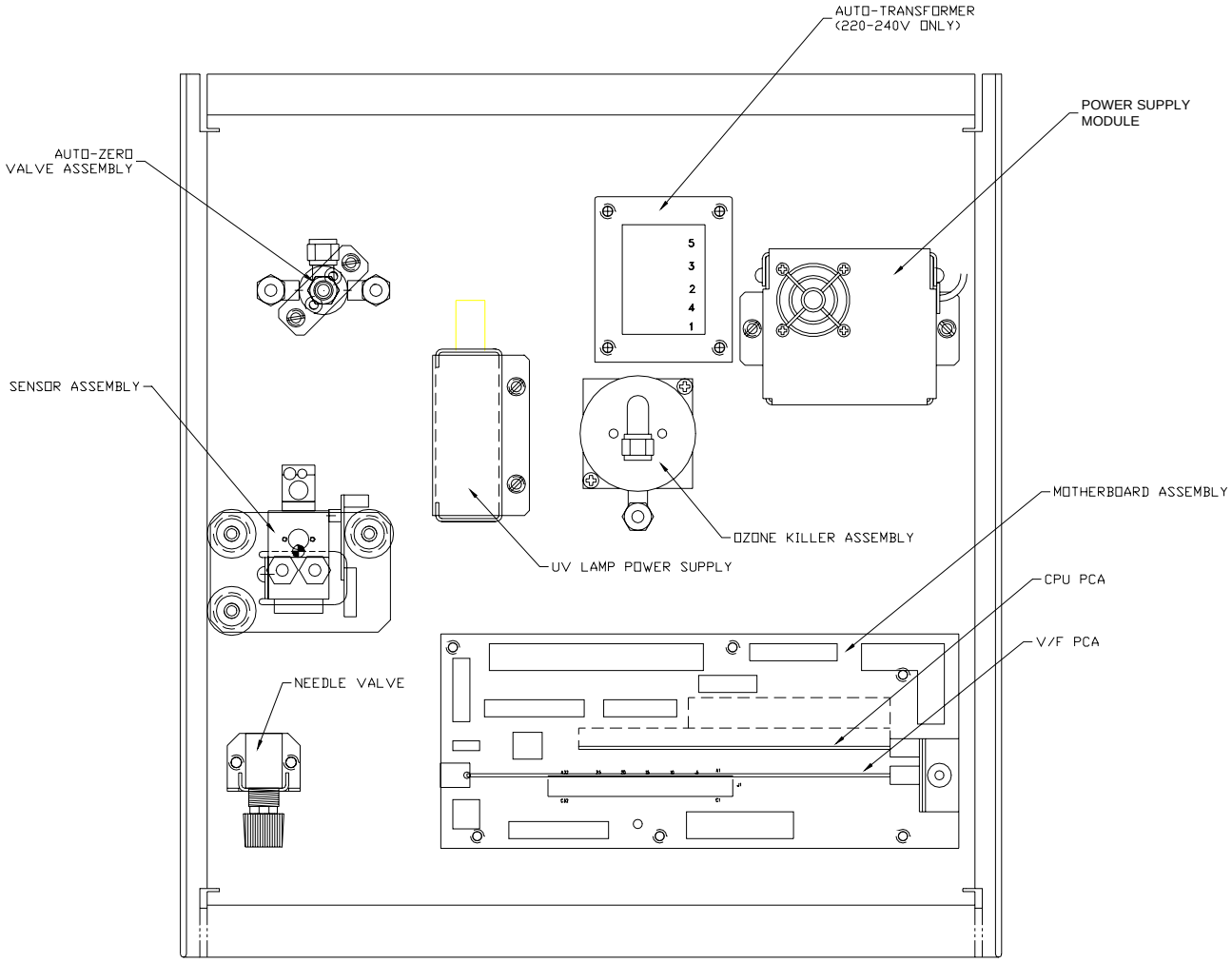


Figure 1.8 - 19” Rack Assembly Layout

1.7 Operation verification

The Model 450H Monitor is now ready for operation.

1. Read Sections 1.3 and all of Section 2 of the manual to understand the Monitor's operation.
2. Turn on the power by pressing the on/off switch (see Figure 2.1). The display should turn on and green (sample) status LED should be energized. The yellow "fault" light may also be on until the temperatures and voltages are within operating limits. Clear the fault messages.
3. Sample Flow - Adjust to 0.5-2.0 L/min using needle valve (See Figure 1.6)
4. After a 20 minute warm-up, review the TEST function values in the front panel display by pushing the keyboard button labeled **TST>**. Not every TEST function is a diagnostic of correct monitor operation, therefore TEST functions not covered below can be ignored for now.
5. O3 REF, O3 MEAS - TEST function values should be between 4200 mV and 4700 mV.
6. Pressure – 14.5-15.2 psia at sea level. Other values will be displayed depending on altitude of monitor.
7. Sample Temp - 20 -50^{o}C
8. Box Temp - Ambient +10 ^{o}C
9. If the TEST functions are within the limits given above the instrument should function correctly. If there is a problem please read the manual and check your set-up.

TEST Values	Observed Value	Units	Nominal Range
O3 MEAS		**mV**	**4200-4700**
O3 REF		**mV**	**4200-4700**
PRESS		**in-Hg-A**	**25 - 35**
GAS TEMP		**°C**	**20-50**
FLOW		**L/MIN**	**0.5-2**
Noise Values			
Noise at Zero(rms)		**G/Nm3**	**.5-1.5**

Factory Installed Options	Option Installed
Power Voltage/Frequency	
Auto-Zero Valve	
Ozone Killer	
Flow-Meter	
Flow Switch	
Rack Mount, w/ Slides	
Isolated 4-20mA Output	
Voltage Range	**0- _____V**

PROM Rev # _____ Serial # _____

Date _____ Technician _____

TABLE 1.3 FINAL TEST AND CALIBRATION VALUES

1.8 Options

1.8.1 Auto-Zero Option

This option consists of a three way valve that is used to admit customer supplied oxygen or zero gas into the instrument for performing an automatic or manual zero calibration. This calibration can be done automatically once a day or at some other pre-set interval, or can be controlled by an external system, such as a PLC.

1.8.2 Isolated Current Output (4-20mA or 2-20mA)

This option converts the M450H's voltage output to an isolated 4-20mA driver with an integral loop power supply. It is programmable for 4-20mA or 0-20mA and has a 1500 V common mode voltage isolation and 240 V RMS normal mode voltage protection. V_{loop} = 28V max which is sufficient to drive up to a 1000 ohm load.

1.8.3 Flow-meter

A variable area flowmeter can be included on the front panel to give a visual indicator of gas flow through the instrument.

1.8.4 Ozone Killer

This option consists of a catalytic ozone scrubber that converts most of the ozone back into oxygen before it is exhausted from the instrument.

1.8.5 Flow Switch

This option is an on/off type flow switch that is used to send a signal to the CPU in case the flow drops below the minimum required for proper operation of the instrument. In case of flow failure, the instrument will issue a warning on the front panel and will turn on the flow warning status bit, indicating an instrument error.

1.8.6 Rack mount with slides

This option, including slides and rack mounting ears, permits the Monitor to be mounted in a standard 19" wide x 30" deep RETMA rack. This option is not available for the NEMA 4X enclosure.

2.0 OPERATION

2.1 Key features

The important features of the Teledyne API Model 450H Ozone Monitor are listed below.

2.1.1 O_3 readout

The Teledyne API Model 450H O_3 Monitor constantly displays the current ozone reading (in units selected) in the upper right hand corner of the alphanumeric display.

2.1.2 Concentration Alarms

The Teledyne API O3 Monitor provides two concentration alarms, HI and HI-HI. The concentrations corresponding to each alarm levels can easily be set using the front panel interface. Two form C relays for the two alarm level are provided on the rear panel. In addition, the alarms can operate in either latching or non-latching modes.

2.1.3 O_3 analog output

The M450H provides an analog output of the current ozone reading on the rear panel (see Figure 1.2). The output can be configured for 0-100mV, 0-1V, 0-5V, 0-10V. Isolated 4-20mA or 2-20mA current output is available as an option. The voltage outputs are bi-polar and also provide for 20% over-range.

2.1.4 E^2 ROM backup of software configuration

The Teledyne API O_3 Monitor has few DIP switches or jumpers that need to be set by the operator. Configuration of the Monitor is done under software control and the configuration options are stored in electrically erasable (E^2) ROM. Thus, configuration options are saved even when the Monitor is powered off.

There is one exception to this. The analog output voltage range is set by DIP Switches on the A/D-I/O board as shown in Section 5.2.

2.1.5 RS-232 interface

The Teledyne API O_3 Monitor features an RS-232 interface which can output the instantaneous and/or average O_3 data to another computer. It can also be used as a command and status channel to allow a computer to control the Monitor.

For more details on the use of the RS232 interface, please contact Teledyne API and request document number 01350.

2.2 Front Panel Display

This section describes the operator interface from the point of view of the front panel. The front panel consists of a 2-line by 40-character alphanumeric display, 8 pushbuttons, and 3 status LED's. Each of these features is described below.

2.2.1 Front panel display fields

The display is divided into 4 main "fields": the **Mode** field in the upper left, the M**essage/Test Function** field in the top center, the ozone **Concentration** field consisting of the most recent instantaneous ozone value field in the upper right, and the **Menu** field which occupies the entire bottom line of the display. The Menu field is used to define the function of the 8 pushbuttons directly below the display. The buttons are then used for selecting menu items and are also used for entering values such as alarm levels. A typical display is shown in Figure 2.1.

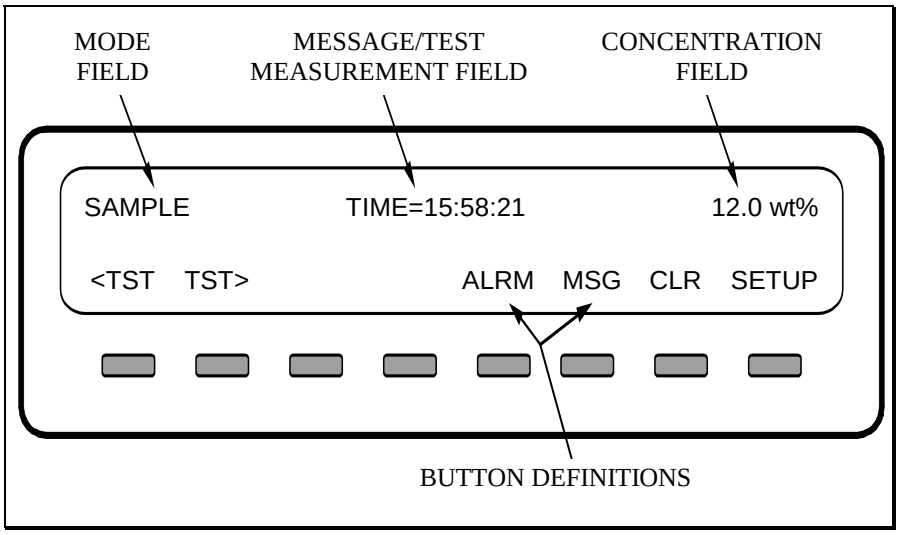


FIGURE 2.1 - MODEL 450H FRONT PANEL

Mode Field

The mode field indicates the current mode of the Monitor. Table 2.1 lists all the possible modes in the Monitor and their meanings.

TABLE 2.1 SYSTEM MODES

Mode	Meaning
SAMPLE	Monitoring
ALARM STATUS	Display of Alarm Status
SETUP xxx (1)	Configuring monitor (monitoring continues)
DIAG CAL	Calibration Menu
DIAG D/A	Configure and Calibrate Digital to Analog converters
DIAG AOUT	Test analog output
DIAG CFG	Instrument Configuation List
(1) xxx = software revision (e.g. A.9)	

Message/Test Measurement Field

The message field shows warning messages or test measurements. Tables 2.2 and 2.3 summarize the test measurements and warning messages and their meanings. Refer to Section 2.3 for detailed information on viewing test measurements and warning messages and clearing warnings.

Test Message	Meaning
TIME=xx:xx:xx	Current time-of-day (HH:MM:SS)
RANGE = xxxx wt%	Full-Scale concentration for analog output
O3 MEAS=xxxxx MV	Current UV reading, measure channel
O3 REF=xxxxx MV	Current UV reading, reference channel
PRESS=xxx PSIA	Absorption cell pressure - psia
GAS TEMP=xxx C	Temperature of the sample gas(deg. C)
LAMP TEMP=xxx C	UV Lamp Temperature (deg C)
BOX TEMP=xxx C	Internal box temperature (deg. C)

TABLE 2.2 TEST MEASUREMENTS

Warning Message	Meaning
SYSTEM RESET	Issued whenever Monitor is powered on
RAM INITIALIZED	RAM was erased
UV LAMP WARNING	UV lamp < 2500mV OR => 5000mV
UV LAMP SHUTDOWN	UV lamp temp control not working
SAMPLE FLOW WARNING	Sample flow < 700 cc/m
SAMPLE PRESSURE WARN	Sample pressure < 15 or > 35 In-Hg-A
GAS TEMP WARNING	Gas temp < 10 or > 50 deg. C
BOX TEMP WARNING	Box temp. < 12 deg. C or > 55 deg. C
ANA LAMP TEMP WARN	UV lamp temp < 51 or > 61 deg. C
V/F NOT INSTALLED	V/F card not installed or bad

TABLE 2.3 WARNING MESSAGES

Menu Field

The menu field changes depending on the mode of the Monitor and the buttons that have been pressed. It indicates the current function of each of the 8 pushbuttons below the display.

The 8 pushbuttons below the display are programmable by the CPU in that their functions change depending on the mode of the Monitor or the operations being performed. The legend above a button identifies its current function. If there is no legend above a button, it has no function and will be ignored if pressed.

2.2.2 Status LED's

The three status LED's to the right of the display indicate the general status of the Model 450H Monitor. The green SAMPLE LED indicates the sampling status. The yellow FAULT LED indicates the fault status. The red ALARM LED indicates the concentration alarm status. Table 2.4 below summarizes the meanings of the status LED's.

LED	State	Meaning
Green	Off	Not monitoring**(1)**
	On	Monitoring normally
Yellow	Off	No warnings exist
	Blinking	Warnings exist
Red	Off	No Alarms active
	Blinking	Alarms active
(1) This occurs during all diagnostics modes		

TABLE 2.4 STATUS LED'S

2.3 Software Operation

This section describes the operation of the instrument software through the front panel interface described in the previous section. The instrument software has been designed to be easy to use, yet powerful enough to allow the user to customize the instrument for a particular application.

2.3.1 Main Menu

Figure 2.2 below shows the shows a typical main menu for a Model 450H.

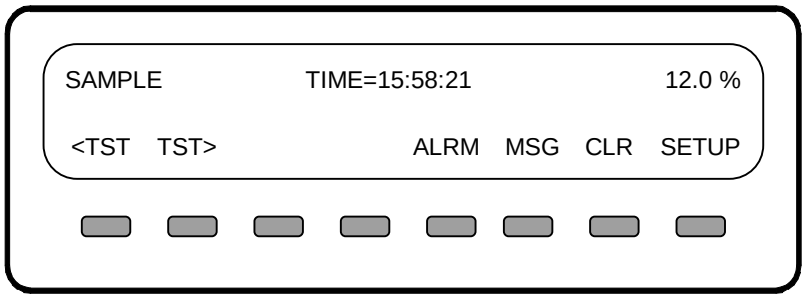


FIGURE 2.2 - MAIN MENU

If <**TST** or **TST**> are pushed, the upper center display cycles through list of available test functions (see Table 2.3).

When the **MSG** button is displayed, it indicates that one or more warnings have been issued. To view the warning messages, press the **MSG** button. Repeatedly pressing this button will cycle through all available warning messages. Pressing **CLR** will clear the warning message from the display. Note: If the conditions that caused the warning messages are still in effect, the warning messages will re-appear after they have been cleared.

The **ALRM** button is displayed when concentration alarms have been triggered. See Section 2.3.3 for operation of the Alarm menu.

2.3.3 Alarm Status Menu

Pressing the **ALRM** button from the main menu when alarms have been triggered will bring up the alarm status menu as shown below in Figure 2.3.

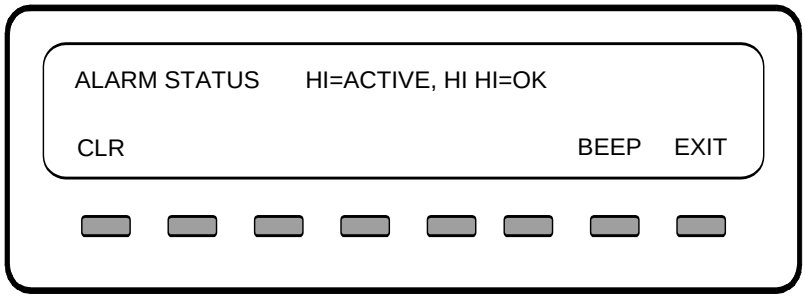


FIGURE 2.3 - ALARM STATUS MENU

Clearing Alarms

If the monitor is configured for Latching type alarms, and either of the alarms can be cleared (ie. The concentration has dropped below the alarm threshold,) then a **CLR** button will appear as shown in Figure 2.3 above. The **CLR** button will clear the alarm condition.

If the monitor is configured for Non-Latching alarms, the **CLR** button will not appear, and all alarms will automatically clear when the concentration drops below the alarm threshold.

Audible Beeper

An audible beeper is sounded when any alarm is activated. A slow beep indicates that the 'HI' alarm has been triggered, and a fast beep indicates that the 'HI-HI' alarm has been triggered. Pressing the **BEEP** button from the alarm menu will silence the audible beeper for 5 minutes. Note: Pressing the **BEEP** button does not clear any of the alarms, it simply silences the audible alarm. If the alarms are not cleared, the audible alarm will automatically resume in 5 minutes.

See Sections 3.1 and 3.5 for details on configuring concentration alarms.

3.0 SETUP MODE

This section describes the setup variables which are used to configure the Monitor. All the setup variables are stored in the Monitor's EEPROM and are retained during power off and even when new software revisions are installed.

NOTE

If a variable is modified, but ENTR is not pressed, the variable will not be changed and the monitor will beep when exit is pressed.

The setup menus are accessed by pressing the **SETUP** button from the instrument's main menu. The top level setup menu is shown in Figure 3.1 below.

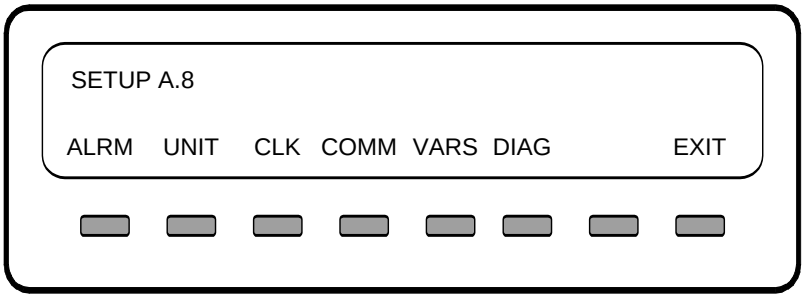


FIGURE 3.1 - SETUP MENU

3.1 Setting the Concentration Alarms (ALRM)

To configure the concentration alarms, press **ALRM** from the SETUP menu. The software will now show a series of prompts for configuring the HI and HI-HI alarms. Each alarm can be independantly enabled and disabled as follows:

HI ALARM:OFF

Pressing the leftmost button on the display will toggle the HI Alarm on and off. Setting the alarm to off disables the alarm. Press **ENTR** to proceed to the next prompt. If the HI Alarm is set to **ON** then the next prompt will show:

HI ALARM LIMIT: 5.00 wt%

The concentration threshold for the HI alarm is shown. To change this value, edit the number shown on the lower line of the display by pressing the button below the digit you want to change. When you are done, press **ENTR** to store the new value. The next set of prompts sets the HI-HI alarm as follows:

HI-HI ALARM:OFF

Pressing the leftmost button on the display will toggle the HI Alarm on and off. Press **ENTR** to proceed to the next prompt. If the HI-HI Alarm is set to **ON** then the next prompt will show:

HI-HI ALARM LIMIT: 10.00 wt%

Edit the HI-HI alarm value and press ENTR to store the value.

3.2 Setting the Concentration Units (UNIT)

To set the concentration units, press **UNIT** from the setup menu. The default concentration units are weight %. Table 3.1 below lists the units available.

Software Abbreviation	Unit
GM3	Grams per m^3 (g/m^3)
WT%	Percent by weight (wt%)
GNM3	Grams per normal m^3 (g/Nm^3)

TABLE 3.1 CONCENTRATION UNITS

3.3 Setting the time-of-day and date (CLK)

To set the current time-of-day, which is used for determining when to do an automatic calibration and for time-stamping the RS-232 reports, press **SETUP-CLK-TIME.** The

CPU will display the current time-of-day as four digits in the format "HH:MM", where "HH" is the hour in 24-hour format (i.e. hours range from 00 to 23) and "MM" is the minute (00 - 59). The operator may change the time-of-day and then press **ENTR** to accept the new time, or press **EXIT** to leave the time unchanged.

To set the current date, which is used for time-stamping the RS-232 reports, press **SETUP-CLK-DATE**. The CPU will display the current date as "DD MMM YY". For example, April 1, 1990 would be displayed as "01 APR 90". Change the date by pressing the button under each field until the desired date is shown. Then press **ENTR** to accept the new date or press **EXIT** to leave the date unchanged.

3.4 Setting the RS-232 baud rate (COMM)

To set the baud rate for the RS-232 channel, press **SETUP-COMM-BAUD**. Press **300**, **1200**, **2400**, **4800**, **9600**, or **19.2** followed by **ENTR** to accept the new baud rate, or **EXIT** to leave the baud rate unchanged.

3.5 Setup variables (VARS)

The setup variables are global settings that can be configured by the user. **Note**: Do not arbitrarily change these settings since these variables affect the fundamental operation of the instrument. The setup variables are accessed from the main menu by pressing **SETUP-VARS.** Use the **PREV** or **NEXT** buttons to scroll to the desired variable and press **EDIT** to change the variable. Set the desired value for the variable and press **ENTR** to save the value. Pressing **EXIT** aborts the edit screen without changing the value. The setup variables available to the user are listed below along with their description.

0) LATCH_ALARMS
This variable sets the operation of the concentration alarms to either latched or non-latched mode. In latched mode, when a concentration alarm is triggered, the alarm will stay on, or latch, until the user resets the alarm through the **ALRM** menu on the front panel. When the alarms are set to non-latching mode(LATCH_ALARMS = OFF) the alarms will automatically turn off when the concentration drops back below the alarm threshold value.

1) ALARM_BEEPER
This variable enables or disables the audible beeper that sounds whenever one of the alarms has been triggered. The beeper sounds a slow beep if any of the 'HI' alarms are active and sounds a fast beep if any of the 'HI-HI' alarms are active.

Note: VAR's 2-6 apply only to instruments with the Auto-Zero valve option

2) USE_ZERO_VALVE
This variable enables the Auto-Zero valve (if installed) during manual zero calibration (See Section X.X.)

3) AZERO_ENABLE
This variable enables the Auto-Zero function which will perform an automatic zero calibration at the interval specified by the AZERO_FREQ variable. This calibration is performed by admitting externally supplied zero gas into the measurement cell for a period of time specified by the AZERO_DWELL variable and then performing a zero calibration.

4) AZERO_CAL_ENABLE
This variable enables automatic calibation during the Auto-Zero cycle and should be set to ON whenever the Auto-Zero function is enabled.

5) AZERO_FREQ
This variable determines the frequency of the Auto-Zero function in hours. The default value is 24 hours.

6) AZERO_DWELL

This variable determines length of time that zero gas is admitted into the measurement cell before the zero calibration is performed. This value must be set to a long enough interval to ensure that the cell is purged of all ozone before the calibration is performed. The defaul value is 20 seconds.

7) AZERO_HOLD_OFF

This variable determines the length of time the instrument waits after the Auto-Zero cycle before normal measurement is resumed. The default value is 5 seconds.

8) GAS_MOLECULAR_WEIGHT

This variable is the molecular weight of the carrier gas that the ozone is being measured in. This value is used in the calculation of the wt% concentration unit. The default value is 32.0 (for Oxygen carrier gas.)

9) CONCENTRATION _RANGE

This variable sets the full-scale concentration range for the analog output. A 15 wt% concentration range means that 0-5 volts on the analog output will coorespond to a concentration range of 0-15 wt%.

10) TPC_ENABLE

This variable enables temperature and pressure compensation for the calculation of the ozone concentration. This variable should always be set to ON unless an external correction is being applied to compensate for temperature and pressure changes.

11) STD_TEMP

12) STD_PRESS

These variables are the standard temperature and pressure that are used to calculate the concentration when the units are set to grams per normal cubic meter (g/Nm^3.)

13) RS232_MODE

This variable set the mode of operation of the RS232 interface. For more details on the use of the RS232 interface, please contact Teledyne API and request document number 01350.

14) CLOCK_ADJ

This variable is used to make slight adjustments to the instrument's internal clock so that it keeps proper time. Setting this variable to a positive value will add that number of seconds each day to the clock while a negative value will subtract that number of seconds per day.

3.5 Diagnostics (DIAG)

3.5.1 Zero Calibration

This menu is used for performing manual zero calibration of the M450H. If the Auto-Zero option has been installed and the USE_ZERO_VALVE variable has been enabled (See Section 3.5) then this calibration can be done using gas from the Zero Gas inlet port on the monitor. If this valve is not used, then the zero calibration gas must be supplied at the Ozone Inlet port. To zero the monitor press the **ZERO** button once. This button will now change to **ENTR**. Press this button once more to confirm the calibration. The Ozone concentration reading should now go to zero.

3.5.2 D/A Calibration

This menu is used for the calibration of the internal A/D converter and DACs on the V/F Card. This procedure is performed at the factory and should not need to be performed again unless the analog output voltage range is changed or the V/F Card is replaced. For details on performing this calibration see Section 5.3.

3.5.3 Analog Output

This diagnostic function will step the analog output through it's full scale range in 20% increments, ie. 0% - 20% - 40% - 60% - 80% - 100%. The function pauses for several seconds at each level. To freeze the analog output at a particular level, press and release the button under the % display. Pressing the button again will resume the cycling. This function is useful for calibrating instruments connected to the analog output.

3.5.4 RS232 Output

This diagnostic function outputs a string of w's out the RS232 port and is used for troubleshooting RS232 connections to a computer. For more details on the use of the RS232 interface, please contact Teledyne API and request document number 01350.

4.0 Maintenance

4.1 Replacing the gas filter element

The Model 450H comes equipped with a gas filter on the ozone inlet. These filters accept 25mm diameter glass fiber elements. Only filter elements of borosilicate glass or quartz fibers should be used. When the instrument is first installed, the sample filters should be checked at least once a week for particulate loading and replaced if necessary. Once the replacement frequency is determined, a regular schedule for filter replacement should be instituted.

For replacement 25mm filter elements, please contact Teledyne API's sales department and request part number 02851.

Filter Replacement Procedure:

1. First ensure that the gas delivery line is not under pressure and has been purged of ozone.
2. Remove the four nuts securing the gas filter assembly.
3. Remove the bottom half of the filter housing
4. Examine the internal sealing o-ring and replace if necessary.
5. Pull out the stainless steel screen securing the filter element.
6. The element can now be removed and replaced. When re-assembling filter, make sure that the top stainless steel screen is pushed into the filter cavity, securing the element in place.
7. After re-assembly, the gas line should be pressurized with oxygen or dry air and checked for leaks using a bubble solution.

4.2 Cleaning Exterior Surfaces of the M450H

If necessary, the exterior surfaces of M450H can be cleaned with a damp cloth. Do not attempt to clean any of the other surfaces of the instrument. Do not submerge any part of the instrument in water or cleaning solution.

4.3 Cleaning the Optical Cell

Over long periods of time the optical cell windows in the sensor assembly may become dirty and affect the operation of the instrument. Each time a zero calibration is done, the instrument can detect changes in the light transmission through the windows and will issue a warning when this value drops to an unacceptable level. The warning message "Optical Cell Warning" will be issued on the front panel and the "Cell Dirty" status output(See Section 1.6.3) will be turned on. The cell assembly should then be cleaned to avoid any degradation in measurement accuracy of the M450H.

Figure 4.1 below shows the disassembly of the measurement cell for cleaning. The cell can be easily disassembled after removing the (4) #8-32 screws from the rear of the sensor assembly. The two sapphire Cell Windows and the Stainless Steel Cell Spacer can be cleaned with isopropyl alcohol and rinsed with distilled water. Before reassembly, inspect all three O-Rings to ensure that they are in good condition and replace if necessary. After reassembly, the sensor should be leak checked.

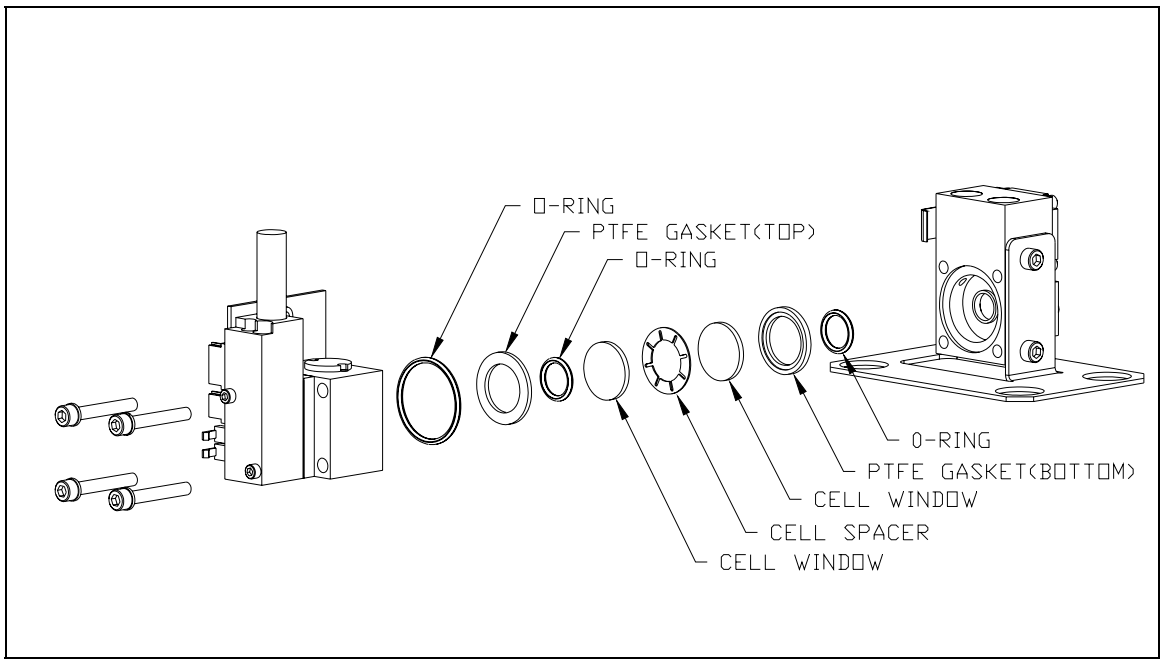
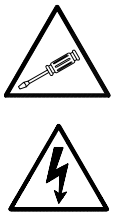


FIGURE 4.1 MEASUREMENT CELL DISASSEMBLY

4.4 Degree of Protection

The Model 450NEMA has a water ingress rating of IPX66 which indicates that it can withstand strong jets of water and is totally protected against dust.

5.0 ADJUSTMENTS



CAUTION

RISK OF ELECTRICAL SHOCK. THE OPERATIONS OUTLINED IN THE FOLLOWING SECTIONS OF THIS CHAPTER ARE TO BE PERFORMED BY QUALIFIED MAINTENANCE PERSONNEL ONLY!

5.1 Calibration

The Model 450H is calibrated using a wet chemistry method (double buffered KI) prior to shipment. The M450H should operate for extended periods without calibration.

5.2 Changing the analog output range

5.2.1 Voltage output

Output voltage ranges are set by DIP switches on the V/F board. To change the range for the analog output:

1. Turn off instrument power. Remove instrument cover. Locate the V/F board near the front of the analyzer using Figure 1.6.
2. Locate switch S1, along the top edge of the card. Select the desired range per Table 4.2 below.
3. Recalibrate the ADC as described in Section 5.3.

Full Scale Output	Switch Settings
100 mV	1,6 = ON
1 V	1,5 = ON
5 V	1,4 = ON
10 V	1,3 = ON

TABLE 4.2 V/F BOARD DIP SWITCH - RANGES FOR ANALOG OUTPUT

5.2.2 Current Output (Optional)

To configure the M450H for 4-20mA current output, perform the following steps:

1. Set the analog voltage range to the 5 Volt scale as described in Section 5.3.1 above.
2. Install Jumper in J2 on the rear panel PCB assembly.
3. Set Jumpers JP3 and JP4 on the rear panel PCB assembly as shown in Figure 4.2 below.

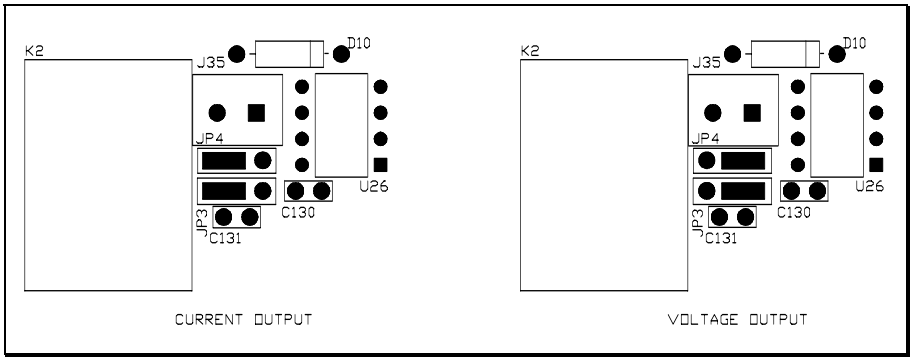


FIGURE 4.2- ANALOG OUTPUT JUMPERS

5.3 A/D - D/A Calibration Procedure

This procedure should be performed whenever a circuit board assembly is exchanged or whenever the analog output voltage range is changed.

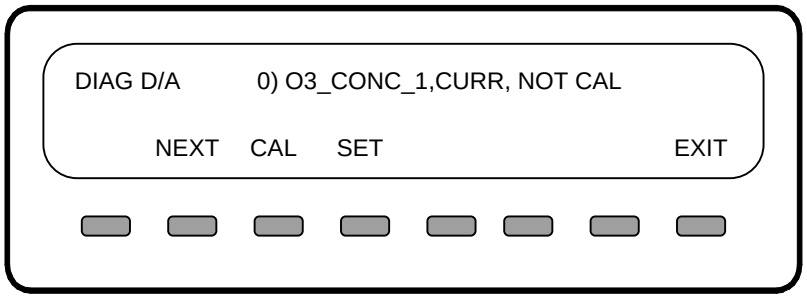
To calibrate the ADC, do the following:

1. Press **SETUP-DIAG**.
2. Enter Diagnostic password and press **NEXT** until D/A CALIBRATION appears in the display and press **ENTR**.
3. Press **ADC** to perform the A/D Cal.
4. The M450H display will read "ADJUST ZERO:A/D=xx.x MV." Put the probe of a voltmeter between TP3(AGND) and TP9(DAC #0) on the top of the V/F card.
5. The value displayed by the voltmeter should be close(+/- 20 mV) to the value on the M450H display. If they are not close then the V/F card has probably been configured improperly.
6. Adjust the Zero pot(R27) on the V/F card until the value on the M450H display matches the value on the voltmeter to within +/- 2 mV. *Note that when adjusting R27, the value on the M450H display will change, the value on the voltmeter will remain constant.*
7. Press **ENTR**.
8. The M450H display will now read "ADJUST GAIN:A/D=xx.x MV."
9. Adjust the Span Pot (R31) on the V/F card until the value on the M450H display matches the value on the voltmeter to within +/- 2 mV.
10. Press **ENTR**.
11. The ADC is now calibrated and the M450H will automatically calibrate all the DAC's. This process takes only a few seconds.
12. Press **EXIT** 3 times to return to the sample menu.

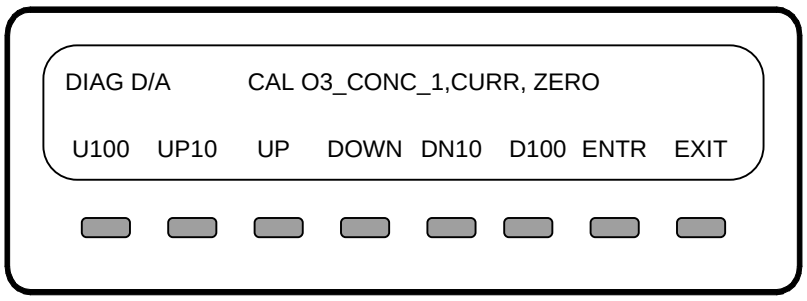
5.4 Current Loop Calibration

A current loop option can be ordered that will provide a 0-20mA or 4-20mA output on the analog output. This calibration must be repeated every time an A/D - D/A calibration is performed. To calibrate the current output, perform the following steps:

1. Perform an A/D - D/A calibration as outlined in Section 5.3.
2. Connect a Multimeter capable of measuring milliamperes to the analog output on the rear panel. **Note: When measuring the current output with a multimeter or similar low-impedance current measuring device, a 400-450 ohm resistor must be placed in series with the meter to simulate a load. Failure to do this will result in erroneous readings**.
3. From the front panel, press **SETUP-DIAG**. Press **NEXT** until D/A CALIBRATION appears and press **ENTR**. Press **CFG** and the properties for analog output Channel 0 will be displayed on the top line. The display should show something like:



4. This indicates that channel 0 is setup for current output and has not been calibrated. If the display shows VOLT instead of CURR then the channel must be setup for current output. To do this, press **SET**, select **CURR** as the output type and press **ENTR**.
5. Next press **CAL** to begin the calibration. At this point the display should show:



6. The zero point for current output can now be set. Pressing **UP**, **UP10** and **U100** will step the zero point up in increments of 1, 10 and 100 steps. The

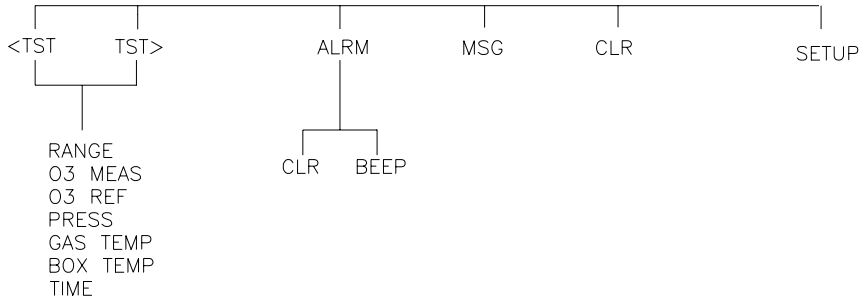
zero point can be adjusted anywhere between 0 and 4 milliamps. Press **ENTR** when you have reached the desired zero point as measured by your test meter.

7. The display will now prompt you to adjust the Gain, or full-scale output of the current loop. Using the UP and DOWN buttons as in step 4, adjust the full-scale (usually 20ma) and press **ENTR**. This completes the current loop calibration. Press **EXIT** several times until you are back at the sample menu.

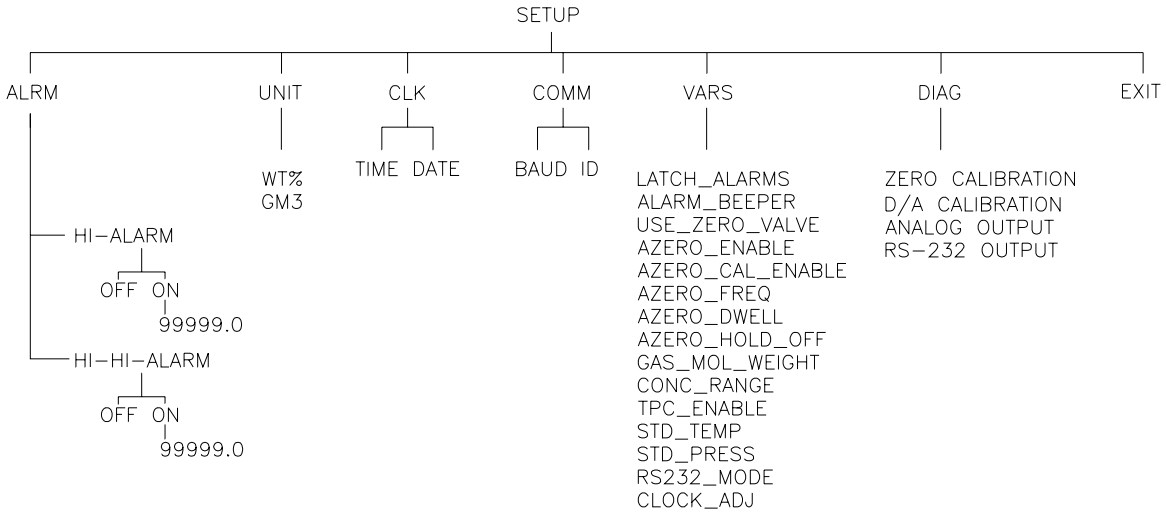
APPENDIX A – SOFTWARE MENU TREE

API MODEL 450H FRONT PANEL DISPLAY

MAIN MENU STRUCTURE



SETUP MENU STRUCTURE



APPENDIX B – SPARE PARTS LIST

PART NO.	DESCRIPTION
030360000	Teledyne API Model 450H Spare Parts List
002760451	CPU Board (450H)
005140300	V/F Board
007040000	Keyboard
007280000	Display
015610000	I2C/Sub Mux, M450
023480000	Filter PAD, Ozone Scrubber
023620100	Rear Panel PCA, Single Channel
023900000	UV Lamp Supply
024040000	Power Supply Module, M450
024740000	Tubing: 6', 1/4" CLR FEP
025710000	Measure Detector Preamp
026490000	Heater, Cartridge, 120V, 20W
026540000	Reference Detector Preamp
027010000	Sensor Assembly, M450
027020000	Assy, Auto Zero Valve
027030000	Assy, Needle Valve, Kalrez Seals
028260000	Manual, Instruction, M450H
028320000	Assy, Sample Filter, 25mm
028330000	Assy, Oxone Killer w/o Flow Switch
028340000	Assy, Thermistor, Cell & Lamp
028350000	Assy, UV Lamp (M450H)
028510000	Kit, 25mm Glass Filters (50)
FM0000016	Flowmeter, 0-2 LPM
HW0000036	TFE Thread Tape (48 FT)
IC0000055	Isolated Current Loop Driver, AD1B22N
OP0000019	Window Sapphire 3/4" x 2mm
OR0000070	Oring, Sensor Assy M450H
OR0000071	Oring,Sensor Assy M450H
OR0000072	Oring, Sensor Assy M450H
PS0000011	Switching PS, 40W, 5V,
PS0000012	Switching PS, 20W
PU0000020	Pump, 115V 50/60 Hz
PU0000022	Pump Rebuild Kit, KNF Model #NO5ATI

APPENDIX C - ELECTRICAL SCHEMATIC INDEX

Drawing Number	Title
00514	V/F - I/O Card Assembly
00515	V/F - I/O Card Schematic
00704	Keyboard Assembly
00705	Keyboard Schematic
0147802	Motherboard Assembly
01479	Motherboard Schmatic
01561	I2C/SubMux Assembly
01562	I2C/SubMux Schematic
02322	UV Lamp Supply Assembly
02323	UV Lamp Supply Schematic
0236200	Rear Panel Assembly
02363	Rear Panel Schematic
02571	UV Detector Preamp PCA
02572	UV Detector Preamp Schematic
02654	O3 Sensor Preamp PCA
02655	O3 Sensor Preamp Schematic
03186	Interconnect Diagram