

# Model 49C

## Instruction Manual

UV Photometric O<sub>3</sub> Analyzer

Part Number 9999

20Dec2007



*The 220V option complies with 89/336/EEC directive for electromagnetic compatibility.*

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# WEEE Compliance

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## EQUIVALENT METHOD DESIGNATION

The Thermo Environmental Instruments, Inc. Model 49C is designated by the United States Environmental Protection Agency (USEPA) as an Equivalent Method for the measurement of ambient concentrations of ozone pursuant with the requirements defined in the Code of Federal Regulations, Title 40, Part 53.

Designated Equivalent Method Number: EQOA-0880-047

EPA Designation Date: August 27, 1980

The Model 49C meets EPA designation requirements when operated as follows:

Range	0 - 0.05 to 1.0 ppm
Averaging Time	10 to 300 seconds
Temperature Range	20 to 30EC
Line Voltage	90 to 110 VAC @ 50/60 Hertz 105 to 125 VAC @ 50/60 Hertz 210 to 250 VAC @ 50/60 Hertz
Pressure Compensation	on or off
Temperature Compensation	on or off
Flow Rate	1 to 3 LPM

### RS-232 Interface

With or without the following options:

100	Teflon™ Particulate Filter
200	Carrying Handle
210	Rack Mounts
440	Internal Ozonator
450	Internal Ozonator with Remote I/O Activation
420	Zero Air Source
610	4-20 mA Current Output
735	Remote I/O Board
780	RS-485 Interface



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## CHAPTER 1

# INTRODUCTION

The Model 49C UV photometric ozone analyzer combines proven detection technology, easy to use menu-driven software, and advanced diagnostics to offer unsurpassed flexibility and reliability. The Model 49C offers the following features:

- Multi-line alphanumeric display
- Menu-driven software
- Field programmable ranges
- Dual range mode
- Autorange mode
- Multiple analog outputs
- High sensitivity
- Fast response time
- Linearity through all ranges
- Dual cell measurement cancels potential interference
- Automatic temperature and pressure correction
- EPA approved

Thermo Environmental Instruments is pleased to supply this ultraviolet (UV) photometric ozone analyzer. We are committed to the manufacture of instruments exhibiting high standards of quality, performance, and workmanship. Service personnel are available to assist with any questions or problems that may arise in the use of this analyzer.

## PRINCIPLE OF OPERATION

The Model 49C is based on the principle that ozone (O<sub>3</sub>) molecules absorb UV light at a wavelength of 254 nm. The degree to which the UV light is absorbed is directly related to the ozone concentration as described by the Beer-Lambert Law:

$$\frac{I}{I_o} = e^{-KLC}$$

where:

$K$  = molecular absorption coefficient,  $308 \text{ cm}^{-1}$  (at  $0^\circ\text{C}$  and 1 atmosphere)

$L$  = length of cell, 38 cm

$C$  = ozone concentration in parts per million (ppm)

$I$  = UV light intensity of sample with ozone (sample gas)

$I_0$  = UV light intensity of sample without ozone (reference gas)

The sample is drawn into the Model 49C through the **SAMPLE** bulkhead and is split into two gas streams, as shown in Figure 1-1. One gas stream flows through an ozone scrubber to become the reference gas ( $I_0$ ). The reference gas then flows to the reference solenoid valve. The sample gas ( $I$ ) flows directly to the sample solenoid valve. The solenoid valves alternate the reference and sample gas streams between cells A and B every 10 seconds. When cell A contains reference gas, cell B contains sample gas and vice versa.

The UV light intensities of each cell are measured by detectors A and B. When the solenoid valves switch the reference and sample gas streams to opposite cells, the light intensities are ignored for several seconds to allow the cells to be flushed. The Model 49C calculates the ozone concentration for each cell and outputs the average concentration to both the front panel display and the analog outputs.

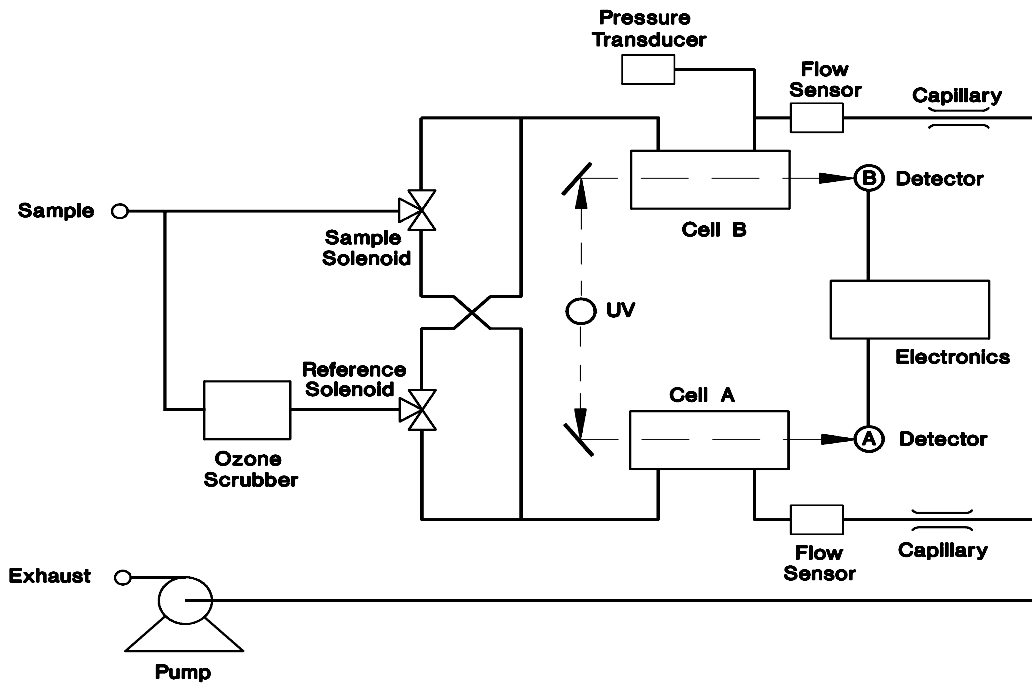


Figure 1-1. Model 49C Flow Schematic 45P804

## SPECIFICATIONS

Preset ranges	0-0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200 ppm 0-0.1, 0.2, 0.4, 1, 2, 4, 10, 20, 40, 100, 200, 400 mg/m <sup>3</sup>
Custom ranges	0-0.05 to 200 ppm 0-0.1 to 400 mg/m <sup>3</sup>
Zero noise	0.5 ppb RMS
Lower detectable limit	1.0 ppb
Zero drift	<1 ppb/24 hour <2 ppb/7 day
Span drift	less than 1% per month (including drift of transducers)
Response time	20 seconds (10 seconds lag time)
Precision	1 ppb
Linearity	± 1% Fullscale
Sample flow rate	1-3 liters/min
Operating temperature	20 - 30°C (may be safely operated over the range of 0 - 45°C)*
Power requirements	90-110 VAC @ 50/60 Hz 105-125 VAC @ 50/60 Hz 210-250 VAC @ 50/60 Hz 150 Watts
Physical dimensions	16.75" (W) X 8.62" (H) X 23"(D)
Weight	35 lbs.
Outputs	selectable voltage 4-20 mA, RS-232, RS-485

\* In non-condensing environments



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## CHAPTER 2

# INSTALLATION

The installation of the Model 49C includes lifting the instrument, unpacking the instrument, connecting sample, zero, and exhaust lines to the instrument, and attaching the analog outputs to a recording device. To install optional equipment, see Chapter 9, "Optional Equipment."

### LIFTING

A procedure appropriate to lifting a heavy object should be used when lifting the analyzer. This procedure consists of bending at the knees while keeping your back straight and upright. The analyzer should be grasped at the bottom, in the front and at the rear of the unit. Do not attempt to lift the analyzer by the cover or other external fittings. While one person may lift the unit, it is desirable to have two persons lifting, one by grasping the bottom in the front and the other by grasping the bottom in the rear.

### UNPACKING

The Model 49C is shipped complete in one container. If, upon receipt of the analyzer, there is obvious damage to the shipping container, notify the carrier immediately and hold for inspection. The carrier, and not Thermo Environmental Instruments Inc., is responsible for any damage incurred during shipment. Follow the procedure below to unpack and inspect the instrument.

1. Remove the instrument from the shipping container and set on a table or bench which will allow easy access to both the front and rear of the instrument.
2. Remove the instrument cover to expose the internal components.
3. Remove any packing material.
4. Check for possible damage during shipment.
5. Check that all connectors and printed circuit boards are firmly attached.
6. Re-install the instrument cover.

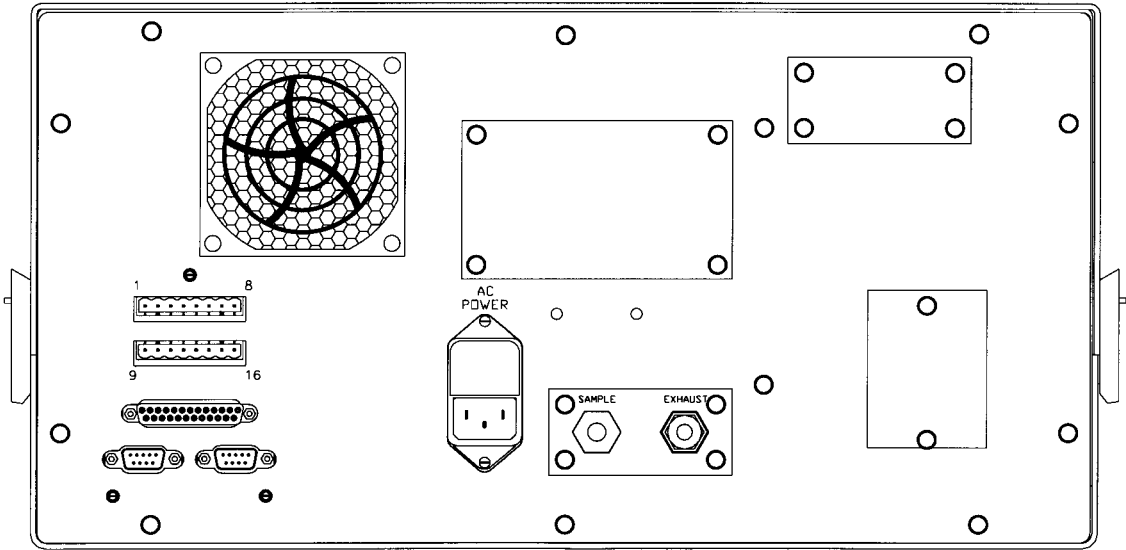
### SETUP PROCEDURE

1. Connect the sample line to the **SAMPLE** bulkhead on the rear panel (see Figure 2-1). Ensure that the sample is not contaminated by dirty, wet or incompatible materials. All tubing should be constructed of FEP Teflon®, 316 stainless steel, borosilicate glass, or similar tubing with an OD of 1/4" and a minimum ID of 1/8" for all sample lines and components. The length of the tubing should be less than 10 feet.

**NOTE:** Gas must be delivered to the instrument at atmospheric pressure. It may be necessary to employ an atmospheric bypass plumbing arrangement, as shown in Figure 2-2.

2. Connect the **EXHAUST** bulkhead to a suitable vent. The exhaust line should be 1/4" OD with a minimum ID of 1/8". The length of the exhaust line should be less than 10 feet. Verify that there is no restriction in this line.
4. Connect a suitable recording device to the rear panel terminals. See Chapter 3, "Operation" for more information about the pin-out of the rear panel terminal.
5. Plug the instrument into an outlet of the appropriate voltage and frequency

**CAUTION:** The Model 49C is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated.



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Figure 2-1. Model 49C Rear panel with Optional Internal Ozonator

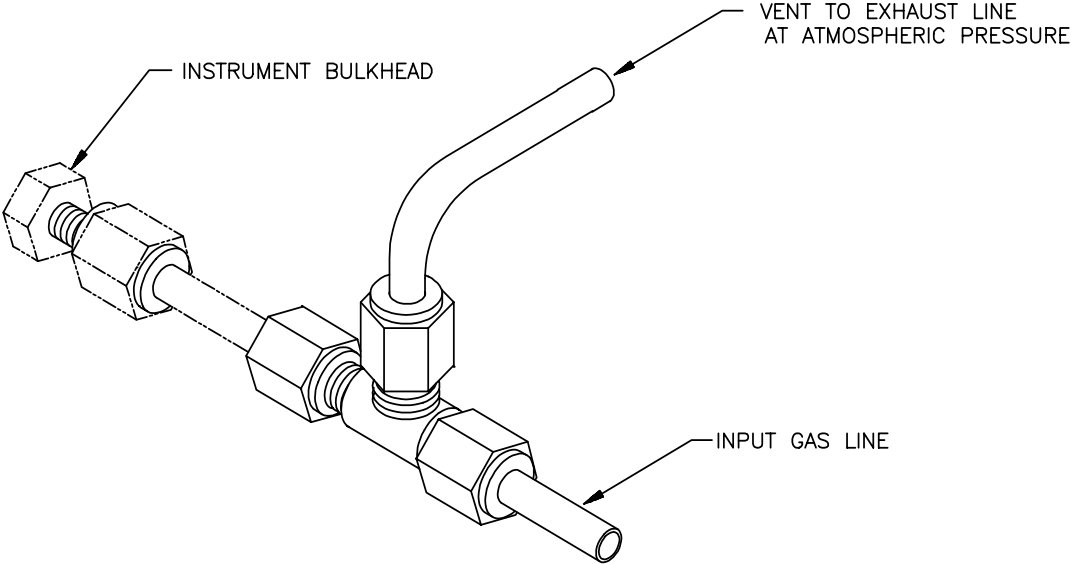


Figure 2-2. Atmospheric Dump Bypass Plumbing

57P7100

### Analog Output Cover Installation

This analog output cover must be mounted over the analog outputs to comply with 89/336/EEC Directive. This procedure describes how to install the user-supplied analog output cable in the instrument's analog output cover. The following shielded cables or their equivalent are recommended:

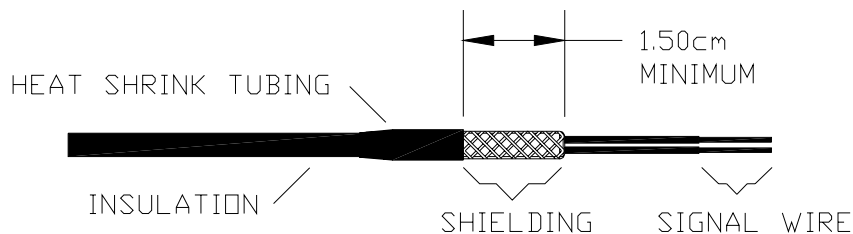
Cable	Gauge	No. of Conductors
Alpha #1741C	20	2
Alpha #1746C	18	2
Alpha #5320/2C*	20	2
Alpha #51 52C*	20	2
Alpha #5162C*	18	2
Alpha #1743C	20	4
Alpha 1747/4C	18	4
Alpha #5320/4C	20	4
Alpha #5154C	20	4
Alpha #5164C	18	4
Belden #8208	18	2

\* Maximum shielding. Under harsh environments, maximum shielding may be required.

The following tools are required:

- Small screwdriver
- Wire stripper
- Electrical tape or heat shrink tubing

The user-supplied shielded analog output cable must be properly grounded by coming into full contact with the cable clamp (mounted to the analog output cover). To ensure full contact, the shielding must be exposed and folded back over the cable as shown in Figure 2-3.



**Figure 2-3.** Shielded Cable with Shielding Pulled Back

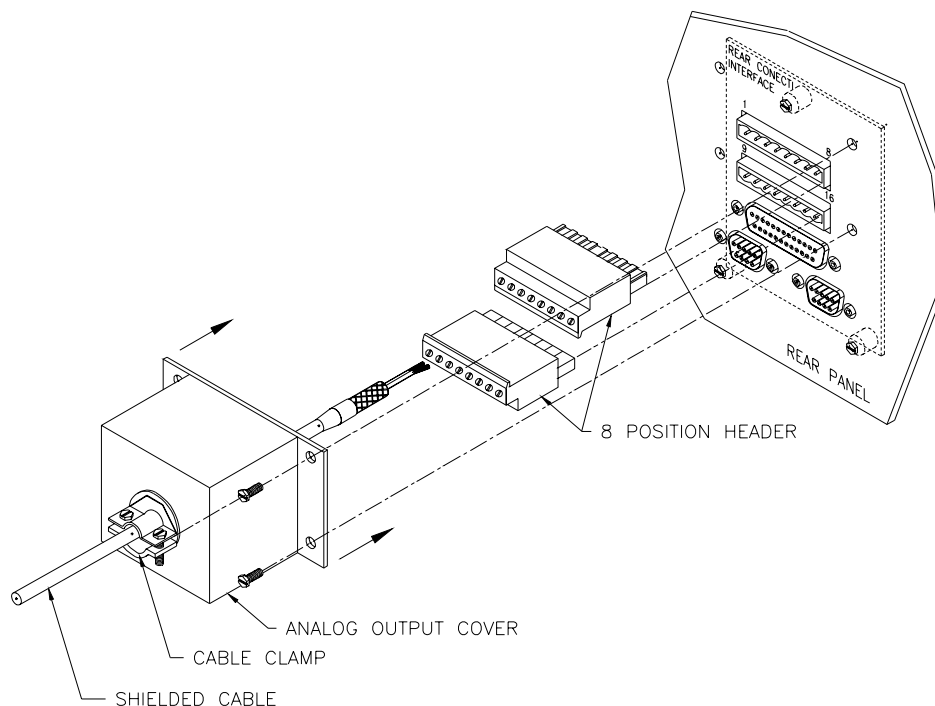


Follow the procedure below to prepare the shielded cable:

1. Remove about 1.8 cm of insulation from the cable.
2. Fold back the shielding.
3. Use electrical tape or shrink tubing to hold the shielding in place. Be sure at least 1.5 cm of shielding is exposed.
4. Strip each signal wire.

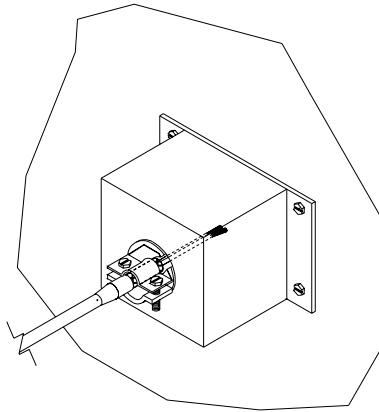
Follow the procedure below to connect the shielded cable to the 8-position header:

1. Pass the shielded cable through the cable clamp on the analog output cover, as shown in Figure 2-4.



**Figure 2-4.** Exploded View of Analog Output Cover Installation

2. Insert the bare signal wire into the slot of the header.
3. Tighten down the corresponding set screw.
4. Repeat steps 2 and 3 for each signal wire.
5. Plug the header(s) into the analog output connectors.
6. Install the analog output cover using the four #6 screws with star lockwashers.
7. Position the cable shielding so that it comes in contact with the cable clamp.
8. Tighten down the cable clamp onto the shielding, as shown in Figure 2-5.



**Figure 2-5.** Properly Installed Shield Cable

1. Install cable clamp into shield cover and secure. Be sure there is good electrical conductivity between clamp and shield cover.

The following is a parts list of components in the analog output cover assembly:

Part No.	Description	Qty.
7592	Analog output cover	1
11519	8-Position header	2
5889	#6 Star lock washers	4
5820	6-32X3/8" screw	4
14549	Cable clamp	1

### STARTUP

1. Turn the power on.
2. Allow 30 minutes for the instrument to stabilize.
3. Set instrument parameters such as operating ranges and averaging times to appropriate settings. For more information about instrument parameters, see Chapter 3, "Operation."
4. Before beginning actual monitoring, perform a multipoint calibration as described in Chapter 4, "Calibration."

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## CHAPTER 3

# OPERATION

This chapter describes the front panel display, front panel pushbuttons, and menu-driven software.

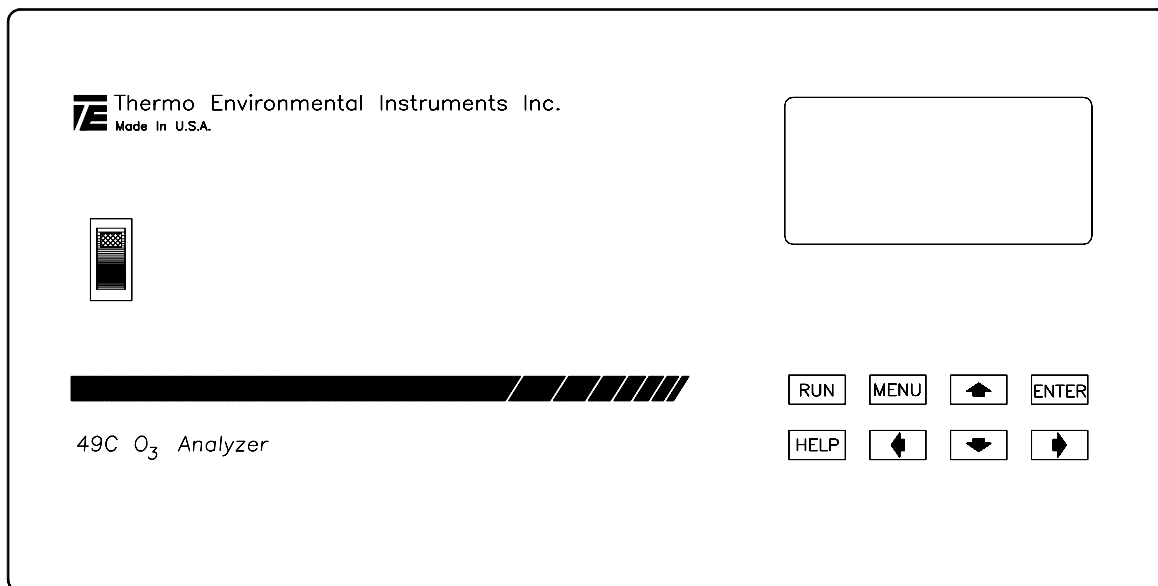
### DISPLAY

The 4 line by 20 character alphanumeric display shows the sample concentrations, instrument parameters, instrument controls, and help messages. Some menus contain more items than can be displayed at one time. For these menus, use the ↑ and ↓ pushbuttons to move the cursor up and down to each choice.

### PUSHBUTTONS

#### Run Pushbutton

The **RUN** pushbutton, shown below, is used to display the Run screen. The Run screen normally displays the O<sub>3</sub> concentration. In addition, the **RUN** pushbutton is used to select the optional internal ozonator levels. For more information about the optional ozonator, see Chapter 9, “Optional Equipment.”



45P738

**Figure 3-1.** Model 49C Front Panel

### Menu Pushbutton

The **MENU** pushbutton is used to display the Main Menu and to display submenus. When in the Run screen, this pushbutton displays the Main Menu. When in any other screen, a submenu is displayed. For more information about the Main Menu, see “Main Menu” later in this chapter.

### Enter Pushbutton

The **ENTER** pushbutton is used to choose a menu item, complete an entry, and toggle on/off functions. In addition, the **ENTER** pushbutton is used to switch between local and remote mode, when the optional remote interface is installed.

### Help Pushbutton

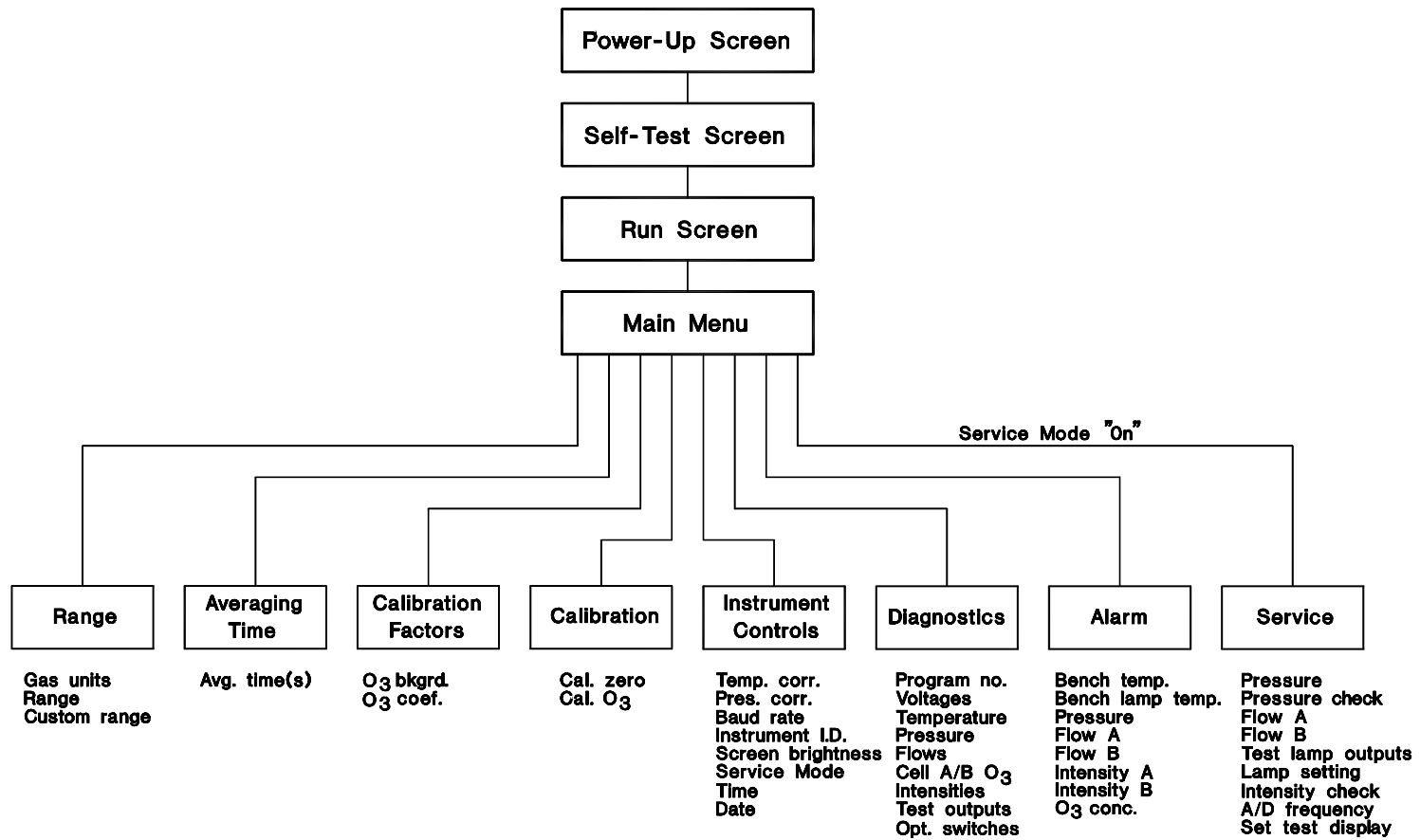
The **HELP** pushbutton is context-sensitive, that is it provides additional information about the screen that is being displayed. Press the **HELP** pushbutton for a concise explanation about the current screen or menu. Help messages are displayed using lower case letters to easily distinguish them from the operating screens. To exit a help screen, press **MENU** to return to the previous screen or **RUN** to return to the Run screen.

### ↑ ↓ ← → Pushbuttons

The four arrow pushbuttons (↑, ↓, ←, and →) move the cursor up, down, right, and left.

## SOFTWARE OVERVIEW

The Model 49C is based on menu-driven software as illustrated by the flowchart in Figure 3-2. The Power-Up and Self-Test screens, shown at the top of the flowchart, are displayed each time the instrument is turned on. These screens are displayed while the instrument is warming up and performing self-checks. After the warm-up period, the Run screen is automatically displayed. The Run screen is the normal operating screen. It is where the O<sub>3</sub> concentration is displayed. From the Run screen, the Main Menu can be displayed by pressing the **MENU** pushbutton. The Main Menu contains a list of submenus. Each submenu contains related instrument parameters and/or functions. This chapter describes each submenu and screen in detail. Refer to the appropriate sections for more information.

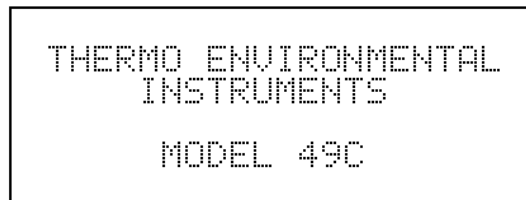


FLOW CHART – MENU DRIVEN  
45P222 REV.A

Figure 3-2. Flowchart of Menu-Driven Software

### Power-Up Screen

The Power-Up screen, as shown below, is displayed on power up of the Model 49C.



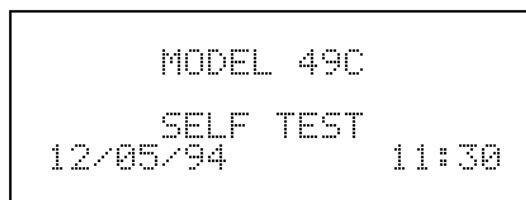
```
THERMO ENVIRONMENTAL
INSTRUMENTS

MODEL 49C
```

**Power-Up Screen**

### Self-Test Screen

The Self-Test Screen, as shown below, is displayed while the internal components are warming up and a diagnostic check is performed.



```
MODEL 49C

SELF TEST
12/05/94      11:30
```

**Self Test Screen**

## Run Screen

The Run screen, shown below, normally displays the O<sub>3</sub> concentration and the time. It also displays the status of the remote interface and optional internal ozonator. For more information about optional equipment, see Chapter 9, “Optional Equipment.”

```
03 PPB           600
                10:25  REMOTE
```

Run Screen

## Main Menu

The Main Menu contains several submenus as shown below. Instrument parameters and features are divided into these submenus according to their function. Use the ↑ and ↓ pushbuttons to move the cursor to each submenu. When the Main Menu is entered directly from the Run screen, the ← pushbutton may be used to jump to the most recently displayed submenu screen. Use the **ENTER** pushbutton to select a submenu.

```
MAIN MENU:      10:25
>RANGE
AVERAGING TIME
CALIBRATION FACTORS
```

```
CALIBRATION
INSTRUMENT CONTROLS
DIAGNOSTICS
ALARM
```

Main Menu

### RANGE MENU

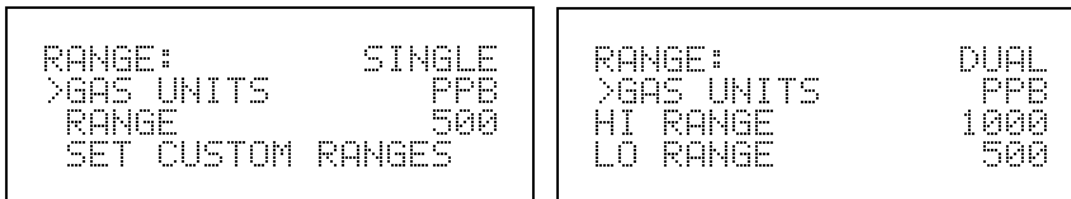
The Range menu appears as shown below. In the upper right-hand corner of the display, the word single, dual, or auto is displayed to indicate the active mode. The Range menu in the dual and autorange modes appear the same except for the word dual or auto, displayed in the upper right-hand corner. For more information about the single, dual, or autorange modes, see “Single Range Mode,” “Dual Range Mode,” and “Autorange Mode” below.

To display the Range Menu:

- From the Main Menu choose Range

To use the Range Menu:

- Press the ↑ and ↓ pushbuttons to move the cursor to each choice
- Press **ENTER** to select a choice
- Press **MENU** to return to the Main Menu
- Press **RUN** to return to the Run screen



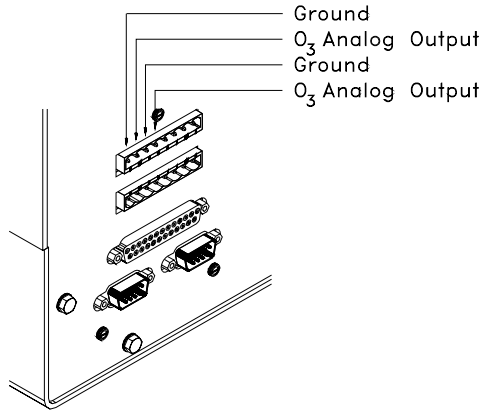
SET CUSTOM RANGES

### Range Menu in Single and Dual/Autorange Mode



### Single Range Mode

In single range mode there is one range, one averaging time, and one span coefficient. Two analog outputs are arranged on the rear panel terminal strip as shown in Figure 3-3. To use the single range mode, option switches 4 and 5 off must be off. For more information about the internal option switches, see “Internal Option Switches,” later in this chapter.

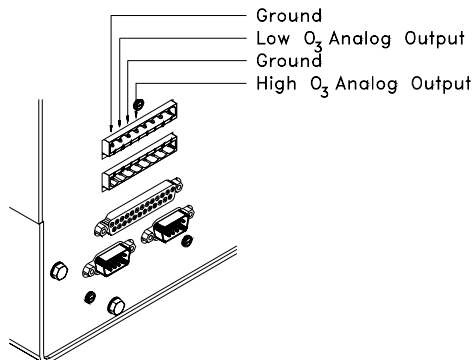


45P951-1

Figure 3-3. Pin-Out of Rear Panel Terminal Strip in Single Range Mode

### Dual Range Mode

In dual range mode there are two independent analog outputs as shown below.



45P951-2

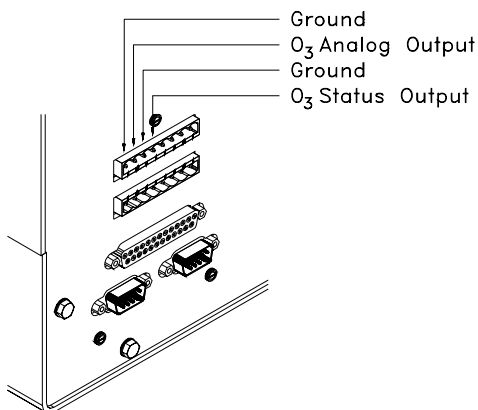
Figure 3-4. Pin-Out of Rear Panel Terminal Strip in Dual Range Mode

There are two ranges, high O<sub>3</sub> range and low O<sub>3</sub> range, that correspond to the high O<sub>3</sub> and low O<sub>3</sub> analog outputs, respectively. This enables the sample concentration reading to be sent to the analog outputs at two different ranges. For example, the low O<sub>3</sub> analog output can be set to output concentrations from 0 to 500 ppb and the high O<sub>3</sub> analog output set to output concentrations from 0 to 1000 ppb. The low O<sub>3</sub> and high O<sub>3</sub> range can be set to the same range in order to provide two identical outputs.

In addition, each O<sub>3</sub> analog output has a span coefficient. There are two span coefficients so that each range can be calibrated separately. This is necessary if the two ranges are not close to one another. For example, the low O<sub>3</sub> range is set to 0-50 ppb and the high O<sub>3</sub> range is set to 0-200 ppm. To use the dual range mode, set option switch 4 on and option switch 5 off. For more information about setting the internal option switches, see “Internal Option Switches,” later in this chapter.

### Autorange Mode

The autorange mode switches the O<sub>3</sub> analog output between a high O<sub>3</sub> range and a low O<sub>3</sub> range, depending on the concentration level. The high O<sub>3</sub> range and the low O<sub>3</sub> range are defined in the Range menu. When concentrations are below the low O<sub>3</sub> range, the O<sub>3</sub> analog output uses the low O<sub>3</sub> range. When concentrations are above the low O<sub>3</sub> range, the O<sub>3</sub> analog output uses the high O<sub>3</sub> range.



45P951-3

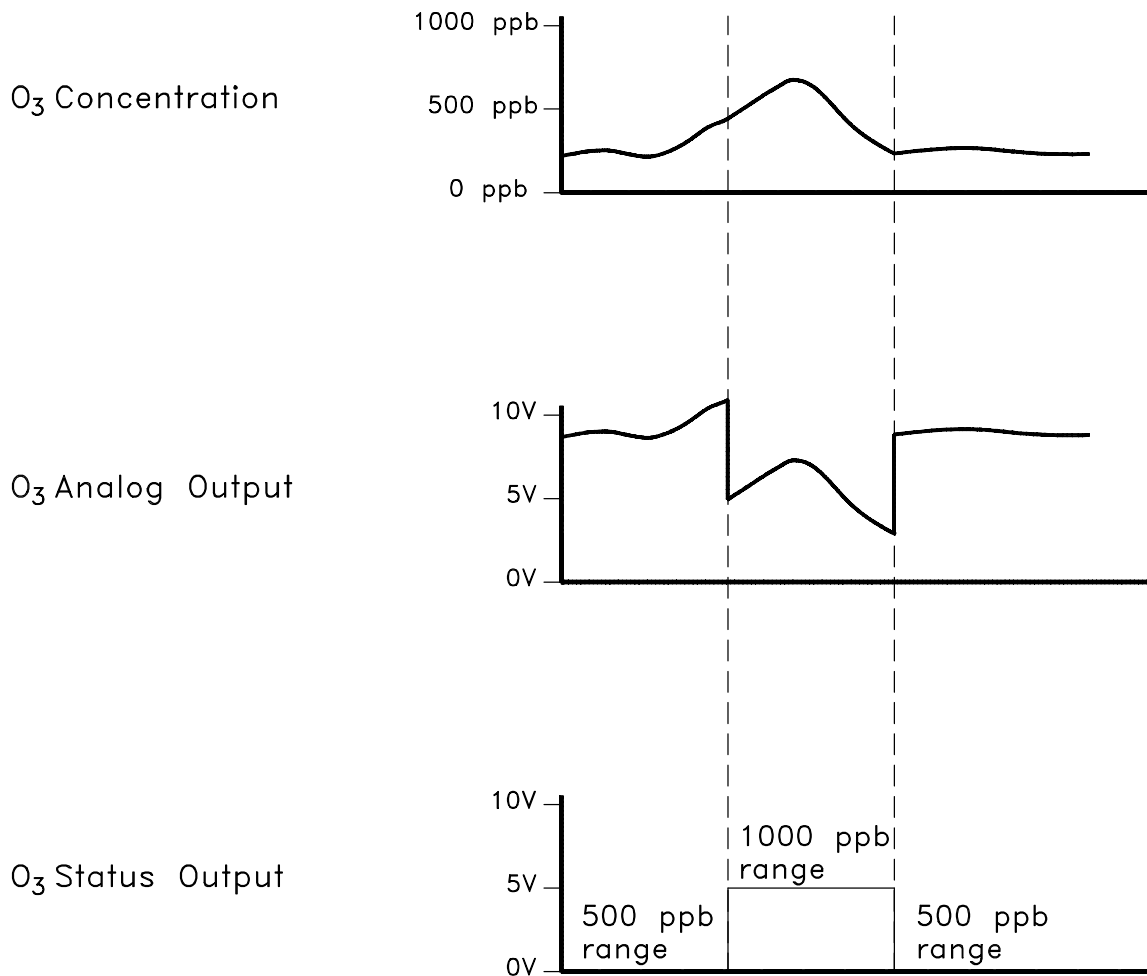
**Figure 3-5.** Pin-Out of Rear Panel Terminal Strip in Autorange Mode

For example, suppose the low O<sub>3</sub> range is set to 500 ppb and the high O<sub>3</sub> range is set to 1000 ppb (see Figure 3-6). Sample concentrations below 500 ppb are presented to the O<sub>3</sub> analog output using the low O<sub>3</sub> range, as shown below. Sample concentrations above 500 ppb are presented to the O<sub>3</sub> analog output using the high O<sub>3</sub> range. The O<sub>3</sub> status output indicates which range the O<sub>3</sub> analog output is using. When the low O<sub>3</sub> range is active, the O<sub>3</sub> status output is at 0 volts. When the high O<sub>3</sub> range is active, the O<sub>3</sub> status output is at 50% of fullscale.

When the high O<sub>3</sub> range is active, the concentration must drop to 85% of the low O<sub>3</sub> range for the low O<sub>3</sub> range to become active.

In addition, there are two span coefficients so that each range can be calibrated separately. This is necessary if the two ranges are not close to one another. For example, the low O<sub>3</sub> range is set to 0-50 ppb and the high O<sub>3</sub> range is set to 0-200 ppm.

To use the autorange mode, set option switch 4 and 5 on. For more information about setting the internal option switches, see “Internal Option Switches,” later in this chapter.



45P951-5

**Figure 3-6.** Analog Output in Autorange Mode

### Gas Units

The Gas Units screen, shown below, defines how the O<sub>3</sub> concentration reading is expressed. Gas units of parts per billion (ppb), parts per million (ppm), micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ), or milligrams per cubic meter ( $\text{mg}/\text{m}^3$ ) are available. The  $\mu\text{g}/\text{m}^3$  and  $\text{mg}/\text{m}^3$  gas concentration modes are calculated using a factory standard pressure of 760 mm Hg and a factory standard temperature of 20°C.

When switching from ppb or ppm to  $\mu\text{g}/\text{m}^3$  or  $\text{mg}/\text{m}^3$ , the O<sub>3</sub> range and custom ranges are set to default to the highest range in that mode. For example, when switching from  $\text{mg}/\text{m}^3$  to ppm, all ranges will be set to 200 ppm.

The current gas units are shown on the first line of the display. The gas units are selected on the second line of the display.

To display the Gas Units screen:

- From the Main Menu choose Range
- From the Range Menu choose Gas Units

To use the Gas Units Screen:

- Use the  $\uparrow$  and  $\downarrow$  pushbuttons to select the gas units
- Press **ENTER** to accept the choice
- Press **MENU** to return to the Range menu
- Press **RUN** to return to the Run screen.

```
GAS UNITS      PPB
SET TO        PPM?
↑↓ SELECT
```

**Gas Units Screen**

## Range

The Range defines the concentration range of the analog outputs. For example, an O<sub>3</sub> range of 0-500 ppb restricts the analog output to concentrations between 0 and 500 ppb.

The second line of the display shows the current O<sub>3</sub> range. The third line of the display is used to change the range. The range screen is similar for the single, dual, and autorange modes as shown below. The only difference between the screens is the word hi or lo displayed on the second line to indicate which range is displayed. For more information about the single, dual, or autorange modes, see “Single Range Mode,” “Dual Range Mode,” and “Autorange Mode” earlier in this chapter.

Table 3-1 lists the available preset ranges.

To display the Range screen:

- From the Main Menu choose Range
- From the Range menu choose Range

To use the Range:

- Use the ↑ and ↓ pushbuttons to scroll through the preset ranges
- Press **ENTER** to accept a range
- Press **MENU** to return to the Range menu
- Press **RUN** to return to the Run screen

```

RANGE:
O3 PPB          500.0
SET TO         1000.0?
↑↓ SELECT
  
```

```

RANGE:
LO O3 PPB       500.0
SET TO         1000.0?
↑↓ SELECT
  
```

### Range Screens in Single and Dual/Autorange Modes

ppb	ppm	$\mu\text{g}/\text{m}^3$	$\text{mg}/\text{m}^3$
50	0.05	100	0.1
100	0.10	200	0.2
200	0.20	400	0.4
500	0.50	1,000	1
1,000	1	2,000	2
2,000	2	5,000	5
5,000	5	10,000	10
10,000	10	20,000	20
20,000	20	40,000	40
50,000	50	100,000	100
100,000	100	200,000	200
200,000	200	400,000	400
C1	C1	C1	C1
C2	C2	C2	C2
C3	C3	C3	C3

**Table 3-1.** Available Operating Ranges

C1, C2, and C3 are custom ranges. For more information about custom ranges, see “Custom Ranges Menu” below.

## Custom Ranges Menu

The Custom Ranges Menu, shown below, lists three custom ranges: C1, C2, and C3. Custom ranges are user-defined ranges. In the ppm (ppb) mode, any value between 0.05 ppm (50 ppb) and 200 ppm (200,000 ppb) can be specified as a range. In the mg/m<sup>3</sup> (µg/m<sup>3</sup>) mode, any value between 0.1 mg/m<sup>3</sup> (100 µg/m<sup>3</sup>) and 400 mg/m<sup>3</sup> (400,000 µg/m<sup>3</sup>) can be specified. See “Custom Range Screen” below for more information about defining the custom ranges.

To display the Set Custom Ranges screen:

- From the Main Menu choose Range
- From the Range menu choose Set Custom Ranges

To use the Set Custom Ranges menu:

- Use the ↑ and ↓ pushbutton to move the cursor between each custom range
- Press **ENTER** to select the custom range to define
- Press **MENU** to return to the Range menu
- Press **RUN** to return to the Run screen

```
SET CUSTOM RANGES:
>C1 PPB           550
  C2 PPB           650
  C3 PPB           750
```

**Set Custom Ranges Menu**

**Custom Range Screen.** The Custom Range screen, shown below, is used to define the custom range.

The first line of the display shows the current custom range. The second line of the display is used to set the range. To use the custom fullscale range, be sure to select either C1, C2, or C3 in the Range screen. See “Range” above for more information.

To display the Custom Range screen:

- From the Main Menu choose Range
- From the Range menu choose Set Custom Ranges
- From the Set Custom Range menu choose C1, C2, or C3

To use the Custom Range screen:

- Use the ↑ and ↓ pushbutton to increment and decrement each digit
- Use the ← and → pushbutton to move the cursor left and right
- Press **ENTER** to accept the custom range
- Press **MENU** to return to the Set Custom Ranges menu
- Press **RUN** to return to the run screen

```
C1 FPM      100.0000
SET TO      200.0000?
↑↓ INC/DEC  ↔ CURSOR
```

**Set Custom Range 1 Screen**



## AVERAGING TIME

The averaging time defines a time period (10 to 300 seconds) during which O<sub>3</sub> measurements are taken. The average concentration of the readings are calculated for that time period. The front panel display and analog outputs are updated every 10 seconds for averaging times between 10 and 300 seconds. An averaging time of 10 seconds, for example, means that the average concentration of the last 10 seconds will be output at each update. An averaging time of 300 seconds means that the moving average concentration of the last 300 seconds will be output at each update. Therefore, the lower the averaging time the faster the front panel display and analog outputs respond to concentration changes. Longer averaging times are typically used to smooth output data.

The Averaging Time screen for the single range and autorange mode is shown below. In the dual range mode, an Averaging Time Menu is displayed before the averaging time screen. This menu is needed because the dual range mode has two averaging times (high and low). The Averaging Time screens function the same way in the single, dual and autorange modes. The following averaging times are available: 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds. Additional averaging times are available when option switch 7 is on. These averaging times include 4, 8, 12, 24, 36, 48, 72, 96, and 120 seconds. For more information about fast update times, see “Option Switches,” later in this chapter.

To display the Averaging Time menu/screen:

- From the Main Menu Choose Averaging Time

To use the Averaging Time screen:

- Use the ↑ and ↓ pushbuttons to select the averaging time
- Press **ENTER** to accept the averaging time
- Press **MENU** to return to the Main Menu
- Press **RUN** to return to the Run screen

```
AUG TIME      10 SEC
SET TO        30 SEC?
↑↓ SELECT
```

**Averaging Time Screen**

### CALIBRATION FACTORS MENU

Calibration factors are determined during automatic and manual calibration and are used to correct the O<sub>3</sub> concentration readings. The Calibration Factors menu displays the calibration factors as shown below. Normally the instrument is calibrated automatically, that is, using the Calibration menu. However, the instrument can be calibrated manually using this menu. To manually calibrate the instrument, see “O<sub>3</sub> Background Correction” and “O<sub>3</sub> Span Coefficient” below for more information.

To display the Calibration Factors Menu:

- From the Main Menu choose Calibration Factors:

To use the Calibration Factors menu:

- Use the ↑ and ↓ pushbuttons to move the cursor up and down
- Press **ENTER** to go to the Calibration Factor screen
- Press **MENU** to return to the Main Menu
- Press **RUN** to return to the Run Screen

```
CALIBRATION FACTORS:
>O3 BKG FPB      0.0
O3 COEF          1.000
```

```
CALIBRATION FACTORS:
>O3 BKG FPB      0.0
O3 HI COEF       1.000
O3 LO COEF       1.000
```

#### Calibration Factors Menu in Single and Dual/Autorange Modes

## **O<sub>3</sub> Background Correction**

The O<sub>3</sub> background correction is determined during zero calibration. The O<sub>3</sub> background is the amount of signal read by the analyzer while sampling zero air. Before the analyzer sets the O<sub>3</sub> reading to zero, it stores the value as the O<sub>3</sub> background correction.

The O<sub>3</sub> Background screen is used to perform a manual zero calibration of the instrument. As such, the instrument should sample zero air until stable readings are obtained. The first line of the display shows the current O<sub>3</sub> reading. This reading is the O<sub>3</sub> background signal. The second line of the display shows the O<sub>3</sub> background correction that is stored in memory and is being used to correct the O<sub>3</sub> reading. That is, the O<sub>3</sub> background correction is subtracted from the O<sub>3</sub> reading.

In the example below, the analyzer is reading 4.4 ppb of O<sub>3</sub> while sampling zero air. The O<sub>3</sub> background correction is 0.0 ppb. That is, the analyzer is not applying a zero background correction. The question mark is used as a prompt to change the background correction. In this case the background correction must be increased to 4.4 ppb in order for the O<sub>3</sub> reading to be at 0 ppb.

To set the O<sub>3</sub> reading in the example below to zero, use the ↑ pushbutton to increment the O<sub>3</sub> background correction to 4.4 ppb. As the O<sub>3</sub> background correction reading is increased, the O<sub>3</sub> reading is decreased. At this point however, no real changes have been made. The analog outputs have not been affected and the stored O<sub>3</sub> background correction of 0.0 ppb is still being used. To escape without making any changes, press the **MENU** pushbutton to return to the Calibration Factors menu or the **RUN** pushbutton to return to the Run screen. Press the **ENTER** pushbutton to set the O<sub>3</sub> reading to 0.0 ppb and store the background correction of 4.4 ppb.

## Chapter 3 Operation

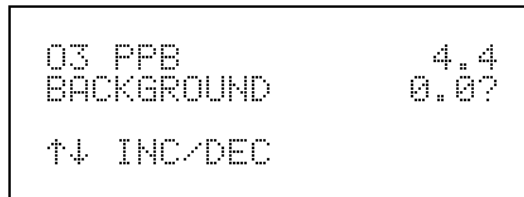
---

To display the O<sub>3</sub> Background screen:

- From the Main Menu choose Calibration Factors
- From the Calibration Factors menu choose O<sub>3</sub> Background

To use the O<sub>3</sub> Background screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the O<sub>3</sub> background
- Press **ENTER** to accept a change in the background
- Press **MENU** to return to the Calibration Factors menu
- Press **RUN** to return to the Run screen



```
O3 PPE          4.4
BACKGROUND     0.0?
↑↓ INC/DEC
```

**O<sub>3</sub> Background Screen**

## O<sub>3</sub> Span Coefficient

The O<sub>3</sub> span coefficient is calculated during calibration. The span coefficient is used to correct the O<sub>3</sub> readings and normally has a value near 1.000.

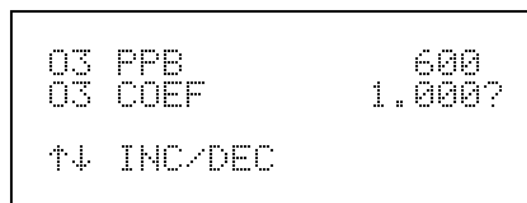
The O<sub>3</sub> Span Coefficient screen enables the O<sub>3</sub> span coefficient to be manually changed while sampling span gas of known concentration. The first line of the display shows the current O<sub>3</sub> concentration reading. The second line of the display shows the O<sub>3</sub> span coefficient that is stored in memory and is being used to correct the O<sub>3</sub> concentration. Notice that as the span coefficient value is changed using the ↑ and ↓ pushbuttons, that the current O<sub>3</sub> concentration reading on the first line also changes. However, no real changes are made until the **ENTER** pushbutton is pressed. Only proposed changes, as indicated by a question mark prompt, are displayed until the **ENTER** pushbutton is pressed.

To display the O<sub>3</sub> Span Coefficient Screen:

- From the Main Menu choose Calibration Factors
- From the Calibration Factors menu choose O<sub>3</sub> Coef

To use the O<sub>3</sub> Span Coefficient Screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the span coefficient
- Press **ENTER** to accept a change
- Press **MENU** to return to the Calibration Factors menu
- Press **RUN** to return to the Run screen



```
O3 FPE          600
O3 COEF          1.000?
↑↓ INC/DEC
```

**O<sub>3</sub> Span Coefficient Screen**

### CALIBRATION MENU

The Calibration menu is used to calibrate zero and span. The calibration menu is similar for the single, dual, and autorange mode as shown below. The dual and autorange modes have two O<sub>3</sub> span factors (high and low). This allows each range to be calibrated separately. This is necessary if the two ranges used are not close to one another. For example a low O<sub>3</sub> range of 50 ppb and a high O<sub>3</sub> range of 20,000 ppb. For more information about calibration, see Chapter 4, "Calibration."

To display the Calibration Menu:

- From the Main Menu choose Calibration

To use the Calibration Menu:

- Use the ↑ and ↓ pushbuttons to move the cursor up and down
- Press **ENTER** to accept the choice
- Press **MENU** to return to the Main Menu
- Press the **RUN** to return to the Run screen

```
CALIBRATION:
>CALIBRATE ZERO
CALIBRATE O3
```

```
CALIBRATION:
>CALIBRATE ZERO
CALIBRATE HI O3
CALIBRATE LO O3
```

### Calibration Menu in Single and Dual/Autorange Modes

## Calibrate Zero

The Calibrate Zero screen, shown below, is used to perform a zero calibration. Be sure the analyzer samples zero air until stable readings are obtained. The second line of the display shows the current O<sub>3</sub> reading.

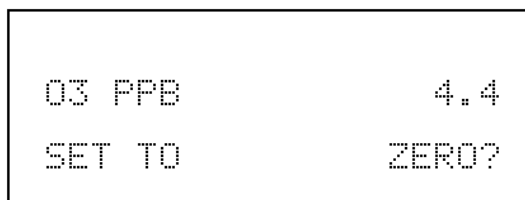
It is important to note the averaging time when calibrating. The longer the averaging time, the more accurate the calibration. To be most accurate, use the 300 second averaging time. For more information about calibration, see Chapter 4, “Calibration.”

To display the Calibrate Zero screen:

- From the Main Menu choose Calibration
- From the Calibration menu choose Calibrate Zero

To use the Calibrate Zero screen:

- Press **ENTER** to set the O<sub>3</sub> reading to zero
- Press **MENU** to return to the Calibration menu
- Press **RUN** to return to the Run screen



```
  O3 PPM          4.4
  SET TO          ZERO?
```

**Zero Calibration Screen**

### Calibrate O<sub>3</sub>

The Calibrate O<sub>3</sub> screen is used to adjust the O<sub>3</sub> span concentration while sampling span gas of known concentration. The first line of the display shows the current O<sub>3</sub> concentration reading. The second line of the display shows the current O<sub>3</sub> range. The third line of the display is where the O<sub>3</sub> calibration gas concentration is entered.

The O<sub>3</sub> span coefficient is calculated, stored, and used to correct the current O<sub>3</sub> reading. For more information about calibration, see Chapter 4, “Calibration.”

It is important to note the averaging time when calibrating. The longer the averaging time the more accurate the calibration will be. For the most accurate calibration, use the 300 second averaging time. For more information about calibration, see Chapter 4, “Calibration.”

To display the Calibrate O<sub>3</sub> screen:

- From the Main Menu choose Calibration
- From the Calibration menu choose Calibrate O<sub>3</sub>

To use the Calibrate O<sub>3</sub> screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement each digit
- Use the ← and → pushbuttons to move the cursor left and right
- Press **ENTER** to calibrate the O<sub>3</sub> reading to the O<sub>3</sub> calibration gas
- Press **MENU** to return to the Calibration menu
- Press **RUN** to return to the Run screen

```
03 PPB           803
RANGE           1000
SET TO         000800.0?
↑↓ INC/DEC
```

**O<sub>3</sub> Calibration Screen**



## INSTRUMENT CONTROLS MENU

The Instrument Controls, shown below, contains a number of items as shown below. The software controls listed in this menu enable control of the listed instrument functions.

To display the Instrument Controls Menu:

- From the Main Menu choose Instrument Controls

To use the Instrument Controls Menu:

- Use the ↑ and ↓ pushbuttons to scroll through the choices
- Press **ENTER** to select a choice
- Press **MENU** to return to the Main Menu
- Press **RUN** to return to the Run screen

```
INSTRUMENT CONTROLS:
>TEMP CORRECTION
  PRESSURE CORRECTION
  BAUD RATE
```

```
INSTRUMENT ID
SCREEN BRIGHTNESS
SERVICE MODE
TIME
DATE
```

### Instrument Controls Menu

### Temperature Correction

Temperature correction provides compensation for any changes to the instrument's output signal due to variations in sample gas temperature. The Model 49C can be operated with or without temperature correction.

The temperature correction screen is shown below. When temperature correction is on, the first line of the display shows the sample gas temperature (measured by a thermistor on the optical bench). When temperature correction is off, the first line of the display shows the standard temperature of 0.0°C.

To display the Temperature Correction screen:

- From the Main Menu choose Instrument Controls
- From the Instrument Controls menu choose Temperature Correction

To use the Temperature Correction screen:

- Press **ENTER** to toggle temperature correction on and off
- Press **MENU** to return to the Instrument Controls menu
- Press **RUN** to return to the Run screen

TEMPERATURE	0.0°C
CORRECTION	OFF
TURN	ON?

**Temperature Correction Screen**

## Pressure Correction

Pressure correction provides compensation for any changes to the instrument's output signal due to variations of sample pressure. The Model 49C can be operated with or without pressure correction.

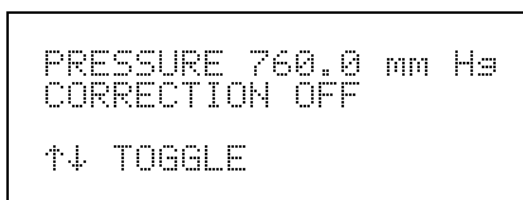
The pressure correction screen is shown below. When pressure correction is on, the first line of the display represents the current sample pressure. When pressure correction is off, the first line of the display shows the standard pressure of 760 mm Hg.

To display the Pressure Correction screen:

- From the Main Menu choose Instrument Controls
- From the Instrument Controls menu choose Pressure Correction

To use the Pressure Correction screen:

- Press **ENTER** to toggle pressure correction on and off
- Press **MENU** to return to the Instrument Controls menu
- Press **RUN** to return to the Run screen



```
PRESSURE 760.0 mm Hg
CORRECTION OFF
↑↓ TOGGLE
```

**Pressure Correction Screen**

### Baud Rate

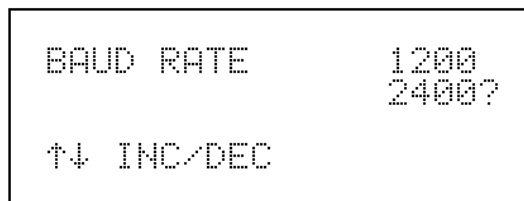
The Baud Rate screen, shown below, is used to set the RS-232 interface baud rate. Baud rates of 1200, 2400, 4800, and 9600 are available.

To display the Baud Rate screen:

- From the Main Menu choose Instrument Controls
- From the Instrument Controls menu choose Baud Rate

To use the Baud Rate screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the baud rate
- Press **ENTER** to accept a change
- Press **MENU** to return to the Instrument Controls menu
- Press **RUN** to return to the Run screen



**Baud Rate Screen**

## Instrument ID

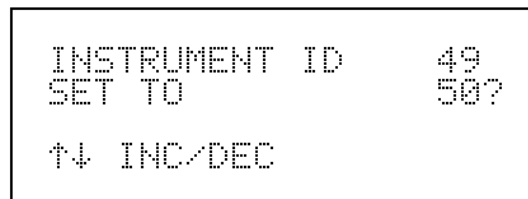
The Instrument ID screen, shown below, enables the Instrument ID to be user-defined. This is useful if two or more of the same instrument are connected to one computer. Valid Instrument ID numbers are from 0 to 99. The Model 49C has a default Instrument ID of 49. For more information about the Instrument ID, see Appendix B, “RS-232 Commands.”

To display the Instrument ID screen:

- From the Main Menu choose Instrument Controls
- From the Instrument Controls menu choose Instrument ID

To use the Instrument ID screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the ID number
- Press **ENTER** to accept a change
- Press **MENU** to return to the Instrument Controls menu
- Press **RUN** to return to the Run screen



```
INSTRUMENT ID    49
SET TO           50?
↑↓ INC/DEC
```

**Instrument ID Screen**

### Screen Brightness

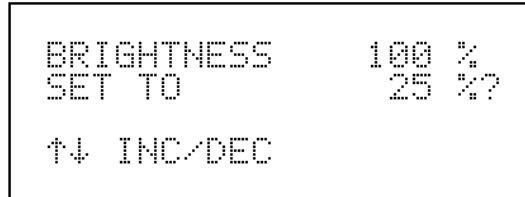
The Screen Brightness screen, shown below, is used to change the screen brightness. Intensities of 25%, 50%, 75%, and 100% are available. Changing the screen brightness to a lower intensity will extend the life of the display.

To display the Screen Brightness screen:

- From the Main Menu choose Instrument Controls
- From the Instrument Controls menu choose Screen Brightness

To use the Screen Brightness screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the screen brightness
- Press **ENTER** to accept a change
- Press **MENU** to return to the Instrument Controls menu
- Press **RUN** to return to the Run screen



```
BRIGHTNESS      100 %  
SET TO          25 %?  
  
↑↓ INC/DEC
```

**Screen Brightness Screen**

### Service Mode

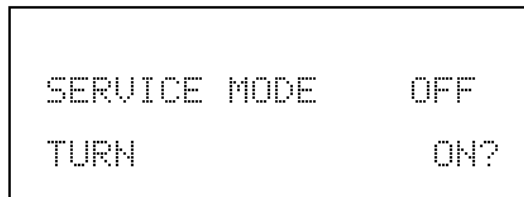
The Service Mode screen, shown below, is used to turn the service mode on and off. The service mode includes parameters and functions that are useful when making adjustments or diagnosing the Model 49C. Meaningful data should not be collected when the instrument is in the service mode. For more information about the service mode, see “Service Mode Menu,” later in this chapter.

To display the Service Mode screen:

- From the Main Menu choose Instrument Controls
- From the Instrument Controls menu choose Service Mode

To use the Service Mode screen:

- Press **ENTER** to toggle service mode on and off
- Press **MENU** to return to the Instrument Controls menu
- Press **RUN** to return to the Run screen



A rectangular box containing the text of the Service Mode screen. The text is arranged in two lines. The first line reads "SERVICE MODE" followed by "OFF" on the right. The second line reads "TURN" followed by "ON?" on the right.

**Service Mode Screen**

### Time

The internal clock is set by the Time screen as shown below. The first line of the display shows the current time (military). The second line of the display is used to change the time. The internal clock is powered by its own battery when instrument power is off.

To display the Time screen:

- From the Main Menu choose Instrument Controls
- From the Instrument Controls menu choose Time

To use the Time screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the hours and minutes
- Use the ← and → pushbuttons to move the cursor left and right
- Press **ENTER** to accept a change
- Press **MENU** to return to the Instrument Controls menu
- Press **RUN** to return to the Run screen

```
TIME          12:00
SET TO        13:00?
↑↓ INC/DEC ←→ CURSOR
```

**Time Screen**



## Date

The date is set by the Date screen as shown below. The first line of the display shows the current date. The second line of the display is used to change the date. The date is updated by the internal clock.

To display the Date screen:

- From the Main Menu choose Instrument Controls
- From the Instrument Controls menu choose Date

To use the Date screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the month, day, and year
- Use the ← and → pushbutton to move the cursor left and right
- Press **ENTER** to accept a change
- Press **MENU** to return to the Instrument Controls menu
- Press **RUN** to return to the Run screen

```
DATE          01/01/95
SET TO        01/02/95?
↑↓ INC/DEC   ↔ CURSOR
```

**Date Screen**

### DIAGNOSTICS MENU

The Diagnostics menu, shown below, provides access to diagnostic information and functions. This menu is useful when troubleshooting the instrument.

To display the Diagnostics menu:

- From the Main Menu choose Diagnostics

To use the Diagnostics menu:

- Use the ↑ and ↓ pushbuttons move the cursor up and down
- Press **MENU** to return to the Main Menu
- Press **RUN** to return to the Run screen

```
DIAGNOSTICS:
>PROGRAM NUMBERS
VOLTAGES
TEMPERATURES
```

```
PRESSURE
FLOWS
CELL A/B O3
INTENSITIES
TEST ANALOG OUTPUTS
OPTION SWITCHES
```

#### Diagnostics Menu

## Program Numbers

The Program Numbers screen, shown below, shows the version number of the programs installed. Prior to contacting the factory with any questions regarding the instrument, please note the program numbers.

To display the Program Numbers screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Program Numbers

To use the Program Numbers screen:

- This is a view only screen
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen

```
INSTRUMENT PROGRAM:
 49 000001 00
COMMUNICATIONS:
49L000001 00
```

**Program Number Screen**

### Voltages

The Voltages screen as shown below, displays the current dc power supply voltages. This allows the power supplies to be quickly tested for low or fluctuating voltages without having to use a voltage meter.

To display the Voltages screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Voltages

To use the Voltages screen:

- This is a view only screen
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen

+5 SUPPLY	4.9 V
+15 SUPPLY	15.1 V
-15 SUPPLY	-15.2 V
BATTERY	-3.2 V

**Voltages Screen**

### Temperatures

The Temperatures screen, as shown below, displays the current bench temperature and bench lamp temperature.

To display the Temperatures screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Temperatures

To use the Temperatures screen:

- This is a view only screen
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen



BENCH	32.3° C
BENCH LAMP	55.2° C
O3 LAMP	.2° C

**Temperatures Screen**

### Pressure

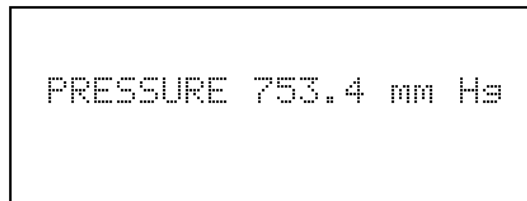
The Pressure screen, shown below, displays the current bench pressure. The pressure is measured by a pressure transducer mounted on the divider panel.

To display the Pressure screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Pressure

To use the Pressure screen:

- This is a view only screen
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen



**Pressure Screen**

### Flows

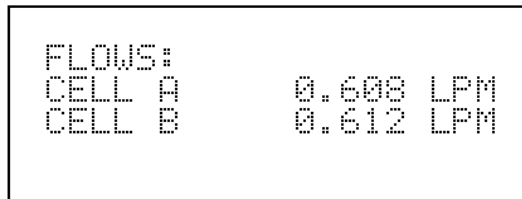
The Flow screen, shown below, displays the current flow rate through Cell A and Cell B. These flows are measured by internal flow sensors (see Figure 1-1).

To display the Flow Screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Flow

To use the Flow screen:

- This is a view only screen
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen



A rectangular box representing a monochrome LCD screen. The text on the screen is as follows:

```
FLOWS:  
CELL A      0.608 LPM  
CELL B      0.612 LPM
```

**Flow Screen**

### Cell A/B O<sub>3</sub>

The Cell A/B O<sub>3</sub> screen, shown below, displays the current O<sub>3</sub> concentration in each cell, as well as the O<sub>3</sub> reading displayed in the Run screen (the average of the two cells).

To display the Cell A/B O<sub>3</sub> Screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu Cell A/B O<sub>3</sub>

To use the Cell A/B O<sub>3</sub> screen:

- This is a view only screen
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen

O <sub>3</sub> PPB	600
CELL A	598
CELL B	602

Cell A/B O<sub>3</sub> Screen



### Intensities

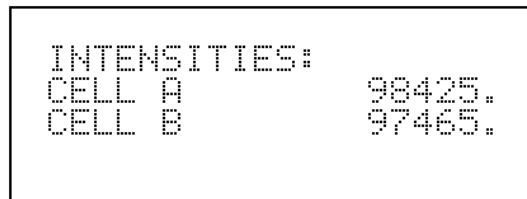
The Intensities screen, shown below, displays the current intensity in Cell A and Cell B in Hertz. The intensities are read by detectors A and B, respectively.

To display the Intensities Screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Intensities

To use the Intensities screen:

- This is a view only screen
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen



```
INTENSITIES:
CELL A      98425.
CELL B      97465.
```

**Intensities Screen**

### Test Analog Outputs

The Test Analog Outputs menu contains three choices as shown below. These functions enable the analog outputs to be set to zero and fullscale in order to adjust the analog outputs to agree with the front panel display. In addition, a digital to analog (DAC) ramp can be generated to fully test the analog outputs.

To display the Test Analog Outputs Menu:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Test Analog Outputs

To use the Test Analog Output menu:

- Use the ↑ and ↓ pushbuttons to move the cursor up and down
- Press **ENTER** to select a choice
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen

```
SET OUTPUTS TO:  
>ZERO  
FULL SCALE  
RAMP
```

### Test Analog Outputs Menu

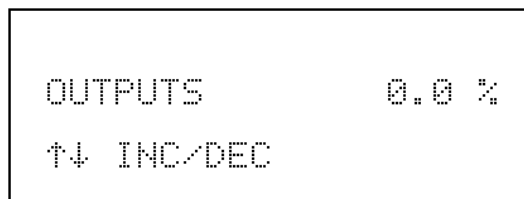
**Zero.** The Zero screen, as shown below, sets the analog outputs to zero volts. Use the ↑ and ↓ pushbuttons to increment/decrement the output level. For example, to set the analog outputs to 5% of fullscale, use the ↑ pushbutton to increment the 0.0% to 5.0%.

To display the Zero screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Test Analog Outputs
- From the Test Analog Outputs menu choose Zero

To use the Zero screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the output level
- Press **MENU** to return to the Diagnostics menu and cancel the zero output
- Press **RUN** to return to the Run screen and cancel the zero output



**Zero Analog Outputs Screen**

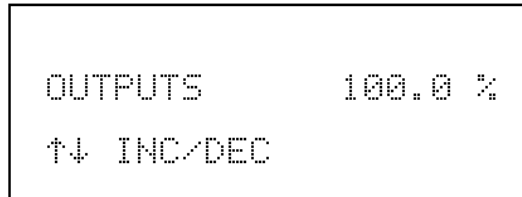
**Fullscale.** The Fullscale screen, as shown below, sets the analog outputs to fullscale. Use the ↑ and ↓ pushbuttons to increment/decrement the output level. For example, to set the analog outputs to 95% of fullscale, use the ↓ pushbutton to decrement the 100.0 to 95.0%.

To display the Fullscale screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Test Analog Outputs
- From the Test Analog Outputs menu choose Fullscale

To use the Fullscale screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the output level
- Press **MENU** to return to the Diagnostics menu and cancel the fullscale output
- Press **RUN** to return to the Run screen and cancel the fullscale output



```
OUTPUTS      100.0 %  
↑↓ INC/DEC
```

**Fullscale Analog Outputs Screen**

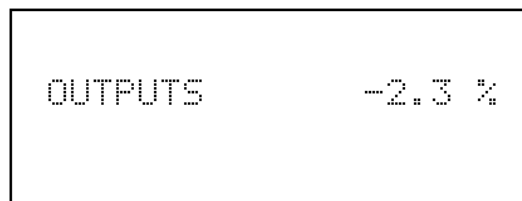
**Ramp.** The digital to analog (DAC) ramp is used to fully test the analog outputs. The analog outputs start at -2.3% and then increments by 0.1% every second until it reaches 100.0%. A linear output indicates a that the analog outputs are operating correctly.

To display the Ramp screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Test Analog Outputs
- From the Test Analog Outputs menu choose Ramp

To use the Ramp screen:

- This is a view only screen
- Press **MENU** to return to the Diagnostics menu and cancel the ramp output
- Press **RUN** to return to the Run screen and cancel the ramp output



**Ramp Analog Outputs Screen**

### Option Switches

The Option Switches screen, shown below, enables the settings of the internal option switches to be viewed. Option switch settings cannot be changed through the software. For more information about the internal option switches, see “Internal Option Switches” later in this chapter.

To display the Option Switches screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Option Switches

To use the Option Switches screen:

- This is a view only screen
- Use the ↑ and ↓ pushbuttons to move up and down
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen

```
OPTION SWITCHES:
>#1 REMOTE           ON
#2 RS-232            ON
#3 OZONATOR          OFF
```

```
#4 DOUBLE RANGE     OFF
#5 AUTORANGE        OFF
#6 LOCK              OFF
#7 FAST UPDATE      OFF
#8 SPARE             OFF
```

#### Option Switch Status Screen

## ALARMS

The Alarms menu, shown below, displays a list of items that are monitored by the analyzer. If the item being monitored goes outside the lower or upper limit, the status of that item will go from OK to either LOW or HIGH, respectively. The number in the upper right-hand corner of the display indicates how many alarms have occurred. If no alarms are detected, the number zero is displayed.

To see the actual reading of an item and its minimum and maximum limits, move the cursor to the item and press **ENTER**.

To display the Alarms menu:

- From the Main Menu choose Alarm

To use the Alarms menu:

- Use the ↑ and ↓ pushbuttons to move up and down
- Press **ENTER** to see the actual reading and the min and max limits
- Press **MENU** to return to the Main Menu
- Press **RUN** to return to the Run screen

```
ALARMS DETECTED: 0
>BENCH TEMP      OK
  BENCH LAMP TEMP OK
  PRESSURE        OK
```

```
FLOW A           OK
FLOW B           OK
INTENSITY A      OK
INTENSITY B      OK
O3 CONC          OK
```

### Alarm Menu

### Bench Temperature

The Bench Temperature screen, shown below, displays the current Bench temperature and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 5 to 50°C. If the internal temperature reading goes beyond either the min or max alarm limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu.

To display the Bench Temperature screen:

- From the Main Menu choose Alarm
- From the Alarm menu choose Bench Temperature

To use the Bench Temperature screen:

- Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- Press **ENTER** to select a choice (service mode on)
- Press **MENU** to return to the Alarm menu
- Press **RUN** to return to the Run screen

BENCH TEMP:	
ACTUAL	32.3° C
>MIN	15.0° C
MAX	35.0° C

**Bench Temperature Screen**



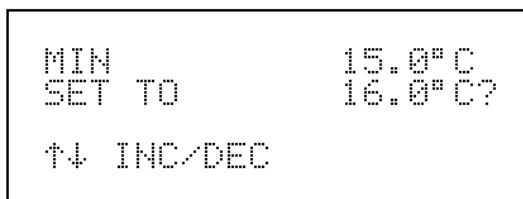
**Min and Max Bench Temperature Limits.** The Min Bench Temperature alarm limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min bench temperature alarm limit. The min and max Bench Temperature screens function the same way.

To display the Min or Max Bench Temperature limit screens (service mode on):

- From the Main Menu choose Alarm
- From the Alarm menu choose Bench Temperature
- From the Bench Temperature menu choose Min or Max

To use the Min or Max Bench Temperature limit screens (service mode on):

- Use the ↑ and ↓ pushbuttons to increment/decrement the value
- Press **ENTER** to accept the change
- Press **MENU** to return to the Bench Temperature menu
- Press **RUN** to return to the Run screen



```
MIN          15.0°C  
SET TO      16.0°C?  
↑↓ INC/DEC
```

**Set Min Bench Temperature Screen**

### Bench Lamp Temperature

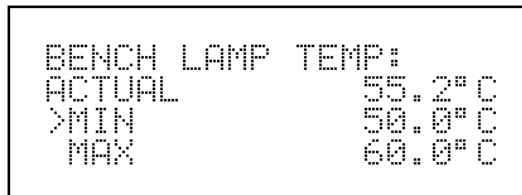
The Bench Lamp Temperature screen, shown below, displays the current bench lamp temperature and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 50 to 60°C. If the bench lamp temperature reading goes beyond either the min or max limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu.

To display the Bench Lamp Temperature screen:

- From the Main Menu choose Alarm
- From the Alarm menu choose Bench Lamp Temperature

To use the Bench Lamp Temperature screen:

- Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- Press **ENTER** to select a choice (service mode on)
- Press **MENU** to return to the Alarm menu
- Press **RUN** to return to the Run screen



```
BENCH LAMP TEMP:  
ACTUAL          55.2° C  
>MIN           50.0° C  
MAX            60.0° C
```

**Bench Lamp Temperature Screen**

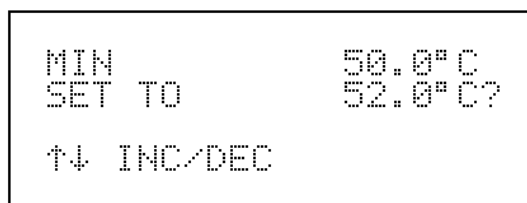
**Min and Max Bench Lamp Temperature Limits.** The Min Bench Lamp Temperature alarm limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min bench lamp temperature alarm limit. The min and max Bench Lamp Temperature screens function the same way.

To display the Min or Max Bench Lamp Temperature limit screens (service mode on):

- From the Main Menu choose Alarm
- From the Alarm menu choose Bench Lamp Temperature
- From the Bench Lamp Temperature menu choose Min or Max

To use the Min or Max Bench Lamp Temperature limit screens (service mode on):

- Use the ↑ and ↓ pushbuttons to increment/decrement the value
- Press **ENTER** to accept the change
- Press **MENU** to return to the Bench Lamp Temperature menu
- Press **RUN** to return to the Run screen



```
MIN          50.0°C
SET TO      52.0°C?
↑↓ INC/DEC
```

**Set Min Bench Lamp Temperature Screen**

### Pressure

The Pressure screen, shown below, displays the current bench pressure reading and the factory-set min max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 200 to 1,000 mm Hg. If the pressure reading goes beyond either the min or max alarm limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu.

To display the Pressure screen:

- From the Main Menu choose Alarm
- From the Alarm menu choose Pressure

To use the Pressure screen:

- Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- Press **ENTER** to select a choice (service mode on)
- Press **MENU** to return to the Alarm menu
- Press **RUN** to return to the Run screen

```
PRESSURE:
ACTUAL      753.4 mm Hg
>MIN        200.0 mm Hg
MAX         1000.0 mm Hg
```

**Pressure Screen**

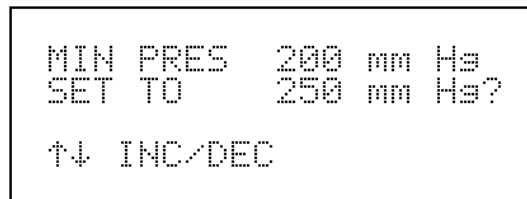
**Min and Max Pressure Limits.** The Min Pressure limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min pressure alarm limit. The min and max Pressure screens function the same way.

To display the Min or Max Pressure limit screens (service mode on):

- From the Main Menu choose Alarm
- From the Alarm menu choose Pressure
- From the Pressure menu choose Min or Max

To use the Min or Max Pressure limit screens (service mode on):

- Use the ↑ and ↓ pushbuttons to increment/decrement the value
- Press **ENTER** to accept the change
- Press **MENU** to return to the Pressure menu
- Press **RUN** to return to the Run screen



```
MIN PRES  200 mm Hg  
SET TO    250 mm Hg?  
  
↑↓ INC/DEC
```

**Set Min Pressure Screen**

### Flow A and B

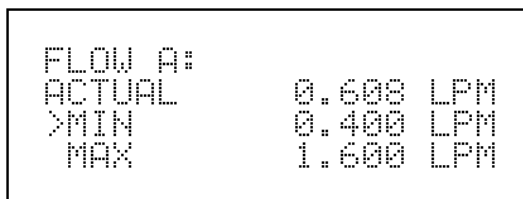
The Flow A screen, shown below, displays the current sample flow reading in Cell A and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 0.4 to 1.6 LPM. If the sample flow reading goes beyond either the min or max alarm limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu. The Flow B screen functions the same way as the Flow A screen.

To display the Flow A or Flow B screen:

- From the Main Menu choose Alarm
- From the Alarm menu choose Flow A or Flow B

To use the Flow A or Flow B screen:

- Use the ↑ and ↓ pushbuttons to move the cursor up and down (service mode)
- Press **ENTER** to select a choice (service mode)
- Press **MENU** to return to the Alarm menu
- Press **RUN** to return to the Run screen



A rectangular box containing a monospaced text display. The text is arranged in four lines. The first line is 'FLOW A:'. The second line is 'ACTUAL' followed by '0.600 LPM'. The third line is '>MIN' followed by '0.400 LPM'. The fourth line is 'MAX' followed by '1.600 LPM'. The text is left-aligned and uses a simple, dot-matrix style font.

FLOW A:	
ACTUAL	0.600 LPM
>MIN	0.400 LPM
MAX	1.600 LPM

**Flow A Screen**

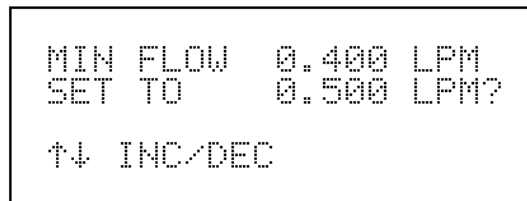
**Min and Max Flow Limits.** The Min Flow A limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min Flow A alarm limit. The min and max Flow A and Flow B screens function the same way.

To display the Min or Max Flow A or Flow B limit screen (service mode on):

- From the Main Menu choose Alarm
- From the Alarm menu choose Flow A or Flow B
- From the Flow menu choose Min or Max

To use the Min or Max Flow A or Flow B limit screen (service mode on):

- Use the ↑ and ↓ pushbuttons to increment/decrement the value
- Press **ENTER** to accept the change
- Press **MENU** to return to the Flow menu
- Press **RUN** to return to the Run screen



```
MIN FLOW  0.400 LPM  
SET TO    0.500 LPM?  
↑↓ INC/DEC
```

**Set Min Flow A Screen**

### Intensity A and B

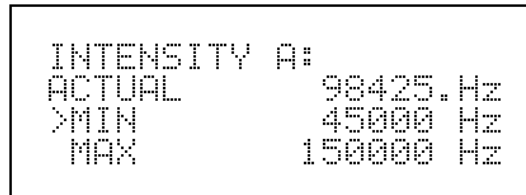
The Intensity A screen, shown below, displays the current lamp intensity reading in Cell A and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 45,000 to 150,000 Hz. If the Cell A lamp intensity reading goes beyond either the min or max alarm limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu. The Intensity A and Intensity B screens function the same way.

To display the Intensity A or Intensity B screen:

- From the Main Menu choose Alarm
- From the Alarm menu choose Intensity A or Intensity B

To use the Intensity A or Intensity B screen:

- Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- Press the **ENTER** pushbutton to select a choice (service mode on)
- Press **MENU** to return to the Alarm menu
- Press **RUN** to return to the Run screen



```
INTENSITY A:
ACTUAL      98425. Hz
>MIN       45000 Hz
MAX       150000 Hz
```

**Lamp Intensity Screen**



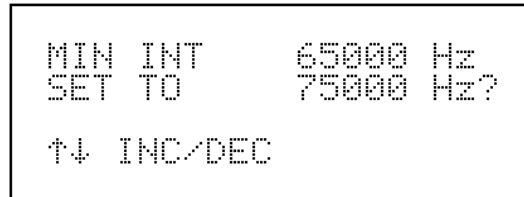
**Min and Max Intensity Limits.** The Min Intensity A limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min intensity alarm limit. The min and max Intensity A and Intensity B screens function the same way.

To display the Min or Max Intensity A or Intensity B limit screens (service mode on):

- From the Main Menu choose Alarm
- From the Alarm menu choose Intensity A or Intensity B
- From the Intensity menu choose Min or Max

To use the Min or Max Intensity A or Intensity B limit screens (service mode on):

- Use the ↑ and ↓ pushbuttons to increment/decrement the value
- Press **ENTER** to accept the change
- Press **MENU** to return to the Intensity menu
- Press **RUN** to return to the Run screen



```
MIN INT      65000 Hz
SET TO      75000 Hz?
↑↓ INC/DEC
```

**Set Min Lamp Intensity Screen**

### O<sub>3</sub> Concentration

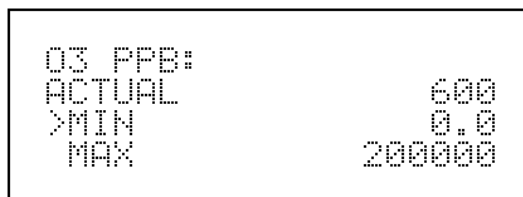
The O<sub>3</sub> Concentration screen, shown below, displays the current O<sub>3</sub> concentration and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 0 to 200 ppm. If the O<sub>3</sub> concentration reading goes beyond either the min or max alarm limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu.

To display the O<sub>3</sub> Concentration screen:

- From the Main Menu choose Alarm
- From the Alarm menu choose O<sub>3</sub> Concentration

To use the O<sub>3</sub> Concentration screen:

- Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- Press the **ENTER** pushbutton to select a choice (service mode on)
- Press **MENU** to return to the Alarm menu
- Press **RUN** to return to the Run screen



```
O3 PPM:
ACTUAL      600
>MIN        0.0
MAX        200000
```

**O<sub>3</sub> Concentration Screen**

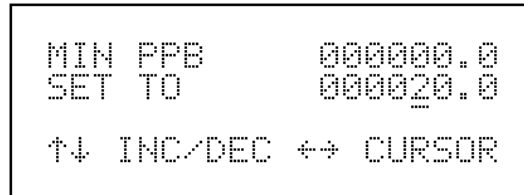
**Min and Max O<sub>3</sub> Concentration Limits.** The O<sub>3</sub> min and max concentration limit screens are accessible only when the instrument is in the service mode. They are used to change the min and max concentration alarm limits. The min O<sub>3</sub> concentration screen is shown below.

To display the Min or Max O<sub>3</sub> Concentration limit screens (service mode on):

- From the Main Menu choose Alarm
- From the Alarm menu choose O<sub>3</sub> Concentration
- From the O<sub>3</sub> Concentration menu choose Min or Max

To use the Min or Max O<sub>3</sub> Concentration limit screens (service mode on):

- Use the ↑ and ↓ pushbuttons to increment/decrement the value
- Press **ENTER** to accept the change
- Press **MENU** to return to the O<sub>3</sub> Concentration menu
- Press **RUN** to return to the Run screen



```
MIN PPB      000000.0
SET TO      000020.0
↑↓ INC/DEC  ↔ CURSOR
```

**Set Min O<sub>3</sub> Concentration Screen**

### SERVICE MODE MENU

The Service Mode menu, shown below, appears only when the instrument is in the service mode. To put the instrument into the service mode, select Instrument Controls from the Main Menu, then from the Instrument Controls menu select Service Mode. When the instrument is in the service mode, the Main Menu extends to include the Service Mode menu. The service mode includes some of the same information found in the Diagnostic menu. However, items such as bench lamp setting, Cell A and Cell B intensities, pressure, and flow readings are updated every second as opposed to every 10 seconds. The rapid update time enables the readings on the display to respond faster to adjustment. In addition, advanced diagnostic functions are included in the service mode. Meaningful data should not be collected when the instrument is in the service mode.

To display the Service Mode menu:

- From the Main Menu choose Service Mode

To use the Service Mode menu:

- Use the ↑ and ↓ pushbuttons to move the cursor up and down
- Press **ENTER** to select a choice
- Press **MENU** to return to the Main Menu
- Press **RUN** to return to the Run screen

```
SERVICE MODE:  
>PRESSURE  
  PRESSURE CHECK  
  FLOW A
```

```
  FLOW B  
  TEST LAMP OUTPUTS  
  LAMP SETTING  
  INTENSITY CHECK  
  A/D FREQUENCY  
  SET TEST DISPLAY
```

#### Service Mode Menu

### Pressure

The Pressure screen, shown below, shows the optical bench pressure. The bench pressure is updated every second. This screen is used while adjusting the pressure transducer potentiometers.

**CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, “Servicing.”

To display the Pressure screen:

- From the Main Menu choose Service Mode
- From the Service Mode menu choose Pressure

To use the Pressure screen:

- This is a view only screen
- Press **MENU** to return to the Service Mode menu
- Press **RUN** to return to the Run screen



PRESSURE 753.4 mm Hg

**Pressure Screen**

### Pressure Check

The Pressure Check menu, shown below, is used to manually control the flow of reference or sample gas through Cell B. This enables the pressure reading of Cell B, with either sample or reference gas, to be determined. Pump Check is used to test the pump. Selecting any of these menu choices will disturb the analog outputs.

To display the Pressure Check menu:

- From the Main Menu choose Service Mode
- From the Service Mode menu choose Pressure Check

To use the Pressure Check menu:

- Use the ↑ and ↓ pushbuttons to move the cursor up and down
- Press **ENTER** to select a choice
- Press **MENU** to return to the Service Mode menu
- Press **RUN** to return to the Run screen

```
PRESSURE CHECK:
>SAMPLE PRESSURE
REFERENCE PRESSURE
PUMP CHECK
```

**Pressure Check Menu**

**Sample and Reference Pressure** The Sample Pressure screen, shown below, displays the pressure of the sample gas in Cell B. The Reference Pressure screen displays the pressure of the reference gas in Cell B.

To display the Sample or Reference Pressure screens (service mode on):

- From the Main Menu choose Service Mode
- From the Service Mode menu choose Pressure Check
- From the Pressure Check screen choose Sample or Reference Pressure

To use the selected screen (service mode on):

- This is a view only screen
- Press **MENU** to return to the Pressure check menu
- Press **RUN** to return to the Run screen

A rectangular box representing a screen display. Inside the box, the text "PRESSURE 753.4 mm Hg" is displayed in a monospaced, pixelated font.

PRESSURE 753.4 mm Hg

**Sample Pressure Screen**

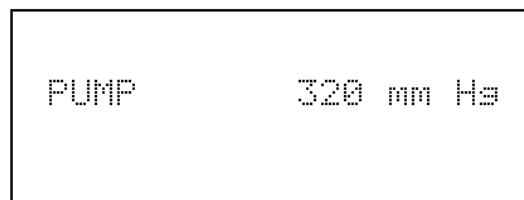
**Pump Check** The Pump Check screen, shown below, is used to test the pump. The solenoids are energized such that there is no flow in Cell B. The flow rate for Cell B drops to zero and the pressure reading should drop below 390 mm Hg in less than 20 seconds. This indicates the effectiveness of the internal pump.

To display the Pump Check screen (service mode on):

- From the Main Menu choose Service Mode
- From the Service Mode menu choose Pressure Check
- From the Pressure Check screen choose Pump Check

To use the Pump Check screen (service mode on):

- This is a view only screen
- Press **MENU** to return to the Pressure check menu
- Press **RUN** to return to the Run screen



**Pump Check Screen**



## Flow A and B

The Flow A screen, shown below, shows the flow in Cell A. The flow reading is updated every second. This screen is used while the Cell A flow sensor potentiometers are adjusted. The potentiometer closest to the mounting flange is the zero adjust potentiometer and the potentiometer farthest from the mounting flange is the span potentiometer. The Flow A and Flow B screens function the same way.

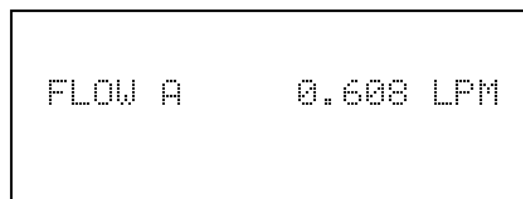
**CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, “Servicing.”

To display the Flow A or Flow B screen:

- From the Main Menu choose Service Mode
- From the Service Mode menu choose Flow A or Flow B

To use the Flow A or Flow B screen:

- This is a view only screen
- Press **MENU** to return to the Service Mode menu
- Press **RUN** to return to the Run screen



**Flow A Screen**

### Test Lamp Outputs

The Test Lamp Outputs menu enables the lamp control circuitry to be calibrated to zero and fullscale. These settings are calibrated at the factory and should not need to be changed. The Test Lamp Outputs menu functions the same as Test Analog Outputs. In fact, the lamp output can be measured on the rear panel analog output connector (between terminals 7 and 8).

To display the Test Lamp Outputs Menu:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Test Lamp Outputs

To use the Test Lamp Outputs menu:

- Use the ↑ and ↓ pushbuttons to move the cursor up and down
- Press **ENTER** to select a choice
- Press **MENU** to return to the Diagnostics menu
- Press **RUN** to return to the Run screen

```
SET OUTPUTS TO:
>ZERO
FULL SCALE
RAMP
```

### Test Analog Outputs Menu

**Zero.** The Zero screen, as shown below, sets the lamp control voltage to zero volts. Use potentiometer R7 on the D/A Board to adjust the lamp control circuit to zero.

**CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, “Servicing.”

To display the Zero screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Test Lamp Outputs
- From the Test lamp Outputs menu choose Zero

To use the Zero screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the output level
- Press **MENU** to return to the Diagnostics menu and cancel the zero output
- Press **RUN** to return to the Run screen and cancel the zero output

```
OUTPUTS          0.0 %  
↑↓ INC/DEC
```

**Zero Lamp Output Screen**

**Fullscale.** The Fullscale screen, as shown below, sets the lamp control circuit to fullscale. Use potentiometer R8 on the D/A Board to adjust the lamp control circuit to fullscale.

**CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, “Servicing.”

To display the Fullscale screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Test Lamp Outputs
- From the Test Lamp Outputs menu choose Fullscale

To use the Fullscale screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the output level
- Press **MENU** to return to the Diagnostics menu and cancel the fullscale output
- Press **RUN** to return to the Run screen and cancel the fullscale output

```
OUTPUTS      100.0 %  
↑↓ INC/DEC
```

**Fullscale Lamp Output Screen**

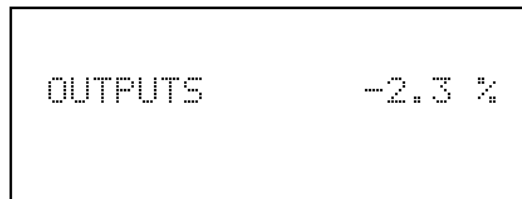
**Ramp.** The digital to analog (DAC) ramp is used to fully test the lamp control circuitry. The analog outputs start at -2.3% and then increments by 0.1% every second until it reaches 100.0%. A linear output indicates a that the lamp control circuitry is operating correctly.

To display the Ramp screen:

- From the Main Menu choose Diagnostics
- From the Diagnostics menu choose Test Lamp Outputs
- From the Test Lamp Outputs menu choose Ramp

To use the Ramp screen:

- This is a view only screen
- Press **MENU** to return to the Diagnostics menu and cancel the ramp output
- Press **RUN** to return to the Run screen and cancel the ramp output



**Ramp Analog Outputs Screen**

### Lamp Setting

The Lamp Setting screen, shown below, is used to adjust the detector intensities. The first and second line of the display shows the intensities of Cell A and Cell B. The third line of the display shows the current lamp setting. Adjust the lamp setting until the intensities are about 100 kHz.

To display the Lamp Setting screen:

- From the Main Menu choose Service Mode
- From the Service Mode menu choose Lamp Setting

To use the Lamp Setting screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the lamp setting
- Press **MENU** to return to the Service Mode menu
- Press **RUN** to return to the Run screen

```
CELL A INT 98425.Hz
CELL B INT 97465.Hz
LAMP SETTING % 72.9
↑↓ INC/DEC
```

**Lamp Setting Screen**

## Intensity Check

The Intensity Check menu, shown below, is used to manually control the flow of reference or sample gas through either Cell A or Cell B. This enables the intensity and noise reading of each detector to be determined with either reference or sample gas flow. Selecting any of these menu choices will disturb the analog outputs.

To display the Intensity Check menu:

- From the Main Menu choose Service Mode
- From the Service Mode menu choose Intensity Check

To use the Intensity Check menu:

- Use the ↑ and ↓ pushbuttons to move the cursor up and down
- Press **ENTER** to select a choice
- Press **MENU** to return to the Service Mode menu
- Press **RUN** to return to the Run screen

```
>INT A REFERENCE GAS
INT A SAMPLE GAS
INT B REFERENCE GAS
INT B SAMPLE GAS
```

### Intensity Check Menu

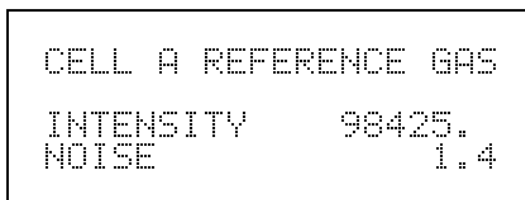
**Intensity A Reference Gas** The Intensity A Reference Gas screen, shown below, switches the solenoid valves so that reference gas is flowing through Cell A. The intensity and noise reading are displayed. The Intensity B Reference Gas screen functions the same way. Also, the Intensity A and Intensity B Sample Gas screens function the same way (only with sample gas instead of reference gas).

To display the Int A or B Ref or Sample screens (service mode on):

- From the Main Menu choose Service Mode
- From the Service Mode menu choose Intensity Check
- From the Intensity Check screen choose Int A or B Ref or Sample

To use the selected screen (service mode on):

- This is a view only screen
- Press **MENU** to return to the Intensity check menu
- Press **RUN** to return to the Run screen



```
CELL A REFERENCE GAS
INTENSITY      98425.
NOISE          1.4
```

**Cell A Reference Gas Screen**



## **A/D Frequency**

The A/D Frequency screen, shown below, displays the frequency of each of the analog to digital (A/D) converters located on the A/D Board. Each A/D has a frequency range between 0 and 100,000 Hertz. This frequency range corresponds to a voltage range of 0 to -10 volts dc. See Appendix B, “Schematics” for the A/D Board schematic. The A/D converters are assigned as follows:

A/D Converter	Function
AN0	Spare
AN1	Ozonator Flow
AN2	Spare
AN3	Flow Cell B
AN4	Spare
AN5	Flow Cell A
AN6	Spare
AN7	Pressure
AN8	Ozonator Lamp Temperature
AN9	Lamp Temperature
AN10	Spare
AN11	Bench Temperature

**Table 3-2.** A/D Converters

## Chapter 3 Operation

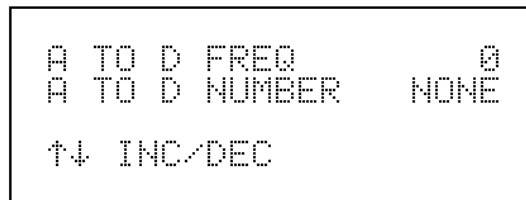
---

To display the A/D Frequency screen:

- From the Main Menu choose Service Mode
- From the Service Mode menu choose A/D Frequency

To use the A/D Frequency screen:

- Use the ↑ and ↓ pushbuttons to increment/decrement the A to D number
- Press **MENU** to return to the Service Mode menu
- Press **RUN** to return to the Run screen



```
A TO D FREQ      0
A TO D NUMBER    NONE
↑↓ INC/DEC
```

**A/D Frequency Screen**

## Set Test Display

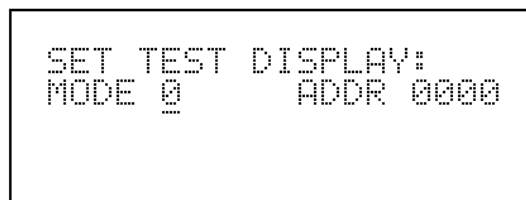
The Set Test Display screen, shown below, displays the contents of a given memory location. This screen is useful to TEI service personnel and should only be used when consulting the factory.

To display the Set Test Display screen:

- From the Main Menu choose Service Mode
- From the Service Mode menu choose Set Test Display

To use the Set Test Display screen:

- Use the ↑ and ↓ pushbuttons to change the display mode
- Press **MENU** to return to the Service Mode menu
- Press **RUN** to return to the Run screen



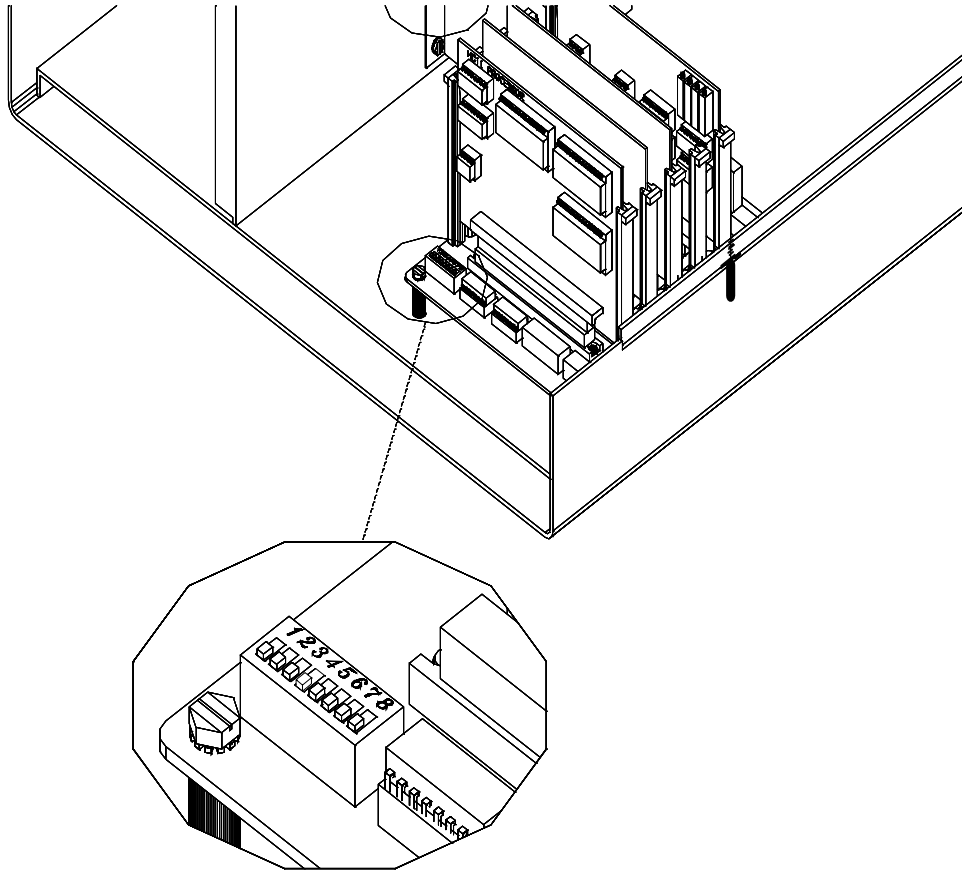
```
SET TEST DISPLAY:  
MODE 0      ADDR 0000
```

**Set Test Display**

## INTERNAL OPTION SWITCHES

The internal option switches are located on the Motherboard (near front panel), as shown in Figure 3-7 below. The function of each option switch is given in Table 3-3. These switches are used to activate hardware and software options.

**CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, “Servicing.”



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**Figure 3-7.** Location of Internal Option Switches

---

Option Switch	Function
1	Remote
2	RS-232
3	Internal Ozonator
4	Double Range
5	Autorange
6	Lock
7	Fast Update Time
8	Spare

**Table 3-3.** Option Switch Functions

## Remote

Option switch 1 is on when a remote interface is installed, such as RS-232 or I/O activation.

## RS-232

Option switch 2 is used to select between RS-232 and I/O activation. When option switch 2 is on, RS-232 is selected. When it is off, I/O activation is selected.

## Internal Ozonator

Option switch 3 is on when the optional internal ozonator is installed. For more information about the internal ozonator, see Chapter 9, “Optional Equipment.”

## Double Range and Autorange

The double range (option switch 4) and autorange (option switch 5) switches are used to activate the single, dual, and autorange modes. The following table shows how each mode is activated. For more information about the single, dual, and autorange modes, see “Operating Modes,” earlier in this chapter.

<b>Operating Mode</b>	<b>Option Switch 4</b>	<b>Option Switch 5</b>
Single Range Mode	Off	On or Off
Dual Range Mode	On	Off
Autorange Mode	On	On

**Table 3-4.** Operating Mode Truth Table

### **Lock**

When option switch 6 is on, instrument parameters are “locked” and can not be changed. This prevents any erroneous entry of instrument parameters. When option switch 6 is off, instrument parameters can be changed.

### **Fast Update Time**

When option switch 7 is on, fast update times (averaging times) are available. These include 4, 8, 12, 24, 36, 48, 72, 96, and 120 seconds. When option switch 7 is off, normal averaging times are available. These include 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds. Use the Averaging Time screen to select an averaging time.

### **Spare**

This option switch is currently not used.

---

## CHAPTER 4

# CALIBRATION

This chapter describes how to perform a multipoint calibration of the photometric ozone analyzer. It is based upon the current EPA approved procedure using a UV photometer as a calibration standard. The information described here should be adequate to perform the calibration. However, for more information refer to the Code of Federal Regulations (Title 40, Part 50, Appendix D) and the EPA's "Technical Assistance Document for the Calibration of Ambient Ozone Monitors."

## EQUIPMENT REQUIRED

### Zero Air Generator

Zero air can be obtained either from compressed cylinders or from scrubbed ambient air. If cylinder air is used, it should be actual and not synthetic. If ambient air is used, the following compounds must be removed: ozone, nitric oxide, nitrogen dioxide, sulfur dioxide, and hydrocarbons. The following scheme is recommended by the EPA in its technical assistance document:

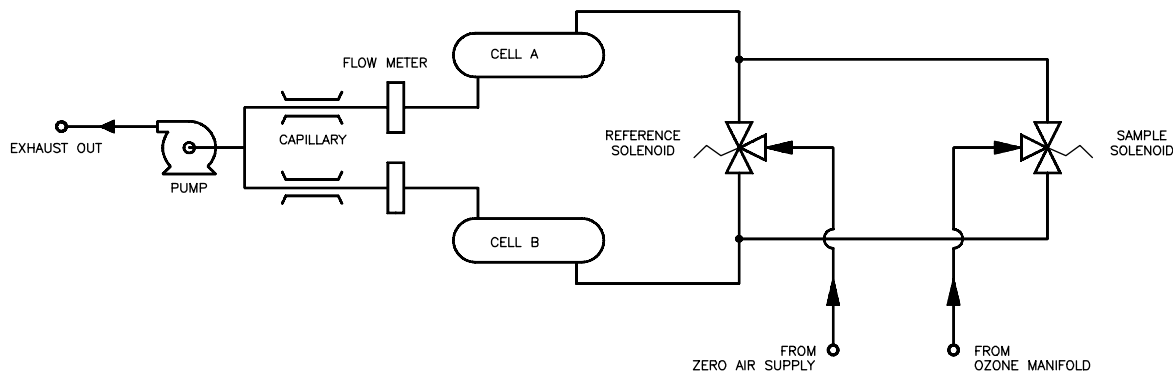
1. Irradiate the air with an ozone generating UV lamp to convert nitric oxide to nitrogen dioxide. Alternatively, pass air through Purafil® which oxidizes nitric oxide to nitrogen dioxide and scrubs nitrogen dioxide.
2. Pass air through a large column of activated charcoal to remove residual nitrogen dioxide, ozone, sulfur dioxide, hydrocarbons, and so on.
3. Pass air through a molecular sieve.
4. Pass air through a final particulate filter to remove particulates which originate in scrubbing columns.

An important requirement for the calibration photometer operation is that the zero air used to reference the photometer come from the same source as the zero air used in the ozonator. This is to effectively cancel impurities present in the zero air source.

### Calibration Photometer System

A UV photometer calibration system which includes an ozone generator, an output port or manifold, a photometer, and a source of zero air is required. The Thermo Environmental Instruments Model 49PS Ozone Photometric Primary Standard satisfies the calibration photometer system requirement in a single convenient package. In addition, the Model 49C can be modified to operate as a calibration photometer by removing the ozone scrubber and plumbing zero air into the common port of the ozone-free solenoid valve, as shown in Figure 4-1.

If the Model 49C is modified to operate as a calibration photometer, it must be dedicated for calibration and not be used for monitoring ozone at any time.



**Figure 4-1.** Model 49C Connected as Calibrator

### INSTRUMENT PREPARATION

Prior to calibration, follow the steps below:

1. Turn on the instrument and allow it to stabilize for a minimum of one hour. Perform the service checks of Chapter 5 “Preventive Maintenance.”
2. Connect the Model 49C to the ozone manifold. If a Teflon® particulate filter is being used, it must be installed prior to calibration.

### CALIBRATION PHOTOMETER SYSTEM PREPARATION

As indicated in the EPA Technical Assistance Document there are several tests that should be performed prior to the use of an ozone UV photometer as a calibrator to ensure the accuracy of the measurements. These tests include:

- System check
- Ozone loss test
- Linearity check
- Intercomparability test



### System Check

A step-by-step checkout procedure to verify proper operation of a Model 49PS (or a Model 49C modified as described earlier) is as follows:

1. Turn the calibration photometer on.
2. Turn on the ozonator.
3. Allow the calibration photometer and ozonator to stabilize for one hour.
4. Perform service checks of Chapter 5 “Preventive Maintenance.”

### Ozone Loss Test

If the calibration photometer passes the leak test of Chapter 5 “Preventive Maintenance,” it is highly unlikely that the system is destroying ozone. If desired, a rigorous test is as follows (this check follows the EPA's Technical Assistance Document with the appropriate change for a time-shared, dual cell system). For this test, if the internal ozonator of the Model 49PS is being used, make sure it is in the manual mode.

1. Calibrate an ozone analyzer using the calibration photometer. Assume the photometer is correct.
2. Generate a stable level of ozone and with the calibrated ozone analyzer measure and note reading as  $R_m$ .
3. Unplug the pump of the calibration photometer from the ac power source and plug the exhaust line and zero-air inlet line.
4. Connect the calibrated ozone analyzer to the access port on the inlet of Cell A (the Model 49PS has caps at all access points so the Teflon® lines do not have to be disconnected).
5. From the Service Mode menu, select Intensity Check. From the Intensity Check menu, select Int B Reference Gas. Wait for a steady reading and record the intensity as  $R(a)_{input}$ .
6. Connect the calibrated ozone analyzer to the access port on the inlet of cell B. From the Service Mode menu, select Intensity Check. From the Intensity Check menu, select Int A Reference Gas. Wait for a steady reading and record the intensity as  $R(b)_{input}$ .
7. Replace access fittings used in steps 4 and 6 above and make sure they are leak tight.
8. Connect the calibrated ozone analyzer to the access port on the outlet of absorption cell of Cell A.
9. From the Service Mode menu, select Intensity Check. From the Intensity Check menu, select Int B Reference Gas. Wait for a steady reading and record the intensity as  $R(a)_{out}$ .

10. Connect the calibrated ozone analyzer to the access port on the outlet of absorption cell of Cell B. From the Service Mode menu, select Intensity Check. From the Intensity Check menu, select Int A Reference Gas. Wait for a steady reading and record the intensity as  $R(b)_{out}$ .
11. Replace access fittings used in steps 8 and 10, and make sure they are leak tight.
12. Compute percent of ozone loss from the following equation:

Percent of Ozone Loss =

$$\frac{R_m - 1/4[R(a)_{input} + R(a)_{out} + R(b)_{input} + R(b)_{out}]}{R_m} \times 100\% \quad (1)$$

If the ozone loss is greater than 2%, check that the absorption cells and Teflon® tubing have not become contaminated by dirt. See Chapter 5, “Preventive Maintenance,” for more information about Cleaning the Optical Bench. If the cells and Teflon® tubing are clean, recondition the optical bench by setting the ozone generator for maximum ozone and adjust the pressure regulator for minimum dump flow (about 1/2 liter per minute). Let calibration photometer run overnight sampling the high level of ozone. Then repeat ozone loss test.

### Linearity Check

Since the Model 49C is inherently linear over the range of interest (0-1 ppm), a linearity test is an effective overall test that the instrument is operating properly. The checks above should identify whether any causes of non-linearity are present. The possible causes of non-linearity are:

- Dirty or contaminated cell, lines, or manifold
- Inadequate conditioning of system
- Leaks in system
- Contamination in zero air
- Non-linear detectors in photometer
- Faulty electronics

To demonstrate linearity, generate a concentration of ozone near the upper range limit of the calibration photometer and accurately dilute the ozonated air with zero air. To do this test accurately, two calibrated flow meters and a mixing chamber are needed: one flow meter to measure the flow into the ozonator, and the other to measure the flow of the dilutant zero air. The percent of non-linearity is calculated as follows:

$$R = \frac{F_o}{F_o + F_d} \quad (2)$$

$$E = \frac{A_1 + \frac{A_2}{R}}{A_1} \times 100\% \quad (3)$$

where:

$F_o$  = Ozonator flow

$F_d$  = Dilutant zero air flow

$E$  = Linearity error, in percent

$A_1$  = Assay of original concentration

$A_2$  = Assay of diluted concentration

$R$  = Dilution ratio

Note that the inherent linearity accuracy of the Model 49PS (or modified Model 49C) is greater than the accuracy measurements of the mass flow meters.

To check the calculations are complete and accurate:

1. With the ozone generator in the manual mode, i.e., gain set to zero, adjust ozone level to generate a level in excess of 0.5 ppm. Wait until ozone concentration is stable.
2. From the Service Mode menu, select Intensity Check. From the Intensity Check menu, select Int A Reference Gas. Wait for stable frequency reading and note as  $I_o(A)$ . Press the **MENU** pushbutton to return to the Intensity Check menu.
3. From the Intensity Check menu, select Int A Sample Gas. Wait for stable frequency reading, note as  $I(A)$ . Press the **MENU** pushbutton to return to the Intensity Check menu.
4. From the Intensity Check menu, select Int B Reference Gas. Wait for stable frequency reading, note as  $I_o(B)$ . Press the **MENU** pushbutton three times to return to the Main Menu.

5. From the Main Menu choose Diagnostics. From the Diagnostics menu choose Temperatures to get the current bench temperature and Pressure to get the current pressure reading.
6. Compute C(A) and C(B) from Equation 4.

$$C = \left( \frac{10^6}{(308) 37.84} \right) \left( \frac{760(273 + T)}{273P} \right) \ln \left( \frac{I_o}{I} \right) \quad (4)$$

This value should agree with the value noted in the Run screen. Note that the concentration determined in this manner does not correct for lamp fluctuation and thus will be noisier than the concentration determined in the Run screen.

### Intercomparability Test

To perform an intercomparability test of a Model 49PS, it may be necessary to have the Model 49PS sample ozone from a source other than the one contained in the instrument. This can be done by:

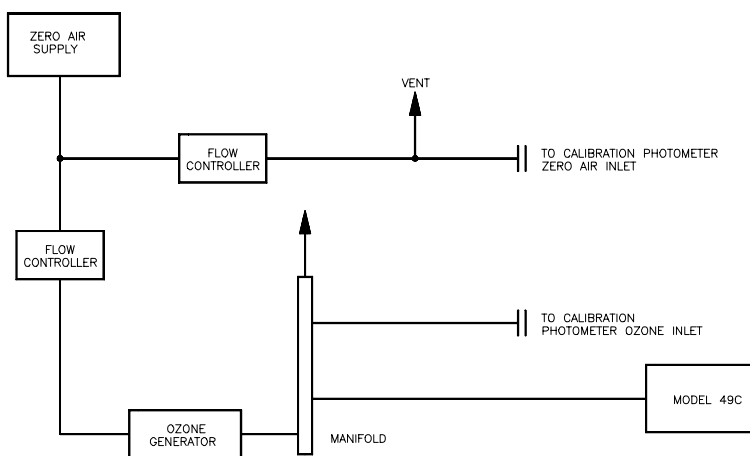
1. Set ozone level thumbwheel to zero.
2. At the Teflon® distribution manifold, disconnect the line from the ozonator to the manifold and cap fitting.
3. Cap bulkhead labeled **VENT**.
4. Connect Teflon® line from bulkhead labeled ozone to manifold of ozone source being utilized for intercomparability study.
5. Make sure the same zero air is feeding both the Model 49PS and the second photometer being used in study.
6. If it is desired to hold usage of zero air to a minimum, adjust the pressure regulator feeding the ozonator to zero pressure.
7. Perform intercomparability test.
8. After completion of test, reconnect ozonator and leak check following the directions of Model 49PS External Leaks in Chapter 5, "Preventive Maintenance."
9. If in addition to the two ozone photometers being checked for intercomparability, an ozone analyzer is available, an easier intercomparability check is to calibrate the ozone analyzer against each photometer individually and then compare the two ozone calibration curves.
10. If a calibration photometer other than a Model 49PS or modified Model 49C is being used, follow the checkout procedure given in the Manual for the calibration photometer, or follow the procedure in the Technical Assistance Document.

## CALIBRATION PROCEDURE

To generate data of the highest confidence, it is recommended that a multipoint calibration be performed every three months, any time major disassembly of components is performed, or any time the zero or span checks give results outside the limits described in “Periodic Zero and Span Checks below.”

### Connect Instrument

Connect the Model 49C to the manifold on the output of the ozonator, as shown in Figure 4-2. If an optional sample line filter is used, the calibration must be performed through this filter. Ensure that the flow rate into the output manifold is greater than the total flow required by the calibration photometer, analyzer, and any other flow demand connected to the manifold.



**Figure 4-2.** Model 49C Connected to Calibration Photometer and External Ozonator

### Zero Adjust

1. Allow sufficient time for the Model 49C Ambient Ozone Analyzer and the calibration photometer to warm up and stabilize.

2. With the zero air supply on, but the ozonator off, allow the Model 49C to sample zero air until a stable response is obtained. From the Main Menu choose Calibration. From the Calibration menu choose Calibrate Zero. Press **ENTER** to perform a zero calibration. Press the **RUN** pushbutton to return to the Run screen. If a strip chart recorder is used, it is recommended that it be adjusted to obtain a record of zero drift and/or zero noise. This can be achieved by using the zero offset capability of the recorder.
3. Record the stable zero air response as  $Z$ .

### Span Adjust

1. Generate an ozone concentration standard of approximately 80% of the upper range limit (URL) of the ozone analyzer (i.e., 0.4 or 0.8 ppm for the 0.5 and 1.0 ppm ranges respectively). Allow the Model 49C Ozone Analyzer to sample this ozone concentration standard until a stable response is obtained.
2. From the Main Menu choose Calibration. From the Calibration menu choose Calibrate Span. Use the  $\uparrow$  and  $\downarrow$  pushbuttons to increment/decrement the known span gas concentration. Press **ENTER** to calibrate the instrument. The recorder response will equal:

$$\text{RecorderResponse (\%Scale)} = \frac{(\text{O}_3)_{\text{out}}}{\text{URL}} \times 100 + Z \quad (5)$$

where:

URL = Upper range limit of the Model 49C, ppm

$Z$  = Recorder response with zero air, % scale

$[\text{O}_3]_{\text{out}}$  = Ozone concentration as determined by the calibration photometer, ppm.

3. Record the ozone concentration as determined by the calibration photometer and the corresponding analyzer response.

### **Additional Concentration Standards**

1. Generate several other ozone concentration standards (at least 5 others are recommended) over the scale range of the Model 49C Ozone Analyzer.
2. For each ozone concentration standard, record the ozone concentration as determined by the calibration photometer and record the corresponding Model 49C analyzer response. If a Model 49PS is being used as the calibration photometer, use the ozone concentration as determined by the photometer and not the value of the ozone level thumbwheel.

### **Calibration Curve**

Plot the Model 49C Analyzer responses versus the corresponding ozone concentrations. Connect the experimental points by using a straight line, preferably determined by linear regression techniques. Points that lie more than  $\pm 4\%$  from this line are an indication of an error in determining the calibration curve. The error may be due to a malfunction of the calibration photometer, or a malfunction of the analyzer being calibrated. The most likely malfunctions in both the analyzer and calibration photometer which can give non-linear results are leaks, a malfunctioning ozone scrubber, a dirty solenoid, or dirt in the optical system. The calibration curve is used to reduce subsequent ambient data.

To generate data of the highest confidence, it is recommended that a multipoint calibration be performed every three months, any time major disassembly of components is performed, or any time the zero or span checks give results outside the limits described in “Periodic Zero and Span Checks” below.

### **PERIODIC ZERO AND SPAN CHECKS**

To achieve data of the highest confidence, it is suggested that periodic zero and span checks be performed. These checks can be performed by:

1. Periodically challenging the Model 49C with zero air. The output flow of the zero air supply should be greater than the flow demand of the Model 49C. In addition, an atmospheric dump bypass should be used to ensure that the zero air gas flow is being delivered at atmospheric pressure. Record the analyzer response in percent of scale as  $A_0$ . Compute the zero drift from the following equation:

$$\text{ZeroDrift} \dots \% = A_0 - Z \tag{6}$$

where Z is the recorder response obtained at the last calibration for zero air, % scale.

- Periodically challenging the Model 49C with an ozone level of approximately 80% URL from a previously calibrated stable ozone generator. The output flow from this generator should be greater than the flow demand of the Model 49C. In addition, an atmospheric dump bypass should be used to ensure the span gas flow is being delivered at atmospheric pressure. Record the analyzer response in % of scale as  $A_{80}$ . Compute the span error from the following equation:

$$\frac{[(A_{80} - Z) \frac{\text{URL}}{100}] - [O_3]}{[O_3]} \times 100 \tag{7}$$

where:

Z = Recorder response obtained at the last calibration for zero air, % scale

$[O_3]$  = Generated span concentration, ppm.

- A zero drift in excess of  $\pm 4\%$  of fullscale, or a span drift in excess of  $\pm 6\%$  of fullscale is an indication of a malfunction either of the zero air supply, ozone source, recorder, or analyzer. Since the Model 49C is a ratio instrument and thus does not have an electronic span or zero drift, it is not recommended that any zero adjustment or span adjustment be performed as the result of a zero or span check. If values are obtained outside of the limits of  $\pm 4\%$  for zero and  $\pm 6\%$  for span drift, the multipoint calibration above is indicated to isolate the problem.
- For detailed guidance in setting up a quality assurance program, refer to the code of Federal Regulations, and the EPA Handbook on Quality Assurance.



## INTERNAL OZONATOR ADJUSTMENT (Options 340 or 350)

The internal ozonator has been designed to satisfy the current EPA regulations on biweekly precision and span checks. Before this option can be used for precision or span checks, it must be certified as a transfer standard. For detailed information on qualification and certification of an ozone generating transfer standard, refer to the EPA Technical Assistance Document on Transfer Standards. For more information about the internal ozonator, see Chapter 9 “Optional Equipment.” To adjust the internal ozonator, follow the directions below:

1. Connect a transfer standard or primary standard to the ozone **OUT** bulkhead fitting of the Model 49C (see Figure 4-3).
2. If an optional remote interface is installed, place the instrument in the local mode.
3. From the Main Menu choose Instrument Controls. From the Instrument Controls menu choose O<sub>3</sub> Level 1.
4. Adjust Level 1 for the desired level (typically 80% URL ).
5. Allow this value to stabilize. Record the value as [O<sub>3</sub>]<sub>80</sub> to be used in the span error equation of step 2 in the “Periodic Zero and Span Checks” section above. Note Level 1 setting. Press **MENU** to return to the Instrument Controls menu.
6. From the Instrument Control menu choose O<sub>3</sub> Level 2.
7. Adjust Level 2 for the desired level (typically 90 ppb ).
8. Allow this value to stabilize. Record the value as [O<sub>3</sub>]<sub>20</sub> to be used in the following error equation:

$$\% \text{ Error} = \frac{[(A_{20} - Z) \frac{\text{URL}}{100}] - [\text{O}_3]_{20}}{[\text{O}_3]_{20}} \times 100 \quad (8)$$

Where:

$A_{20}$  = Recorder response of Model 49C with precision level, % scale;

$Z$  = Recorder response obtained at the last calibration for zero air, % scale.

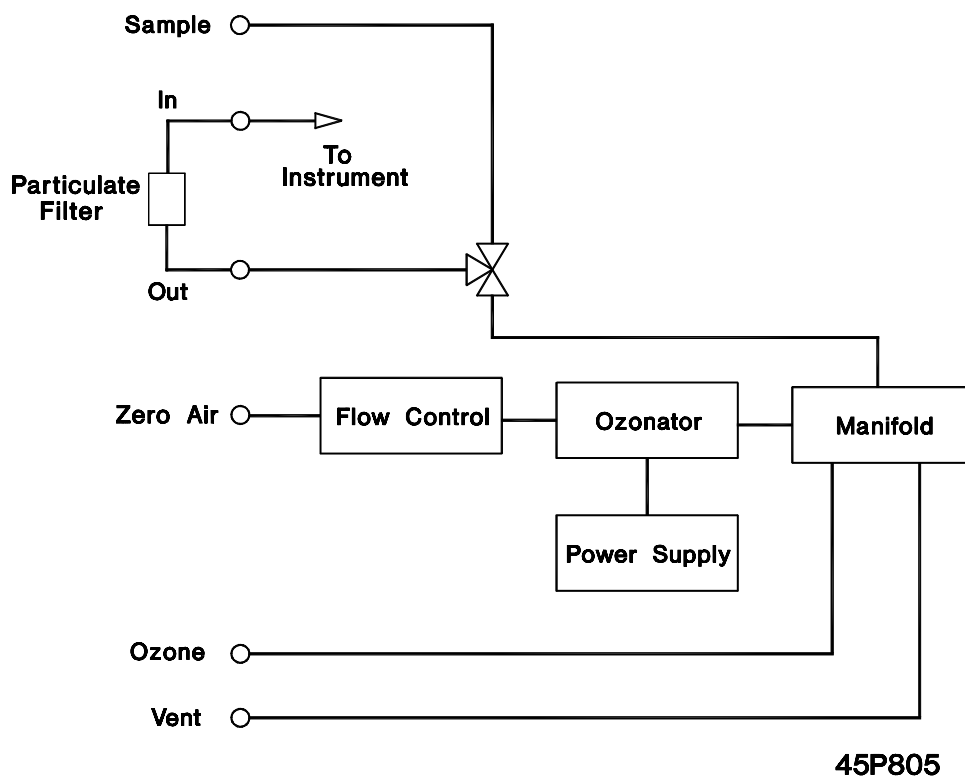


Figure 4-3. Ozonator Flow Scheme

It should be noted that the expected stability of the analyzer section of the Model 49C is greater than the expected stability of the internal ozonator.

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## CHAPTER 5

# PREVENTIVE MAINTENANCE

This chapter describes the periodic maintenance procedures that should be performed on the instrument to ensure proper, uninterrupted operation. Certain components such as the sample pump, solenoid valve, ozone scrubber, and lamp, have a limited life and should be replaced or at least checked on a regular calendar basis. Other operations, such as cleaning the optical bench and calibration check of the pressure and temperature transducers, should also be performed on a regular basis. What follows is a check and/or cleaning procedure for these elements. Replacement procedures for components found to be defective by these checks are given in Chapter 7, "Servicing."

## SPARE PARTS

Table 5-1 lists recommended spare parts.

<b>Part Number</b>	<b>Description</b>
8540	Photometer Lamp
8573	Solenoid Valve
4127	Capillary - 15 mil
14679	Ozone Scrubber
8606	Pump Rebuild Kit
4509	Fuse (115V) T, 2A, 250V
14009	Fuse (220V) T, 1.25A, 250V
8645	Ozonator Lamp
9999	Model 49C Instruction Manual

**Table 5-1.** Recommended Spare Parts

### CLEANING OF OPTICAL BENCH

Best results are obtained when the optical bench is cleaned prior to recalibration. The cleanliness of the bench should also be checked any time the detector frequencies drop below 65 kHz, since one source of low output is light attenuation due to dirt in the cell. Dirt particulates are usually effective ozone removers.

To clean the optical bench, follow the procedure below:

**CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, “Servicing.”

1. Turn off the power and disconnect the power line.
2. Loosen the knurled nut around the tube and carefully slide out tube.
3. Push a piece of lens paper down the tube using a 1/4" piece of Teflon® tubing so as not to damage the tube. Use a cotton swab to clean the window surfaces through the holes that the tube fits into.
4. Both absorption tubes are identical, so they can be replaced in either position. Replacement of absorption cells is opposite to that of removal. Since the Model 49C is a ratio instrument, and cleaning the absorption tubes does not affect the calibration, it is not necessary to recalibrate the instrument every time the cells are cleaned.
5. Re-install the instrument cover.

If windows are severely contaminated, they are best cleaned by removing the windows from the bench. The windows on the detector side can be removed by removing the detector block and carefully removing the windows. The windows on the source side can be removed by removing the source block to gain access to the windows. It is recommended that the Model 49C be recalibrated if the optical bench has been completely disassembled. Always leak-check the system after any component removal.

### LAMP REPLACEMENT

The lamp control system of the Model 49C has been designed to operate the lamp conservatively to increase its life. However, the lamp should be replaced when any one of the following conditions hold:

- No light output.
- Inability to adjust lamp position to obtain an output detection frequency of 65 kHz.
- Noisy output signal, which has been traced to an unstable lamp (see Troubleshooting Section).

It is not necessary to recalibrate the Model 49C since it is a ratio instrument and replacing the lamp does not affect the calibration.

### DETECTOR FREQUENCIES AND NOISE

The Model 49C measures intensity ratios and not absolute values. Therefore, a large range of detector frequencies are acceptable for proper operation of the instrument. The nominal values are 65 to 120 kHz. These frequencies can be monitored from the Intensities screen in the Diagnostics menu.

Degradation of detector frequencies to below 65 kHz indicates either a dirty cell or low lamp output. In addition to degrading the measured detector frequency, dirt in the cells can decompose the ozone and give erroneous readings. Therefore, the cells should first be cleaned and the frequency remeasured. If the frequencies are still low, the light output can be increased by using the Lamp Setting screen in the service mode. If the frequency cannot be set above 65 kHz, replace the lamp. To monitor the lamp noise, choose Intensity Check from the Service Mode menu. The noise value displayed after 20 seconds should be below 4.0 Hz for a fully warmed-up lamp (see Chapter 6, “Troubleshooting” if the noise is excessive).

### SYSTEM LEAKS AND PUMP

There are two types of leaks: external leaks and internal leaks.

#### External Leaks

1. To test for the presence of leaks around the fittings, disconnect the sample input line and plug the sample fitting. Disconnect the sample and zero-air input lines and plug. Also plug the ozone and vent outputs if the optional internal ozonator is installed. The flows as displayed in the Flows screen of the Diagnostics menu should slowly decrease to zero. The pressure as displayed in the Pressure screen should drop to below 250 mm Hg. If the pump diaphragm is in good condition and the capillary not blocked, it should take less than 20 seconds from the time the inlet is plugged to the time of reading below 250 mm Hg is achieved. Leaks can best be detected by carefully tightening each fitting until the leak is found.

### Leaks Through Solenoid

Leaks across the solenoid valve can be caused by cold-flowing of the Teflon® across the seat, or by particulates on the seat.

To check for leaks through the solenoid, generate an ozone concentration of about 0.5 ppm, feed the ozone into the Model 49C. From the Main Menu choose Diagnostics. From the Diagnostics menu choose Cell A/B O3. This displays the concentration as determined in each cell individually. If the Model 49C has stabilized, the average of ten successive simultaneous readings should agree to within  $\pm 3\%$  percent. A balance measurement of better than 3% indicates that there is no leak across the solenoid. A constant low reading from one cell indicates an imbalance. The imbalance can be caused either by one cell or lines to that cell being extremely dirty, or by a leaky valve. If cleaning the cells and lines does not correct the imbalance, a leaky valve is indicated. See, "Ozone Scrubber Test" below for determination of which of the two valves is faulty. To check if the imbalance is caused by an absorption cell, interchange cells. If imbalanced side switches, imbalance is due to cell, if not, it is independent of cell and due to other causes as noted below.

### Confirmation of Leak Through Solenoid

An independent direct check of the solenoid valve can be performed as follows:

1. Remove the suspect solenoid valve following directions given in Chapter 8 "Servicing."
2. Connect the pump directly to the common port of the solenoid.
3. Connect the pressure transducer to the normally open port of the solenoid.
4. From the Main Menu choose Diagnostics. From the Diagnostics menu choose Pressure. Note the pressure as  $P_{NO}$ .
5. Connect the pressure transducer to the normally closed port of the solenoid.
6. Plug the solenoid power line into the solenoid position on the Power Supply Board. Make sure the solenoid is activated by choosing Pressure from the Diagnostics menu.
7. Note the pressure as  $P_{NC}$ .
8. If either  $P_{NC}$  or  $P_{NO}$  is greater than the pressure determined in the "External Leaks" section above, the solenoid is faulty.

## OZONE SCRUBBER TEST

The efficiency of the ozone scrubber can be determined as follows:

1. Generate a source of ozone of about 0.5 ppm and feed into the instrument. Note the concentration as C.
2. From the Main Menu choose Service Mode. From the Service Mode menu choose Intensity Check. From the Intensity Check menu choose Int Reference Gas. Wait until the frequency is stable. Note the frequency as FREQ 1.
3. Turn ozonator off and wait for the frequency to stabilize. Note the frequency as FREQ 2.
4. Determine pressure and temperature, note as P and T.
5. The approximate efficiency is given as follows:

$$\% \text{ Efficiency} = \frac{\frac{(273 + T) 10^6}{P} \frac{760}{\text{KL}} \frac{1}{273} \ln \frac{\text{FREQ2}}{\text{FREQ1}}}{C} \times 100\%$$

$$= \frac{\frac{(273 + T)(238.9)}{P} \ln \frac{\text{FREQ2}}{\text{FREQ1}}}{C} \times 100\%$$

6. Repeat for Cell B with sample flowing in Cell A.
7. If the instrument passes the balance test of “Leaks Through Solenoid” above and the measured efficiency is low, replace the ozone scrubber. If the balance test indicates a leaky valve, and if the efficiency test shows a low efficiency in the same cell that was low in the balance test, replace sample solenoid. If the efficiency test shows a low efficiency in the opposite cell that was low in the balance test, replace the reference solenoid.

## DIGITAL TO ANALOG CONVERTER TEST

The digital to analog converter test is used to fully test the analog outputs. It is normally performed only when a problem with the analog outputs is suspected. From the Main Menu choose Diagnostics. From the Diagnostics menu choose Test Analog Outputs. From the Test Analog Output menu choose Ramp. The analog outputs start at -2.3% and then increment by 0.1% every second until it reaches 100.0%. A linear output indicates that the analog outputs are operating correctly.





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## CHAPTER 6

# TROUBLESHOOTING

The Model 49C has been designed to achieve a high level of reliability. Only premium components are used, thus complete failure is rare. In the event of problems or failure, the troubleshooting guidelines presented in this chapter should be helpful in isolating the fault(s). The Service Department at Thermo Environmental can also be consulted in the event of problems at (508) 520-0430. In any correspondence with the factory please note both the serial number and program number of the instrument.

**CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

### TROUBLESHOOTING GUIDE

MALFUNCTION	POSSIBLE CAUSE	ACTION
Does not start up	No power	Check that the instrument is plugged into the proper source (115 or 220 volts)  Check instrument fuse
	Power supply	Check voltages from power supply
	Digital electronics	Check that all boards are seated properly  Replace boards one at a time with spare boards to isolate the faulty board.

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## Chapter 6 Troubleshooting

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<b>MALFUNCTION</b>	<b>POSSIBLE CAUSE</b>	<b>ACTION</b>
Cell A <b>or</b> B frequency high	Light adjustment	Readjust Lamp Setting. From the Service Mode menu choose Lamp Setting.
	Defective detector	Interchange detectors at Motherboard connectors to determine if detector is defective.
Cell A <b>and</b> B frequency high	Lamp supply	Check for 1.7 volt peak to peak waveform at lamp current check point on Lamp Power Supply Board
	Digital electronics defective	Replace one board at a time with a spare board to isolate defective board.
Cell A <b>or</b> B frequency low or zero	Light adjustment	Readjust lamp setting. From the Service Mode menu choose Lamp Setting.
	One cell excessively contaminated	Clean cell
	Defective detector	Interchange detectors at Motherboard connectors to determine if detector is defective.
	Digital electronics defective	Replace one board at a time with a spare board to isolate defective board.

MALFUNCTION	POSSIBLE CAUSE	ACTION
Cell A <b>and</b> B frequency low or zero	Dirty cells	Clean cells
	Light adjustment	Check for 1.7 volt peak to peak waveform at lamp current check point on Lamp Power Supply Board
	Lamp	Remove one cell and look for blue light in hole of input block
	Lamp heater	Check lamp temperature. From the Diagnostics menu choose Temperatures.
	±15 volt power supply	Check ±15 volts. From the Diagnostics menu choose Voltages.
Cell A <b>or</b> B noise excessive	Digital electronics defective	Replace one board at a time with a spare board to isolate defective board.
	Foreign material in one cell	Clean cell.
	Defective detector	Interchange detectors at Motherboard connectors to determine if detector is defective.
	Digital electronics defective	Replace one board at a time with a spare board to isolate defective board.

## Chapter 6 Troubleshooting

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<b>MALFUNCTION</b>	<b>POSSIBLE CAUSE</b>	<b>ACTION</b>
Cell A <b>and</b> B noise excessive	Foreign material in cells	Clean cells
	Lamp failure	Check for 1.7 volt peak to peak waveform at lamp current check point on Lamp Power Supply Board
	±15 volt power supply	Check ±15 volts. From the Diagnostics menu choose Voltages.
	Digital electronics defective	Replace one board at a time with a spare board to isolate defective board.
Pressure transducer does not hold calibration	Pressure transducer	Replace pressure transducer
	Digital electronics	Replace one board at a time with a spare board to isolate defective board.
Output signal noisy	Recorder	Replace or repair recorder
	Sample is varying	Run Model 49C on stable ozone source. If quiet, no malfunction.
	Foreign material in cell	Clean cell
	Sticky solenoid valve	Replace with known good solenoid valve.

<b>MALFUNCTION</b>	<b>POSSIBLE CAUSE</b>	<b>ACTION</b>
Output signal noisy (continued)	Digital electronics defective	Replace one board at a time with a spare board to isolate defective board.
Analyzer does not calibrate properly	Leak	Perform leak test
	Contaminated scrubber	Perform scrubber efficiency test. Replace if necessary.
	Pressure transducer out of calibration	Recalibrate pressure transducer
	Dirty system	Clean cells and flow components
	Solenoid defective	Perform “Confirmation of Leak Through Solenoid” test described in Chapter 5, “Preventive Maintenance.”
Slow response	Digital electronics	Replace one board at a time with a spare board to isolate the defective board.
	Averaging time	Verify averaging time is set properly
	Contaminated optical bench	Clean bench and then condition system overnight



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## CHAPTER 7

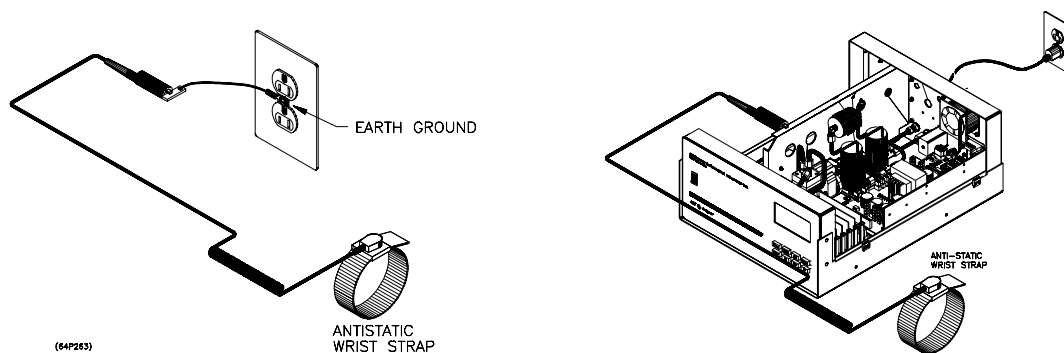
# SERVICING

This chapter explains how to replace the Model 49C subassemblies. Fault location is accomplished in the preceding chapters of “Preventive Maintenance” and “Troubleshooting.” This chapter assumes that a subassembly has been identified as defective and needs to be replaced. For additional service assistance, see “Servicing Locations” later in this chapter.

### SAFETY PRECAUTIONS

Some internal components can be damaged by the discharge of static electricity. To avoid damaging internal components, follow these precautions when performing any service procedure:

- Wear an antistatic wrist strap that is properly connected to earth ground (note that when the analyzer is unplugged, the chassis is not at earth ground)
- If an antistatic wrist strap is not available, be sure to touch a grounded metal object before touching any internal components
- Handle all printed circuit boards by the edges
- Carefully observe the instructions in each procedure



64P263/45P765

**Figure 7-1.** Properly Grounded Antistatic Wrist Strap

### REPLACEMENT PARTS LIST

Table 7-1 lists the part numbers of the major subassemblies in the Model 49C. Refer to Figure 7-2 to identify their location.

Part Number	Description
9837	Processor Board
10761	Analog to Digital Board
9839	Digital to Analog Board
9956	Remote I/O Board (optional)
9843	C-Link Board
9833	Motherboard
9847	Power Supply Board
10758	Lamp Power Supply
8592	Detector System
8593	Lamp Block Heater
8540	Source Lamp
4127	Capillary - 15 mil
9877	Pressure Transducer
9934	Flow Sensor
14679	Ozone Scrubber
4509	Fuse - 2 amp slo-blo
8573	Solenoid Valve
8606	Pump Rebuild Kit
8550	Pump 110V
8551	Pump 220V

**Table 7-1.** Replacement Parts



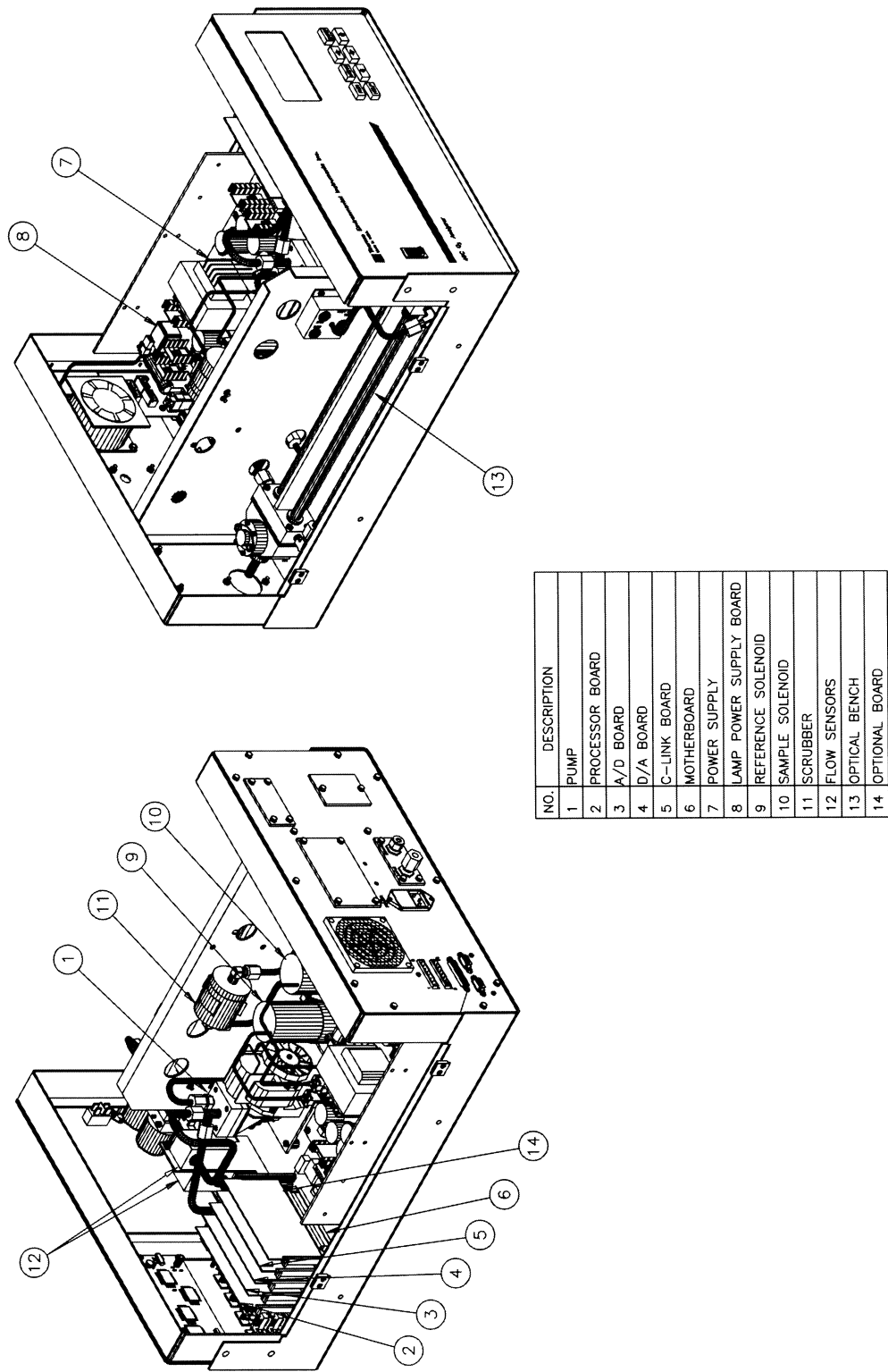


Figure 7-2. Model 49C Component Layout

**NOTE:** Power should be removed from the instrument before any servicing is performed.

### SOURCE LAMP REPLACEMENT

Equipment required:

New Lamp (Part No. 8540)  
Allen Wrench - 7/64" and 3/32"  
Screwdriver - flat - medium size

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect the lamp from the lamp power supply.
4. Remove access hole cover on the rear panel
5. Loosen Allen screw on lamp clamp.
6. Loosen two screws holding the clamp to the base.
7. Carefully slide lamp out of bench and instrument case through access hole.
8. Carefully slide new lamp into bench until it bottoms. Loosely tighten the Allen screw on clamp. Tighten two screws holding clamp to bench. Pull lamp out approximately 1/32" to 1/16" to allow for expansion when the lamp warms up; tighten Allen screw.
9. Plug new lamp into lamp power supply.
10. Replace access hold cover.
11. Reconnect power and turn instrument on.
12. After lamp has stabilized (approximately 15 minutes), adjust the lamp voltage in the Service Mode menu until the output from each detector is about 100 kHz.
13. Re-install the instrument cover.

### SCRUBBER REPLACEMENT

Equipment required:

New Ozone Scrubber (Part No. 14679)  
5/8" Open-End Wrench  
Nut Driver - 1/4"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.

2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Loosen fittings on each end of scrubber.
4. Remove converter clamp from divider panel.
5. Remove scrubber.
6. Replace scrubber by following the above procedure in reverse. Make sure that the converter tube ends have passed through the ferrule of the fitting and that the fittings are tight.
7. Re-install the instrument cover.
8. Perform a leak test.
9. Perform a multipoint calibration.

### OPTICAL BENCH SOLENOID REPLACEMENT

Equipment required:

Solenoid (Part No. 8573)  
Screwdriver  
5/8" Open-End Wrench

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect electrical connections of solenoids from Power Supply Board.
4. Remove ozone scrubber (see previous section).
5. Loosen and remove two fittings from solenoid assembly to bench and the fitting from solenoid assembly to sample inlet.
6. Remove solenoid bracket from floor plate.
7. Remove solenoid bracket.
8. Replace solenoid by following the above procedure in reverse, making sure all fittings are tight.
9. Re-install the instrument cover.
10. Perform a leak test.

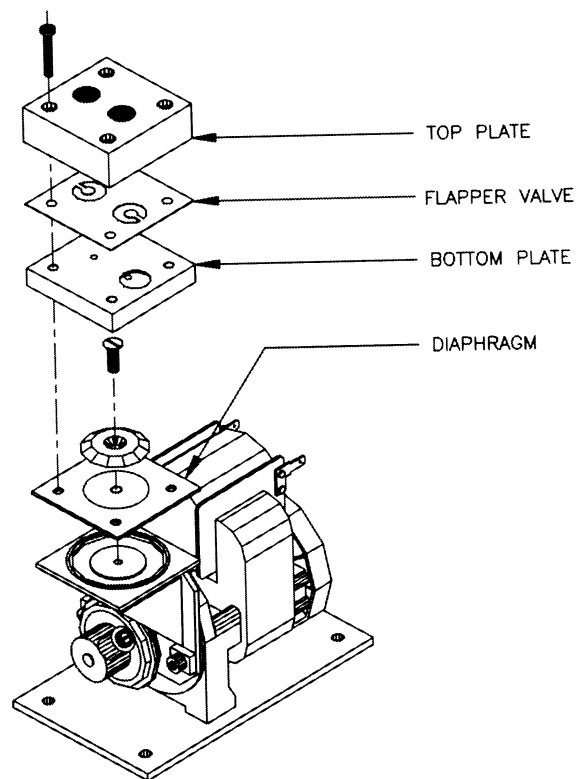
### REBUILDING PUMP

Equipment Required:

Screwdriver  
Pump Repair Kit (Part No. 8606)

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Loosen fittings and remove all 1/4" Teflon® lines.

4. Remove four screws from top plate, remove plate-flapper valve and bottom plate.
5. Remove screw holding diaphragm onto piston.
6. Assemble pump by following the above procedure in the reverse; make sure Teflon® (white) side of diaphragm is facing up and that the flapper valves cover holes.
7. Re-install the instrument cover.
8. Perform a leak test.



**Figure 7-3.** Pump Assembly

93P737

## REPLACEMENT OF PUMP

Equipment Required:

Screwdriver  
110V Pump (Part No. 8550)  
220V Pump (Part No. 8551)

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Unplug power line of pump from Power Supply Board.
4. Loosen fittings, remove all 1/4” Teflon® lines, remove fittings from pump.
5. Remove four screw holding pump bracket to shock mounts.
6. Remove two screws holding pump to pump bracket.
7. Install new pump by following the above procedure in reverse.
8. Re-install the instrument cover.
9. Perform a leak test.

## DETECTOR REPLACEMENT

Equipment Required:

New Detector Assembly (Part No. 8592)  
Allen Wrench - 1/16”

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Unplug faulty detector from Motherboard.
4. Loosen both Allen screws holding detector in detector block and remove detector.
5. Install new detector by following the above procedure in reverse.
6. Re-install the instrument cover.

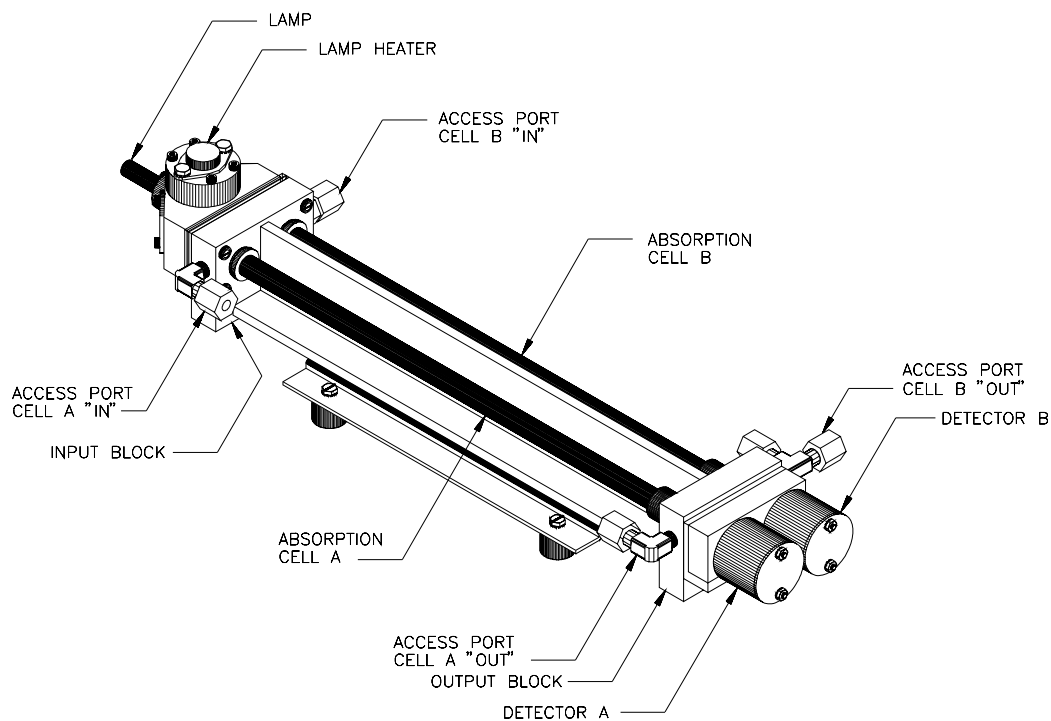
## PRESSURE TRANSDUCER

Equipment Required:

New Pressure Transducer (Part No. 9936)  
Nut Driver

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.

2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect pressure transducer from Motherboard.
4. Disconnect the tube connecting the pressure transducer to the optical bench.
5. Remove screws holding pressure transducer to divider panel.
6. Install new pressure transducer by following the above procedure in reverse.
7. Re-install the instrument cover.
8. Check calibration of pressure transducer.



**Figure 7-4. Model 49C Optical Bench** 45P740

### DC AND LAMP POWER SUPPLY BOARD REPLACEMENT

Equipment Required:

- Nut Driver - 1/4"
- Screwdriver
- Lamp Power Supply Board (Part No. 10758)
- DC Power Supply Board (Part No. 9847)

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect all plug-in connections from power supply board being replaced.
4. Remove screws holding board to chassis and remove board.
5. On power supply board, check that transformer is wired for proper voltage.
6. Install new board by following the above directions in reverse. Care should be exercised to assure that the voltage regulators fit into the plug on the board.
7. Re-install the instrument cover.

### **CAPILLARY SERVICE**

Equipment Required:

Capillary (Part No. 4127)  
Wire to Clean Old Capillary

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Remove capillary, clear blockage with less than 0.015”D wire or replace.
4. Replace capillary by following the above directions in reverse.
5. Re-install the instrument cover.

### **OZONATOR LAMP REPLACEMENT**

Equipment Required:

Replacement Lamp (Part No. 8645)  
Allen Wrench 7/64”

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Unplug lamp from Ozonator Power Supply Board.
4. Slide insulation off the lamp handle onto the lamp cord.
5. Loosen both Allen screws down lamp clamp.
6. Carefully slide lamp out of ozonator housing.
7. Slide insulation off of old lamp and slide onto new lamp.
8. Carefully slide new lamp into ozonator housing until it bottoms. Pull lamp out approximately 1/16” to allow for expansion when the lamp warms up, tighten Allen screws.
9. Plug lamp into ozonator power supply, replace cover, reconnect power.

### OZONATOR HEATER REPLACEMENT

Equipment Required:

New Heater (Part No. 8593)  
Allen Wrench 7/64"  
Screwdriver  
Heat Conductive Compound

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Unplug heater from ozonator power supply.
4. Remove top flange of ozonator housing.
5. Remove ozonator heater block from ozonator by removing four Allen screws.
6. Coat new heater block with thin film of heat conductive compound.
7. Install new ozonator heater block by following the above procedure in reverse.
8. Re-install the instrument cover.

### OZONATOR POWER SUPPLY REPLACEMENT

Equipment Required:

New Ozonator Power Supply (Part No. 8515)  
Screwdriver  
Nut Driver - 1/4"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Unplug lamp, heater and cable to main power supply.
4. Remove seven screws holding ozonator power supply board to bracket and remove board with a gently, but firm upwards pull.
5. Check that transformer is wired for proper voltage.
6. If regulators are being replaced, make sure orientation is correct. Compare to PC board.
7. Install new ozonator power supply by following the above procedure in reverse. Care should be exercised to assure that the voltage regulators fit into the plugs or the board.
8. Re-install the instrument cover.



## SPAN/ZERO SOLENOID REPLACEMENT

Equipment Required:

New Solenoid (Part No. 8573)  
Nut Driver - 1/4"  
Nut Driver - 5/16"

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Remove tubing from the three fittings.
4. Remove solenoid/bracket assembly by removing two nuts holding bracket to back panel.
5. Remove solenoid from bracket by removing two nuts holding solenoid to bracket.
6. Install new solenoid by following the above procedure in reverse.
7. Re-install the instrument cover.
8. Perform a leak test.

## ANALOG OUTPUT ADJUSTMENT

The analog outputs need only be adjusted if the concentration value on the front panel display disagrees with the analog outputs. To see if the analog outputs need to be adjusted, compare the front panel display to the analog output voltage. If they differ by more than 1%, then the analog outputs should be adjusted. This procedure should only be performed by an instrument service technician.

1. Wear an antistatic wrist strap that is properly connected to earth ground, see “Safety Precautions,” earlier in this chapter for more information.
2. Remove the instrument cover.
3. From the Run screen, press the **MENU** pushbutton to display the Main Menu. Use the ↓ pushbutton to move the cursor to Diagnostics, and press **ENTER** to display the Diagnostics menu. Use the ↓ pushbutton to move the cursor to Test Analog Outputs, and press **ENTER**. The Test Analog Output screen appears as shown below.

```
SET OUTPUTS TO:  
>ZERO  
FULL SCALE  
RAMP
```

**Test Analog Outputs Menu**

4. Press **ENTER** to select Zero. The zero screen appears as shown below. Using a small screwdriver, adjust potentiometer R1 and R3 on the D/A Board until the analog outputs read 0 volts. Press the **MENU** pushbutton to return to the Test Analog Outputs menu.

```
OUTPUTS          0.0 %  
↑↓ INC/DEC
```

### Zero Analog Outputs Screen

5. Press the ↓ pushbutton to move the cursor to Fullscale and press **ENTER**. The fullscale screen appears as shown below. Using a small screwdriver, adjust potentiometer R2 and R4 on the D/A Board until the analog outputs read 10 volts (standard instrument). Press the **MENU** pushbutton to return to the Test Analog Outputs menu.

```
OUTPUTS          100.0 %  
↑↓ INC/DEC
```

### Fullscale Analog Outputs Screen

6. Repeat the above steps to ensure the adjustments are accurate.
7. Re-install the instrument cover.

## PRESSURE TRANSDUCER ADJUSTMENT

This procedure should only be performed by an instrument service technician.

Equipment Required:  
Vacuum Pump  
Screwdriver

**CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Wear an antistatic wrist strap that is properly connected to earth ground, see “Safety Precautions,” earlier in this chapter for more information.
2. Remove the instrument cover.
3. Disconnect the tubing from the pressure transducer and connect a vacuum pump known to produce a vacuum less than 1 mm Hg.
4. From the Run screen, press **MENU** to display the Main Menu. Use the ↓ pushbutton to move the cursor to Instrument Control. Press **ENTER** to display the Instrument Control menu. Use the ↓ pushbutton to move the cursor to Pressure Correction. Press **ENTER** to display the pressure reading.
5. Adjust the zero potentiometer on the pressure transducer for a reading of zero mm Hg.
6. Disconnect the vacuum pump. The display should read the current local barometric pressure. If this value does not agree with a known accurate barometer, adjust the span potentiometer.
7. Re-install the instrument cover.

An error in the zero setting of the pressure transducer does not introduce a measurable error in the output concentration reading. Therefore, if only a barometer is available and not a vacuum pump, only adjust the span setting. A rough check of the pressure accuracy can be made by obtaining the current barometric pressure from the local weather station or airport and comparing it to the pressure reading. However, since these pressures are usually corrected to sea level, it may be necessary to correct the reading to local pressure by subtracting 0.027 mm Hg per foot of altitude. Do not try to calibrate the pressure transducer unless the pressure is known accurately.

### BENCH TEMPERATURE SENSOR ADJUSTMENT

This procedure should only be performed by an instrument service technician.

Equipment Required:

Calibrated Thermometer or  $10\text{K}\Omega \pm 1\%$  Resistor  
Screwdriver

**CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Wear an antistatic wrist strap that is properly connected to earth ground, see “Safety Precautions,” earlier in this chapter for more information.
2. Remove the instrument cover.
3. Tape the thermistor plugged into the optical bench to a calibrated thermometer.
4. Adjust the **GAIN** potentiometer on the Analog to Digital Board until the internal temperature reading agrees with the value on the calibrated thermometer. Since the thermistors used in the Model 49C are interchangeable to an accuracy of  $\pm 0.2^\circ\text{C}$ , and have a value of 10K ohms at  $25^\circ\text{C}$ , an alternate procedure is to connect an accurately known 10K resistor to the thermistor input on the Motherboard, and adjust the **GAIN** potentiometer for an internal temperature reading of  $25^\circ\text{C}$ . Note that a  $1^\circ\text{C}$  change corresponds to a  $\pm 5\%$  change in resistance, thus this alternative procedure can be quite accurate as a check; however, it clearly is not NIST traceable.
5. Re-install the instrument cover.

### FUSE REPLACEMENT

Equipment Required:

115V T, 2A, 250V (Part No. 4509)  
220V T, 1.25A, 250V (Part No. 14009)

1. Disconnect power to instrument.
2. Remove fuse drawer, located on the AC power connector.
3. Replace both fuses, if either is blown.
4. Insert fuse drawer and reconnect power cord.

**SERVICE LOCATIONS**

For additional assistance, Environmental Instruments Division has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information.

**866-282-0430 Toll Free**  
**508-520-0430 International**



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## CHAPTER 8

# THEORY OF OPERATION

In order to understand the operation of the Model 49C, a general knowledge of the electronics, software, and subassemblies is necessary.

### ELECTRONICS

The electronics can be broken down into the following subassemblies:

- DC Power Supply
- Lamp Power Supply
- Ozonator Power Supply
- Detector System
- Microprocessor System

A brief description of each follows. Note that all the electrical schematics are given in Appendix C, "Schematics."

#### DC Power Supply

The DC Power Supply outputs the regulated and unregulated dc voltages necessary to operate the analog and digital electronics. It outputs +24 volts unregulated and  $\pm 15$  volts and +5 volts regulated. The power supply board also contains the circuitry for driving the solenoid valves.

#### Lamp Power Supply

The lamp is driven by a square wave signal at approximately 15 kHz. The square wave is generated by a monolithic pulse width modulation control circuit (U2). The square wave feeds two switching transistors (Q2 & Q3) which drive the primary of the lamp transformer (T1).

The secondary circuit includes the secondary winding, a 50K ohm resistor (R3), the lamp, and a 100 ohm resistor (R5) in series. One end of the transformer is at ground potential. The 50K ohm resistor acts as a current limiting resistor to limit the current to the lamp. The 100 ohm resistor can be used to check the wave form and the current through the lamp.

In addition to driving the lamp, the lamp power supply also includes the lamp block heating circuit (U1 and associated circuitry). The lamp block is heated by a power transistor. The temperature is measured by a thermistor. The current, and thus the heat into the transistor, is controlled by the operational amplifier integrated circuit (U1). As long as the temperature as determined by the thermistor is low, the lamp power supply is off. When the temperature is above 50°C, the lamp ignites. If the temperature of the lamp block should ever fall below its set point, the lamp will be turned off. The lamp is turned off and on by turning the pulsed width modulator (U2) on or off as controlled by the line between Pins 15 of U2 and the output of the temperature controlling op amp, Pin 8 of U1. The Lamp Power Supply Board also contains circuitry for adjusting the lamp amplitude and sensing the lamp temperature.

### **Ozonator Power Supply**

The Ozonator Power Supply includes a rectifier and dc power supply circuit, and a heater control circuit identical to the lamp power supply. The generation of the 15 kHz square wave is identical to that of the lamp power supply. The ozonator power supply includes the span/zero solenoid driving circuitry and also the control circuitry for adjusting the lamp amplitude and sensing the lamp temperature.

### **Detector System**

The detector system consists of a solar blind vacuum photo-diode which feeds an electrometer operational amplifier (IC-111). since the sensitivity of the detector varies from tube to tube, the gain of the electrometer is matched for each tube by choice of R 112. The output of the electrometer is fed into a V-F (voltage-to-frequency) converter (IC-112). Thus the frequency output of the detector system is proportional to the light intensity reaching the detector. The whole system is mounted in a small, well shielded holder.



## The Microprocessor System

The microprocessor system consists of P.C. boards which plug into a motherboard, connecting them to each other and to the rest of the instrument. These boards are as follows:

- Display Module
- Processor Board
- Analog to Digital Board
- Digital to Analog Board
- C-Link Board

**Display Module** The vacuum fluorescent display module shows O<sub>3</sub> concentration, instrument parameters, and help messages. The single board display module consists of 80 characters (4 line by 20 column), refresh memory, character generator, dc/dc converter and all necessary control logic. The display module is powered by +5 volts dc.

**Processor Board** The Processor Board contains a Motorola M68HC11F1 microprocessor (U4), RAM (U5), and EPROM (U2). In addition, this high-performance, nonmultiplexed 68-pin microprocessor contains 512 bytes of EEPROM and 1K of RAM. It is operated at a frequency of 2 MHz, which is generated by crystal X1.

**Digital/Analog Board** The Digital to Analog Board contains four D/A converters. Each is addressed by the processor via signals from PA0-PA7 and PG0 and PG1. The D/A converters are zeroed using potentiometers R1, R3, R5, and R7 and span is set using potentiometers R2, R4, R6, and R8. The fullscale output of the four D/A converters is set by jumpers on switches SW1-SW4 on the D/A board. Fullscale voltages of 10, 5, 1, and 0.1 volts are available.

**Analog to Digital Board** The Analog to Digital Board acts as an interface between all the signals monitored by the processor system and the microprocessor itself. Up to 12 analog inputs are available. The bench temperature, bench lamp temperature, pressure, power supply voltages, lamp voltage, and flow rates are examples of analog signals converted to digital signals used by the microprocessor.

**C-Link Board** The C-Link Board contains the RS-232 circuitry, clock, and memory for the datalogger. Incoming RS-232 signals are converted to TTL levels by U3, an RS-232 driver/receiver. The TTL signals are then interpreted by U5, a 68HC11 microprocessor, which is dedicated to remote communications. Data records from the internal datalogger are stored in U2, a 128K RAM, and the link program is stored in U6, a 64K EPROM. U10 is the internal clock. A battery supplies +5 volts to the clock and the data logger memory when instrument power off.

### SUBASSEMBLIES

#### Optical Bench

The optical bench is a dual cell device, with each cell having a length of 37.84 cm. It has been designed for easy disassembly for cleaning. All internal surfaces have been coated with polyvinylidene fluoride to ensure that ozone undergoes no decomposition upon exposure to the internal surface of the bench. Both the source and detectors mount rigidly onto the bench. The optical bench is very rigid and needs no optical alignment.

#### Lamp and Lamp Power Supply

The lamp is a low pressure mercury vapor lamp with an expected lifetime in excess of one year. The lamp is driven by a precisely regulated power supply with a square wave at about 15 kHz to ensure a high level of stability. In order to achieve the highest level of stability of light output, the lamp itself is mounted in a temperature controlled, insulated aluminum block that provides the necessary thermal stability.

#### Flow Components

The Model 49C operates at nominal atmospheric pressure. A downstream pump and two capillaries control sample flow through the cells which is monitored by two flow sensors. Total flows of less than 1 LPM (2 scfh) should be avoided since the flush time would be excessive. Total flows of greater than 3 LPM should also be avoided since there would not be enough residence time in the converter to ensure greater than 99% conversion of the ozone. The solenoid valves operating under computer control allow sample gas to pass through Cell A and reference gas through Cell B, or vice versa, depending upon which cycle the instrument is performing.

#### Ozonator

The internal ozonator option in the Model 49C operates on the photolytic principle. The ozone level produced is a function of light intensity at 185 nm and gas flow. The light intensity is varied by changing the current into the lamp. The gas flow is held constant by a pressure regulator followed by a capillary. The distribution manifold is all Teflon®.

# CHAPTER 9 OPTIONAL EQUIPMENT

This chapter describes optional equipment available for the Model 49C.

## RACK MOUNTS WITH SLIDES

Rack mounts with slides for standard 19-inch relay racks are available. Figures 9-1 and 9-2 illustrate the installation of the rack mount option. Also available, as Option 209, are the handle mounting brackets and handles without the rack mounts.

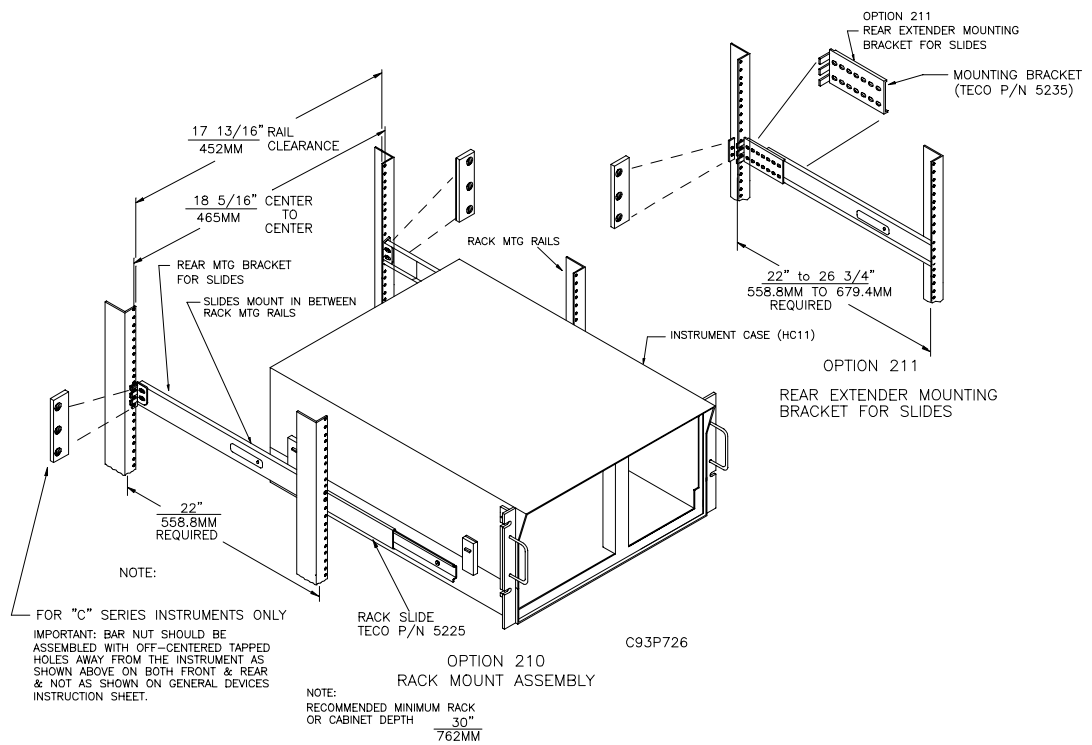
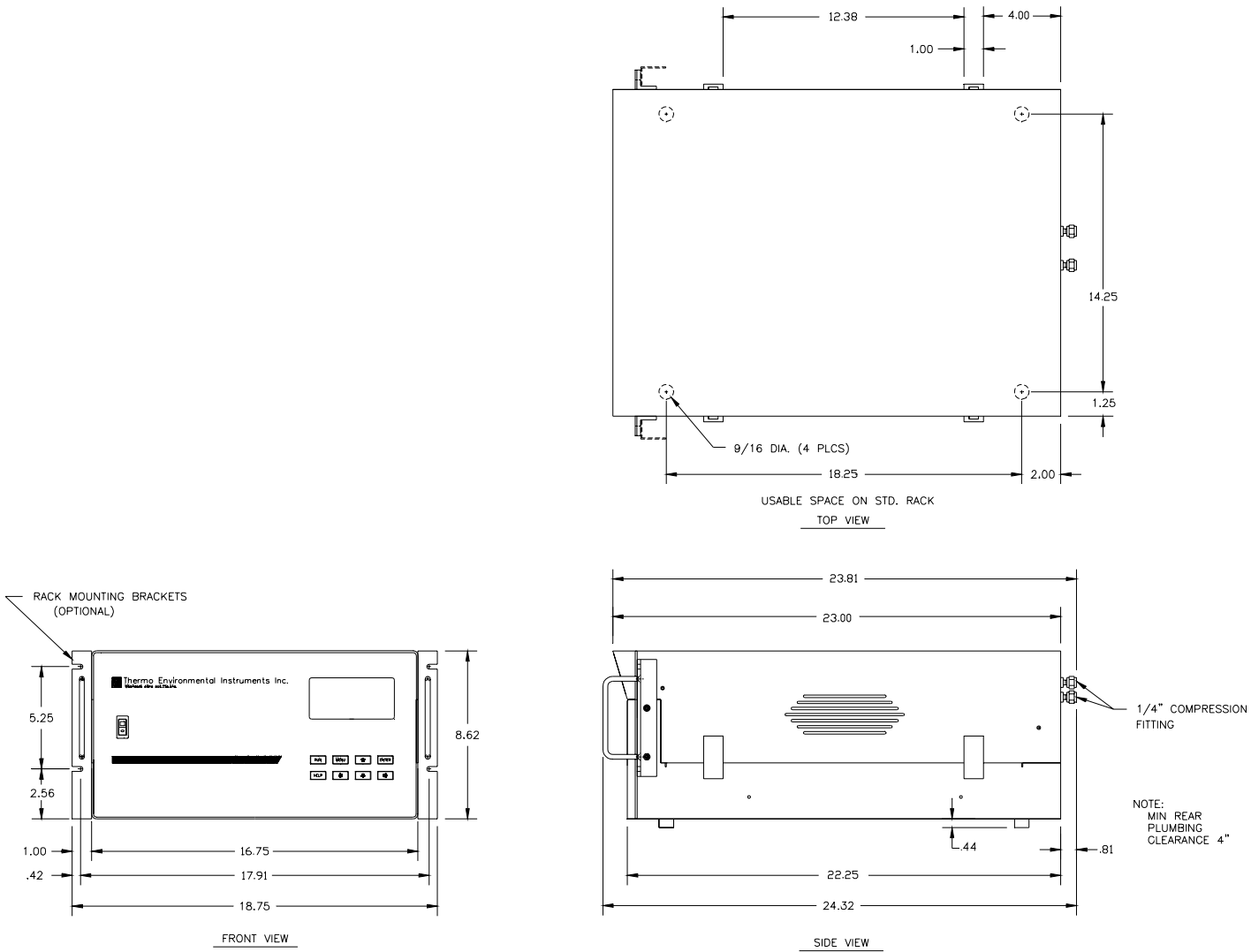


Figure 9-1. Rack Mount Option Assembly<sup>93P726</sup>



93P761

Figure 9-2. Model 49C Dimensional Outline

## PARTICULATE FILTER

A Teflon® particulate (5 to 10 micron pore) is available for the Model 49C. The filter should be installed close to the **SAMPLE** bulkhead using a 2- to 4-inch piece of tubing. When this filter is installed, all calibrations, precision, and Level 1 span checks must be performed through the particulate filter.

## INTERNAL OZONATOR

The internal ozone generator provides an easy determination of zero, precision, and level 1 span checks. Option switch 3 must be on if the internal ozonator is installed.

When in the Run screen, use the **RUN** pushbutton to select sample, zero, level 1, and level 2. The Diagnostics menu, shown below, has three additional menu choices when the internal ozonator is installed. These screens are used to set the ozonator solenoid position and the two ozone concentrations.

```
INSTRUMENT CONTROLS:
>TEMP CORRECTION
PRESSURE CORRECTION
OZONATOR SOLENOID
```

```
OZONATOR LEVEL 1
OZONATOR LEVEL 2
BAUD RATE
INSTRUMENT ID
SCREEN BRIGHTNESS
SEVICE MODE
TIME
DATE
```

### Instrument Diagnostics menu

### Ozonator Solenoid

The Ozonator Solenoid screen, shown below, is used to switch the ozonator solenoid on and off. When the ozonator solenoid is on, the output of the internal ozonator is fed into the analyzer. When the ozonator solenoid is off, the output of the internal ozonator is fed to the manifold.

```
SOLENOID          ON
TURN              OFF?
```

**Ozonator Solenoid Screen**

### Ozonator Level 1 and 2

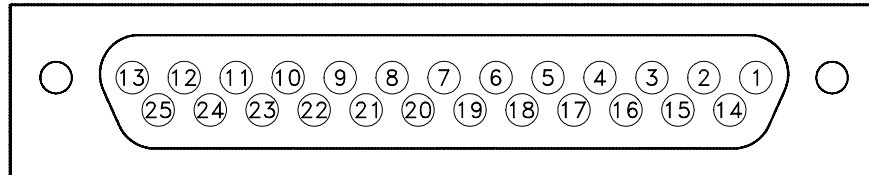
The Ozonator Level 1 screen, shown below, is used to set ozone level 1. The first line of the display shows the current ozone reading. Note that if the ozonator solenoid is off, this reading will not be the output of the ozonator. The second line of the display shows the percentage of the lamp intensity used to produce the ozone. A percentage of 100% results in the maximum amount of ozone production. A percentage of 0% results in no ozone production. The range of percentages, however, are not linear. The Ozonator Level 2 screen functions the same way.

```
O3 PPB           620
LEVEL 1 %        050.0
SET TO           055.0?
↑↓ INC/DEC
```

**Ozonator Level 1 Screen**

## REMOTE ACTIVATION OF INTERNAL OZONATOR

The rear panel I/O (DB25) connector, shown in Figure 9-3, enables the zero, level 1, level 2 ozonator settings to be remotely controlled via contact closure. In addition, the connector has several instrument status outputs. Option switch 1 must be on and option switch 2 off in order to enable the remote I/O connector.



### Pin Out

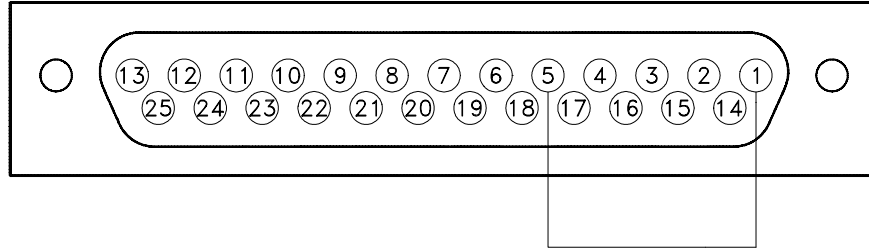
- |                                   |                                |
|-----------------------------------|--------------------------------|
| (1) Ground                        | (13) NC                        |
| (2) NC                            | (14) Ground                    |
| (3) NC                            | (15) NC                        |
| (4) INPUT - Ozonator Solenoid     | (16) NC                        |
| (5) INPUT - Zero Gas              | (17) INPUT - Ozonator Level 2  |
| (6) Ground                        | (18) INPUT - Ozonator Level 1  |
| (7) Relay Common                  | (19) Ground                    |
| (8) STATUS - Concentration Alarm  | (20) Relay Common              |
| (9) STATUS - Local or Remote Mode | (21) STATUS - Zero Gas Mode    |
| (10) STATUS - ppm or mg/m3 mode   | (22) STATUS - Ozonator Level 1 |
| (11) STATUS - General Alarm       | (23) STATUS - Ozonator Level 2 |
| (12) Relay Common                 | (24) STATUS - Sample Gas Mode  |
|                                   | (25) Relay Common              |

64P947-5

**Figure 9-3.** Rear Panel I/O Connector

### Input Pins

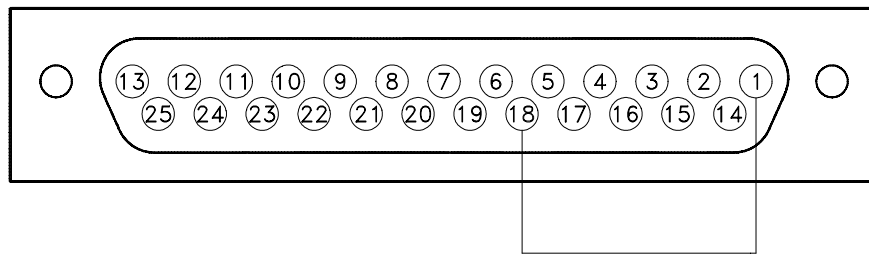
To activate the zero gas mode, connect pin 1, 6, 14, or 19 (ground) to pin 5 (zero gas mode), as shown in Figure 9-4. To deactivate the zero gas mode, disconnect ground from the zero gas mode input.



64P947-6

**Figure 9-4.** Remote I/O Zero Gas Mode Activation

To activate ozonator level 1, connect pin 1, 6, 14, or 19 (ground) to pin 18 (ozonator level 1), as shown in Figure 9-5. To activate ozonator level 2, connect pin 1, 6, 14, or 19 (ground) to pin 17 (ozonator level 2). Disconnect ground to deactivate.



64P947-7

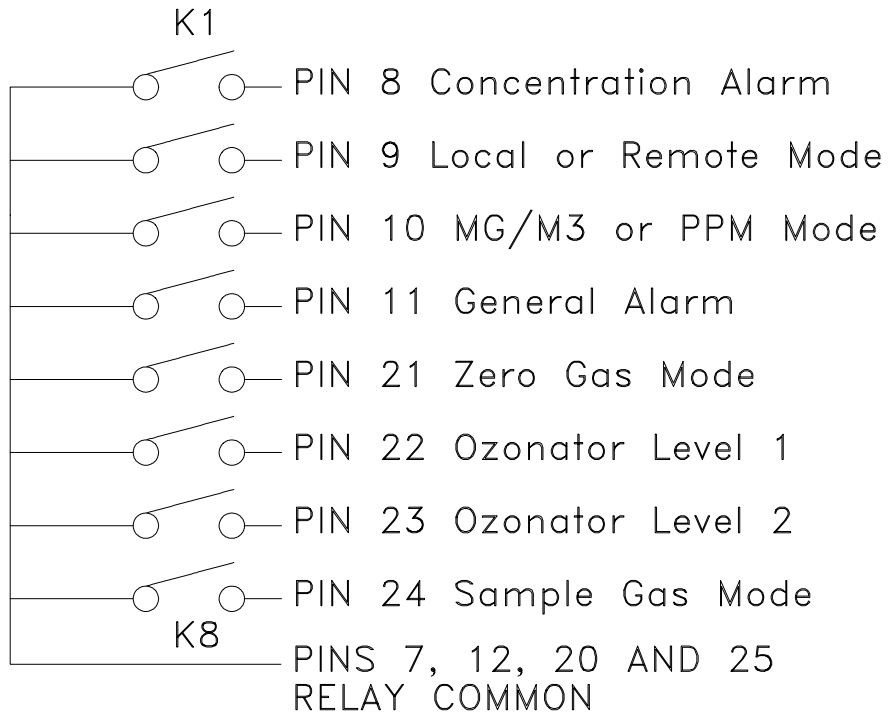
**Figure 9-5.** Remote I/O Ozonator Level 1 Activation

To turn the ozonator solenoid off (output of ozonator is fed to manifold instead of analyzer) connect pin 1, 6, 14, or 19 (ground) to pin 4 (ozonator solenoid).

**Instrument Status Outputs**

Several instrument status outputs are available on the rear panel I/O connector via reed relays on the I/O Board. The reed relays are arranged as shown in Figure 9-6. In the instrument status output truth table, each pin is referred to as open or closed (based on the physical position of the corresponding relay). The Relay Common line is common to each of the relays.





45P951-4

Figure 9-6. Instrument Status Output Relays

Status	Pin	Relay Closed	Relay Open
Concentration Alarm	8	Alarm	No Alarm
Local or Remote Mode	9	Local or Service Mode	Remote Mode
MG/M <sup>3</sup> or PPM Mode	10	mg/m <sup>3</sup> mode	ppm mode
General Alarm	11	Alarm	No Alarm

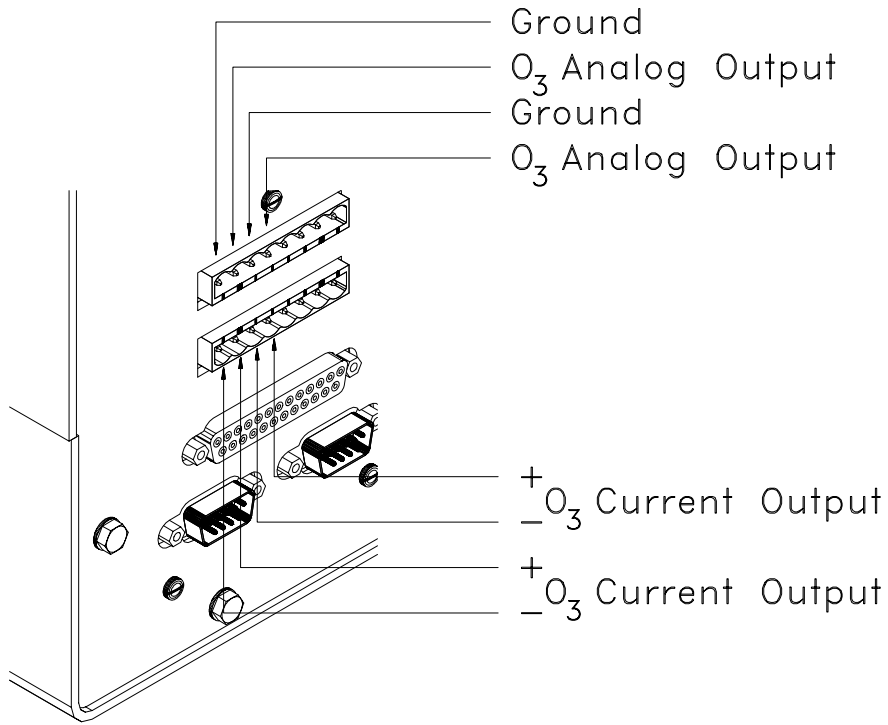
  

Active Mode	Pin 21	Pin 22	Pin 23	Pin 24
Sample Gas Mode	Relay Open	Relay Open	Relay Open	Relay Closed
Zero Gas Mode	Relay closed	Relay Open	Relay Open	Relay Open
Ozonator Level 1	Relay Closed	Relay Closed	Relay Open	Relay Open
Ozonator Level 2	Relay Open	Relay Open	Relay Closed	Relay Open

Table 9-1. Instrument Status Output Truth Table

**4-20 mA ISOLATED CURRENT OUTPUT**

A 4-20 mA Isolated Current Output enables the O<sub>3</sub> concentration to be output at 4-20 mA as shown in Figure 9-3.

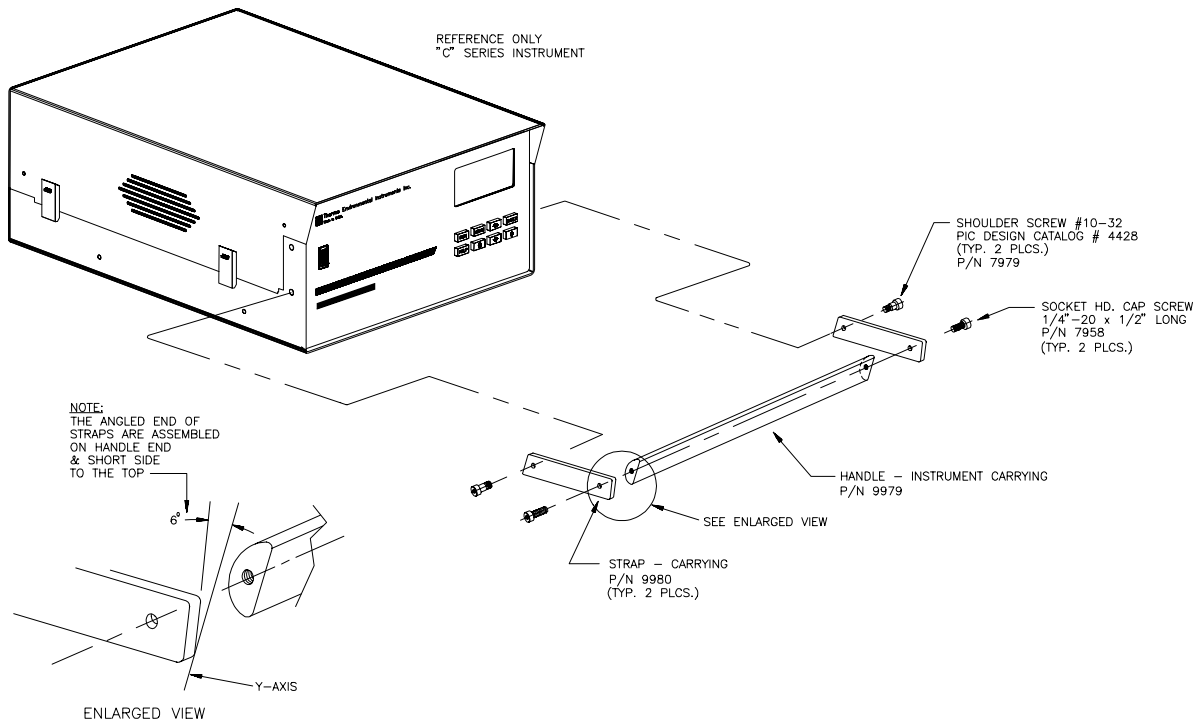


45P951-4

**Figure 9-7.** Pin-Out of Rear Panel Terminal Strip with Optional Current Output

**INSTRUMENT HANDLE**

An instrument handle is available to aid in carrying the instrument. It also enables the instrument to be slightly elevated while resting on a table or bench, to increase visibility of the display. Figure 9-4 shows the installation of the instrument handle.



93P727

Figure 9-8. Instrument Handle Assembly



# Appendix A

## Warranty

Seller warrants that the Products will operate or perform substantially in conformance with Seller's published specifications and be free from defects in material and workmanship, when subjected to normal, proper and intended usage by properly trained personnel, for the period of time set forth in the product documentation, published specifications or package inserts. If a period of time is not specified in Seller's product documentation, published specifications or package inserts, the warranty period shall be one (1) year from the date of shipment to Buyer for equipment and ninety (90) days for all other products (the "Warranty Period"). Seller agrees during the Warranty Period, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in substantial conformance with said published specifications; provided that (a) Buyer shall promptly notify Seller in writing upon the discovery of any defect, which notice shall include the product model and serial number (if applicable) and details of the warranty claim; (b) after Seller's review, Seller will provide Buyer with service data and/or a Return Material Authorization ("RMA"), which may include biohazard decontamination procedures and other product-specific handling instructions; and (c) then, if applicable, Buyer may return the defective Products to Seller with all costs prepaid by Buyer. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to Buyer of repaired or replacement Products shall be made in accordance with the Delivery provisions of the Seller's Terms and Conditions of Sale. Consumables, including but not limited to lamps, fuses, batteries, bulbs and other such expendable items, are expressly excluded from the warranty under this warranty.

Notwithstanding the foregoing, Products supplied by Seller that are obtained by Seller from an original manufacturer or third party supplier are not warranted by Seller, but Seller agrees to assign to Buyer any warranty rights in such Product that Seller may have from the original manufacturer or third party supplier, to the extent such assignment is allowed by such original manufacturer or third party supplier.

In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of (i) normal wear and tear, (ii) accident, disaster or event of force majeure, (iii) misuse, fault or negligence of or by Buyer, (iv) use of the Products in a manner for which

they were not designed, (v) causes external to the Products such as, but not limited to, power failure or electrical power surges, (vi) improper storage and handling of the Products or (vii) use of the Products in combination with equipment or software not supplied by Seller. If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller's then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by the warranty provided in this warranty, Buyer shall pay Seller therefor at Seller's then prevailing time and materials rates. ANY INSTALLATION, MAINTENANCE, REPAIR, SERVICE, RELOCATION OR ALTERATION TO OR OF, OR OTHER TAMPERING WITH, THE PRODUCTS PERFORMED BY ANY PERSON OR ENTITY OTHER THAN SELLER WITHOUT SELLER'S PRIOR WRITTEN APPROVAL, OR ANY USE OF REPLACEMENT PARTS NOT SUPPLIED BY SELLER, SHALL IMMEDIATELY VOID AND CANCEL ALL WARRANTIES WITH RESPECT TO THE AFFECTED PRODUCTS.

THE OBLIGATIONS CREATED BY THIS WARRANTY STATEMENT TO REPAIR OR REPLACE A DEFECTIVE PRODUCT SHALL BE THE SOLE REMEDY OF BUYER IN THE EVENT OF A DEFECTIVE PRODUCT. EXCEPT AS EXPRESSLY PROVIDED IN THIS WARRANTY STATEMENT, SELLER DISCLAIMS ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, ORAL OR WRITTEN, WITH RESPECT TO THE PRODUCTS, INCLUDING WITHOUT LIMITATION ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. SELLER DOES NOT WARRANT THAT THE PRODUCTS ARE ERROR-FREE OR WILL ACCOMPLISH ANY PARTICULAR RESULT.

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## APPENDIX B

# RS-232 COMMANDS

The RS-232 interface enables the Model 49C to be remotely controlled by a host RS-232 device such as, a PC, PLC, datalogger, etc.

### CONNECTIONS

On the rear panel of the analyzer there are two male DB9 connectors. Both connectors are identical, so either can be connected to the remote device. The remaining connector can be used to connect a second analyzer. Using a daisy-chain configuration, several analyzers can be connected to one remote device.

A null modem (crossed) cable is required when connecting the analyzer to an IBM Compatible PC. However, a straight cable (one to one) may be required when connecting the analyzer to other host remote devices. As a general rule, when the connector of the host remote device is female, a straight cable is required and when the connector is male, a null modem cable is required.

### DATA FORMAT

1200, 2400, 4800, or 9600 baud  
8 data bits  
1 stop bit  
no parity  
All responses are terminated with a carriage return (hex 0D)

### INSTRUMENT IDENTIFICATION NUMBER

Each command sent to the analyzer must begin with the instrument's identification number plus 128. For example, if the instrument ID is set to 25, then decimal 153 precedes each command. The analyzer ignores any command that does not begin with its instrument identification number.

### COMMANDS

The analyzer must be in the remote mode in order to change instrument parameters via RS-232. However, the command "set mode remote" can be sent to the Model 49C to put it in the remote mode. Report commands can be issued either in the remote or local mode.

The RS-232 commands can be sent in either uppercase or lowercase characters. In the examples below, only the characters between the quotation marks (") are sent and received. If an incorrect command is sent, a "bad cmd" message will be received. The example below sends the incorrect command "set time avg" instead of the correct command "set avg time".

Send: "set time avg"  
Receive: "set time avg bad cmd"

---

### **o3**

This command reports the current O<sub>3</sub> concentration reading. The example below reports that the current O<sub>3</sub> reading is 40 ppm.

Send: "o3"  
Receive: "o3 0040E+0 ppm"

---

### **gas mode**

This reports the current mode of sample, zero, or span. The example below reports that the gas mode is sample.

Send: "gas mode"  
Receive: "gas mode sample"

---

### **set sample gas**

This command sets the optional valves to the sample mode. The example below sets the instrument to sample mode, that is, the instrument is reading the sample gas.

Send: "set sample gas"  
Receive: "set sample gas ok"

---



### **set zero gas**

This command sets the optional valves to the zero mode. The example sets the instrument in the zero mode, that is, the instrument is sampling zero air.

Send: "set zero"  
Receive: "set zero ok"

---

### **set level 1** **set level 2**

These commands set the optional internal ozonator to either level 1 or level 2. The example below sets the internal ozonator to level 1.

Send: "set level 1"  
Receive: "set level 1 ok"

---

### **mode**

This reports what operating mode the instrument is in: local or remote. The example below shows that the instrument is in the remote mode.

Send: "mode"  
Receive: "mode remote"

---

### **set mode local** **set mode remote**

These commands set the instrument to local or remote mode. The example below sets the instrument to the local mode.

Send: "set mode local"  
Receive: "set mode local ok"

---

---

### gas unit

This reports the current gas units (ppm or mg/m<sup>3</sup>). The example reports that the gas unit is set to ppm.

Send: "gas unit"  
Receive: "gas unit ppm"

---

### set gas unit *unit*

*unit* = | ppm | mg/m<sup>3</sup> |

This command sets the gas units to ppm or mg/m<sup>3</sup>. The example below sets the gas units mg/m<sup>3</sup>.

Send: "set gas unit mg/m3"  
Receive: "set gas unit mg/m3 ok"

---

### range

This command reports the current range. The example below reports that the range is set to 50 ppm.

Send: "range"  
Receive: "range 5: 5000E-2 ppm"

---

### set range *d*

*d* = Code in table below

This command selects the fullscale range according to the table below. The example below sets the fullscale range to 50 ppm.

Send: "set range 9"  
Receive: "set range 9 ok"

<b>Code</b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
0	0.05	0.1
1	0.1	0.2
2	0.2	0.4
3	0.5	1
4	1	2
5	2	4
6	5	10
7	10	20
8	20	40
9	50	100
10	100	200
11	200	400
12	C1	C1
13	C2	C2
14	C3	C3

**set range *d***

*d* = | 1 | 2 | 3 |

This reports the user-defined value of custom range 1, 2, or 3. The example below reports that custom range 1 is defined to 55.0 ppm.

Send: "custom 1"  
Receive: "custom 1 5500E-2 ppm"

---

---

**set custom 1 range** *dddd.d*  
**set custom 2 range** *dddd.d*  
**set custom 3 range** *dddd.d*

These commands are used to define the custom ranges. To use the custom range select it using the set range command. The example below defines custom range 1 to 55.5 ppm.

Send: "set custom 1 range 55.5"  
Receive: "set custom 1 range 55.5 ok"

---

### **avg time**

This reports the averaging time setting. The example below reports that the averaging time is set to 60 seconds.

Send: "avg time"  
Receive: "avg time 060 sec"

---

### **set avg time** *d*

*d* = Code in table below

Sets the averaging time according to the Table below. The example below sets the averaging time to 60 seconds.

Send: "set avg time 3"  
Receive: "set avg time 3 ok"

<b>Code</b>	<b>Averaging time (seconds)</b>
0	10
1	20
2	30
3	60
4	90
5	120
6	180
7	240
8	300

---

**o3 bkg**

This command reports the current O<sub>3</sub> background. The example below reports that the O<sub>3</sub> background is 1.4 ppb.

Send: "o3 bkg"  
Receive: "03 bkg 001.4 ppb"

---

**set o3 bkg *dd.d***

This command is used to set the O<sub>3</sub> background to a user-defined value. The example below sets the O<sub>3</sub> background to 1.4 ppb.

Send: "set o3 bkg 1.4"  
Receive: "set 03 bkg 1.4 ok"

---

---

### **o3 coef**

This command reports the current O<sub>3</sub> coefficient. The example below reports that the O<sub>3</sub> coefficient is 1.005.

Send: "o3 coef"  
Receive: "o3 coef 1.005"

---

### **set o3 coef *d.ddd***

This command sets the O<sub>3</sub> coefficient to a user-defined value. The example below sets the O<sub>3</sub> coefficient to 1.005.

Send: "set o3 coef 1.005"  
Receive: "set o3 coef 1.005 ok"

---

### **temp comp**

This reports whether temperature compensation is on or off. The example below shows a typical response to this command.

Send: "temp comp"  
Receive: "temp comp off"

---

### **set temp comp on set temp comp off**

This command turns the temperature compensation on and off. The example below turns temperature compensation off.

Send: "set temp comp off"  
Receive: "set temp comp off ok"

---

---

**pres comp**

This reports whether pressure compensation is on or off. The example below shows that pressure compensation is on.

Send: "pres comp"  
Receive: "pres comp on"

---

**set pres comp on**  
**set pres comp off**

These commands turn the pressure compensation on and off. The example below turns pressure compensation off.

Send: "set pres comp off"  
Receive: "set pres comp off ok"

---

**time**

This reports the current time (military time). The example below reports that the internal time is 2:15:30 pm.

Send: "time"  
Receive: "time 14:15:30"

---

**set time** *hh:mm:ss*

*hh* = hours  
*mm* = minutes  
*ss* = seconds

Sets the internal clock (military time). The example below sets the internal time to 2:15 pm. Note that if seconds are omitted, the seconds default to 00.

Send: "set time 14:15"  
Receive: "set time 14:15 ok"

---

---

### **date**

This reports the current date. The example below reports the date as December 1, 1994.

Send: "date"  
Receive: "date 12-01-94"

---

### **set date** *mm-dd-yy*

*mm* = month

*dd* = day

*yy* = year

Sets the internal date. The example below sets the internal date to December 1, 1994.

Send: "set date 12-01-94"  
Receive: "set date 12-01-94 ok"

---

### **bench temp**

This reports the current bench temperature. The first temperature reading is the temperature being used in instrument calculations. The second temperature is the actual temperature being measured. If temperature compensation is on, then both temperature readings are the same. If temperature compensation is off, a temperature of 0°C is used as the default temperature even though the actual bench temperature is 32.3°C. The example below shows that temperature compensation is on and that the bench temperature is 32.3°C.

Send: "bench temp"  
Receive: "bench temp 032.3 deg C, actual 032.3"

---

### **lamp temp**

This reports the current bench lamp temperature. The example below reports that the current bench temperature is 55.2 °C.

Send: "lamp temp"  
Receive: "lamp temp 055.2 deg C"

---



---

### **cell a int** **cell b int**

These commands report the current lamp intensity. The example below reports that the lamp intensity in Cell A is 98,425 Hz.

Send: "cell a int"  
Receive: "cell a int 98425 Hz"

---

### **lamp setting**

This command reports the current lamp setting. The example below reports that the lamp setting is 72.9%.

Send: "lamp setting"  
Receive: "lamp setting 72.9%"

---

### **pres**

This reports the current reaction chamber pressure. The first pressure reading is the pressure reading being used in instrument calculations. The second pressure is the actual pressure reading being measured. If pressure compensation is on, then both pressure readings are the same. If pressure compensation is off, a pressure of 760 mm Hg is used as the default pressure even though the actual pressure is 753.4 mm Hg. The example below shows that actual reaction chamber pressure is 753.4 mm Hg.

Send: "pres"  
Receive: "pres 760.0 mm Hg, actual 753.4"

---

### **flow a** **flow b**

These commands report the sample flow in Cell A and Cell B. The example below reports that the current sample flow in Cell A is 0.608 liters/minute.

Send: "flow a"  
Receive: "flow a 0.608 l/m"

---

### oz flow

This command reports the flow of the optional internal ozonator. The example below reports that the current internal ozonator flow is 0.100 liters/minute.

Send: "oz flow"  
Receive: "oz flow 0.100 l/m"

---

### dtoa *d*

*d* = DTOA in table below

This reports the outputs of the 7 Digital to Analog converters (0000 = 0.0% FS, 1000 = 100.0% fullscale). The example below shows that the D/A for the CO voltage Out is 97.7% fullscale.

Send: "dtoa 1"  
Receive: "dtoa 1 0977"

<u>DTOA</u>	<u>Function</u>
1	O <sub>3</sub> Voltage Output
2	O <sub>3</sub> Voltage Output
3	Not Used
4	Not Used
5	O <sub>3</sub> Current Output
6	O <sub>3</sub> Current Output
7	Not Used

---

### option switches

This reports the status (on/off) of the 8 option switches. For example, a return of 11100000, means that option switches 1, 2, and 3 are on and the others are off (see "Internal Option Switches" in Chapter 3 "Operation," for more information about option switches). The example below shows that option switches 1, 2, and 3 are on.

Send: "option switches"  
Receive: "option switches 11100000"

---

---

**program no**

This reports the analyzer's program number and the Link (communications) program number. The example below shows that the installed processor program is 49 00000100 and the installed communication program (link) is 49L 00000100.

Send: "program no"  
Receive: "program no processor 49 00000100 link 49L 00000100"

---

**set save params**

This command stores parameters in the EEPROM. It is important that each time instrument parameters are changed, that this command be sent. If changes are not saved, they will be lost in the event of a power failure. The example below saves the parameters to EEPROM.

Send: "set save params"  
Receive: "set save params ok"

---

**screen**

This reports the information currently being displayed on the instrument's front panel display. The example below shows a typical response to this command.

Send: "screen"  
Receive: " " "  
"O3 PPB 600"  
" "  
"SAMPLE 14:25 REMOTE"

---

### button

*button* = | run | menu | enter | help | up | down | left | right |

This command is used to simulate pressing the Model 49C front panel pushbuttons. In the example below, the push command is used in conjunction with the screen command to view the Main Menu. Note that the instrument is in the Run screen initially.

```
Send:      "menu"
Receive:   "menu ok"

Send:      "screen"
Receive:   "MAIN MENU:          10:25"
           ">RANGE                "
           " AVERAGING TIME      "
           " CALIBRATION FACTORS "
```

---

### format

This command reports the current reply termination format as shown below:

```
Send:      "format"
Receive:   "format 00"
```

<b>Code</b>	<b>Reply Termination</b>
00	<CR>
01	0x80 xxxx <CR>

where xxxx = the sum of all characters in the message

---

**set format *dd***

*dd* = | 00 | 01 |

This command sets the reply termination format. The example below sets the reply termination format to checksum.

Send: "format 01"  
Receive: "format 01 ok"  
"sum 0570"

<b>Code</b>	<b>Reply Termination</b>
00	<CR>
01	<nl>sum xxxx<CR>

where xxxx = 4 hexadecimal digits that represent the sum of all the characters in the message

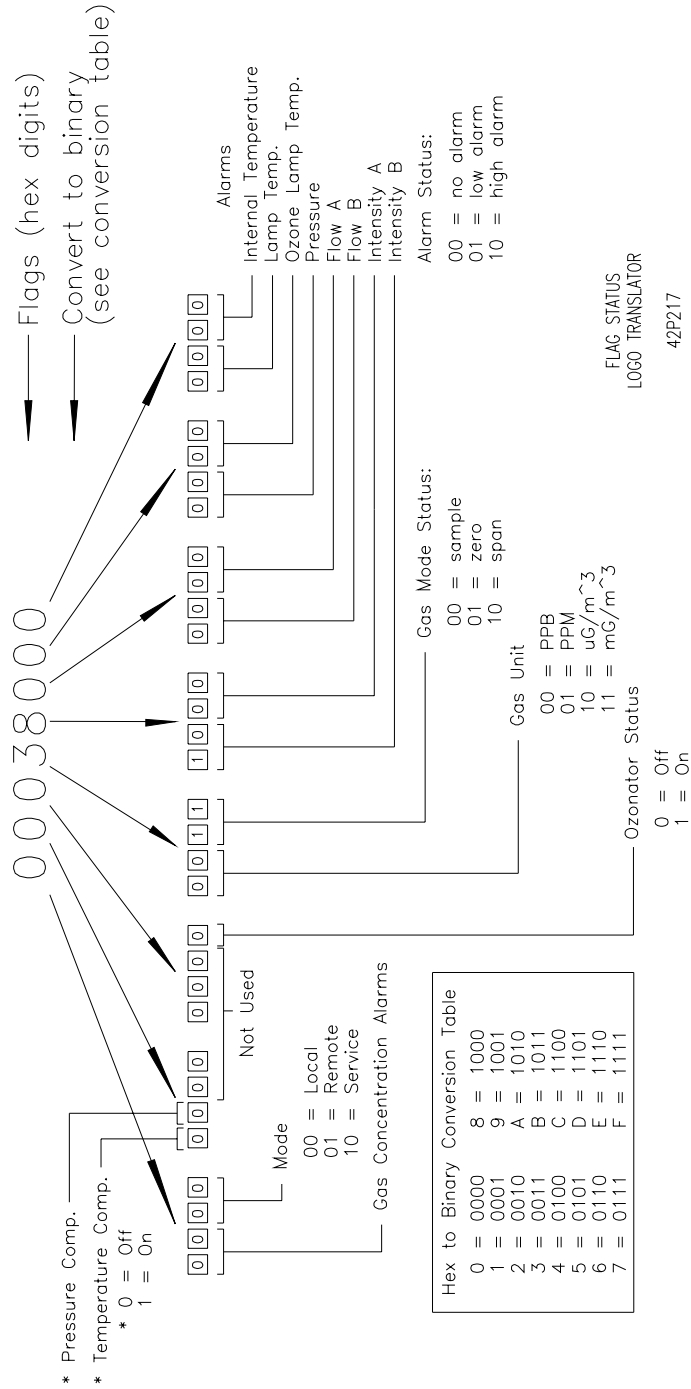
---

**flags**

This reports 8 hexadecimal digits (or flags) that represent the status of the AGC circuit, gas mode, and alarms. To decode the flags, each hexadecimal digit is converted to binary as shown in the figure below. It is the binary digits that define the status of each parameter. In the example below, the instrument is reporting that the AGC circuit is on, that the instrument is in the span gas mode, and that the CO high concentration alarm is activated.

Send: "flags"  
Receive: "flags 00028000"

# Appendix B RS-232 Commands



**set lrec format** *tt ff*  
**set srec format** *tt xx*

*tt* = | 00 | 01 | 02 | 03 | 04 |  
*ff* = | 00 | 01 | 02 | 03 |  
*xx* = | 00 | 01 |

There are two types of records that the internal data logger stores: long records and short records. Both records contain the time, date, O<sub>3</sub> average, and the instrument status flags. The O<sub>3</sub> average is taken over the logging interval. For example, if the long record (or lrec) logging time is set to 30 minutes, then the O<sub>3</sub> reading is the average O<sub>3</sub> reading during the last 30 minutes. In addition, the long record contains the following data: Cell A intensity, Cell B intensity, bench temperature, bench lamp temperature, flow A, flow B, and pressure readings. These readings are instantaneous measurements. The data logger can store 1,792 long records and 4,096 short records.

The logging time for each record is defined as follows:

Time	Logging Time (minutes)
00	1
01	5
02	15
03	30
04	60

The records may be output several ways:

Reply	Output Format
00	Short reply (no temps, flows, etc.) with no text
01	Short reply (no temps, flows, etc.) with text
02	Long reply (temps, flows, etc.) with no text
03	Long reply (temps, flows, etc.) with text

## Appendix B RS-232 Commands

---

The example below sets the lrec logging time to 5 minutes and the output format to long reply with text.

```
Send:      "set lrec format 01 03"  
Receive:   "set lrec format 01 03 ok"
```

---

**lrec** *xxxx yy*  
**srec** *xxxx yy*

*xxxx* = number of records back  
*yy* = the number of records to return (0 to 10)

These commands output the contents of the data logger's records. If the lrec or srec command is issued without either of the *xxxx* or *yy* variables, only the last record stored will be returned. The output format and logging time are determined by the set lrec format and set srec format commands as described above. In the example below, the instrument reports the contents of 5 long records, starting with the 100th previous record. The logging time is set to 5 minutes and the text is being displayed.

```
Send:      "lrec 100 5"  
Receive:
```

```
"10:15 12-28 o3 2560E+0 ppb flags 00000000 inta 98625 intb 99507 flowa 0.608 flowb  
0.701 btmp 32.3 ltmp 55.2 pres 753.4  
10:20 12-28 o3 2564E+0 ppb flags 00000000 inta 98455 intb 99627 flowa 0.608 flowb  
0.701 btmp 32.3 ltmp 55.2 pres 753.4  
10:25 12-28 o3 2563E+0 ppb flags 00000000 inta 98465 intb 99637 flowa 0.608 flowb  
0.701 btmp 32.3 ltmp 55.2 pres 753.4  
10:30 12-28 o3 2560E+0 ppb flags 00000000 inta 98225 intb 99657 flowa 0.608 flowb  
0.701 btmp 32.3 ltmp 55.2 pres 753.4  
10:35 12-28 o3 2561E+0 ppb flags 00000000 inta 98125 intb 99807 flowa 0.608 flowb  
0.701 btmp 32.3 ltmp 55.2 pres 753.4"
```

where:

inta = Cell A Intensity  
intb = Cell B Intensity  
flowa = Cell A Flow  
flowb = Cell B Flow  
btmp = Bench Temperature  
ltmp = Lamp Temperature  
pres = Pressure

---



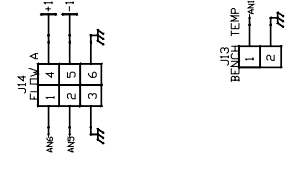
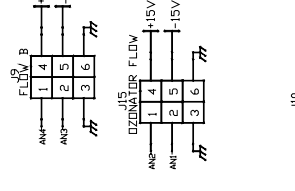
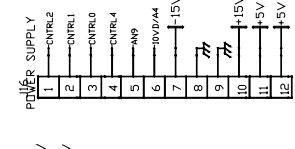
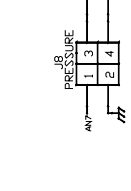
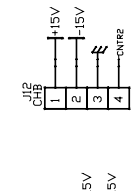
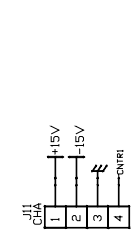
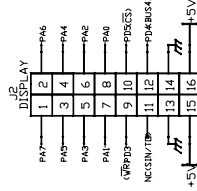
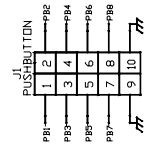
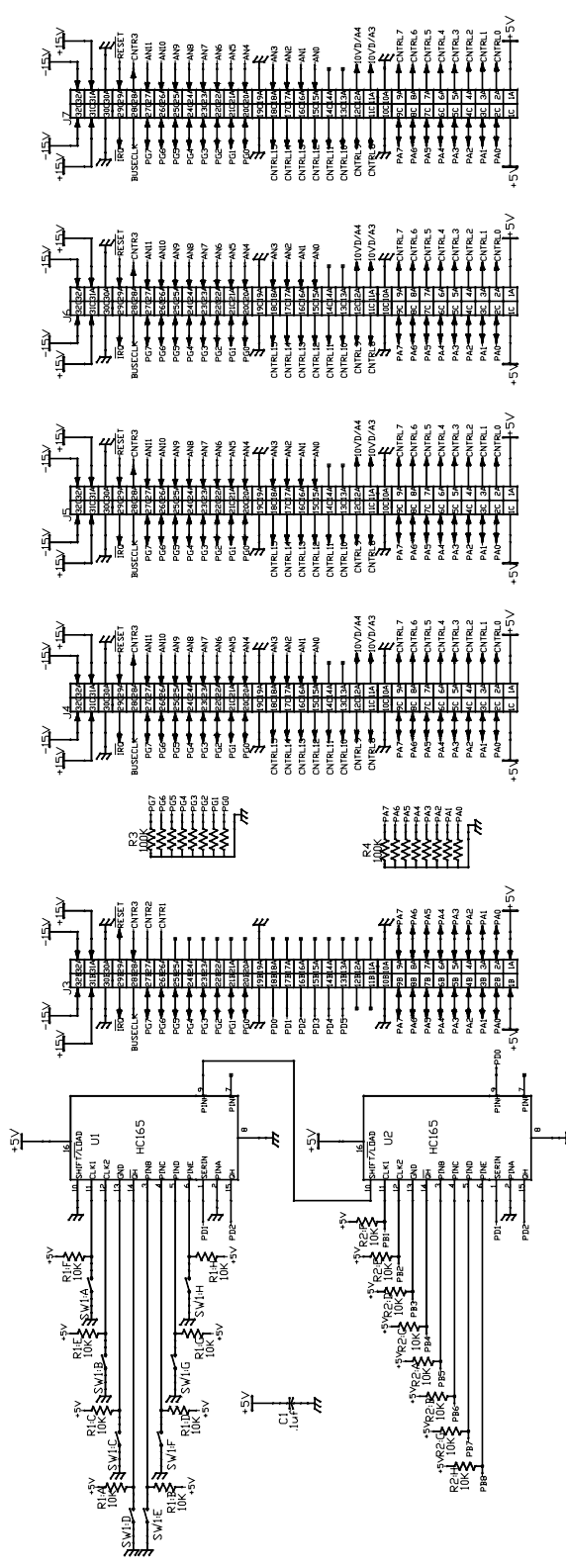
---

## APPENDIX C

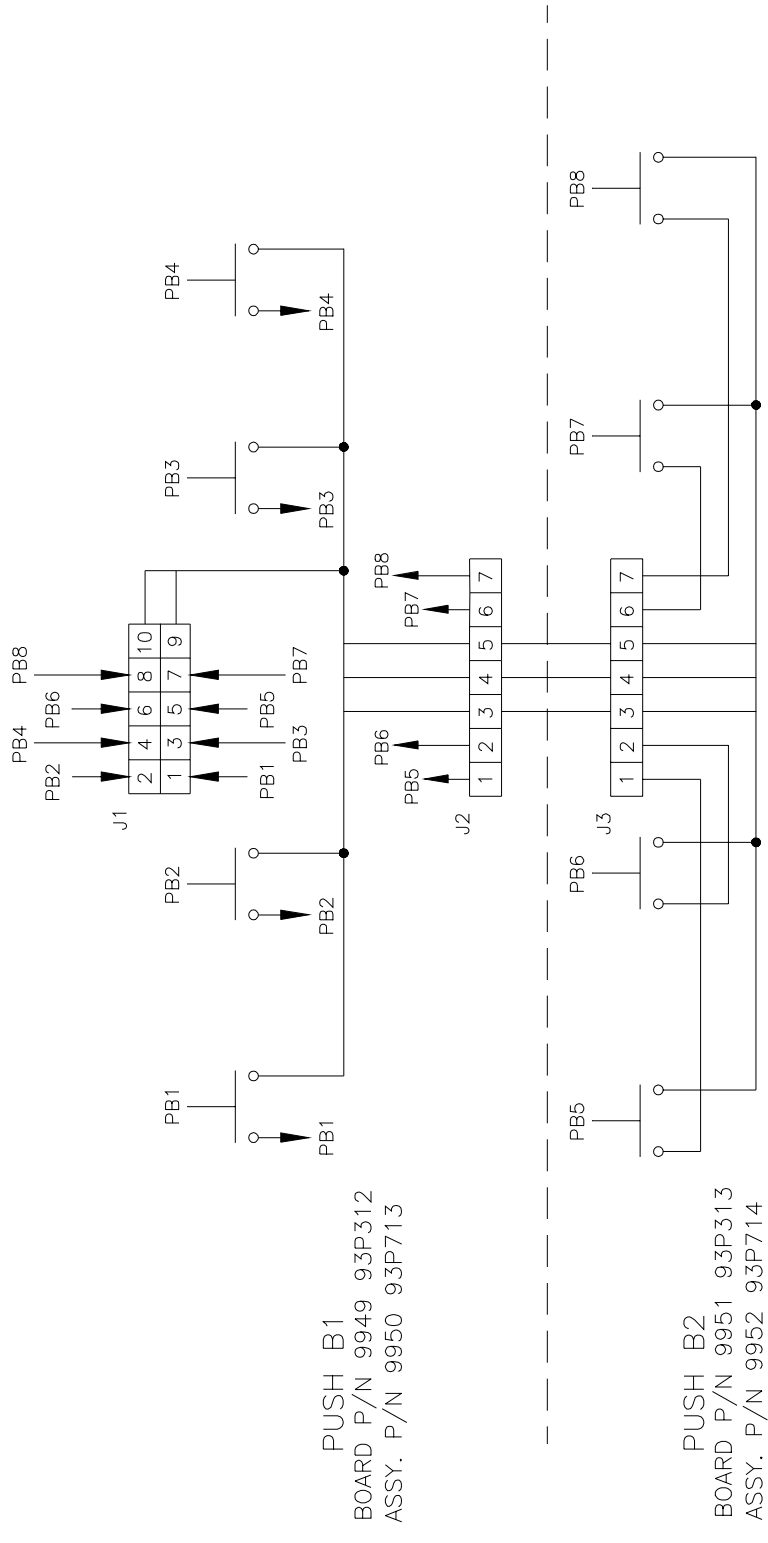
# SCHEMATICS

This appendix contains the schematics for the standard and optional printed circuit boards contained in the Model 49C. Always turn off the instrument and unplug the power cord before removing any printed circuit board. For more information about appropriate safety precautions, see Chapter 7, “Servicing.” A description of each board can be found in Chapter 8, “Theory of Operation.”

<b>PC Board</b>	<b>Drawing No.</b>	<b>Part No.</b>	<b>Page</b>
Motherboard	45P946	9833	C-2
Pushbutton Board 1	93P906	9950	C-3
Pushbutton Board 2	93P906	9952	C-3
Processor Board	93P907	9837	C-4
Analog/Digital Board	45P950	10761	C-5
Digital/Analog Board	93P908	9839	C-6
Power Supply Board	45P947	9847	C-7
Lamp Power Supply Board	45P948	10758	C-8
Detector System	45P911	8592	C-9
C-Link Board	93P914	9843	C-10
4-20 mA Outputs (optional)	93P912	9954	C-11
Input/Output Board (optional)	93P913	9956	C-12
Ozonator Power Supply (optional)	45P949	10760	C-13
Rear Connector Interface Board	93P915	9903	C-14



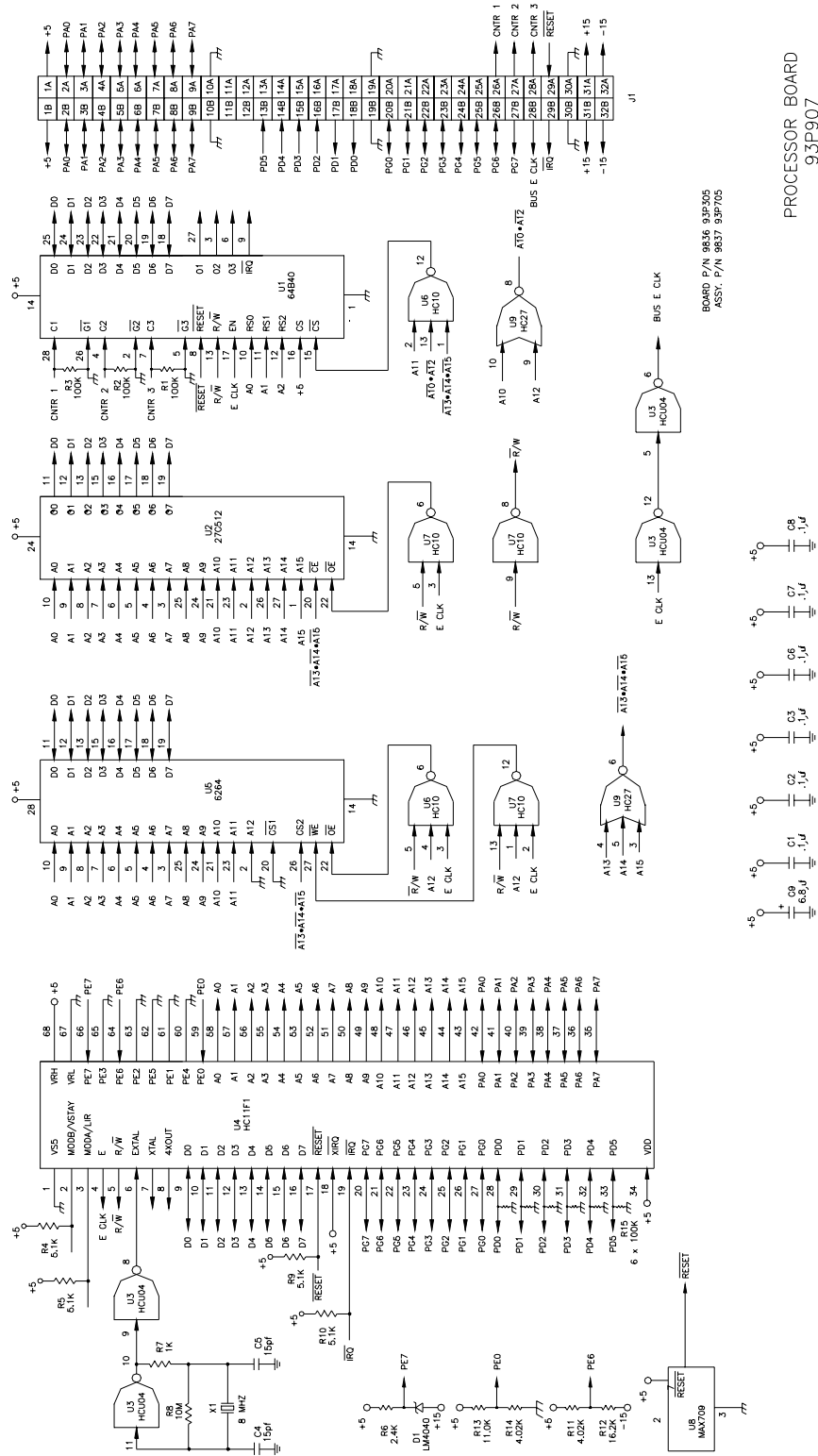
BOARD 9832 DWG 45P315  
 ASY 9833 ASY DWG 45P754  
 SCHEMATIC -  
 MOTHERBOARD  
 45P946 REV.C



PUSH B1  
 BOARD P/N 9949 93P312  
 ASSY. P/N 9950 93P713

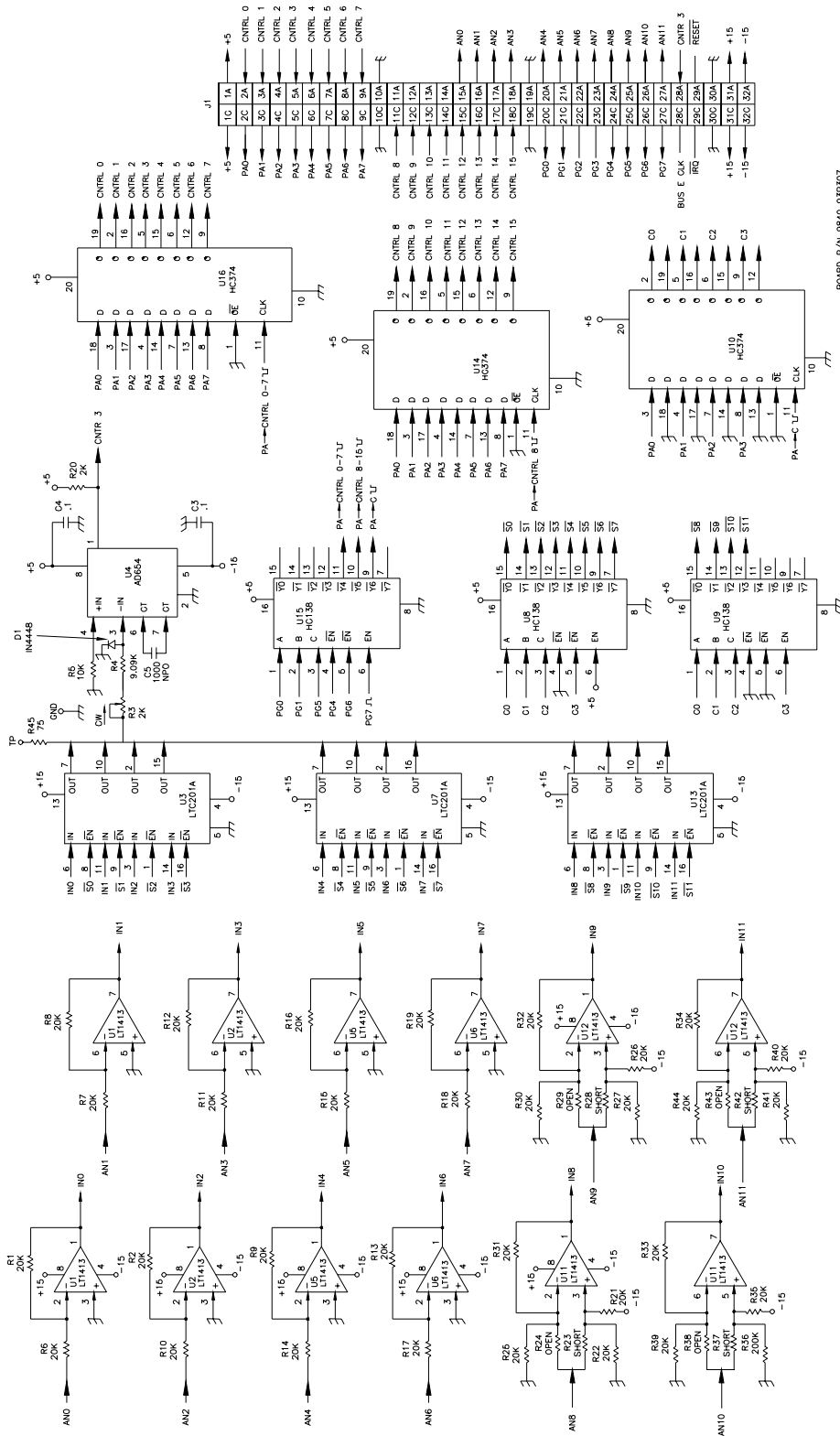
PUSH B2  
 BOARD P/N 9951 93P313  
 ASSY. P/N 9952 93P714

SCHEMATIC - PUSHBUTTON B1 & B2  
 93P906



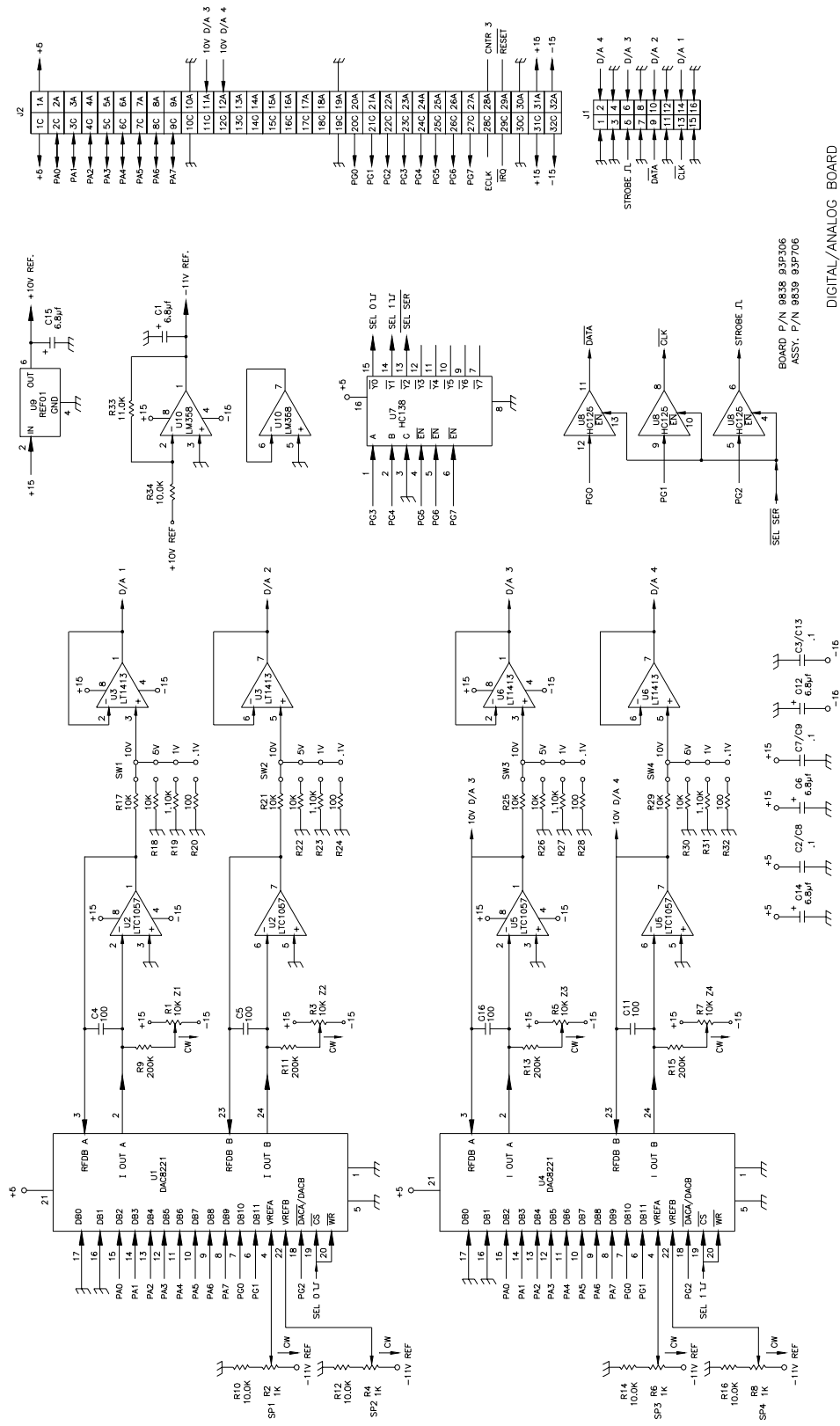
BOARD P/N 9836 9.3P.905  
 ASSY. P/N 9837 9.3P.705

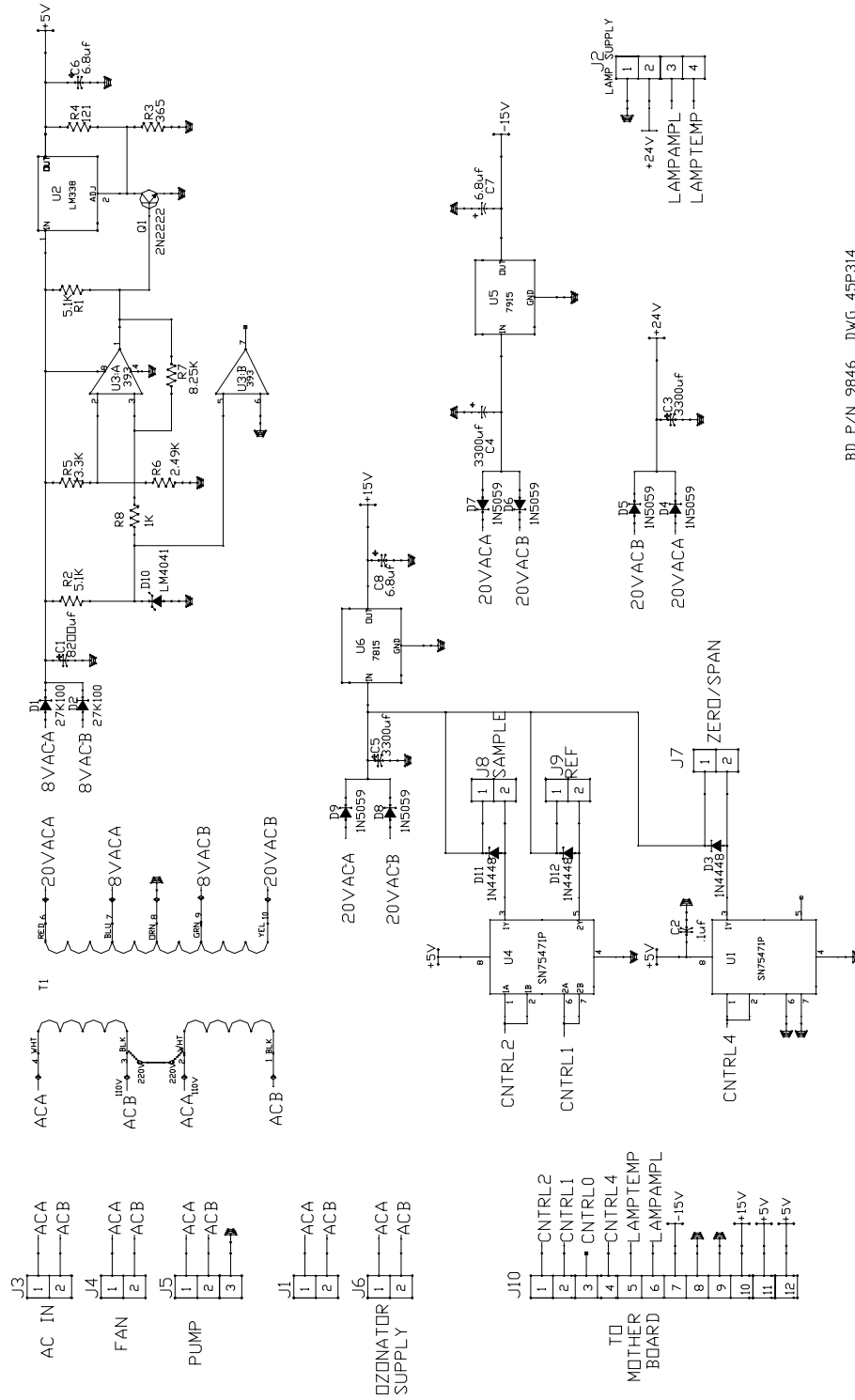
PROCESSOR BOARD  
 9.3P.907



BOARD P/N 8840 83P307  
 ASSY. P/N 10761 45P766

SCHEMATIC — ANALOG/DIGITAL BOARD  
 45P950 REV.F

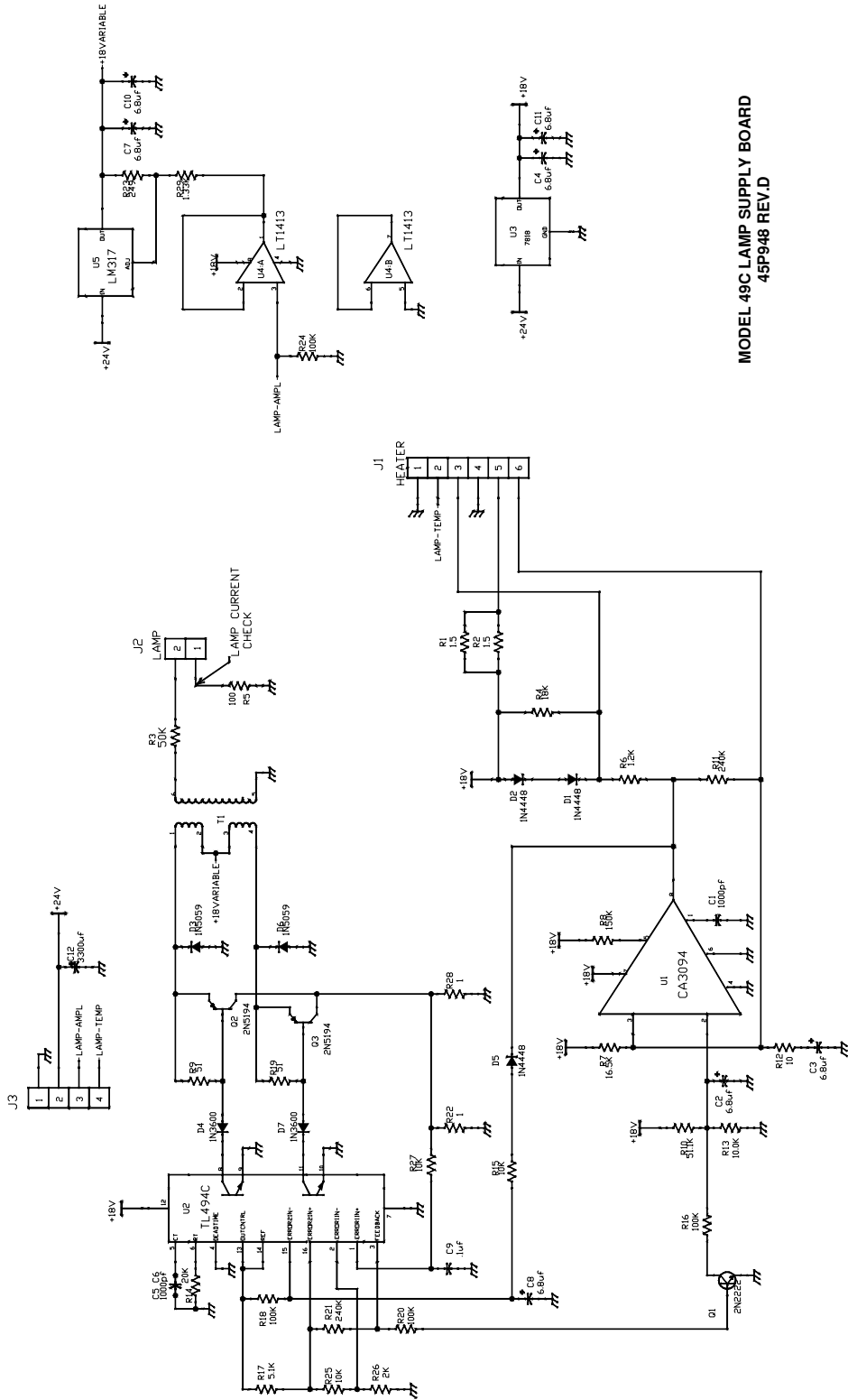




BD P/N 9846 DWG 45P314  
 ASY P/N 9847 ASY DWG 45P753

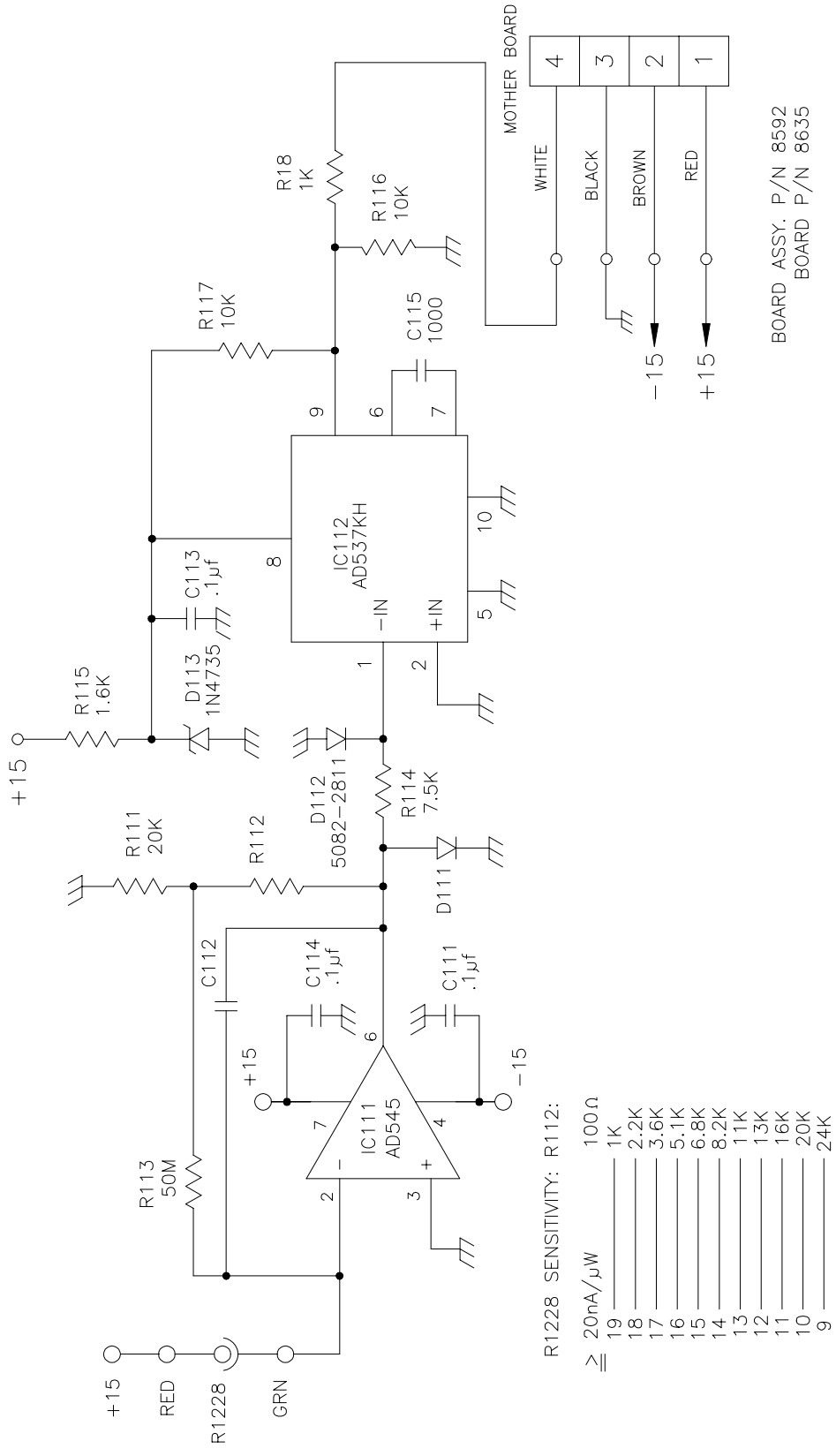
SCHEMATIC -  
 POWER SUPPLY

45P947



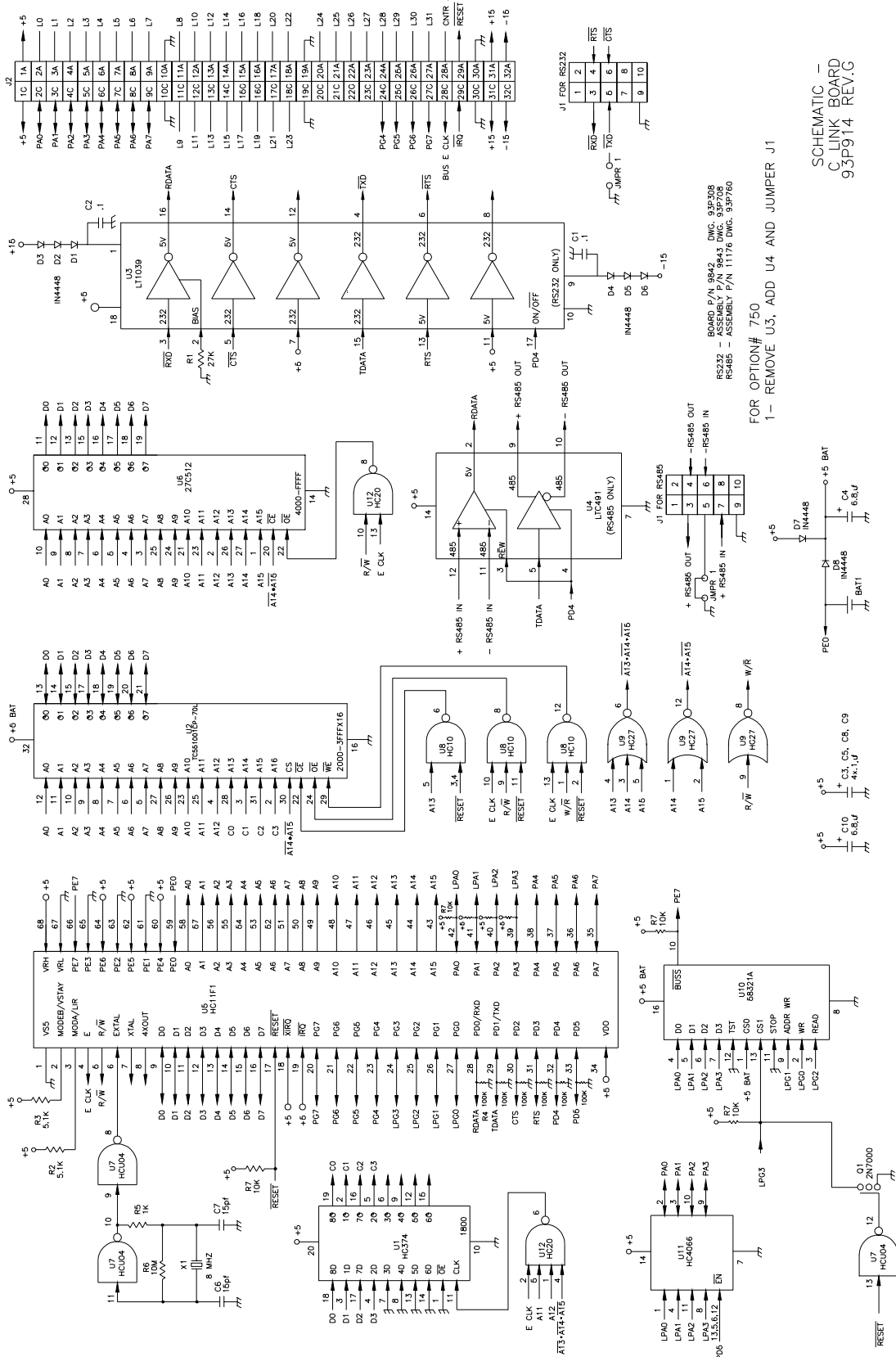
MODEL 49C LAMP SUPPLY BOARD  
45P948 REV.D





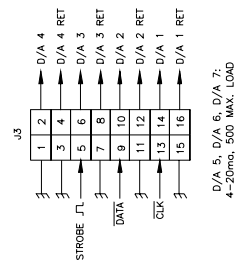
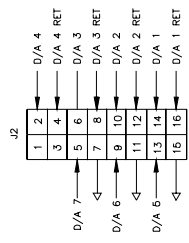
BOARD ASSY. P/N 8592  
BOARD P/N 8635

I/F DETECTOR SYSTEM SCHEMATIC (49-11)  
B45P911 REV.A

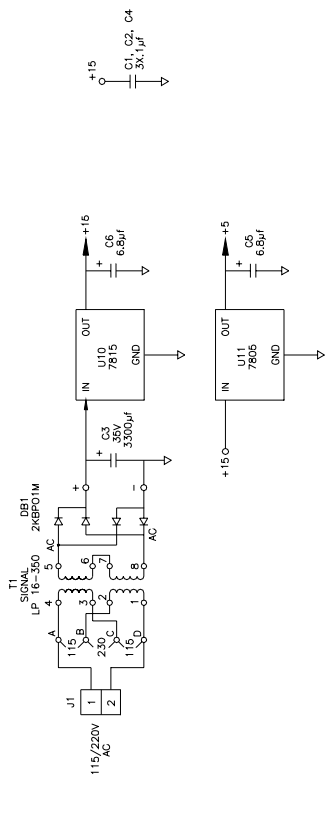
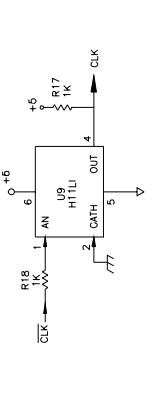
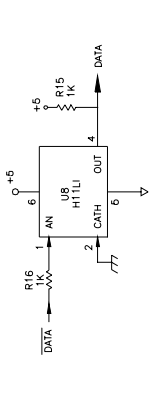
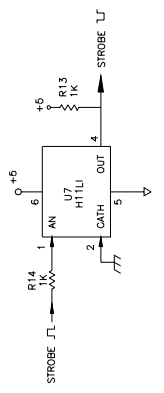
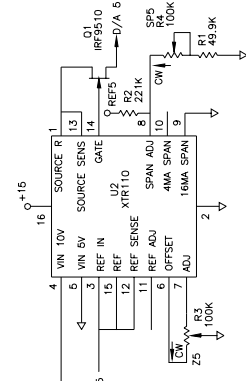
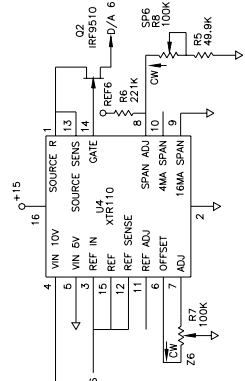
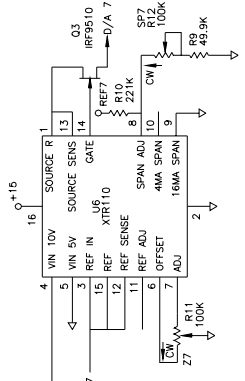


FOR OPTION# 750  
1 - REMOVE U3, ADD U4 AND JUMPER J1

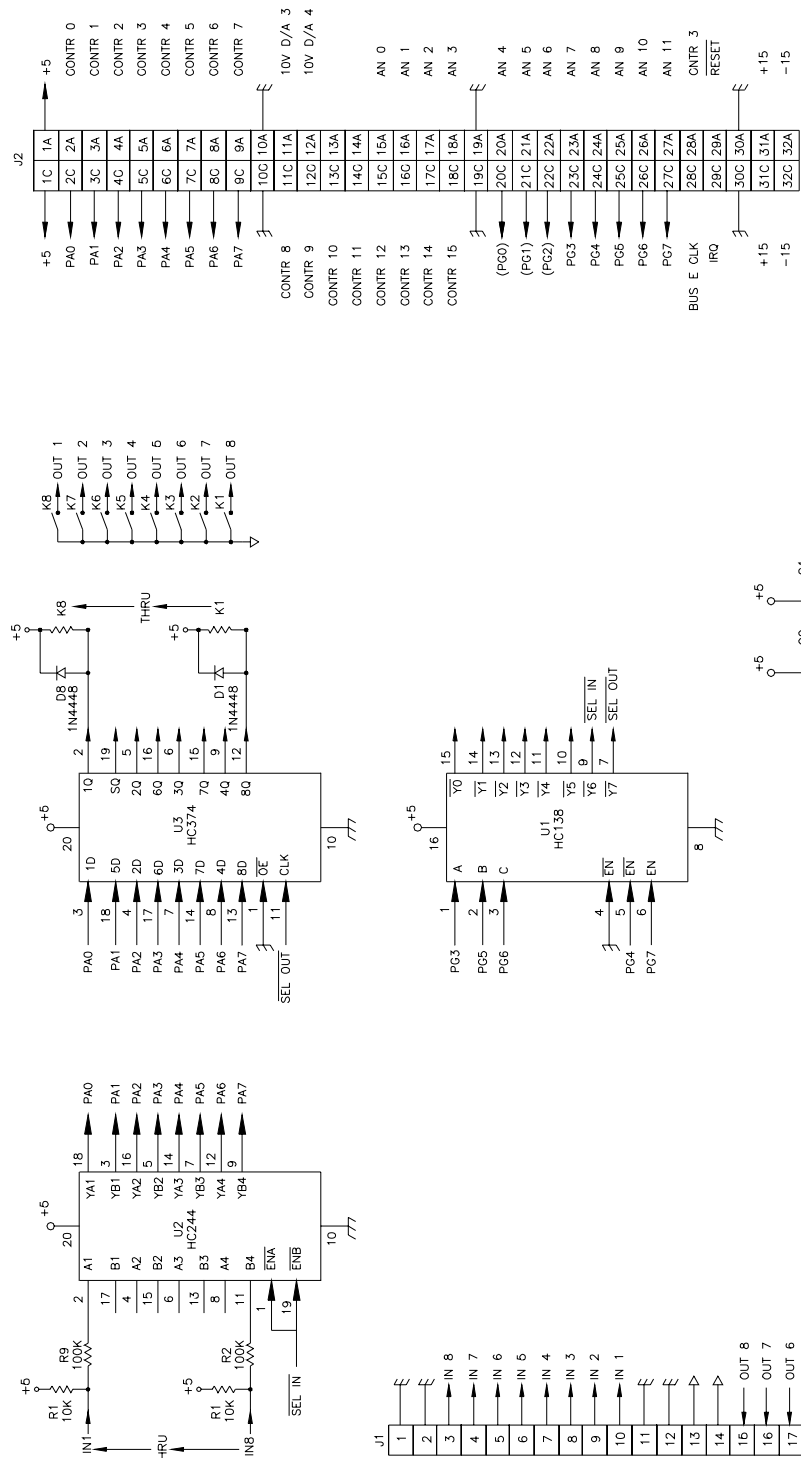
SCHEMATIC -  
C LINK BOARD  
93P914 REV.G



D/A 5, D/A 6, D/A 7:  
4-20mA, 500 MAX. LOAD



BOARD P/N 9953 DWG. 93P317  
ASSEMBLY P/N 9954 DWG. 93P718  
CURRENT OUTPUT 4-20MA  
D93P912

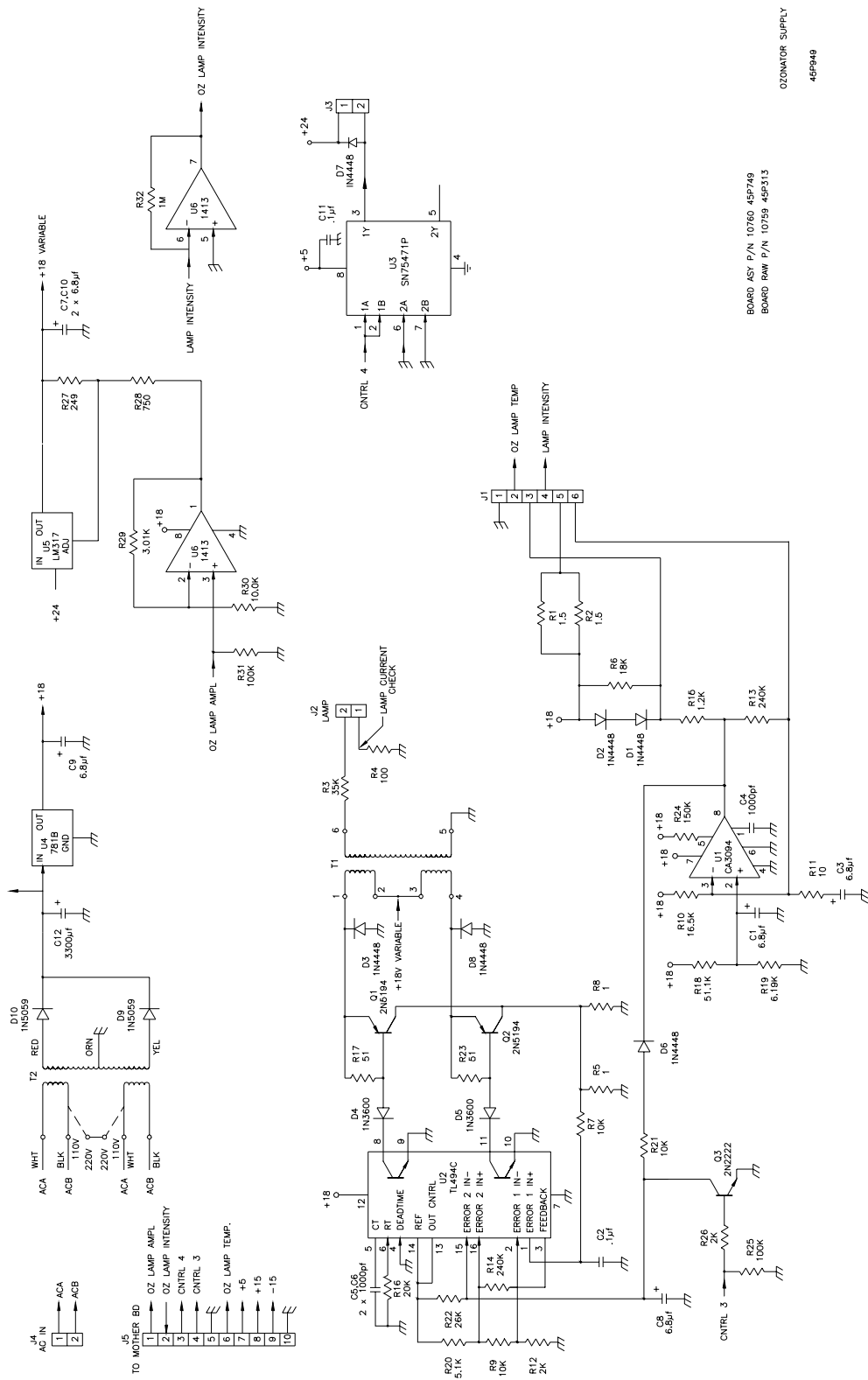


NOTE: SYSTEM GROUND ↗  
 SIGNAL GROUND ↘

BOARD RAW P/N 9955 93P318  
 BOARD ASY P/N 9956 93P719

SCHEMATIC --  
 INPUT/OUTPUT  
 BOARD

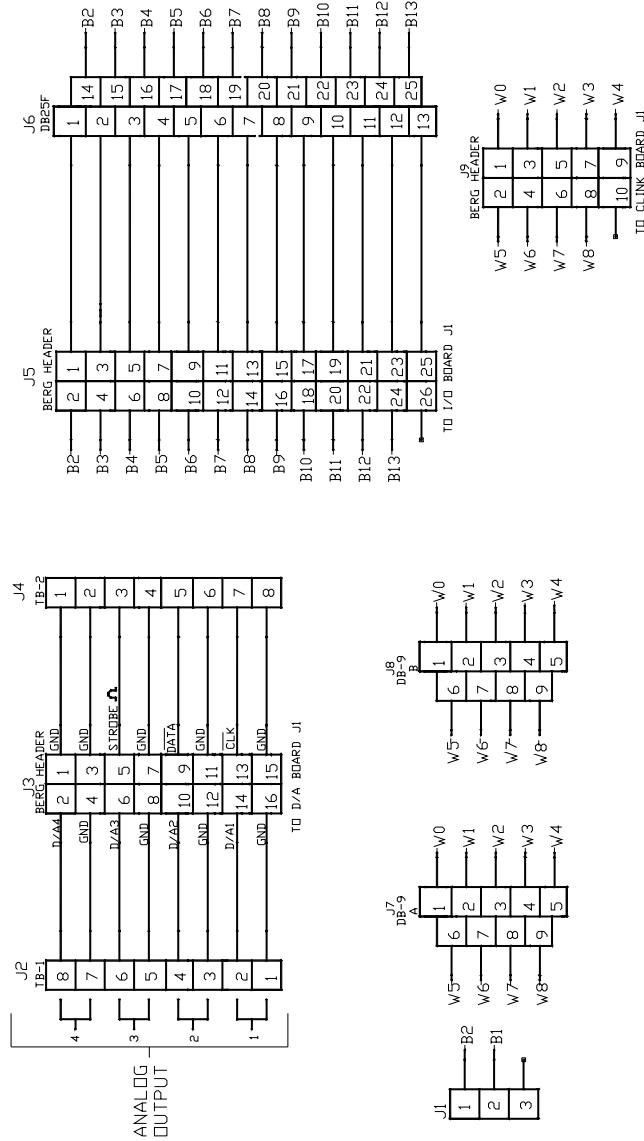
93P913 REV. C



BOARD ASY P/N 10760 45P7749  
 BOARD RAW P/N 10759 45P513

OZONATOR SUPPLY  
 46P949

DB25	J5	FUNCTION
1	1	GROUND
2	3	IN #8
3	5	IN #6
4	7	IN #4
5	9	IN #2
6	11	GROUND
7	13	SIG GND
8	15	OUT #8
9	17	OUT #6
10	19	OUT #4
11	21	OUT #2
12	23	SIG GND
13	25	N/U
14	2	GROUND
15	4	IN #7
16	6	IN #5
17	8	IN #3
18	10	IN #1
19	12	GROUND
20	14	SIG GND
21	16	OUT #7
22	18	OUT #5
23	20	OUT #3
24	22	OUT #1
25	24	SIG GND
*	26	N/U



P/N 9903 DWG 93P319  
 ASY 9904 DWG 93P738

REAR CONNECTOR  
 INTERFACE BOARD  
 93P915 REV.E

**APPENDIX D**

**PUMP MAINTENANCE**





## Operating and Maintenance Instructions

### Diaphragm Vacuum Pump Models: 8550, 8551, 8706

#### Operating Instructions

**Note:** The following guidelines should be observed to promote safe and reliable operation of your TEI pump.

1. TEI units are all 100% oil-free. No maintenance at all is necessary for the bearings and NO lubrication should be done. All bearings are sealed and permanently lubricated. For repair service, call TEI Customer Service.
2. Be sure that the available electric power matches specifications marked on the motor. Serious damage may occur to the motor if connected to an improper voltage. All TEI units should be grounded using the provided brass screw. In the event of an electrical short circuit, grounding reduces the risk of electric shock by providing an escape wire for the electric current.
3. The pump should be placed where the surrounding temperature remains between 40°F and 104°F (5°C and 41°C). This is particularly important when the unit is installed in a confined space where heat may build up during operation.
4. Standard models are designed to *start against atmospheric pressure only, not under load (Pressure or vacuum)*. Care must be taken to eliminate load when pump is turned off for any reason.
5. Use this pump only to pump air or gas, not liquids or particulates. *Damage to the pump or loss of performance can occur if liquids or particulates enter the system.* In the event that corrosive gases are to be pumped, be certain that a corrosion-resistant model is used. *The life of the pump can be prolonged if the formation of condensate within the pump is avoided.*
6. Always install the pump in such a location that it is protected from direct (or indirect) moisture contact.
7. Avoid operating the pump in very dusty conditions. If this cannot be prevented, then be sure to install an inlet filter and inspect and change it frequently.
8. If flow is throttled or restricted for any reason, care must be taken to avoid exceeding the maximum continuous operating design pressure of the unit.

9. Be sure that the pump is installed at the highest point within the system to prevent possible condensate from entering the unit.
10. Please remove any protective plastic plugs supplied in the intake or outlet ports of your pump prior to applying power to the motor.

#### Troubleshooting

**WARNING! AC motors are thermally protected and will automatically restart unexpectedly when the overload device resets. Don't pump flammable or explosive gases or operate this pump in an atmosphere containing flammable or explosive gases.**

Your TEI Pump should perform to specifications for years if the simple operating instructions and precautions are observed.

If you experience a problem and suspect the pump, try these simple checks prior to calling for assistance:

1. Check that all system interconnections are gas-tight.
2. Remove the head assembly as described in "Changing the Diaphragm and Valves". Look for any foreign matter; usually bits of Teflon® tape or particulates carried into the valving system or crystallized material from previously pumped vapors. All of the above must be cleared out and the pump reassembled with clean parts.
3. If pitting of the pump parts or tearing of the diaphragm is observed, it is possible that the gas/vapor being pumped is capable of attacking the wetted parts of the pump.

Chemical resistance charts should be consulted if you are in doubt. Generally, replacing the diaphragm and valves will restore the pump to operating specifications if the valve plate is not pitted in the valve seat area.

#### Limited Warranty

**THERMO ENVIRONMENTAL INSTRUMENTS, INC. (TEI) warrants to buyer that its products will be free from defects in material and workmanship under normal and appropriate use, and agrees to repair or replace any of its products without charge for parts or labor within one year from the date of shipment to the original purchaser.**

#### Products to be evaluated for warranty coverage:

Determination of coverage under this warranty is the sole responsibility of the manufacturing engineering representative of TEI. This determination will frequently require the return of the product to TEI. All product returns will be handled in accordance with TEI's product return policy. TEI reserves the right to inspect custom installations and devices that use TEI products as part of the warranty evaluation process. This warranty does not cover any misuse, negligence, deterioration by chemical action, unauthorized repair or alteration in any way, inappropriate handling or storage that in our judgement caused the product failure. TEI shall not be liable for any inconvenience, loss of use, or any consequential loss, damage or injury arising from any cause whatsoever. No employee, agent or representative of TEI shall have any right or authority to vary or alter the terms of this warranty. This warranty gives you specific legal rights, and you may have other rights which vary from state to state.

#### Important Note

TEI offers engineering and technical assistance to support the application and selection of our products. We strongly suggest that you ensure that the product you have purchased from us is suitable for the use that you intend; we cannot be responsible for any problems or inconveniences that result from the incorrect application or use of our products. If you provide enough information to us, we will work with you to optimize the performance of our products in your application.

Please call our Technical Sales Department for further information.

#### Return Requests / Inquiries

Direct all warranty and repair requests to TEI Customer Service Department for instructions before returning any unit for repair or evaluation. We will fax you a "Return Instruction Sheet" for guidance on the proper marking, packing and documentation requirements.

Important information conforming to the "Right To Know" act, such as a Material Safety Data Sheet may be required.

**Products shipped to TEI must have a Return Materials Authorization Number (RMA) file number marked on the outside of the package, otherwise they will be refused by our receiving department.**

## Spare Parts Kits

### For TEI Pump 8550

115V/60Hz  
Kit Part Number: 8606

### For TEI Pump 8551

220/240V/50/60Hz  
Kit Part Number: 8606

### For TEI Pump 8706

110V/50-60Hz 220V/50-60Hz  
Kit Part Number: 8606

## Changing the Diaphragm and Valve Plate

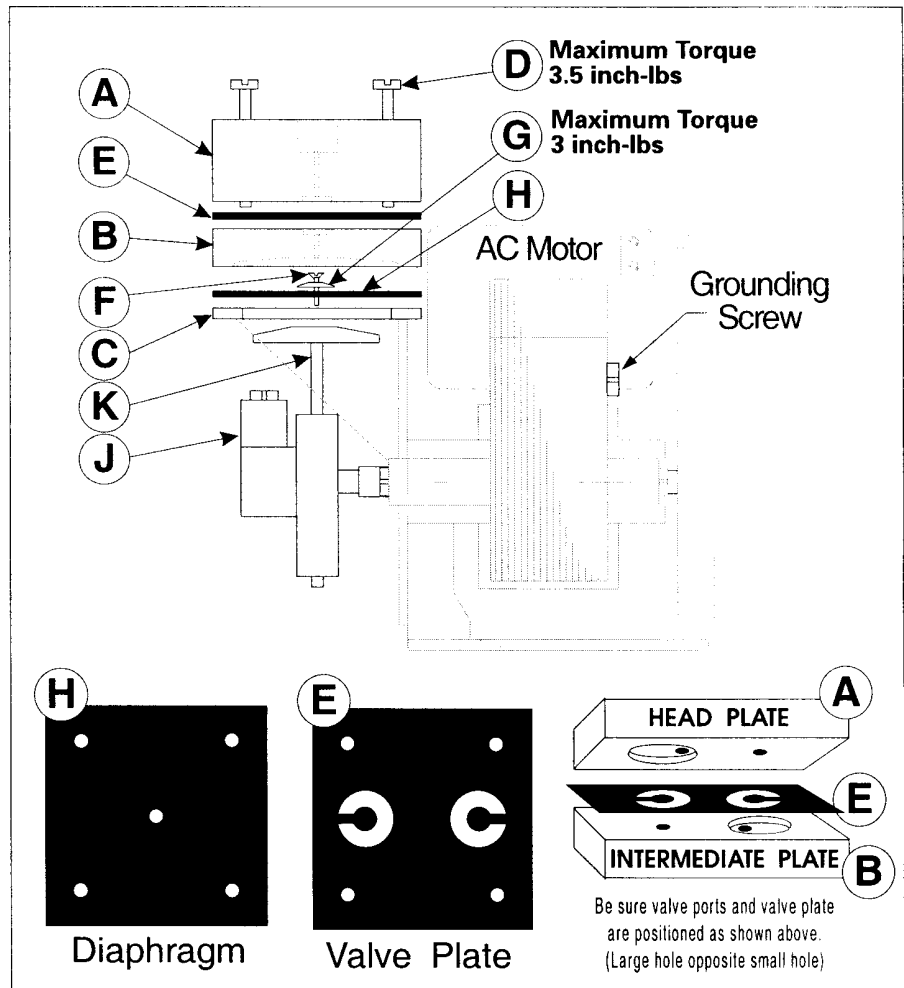
During normal use, the diaphragm and valve plate are the only parts of the pump that need to be replaced. Changing them is a simple process when the following steps are taken.

If you run into a problem or have a question regarding the following procedure, please call the TEI Service Department for assistance.

### Materials/Tools needed:

The proper replacement kit(s)  
Marking Pencil  
Slotted-head screwdriver

1. Disconnect the pump from electrical power.
2. Mark the relative positions of the head plate **A**, intermediate plate **B** and crankcase housing **C** with a line using a marker for ease of reassembly later.
3. Undo the 4 slotted-head cap screws **D** and lift off the head plate **A**, valve plate **E** and intermediate plate **B**.
4. Lightly clean the valve seat area of the head plate **A** and intermediate plate **B** of any debris or deposits with fine steel wool. This area must be clean and smooth, without pits or scratches.
5. Loosen the countersunk clamping disc screw **F** and remove the clamping disc **G**, and the diaphragm **H**.
6. Turn the counterweight **J** until the connecting rod **K** is at mid-stroke, and place the new diaphragm **H** (Teflon (white) side up on AT or ST models) on the housing **C**, lining it up with the screw holes.
7. Place the clamping disc **G** (bevel side up) on top of the new diaphragm **H**. Tighten the assembly using the countersunk clamping disc screw **F** to a maximum torque of 3 inch-lbs. **DO NOT OVERTIGHTEN!**
8. Place the intermediate plate **B** over the diaphragm, lining up the marks made previously in step 2.



9. Place the valve plate **E** on top of the intermediate plate **B**, orienting the valve flaps with the holes. There is no top or bottom of the valve plate.
10. Place the head plate **A** on top of the valve plate **E**, lining it up with the markings you made in step 2. Note orientation of the valve ports in the diagram.
11. Be sure that all components are centered, then tighten the 4 slotted-head cap screws **C** uniformly to a maximum torque of 3.5 inch-lbs. in a criss-cross pattern. **DO NOT OVERTIGHTEN!**
12. Check that the pump runs freely by turning the counterweight **J** by hand. Check all mechanical and electrical connections for tightness.
13. Apply power to the pump. Listen for a possible "knocking sound." If it is present, equally loosen the four head screws slightly until the sound just disappears. This step is to be sure that the clamping disc does not touch the intermediate plate during operation.

### Please Note:

Excessive tightening of the clamping disc screw and the four head screws will cause premature wear on the diaphragm and bearings and must be avoided. Observe stated torque specifications.

For service or parts CONTACT:

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