INSTRUCTION MANUAL

MODEL 450
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 450. 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 Teledyne API Model 450 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 450 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 (T-API)

02024b

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-TELEDYNE 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 Teledyne 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 Teledyne 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 TELEDYNE 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 450 uses a mercury lamp constructed so that a large majority of the light emitted is at the 254nm wavelength. Light from the lamp shines down a hollow quartz tube that is alternately filled with sample gas, then filled with gas scrubbed to remove ozone. The ratio of the intensity of light passing through the scrubbed gas to that of the sample forms a 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.

$$C_{O_3} = -\frac{10^9}{\alpha \times \ell} \times \frac{\mathrm{T}}{273^o\,\mathrm{K}} \times \frac{29.92 in Hg}{\mathrm{P}} \times \ell n \frac{\mathrm{I}}{\mathrm{I}_o}$$

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 ppb
T = sample temperature in degrees Kelvin
P = pressure in inches of mercury

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 tube 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 tube.

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.

Every 6 seconds the M450 completes a measurement cycle consisting of a 2 second wait period for the sample tube to flush, followed by a 1 second measurement of the UV light intensity to obtain I. The sample valve is switched to admit scrubbed sample gas for 2 seconds, followed by a 1 second measurement of the UV light intensity to obtain I_O. Measurement of the I_O every 6 seconds minimizes instrument drift due to changing intensity of the lamp due to aging and dirt.

1.4 Specifications

Ranges	User selectable to any full scale range from 1ppm to 1000 ppm
Measurement Units	ppbv, ppmv, ppmw, pphm, µg/m^3, mg/ m^3
Zero Noise	< .0015 ppm (rms)
Span Noise	< .5% of reading (rms) (above 0.1 ppm)
Lower Detectable Limit	< .003 ppm (rms)
Linearity	Better than 1% full scale
Response Time (95%)	<30 sec
Minimum Stream Duration (Cycle Time)*	1.0 min
Sample Flow Rate	1-2.5 L/min
Temperature Range	5-45^o C
Humidity Range	10-90% RH, Non-Condensing
Dimensions (H x W x D)	7" x 17" x 18.2" (178 mm x 432 mm x 463 mm)
Weight	28 lb. (12.7 kg) - Single Channel Monitor, 19" Rack Mount 30 lb. (13.6 kg) - Multi-Channel Monitor, 19" Rack Mount 38 lb (17.3 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 0-20mA Mode**	Maximum voltage between outputs and ground 60V peak

*Multi-Channel Monitor only
**Optional

1.5 Installation (19" Rack Mount Enclosure)

The Model 450 is shipped with the following standard equipment:

1. Power cord.
2. Instruction manual.

CAUTION

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

Upon receiving the Model 450 please do the following:

1. Verify no apparent shipping damage. (If damage has occurred please advise shipper first, then Teledyne API.)
2. Remove all red colored shipping screws from the inside and bottom of the instrument. There are four screws on the optical bench mounts that are accessed from the inside of the instrument and two on the pump bracket that are accessed from the bottom of the instrument. ***Note:*** **Save these shipping screws and re-install them whenever the unit is shipped to another location.**
3. When installing the Model 450, allow a minimum of 4 inches of clearance at the back of the instrument and 1 inch of clearance on each side for proper ventilation.
4. Connect sample inlet line(s) to the sample port on rear panel.

CAUTION

Connect the exhaust fitting on the rear panel (See Fig. 1.1) to a suitable vent outside the monitor area.

NOTE

See Figure 1.1 for rear panel pneumatic connections. Sample lines made from an inert material such as Teflon should be used to minimize sample degradation.

5. Connect the power cord to an appropriate power outlet (see the serial number tag for correct voltage and frequency).

CAUTION

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

6. Turn on the M450 by switching the switch on the lower right corner of the front panel. The front panel display should light with a sequence of messages, -API - M450 - software version number, then a normal display as shown in Figure 2.2.
7. Allow about 20 minutes for the UV lamp temperature to come up to it's setpoint 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 1.2. The values observed should closely match the Table 1.2 values.

NOTE

Words in all caps are messages on the monitor front panel.

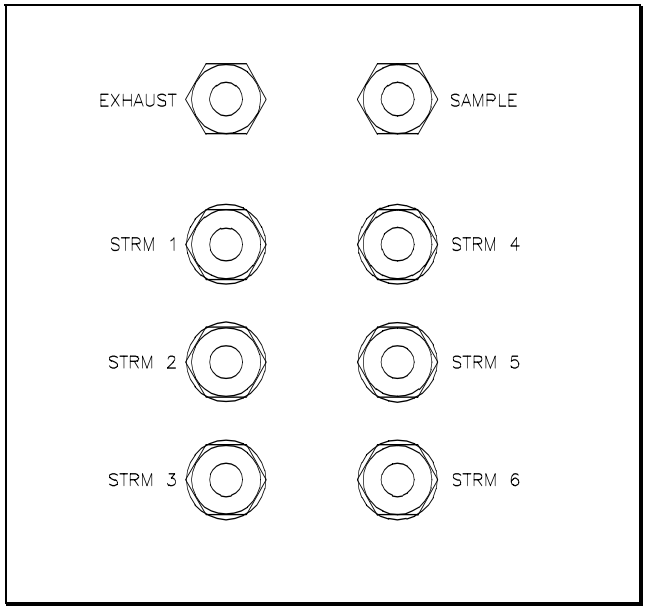


FIGURE 1.1 - REAR PANEL PNEUMATIC CONNECTIONS

1.6 Installation (NEMA 4X, Wall Mount Enclosure)

The Model 450 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 450.

Upon receiving the Model 450 please do the following:

1. Verify no apparent shipping damage. (If damage has occurred please advise shipper first, then Teledyne API.)
2. Mount the NEMA 4X enclosure to a vertical surface using four 5/16" bolts. Mounting hole dimensions are shown in Figure 1.2.
3. Check the serial number tag on the front panel to ensure that the monitor has been configured for the proper AC line voltage and frequency.
4. Route the line power cable through one of the conduit bulkheads on the bottom surface of the enclosure.
5. Connect the line power to the power entry barrier strip shown in Figure 1.3.

CAUTION

Use a 3-wire grounded power cord
and connect as shown in Figure 1.3

6. Route signal wires into the enclosure through the conduit bulkheads. These wires should be routed up to the front panel through the notch in the lower left-hand corner of the front panel as shown in Figure 1.4. Make sure to allow enough extra length in these wires so that the panel can still swing open without stressing the wires.
7. Connect ¼" sample inlet line(s) to the sample inlet fitting(s) shown in Figure 1.5.
8. Connect a ¼" exhaust line to the fitting shown in Figure 1.5.

CAUTION

Connect the exhaust fitting to a suitable vent outside the monitor area.

9. The Model 450 can now be turned on using the power switch located on the front panel.

10. Allow about 20 minutes for the UV lamp temperature to come up to it's setpoint 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 1.2. The values observed should closely match the Table 1.2 values.

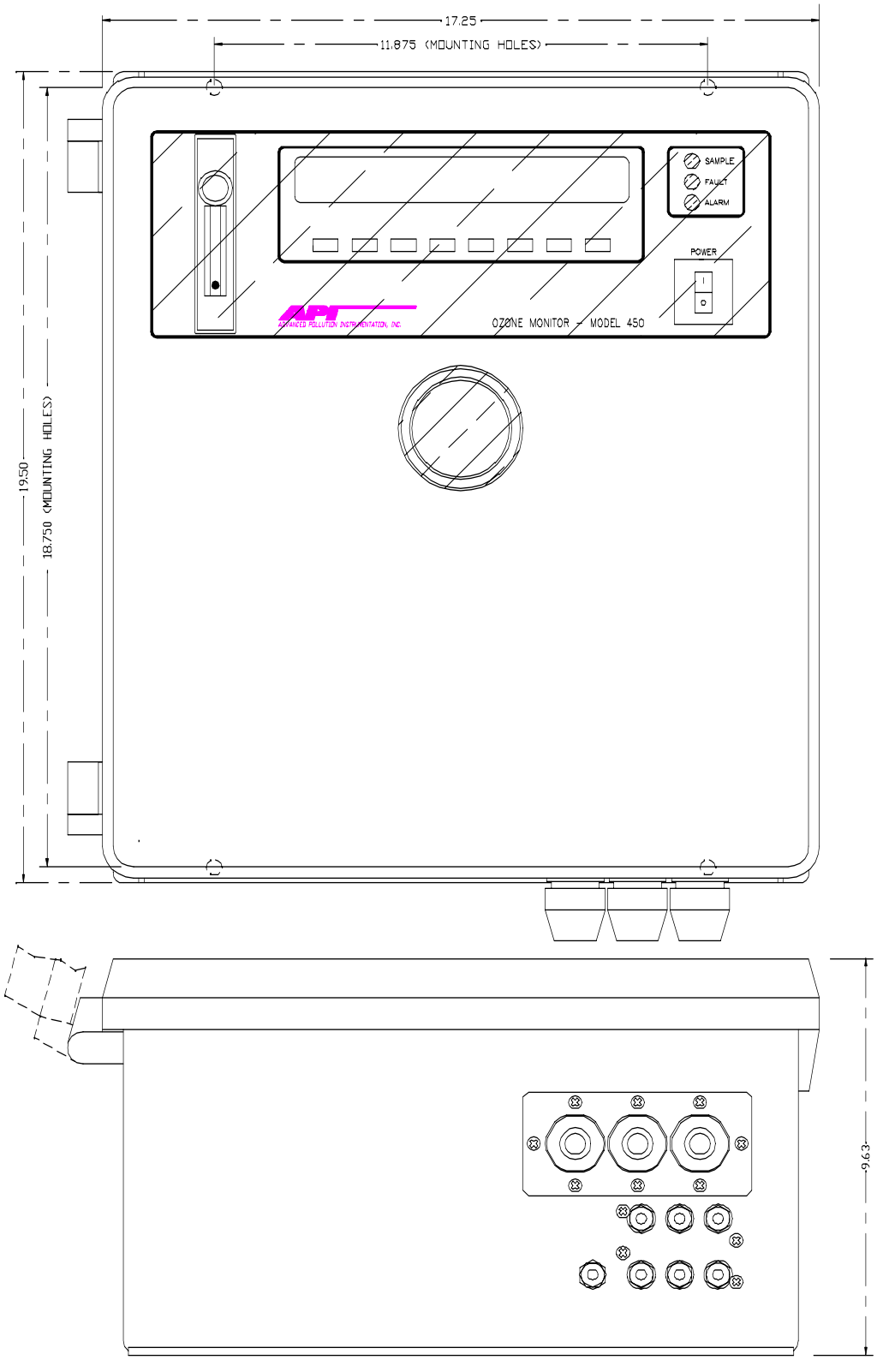


FIGURE 1.2 – NEMA 4X ENCLOSURE DIMENSIONS

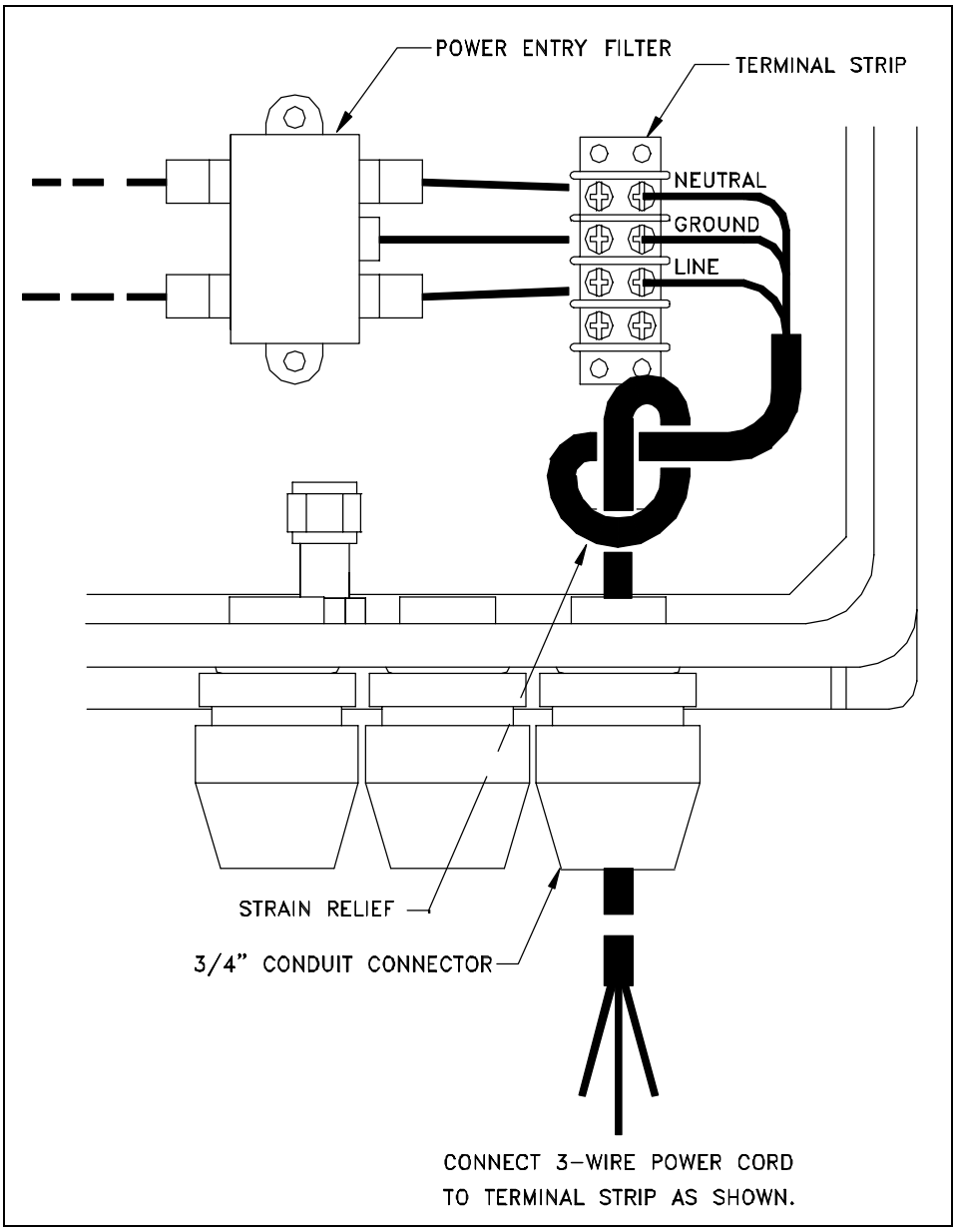


FIGURE 1.3 – NEMA 4X AC LINE POWER CONNECTION

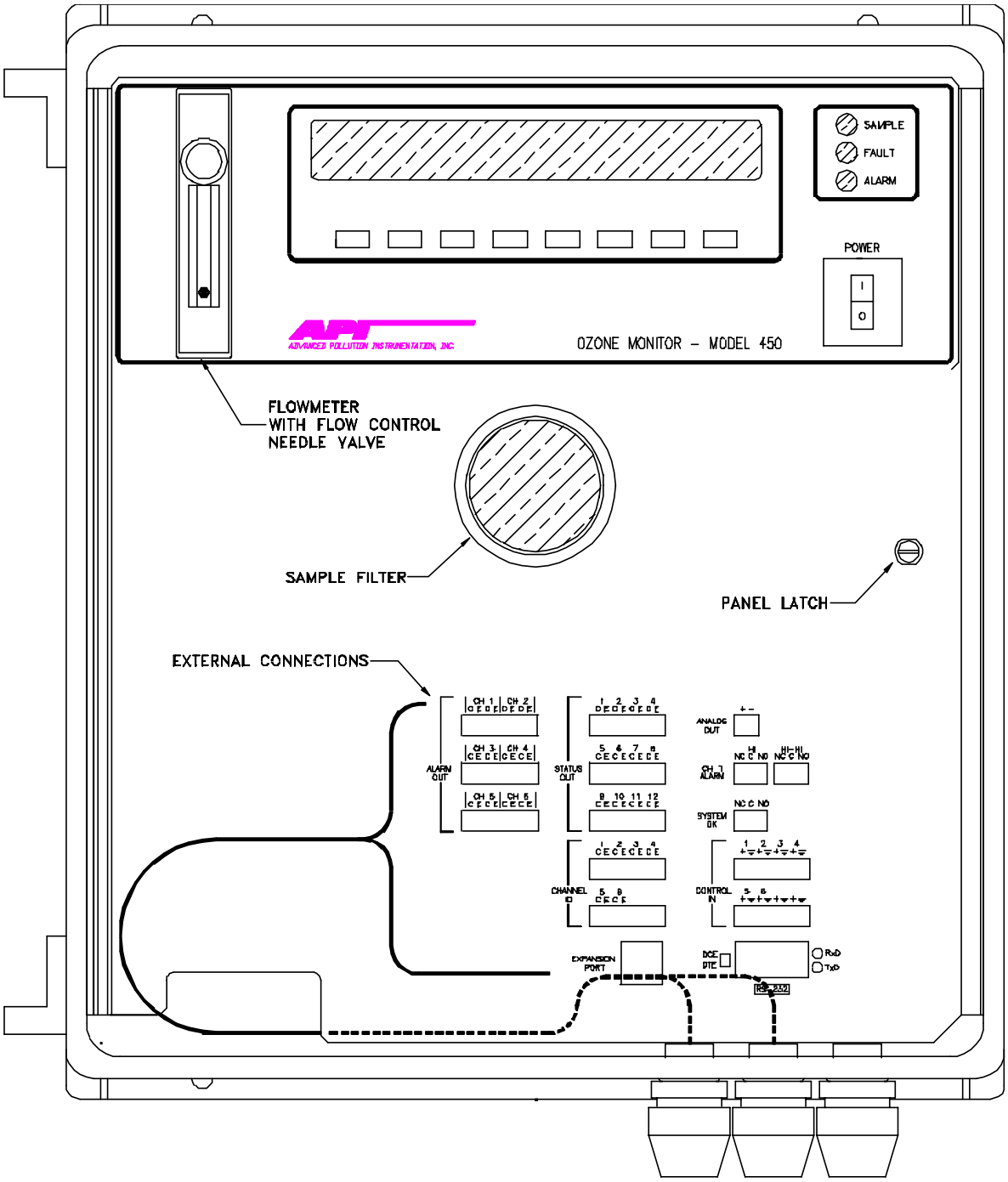


FIGURE 1.4 – NEMA 4X FRONT PANEL

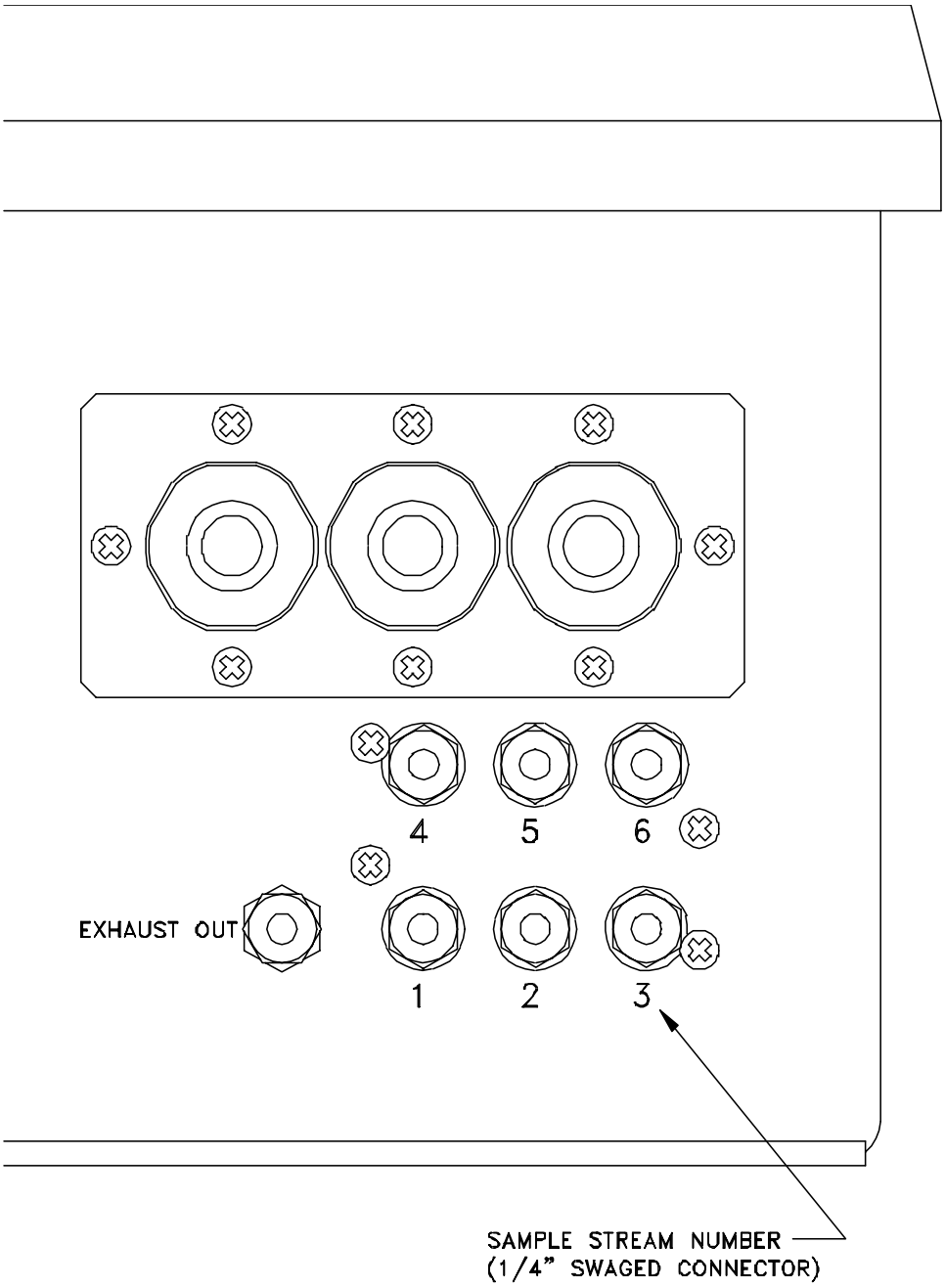


FIGURE 1.5 – NEMA 4X PNEUMATIC CONNECTIONS

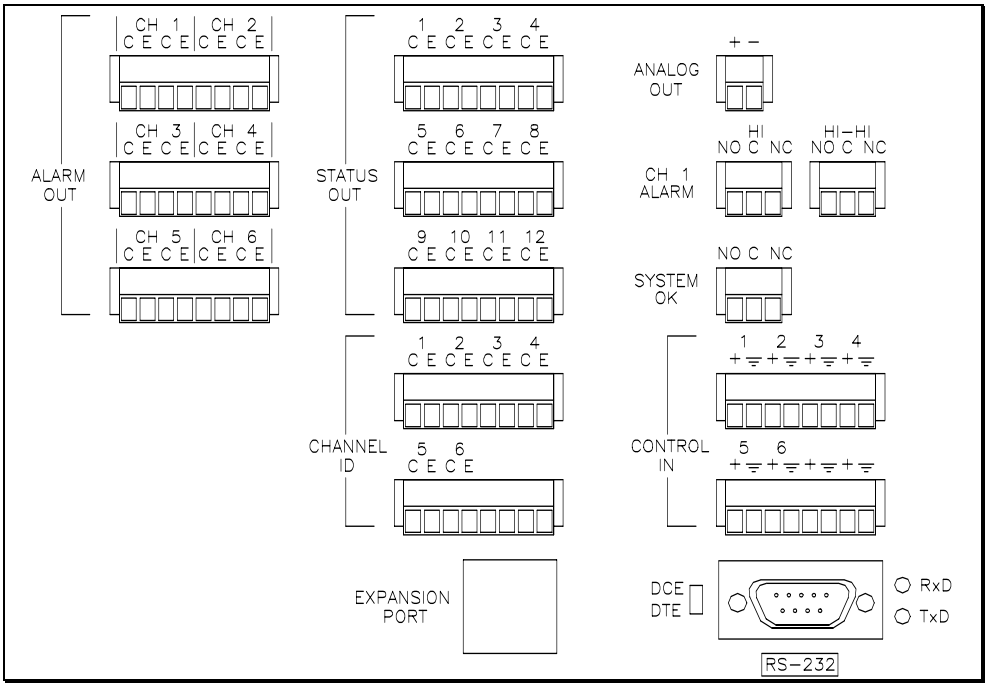


FIGURE 1.6 - ELECTRICAL SIGNAL CONNECTIONS

1.7 Electrical and pneumatic connections

1.7.1 Analog Output

The analog output is a two pin connector on the rear panel (See Figure 1.6). 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 5.3 for information on setting other output ranges.

1.7.2 Relay Outputs

Three form C relay outputs are provided on the rear panel on three pin connectors (See Figure 1.6). These outputs correspond to the 'HI' and 'HI-HI' alarms for Stream 1 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.

1.7.3 Digital Outputs

There are three sets of digital outputs on the rear panel. 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. The outputs labeled ‘CHANNEL ID’ are used to indicate which channel(stream), the instrument is currently monitoring. The outputs labeled ‘ALARM OUT’ are used to indicate the status of the HI and HI-HI alarms for each channel. Table 1.1 below summarizes the functions of all the digital outputs.

Output	Description
STATUS OUT	
1	Power OK
2	Diagnostics Mode(Instrument not monitoring)
3	Temperature Fault
4	Pressure Fault
5	UV Lamp Fault
6	Flow Fault
7-11	Not Used
12	System OK(no faults)
CHANNEL ID	
1	Monitoring Stream #1
2	Monitoring Stream #2
3	Monitoring Stream #3
4	Monitoring Stream #4
5	Monitoring Stream #5
6	Monitoring Stream #6
ALARM OUT	
CH 1	HI and HI-HI alarms for Stream #1
CH 2	HI and HI-HI alarms for Stream #2
CH 3	HI and HI-HI alarms for Stream #3
CH 4	HI and HI-HI alarms for Stream #4
CH 5	HI and HI-HI alarms for Stream #5
CH 6	HI and HI-HI alarms for Stream #6

TABLE 1.1 DIGITAL OUTPUTS

Each digital output is configured as a Collector/Emitter pair. The rear panel labels are ‘C’ and ‘E’ for these contacts, respectively. Figure 1.7 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.

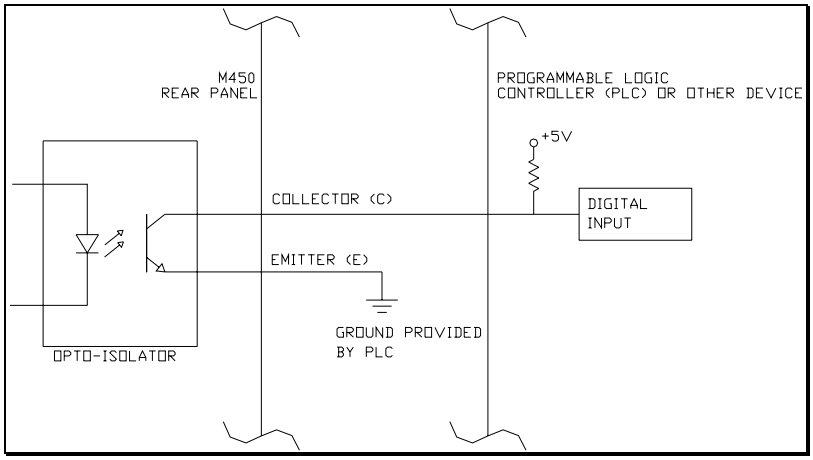


FIGURE 1.7 - CONNECTING DIGITAL OUTPUTS TO AN EXTERNAL DEVICE

1.7.4 RS232 Output

The RS232 output is provided on the 9-pin D-Sub connector shown in Figure 1.6. 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. 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.

1.7.5 Pneumatic system

Figure 1.8 shows a block diagram of the M450 pneumatic system. The Model 450 is equipped with a vacuum pump that pulls the sample gas through the instrument. The sample flow is set using the needle valve located on the front panel flowmeter. The sample flow should be 1-2.5 L/min. A sample flow of less than 1 L/min will result in inaccurate ozone measurement.

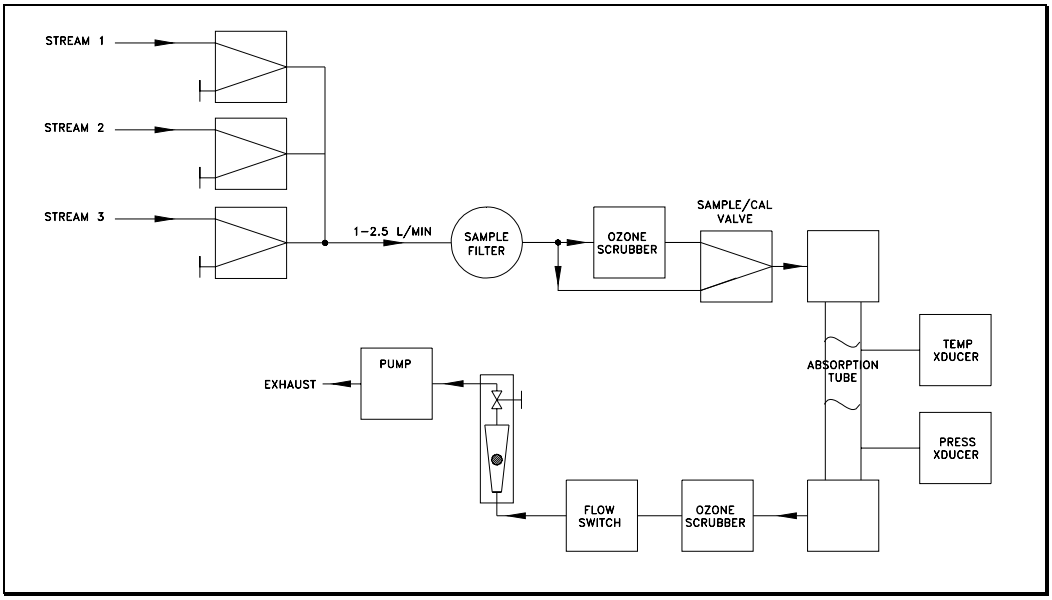


FIGURE 1.8 - FLOW DIAGRAM

1.7.6 Sample gas connection

1/4" O.D. PTFE or FEP (Teflon™) tubing is needed to connect the sample source to the monitor. Any fittings used in the sample lines should be constructed of stainless steel or PTFE.

Teledyne API recommends that the length of tubing connecting the sample points to the monitor should be kept to 100 feet or less. When running long sample lines, maintaining a high sample flow near 2 L/min will aid in reducing ozone loss in these lines. If more than 100 feet of sample line must be used, check to make sure that the pressure drop between the sampling point and the monitor be kept to 5 in-Hg or less. This can be measured by observing the Sample Pressure test function on the front panel of the instrument with the sample line connected at the rear panel and with the sample line disconnected. The difference between the two pressures is approximately equal to the pressure drop in the sample line.

NOTE

For the sampling lines, use only ¼" O.D. PTFE or FEP tubing. The tubing must be pre-conditioned to ozone prior to installation to minimize ozone loss in the sampling lines. Pre-conditioned ¼" FEP tubing is available from Teledyne API (Part number 02639)

Provision should be made for keeping dust and other particulate matter out of the monitor. As an option, the monitor may be configured with a PTFE particulate filter downstream of the stream selector manifold. In addition to this, in-line filters should be installed in the sample lines for each stream. To avoid dust build up in the sample lines, these filters should be placed at the inlet end of the sampling line. These filters should be

constructed of PTFE or other inert material to avoid degradation of the ozone concentration. Contact Teledyne API's sales department for additional information on particulate filters.

Care must be taken in the design of the sampling system to ensure that water vapor does not condense in the sampling lines or in the instrument itself. The sample lines should be routed to avoid large temperature gradients along the lines. If sample is brought in from a hot, humid area into a much cooler area, then low power heating tape should be wrapped around the lines to keep the temperature of the sample lines up and avoid condensation. The lines should also not have loops or low points where water could collect.

For applications that require sampling of very humid gas, a Sample Conditioner may be required to lower sample gas humidity. Please contact the Teledyne API Sales Department for additional information.

1.7.7 Exhaust connections

A single 1/4" O.D. tube should be connected from the Monitor sample exhaust to an area outside of the room the monitor occupies. The maximum length of the exhaust line should not exceed 30 feet.

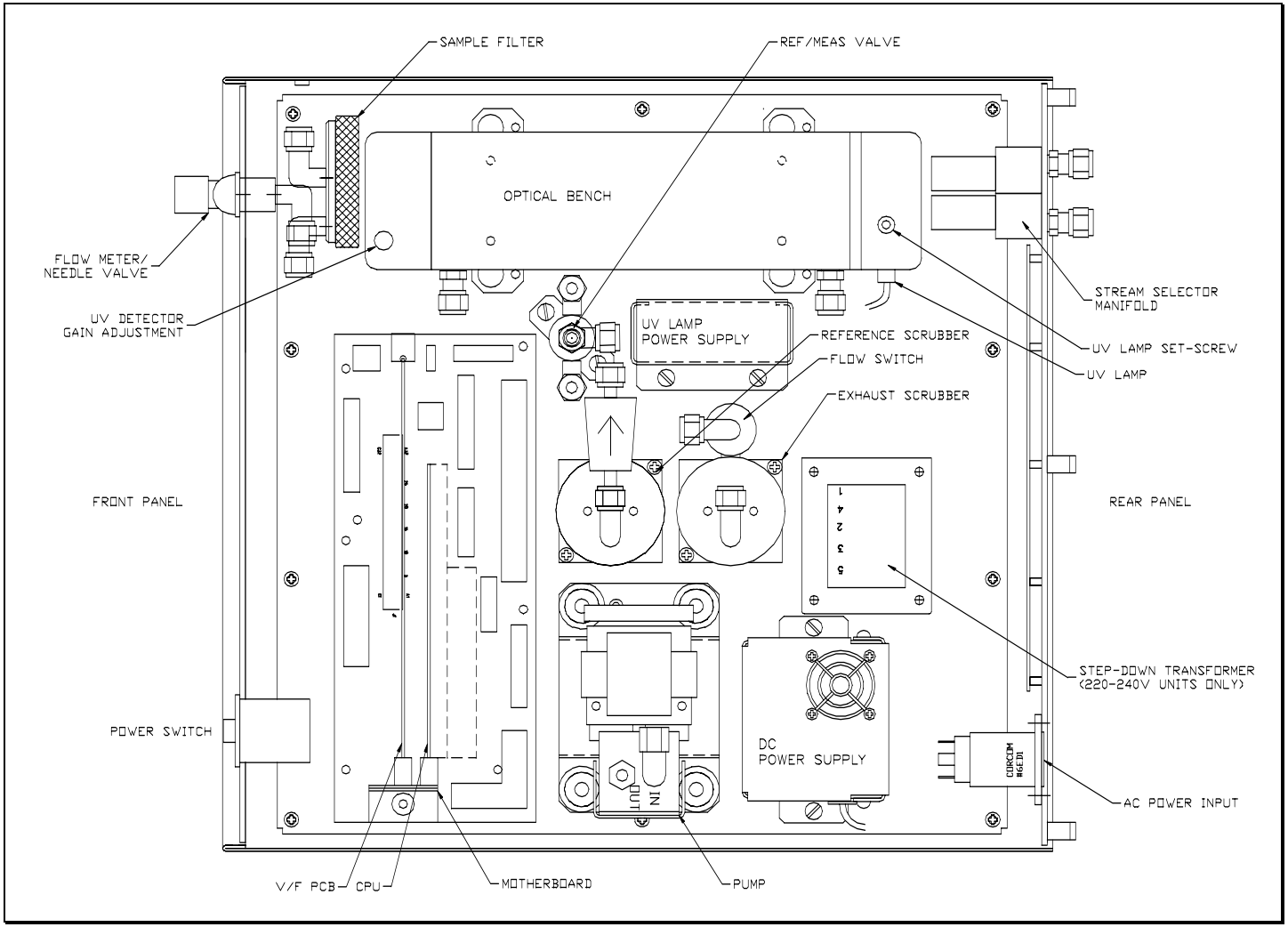


FIGURE 1.9 - M450 ASSEMBLY LAYOUT

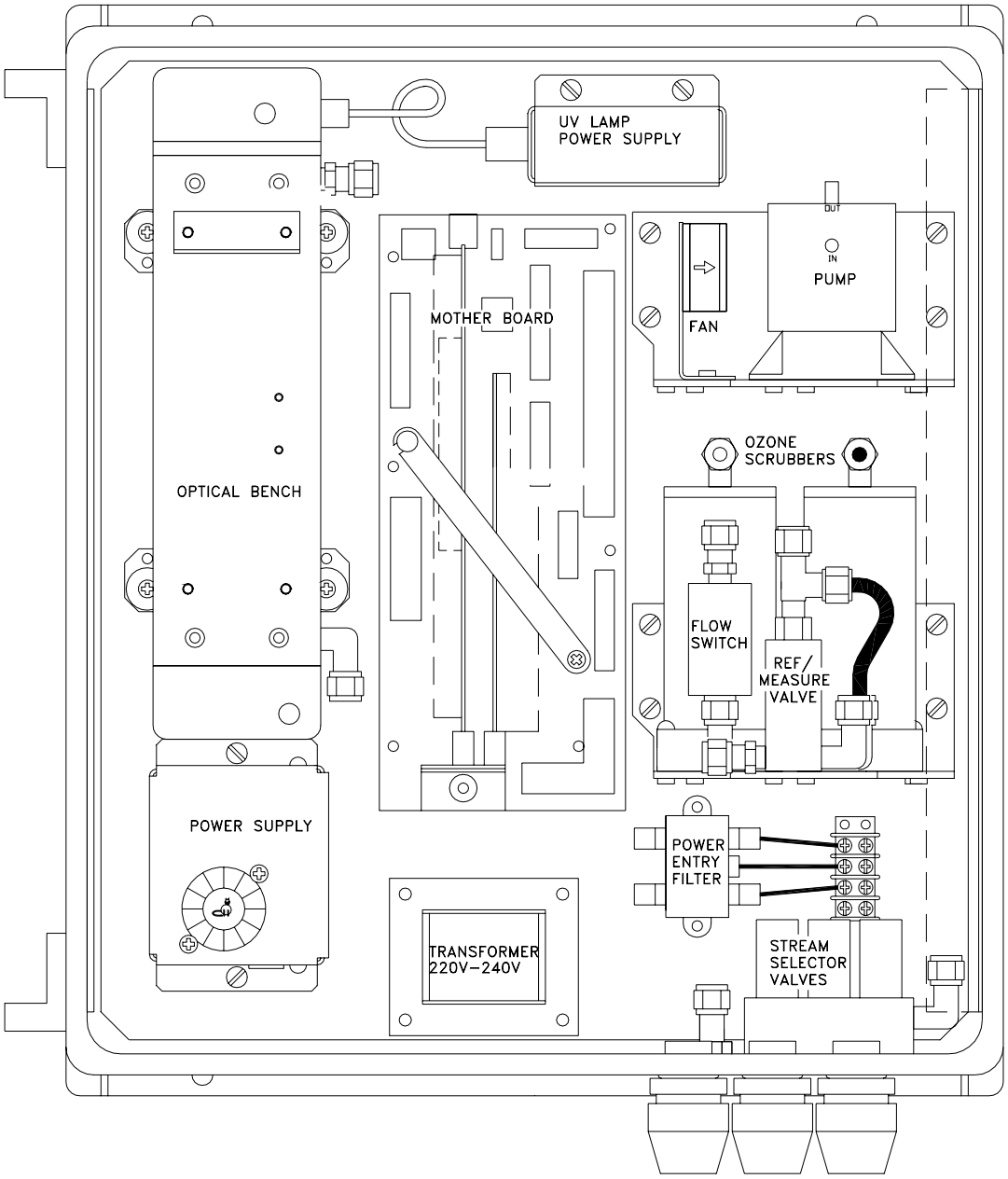


FIGURE 1.10 - M450 NEMA 4X LAYOUT

1.7 Operation verification

The Model 450 Monitor is now ready for operation.

1. Read Sections 1.3 and all of Section 4 of the manual to understand the Monitor's operation.
2. Turn on the power by pressing the on/off switch on the front panel (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 flows, temperatures and voltages are within operating limits. Clear the fault messages.
3. Sample Flow - Adjust to 1-2.5 L/min using needle valve on flowmeter.
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 - 29 to 30 Inches-Mercury-Absolute 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**
SAMPLE TEMP		**°C**	**20-50**
FLOW		**L/MIN**	**1-2.5**
Span Values			
Noise at Zero(rms)		**PPB**	**.5-1.5**
Noise at Span(rms)		**PPB**	**.5% of reading**

Factory Installed Options	Option Installed
Power Voltage/Frequency	
Stream Selector (3 channel)	
Stream Selector (6 channel)	
Sample Filter	
Flow Switch	
All SS Fittings	
Rack Mount, w/ Slides	
Isolated 4-20mA Output	
Voltage Range	**0- _____V**

PROM Rev # _____ Serial # _____

Date _____ Technician _____

TABLE 1.2 FINAL TEST AND CALIBRATION VALUES

1.8 Options

1.8.1 Stream Selector (3 or 6 Channel)

This option allows the M450 to measure ozone at up to six different sampling points by using an internal stream selector. 3 or 6 channel stream selectors are available. This option includes digital outputs for HI and HI-HI alarms and a channel ID for each channel in the stream selector.

1.8.2 Sample Filter

This option consists of a 47mm diameter PTFE particulate filter inside the instrument. In instruments with the stream selector option, this filter is placed immediately downstream of the stream selector. The filter can be easily accessed through the front of the instrument by folding down the hinged front panel. No tools are necessary to change the filter element.

1.8.3 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 off the System OK relay, indicating an instrument error.

1.8.4 Isolated Current Output(4-20mA)

This option converts the M450's voltage output to an isolated 4-20mA driver with an integral loop power supply. When connecting to the current output, ensure that the maximum voltage between the outputs and ground is 60V peak.

1.8.5 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.

2.0 OPERATION

2.1 Key features

The important features of the Teledyne API Model 450 O_3 Monitor are listed below.

2.1.1 O_3 readout

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

If a multi-channel option has been installed, the reading represents the ozone concentration for the stream currently being monitored. The last concentration measurement for the other channels can be viewed by scrolling through the Test functions (See Section 2.2.)

2.1.2 Stream Selector (Optional)

As an option, the Model 450 can be equipped to sequentially monitor up to 6 separate sample streams. The monitoring duration for each stream as well as the sequence order can be configured by the user through the front panel software. See Sections 3.1 and 3.2 for stream and configuration sequencing.

2.1.3 Concentration Alarms

The Teledyne API O_3 Monitor provides two concentration alarms, HI and HI-HI, per sample stream. The concentrations corresponding to each alarm levels can be independently configured for each sample stream. In addition, the alarms can operate in either latching or non-latching modes.

2.1.4 O_3 analog output

The Teledyne API O_3 Monitor provides an analog output of the current O_3 reading on the rear panel (see Figure 1.6). The output can be configured for 0-100mV, 0-1V, 0-5V, 0-10V or 4-20mA non-isolated current output. 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.

2.1.5 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 5.3.

2.1.6 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.

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 buttons 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.

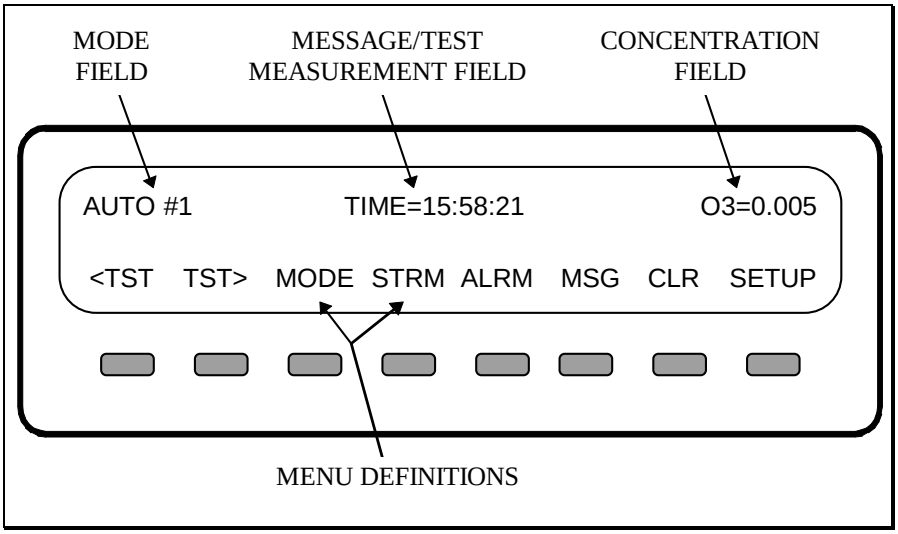


FIGURE 2.1 - MODEL 450 FRONT PANEL

Mode Field

The mode field indicates the current mode of the Monitor. If it shows "AUTO #1", the instrument is in the automatic sequence mode(multi-stream instruments only) and that stream #1 is the active stream. Table 2.1 lists all the possible modes in the Monitor and their meanings.

Mode	Meaning
AUTO #x	Measuring stream #x in auto sequence mode(multi-stream instruments only)
MANUAL #x	Measuring stream #x in manual mode
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)	

TABLE 2.1 SYSTEM MODES

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)
STREAMx=x.xxx PPM	Current O_3 concentration for stream x
O3 MEAS=xxxxx MV	Current UV reading, measure channel
O3 REF=xxxxx MV	Current UV reading, reference channel
PRES=xxx IN-HG-A	Absorption cell pressure - inches Hg
SAMPLE TEMP=xxx C	Temperature of the sample (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
ANA LAMP WARNING	UV lamp < 2500mV OR => 5000mV
ANA 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
SAMPLE TEMP WARNING	Sample 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 450 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
	Blinking	Monitoring, Manual Mode
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 450 with the multi-stream option.

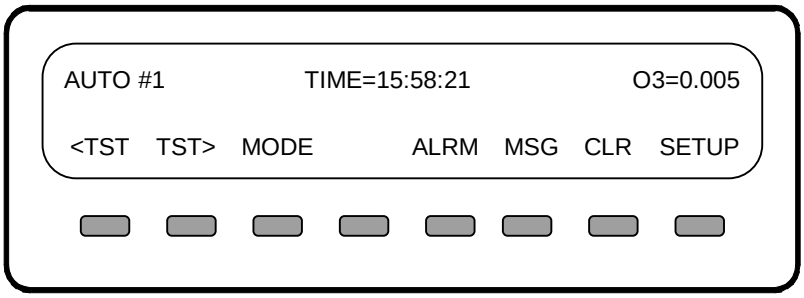


FIGURE 2.2 - MAIN MENU

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.

The **MODE** button will toggle the instrument between Auto and Manual modes. The current mode is shown in the upper left-hand corner of the display. In Auto mode, the instrument will continuously cycle through a user defined sequence of streams(See Section 3.2 for sequence configuration.) When the instrument is in manual mode, it will hold on a particular stream being measured until the user switches back to Auto mode or manually switches to a different stream. Figure 2.3 below shows the main menu when the instrument is in Manual mode.

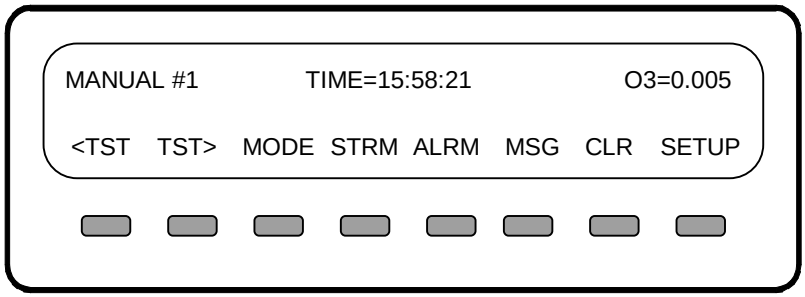


FIGURE 2.3 - MAIN MENU, MANUAL MODE

In Manual mode, the **STRM** button appears. Pressing this button will manually cycle through the available streams. Press **STRM** until the stream you wish to monitor appears in the mode display in the upper left-hand corner of the display. The instrument will hold and monitor this stream until the user places the instrument into Auto mode or manually switches to another stream by pressing the **STRM** button again.

Pressing **MODE** will toggle the instrument back to Auto mode and the automatic sequence will resume.

2.3.2 Multi-Stream Operation

This section describes the operation of the Multi-Stream M450 in automatic sequence mode (AUTO.) In this mode the monitor is designed to continuously cycle through a user-defined sequence of sampling points. This cycling is accomplished by activating valves on the stream selector manifold on the rear panel to admit sample gas for a particular stream.

When the M450 first switches to a new sample stream, the instrument goes through a 30 second dwell phase where sample gas is pulled from the new sample stream but no readings are taken. The purpose of this dwell phase is to purge out any “old” sample gas

that has been sitting in the sample line while that stream was inactive. During the dwell phase the Concentration field on the display (see Figure 2.1) will blink and the instrument will display the last concentration recorded for that stream. After the 30 seconds has elapsed, the concentration field will stop blinking and the current concentration will be displayed. The current stream will now be monitored for the rest of the Monitoring Duration that has been set for that stream (see Section 3.2 for details on configuring the individual streams.) The actual time period that the stream is measured is the Monitoring Duration minus the 30-second dwell. So a 1-minute Monitoring Duration consists of 30 seconds of dwell followed by 30 seconds of measurement.

For systems that do not require a 30 second dwell between streams, this value can be changed. Please consult Teledyne API Customer Service for instructions on how to do this.

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 2.4.

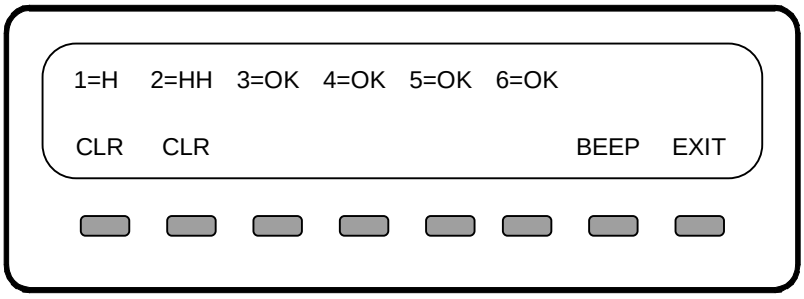


FIGURE 2.4 - ALARM STATUS MENU

The Alarm menu displays the alarm status of all available streams along the top row of the display. The status of each stream is indicated by a one or two letter code shown in Table 2.5 below.

Alarm Code	Meaning
OK	No alarms triggered
H	'HI' alarm triggered
HH	'HI-HI' alarm triggered

TABLE 2.5 ALARM CODES

Clearing Alarms

If the monitor is configured for Latching type alarms, then a **CLR** button will appear below each stream with an active alarm. Pressing the **CLR** button will clear the alarm

condition, provided that the concentration for that stream has dropped below the alarm threshold.

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 one ore more 'HI' alarms has been triggered, and a fast beep indicates that one or more 'HI-HI' alarms 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 3.2 and 3.6 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.

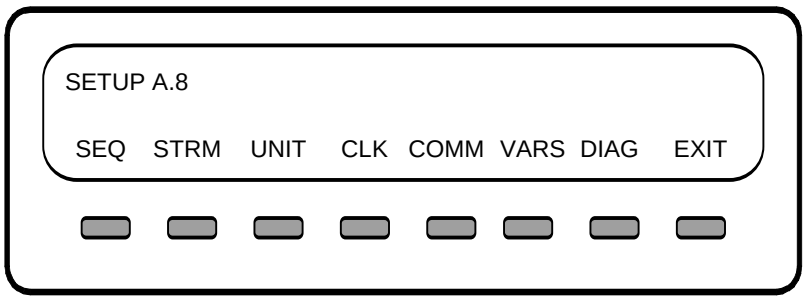


FIGURE 3.1 - SETUP MENU

3.1 Configuring Auto Sequence (SEQ)

The automatic sequence determines the monitoring order for the streams in a multi-stream instrument. The default setting for a six channel instrument is 1-2-3-4-5-6. With this setting the instrument will cycle through all six channels in numerical order and loop back to the beginning when the cycle is complete. This sequence can be modified, however, to cycle through the channels in any order desired. The sequence can also be modified to monitor certain streams more often than others, 1-2-1-3-1-4-1-5-1-6 for example.

To modify the auto sequence, press **SEQ** from the setup menu. The sequence editing screen is shown in Figure 3.2 below.

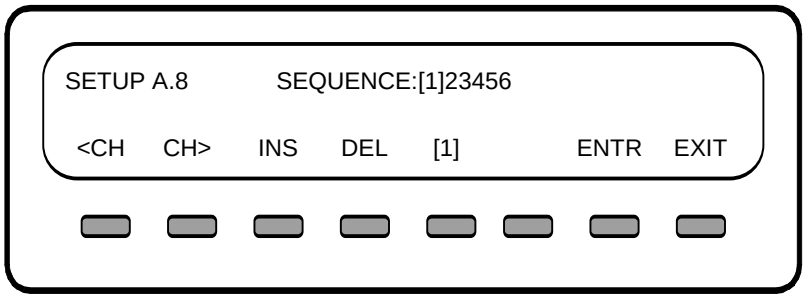


FIGURE 3.2 - SEQUENCE EDITING

The current sequence is shown at the top center of the display as a string of digits. Each digit in the sequence represents a stream number. To edit a digit, press the **<CH** or **CH>** buttons until the digit you wish to edit is shown in brackets []. As you scroll through the steps in the sequence, the digit in brackets is displayed above one of the buttons on the display. To change this digit to another stream number, simply press the button below the digit to increment the stream number. Pressing **INS** will insert a digit in front of the bracketed digit and pressing **DEL** will delete the bracketed digit. A stream can be inserted in the sequence more than once. The sequence can consist of a maximum of 12 digits.

When you are finished editing the sequence, press **ENTR** to store the new sequence in memory. The new sequence remains in memory even when the instrument is powered down. Pressing **EXIT** will exit the sequence editing menu without saving any changes.

3.2 Stream Configuration (STRM)

The stream configuration menu is used to set alarm thresholds, monitoring duration, and analog output ranges for each individual stream. This menu is accessed by pressing the **STRM** button from the setup menu. The stream configuration menu is shown in Figure 3.3 below.

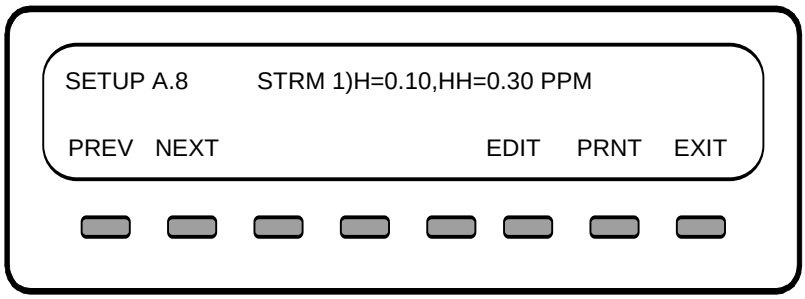


FIGURE 3.3 - STREAM CONFIGURATION MENU

Pressing **PREV** or **NEXT** will cycle through the available streams. The top center of the display shows the stream number and a summary of the alarm thresholds for this stream. In the example shown in Figure 3.3 above, Stream 1 is configured for a HI alarm at 0.10 PPM and a HI-HI alarm at 0.30 PPM.

To edit the parameters for a particular stream, scroll using the **PREV** or **NEXT** buttons until the stream is displayed on the top line. Press the **EDIT** button. A series of prompts will now be displayed 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:0.100 PPM

The default value for the HI alarm threshold is 0.100 PPM. 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:0.300 PPM

Edit the HI-HI alarm value and press **ENTR** to store the value. The next prompt is:

ANA. OUT RANGE: 1.000 PPM

This is the analog output range setting. This is the concentration level that will correspond to a full scale voltage or current(4-20mA) output at the instrument's analog output on the rear panel. Edit this value and press **ENTR**. The next prompt is:

MONITOR DUR.: 10.00 Minutes

This prompt sets the monitoring duration for a particular stream. The monitoring duration includes a 30-second purge cycle at the beginning of each measurement. During the purge cycle, the monitor takes no readings. Therefore, for a monitoring duration of 10 minutes, the instrument will purge for 30 seconds and then take readings for the next 9 minutes, 30 seconds before switching to the next stream in the sequence.

Pressing **ENTR** takes you back to the main stream configuration menu shown in Figure 3.3. You may now scroll to another stream and repeat the steps shown above or press **EXIT** to exit back to the previous menu.

3.3 Setting the Concentration Units (UNIT)

To set the concentration units, press **UNIT** from the setup menu. The default concentration units are PPM(Parts per Million). Table 3.1 below lists the units available.

Software Abbreviation	Unit
PPB	Parts per Billion by Volume
PPHM	Parts per Hundred Million by Volume
PPM	Parts per Million by Volume
PPMW	Parts per Million by Weight
UGM	Micrograms per Cubic Meter($\mu g/m^3$)
MGM	Milligrams per Cubic Meter(mg/ m^3)

TABLE 3.1 CONCENTRATION UNITS

3.4 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.

3.5 Setting the RS-232 baud rate (COMM)

To set the baud rate for the RS-232 channel, press **SETUP-COMM-BAUD**. Press **300**, **1200**, **2450**, **4800**, **9600**, or **19.2** followed by **ENTR** to accept the new baud rate, or **EXIT** to leave the baud rate unchanged.

3.6 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.

2) ANA_OUTPUT_MODE
This variable sets the Analog Output Mode for the Model 550 relay box accessory, if this is installed. This variable has no effect on the analog output of the M450 itself. The possible selections are: CURR (0-20mA or 4-20mA), 0.1V, 1.0V, 5V, 10V.

3) 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.

4) STD_TEMP, 5) STD_PRESS
These variables are the standard temperature and pressure that are used to calculate the concentration when the units are set to Micrograms per Cubic Meter($\mu g/m^3$) or Milligrams per Cubic Meter(mg/ m^3). These variables do not affect the ozone measurement in PPM or PPB units.

6) RS232_MODE
This variable sets the mode of operation for the RS232 interface. For more details on the use of the RS232 interface, please contact Teledyne API and request document number 01350.

7) 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.

4.0 Maintenance

4.1 Replacing the sample filter element

If your Model 450 has been equipped with an internal or external sample filter, the Teflon™ filter elements must be replaced on a regular basis to ensure accurate readings from the M450. The frequency of this operation will be determined by the particulate loading from the air being sampled and will vary greatly from location to location. When the instrument is first installed, the sample filters should be checked at least once a week for dirt loading and replaced if necessary. Once the replacement frequency is determined, a regular schedule for filter replacement should be instituted.

For replacement 47mm Teflon filter elements, please contact Teledyne API's sales department and request part number 00969.

Filter Replacement Procedure:

1. If the M450 has been equipped with an internal filter, access the filter by releasing the two quick-release tabs near the top of the front panel. The front panel will now swing down and the filter element can be viewed through the glass cover on the filter assembly, which is located on the left hand side of the panel.
2. To replace the element, unscrew the black knurled ring over the glass cover and carefully remove the glass cover and the white Teflon retaining ring over the element. The element can now be removed and replaced.
1. Replace the Teflon retaining ring and glass cover. **Note: When re-installing the Teflon retaining ring, make sure the notches in the ring are visible and facing up towards the glass cover.**

NOTE

Take care when handling the filter element and the sample filter parts that they are not contaminated with oil from your fingers or other sources. Even a small amount of oil on the wetted surfaces can cause the instrument to respond very slowly to ozone. Clean gloves or tweezers should be used to handle the clean filter elements.

2. Screw the black ring onto the glass cover. The ring should be screwed to a snug position by hand, no tool should ever be used for installing the knurled ring.

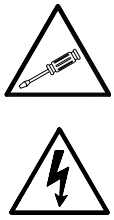
4.2 Cleaning Exterior Surfaces of the M450

If necessary, the front panel mask and keyboard of the M450 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.

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 450 is calibrated to NIST traceable standards on the 0-1 ppm range prior to shipment. A calibration certificate for your instrument can be purchased from Teledyne API if required. Teledyne API also recommends that the Model 450 be re-calibrated once a year. Teledyne API can provide NIST traceable calibration services at our factory or on-site. Please contact our Customer Service department for details on these services.

5.2 Adjusting UV lamp and detector

Basic operation of the source lamp and detector can be determined by observing the value of the O3 REF test function. After the analyzer is warmed-up (15 min. to 30 min. after power-on), this value will give a good indication of the state of Lamp and Detector operation as follows:

UV Source Lamp and Detector Diagnostics	
O3 REF Value	**Meaning**
4700 mV to 5000 mV	The Source Lamp and Detector are operating, but adjustment is required
4000 mV to 4700 mV	The Source Lamp and Detector are operating properly; no adjustment is needed
2500 mV to 4000 mV	The Source Lamp and Detector are operating. Adjustment is useful but not required
150 mV to 2500 mV	The Source Lamp and Detector are operating, but adjustment is required
90 mV to 150 mV	Either the Source Lamp or the UV detector is not functioning
Less than 90 mV	The Detector Pre-Amp or V/F Board has failed or is disconnected

TABLE 4.1 UV SOURCE LAMP AND DETECTOR DIAGNOSTICS

Adjustment required or Adjustment useful:

The first adjustment that should be made is to adjust the gain on the UV Detector Preamp. The adjustment for the preamp is located through the preamp cover at the front of the optical bench (See Figure 4.1). The preamp should be adjusted to 4500 mV +/- 100mV.

If the preamp cannot be adjusted to achieve this value, additional adjustment can be made by rotating the lamp inside the lamp housing at the rear of the optical bench(See Figure 1.9.) To adjust the lamp, loosen the lamp set-screw on the top of the optical bench and slowly rotate the lamp while observing the O3 REF value. Re-tighten the lamp setscrew.

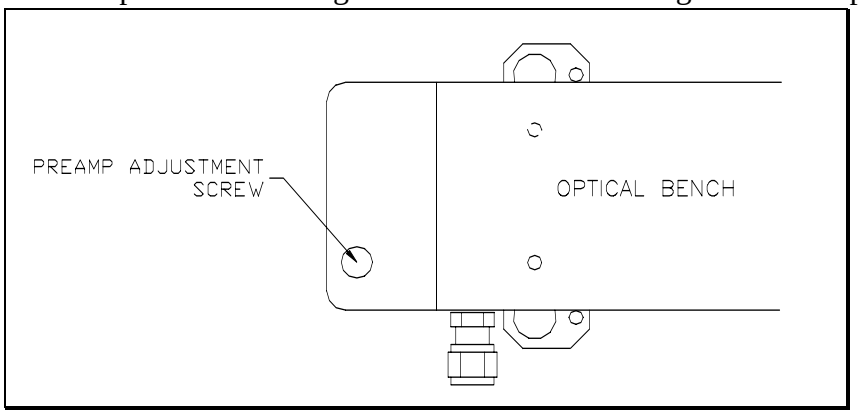


FIGURE 4.1 - DETECTOR PREAMP ADJUSTMENT

If it is not possible to achieve an acceptable O3 REF test Value by means of adjustment, it is possible that the lamp has deteriorated beyond its useful range and should be replaced.

Lamp or Detector Failure:

WARNING

UV LIGHT PRESENT

DO NOT LOOK DIRECTLY AT THE UV LAMP SINCE UV LIGHT COULD CAUSE EYE DAMAGE. ALAWYS USE UV FILTERING GLASSES OR VIEW THROUGH GLASS.

A O3 REF value of approximately 125 mV usually indicates a total failure of either the source lamp or the detector. To determine which component is at fault, remove the top cover of the optical bench and observe the "lamp end" of the glass absorption tube. If a blue-white light is visible, the lamp is operating and the detector is at fault and should be replaced. If no light is visible, the UV lamp should be replaced. Please contact Teledyne API for obtaining replacement parts.

NOTE

In cold ambient conditions, it may require 5 to 15 minutes of warm-up before the source lamp initially fires. Be sure to wait for this period before troubleshooting the lamp/detector.

5.3 Changing the analog output range

5.3.1 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 1.9.
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 5.4.

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

5.3.2 Current Output (Optional)

To configure the M450 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.

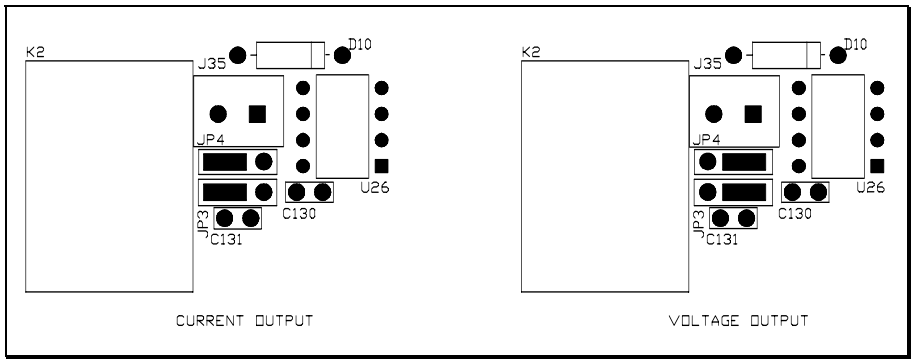


FIGURE 4.2- ANALOG OUTPUT JUMPERS

5.4 A/D - D/A Calibration Procedure

Due to the stability of modern electronics, this procedure should not have to be performed more than once a year or whenever a major sub-assembly is exchanged or whenever analog output voltage range is changed .

To calibrate the ADC, do the following:

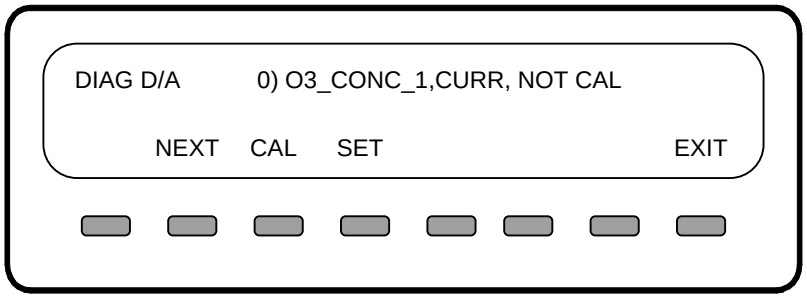
1. Press **SETUP-DIAG**.
2. Enter Diagnostic password and press **NEXT** until D/A CALIBRATION appears in the display and press **ENTR**.
3. Press **ADC** to perform the A/D Cal.

4. The M450 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 M450 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 M450 display matches the value on the voltmeter to within +/- 2 mV. *Note that when adjusting R27, the value on the M450 display will change, the value on the voltmeter will remain constant.*
7. Press **ENTR**.
8. The M450 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 M450 display matches the value on the voltmeter to within +/- 2 mV.
10. Press **ENTR**.
11. The ADC is now calibrated and the M450 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.

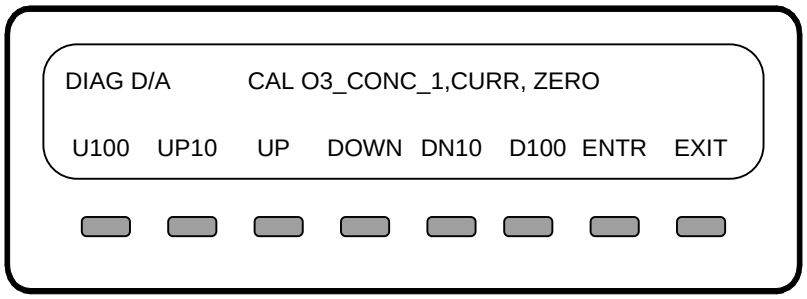
5.5 Current Loop Calibration

A current loop option can be ordered that will provide 0-20mA or 4-20mA analog 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 5.4.
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.

6.0 MODEL 450 SPARE PARTS

002760450	ASSY, CPU, 256K PROM/SW, M450 (AMX)
003290000	THERMISTOR, BASIC
004204000	ASSY, O3 PROM W/SOFTWARE, M450
005140300	PCA, V/F CARD, W/ SCHEMATIC
005260100	ASSY, BENCH LAMP, M400/M401/M700
007040000	PCA, KEYBOARD DISPLAY
007280000	DISPLAY ASSY
009690000	AKIT, TFE FLTR ELEMENTS, 47MM, (100)
009690100	AKIT, TFE FLTR ELEMENTS, 47MM, (25)
019300000	PCA, KEYBOARD DISPLAY, CEMARK
020280000	PCA, UV DET PREAMP, M400A/M450
022920000	ABSORPTION TUBE, M450
023430000	ASSY, REF SCRUBBER, M450
023430100	OPTION, OZONE SCRUBBER, W/FLOW SWITCH
023430200	ASSY, OZONE SCRUBBER, W/O FLOW SWITCH
023480000	FILTER PAD, OZONE SCRUBBER, M450
023620000	PCA, REAR PANEL, M450
023620100	PCA, REAR PANEL, SINGLE CHANNEL, M450
023850000	ASSY, OPTICAL BENCH, M450, 1000PPM
023900000	ASSY, UV LAMP SUPPLY, M450
023930000	ASSY, PRESSURE XDUCER, M450
023940000	ASSY, SWITCHING VALVE, M450
023950000	MANUAL, INSTRUCTION, M450
024020000	OPTION, SAMPLE FILTER, M450 (47MM)
024040000	ASSY, POWER SUPPLY MODULE, M450
024140000	ASSY, SAMPLE THERMISTOR, M450
024190000	ASSY, HTR/THERM, OPTICAL BENCH, M450
024190000	ASSY, OPTICAL BENCH HEATER/THERMISTOR
FL0000003	FILTER, DFU
FM0000014	FLOWMETER W/NEEDLE VALVE, .2-2.5LPM
FM0000015	FLOW SWITCH, ACRYLIC 560 CCM
HW0000036	TFE TAPE, 1/4" (48 FT/ROLL)
HW0000037	TIE, CABLE
HW0000150	CLAMP, HOSE, NYLON, 1/4"
OP0000012	PHOTOTUBE, ALSO SEE OP1
OR0000011	ORING, 2-109S
OR0000014	ORING, 2-116V
OR0000048	ORING, 2-112S
OR0000061	ORING, 2-113S
OR0000069	ORING, 2-129V
PS0000011	SWITCHING PS, 40W, +5V, +/-15V
PS0000012	SWITCHING PS, 20W, 12V
PU0000020	PUMP, KNF, TEFLON
PU0000022	DIAPHRAM KIT, KNF ,TEFLON, PU20

SW0000026	PRESSURE XDUCER, 0-15 PSIA
TU0000009	TUBING, 1/8 X 1/4 TYGON
TU0000018	FEP TEFLON TUBING 1/4 OD 5/32 ID
VA0000034	VALVE, 2-WAY, SS, MANIFOLD MOUNT
VA0000035	VALVE, 3-WAY, SS, 12VDC, VITON, M450

APPENDIX A - 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 Schematic
01561	I2C/SubMux Assembly
01562	I2C/SubMux Schematic
01930	CE Keyboard Assembly
01931	CE Keyboard Schematic
02028	UV Detector Preamp Assembly
02029	UV Detector Preamp Schematic
02322	UV Lamp Driver Assembly
02323	UV Lamp Driver Schematic
0236200	M450 Rear Panel Assembly
02363	M450 Rear Panel Schematic
02421	Pressure Transducer Assembly
02422	Pressure Transducer PCB Schematic