Model 146*i*

Instruction Manual
Dynamic Gas Calibrator
Part Number 102482-00
30Jan2008

CE

CE

Thermo
SCIENTIFIC

WEEE Compliance

This product is required to comply with the European Union's Waste Electrical & Electronic Equipment (WEEE) Directive 2002/96/EC. It is marked with the following symbol:

Thermo Fisher Scientific has contracted with one or more recycling/disposal companies in each EU Member State, and this product should be disposed of or recycled through them. Further information on Thermo Fisher Scientific's compliance with these Directives, the recyclers in your country, and information on Thermo Fisher Scientific products which may assist the detection of substances subject to the RoHS Directive are available at: www.thermo.com/WEEERoHS.

About This Manual

This manual provides information about operating, maintaining, and servicing the analyzer. It also contains important alerts to ensure safe operation and prevent equipment damage. The manual is organized into the following chapters and appendices to provide direct access to specific operation and service information:

- Chapter 1 "Introduction" provides an overview of product features, describes the principles of operation, and lists the specifications.

- Chapter 2 "Installation" describes how to unpack, setup, and startup the analyzer.

- Chapter 3 "Operation" describes the front panel display, the front panel pushbuttons, and the menu-driven software.

- Chapter 4 "Calibration" provides the procedures for calibrating the analyzer and describes the required equipment.

- Chapter 5 "Preventive Maintenance" provides maintenance procedures to ensure reliable and consistent instrument operation.

- Chapter 6 "Troubleshooting" presents guidelines for diagnosing analyzer failures, isolating faults, and includes recommended actions for restoring proper operation.

- Chapter 7 "Servicing" presents safety alerts for technicians working on the analyzer, step-by-step instructions for repairing and replacing components, and a replacement parts list. It also includes contact information for product support and technical information.

- Chapter 8 "System Description" describes the function and location of the system components, provides an overview of the software structure, and includes a description of the system electronics and input/output connections.

- Chapter 9 "Optional Equipment" describes the optional equipment that can be used with this analyzer.

Safety

Review the following safety information carefully before using the analyzer. This manual provides specific information on how to operate the analyzer, however if the analyzer is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Safety and Equipment Damage Alerts

This manual contains important information to alert you to potential safety hazards and risks of equipment damage. Refer to the following types of alerts you may see in this manual.

Safety and Equipment Damage Alert Descriptions

Alert		Description
⚠	**DANGER**	A hazard is present that will result in death or serious personal injury if the warning is ignored. ▲
⚠	**WARNING**	A hazard is present or an unsafe practice can result in serious personal injury if the warning is ignored. ▲
⚠	**CAUTION**	The hazard or unsafe practice could result in minor to moderate personal injury if the warning is ignored. ▲
⚠	**Equipment Damage**	The hazard or unsafe practice could result in property damage if the warning is ignored. ▲

Safety and Equipment Damage Alerts in this Manual

Alert		Description
⚠	**WARNING**	This instrument contains 120 volts AC (or 220 volts AC) and 800 volts DC. Normal precautions should be used when working on the inside of the instrument with the power connected. ▲
		If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲
		The service procedures in this manual are restricted to qualified service personnel only. ▲
		The Model 146*i* is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated. ▲

Safety and Equipment Damage Alerts in this Manual, continued

Alert		Description
⚠	**CAUTION**	If the LCD panel breaks, do not to let the liquid crystal contact your skin or clothes. If the liquid crystal contacts your skin or clothes, wash it off immediately using soap and water. ▲
⚠	**Equipment Damage**	Do not attempt to lift the analyzer by the cover or other external fittings. ▲
		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. ▲
		This adjustment should only be performed by an instrument service technician. ▲
		Handle all printed circuit boards by the edges only. ▲
		Do not remove the panel or frame from the LCD module. ▲
		The LCD module polarizing plate is very fragile, handle it carefully. ▲
		Do not wipe the LCD module polarizing plate with a dry cloth, it may easily scratch the plate. ▲
		Do not use Ketonics solvent or aromatic solvent to clean the LCD module, use a soft cloth moistened with a naphtha cleaning solvent. ▲
		Do not place the LCD module near organic solvents or corrosive gases. ▲
		Do not shake or jolt the LCD module. ▲

FCC Compliance

⚠ **WARNING** Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. ▲

Note This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. ▲

WEEE Symbol

The following symbol and description identify the WEEE marking used on the instrument and in the associated documentation.

Symbol	Description
	Marking of electrical and electronic equipment which applies to electrical and electronic equipment falling under the Directive 2002/96/EC (WEEE) and the equipment that has been put on the market after 13 August 2005.

Where to Get Help

Service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430

1-508-520-0430

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Chapter 1
Introduction

The Model 146*i* Multi-gas Calibrator dilutes calibration gases to precise concentrations. The diluted gases are used to perform zero, precision and Level 1 span checks, audits, and multipoint calibration of analyzers. The design of the Model 146*i* meets or exceeds all published U.S. Environmental Protection Agency requirements for multipoint calibration, audit, Level 1 span and precision checks.

For details of the calibrator's principle of operation and product specifications, see the following topics:

* "Principle of Operation" on page 1-1
* "Specifications" on page 1-7

Principle of Operation

All of the components used such as mass flow controllers, ozone generator, permeation tube oven, power supplies, solenoid valves, and photometer have been used previously for calibration purposes, and are known for their accuracy and reliability. In the Model 146*i*, these components are integrated into a single microprocessor-controlled unit. The instrument can be controlled locally via the front-panel interface or remotely, using a datalogger or computer.

Dilution

The standard Model 146*i* hardware/plumbing configuration comprises gas and zero air flow controllers, as shown in Figure 1–1. The basic unit can handle three gas standards, controlled by individual solenoids (a six-gas option is also available). The zero air flow and the gas flow are regulated by mass flow controllers. The zero air controller is high flow (typically 10 slm full scale). The gas flow controller is low flow (typically 100 sccm). A Teflon mixing chamber is used to achieve complete mixing of the two components at the desired concentration level. This hardware/plumbing configuration allows precision gas dilution.

Ozone Generation

The Model 146*i* can be equipped with an optional internal ozone generator. The hardware/plumbing configuration of the standard instrument with the ozone generator is shown in Figure 1–2. The generator

produces ozone by exposing air to light at 185nm. The ozone level is changed by varying the intensity of the lamp and varying the zero air flow. With all of the gas standard solenoids deactivated, the Model 146*i* can be used as a transfer standard ozone-generating source.

Gas Phase Titration

Gas Phase Titration (GPT) is achieved by combining ozone with a known NO concentration, and measuring the loss of NO using the NO channel of a chemiluminescence analyzer. The amount of NO_2 formed is equal to the measured decrease in the NO level, as shown in the following equation:

$$NO + O_3 \rightarrow NO_2 + O_2$$
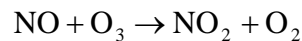
In the Model 146*i*, GPT is accomplished by routing zero air, at approximately 150 cc per minute, through the internal ozone generator and then precisely mixing this with NO from a gas cylinder connected to one of the gas inlets. From there, the NO/O_3 goes to the reaction chamber whose volume meets the dynamic parameter specification requirements of the U.S. EPA. The gas is then fed into the mixing chamber and out the manifold at the rear of the instrument.

Permeation Oven

The Model 146*i* can also be used as a permeation gas source when equipped with an optional permeation tube oven, as shown in Figure 1–3. Accuracy is achieved since both the release rate of the permeation tube gas and the flow of zero air through the zero-air mass flow controller are known, and the temperature of the permeation tube is stable. Temperature stability of the permeation tube is accomplished by allowing only a small amount of zero air to enter the permeation tube oven to be heated. The major portion of zero air bypasses the oven and is routed to the mixing chamber. The solenoids on either side of the permeation tube oven, under microprocessor control, are used to route the flow of gas going through the oven to either the main air stream or to exhaust. It should be noted that zero air must always flow through the permeation tube oven, regardless of the 146*i* output flow, so the oven may be kept at a stable temperature. To accomplish this, a flow of zero air set by a capillary at approximately 150 cc per minute is continuously fed through the permeation tube oven.

When only the permeation oven is activated, up to five permeation dilution gas levels (ppm) can be set. When the permeation gas source is used in conjunction with the gas dilution system, a permeation dilution concentration cannot be specified because the gas dilution system controls the flow rate of zero air. In that case, only the permeation concentration, and not a permeation level, is displayed.

Figure 1–4 shows the hardware/plumbing configuration with both the optional ozone generator and permeation oven installed. This figure is for illustration purposes only, since there is no calibration gas requirement that would necessitate activating both hardware components simultaneously.

Photometer   The Model 146*i* photometer operates on the principle that ozone (O_3) 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 cm^{-1} (at 0°C and 1 atmosphere)

L = length of cell, 17.90 cm

C = ozone concentration in parts per million (ppm)

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

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

Zero air is supplied to the Model 146*i* through the *zero air* bulkhead and is split into two gas streams, as shown in Figure 1–5. One gas stream flows through the zero air solenoid and through the zero air mass flow controller, then through the ozonator to the manifold and to the external/internal solenoid to become the sample gas (I). The other stream flows from the zero air bulkhead to the sample/reference solenoid in the photometer and is used as the reference gas (I_o). Alternately, the sample gas may be pulled from an external source through the external/internal solenoid. The sample/reference solenoid valve alternates the reference and sample gas streams between the cell every 5 seconds. Ozone measured by the photometer is dumped out the exhaust bulkhead.

Figure 1–5 and Figure 1–6 show the hardware/plumbing configuration with optional ozone generator, internal permeation oven, and photometer.

The UV light intensities of the zero and sample gases are measured by the detector. When the solenoid valves switch the reference and sample gas streams, the light intensity is ignored for several seconds to allow the cell to be flushed. The Model 146*i* calculates the ozone concentration from the ratio of zero and sample gas intensities and outputs the concentration to the front panel display, the analog outputs, and also makes the data available over the serial or Ethernet connection.
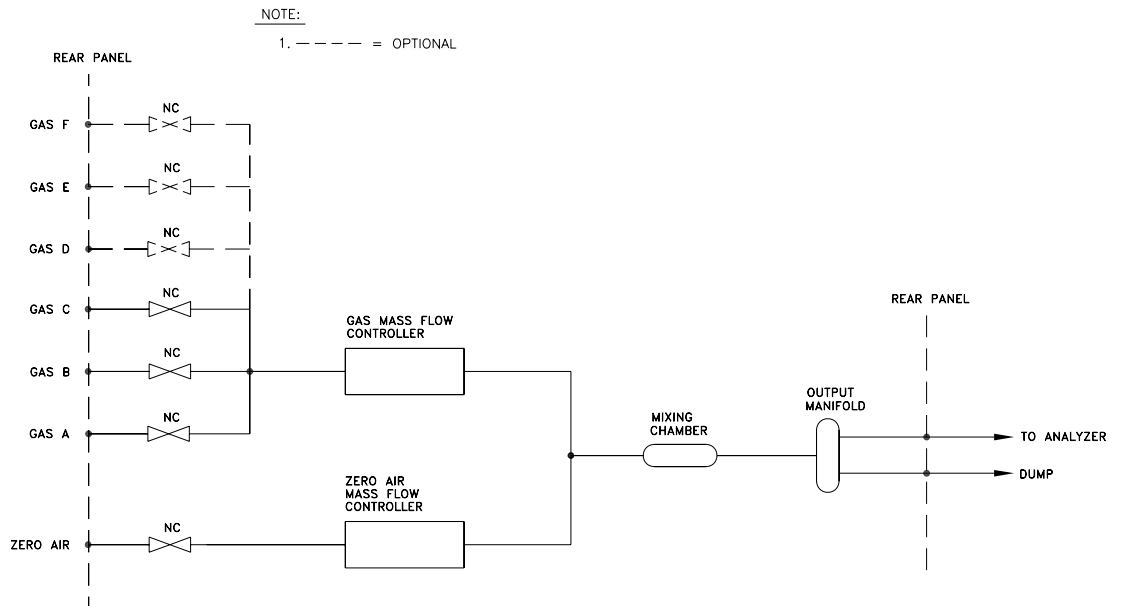
Figure 1–1. Standard Gas Dilution System
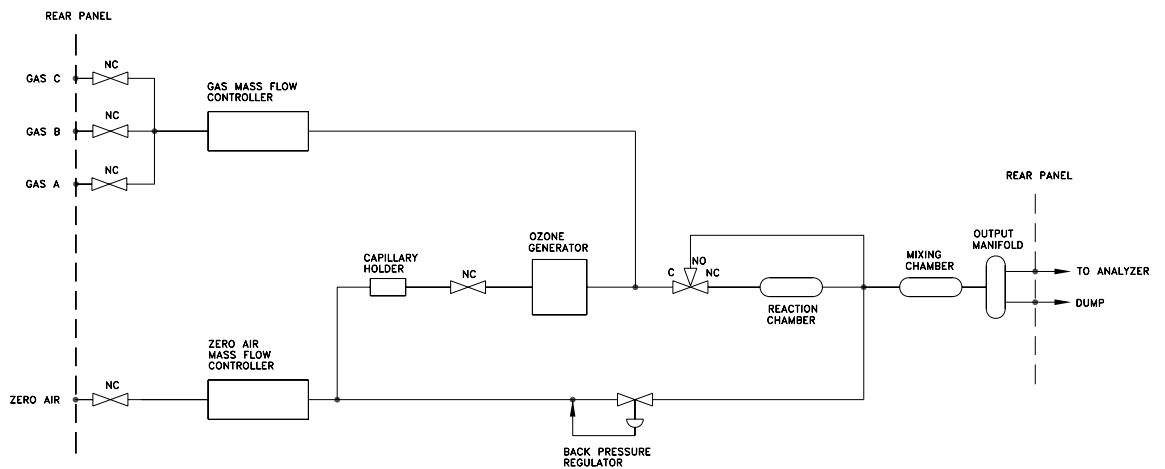
Figure 1–2. Standard Gas Dilution System with Ozonator Option
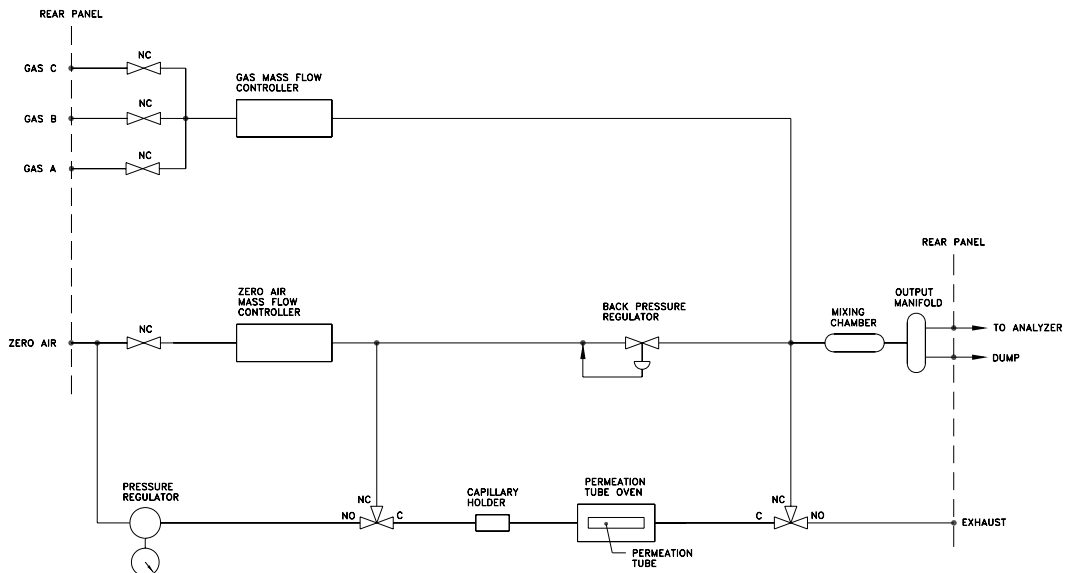
Figure 1–3. Standard Gas Dilution System with Permeation Tube Oven Option
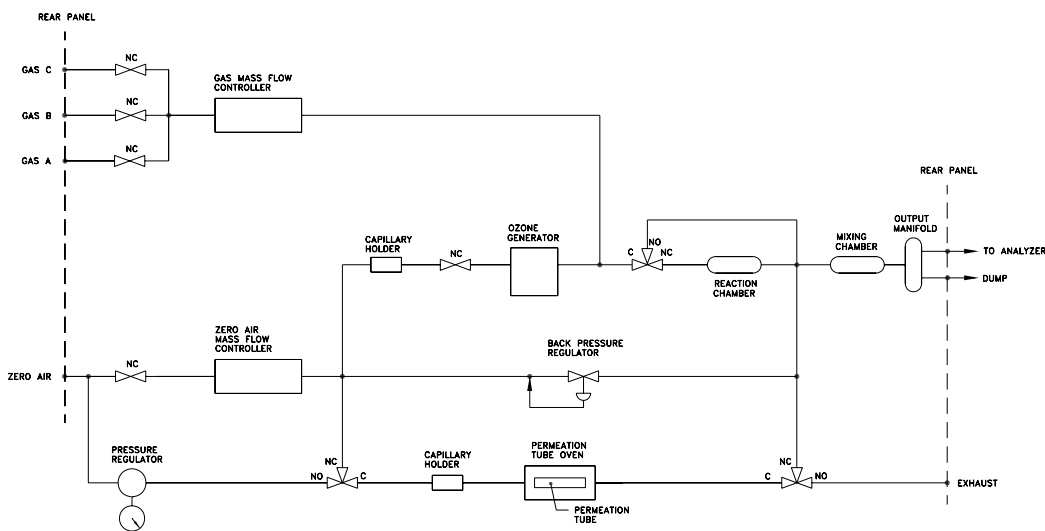
Figure 1–4. Standard Gas Dilution with Ozonator and Permeation Tube Oven Options
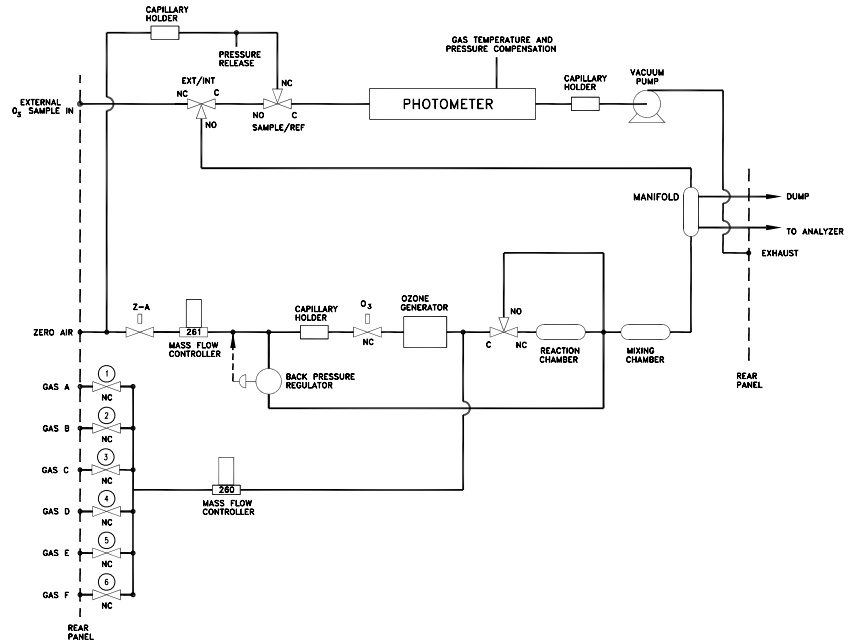
Figure 1–5. Standard Gas Dilution System with Photometer Option
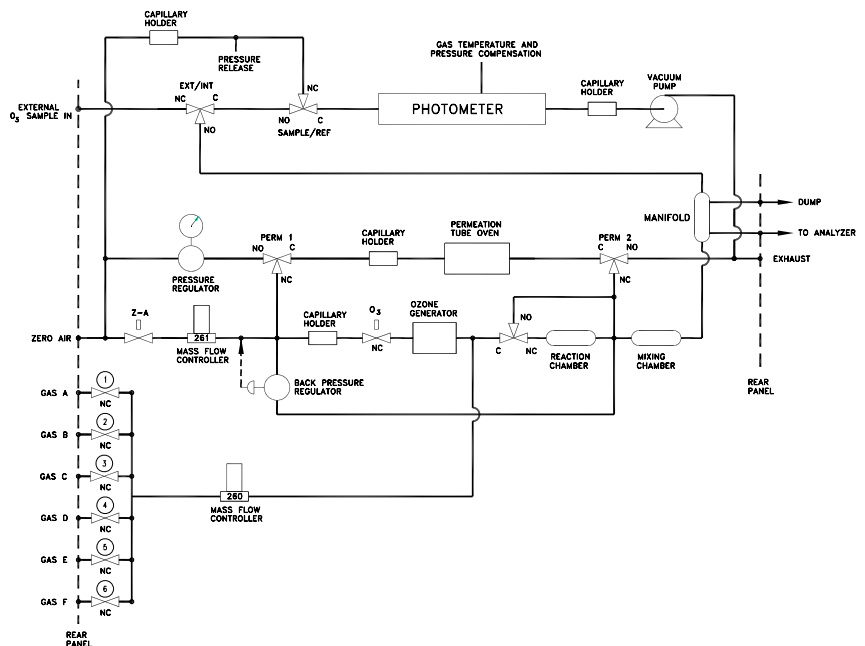
Figure 1–6. Standard Gas Dilution System with Ozonator, Permeation Tube Oven, and Photometer Options

Specifications

Table 1–1 lists the specifications for the Model 146*i*.

Table 1–1. Model 146*i* Specifications

Gas Dilution	
Accuracy of each Mass Flow Measurement	± 2% of reading or 1% of full-scale, whichever is less (20 to 100% full-scale)
Linearity of Mass Flow Measurement	0.5% of full-scale
Repeatability of Mass Flow Measurement	± 2% of reading or 1% of full-scale, whichever is less (20 to 100% full-scale)

Available Ranges	
Zero Air	5, 10, 15, 20 slm
Span Gas	25, 50, 100, 200, 500 sccm
Dilution Ratio	Depends upon choice of Mass Flow Controllers
Response time as measured at output of manifold to 99% of final value	Less than one minute for low flows. Faster for high flow (for gas-phase titration mode response time increases to 4 minutes). (Meets or exceeds U.S. EPA Dynamic Parameters specification requirements for gas-phase titration.)
Operating temperature	0–45 °C*
Power Requirements	100 VAC @ 50/60 Hz 115 VAC @ 50/60 Hz 220–240 VAC @ 50/60 Hz 275 watts
Physical dimensions	16.75" (W) X 8.62" (H) X 23" (D)
Weight	Approximately 54 lbs. with all options

Permeation Oven	
Temperature Control	Single point 30, 35, 45 °C
Temperature Stability	± 0.1 °C
Warm-up Time – Oven	1 hour (permeation device can take 24-48 hours to stabilize
Carrier Gas Flow	150 sccm nominal
Chamber Size	Accepts permeation tubes up to 9 cm in total length; 1 cm in diameter

Ozone Generator	
Ozone Output	6 ppm-liters

Photometer	
Preset ranges	0.05, 0.1, 0.2, 0.5, 1.0, 2.0, 5.0 ppm
Custom ranges	0.05 to 5.0 ppm
Zero noise	0.75 ppb (300 second averaging time)
Lower detectable limit	1.5 ppb (300 second averaging time)
Response time (in control mode)	<180 seconds
Linearity	± 1% of full-scale
Flow rate	0.6 LPM

Stability and Repeatability	Meets or exceeds U.S. EPA requirements for a Transfer Standard

Remote Operation	
External Solenoid outputs	Up to (8) 24 VDC external solenoids can be controlled by Model 146*i*
Analog outputs	6 voltage outputs; 0–100 mV, 1, 5, 10 V (User selectable), 5% of full-scale over/under range, 12 bit resolution, user selectable for measurement input. Optional 6 current outputs: 0-20 mA or 4-20 mA.
Digital outputs	1 power fail relay Form C, 10 relays Form A, user selectable alarm output, relay logic, 100 mA @ 200 VDC
Digital inputs	16 digital inputs, user select programmable, TTL level, pulled high
Serial Ports	1 RS-232 or RS-485 with two connectors, baud rate 1200–115200, Protocols: C-Link, MODBUS, and streaming data (all user selectable)
Ethernet connection	RJ45 connector for 10Mbs Ethernet connection, static or dynamic TCP/IP addressing

*In non condensing environments.

Chapter 2 Installation

Installing the Model 146*i* includes the following recommendations and procedures:

- "Lifting" on page 2-1

- "Unpacking and Inspection" on page 2-1

- "Setup Procedure" on page 2-3

- "Remote Interconnections" on page 2-6

- "Connecting External Devices" on page 2-10

- "Startup" on page 2-14

Lifting

When lifting the instrument, use procedure appropriate to lifting a heavy object, such as, bending at the knees while keeping your back straight and upright. Grasp the instrument at the bottom in the front and at the rear of the unit. Although one person can 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.

⚠ **Equipment Damage** Do not attempt to lift the instrument by the cover or other external fittings. ▲

Unpacking and Inspection

The Model 146*i* is shipped complete in one container. If there is obvious damage to the shipping container when you receive the instrument, notify the carrier immediately and hold for inspection. The carrier is responsible for any damage incurred during shipment.

Use the following procedure to unpack and inspect the instrument.

1. Remove the instrument from the shipping container and set it on a table or bench that allows easy access to both the front and rear.

2. Remove the cover to expose the internal components.

3. Remove the packing material (Figure 2-1).

Remove Packing
(2 pieces)

Remove Packing
(2 pieces)

Units without Optional I/O Board

Units with Optional I/O Board
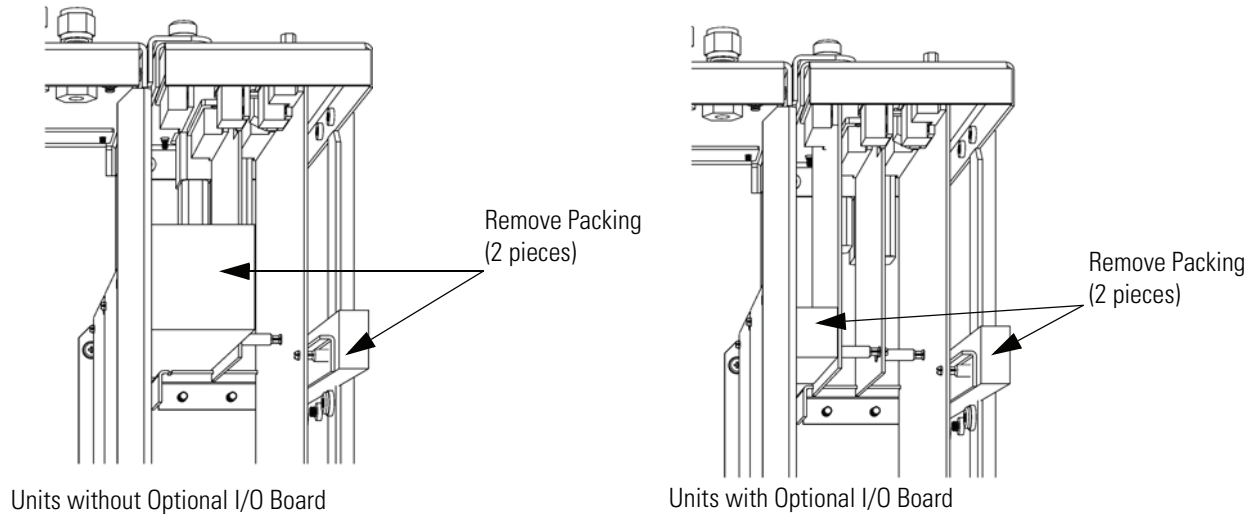
Figure 2-1. Remove the Packing Material

4. If the photometer option is installed (includes pump), remove the three shipping screws (Figure 2-2).
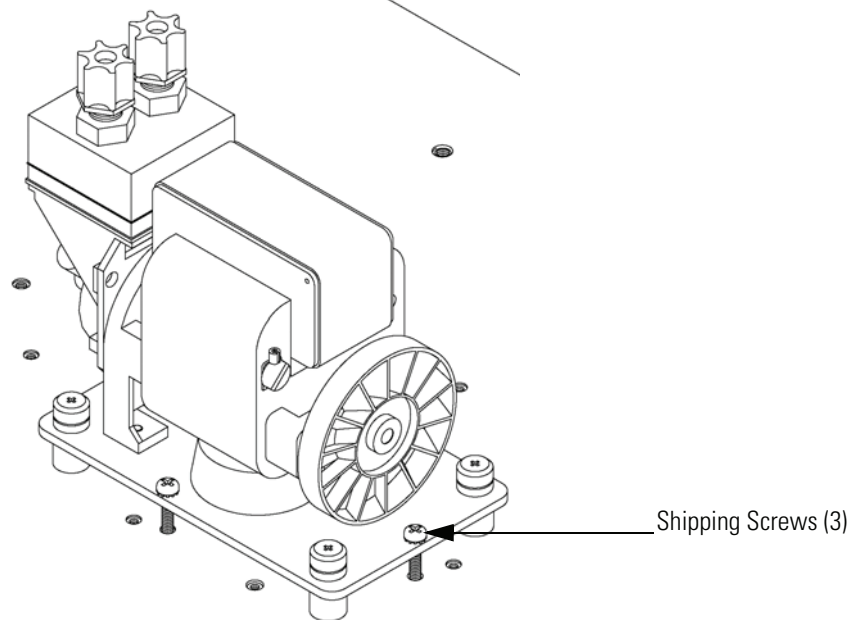
Shipping Screws (3)

Figure 2-2. Remove the Shipping Screws

5. Check for possible damage during shipment.

6. Check that all connectors and circuit boards are firmly attached.

7. Re-install the cover.

Setup Procedure

Use the following procedure to setup the instrument.

1. Connect a source of zero-air to the inlet port labeled **ZERO AIR**. The zero-air source is capable of supplying the full-scale flows of the zero-air controller at a pressure between 10 and 40 psi.

2. Connect the standard gas cylinders to the ports labeled A, B and C.

3. Install the permeation tube using the following procedure (applicable only if the permeation option is installed).

   a. Remove the instrument cover and locate the permeation oven ("Component Layout" on page 7-8).

   b. Release the latches on the sides of the oven cover and remove cover.

   c. Remove glass chamber assembly (Figure 2-3) by loosening (not removing) knurled screw, located at the top of the chamber, and gently pulling assembly upward. Completely remove assembly from oven.
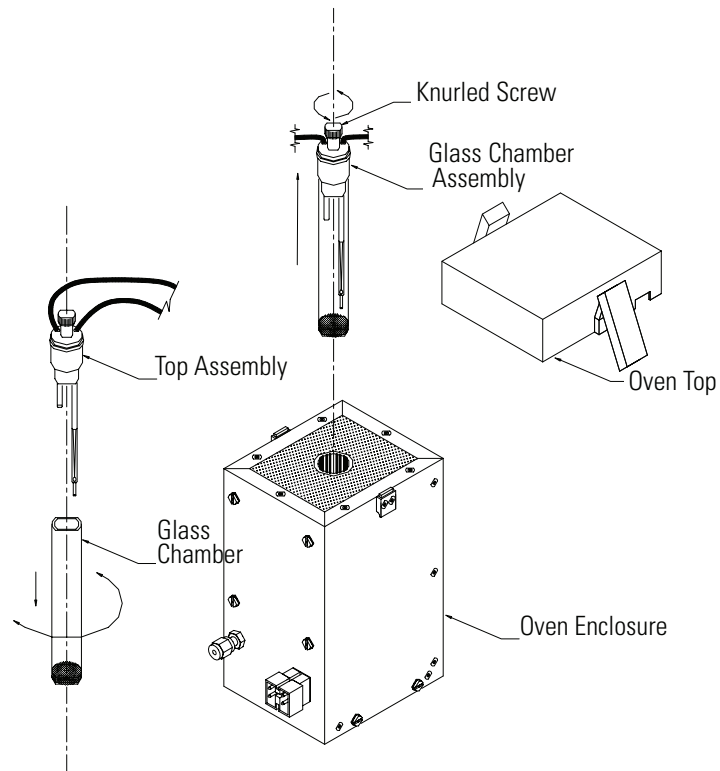
Figure 2-3. Removing the Glass Chamber Assembly

    d. Separate glass chamber from top assembly by twisting and gently pulling glass away from top (Figure 2-3). Keep glass clean by using Kimwipes or similar material to handle glass.

    e. Place permeation tube in chamber.

    f. Attach glass chamber to top assembly by gently pushing together with a slight twisting motion (Figure 2-3).

    g. Replace glass chamber assembly into oven until top of assembly is flush or slightly below oven top (Figure 2-4).
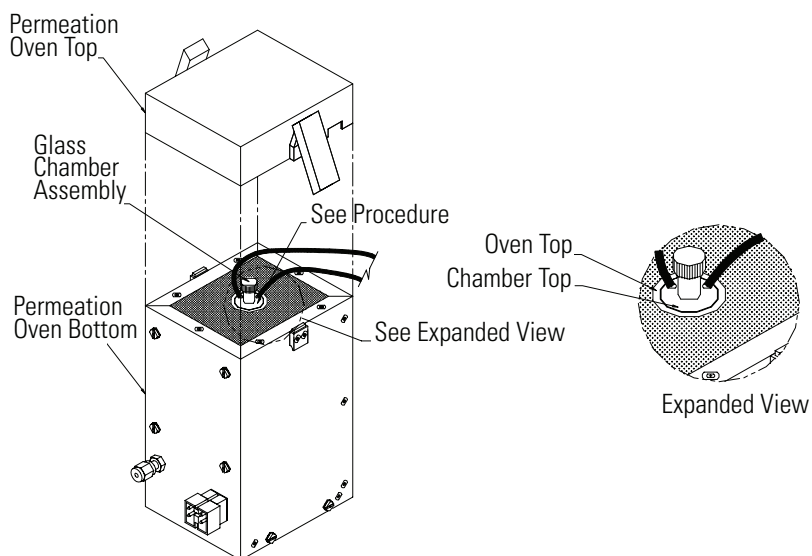
Figure 2-4. Replacing the Glass Chamber Assembly

    h.   Tighten knurled screw with finger. Do not use tools to tighten.

    i.   Replace oven cover, being careful to place tubing and wire in slot of cover.

4.   Connect the EXHAUST bulkhead to a suitable vent. The exhaust line should be 1/4-inch OD with a minimum ID of 1/8-inch. The length of the exhaust line should be less than 10 feet. Verify that there is no restriction in this line.

5.   Connect a suitable recording device to the rear panel connector. For detailed information about connecting to the instrument, refer to:

       "Connecting External Devices" on page 2-10

       "External Device Connection Components" on page 7-7

       "Terminal Block and Cable Kits" on page 9-11

       "Instrument Controls Menu" in the Operation chapter

For detailed information about troubleshooting a connection, refer to "Analog Output Testing" on page 7-19.

6. Plug the instrument into an outlet of the appropriate voltage and frequency.

⚠ **WARNING** The Model 146*i* is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated. ▲
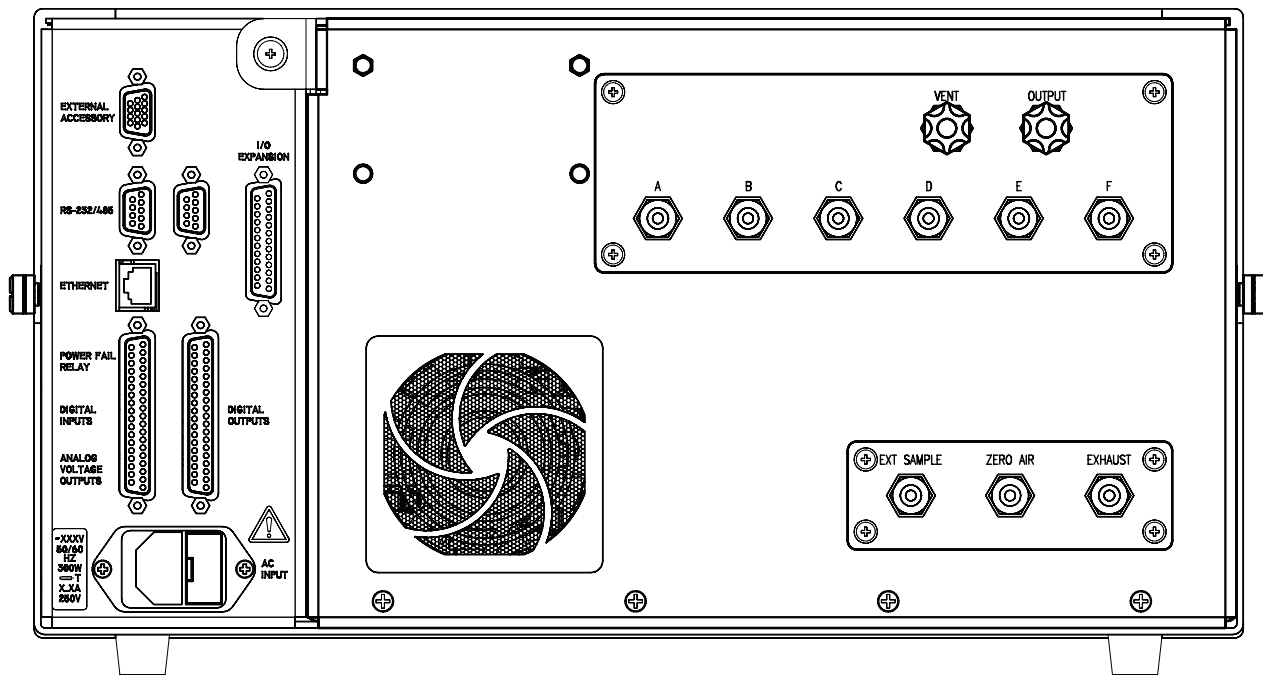
Figure 2-5. Model 146*i* Rear Panel

Remote Interconnections

The rear panel I/O (DB37M) connector enables flow modes, ozone levels, and gas settings to be remotely controlled using contact closure. In addition, the connector mimics any input settings with corresponding relay outputs.

Inputs

The Model 146*i* is controllable through the 37-pin male rear-panel connector. Refer to the following tables when selecting the appropriate gas, gas span level, and ozonator or permeation oven level for the Model 146*i*.

Note These are the default settings that can be changed by the operator. A 1 indicates contact closure to ground and 0 indicates no contact, assuming the digital input channel is set to Normally Open. ▲

Pins 3, 4, and 23 select a gas. Pins 2, 5, 10, 13, 16, 18, 19, 22, 26, 32, 35, and 37 are ground.

Note Gases D, E, and F are available only when the instrument is equipped with the 6-gas option. ▲

Gas Bit 3 Pin 23	Gas Bit 2 Pin 4	Gas Bit 1 Pin 3	Gas Type
0	0	0	Gas Off
0	0	1	Gas A
0	1	0	Gas B
0	1	1	Gas C
1	0	0	Gas D
1	0	1	Gas E
1	1	0	Gas F

Pins 24, 6, and 25 select a gas span level gas.

Span Bit 3 Pin 25	Span Bit 2 Pin 6	Span Bit 1 Pin 24	Span Level
0	0	0	Span 0
0	0	1	Span 1
0	1	0	Span 2
0	1	1	Span 3
1	0	0	Span 4
1	0	1	Span 5
1	1	0	Manual

Pins 7, 8, 27, and 9 select an ozonator or permeation oven level gas.

Oz/Perm Bit 4 Pin 9	Oz/Perm Bit 3 Pin 27	Oz/Perm 2 Pin 8	Oz/Perm Bit 1 Pin 7	Ozonator or Permeation Oven Levell
0	0	0	0	Ozon/Perm Off
0	0	0	1	Ozon Manual
0	0	1	0	Ozon 1
0	0	1	1	Ozon 2
0	1	0	0	Ozon 3
0	1	0	1	Ozon 4

0	1	1	0	Ozon 5
0	1	1	1	Perm 1
1	0	0	0	Perm 2
1	0	0	1	Perm 3
1	0	1	0	Perm 4
1	0	1	1	Perm 5

Pins 28 and 29 select the photometer mode.

Phot Bit 2 Pin 29	Phot Bit 1 Pin 28	
0	0	Photometer Off
0	1	Photometer Internal
1	0	Photometer External
1	1	Photometer Ozonator Control

Pin 11 sets all analog outputs to zero. This can be used to test the analog output functionality.

Pin 30 sets all analog outputs to full-scale values. This can be used to test the analog output functionality.

Outputs   The Model 146*i* is controllable through the 37-pin female rear-panel connector.

The output relays report the status of the 146*i*. They default to Normally Open (meaning that the relays are closed when the condition exists) and can be user-configured as NO or NC. Refer to the following tables for the indicated gas, gas span level, and ozonator or permeation oven level for the Model 146*i*.

Pins 1, 2, and 3 to report the selected gas (1 indicates contact closure):

Gas Bit 3 Pins 3,22	Gas Bit 2 Pins 2,21	Gas Bit 1 Pins 1,20	Gas Type
0	0	0	Gas Off
0	0	1	Gas A
0	1	0	Gas B
0	1	1	Gas C
1	0	0	Gas D

1	0	1	Gas E
1	1	0	Gas F

Pins 4, 5, and 6 to report the selected gas span level (1 indicates contact closure):

Span Bit 3 Pins 6,25	Span Bit 2 Pins 5,24	Span Bit 1 Pins 4,23	Span Level
0	0	0	Span 0
0	0	1	Span 1
0	1	0	Span 2
0	1	1	Span 3
1	0	0	Span 4
1	0	1	Span 5
1	1	0	Manual

Pins 7, 8, 9, and 10 to report the selected ozonator and permeation oven level (1 indicates contact closure):

Oz/Perm Bit 7 Pins10,29	Oz/Perm Bit 8 Pins 9,28	Oz/Perm 9 Pins 8,27	Oz/Perm Bit 10 Pins 7,26	Ozonator or Permeation Oven Levell
0	0	0	0	Ozon/Perm Off
0	0	0	1	Ozon Manual
0	0	1	0	Ozon 1
0	0	1	1	Ozon 2
0	1	0	0	Ozon 3
0	1	0	1	Ozon 4
0	1	1	0	Ozon 5
0	1	1	1	Perm 1
1	0	0	0	Perm 2
1	0	0	1	Perm 3
1	0	1	0	Perm 4
1	0	1	1	Perm 5

Pins 12 to 19 are user-controllable solenoid outputs. The following table lists their default values. When the condition is active, 24V is provided on the pin.

Pin 12	Gas A
Pin 13	Gas B
Pin 14	Gas C
Pin 15	Gas D
Pin 16	Gas E
Pin 17	Gas F
Pin 18	Ozonator
Pin 19	Perm Oven

Connecting External Devices

Several components are available for connecting external devices to *i*Series instruments.

These connection options include:

- Individual terminal board PCB assemblies

- Terminal block and cable kits (optional)

- Individual cables (optional)

For detailed information on the optional connection components, refer to the "Optional Equipment" chapter. For associated part numbers, refer to "External Device Connection Components" on page 7-7.

Terminal Board PCB Assemblies

The following terminal board PCB assemblies are available for *i*Series instruments:

- I/O terminal board PCB assembly, 37 pin (standard)

- D/O terminal board PCB assembly, 37 pin (standard)

- 25-pin terminal board PCB assembly (included with optional I/O Expansion Board)

I/O Terminal Board   Figure 2-6 shows the recommended method for attaching the cable to the terminal board using the included tie-down and spacer. Table 2-1 identifies the connector pins and associated signals.

See Detail "A"   See Detail "B"

Component Side Viewed from Top of Board

Detail "A"   Detail "B"

Assembled Connector
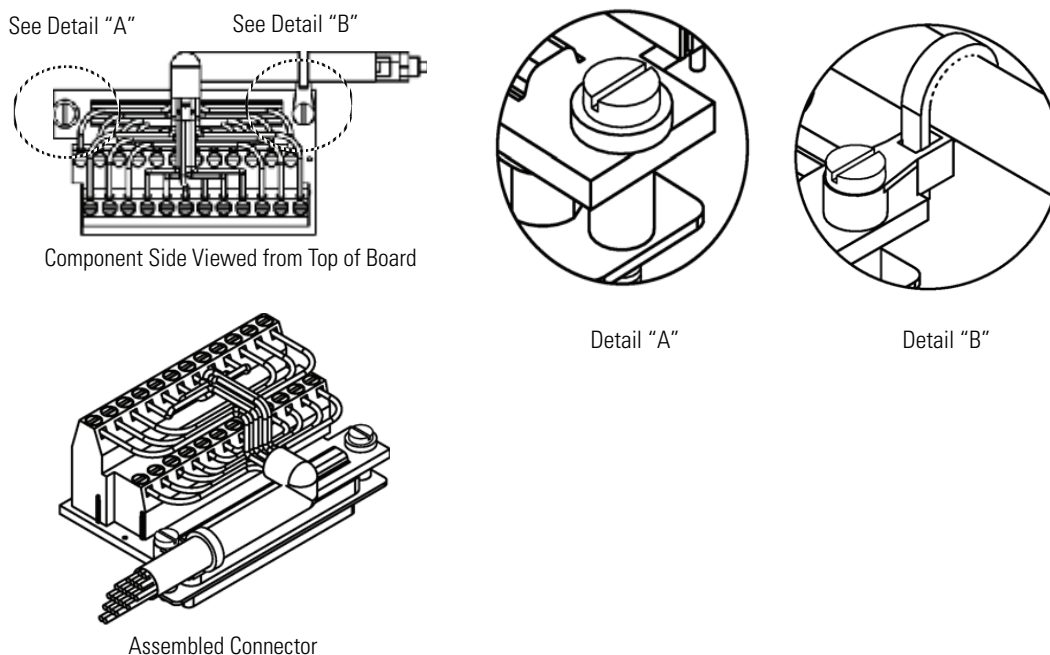
Figure 2-6. I/O Terminal Board Views

Table 2-1. I/O Terminal Board Pin Descriptions

Pin	Signal Description	Pin	Signal Description
1	Analog1	13	Power_Fail_NC
2	Analog ground	14	Power_Fail_COM
3	Analog2	15	Power_Fail_NO
4	Analog ground	16	TTL_Input1
5	Analog3	17	TTL_Input2
6	Analog ground	18	TTL_Input3
7	Analog4	19	TTL_Input4
8	Analog ground	20	Digital ground
9	Analog5	21	TTL_Input5
10	Analog ground	22	TTL_Input6
11	Analog6	23	TTL_Input7
12	Analog ground	24	Digital ground

D/O Terminal Board   Figure 2-7 shows the recommended method for attaching the cable to the terminal board using the included tie-down and spacer. Table 2-2 identifies the connector pins and associated signals.

See Detail "A"   See Detail "B"

Component Side Viewed from Top of Board

Detail "A"   Detail "B"

Assembled Connector
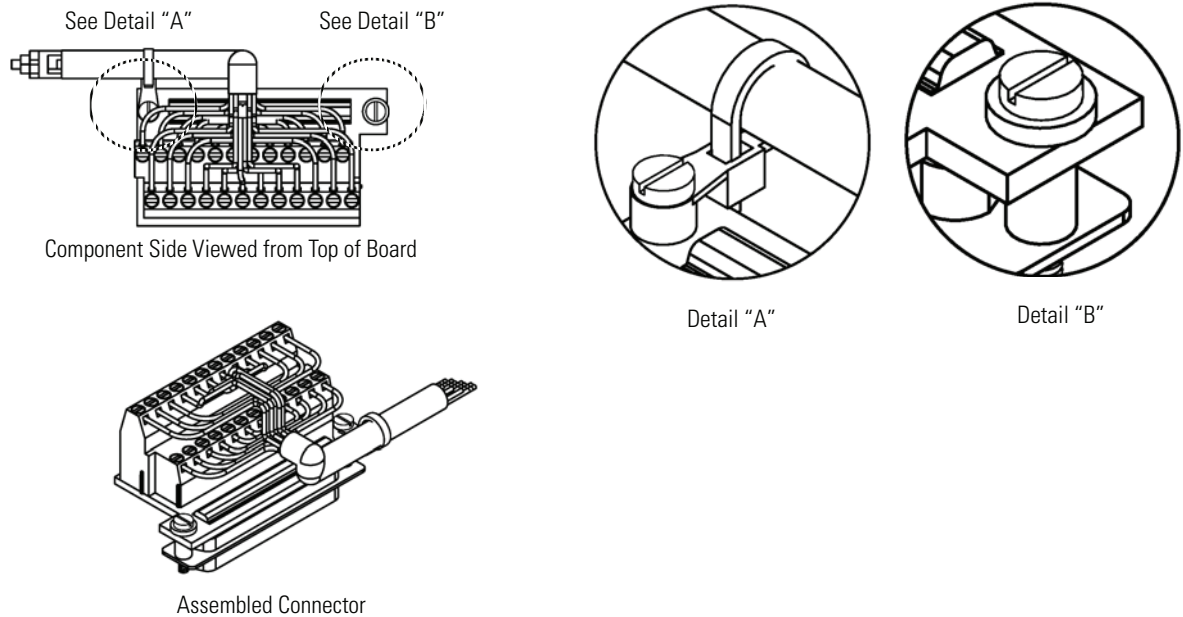
Figure 2-7. D/O Terminal Board Views

Table 2-2. D/O Terminal Board Pin Descriptions

Pin	Signal Description	Pin	Signal Description
1	Relay1_ContactA	13	Relay7_ContactA
2	Relay1_ContactB	14	Relay7_ContactB
3	Relay2_ContactA	15	Relay8_ContactA
4	Relay2_ContactB	16	Relay8_ContactB
5	Relay3_ContactA	17	Relay9_ContactA
6	Relay3_ContactB	18	Relay9_ContactB
7	Relay4_ContactA	19	Relay10_ContactA
8	Relay4_ContactB	20	Relay10_ContactB
9	Relay5_ContactA	21	Solenoid_Drive_Output1
10	Relay5_ContactB	22	+24V
11	Relay6_ContactA	23	Solenoid_Drive_Output2
12	Relay6_ContactB	24	+24V

25-Pin Terminal Board The 25-pin terminal board is included with the optional I/O Expansion Board. Figure 2-8 shows the recommended method for attaching the cable to the terminal board using the included tie-down and spacer. Table 2-3 identifies the connector pins and associated signals.

See Detail "A" See Detail "B"

Component Side Viewed from Top of Board

Detail "A" Detail "B"

Assembled Connector
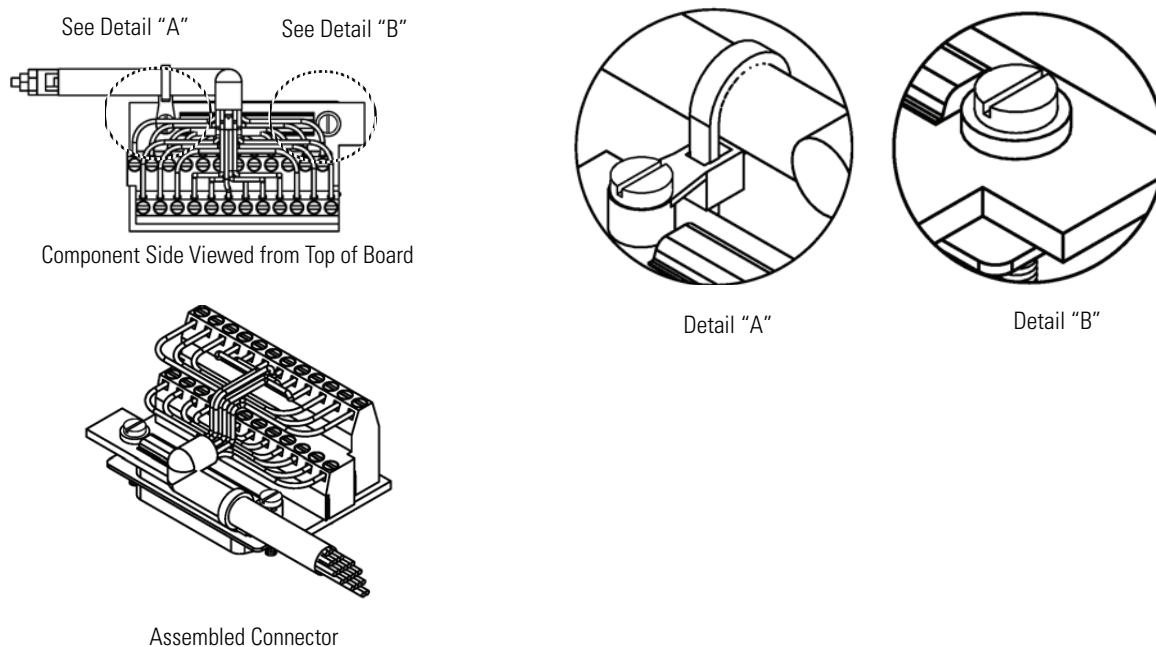
Figure 2-8. 25-Pin Terminal Board Views

Table 2-3. 25-Pin Terminal Board Pin Descriptions

Pin	Signal Description	Pin	Signal Description
1	IOut1	13	Analog_In1
2	GND_ISO	14	Analog_In2
3	IOut2	15	Analog_In3
4	GND_ISO	16	GNDD
5	IOut3	17	Analog_In4
6	GND_ISO	18	Analog_In5
7	IOut4	19	Analog_In6
8	GND_ISO	20	GNDD
9	IOut5	21	Analog_In7
10	GND_ISO	22	Analog_In8
11	IOut6	23	GNDD

Table 2-3. 25-Pin Terminal Board Pin Descriptions, continued

Pin	Signal Description	Pin	Signal Description
12	GND_ISO	24	GNDD

Startup

Use the following procedure when starting the instrument.

1. Turn the power ON.

2. Allow 90 minutes for the instrument to stabilize.

3. Set instrument parameters such as gas setup and flow modes to appropriate settings. For more information about instrument parameters, see the "Operation" chapter.

Chapter 3
Operation

The Model 146*i* can produce accurate gas concentrations by diluting gas from a gas cylinder or a permeation tube, ozone transfer standard, ozone calibration, and Gas Phase Titration (GPT). This chapter provides step-by-step procedures to produce each type of concentration gas, and describes the following front panel display, front panel pushbuttons, and menu-driven software. For details, see the following topics:

Display

The 320 x 240 graphics liquid-crystal display (LCD) shows the sample concentrations, instrument parameters, instrument controls, help, and error messages. Some menus contain more items than can be displayed at one time. For these menus, use [↑] and [↓] to move the cursor up and down to each item.
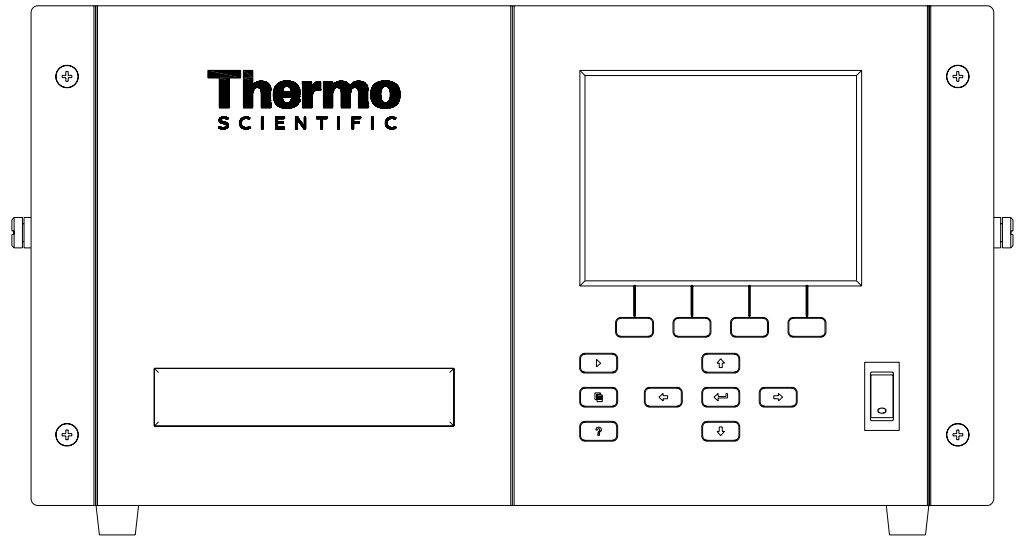
Figure 3–1. Front Panel Display

⚠ **CAUTION** If the LCD panel breaks, do not to let the liquid crystal contact your skin or clothes. If the liquid crystal contacts your skin or clothes, wash it off immediately using soap and water. ▲

Pushbuttons

The Pushbuttons allow the user to traverse the various screens/menus.
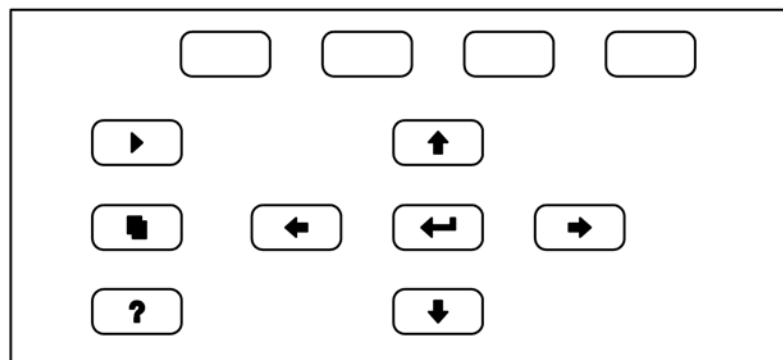
Figure 3–2. Front Panel Pushbuttons

Table 3–1 lists the front panel pushbuttons and their functions.

Table 3–1. Front Panel Pushbuttons

Key Name	Function
[ ] = Soft Keys	The [ ] (soft keys) are used to provide shortcuts that allow the user to jump to user-selectable menu screens. For more information on processing soft keys, see "Soft Keys" below
[▶] = Run	The [▶] is used to display the Run screen. The Run screen normally displays the current flows, parameters, and controls of the instrument.
[■] = Menu	The [■] is used to display the Main Menu when in the Run screen, or back up one level in the menu system. For more information about the Main Menu, see "Main Menu" later in this chapter.
[?] = Help	The [?] is context-sensitive, that is, it provides additional information about the screen that is being displayed. Press [?] for a brief 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 [■] or [?] to return to the previous screen, or [▶] to return to the Run screen.
[↑] [↓] = Up, Down [←] [→] = Left, Right	The four arrow pushbuttons ([↑], [↓], [←], and [→]) move the cursor up, down, left, and right or change values and states in specific screens.
[↵] = Enter	The [↵] is used to select a menu item, accept/set/save a change, and/or toggle on/off functions.

Soft Keys

The Soft Keys are multi-functional keys that use part of the display to identify their function at any moment. The function of the soft keys allows immediate access to the menu structure and most often used menus and screens. They are located directly underneath the display and as the keys' functions change this is indicated by user-defined labels in the lower part of the display, so that the user knows what the keys are to be used for.

To change a soft key, place the menu cursor ">" on the item of the selected menu or screen you wish to set. Press [→] followed by the selected soft key within 1 second of pressing the right-arrow key. The edit soft key prompt will be displayed for configuration for the new label.

Note Not all menu items may be assigned to soft keys. If a particular menu or screen item cannot be assigned, the key assignment screen will not come up upon entering right-arrow-soft key combinations. All items under the Service menu (including the menu itself) cannot be assigned soft keys. ▲

```
EDIT SOFT KEY PROMPT:
 CURRENTLY:OPER
              OPER
       ABCDEFGHIJKLMN   BKSP
       OPQRSTUVWXYZ     PAGE
       0123456789 ./-   SAVE

  OPER   MODE   DIAGS ALARM
```

Software Overview

The Model 146*i* utilizes the menu-driven software as illustrated by the flowchart in Figure 3–3. The Power-Up screen, shown at the top of the flowchart, is displayed while the instrument is warming up and performing self-checks. After the warm-up period, the Run screen is automatically displayed. From the Run screen, the Main Menu can be displayed by pressing (■). The Main Menu contains a list of submenus. Each submenu contains related instrument controls and settings. This chapter describes each submenu and screen in detail. Refer to the appropriate sections for more information.
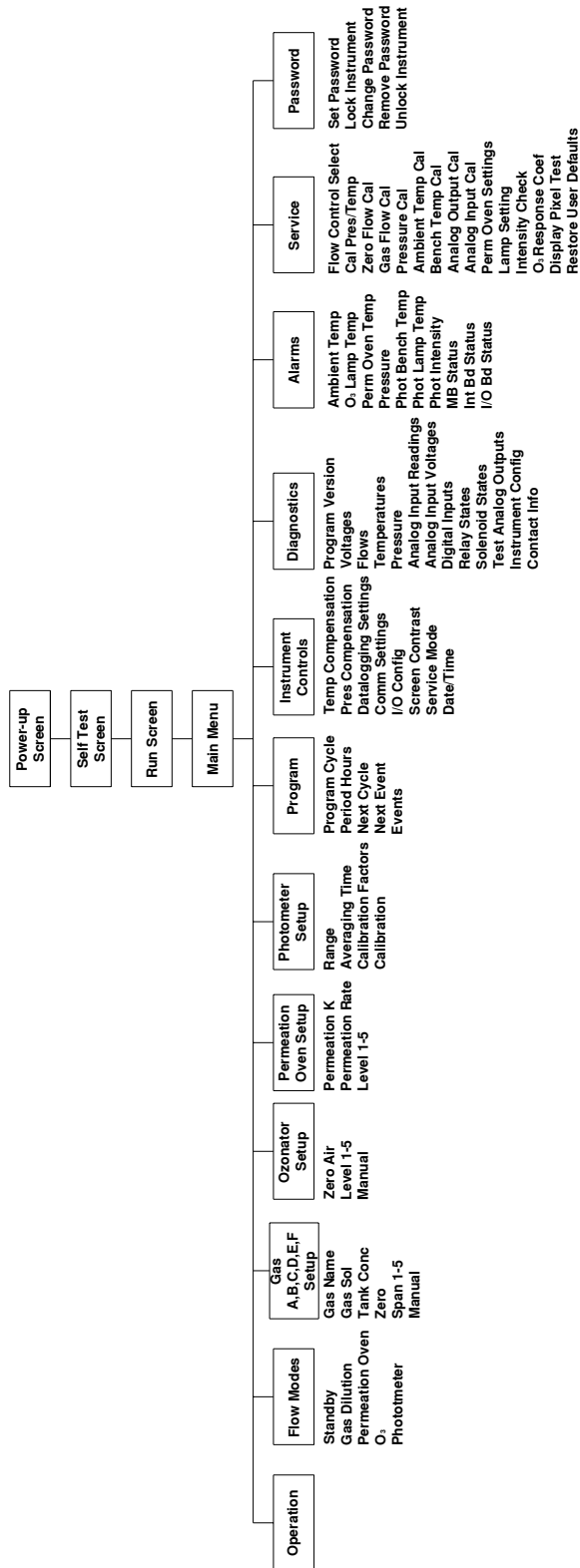
Figure 3–3. Flowchart of Menu-Driven Software

Power-Up Screen

The Power-Up screen is displayed on power up of the Model 146*i*. The Self-Test is displayed while the internal components are warming up and diagnostic checks are performed.

Thermo
SCIENTIFIC
*i*Series

Please wait while booting...

Run Screen

The Run screen is the normal operating screen when the menu is not displayed. The status bar displays the instrument's current flow selections, selected gas span level (if ozonator and permeation oven are both off), permeation oven and ozonator levels, time, and alarm status. There are 5 values that may be displayed on the run screen that include the following:

TFLOW   (total flow in sccm, as measured by the zero and gas flow controllers)

GAS X   (dilution concentration of gas from selected tank in ppm, name is user definable)

O3   (concentration of ozone measured by photometer in ppm)

PERM   (concentration from permeation tube in ppm)

GPT   (drive level of ozonator in GPT mode in percent)

If a particular option is not installed or not being used, it is removed from the display. The example below shows the Model 146*i* Run screen with gas dilution, photometer (internal measurement), permeation oven (installed but off), and GPT.

```
   MODEL 146i CALIBRATOR

 TFLOW          1500.4SSCM

 GAS A            56.7PPM

 O3              0.810PPM

 GPT               80%


 OZONE 3   12:34     ALARM

 OPER   MODE   DIAGS ALARM
```

Main Menu

The Main Menu contains a number of submenus. Instrument parameters and settings can be read and modified within the submenus according to their function. The measurement values appear above the main menu and submenus in every screen. The OZONATOR SETUP, PERMEATION OVEN SETUP, AND PHOTOMETER SETUP menu items are only displayed if these options are installed. The SERVICE menu is visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" later in this chapter.

- Use ⬆ and ⬇ to move the cursor up and down.
- Press ↩ to select a choice.
- Press ■ to return to the top of the Main Menu or ▶ to return to the Run screen.

```
MAIN MENU:
>OPERATION
 FLOW MODES
 GAS SETUP
 OZONATOR SETUP
 PERMEATION OVEN SETUP
 PHOTOMETER SETUP
 PROGRAM                    ⬇

 OPER   MODE   DIAGS ALARM

 INSTRUMENT CONTROLS
 DIAGNOSTICS
 ALARMS
 SERVICE
 PASSWORD
```

Operation

The Operation screen is used to modify the calibrator's operational settings. This is a powerful screen that allows the user to select the gas span level, the permeation level, the ozonator level, and the photometer mode. Like the run screen, if any of these options are not installed, then their controls are not displayed on the operation screen. In addition, flow and level settings for the active mode may be edited from this screen.

The first line of the operation screen allows selection of the dilution gas. The Model 146*i* can support up to three external gases (standard GAS A through C) or up to six external gases (optional GAS A through F). The displayed gas names may be changed by the user via the GAS SETUP menu. The number to the right of the gas selection is either the total flow or the zero air flow, as indicated based on the currently selected span mode.

The span mode (ZERO, SPAN 1 through SPAN 5, and MANUAL) is selected on the next line. The instrument sets the flow parameters to meet the selected criteria. For ZERO, the gas flow controller is shut off and a previously determined zero air flow is output. For SPAN 1 through SPAN 5, the zero and gas flow controllers are set to provide the previously determined total flow and gas concentration. For MANUAL, the flow rates for the zero and gas flow controllers may be set directly.

The next line is used to set the permeation oven output level, if installed. The allowable modes are OFF, PERM 1 through 5, and manual. The concentration for these modes is displayed on the right. If a gas span value is also selected, then the output from the permeation oven will be determined by the flow rates required for the gas dilution and will not be the values shown here.

If installed, the ozonator mode is displayed on the next line. The allowable modes are OFF, OZONE 1 through 5, and manual. The value to the right of this shows the output level. This level is displayed in % units or PPM units, depending on the photometer mode.

The last line shows the photometer mode, if installed. The allowable modes are OFF, INT, EXT, and CTL. In INT mode, the photometer is configured to take sample from the manifold and report the ozone concentration. In EXT mode, the photometer takes sample from a rear-panel bulkhead fitting and reports the ozone concentration. In CTL mode, the photometer is configured the same as INT mode, the reaction chamber is bypassed, and the ozonator drive signal is controlled to provide a pre-set ozone concentration. This concentration is maintained by constantly updating the drive signal to the ozonator lamp based on the measured concentration.

Note Changing the span concentration may affect allowable limits for total flow (TFLOW). It is advisable to check this setting. ▲

Detailed information about each of the above options can be found in the appropriate menu screens. For more information on options, see Chapter 1 "Introduction".

Note If changes are made to the operating parameters via events, C-Link, or digital inputs, this screen will show the new values, and any unsaved changes will be lost. ▲

● In the Main Menu, choose **Operation (or press the OPER soft key)**

● Use [↑] and [↓] to move the cursor up and down to select a mode or setting or change the number in the numeric edit field.

● Press [↵] to save the mode, switch to numeric entry, or save the numeric entry.

● Use [←] and [→] to change the mode or move the cursor in the numeric edit field.

● Press [■] to return to the Main Menu or [▶] to return to the Run screen.

```
OPERATION:
>GAS A     ZFLOW 10000 SCCM
 MANUAL    GFLOW   100 SCCM
 PERM OFF        0.000 PPM
 OZONE OFF         0.0 %
 PHOT OFF



 OPER   MODE   DIAGS ALARM
```

Flow Modes

The Flow Modes menu allows the user to set the operational mode of the calibrator in a more intuitive manner than the operation screen. Items displayed are determined by the options installed. After selecting the desired mode, a summary screen is displayed to show the new mode and the user must press [↵] to activate the new mode.

● In the Main Menu, choose **Flow Modes (or press the MODE soft key)**

```
FLOW MODES:
>STANDBY
 GAS DILUTION
 PERMEATION OVEN
 O3
 PHOTOMETER


 OPER   MODE   DIAGS ALARM
```

Standby

The Standby screen is used to turn the standby mode on or off. When Standby mode is on, the zero air and all of the gas valves are closed and the ozonator and photometer are turned off. A small amount of Zero air is still routed through the permeation oven and photometer. The previous operating parameters are restored when standby mode is turned back off.

● In the Main Menu, choose **Standby.**

```
STANDBY:
 CURRENTLY:              OFF
    SET TO:              ON ?


            ← TOGGLE VALUE
 OPER   MODE   DIAGS ALARM
```

Gas Dilution

The Gas Dilution menu is used to select a gas valve, flow and span concentration. The Gas A, B, or C menus set the zero-air flow (span 0 flow) and the total flow output for a maximum of five span settings for each gas. Additionally, the gas menus let you manually set the zero-air and gas flows manually for each gas. Gas D, E, and F are available if the six gas option is installed and function the same way.

● In the Main Menu, choose > Flow Modes > **Gas Dilution.**

```
GAS SELECTION:
>GAS A                  GAS A
 GAS B                  GAS B
 GAS C                  GAS C
 GAS D                  GAS D
 GAS E                  GAS E
 GAS F                  GAS F


 OPER   MODE   DIAGS ALARM
```

Gas Span Selection   The Gas Span Selection screen is used to select the span level and flow for the previously selected gas. Once selected the screen reports the new flow mode. The user must press [↵] to accept and activate these settings. The message "SAVING" is displayed for 3 seconds, then removed.

● In the Main Menu, choose Flow Modes > Gas Dilution > Gas A-F > **Zero** or **Span 1**-**5.**

```
GAS A SPAN SELECTION:
 ZERO            0.000 PPM
 SPAN 1          0.020 PPM
>SPAN 2          2.000 PPM
 SPAN 3          0.000 PPM
 SPAN 4          0.000 PPM
 SPAN 5          0.000 PPM
 MANUAL

 OPER   MODE   DIAGS ALARM
```

```
FLOW MODE GAS A SPAN 2:
 GAS CONC:  100.000 PPM
    TFLOW:     1000 SCCM
            SAVING

    ↵ SAVE FLOW MODE
 OPER   MODE   DIAGS ALARM
```

Gas Manual Flow   The Gas Manual Flow screen displays the zero-air and gas flows, and lets the user manually set the zero-air and gas flows.

● In the Main Menu, choose Flow Modes > Gas Dilution > Gas A-F > **Manual.**

```
MANUAL SELECTION:
>ZERO AIR      10000 SCCM
 GAS          100.00 SCCM




 OPER   MODE   DIAGS ALARM
```

Zero Air   The Manual Zero Air Flow screen sets the manual zero-air flow value for the previously selected gas. The screen identifies the minimum and maximum acceptable zero-air flow rates based on the installed flow controller and lets the user select a flow rate between these two settings. If the selected zero-air flow is lower or higher than the acceptable range, "TOO LOW" or TOO HIGH" appears on the screen.

● In the Main Menu, choose Flow Modes > Gas Dilution > Gas A-F > Manual > **Zero Air.**

```
MAN GAS A ZERO AIR FLOW:
  MINIMUM:     00400 SCCM
  MAXIMUM:     10000 SCCM
  SET TO:      05001 SCCM?
               ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE      ↵ SAVE

 OPER    MODE   DIAGS ALARM
```

Gas   The Manual Gas Flow screen sets the manual gas flow value for the previously selected gas. The screen identifies the minimum and maximum acceptable gas flow rates based on the installed flow controller and lets the user select a flow rate between these two settings. If the selected gas flow is lower or higher than the acceptable range, "TOO LOW" or TOO HIGH" appears on the screen.

● In the Main Menu, choose Flow Modes > Gas Dilution > Gas A-F > Manual > **Gas.**

```
MAN GAS A GAS FLOW:
  MINIMUM:     004.00 SCCM
  MAXIMUM:     100.00 SCCM
  SET TO:      050.01 SCCM?
               ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE      ↵ SAVE

 OPER    MODE   DIAGS ALARM
```

Permeation Oven   The Permeation Oven flow mode menu is used to select the permeation oven output level (if the permeation oven option is installed). Once selected the screen reports the new flow mode. The user must press [↵]

to accept and activate these settings. The message "SAVING" is displayed for 3 seconds, then removed.

● In the Main Menu, choose Flow Modes > Permeation Oven > **Level 1-5.**

```
PERMEATION OVEN LEVEL:
>LEVEL 1          0.200 PPM
 LEVEL 2          0.400 PPM
 LEVEL 3          0.600 PPM
 LEVEL 4          0.800 PPM
 LEVEL 5          1.000 PPM
 GAS MIX


   OPER   MODE   DIAGS ALARM
```

```
FLOW MODE PERM LEVEL 1:
  PERM CONC:    00.200 PPM
      TFLOW:      1000 SCCM
                SAVING

     ↵ SAVE FLOW MODE
   OPER   MODE   DIAGS ALARM
```

Permeation Oven Gas Mix Selection

The Gas Selection screen is used to select the gas to mix with the permeation gas. Gas D, E, and F are available if the six gas option is installed.

● In the Main Menu, choose Flow Modes > Permeation Oven > **Gas Mix.**

```
GAS SELECTION:
>GAS A                  GAS A
 GAS B                  GAS B
 GAS C                  GAS C
 GAS D                  GAS D
 GAS E                  GAS E
 GAS D                  GAS F


   OPER   MODE   DIAGS ALARM
```

Permeation Oven Gas Span Select

The Gas Span Select screen is used to select the span level for the previously selected gas. Gas D, E, and F are available if the six gas option is installed.

Once selected the screen reports the new flow mode. The user must press
[⏎] to accept and activate these settings. The message "SAVING" is
displayed for 3 seconds, then removed.

● In the Main Menu, choose Flow Modes > Permeation Oven > Gas Mix
 > Gas A-F > **Zero** or **Span 1-5.**

```
GAS A SPAN SELECTION:
 ZERO              0.000 PPM
 SPAN 1            0.020 PPM
>SPAN 2            2.000 PPM
 SPAN 3            0.000 PPM
 SPAN 4            0.000 PPM
 SPAN 5            0.000 PPM
 MANUAL

 OPER   MODE   DIAGS ALARM
```

```
FLOW MODE GAS A PERM MIX:
  GAS CONC:       02.00 PPM
 PERM CONC:       0.100 PPM
     TFLOW:       1000 SCCM
               SAVING
   ↵ SAVE FLOW MODE

 OPER   MODE   DIAGS ALARM
```

**Permeation Oven Manual
Flow**

The Permeation Oven Gas Manual Flow screen shows the zero-air and gas
flows and is used to manually set them for the previously selected gas. If the
selected zero-air flow is lower or higher than the acceptable range, "TOO
LOW" or "TOO HIGH" appears on the screen.

● In the Main Menu, choose Flow Modes > Permeation Oven > Gax Mix
 > Gas A-F > **Manual.**

```
MANUAL SELECTION:
>ZERO AIR       10000 SCCM
 GAS            100.00 SCCM




 OPER   MODE   DIAGS ALARM
```

Zero Air   The Manual Gas Zero Air Flow screen sets the manual zero-air flow value for the previously selected gas. The screen identifies the minimum and maximum acceptable zero-air flow rates and lets the user select a flow rate between these two settings. If the selected zero-air flow is lower or higher than the acceptable range, "TOO LOW" or TOO HIGH" appears on the screen.

● In the Main Menu, choose Flow Modes > Permeation Oven > Gas Mix > Gas A-F > Manual > **Zero Air.**
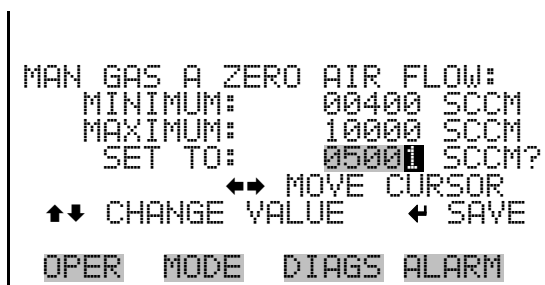
```
MAN GAS A ZERO AIR FLOW:
   MINIMUM:    00400 SCCM
   MAXIMUM:    10000 SCCM
   SET TO:     0500█ SCCM?
            ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ← SAVE

 OPER   MODE   DIAGS ALARM
```

Gas   The Manual Gas Flow screen sets the manual gas flow value for the previously selected gas. The screen identifies the minimum and maximum acceptable gas flow rates and lets the user select a flow rate between these two settings. If the selected gas flow is lower or higher than the acceptable range, "TOO LOW" or TOO HIGH" appears on the screen.

● In the Main Menu, choose Flow Modes > Permeation Oven > Gas Mix > Gas A-F > Manual > **Gas.**

```
MAN GAS A GAS FLOW:
   MINIMUM:    004.00 SCCM
   MAXIMUM:    100.00 SCCM
   SET TO:     050.0█ SCCM?
            ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ← SAVE

 OPER   MODE   DIAGS ALARM
```

O₃   The O_3 flow mode menu is used to set the operational mode of the ozonator (if the ozonator option is installed). Selecting OFF reports the new flow mode. The user must press ⏎ to accept and activate these settings. The message "SAVING" is displayed for 3 seconds, then removed.

● In the Main Menu, choose Flow Modes > **O3.**

```
O3 MODE SELECTION:
>OFF
 TRANSFER STANDARD
 GPT
 PHOTOMETER CONTROL



 OPER   MODE   DIAGS ALARM
```

```
FLOW MODE:
        OZONATOR OFF

           SAVING

      ← SAVE FLOW MODE
 OPER   MODE   DIAGS ALARM
```

Transfer Standard   Five ozonator levels (1-5) can be set using the Ozonator Level Selection screen. Once selected the screen reports the new flow mode. The user must press ⏎ to accept and activate these settings. The message "SAVING" is displayed for 3 seconds, then removed.

● In the Main Menu, choose Flow Modes > O3 > Transfer Standard > **Level 1**-**5.**

```
O3 LEVEL SELECTION:
>LEVEL1          20.0 %
 LEVEL2          25.0 %
 LEVEL3          40.0 %
 LEVEL4          60.0 %
 LEVEL5          80.0 %
 MANUAL           2.0 %


 OPER   MODE   DIAGS ALARM
```

```
┌──────────────────────────────────────┐
│ FLOW MODE O3 LEVEL 1:                 │
│   O3 LEVEL:        20.0 %             │
│   TFLOW:           5000 SCCM          │
│                 SAVING                │
│                                       │
│         ↵ SAVE FLOW MODE              │
│   OPER   MODE   DIAGS ALARM           │
└──────────────────────────────────────┘
```
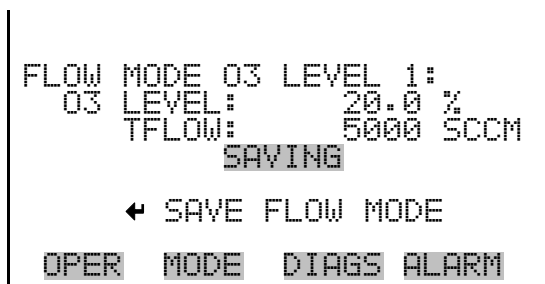
Manual O₃ Adjust

The Manual screen is used to set the ozonator lamp output manually.

● In the Main Menu, choose Flow Modes > O3 > Transfer Standard > **Manual.**

```
┌──────────────────────────────────────┐
│ MANUAL O3 LAMP SETTING:               │
│   CURRENTLY:        0.0 %             │
│   SET TO:           5.0 % ?           │
│                                       │
│         ↑↓ CHANGE VALUE               │
│          ↵ SAVE VALUE                 │
│   OPER   MODE   DIAGS ALARM           │
└──────────────────────────────────────┘
```
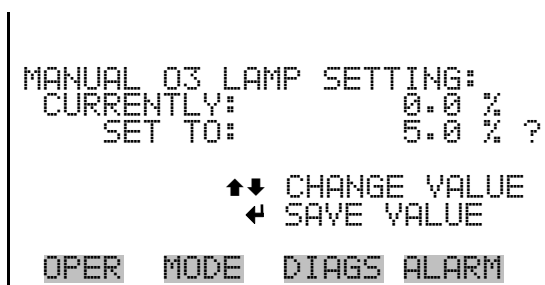
GPT/Photometer Control

The ozonator output level can be set using the Ozonator GPT Select screen. Alternately, if Photometer Control is selected then all ozonator levels are shown in parts per million (ppm) instead of percent (%). The MANUAL screen is used to set the ozonator output to the manual level, in ppm or %.

● In the Main Menu, choose Flow Modes > O3 > GPT/Photometer Control > **Level 1-5.**

```
┌──────────────────────────┐  ┌──────────────────────────┐
│ O3 LEVEL SELECTION:      │  │ O3 LEVEL SELECTION:      │
│ >LEVEL1        100.0 %   │  │ >LEVEL1        1.000 PPM │
│  LEVEL2         80.0 %   │  │  LEVEL2        0.800 PPM │
│  LEVEL3         50.0 %   │  │  LEVEL3        0.500 PPM │
│  LEVEL4         20.0 %   │  │  LEVEL4        0.200 PPM │
│  LEVEL5         10.0 %   │  │  LEVEL5        0.100 PPM │
│  MANUAL        0.000 %   │  │  MANUAL        0.000 PPM │
│                          │  │                          │
│  OPER  MODE  DIAGS ALARM │  │  OPER  MODE  DIAGS ALARM │
└──────────────────────────┘  └──────────────────────────┘
```

```
┌─────────────────────────────────┐  ┌─────────────────────────────────┐
│ MANUAL O3 OUTPUT:               │  │ MANUAL O3 OUTPUT CONC:          │
│  CURRENTLY:        100 %        │  │  CURRENTLY:     0.200 PPM       │
│     SET TO:     000000█ % ?     │  │     SET TO:     ▓0.00█ PPM ?    │
│                                 │  │                                 │
│           ↑↓ INC/DEC            │  │           ↑↓ INC/DEC            │
│           ↵  SAVE VALUE         │  │           ↵  SAVE VALUE         │
│                                 │  │                                 │
│   OPER   MODE   DIAGS ALARM     │  │   OPER   MODE   DIAGS ALARM     │
└─────────────────────────────────┘  └─────────────────────────────────┘
```

Gas Selection   The Gas Selection screen is used to select a gas to mix with ozone. Gas D, E, and F are available if the six gas option is installed. If NONE is selected the screen reports the new flow mode. The user must press [↵] to accept and activate these settings. The message "SAVING" is displayed for 3 seconds, then removed.

● In the Main Menu, choose Flow Modes > O3 > GPT/Photometer Control > Level 1-5 > **Gas A-F.**

```
┌─────────────────────────────────┐
│ GAS SELECTION:                  │
│ >NONE                           │
│  GAS A                   GAS A  │
│  GAS B                   GAS B  │
│  GAS C                   GAS C  │
│  GAS D                   GAS D  │
│  GAS E                   GAS E  │
│  GAS F                   GAS F  │
│                                 │
│   OPER   MODE   DIAGS ALARM     │
└─────────────────────────────────┘
```

Gas Span Selection   The Gas Span Selection screen is used to select the span level for the previously selected gas. Gas D, E, and F are available if the six gas option is installed. Once selected the screen reports the new flow mode. The user must press [↵] to accept and activate these settings. The message "SAVING" is displayed for 3 seconds, then removed.

● In the Main Menu, choose Flow Modes > O3 > GPT/Photometer Control > Level 1-5 > Gas A-F > **Zero** or **Span 1-5.**

```
GAS A SPAN SELECTION:          GAS A SPAN SELECTION:
>ZERO          0.000 %         >ZERO          0.000 PPM
 SPAN 1       100.0 %           SPAN 1        10.00 PPM
 SPAN 2        80.0 %           SPAN 2         8.00 PPM
 SPAN 3        50.0 %           SPAN 3         6.00 PPM
 SPAN 4        20.0 %           SPAN 4         2.00 PPM
 SPAN 5        10.0 %           SPAN 5         0.50 PPM
 MANUAL                         MANUAL

  OPER   MODE   DIAGS ALARM      OPER   MODE   DIAGS ALARM
```

```
FLOW MODE:                     FLOW MODE:
 O3 LEVEL:       90.0 %         O3 LEVEL:      0.800 PPM
SPAN CONC:      08.00 PPM      SPAN CONC:      08.00 PPM
    TFLOW:      02001 SCCM         TFLOW:      02001 SCCM

   ← SAVE FLOW MODE              ← SAVE FLOW MODE
  OPER   MODE   DIAGS ALARM      OPER   MODE   DIAGS ALARM
```

Gas Manual Flow   The Gas Manual Flow screen shows the zero-air and gas flows and is used to manually set them for the previously selected gas. If the selected zero-air flow is lower or higher than the acceptable range, "TOO LOW" or "TOO HIGH" appears on the screen.

● In the Main Menu, choose Flow Modes > O3 > GPT/Photometer Control > Gas A-F > Level 1-5 > **Manual.**

```
MANUAL SELECTION:
>ZERO AIR      10000 SCCM
 GAS          100.00 SCCM




  OPER   MODE   DIAGS ALARM
```

Zero Air   The Manual Gas Zero Air Flow screen sets the manual zero-air flow value for the previously selected gas. The screen identifies the minimum and maximum acceptable zero-air flow rates and lets the user select a flow rate between these two settings. If the selected zero-air flow is lower or higher

than the acceptable range, "TOO LOW" or TOO HIGH" appears on the screen.

● In the Main Menu, choose Flow Modes > O3 > GPT/Photometer Control > Gas A-F > Level 1-5 > Manual > **Zero Air.**
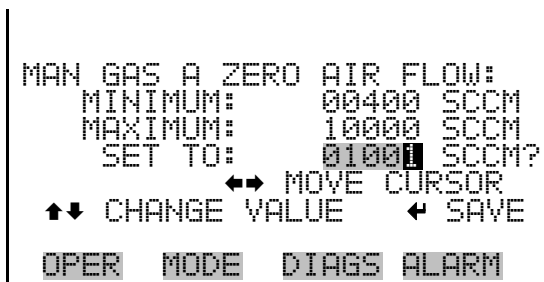
```
MAN GAS A ZERO AIR FLOW:
   MINIMUM:    00400 SCCM
   MAXIMUM:    10000 SCCM
   SET TO:     0100█ SCCM?
              ←→ MOVE CURSOR
   ↑↓ CHANGE VALUE    ← SAVE
  OPER   MODE   DIAGS ALARM
```

Gas   The Manual Gas Flow screen sets the manual gas flow value for the previously selected gas. The screen identifies the minimum and maximum acceptable gas flow rates and lets the user select a flow rate between these two settings. If the selected gas flow is lower or higher than the acceptable range, "TOO LOW" or TOO HIGH" appears on the screen.

● In the Main Menu, choose Flow Modes > O3 > GPT/Photometer Control > Gas A-F > Level 1-5 > Manual > **Gas.**

```
MAN GAS A GAS FLOW:
   MINIMUM:    004.00 SCCM
   MAXIMUM:    100.00 SCCM
   SET TO:     050.0█ SCCM?
              ←→ MOVE CURSOR
   ↑↓ CHANGE VALUE    ← SAVE
  OPER   MODE   DIAGS ALARM
```
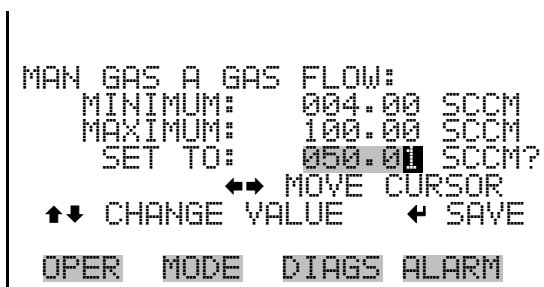
Photometer   The Photometer flow mode menu is used to select the photometer measurement mode. Available choices include: PHOT OFF, PHOT INT, and PHOT EXT. Ozonator control mode may not be selected from this screen, and must be selected via the ozonator screen. If the instrument is in control mode a warning will display "IN OZONATOR CONTROL MODE". Once a choice is selected the screen reports that the new mode has been accepted and activated. The message "SAVING" is displayed for 3 seconds, then removed.

● In the Main Menu, choose Flow Modes > **Photometer.**

```
┌──────────────────────────────────┐
│ PHOTOMETER MODE:                 │
│  CURRENTLY:    PHTO OFF          │
│     SET TO:    PHOT INT   ?      │
│              SAVING              │
│           ↑↓ CHANGE VALUE        │
│            ↵ SAVE VALUE          │
│                                  │
│ OPER   MODE   DIAGS ALARM        │
└──────────────────────────────────┘
```

Gas Setup Menu

The Gas Setup menu is used to configure flow for each gas. The Gas A, B, or C menus assign a name, solenoid, and tank concentration to each gas. The gas menus set the zero-air flow (span 0 flow) and the total flow output for a maximum of five span settings for each gas. Additionally, the gas menus manually set the zero-air and gas flows for each gas. Gas D, E, and F are available if the six gas option is installed.

● In the Main Menu, choose Flow Modes > **Gas Setup.**

```
┌──────────────────────────────────┐
│ GAS SETUP:                       │
│ >GAS A                  GAS A    │
│  GAS B                  GAS B    │
│  GAS C                  GAS C    │
│  GAS D                  GAS D    │
│  GAS E                  GAS E    │
│  GAS F                  GAS F    │
│                                  │
│ OPER   MODE   DIAGS ALARM        │
└──────────────────────────────────┘
```

```
┌──────────────────────────────────┐
│ GAS A SETUP:                     │
│ >GAS NAME               GAS A    │
│  GAS SOL                    A    │
│  TANK CONC      100.000 PPM      │
│  ZERO              2000 CCM      │
│  SPAN 1          10.000 PPM      │
│  SPAN 2           8.000 PPM      │
│  SPAN 3           5.000 PPM↓     │
│ OPER   MODE   DIAGS ALARM        │
└──────────────────────────────────┘
    SPAN 4           0.000 PPM
    SPAN 5           0.000 PPM
    MANUAL
```

Gas Name

The Gas Name screen is used to identify each gas. As initially delivered, the instrument lists the gas standards using the letters A, B, C (and D, E, F if the six gas option is installed). These characters can be changed to represent

actual chemical symbols of the gases used by each (for example, SO2, NO, CO2), or any other representation, up to five characters. Once a name is selected the screen reports that the new name has been accepted and activated. The message "SAVING" is displayed for 3 seconds, then removed.

● In the Main Menu, choose > Gas Setup > Gas A-F > **Gas Name.**

```
GAS A NAME:
  CURRENT: GAS A
           ▮AS A
  ▮BCDEFGHIJKLMN  BKSP
  OPQRSTUVWXYZ    PAGE
  0123456789 ./-  SAVE

 OPER   MODE   DIAGS ALARM
```
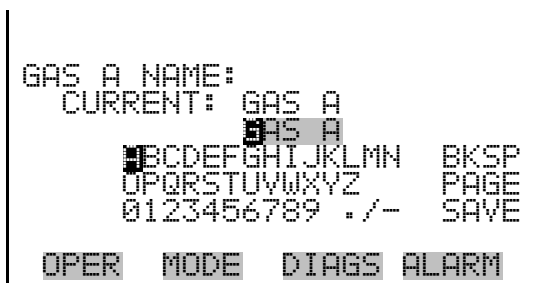
Gas Solenoid

The Gas Solenoid screen lets you select a solenoid to control each of the gases. Default solenoid designations are: Solenoid A for Gas A, Solenoid B for Gas B, and Solenoid C for Gas C (the same default designation system applies to Solenoids D through F, if the six gas option is installed).

Allowable selections are : "SOLENOID A", "SOLENOID B", "SOLENOID C", "SOLENOID D (if installed), "SOLENOID E" (if installed), and "SOLENOID F" (if installed).

● In the Main Menu, choose > Gas Setup > Gas A-F > **Gas Solenoid.**

```
GAS A SOLENOID:
 CURRENTLY:    SOLENOID A
    SET TO:    SOLENOID B ?

        ↑↓ CHANGE VALUE
        ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```
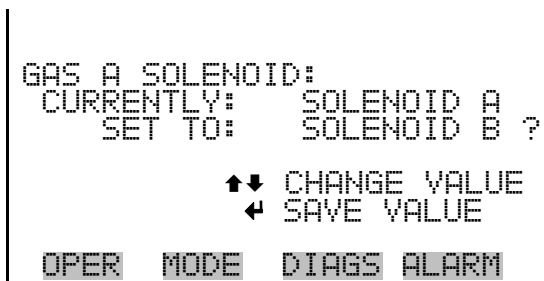
Tank Concentration

The Tank Concentration screen lets you enter the concentration, in parts per million (ppm), of each tank gas (note that Gas A has been identified in the Name screen as SO_2, and the Tank Concentration screen retains the identification).

Note Changing this valve may affect allowable limits for span concentration and total flow. It is advisable to check these settings. ▲

● In the Main Menu, choose > Gas Setup > Gas A-F > **Tank
Concentration.**

```
SO2 TANK CONC:
 CURRENTLY:00100.000 PPM
      SET TO:000200.0█ PPM ?

             ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE   ↵ SAVE

  OPER   MODE   DIAGS ALARM
```

Zero Air   The Zero Air Flow screen sets the total flow for zero concentration output.
The screen identifies the minimum and maximum acceptable zero air flow
rates and is used to select a flow rate between these two settings. If the
selected zero flow is lower or higher than the acceptable range, "TOO
LOW" or TOO HIGH" appears on the screen.

● In the Main Menu, choose Gas Setup > Gas A-F > **Zero.**

```
GAS A ZERO AIR FLOW:
   MINIMUM:   00400 SCCM
   MAXIMUM:   10000 SCCM
   SET TO:    0100█ SCCM ?
             ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE   ↵ SAVE

  OPER   MODE   DIAGS ALARM
```
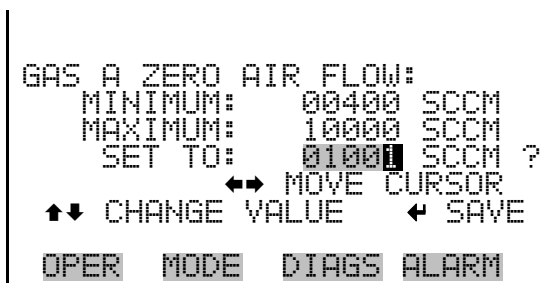
Span 1-5   The Span menu displays the span concentration and total flow rate.
settings, with a maximum of five span levels. The span concentration
and/or total flow rate can be selected using this menu to change these
settings.

● In the Main Menu, choose Gas Setup > Gas A-F > **Span 1-5.**

```
GAS A SPAN 1 FLOW:
>CONC            10.000 PPM
 TFLOW            1000 CCM




  OPER   MODE   DIAGS ALARM
```

Span Concentration   The Span Concentration screen displays the minimum and maximum concentration for spans 1 through 5 of each gas. Minimum and maximum values are calculated based upon the tank concentration and the mass flow controller. The desired concentrations can be set between these two limits. If the concentration is entered outside of the minimum or maximum values, the message "TOO LOW" or TOO HIGH" appears on the screen.

Note Changing this valve may affect allowable limits for span flow. It is advisable to check this setting. ▲

●   In the Main Menu, choose Gas Setup > Gas A-F > Span 1-5 > **Conc.**

```
GAS A SPAN 1 CONC:
   MINIMUM:00000.040 PPM
   MAXIMUM:00020.000 PPM
    SET TO:00010.000 PPM ?
          ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ← SAVE

  OPER   MODE   DIAGS ALARM
```

Span Flow   The Span Flow screen displays the minimum and maximum flows for spans 1 through 5 of each gas. Minimum and maximum values are calculated based upon the tank concentration and the mass flow controller. The desired concentrations can be set between these two limits. If the concentration is entered outside of the minimum or maximum values, the message "TOO LOW" or TOO HIGH" appears on the screen.

●   In the Main Menu, choose Gas Setup > Gas A-F > Span 1-5 > **Flow.**

```
GAS A SPAN 1 FLOW:
   MINIMUM:     444 SCCM
   MAXIMUM:   01000 SCCM
   SET TO:    00808 SCCM ?
            ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ← SAVE

OPER   MODE   DIAGS ALARM
```
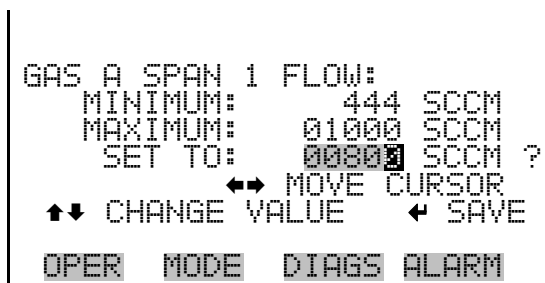
Manual Flow

The Manual Flow screen displays the zero-air and gas flows, and lets you manually set the zero-air and gas flows.
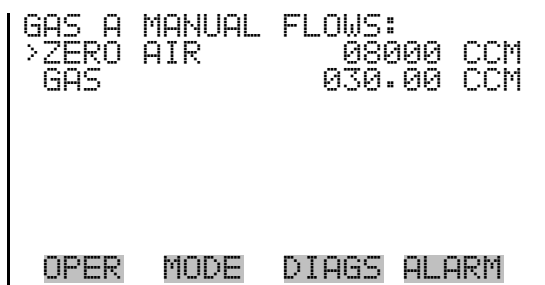
● In the Main Menu, choose Gas Setup > Gas A-F > **Manual.**
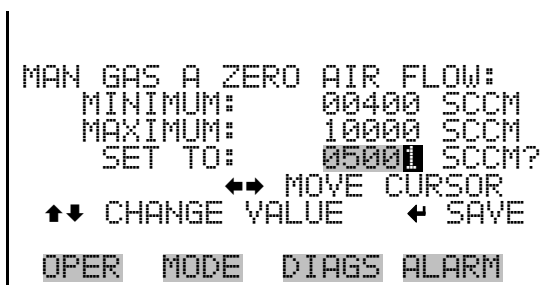
```
GAS A MANUAL FLOWS:
>ZERO AIR        08000 CCM
 GAS             030.00 CCM




OPER   MODE   DIAGS ALARM
```

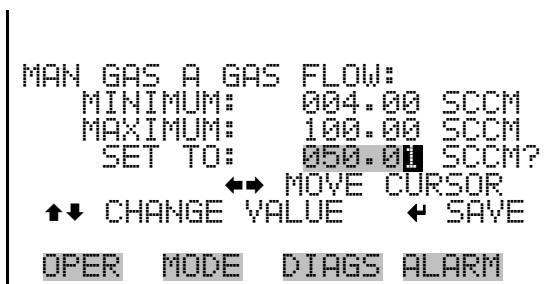## Zero Air

The Manual Zero Air Flow screen sets the manual zero-air flow value for the previously selected gas. The screen identifies the minimum and maximum acceptable zero-air flow rates and lets the user select a flow rate between these two settings. If the selected zero-air flow is lower or higher than the acceptable range, "TOO LOW" or TOO HIGH" appears on the screen.

● In the Main Menu, choose Gas Setup > Gas A-F > Manual > **Zero Air.**

```
MAN GAS A ZERO AIR FLOW:
   MINIMUM:   00400 SCCM
   MAXIMUM:   10000 SCCM
   SET TO:    01001 SCCM ?
            ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ← SAVE

OPER   MODE   DIAGS ALARM
```
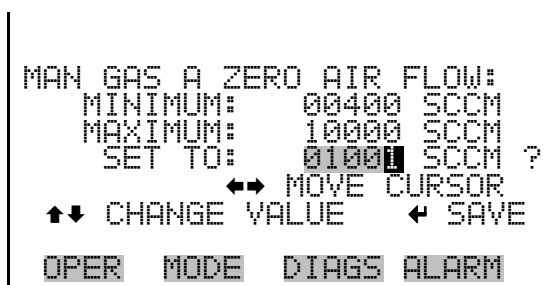
Gas The Manual Gas Flow screen displays the minimum and maximum gas flows that are allowed for the previously selected gas. Minimum and maximum values are calculated based upon the tank concentration and the mass flow controller. The desired concentration can be set between the two displayed limits. If the concentration entered is outside of the minimum or maximum values, the message "TOO LOW" or TOO HIGH" is displayed.

● In the Main Menu, choose Gas Setup > Gas A-F > Manual > **Gas.**

```
MAN GAS A GAS FLOW:
   MINIMUM:  004.00 SCCM
   MAXIMUM:  100.00 SCCM
   SET TO:   030.00  SCCM ?
             ◄► MOVE CURSOR
  ↑↓ CHANGE VALUE     ↵ SAVE

 OPER   MODE   DIAGS ALARM
```

Ozonator Setup Menu

The Model 146*i* can be equipped with an optional internal ozonator. The production of ozone is regulated by either changing the flow of zero-air or by changing the intensity of the ozone-producing lamp.

The Ozonator Setup menu sets the amount of zero-air flow. From this menu, the ozone generation can be set manually, or up to five ozone levels can be set.

● In the Main Menu, choose **Ozonator Setup.**

```
OZONATOR:
>ZERO AIR         5000 SCCM
 LEVEL 1          100.0 %
 LEVEL 2           80.0 %
 LEVEL 3           50.0 %
 LEVEL 4           20.0 %
 LEVEL 5           10.0 %
 MANUAL             0.0 %

 OPER   MODE   DIAGS ALARM
```

Zero Air The Zero Air screen sets the amount of zero air flow through the ozonator.

● In the Main Menu, choose Ozonator Setup > **Zero Air.**

```
ZERO AIR FLOW:
   MINIMUM:     00400 SCCM
   MAXIMUM:     10000 SCCM
    SET TO:     0500█ SCCM?
              ←→ MOVE CURSOR
   ↑↓ CHANGE VALUE    ↵ SAVE

 OPER   MODE   DIAGS ALARM
```
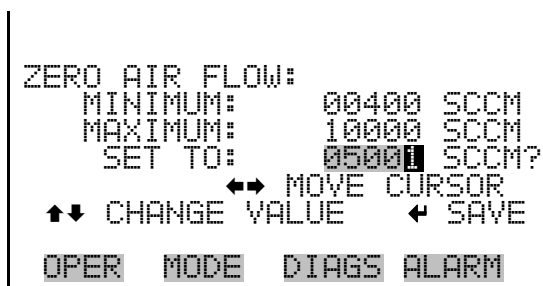
Level 1-5   Five ozonator levels can be set using the Ozonator Level screen. This screen is allows the user to change the custom ozonator levels.

● In the Main Menu, choose Ozonator Setup > **Level 1-5.**

```
CUSTOM O3 LEVEL 2:
 LAMP SETTING:      50.0%


              ↑↓ INC/DEC
              ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```
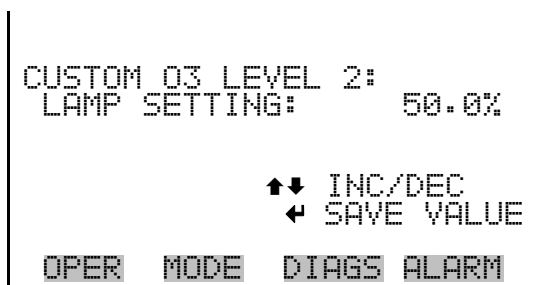
Manual O₃ Lamp Setting   The ozonator can be certified for use as a transfer standard. To determine a calibration curve, an external ozone primary standard such as the Model 49i Primary Standard, must be used.

Due to changes in light intensity, flow, and ambient temperature, the calibration curve is accurate only for a short time after a transfer standard reading is taken. Since the setting is not remembered once the instrument is powered down, the calibration curve is not retained and must be regenerated on instrument start up. This ensures that the calibration is accurate. The Ozonator Manual Level screen is used when certifying the ozone generator as a transfer standard.

● In the Main Menu, choose Ozonator Setup > **Manual.**

```
MANUAL O3 LAMP SETTING:
 LAMP SETTING:      0.0%


              ↑↓ INC/DEC
              ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```
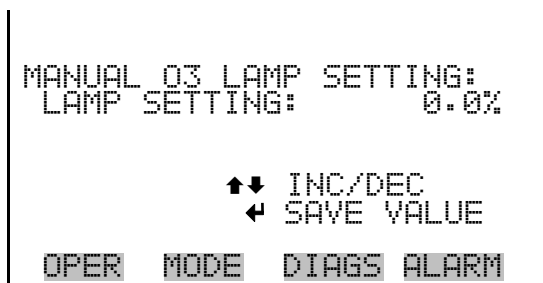
Permeation Oven Setup Menu

The Model 146*i* can be equipped with an optional permeation oven. The permeation oven supplies an internal source of calibration gas. A small amount of zero-air flows through the permeation tube and is mixed with the remainder of the zero-air flow in the mixing chamber. This menu in only available if the PERMEATION OVEN option is enabled in the INSTRUMENT CONFIGURATION menu under DIAGNOSTICS.

Note Permeation oven temperature selection and calibration may be done via the Service > **Perm Oven Settings** menu. ▲

● In the Main Menu, choose **Permeation Oven Setup.**

```
PERMEATION OVEN:
>PERMEATION K        1.000
 PERMEATION RATE    1000.0
 LEVEL 1         0.000 PPM
 LEVEL 2         0.000 PPM
 LEVEL 3         0.000 PPM
 LEVEL 4         0.000 PPM
 LEVEL 5         0.000 PPM

  OPER   MODE   DIAGS ALARM
```

Permeation K

The Permeation K (constant) screen allow the user to set the multiplier for the permeation tube for a given oven temperature. Allowable values are 0.000 to 9.999. If the values selected are lower or higher than allowed, "TOO LOW" or TOO HIGH" appears on the screen.

Note Changing this value may affect allowable limits for permeation concentration levels. It is advisable to check these settings. ▲

● In the Main Menu, choose Permeation Oven Setup > **Permeation K**.

```
PERMEATION K:
 CURRENTLY:         1.000
   SET TO:         1.000 ?

          ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE   ↵ SAVE

  OPER   MODE   DIAGS ALARM
```

Permeation Rate   The Permeation Rate screen is used to enter the permeation rate of the permeation capsule used. Allowable values are 1.0 to 99999.9. If the values selected are lower or higher than allowed, "TOO LOW" or TOO HIGH" appears on the screen.

Note Changing this value may affect allowable limits for permeation concentration levels. It is advisable to check these settings. ▲

● In the Main Menu, choose Permeation Oven Setup > **Permeation Rate**.

```
PERMEATION RATE NG/NG/MIN:
  CURRENTLY:         1000.0
     SET TO:       01020.0 ?

            ◆➡ MOVE CURSOR
 ▲◆ CHANGE VALUE    ◆ SAVE

 OPER   MODE   DIAGS ALARM
```

Level 1-5   The Permeation Level 1-5 screens are used to set minimum and maximum permeation levels. These levels can be selected from the Operation or Flow Modes screens.

Note When a gas is selected and mixed with the permeation oven output, permeation levels cannot be selected. ▲

● In the Main Menu, choose Permeation Oven Setup > **Level 1-5**.

```
PERMEATION CONC LEVEL 1
     MIN:        0.100 PPM
     MAX:        5.000 PPM
  SET TO: 000001.200 PPM ?
            ◆➡ MOVE CURSOR
 ▲◆ CHANGE VALUE    ◆ SAVE

 OPER   MODE   DIAGS ALARM
```

Photometer Setup Menu

The Model 146*i* can be equipped with an optional internal photometer, which is used to measure concentration of ozone.

The Photometer Setup menu sets up the photometer.

● In the Main Menu, choose **Photometer Setup.**

```
PHOTOMETER:
>RANGE
 AVERAGING TIME
 CALIBRATION FACTORS
 CALIBRATION




 OPER   MODE   DIAGS ALARM
```

Range

The Range menu allows the operator to view the gas units (always in ppm), to select the O₃ range, and to set the custom ranges.

● In the Main Menu, choose Photometer Setup > **Range.**

```
RANGE:
 GAS UNITS              PPM
>RANGE                 5.00
 SET CUSTOM RANGES




 OPER   MODE   DIAGS ALARM
```

O₃ Range

The O₃ Range screen defines the concentration range of the analog outputs. For example, an O₃ range of 0–5 ppm sets the analog output to concentrations between 0 and 5 ppm. Available operating ranges include: 0.05, 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, C1, C2, and C3.

C1, C2, and C3 are custom ranges. For more information about custom ranges, see "Set Custom Ranges" below.

The display shows the current O₃ range. The next line of the display is used to change the range.

● In the Main Menu, choose Range > **O3 Range**.

```
RANGE:
  CURRENTLY:           5.00
     SET TO:        0.0500 ?

              ↑↓ CHANGE VALUE
               ↵ SAVE VALUE

  OPER   MODE   DIAGS ALARM
```
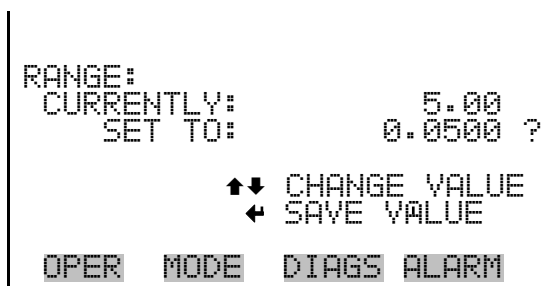
The analog outputs are arranged on the rear panel connector as shown in Figure 3-4. See Table 3-3 for channels and pin connections.
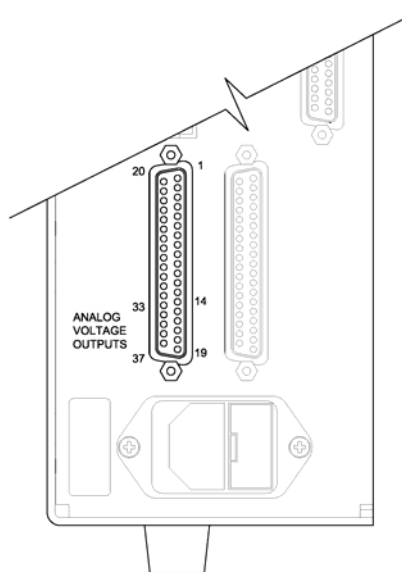
Figure 3–4. Pin-Out of Rear Connector

Table 3–2. Default Analog Outputs

Channel	Pin	Description
1	14	Gas Conc Analog Output
2	33	Gas Conc Analog Output
3	15	None
4	34	None
5	17	None
6	36	None
Ground	16, 18, 19, 35, 37	Signal Ground

Note All channels are user definable. If any customization has been made to the analog output configuration, the default selections my not apply. ▲

Set Custom Ranges   The Custom Ranges Menu lists three custom ranges: C1, C2, and C3. Custom ranges are user-defined ranges. In the standard range mode, any value between 0.05 ppm and 5 ppm) can be specified as a range.

● In the Main Menu, choose Photometer Setup > Range > **Set Custom Ranges**.

```
CUSTOM RANGES:
>CUSTOM RANGE 1        2.00
 CUSTOM RANGE 2        3.00
 CUSTOM RANGE 3        4.00




 OPER   MODE   DIAGS ALARM
```

Custom Ranges   The Custom Ranges screen is used to define the custom ranges.

The display shows the current custom range. The next line of the display is used to set the range. To use the custom full-scale range, be sure to select it (Custom range 1, 2, or 3) in the O_3 Ranges screen. For more information about selecting ranges, see "O3 Range" above.

● In the Main Menu, choose Photometer Setup > Range > Set Custom Ranges > **Custom range 1, 2,** or **3**.

```
CUSTOM RANGE 1:
 CURRENTLY:            2.00
    SET TO:        00002.0█ ?

              ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE     ← SAVE
 OPER   MODE   DIAGS ALARM
```

Averaging Time   The Averaging Time defines a time period (60 to 300 seconds) during which O_3 measurement is taken. The average concentration of the reading is calculated for that time period. The front panel display and analog

outputs are updated every 5 seconds regardless of the averaging time. An averaging time of 300 seconds means that the moving average concentration of the last 300 seconds will be output every 5 seconds. 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 following averaging times are available: 60, 90, 120, 180, 240, and 300 seconds.

● In the Main Menu, choose Photometer Setup > **Averaging Time**.

```
AVERAGING TIME:
 CURRENTLY:       90 SEC
    SET TO:      120 SEC ?

           ↑↓ CHANGE VALUE
            ↵ SAVE VALUE

 OPER   MODE   DIAGS ALARM
```
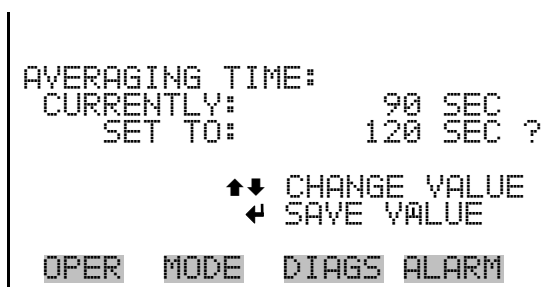
Calibration Factors

The Calibration Factors menu displays the calibration factors and is used to make minor compensations to the O_3 concentration.

● In the Main Menu, choose Photometer Setup > **Calibration Factors**.

```
CALIBRATION FACTORS:
>O3 BKG            0.0000
 O3 COEF           1.000
 RESET USER CAL DEFAULTS




 OPER   MODE   DIAGS ALARM
```
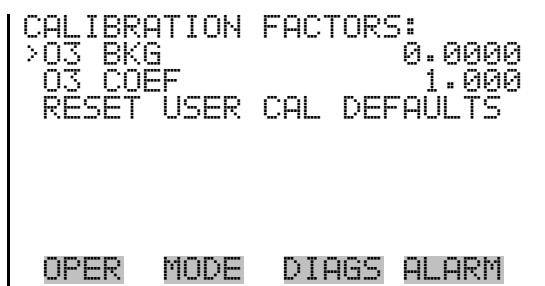
O_3 Background

The O_3 Background screen is used to perform a manual adjustment of the instruments zero background. Before performing a background adjustment, allow the analyzer to sample zero air until stable readings are obtained.

● In the Main Menu, choose Photometer Setup > Calibration Factors > **O3 Bkg**.

```
O3 BACKGROUND:
         O3:          4.400
  SET BKG TO:       0.0000 ?

              ↑↓ INC/DEC
               ↵ SAVE VALUE
   OPER   MODE   DIAGS ALARM
```
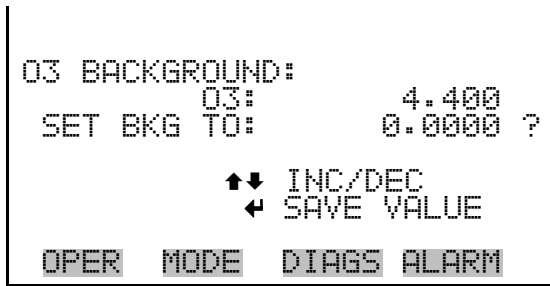
O₃ Coefficient   The O$_3$ Coefficient screen allows the O$_3$ span coefficient to be manually changed while sampling span gas of known concentration.

Note The concentration value will show "ERROR" if the measured concentration is not a valid span value (either higher than the selected range, or 0 or lower). ▲

● In the Main Menu, choose Photometer Setup > Calibration Factors > **O3 Coef**.

```
O3 COEFFICIENT:
         O3:            600
  SET COEF TO:       1.000

              ↑↓ INC/DEC
               ↵ SAVE VALUE
   OPER   MODE   DIAGS ALARM
```
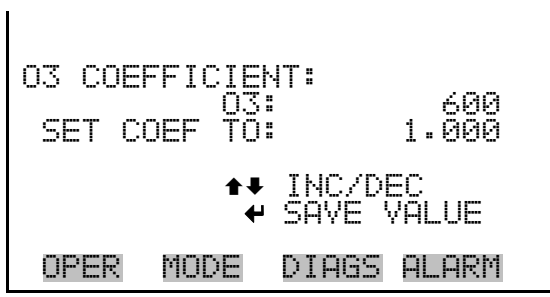
Reset User Calibration Default   The Reset User Calibration Default screen allows the user to reset the calibration configuration values to factory defaults.

● In the Main Menu, choose Photometer Setup > Calibration Factors > **Reset User Cal Defaults**.

```
┌─────────────────────────────────┐  ┌─────────────────────────────────┐
│ RESTORE DEFAULT CAL:            │  │ RESTORE DEFAULT CAL:            │
│                                 │  │                        ↵ RESTORE│
│                     ↵ RESTORE   │  │ ARE YOU SURE YOU WANT TO?       │
│                                 │  │ PRESS  ➜ TO CONFIRM RESTORE     │
│                                 │  │                                 │
│                                 │  │                                 │
│ OPER   MODE   DIAGS ALARM       │  │ OPER   MODE   DIAGS ALARM       │
└─────────────────────────────────┘  └─────────────────────────────────┘
```
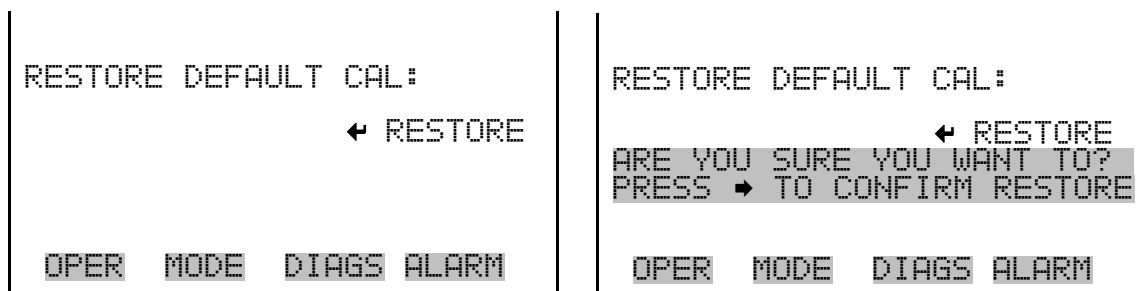
Calibration   The Calibration menu is used to calibrate zero and span.

● In the Main Menu, choose Photometer Setup > **Calibration**.

```
┌─────────────────────────────────┐
│ CALIBRATION:                    │
│ >CAL ZERO                       │
│  CAL O3 COEF                    │
│                                 │
│                                 │
│                                 │
│                                 │
│                                 │
│ OPER   MODE   DIAGS ALARM       │
└─────────────────────────────────┘
```

Calibrate Zero   The Calibrate Zero screen is used to automatically adjust the O_3
background, or perform a "zero calibration". Before performing a zero
calibration, ensure the analyzer samples zero air for at least 5 minutes.

It is important to note the averaging time when calibrating. The longer the
averaging time, the more accurate the calibration will be. To be most
accurate, use the 300-second averaging time.

● In the Main Menu, choose Photometer Setup > Calibration > **Cal
Zero**.

```
┌─────────────────────────────────┐
│ O3 BACKGROUND:                  │
│          O3:        0.0000      │
│  CURRENTLY:         0.0000      │
│                                 │
│            ↵ SET O3 TO ZERO     │
│                                 │
│ OPER   MODE   DIAGS ALARM       │
└─────────────────────────────────┘
```
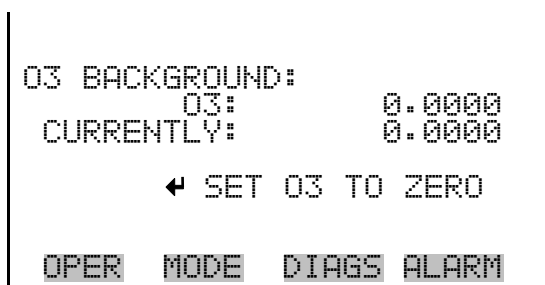
Calibrate O₃ Coefficient   The Calibrate O₃ Coefficient screen is used to automatically adjust the O₃ coefficient and enter the span concentration. The display shows the current O₃ concentration reading and the current O₃ range. The next line of the display is where the O₃ calibration gas concentration is entered.

It is important to note the averaging time when calibrating. The longer the averaging time, the more accurate the calibration will be. To be most accurate, use the 300-second averaging time.

● In the Main Menu, choose Photometer Setup > Calibration > **Cal O3 Coef**.

```
CALIBRATE O3:
       O3:           0.803
  SPAN CONC:     0000.80█ ?

            ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ← SAVE

  OPER   MODE   DIAGS ALARM
```
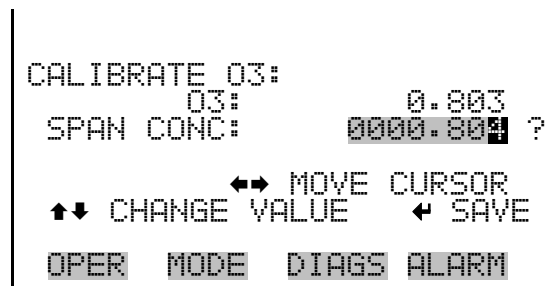
Program Menu

The Program menu sets the Model 146i's internal computer program to conduct a series of calibration events at preset times and durations. Up to 32 calibration events can be programmed. Next Event is read only and shows the status of the next event number and time, there is no setting screen.

Each event can be assigned gas, span, ozonator and permeation levels, photometer mode, and event set time. This function is only available when the instrument is NOT in service mode. If the service mode is active when the next cycle time occurs, the program will not be triggered. Turn service mode OFF to run next program cycle time. For more information on the service mode, see "Service Mode" later in this chapter.

Note When events are running, none of the settings may be changed via the front panel interface, except for the program cycle enable/disable, which may be toggled to cancel the current program. ▲

● In the Main Menu, choose **Program**.

```
PROGRAM:
>PROGRAM CYCLE     ENABLED
 PERIOD HOURS           24
 NEXT CYCLE 19JAN06 08:27
 NEXT EVENT      #31 15:00
 EVENTS


 OPER   MODE   DIAGS ALARM
```

Program Cycle

The Program Cycle screen is used turn the program mode on or off. When enabled, the status bar shows the current status of programmed events, either ACTIVE or INACTIVE. Inactive means enabled but not currently running, and active means running current event. When disabled, the program will not be run at its assigned interval. This screen is also used to cancel a running program.

● In the Main Menu, choose > Program > **Program Cycle**.

```
PROGRAM CYCLE STATUS
 CURRENTLY:        DISABLED
     SET TO:       ENABLED?

              ↵ TOGGLE VALUE


 OPER   MODE   DIAGS ALARM
```

Period Hours

The Period Hours screen is used select how many hours starting between cycles of the program. Valid values are 0 to 999. If 0 is selected, the program will run only once then it will be disabled.

● In the Main Menu, choose > Program > **Period Hours**.

```
PROGRAM CYCLE PERIOD:
  CURRENTLY:        024 HRS
     SET TO:        120 HRS?

                ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE
 OPER   MODE   DIAGS ALARM
```

Next Cycle   The Next Cycle screen is used view and change the start date and time of the program in 24-hour time.

● In the Main Menu, choose > Program > **Next Cycle**.

```
┌─────────────────────────────┐  ┌─────────────────────────────┐
│                             │  │                             │
│ NEXT CYCLE START TIME:      │  │ NEXT CYCLE START TIME:      │
│  18 JAN 2006  12:07         │  │  18 JAN 2006  12:07  ?      │
│ PRESS ← TO EDIT             │  │ SETTING: DAYS               │
│                             │  │              → SET MONTHS   │
│                             │  │             ↑↓ CHANGE VALUE │
│                             │  │              ← SAVE VALUE   │
│                             │  │                             │
│ OPER   MODE   DIAGS ALARM   │  │ OPER   MODE   DIAGS ALARM   │
└─────────────────────────────┘  └─────────────────────────────┘
```
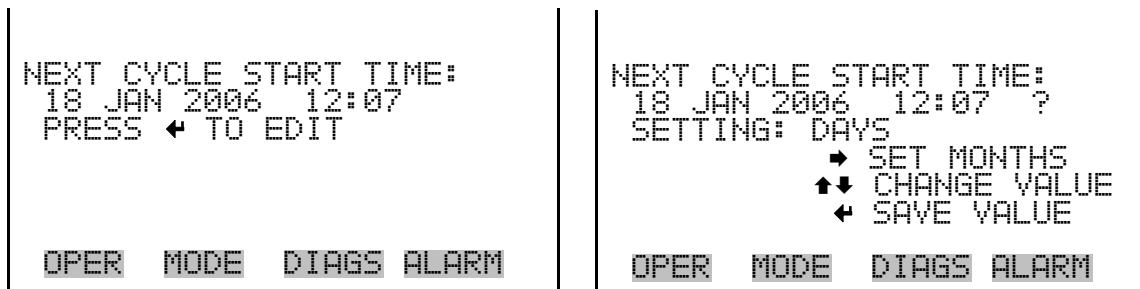
Events   The Events menu lets you configure events that are part of the program cycle. The number of events and total time of enabled events are displayed. The target values on the right side of the display, is an abbreviated line that describes the settings for that specific event, and should show the desired values based on the displayed operation parameters on the left side. Specific parameters include: gas (A-F, Zero), span level for that gas (1-5, Zero), ozonator and permeation levels (1-5, OFF), photometer mode (I=internal, E=external, C=control), and event duration time in minutes. Selecting an event allows detailed setup of that event. A maximum of 32 events can be controlled from this menu.

Note When events are running, none of the settings may be changed via the front panel interface, except for the program cycle enable/disable screen. ▲

● In the Main Menu, choose > Program > **Events**.

```
┌─────────────────────────────┐
│ PROGRAM CYCLE EVENTS:       │
│  TOT EVENTS   2 TIME 0:06   │
│ >EVENT 1  GA2 03 P1 I    1  │
│  EVENT 2  GC4 03    C    5  │
│  EVENT 3  G2      P4   OFF  │
│  EVENT 4            OFF     │
│  EVENT 5            OFF     │
│  EVENT 6            OFF↓    │
│                             │
│  OPER   MODE   DIAGS ALARM  │
└─────────────────────────────┘
```
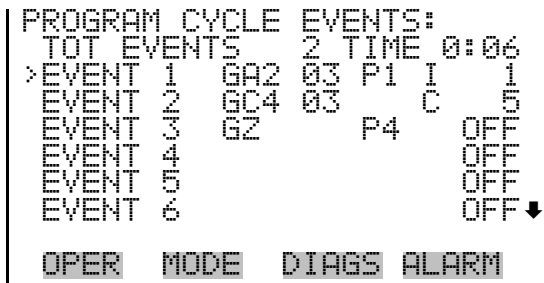
Events 1-32

The Events 1-32 screens allow the user to turn events on or off and modify the calibrator's operational settings. These screens are similar to the operation screen, but the numeric values cannot be changed, except duration minutes. Duration minutes lets you set the duration of an event and can be set by pressing (➡) and using (⬆) (⬇) enter a value in minutes. Press (↵) to save the value or (◀) to leave the screen. User 1-8 allows the instrument to control the user configured digital outputs as part of the event. When set to NONE, it will leave that event alone (it stays the same as it was before the event started). If set ON, it will turn user outputs on. If set OFF, it will turn outputs to off.

- In the Main Menu, choose > Program > Events > **Event 1-32**.

- Press (➡) or (◀) to toggle and (↵) to set following items.

```
EVENT 10:
>ENABLED: ?         32   MIN
 GAS A    ?      0.212 SCCM
 SPAN 1           2314 PPM
 PHOT OFF            0 PPM
 PERM OFF            0 PPM
 OZONE OFF           0 %
 USER1 DOUT         ON        ↓

 OPER   MODE   DIAGS ALARM
```

```
USER2 DOUT         OFF
USER3 DOUT        NONE
USER4 DOUT        NONE
USER5 DOUT        NONE
USER6 DOUT        NONE
USER7 DOUT        NONE
USER8 DOUT        NONE
```

Instrument Controls Menu

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

- In the Main Menu, choose **Instrument Controls**.

```
INSTRUMENT CONTROLS:
>TEMPERATURE COMPENSATION
 PRESSURE COMPENSATION
 DATALOGGING SETTINGS
 COMMUNICATION SETTINGS
 I/O CONFIGURATION
 SCREEN CONTRAST
 SERVICE MODE              ↓

 OPER   MODE   DIAGS ALARM
```

DATE/TIME

Temperature Compensation

The Temperature Compensation screen is used to turn temperature compensation on or off. When temperature compensation is on, the display shows the current ambient instrument temperature (measured by a thermistor on the Interface board). When temperature compensation is off, the display shows 0.0 °C.

● In the Main Menu, choose Instrument Controls > **Temperature Compensation**.

```
TEMPERATURE COMPENSATION:
 COMP TEMP:        32.6 °C
CURRENTLY:              ON
  SET TO:            OFF ?

            ↵ TOGGLE VALUE

 OPER   MODE   DIAGS ALARM
```

Pressure Compensation

The Pressure Compensation screen is used to turn the pressure correction on or off. When pressure compensation is on, the first line of the display represents the current chamber pressure. When pressure compensation is off, the first line of the display shows the factory standard pressure of 760 mmHg.

● In the Main Menu, choose Instrument Controls > **Pressure Compensation**.

```
PRESSURE COMPENSATION:
 COMP PRES:     743.0 mmHg
 CURRENTLY:           ON
    SET TO:          OFF ?

               ← TOGGLE VALUE

 OPER   MODE   DIAGS ALARM
```

Datalogging Settings

The Datalogging Settings menu deals with datalogging.

● In the Main Menu, choose Instrument Controls > **Datalogging Settings**.

```
DATALOGGING:
>SELECT SREC/LREC     SREC
 VIEW LOGGED DATA
 ERASE LOG
 SELECT CONTENT
 COMMIT CONTENT
 RESET TO DEFAULT CONTENT
 CONFIGURE DATA LOGGING

 OPER   MODE   DIAGS ALARM
```

Select SREC/LREC

The Select SREC/LREC is used to select short record or long record format for other operations in this menu.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > **Select SREC/LREC**.

```
SELECT LOG TYPE:
 CURRENTLY:          SREC
    SET TO:          LREC ?

               ← TOGGLE VALUE

 OPER   MODE   DIAGS ALARM
```

View Logged Data

The View Logged Data screen is used to select the start point to view the logged data by number of records or date and time.

● In the Main Menu, choose Instrument Controls > Datalogging Settings
> Select SREC or LREC > **View Logged Data**.

```
┌──────────────────────────────────┐
│                                  │
│   SELECT START POINT BY:         │
│                                  │
│      SET TO: # OF RECS           │
│                                  │
│                                  │
│   ♠♦ CHANGE      ↵ ACCEPT        │
│  OPER   MODE   DIAGS ALARM       │
└──────────────────────────────────┘
```

Number of Records The Number of Records screen is used to select the starting point to display
the number of records back to view.

```
┌──────────────────────────────────┐
│                                  │
│   SET # BACK FROM CURRENT:       │
│                      000000█     │
│   TOTAL LRECS:            20     │
│                                  │
│                 ♠♦ MOVE CURSOR   │
│   ♠♦ CHANGE VALUE     ↵ SAVE     │
│  OPER   MODE   DIAGS ALARM       │
└──────────────────────────────────┘
```

The Record Display screen (read only) displays the selected records.

```
┌──────────────────────────────────┐
│                                  │
│   time    date      flags        │
│   10:01 06/20/05   C008890       │
│   10:02 06/20/05   C008890       │
│   10:03 06/20/05   C008890       │
│   10:04 06/20/05   C008890       │
│    ♠♦ PGUP/DN   ♠♦ PAN L/R       │
│  OPER   MODE   DIAGS ALARM       │
└──────────────────────────────────┘
```

Date and Time The Date and Time screen is used to set a start date and time for which to
view logged data. For example, if "20 JUN 2005 10:00" is entered, then
the first logged data record that is displayed is the first record after this
time. If set to one minute logging, this would be at "20 JUN 2005 10:01".

```
DATE AND TIME:
 20 JUN 2005  10:00
↑↓ CHG    DAYS
→ SET CURSOR TO MONTHS
↵ ACCEPT AS SHOWN


OPER   MODE   DIAGS ALARM
```

The Record Display screen (read only) displays the selected records.

```
time     date     flags
10:01 06/20/05  C008890
10:02 06/20/05  C008890
10:03 06/20/05  C008890
10:04 06/20/05  C008890
↑↓ PGUP/DN    ←→ PAN L/R

OPER   MODE   DIAGS ALARM
```

Erase Log   The Erase Log is used to erase all saved data for the selected record type
(not all short records and long records).

● In the Main Menu, choose Instrument Controls > Datalogging Settings
> **Erase Log**.

```
ERASE LREC LOG FILE DATA?

          ↵ ERASE




OPER   MODE   DIAGS ALARM
```

```
ERASE LREC LOG FILE DATA?

          ↵ ERASE
ARE YOU SURE YOU WANT TO?
PRESS → TO CONFIRM ERASURE


OPER   MODE   DIAGS ALARM
```

Select Content   The Select Content submenu displays a list of 32 record fields to use and a
submenu list of the analog output signal group choices to choose from.
Choices are Concentrations, Other Measurements, and Analog Inputs (if
the I/O expansion board is installed). This is a temporary list of items for
the selected record type that must be committed via the datalogging menu
before the changes will apply. Note that committing any changes to this list

will erase all currently logged data, as the format of the stored data is changed.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > **Select Content**.

```
LREC FIELDS:
>FIELD 1              CONC
 FIELD 2             TGFLO
 FIELD 3             AGFLO
 FIELD 4              TZFLO
 FIELD 5             AZFLO
 FIELD 6             TTFLO
 FIELD 7             ATFLO  ↓

 OPER   MODE   DIAGS ALARM
```

```
DATA IN LREC FIELD 1:
>CONCENTRATIONS
 OTHER MEASUREMENTS
 ANALOG INPUTS




 OPER   MODE   DIAGS ALARM
```

Concentrations   The Concentrations screen allows the user to select the output signal that is tied to the selected field item. The selected item is shown by "<--" after it. Note that at this point, pressing ⏎ indicates that these are proposed changes as opposed to implemented changes. To change the selected record format and erase record log file data, see "Commit Content" below.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content > Select Field > **Concentrations**.

```
CONCENTRATIONS:
>NONE
 GAS CONC                  <--
 O3 CONC
 PERM CONC




 OPER   MODE   DIAGS ALARM
```

Other Measurements   The Other Measurements screen allows the user to select the output signal that is tied to the selected field item. The selected item is shown by "<--" after it. Items displayed are determined by the options installed. Note that at this point, pressing ⏎ indicates that these are proposed changes as opposed to implemented changes. To change the selected record format and erase record log file data, see "Commit Content" below.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content > Select Field > **Other Measurements**.

```
OTHER MEASUREMENTS:
>NONE
 TARGET GFLOW
 ACTUAL GFLOW
 TARGET ZFLOW
 ACTUAL ZFLOW
 TARGET TFLOW
 ACTUAL TFLOW              ↓

 OPER   MODE   DIAGS ALARM
```

```
 PRESSURE
 BENCH TEMP
 LAMP TEMP
 O3 LAMP TEMP
 INTENSITY
 NOISE
```

Analog Inputs   The Analog Inputs screen allows the user to select the output signal (none or analog inputs 1-8) that is tied to the selected field item. The selected item is shown by "<--" after it. Note that at this point, pressing ⏎ indicates that these are proposed changes as opposed to implemented changes. To change the selected record format and erase record log file data, see "Commit Content" below.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content > Select Field > **Analog Inputs**.

```
ANALOG INPUTS:
>NONE
 ANALOG IN 1
 ANALOG IN 2
 ANALOG IN 3
 ANALOG IN 4
 ANALOG IN 5
 ANALOG IN 6              ↓

 OPER   MODE   DIAGS ALARM
```

Commit Content   The Commit Content screen is used to save the selected output signal that is tied to the selected field item. If no changes have been made "NO CHANGES TO RECORD LIST!" will appear. For more information about selecting the analog output signal group choices, see "Select Content" above.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > **Commit Content**.

```
CHANGE LREC DATA AND
ERASE LREC LOG FILE DATA?
                 ↵ COMMIT



 OPER   MODE   DIAGS ALARM
```

```
CHANGE LREC DATA AND
ERASE LREC LOG FILE DATA?
                 ↵ COMMIT
ARE YOU SURE YOU WANT TO?
PRESS  ➡ TO CONFIRM ERASURE

 OPER   MODE   DIAGS ALARM
```

Reset to Default Content   The Reset to Default Content screen is used to reset all of the datalogging field items to default values. For more information about selecting the analog output signal group choices, see "Select Content" above.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > **Reset to Default Content**.

```
RESET LREC DATA AND
ERASE LREC LOG FILE DATA?
                 ↵ RESET



 OPER   MODE   DIAGS ALARM
```

```
RESET LREC DATA AND
ERASE LREC LOG FILE DATA?
                 ↵ RESET
ARE YOU SURE YOU WANT TO?
PRESS  ➡ TO CONFIRM RESET

 OPER   MODE   DIAGS ALARM
```
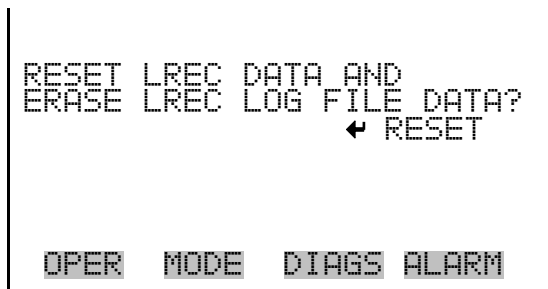
Configure Datalogging   The Configure Datalogging menu deals with datalogging configuration for the currently selected record type.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > **Configure Datalogging**.

```
DATALOGGING SETTINGS:
>LOGGING PERIOD MIN    60
 MEMORY ALLOCATION %   50
 DATA TREATMENT       AVG




   OPER   MODE   DIAGS ALARM
```

Logging Period Min

The Logging Period Min screen is used to select the logging period in minutes for the record format (srec or lrec). List of choices include: off, 1, 5, 15, 30, and 60 minutes (default).

● In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > **Logging Period Min**.

```
SET PERIOD FOR SREC:
 CURRENTLY:          60 MIN
    SET TO:          OFF MIN

 ↑↓ CHANGE VALUE    ← SAVE

   OPER   MODE   DIAGS ALARM
```

Memory Allocation Percent

The Memory Allocation Percent screen is used to select the percentage of each record type for both short records and long records. Percentages between 0 and 100% are available in increments of 10. Changing this value results in log erasure for both short records and long records.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > **Memory Allocation %**.

```
SET PERCENT LRECS:
 CURRENTLY:           50%
  SET TO:             60% ?

 ↑↓ CHANGE VALUE    ← SAVE

   OPER   MODE   DIAGS ALARM
```

Data Treatment   The Data Treatment screen is used to select the data type for the selected record: whether the data should be averaged over the interval, the minimum or maximum used, or the current value logged. Data treatment doesn't apply to all data, just to the concentration measurement. All other data points log the current value at the end of the interval.

● In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > **Data Treatment**.

```
SET LREC DATA TYPE:
 CURRENTLY:  AVG
     SET TO:  MAX         ?

 ↑↓ CHANGE VALUE    ↵ SAVE


 OPER   MODE   DIAGS ALARM
```

Communication Settings

The Communication Settings menu is used with communications control and configuration.

● In the Main Menu, choose Instrument Controls > **Communication Settings**.

```
COMMUNICATION SETTINGS:
>BAUD RATE
 INSTRUMENT ID
 COMMUNICATION PROTOCOL
 STREAMING DATA CONFIG
 RS-232/RS-485 SELECTION
 TCP/IP SETTINGS

 OPER   MODE   DIAGS ALARM
```

Baud Rate   The Baud Rate screen is used to set the RS-232/RS-485 interface baud rate. Baud rates of 1200, 2400, 4800, and 9600, 19200, 38400, 57600, and 115200 are available.

● In the Main Menu, choose Instrument Controls > Communication Settings > **Baud Rate**.

```
BAUD RATE:
 CURRENTLY:            9600
    SET TO:           19200    ?

               ↑↓ CHANGE VALUE
                ↵ SAVE VALUE
 OPER    MODE   DIAGS ALARM
```
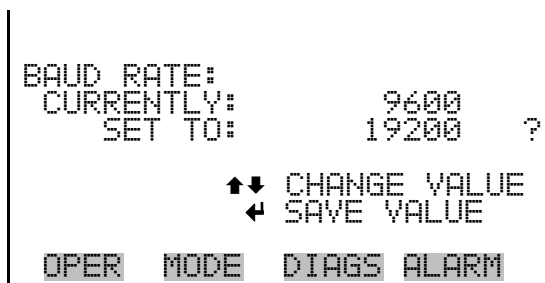
Instrument ID   The Instrument ID screen allows the operator to edit the instrument ID. The ID is used to identify the instrument when using the C-Link or MODBUS protocols to control the instrument or collect data. It may be necessary to edit the ID number if two or more of the same instruments are connected to one computer. Valid Instrument ID numbers are from 0 to 127. The Model 146*i* has a default Instrument ID of 51. For more information about the Instrument ID, see Appendix B "C-Link Protocol Commands" or Appendix C "MODBUS Protocol".

● In the Main Menu, choose Instrument Controls > Communication Settings > **Instrument ID**.

```
INSTRUMENT ID:
 CURRENTLY:              51
    SET TO:              52 ?

               ↑↓ CHANGE VALUE
                ↵ SAVE VALUE
 OPER    MODE   DIAGS ALARM
```
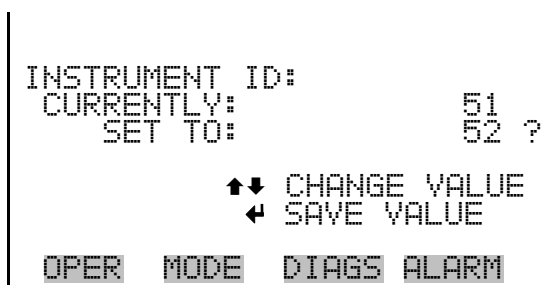
Communication Protocol   The Communication Protocol screen is used to change the instrument communication protocol for serial communications.

● In the Main Menu, choose Instrument Controls > Communication Settings > **Communication Protocol**.

```
COMMUNICATION PROTOCOL:
 CURRENTLY:        CLINK
    SET TO:    STREAMING ?

            ⬆⬇ CHANGE VALUE
             ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```
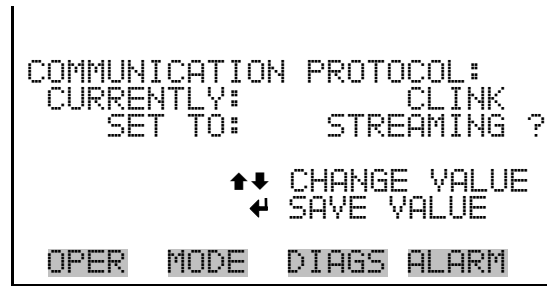
Streaming Data Configuration

The Streaming Data Configuration menu is used to allow for configuration of the 8 streaming data output items, streaming interval, current data format, and current timestamp setting. The Choose Item Signal submenu displays a list of the analog output signal group choices to choose from. Choices are Concentrations, Other Measurements, and Analog Inputs (if the I/O expansion board option is installed).

● In the Main Menu, choose Instrument Controls > Communication Settings > **Streaming Data Config**.

```
STREAMING DATA CONFIG
>INTERVAL          10 SEC
 ADD LABELS            NO
 PREPEND TIMESTAMP    YES
 ITEM 1             CONC
 ITEM 2            TGFLO
 ITEM 3            AGFLO
 ITEM 4            TZFLO ⬇
 OPER   MODE   DIAGS ALARM
```

```
CHOOSE STREAM DATA:
>CONCENTRATIONS
 OTHER MEASUREMENTS
 ANALOG INPUTS




 OPER   MODE   DIAGS ALARM
```
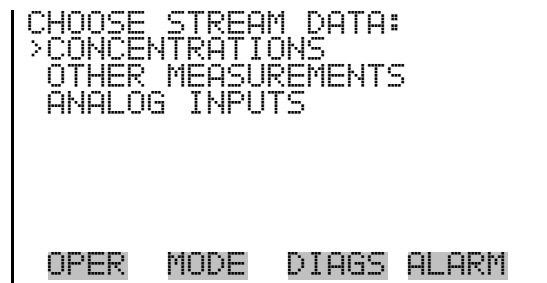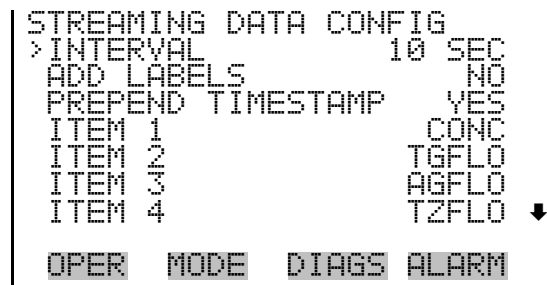
Streaming Data Interval

The Streaming Data Interval screen is used to adjust the streaming data interval. The following interval times are available: 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds.

● In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > **Streaming Data Interval**.
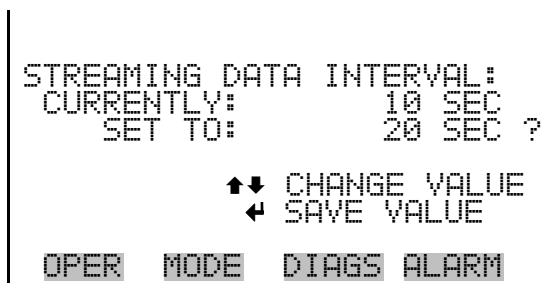
```
┌─────────────────────────────────────┐
│ STREAMING DATA INTERVAL:             │
│  CURRENTLY:           10 SEC         │
│     SET TO:           20 SEC ?       │
│                                      │
│              ↑↓ CHANGE VALUE         │
│              ↵ SAVE VALUE            │
│ ▓OPER▓  ▓MODE▓  DIAGS ALARM          │
└─────────────────────────────────────┘
```

Concentrations   The Concentrations screen allows the user to select the output signal that is tied to the selected streaming data item. The selected item is shown by "<--" after it.

● In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > Select Item > **Concentrations**.

```
┌─────────────────────────────────────┐
│ CONCENTRATIONS:                      │
│ >NONE                                │
│  GAS CONC                    <--     │
│  O3 CONC                             │
│  PERM CONC                           │
│                                      │
│                                      │
│                                      │
│ ▓OPER▓  ▓MODE▓  DIAGS ALARM          │
└─────────────────────────────────────┘
```

Other Measurements   The Other Measurements screen allows the user to select the output signal that is tied to the selected streaming data item. The selected item is shown by "<--" after it.

● In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > Select Item > **Other Measurements**.
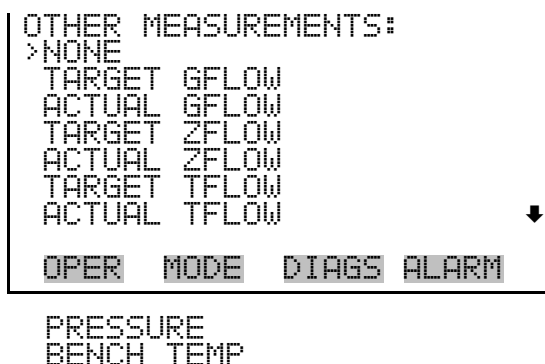
```
┌─────────────────────────────────────┐
│ OTHER MEASUREMENTS:                  │
│ >NONE                                │
│  TARGET GFLOW                        │
│  ACTUAL GFLOW                        │
│  TARGET ZFLOW                        │
│  ACTUAL ZFLOW                        │
│  TARGET TFLOW                        │
│  ACTUAL TFLOW                  ↓     │
│ ▓OPER▓  ▓MODE▓  DIAGS ALARM          │
└─────────────────────────────────────┘
     PRESSURE
     BENCH TEMP
```

```
LAMP TEMP
O3 LAMP TEMP
INTENSITY
NOISE
```

Analog Inputs The Analog Inputs screen allows the user to select the analog input signal (none or analog inputs 1-8) that is tied to the selected streaming data item. The selected item is shown by "<--" after it.

● In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > Select Item > **Analog Inputs**.

```
ANALOG INPUTS:
>NONE
 ANALOG IN 1
 ANALOG IN 2
 ANALOG IN 3
 ANALOG IN 4
 ANALOG IN 5
 ANALOG IN 6          ↓

 OPER   MODE   DIAGS ALARM
```

RS-232/RS-485 Selection The RS-232/RS-485 Selection screen allows the user to choose between the RS-232 or RS-485 specification for serial communication.

Note Disconnect the serial cable before changing RS-232 and RS-485 selection to prevent damage to the connected equipment. ▲

● In the Main Menu, choose Instrument Controls > Communication Settings > **RS-232/RS-485 Selection**.

```
RS-232/RS-485 SELECTION:
     ** WARNING **
 DISCONNECT THE SERIAL
 CABLES BEFORE CHANGING
     THE SELECTION!
             ↵ TO CONTINUE

 OPER   MODE   DIAGS ALARM
```

```
RS-232/RS-485 SELECTION:
 CURRENTLY:        RS-232
     SET TO:       RS-485 ?
 MAKE SURE THAT THE CABLE
 IS OFF: PRESS  ➡ TO CONFIRM
             ↵ TOGGLE VALUE

 OPER   MODE   DIAGS ALARM
```

TCP/IP Settings   The TCP/IP Settings menu is used for defining TCP/IP settings

Note The instrument power must be cycled after this parameter has been changed for the change to take effect. ▲

● In the Main Menu, choose Instrument Controls > Communication Settings > **TCP/IP Settings**.

```
TCP/IP SETTINGS:
>USE DHCP              OFF
 IP ADDR    192.168.1.200
 NETMASK    255.255.255.0
 GATEWAY      0.  0.0.0
 HOST NAME      iSeries


 OPER   MODE   DIAGS ALARM
```

Use DHCP   The Use DHCP screen is used to specify whether to use DHCP or not.

● In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > **Use DCHP**.

```
DHCP:
 CURRENTLY:            OFF
    SET TO:           ON ?

               ↵ TOGGLE VALUE
CYCLE POWER TO CHANGE DHCP

 OPER   MODE   DIAGS ALARM
```

IP Address   The IP Address screen is used to edit the IP address. The IP address can only be changed when DHCP is on. For more information on DHCP, see "Use DHCP" above.

● In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > **IP Address**.

```
IP ADDRESS:
 CURRENT: 192.168.0.200
  SET TO: 192.168.1.131
          ←→ MOVE CURSOR
          ↑↓ CHANGE VALUE
           ↵ SAVE VALUE

 OPER   MODE   DIAGS ALARM
```

Netmask   The Netmask screen is used to edit the netmask.

● In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > **Netmask**.

```
NETMASK:
 CURRENT: 255.255.255.0
  SET TO: 255.255.255.00
          ←→ MOVE CURSOR
          ↑↓ CHANGE VALUE
           ↵ SAVE VALUE

 OPER   MODE   DIAGS ALARM
```

Default Gateway   The Default Gateway screen is used to edit the gateway address.

● In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > **Gateway**.

```
DEFAULT GATEWAY:
 CURRENT: 10.209.42.1
  SET TO: 10.209.42.1
          ←→ MOVE CURSOR
          ↑↓ CHANGE VALUE
           ↵ SAVE VALUE

 OPER   MODE   DIAGS ALARM
```

Host Name   The host name screen is used to edit the host name. When DHCP is enabled, this name is reported to the DHCP server.

● In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > **Host Name**.

```
HOST NAME:
  CURRENT: ISERIES
           ISERIES      ?
    ABCDEFGHIJKLMN  BKSP
    OPQRSTUVWXYZ    PAGE
    0123456789 ./-  SAVE

  OPER   MODE   DIAGS ALARM
```

I/O Configuration

The I/O Configuration menu deals with configuration of the instrument's I/O system. The analog input configuration is displayed only if the I/O expansion board option is installed.

● In the Main Menu, choose Instrument Controls > **I/O Configuration**.

Note The digital outputs may take up to one second after the assigned state occurs to show up on the outputs. ▲

```
I/O CONFIGURATION:
>OUTPUT RELAY SETTINGS
 DIGITAL INPUT SETTINGS
 EXTERNAL SOLENOIDS
 ANALOG OUTPUT CONFIG
 ANALOG INPUT CONFIG



  OPER   MODE   DIAGS ALARM
```

Output Relay Settings

The Output Relay Settings menu displays a list of the 10 analog output relays available, and allows the user to select the logic state or instrument parameter for the relay selected.

● In the Main Menu, choose Instrument Controls > I/O Configuration > **Output Relay Settings**.

```
OUTPUT RELAY SETTINGS:
>1    NOP         GAS BIT 1
 2    NOP         GAS BIT 2
 3    NOP         GAS BIT 3
 4    NOP        SPAN BIT 1
 5    NOP        SPAN BIT 2
 6    NOP        SPAN BIT 3
 7    NOP     O3/PERM BIT 1  ↓
 OPER   MODE   DIAGS ALARM
```

Logic State   The Logic State screen is used to change the I/O relay to either normally open or normally closed.

● Press ⏎ to toggle and set the logic state open or closed.

```
OUTPUT RELAY SETUP:
>LOGIC STATE          OPEN
 INSTRUMENT STATE




 OPER   MODE   DIAGS ALARM
```

Instrument State   The Instrument State menu allows the user to select the instrument state that is tied to the selected relay output. A submenu lists signal types of either alarm or non-alarm to choose from.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Output Relay Settings > Select Relay > **Instrument State**.

```
CHOOSE SIGNAL TYPE:
>ALARMS
 NON-ALARM




 OPER   MODE   DIAGS ALARM
```

Alarms   The Alarms status screen allows the user to select the alarm status for the selected relay output. The selected item is shown by "<--" after it.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Output Relay Settings > Select Relay > Instrument State > **Alarms**.

```
ALARM STATUS ITEMS:
>NONE
 GEN ALARM
 AMBIENT TEMP
 O3 LAMP TEMP
 PERM GAS TEMP
 PRESSURE
 PHOT BENCH TEMP              ↓

 OPER   MODE   DIAGS ALARM
```

```
PHOT LAMP TEMP
PHOT INTENSITY
O3 LEVEL
```

Non-Alarm   The Non-Alarm status screen allows the user to select the non-alarm status for the selected relay output. The selected item is shown by "<--" after it. For more information on the I/O connections, see "Remote Interconnections" in the "Installation" chapter.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Output Relay Settings > Select Relay > Instrument State > **Non-Alarm**.

```
NON ALARM STATUS ITEMS:
>NONE
 GAS BIT 1                    <--
 GAS BIT 2
 GAS BIT 3
 SPAN BIT 1
 SPAN BIT 2
 SPAN BIT 3                   ↓

 OPER   MODE   DIAGS ALARM
```

```
O3/PERM BIT 1
O3/PERM BIT 2
O3/PERM BIT 3
O3/PERM BIT 4
PHOTO BIT 1
PHOTO BIT 2
GAS A
GAS B
GAS C
GAS D
GAS E
GAS F
```

```
OZONATOR
PERM OVEN
USER 1
USER 2
USER 3
USER 4
USER 5
USER 6
USER 7
USER 8
```

Digital Input Settings   The Digital Input Settings menu displays a list of the 16 digital inputs available, and allows the user to select the logic state and instrument parameter for the relay selected.

Note The digital inputs must be asserted for at least one second for the action to be activated. ▲

● In the Main Menu, choose Instrument Controls > I/O Configuration > **Digital Input Settings**.

```
DIGITAL INPUT SETTINGS:
>1    NOP       GAS BIT 1
 2    NOP       GAS BIT 2
 3    NOP       GAS BIT 3
 4    NOP      SPAN BIT 1
 5    NOP      SPAN BIT 2
 6    NOP      SPAN BIT 3
 7    NOP   O3/PERM BIT 1  ↓

 OPER   MODE   DIAGS ALARM
```

Logic State   The Logic State screen is used to change the I/O relay to either normally open or normally closed. The default state is open, which indicates that a relay connected between the digital input pin and ground is normally open and closes to trigger the digital input action. If nothing is connected to the digital input pin, the state should be left at open to prevent the action from being triggered.

● Press ⏎ to toggle and set the logic state open or closed.

```
DIGITAL INPUT SETUP:
>LOGIC STATE          OPEN
 INSTRUMENT STATE



  OPER   MODE   DIAGS ALARM
```

Instrument Action   The Instrument Action screen allows the user to choose the instrument action that is tied to the selected digital input.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Digital Input Settings > Select Relay > **Instrument Action**.

```
CHOOSE ACTION:
>NONE
 GAS BIT 1              <——
 GAS BIT 2
 GAS BIT 3
 SPAN BIT 1
 SPAN BIT 2
 SPAN BIT 3             ↓
  OPER   MODE   DIAGS ALARM
```

```
 O3/PERM BIT 1
 O3/PERM BIT 2
 O3/PERM BIT 3
 O3/PERM BIT 4
 PHOTO BIT 1
 PHOTO BIT 2
 AOUTS TO ZERO
 AOUTS TO FS
```

External Solenoid Settings   The Model 146*i* can drive up to eight external solenoids. You can select the external solenoids with the External Solenoids menu. Each solenoid can be connected to the following: Gas A, B, or C (or D, E, or F if the six gas option is installed), the ozonator, or the permeation oven.

● In the Main Menu, choose Instrument Controls > I/O Configuration > **External Solenoids**.

```
EXT SOLENOID SETTINGS:
>1    NOP              GAS A
 2    NOP              GAS B
 3    NOP              GAS C
 4    NOP              GAS D
 5    NOP              GAS E
 6    NOP              GAS F
 7    NOP           OZONATOR  ↓
  OPER   MODE   DIAGS ALARM
```

Logic State   The Logic State screen is used to change the I/O solenoid to either normally open or normally closed.

● Press ⏎ to toggle and set the logic state open or closed.

```
EXT SOLENOID SETUP:
>LOGIC STATE          OPEN
 INSTRUMENT STATE



  OPER   MODE   DIAGS ALARM
```

Instrument State   The Instrument State menu allows the user to select the instrument state that is tied to the selected solenoid output. A submenu lists signal types of either alarm or non-alarm to choose from.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Ext Solenoid Settings > Select Solenoid > **Instrument State**.

```
CHOOSE SIGNAL TYPE:
>ALARMS
 NON-ALARM



  OPER   MODE   DIAGS ALARM
```

Alarms The Alarms status screen allows the user to select the alarm status for the selected solenoid output. The selected item is shown by "<--" after it.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Ext Solenoid Settings > Select Solenoid > Instrument State > **Alarms**.

```
ALARM STATUS ITEMS:
>NONE
 GEN ALARM
 AMBIENT TEMP
 O3 LAMP TEMP
 PERM GAS TEMP
 PRESSURE
 PHOT BENCH TEMP          ↓

 OPER   MODE   DIAGS ALARM
```

```
 PHOT LAMP TEMP
 PHOT INTENSITY
 O3 LEVEL
```

Non-Alarm The Non-Alarm status screen allows the user to select the non-alarm status for the selected solenoid output. The selected item is shown by "<--" after it.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Ext Solenoid Settings > Select Solenoid > Instrument State > **Non-Alarm**.

```
NON ALARM STATUS ITEMS:
>NONE
 GAS A                      <--
 GAS B
 GAS C
 GAS D
 GAS E
 GAS F                       ↓

 OPER   MODE   DIAGS ALARM
```

```
 OZONATOR
 PERM OVEN
 USER 1
 USER 2
 USER 3
 USER 4
 USER 5
 USER 6
 USER 7
 USER 8
```

Analog Output Configuration

The Analog Output Configuration menu displays a list of the analog output channels available for configuration. Channel choices include all voltage channels, all current channels, voltage channels 1-6, and current channels 1-6 (if the I/O expansion board option is installed). Configuration choices include selecting range, setting minimum/maximum values, and choosing signal to output.

● In the Main Menu, choose Instrument Controls > I/O Configuration > **Analog Output Config**.

```
OUTPUT CHANNELS:
>ALL VOLTAGE CHANNELS
 ALL CURRENT CHANNELS
 VOLTAGE CHANNEL 1
 VOLTAGE CHANNEL 2
 VOLTAGE CHANNEL 3
 VOLTAGE CHANNEL 4
 VOLTAGE CHANNEL 5          ↓

 OPER   MODE   DIAGS ALARM
```

```
ANALOG OUTPUT CONFIG:
>SELECT RANGE
 SET MINIMUM VALUE
 SET MAXIMUM VALUE
 CHOOSE SIGNAL TO OUTPUT




 OPER   MODE   DIAGS ALARM
```

Select Output Range

The Select Output Range screen is used to select the hardware range for the selected analog output channel. Possible ranges for the voltage outputs are: 0-100 mV, 0-1, 0-5, 0-10 V.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Output Config > Select Channel > **Select Range**.

```
┌─────────────────────────────────────┐
│                                     │
│  SELECT OUTPUT RANGE:               │
│   SELECTED OUTPUT:    V ALL         │
│   CURRENTLY:        0-10V           │
│      SET TO:        0-5V   ?        │
│                                     │
│   ♦↓ CHANGE VALUE    ↵ SAVE         │
│                                     │
│  OPER   MODE   DIAGS ALARM          │
│                                     │
└─────────────────────────────────────┘
```
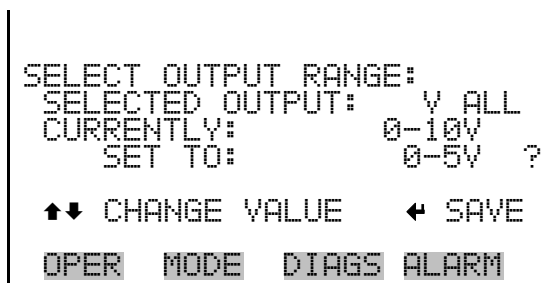
Minimum and Maximum Value

The Minimum Value screen is used to edit the zero (0) to full-scale (100) value in percentages for the selected analog output channel. See Table 3–3 for a list of choices. The minimum and maximum output value screens function the same way. The example below shows the set minimum value screen.

● In the Main Menu, choose Instrument Controls > IO Configuration > Analog Output Config > Select Channel > **Set Minimum** or **Maximum Value**.

```
┌─────────────────────────────────────┐
│                                     │
│  MINIMUM OUTPUT PERCENT:            │
│   SELECTED OUTPUT:    V ALL         │
│   CURRENTLY:         N/A %          │
│      SET TO:      0000.0 %  ?       │
│                                     │
│   ♦↓ CHANGE VALUE    ↵ SAVE         │
│                                     │
│  OPER   MODE   DIAGS ALARM          │
│                                     │
└─────────────────────────────────────┘
```
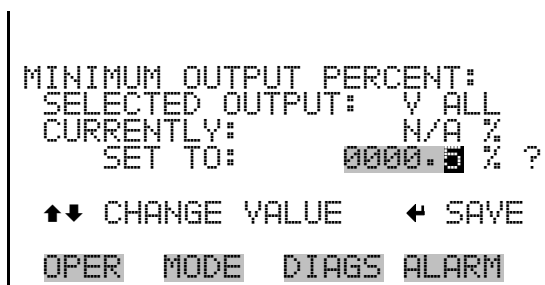
Table 3–3. Analog Output Zero to Full-Scale Table

Output	Zero % Value	Full-Scale 100% Value
Gas Conc	Zero (0)	10,000 ppm
O_3 Conc	Zero (0)	Range setting
Perm Conc	Zero (0)	10,000 ppm
Target Gflow	0.0	Gas flow controller setting
Actual Gflow	0.0	Gas flow controller setting
Target Zflow	0.0	Zero flow controller setting
Actual Zflow	0.0	Zero flow controller setting
Target Tflow	0.0	Total gas and zero flow controller settings

Output	Zero % Value	Full-Scale 100% Value
Actual Tflow	0.0	Total gas and zero flow controller settings
Pressure	User-set alarm min value	User-set alarm max value
Bench Temperature	User-set alarm min value	User-set alarm max value
Lamp Temperature	User-set alarm min value	User-set alarm max value
O3 Lamp Temperature	User-set alarm min value	User-set alarm max value
Intensity	User-set alarm min value	User-set alarm max value
Noise	0.0	100.0

Choose Signal to Output

The Choose Signal Type to Output screen displays a submenu list of the analog output signal group choices. Group choices are Concentrations, Other Measurements, and Analog Inputs (if the I/O expansion board option is installed). This allows the user to select the output signal to the selected output channel. The Concentrations screen is shown below. See Table 3–4 below for a list of items for each signal group choice.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Output Config > Select Channel > **Choose Signal To Output**.

```
CHOOSE SIGNAL TYPE:
>CONCENTRATIONS
 OTHER MEASUREMENTS
 ANALOG INPUTS




 OPER   MODE   DIAGS ALARM
```

```
CHOOSE SIGNAL -    CONC
 SELECTED OUTPUT:    V1
 CURRENTLY: GAS CONC
    SET TO: NONE       ?

 ↑↓ CHANGE VALUE   ← SAVE

 OPER   MODE   DIAGS ALARM
```

Table 3–4. Signal Type Group Choices

Concentrations	Other Measurements	Analog Inputs
None	None	None
Gas Conc	Target Gflow	Analog Input 1
O_3 Conc	Actual Gflow	Analog Input 2
Perm Conc	Target Zflow	Analog Input 3
	Actual Zflow	Analog Input 4
	Target Tflow	Analog Input 5
	Actual Tflow	Analog Input 6
	Pressure	Analog Input 7
	Bench Temperature	Analog Input 8
	Lamp Temperature	
	O_3 Lamp Temperature	
	Intensity	
	Noise	

Analog Input Configuration

The Analog Input Configuration menu displays a list of the 8 analog input channels available for configuration. This screen is only displayed if the I/O expansion board option is installed. Configuration includes entering descriptor, units, decimal places, choice of 1-10 points in the table, and corresponding number of points selected.

● In the Main Menu, choose Instrument Controls > I/O Configuration > **Analog Input Config**.

```
ANALOG INPUT CONFIG:
>CHANNEL 1          IN1
 CHANNEL 2          IN2
 CHANNEL 3          IN3
 CHANNEL 4          IN4
 CHANNEL 5          IN5
 CHANNEL 6          IN6
 CHANNEL 7          IN7↓

  OPER   MODE   DIAGS ALARM
```

```
ANALOG INPUT 01 CONFIG:
>DESCRIPTOR            IN1
 UNITS                  V
 DECIMAL PLACES         2
 TABLE POINTS           2
 TABLE POINT 1
 TABLE POINT 2


 OPER   MODE   DIAGS ALARM
```

Descriptor   The Descriptor screen allows the user to enter the descriptor for the selected analog input channel. The descriptor is used in datalogging and streaming data to report what data is being sent out. The descriptor may be from 1 to 3 characters in length, and defaults to IN1 to IN8 (user input channel number).

● In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > **Descriptor**.

```
ANALOG INPUT DESCRIPTOR:
 CURRENTLY:  IN1
             IN1
    ABCDEFGHIJKLMN   BKSP
    OPQRSTUVWXYZ     PAGE
    0123456789 ./-   SAVE

 OPER   MODE   DIAGS ALARM
```

Units   The Units screen allows the user to enter the units for the selected analog input channel. The units are displayed on the diagnostic screen and in datalogging and streaming data. The units may be from 1 to 3 characters in length, and defaults to V (volts).

● In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > **Units**.

```
ANALOG INPUT UNITS:
 CURRENTLY: V
            V
     ABCDEFGHIJKLMN  BKSP
     OPQRSTUVWXYZ    PAGE
     0123456789 ./-  SAVE

 OPER   MODE   DIAGS ALARM
```
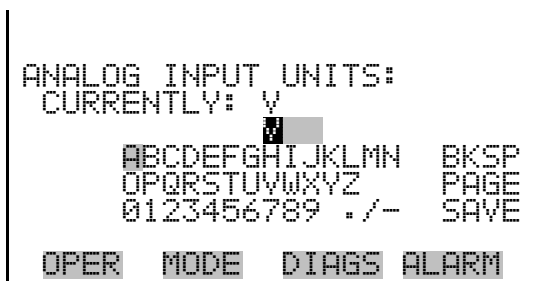
Decimal Places
The Decimal Places screen allows the user to select how many digits are displayed to the right of the decimal, from 0 to 6, with a default of 2.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > **Decimal Places**.

```
DECIMAL PLACES:
 CURRENTLY:             2
    SET TO:             3 ?

          ↑↓ CHANGE VALUE
          ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```

Number of Table Points
The Number of Table Points screen allows the user to select how many points are used in the conversion table. The points range from 2 to 10, with a default of 2.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > **Table Points**.

```
NUMBER OF TABLE POINTS:
 CURRENTLY:             2
    SET TO:            10 ?

          ↑↓ CHANGE VALUE
          ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```
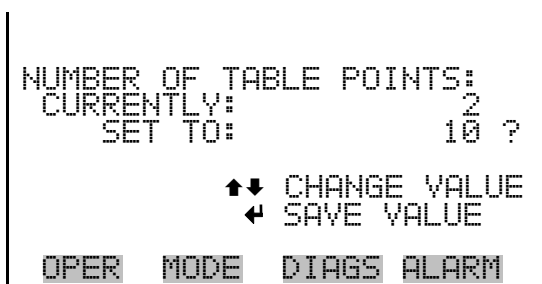
Table Point   The Table Point submenu allows the user to set up an individual table point.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > **Point 1-10**.

```
TABLE POINT 01 CONFIG:
>VOLTS              0.00
 USER VALUE         0.00




 OPER   MODE   DIAGS ALARM
```

Volts   The Volts screen allows the user to set the input voltage for the selected table point in the conversion table, from 0.00 to 10.50. The default table is a two-point table with point 1: 0.00 V = 000.0 U and point 2: 10.00 V = 10.0 U.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > Select Point > **Volts**.

```
TABLE POINT 01 VOLTS:
 CURRENTLY:         0.00
   SET TO:         00.00

         ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE
 OPER   MODE   DIAGS ALARM
```

User Value   The User Value screen allows the user to set the output value for the corresponding input voltage for the selected table point in the conversion table, from -9999999 to 99999999. The default table is a two-point table with point 1: 0.00 V = 000.0 U and point 2: 10.00 V = 10.0 U.

● In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Table Point > **User Value**.

```
┌─────────────────────────────────────┐
│ TABLE POINT 01 USER VAL:            │
│  CURRENTLY:            0.00         │
│     SET TO:        00000.0▉         │
│                                     │
│              ←→  MOVE CURSOR        │
│   ↑↓ CHANGE VALUE    ↵ SAVE         │
│                                     │
│  OPER   MODE   DIAGS ALARM          │
└─────────────────────────────────────┘
```
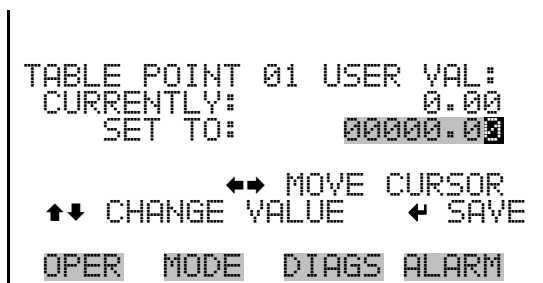
Screen Contrast   The Screen Contrast screen is used to change the contrast of the display. Intensities between 0 and 100% in increments of 10 are available. Changing the screen contrast may be necessary if the instrument is operated at extreme temperatures.

● In the Main Menu, choose Instrument Controls > **Screen Contrast**.

```
┌─────────────────────────────────────┐
│ SCREEN CONTRAST:                    │
│  CURRENTLY:           50 %          │
│     SET TO:           60 % ?        │
│                                     │
│              ↑↓ CHANGE VALUE        │
│               ↵ SAVE VALUE          │
│  OPER   MODE   DIAGS ALARM          │
└─────────────────────────────────────┘
```
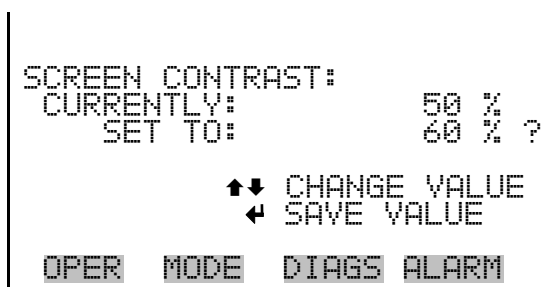
Service Mode   The Service Mode screen is used to turn the service mode on or off. The service mode locks out any remote actions and includes parameters and functions that are useful when making adjustments or diagnosing the Model 146*i*. For more information about the service mode, see "Service Menu" later in this chapter.

Note The service mode should be turned off when finished, as it prevents remote operation. ▲

● In the Main Menu, choose Instrument Controls > **Service Mode**.

```
SERVICE MODE:
 CURRENTLY:              OFF
    SET TO:              ON ?


                ↵ TOGGLE VALUE
 OPER   MODE   DIAGS ALARM
```

Date/Time

The Date/Time screen allows the user to view and change the system date and time (24-hour format). The internal clock is powered by its own battery when instrument power is off.

● In the Main Menu, choose Instrument Controls > **Date/Time**.

```
DATE AND TIME:
 19 MAR 2005  12:34:56
 PRESS ↵ TO EDIT



 OPER   MODE   DIAGS ALARM
```

```
DATE AND TIME:
 19 MAR 2005  12:34:56   ?
 SETTING: DAYS
             ➜ SET MONTHS
            ↑↓ CHANGE VALUE
             ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```

Diagnostics Menu

The Diagnostics menu provides access to diagnostic information and functions. This menu is useful when troubleshooting the instrument. The analog input readings and analog input voltages are only displayed if the I/O expansion board option is installed.

● In the Main Menu, choose **Diagnostics**.

```
DIAGNOSTICS:
>PROGRAM VERSION
 VOLTAGES
 FLOWS
 TEMPERATURES
 PRESSURE
 ANALOG INPUT READINGS
 ANALOG INPUT VOLTAGES      ↓
 OPER   MODE   DIAGS ALARM

 DIGITAL INPUTS
 RELAY STATES
```

```
        SOLENOID STATES
        TEST ANALOG OUTPUTS
        INSTRUMENT CONFIGURATION
        CONTACT INFORMATION
```

Program Version

The Program Version screen (read only) shows the version number of the program installed. Prior to contacting the factory with any questions regarding the instrument, please note the product model name and program version number.

● In the Main Menu, choose Diagnostics > **Program Version**.

```
  PROGRAM VERSION:
      PRODUCT:   MODEL 146i
      VERSION: 01.02.12.095



   OPER   MODE   DIAGS ALARM
```

Voltages

The Voltages menu displays the current diagnostic voltage readings. This screen enables the power supply to be quickly read for low or fluctuating voltages without having to use a voltage meter. The I/O board is only displayed if the I/O expansion board option is installed.

● In the Main Menu, choose Diagnostics > **Voltages**.

```
  VOLTAGES:
  >MOTHERBOARD
   INTERFACE BOARD
   I/O BOARD



   OPER   MODE   DIAGS ALARM
```

Motherboard Voltages

The Motherboard screen (read only) is used to display the current voltage readings on the motherboard.

● In the Main Menu, choose Diagnostics > Voltages > **Motherboard Voltages**.

```
MOTHERBOARD VOLTAGES:
   3.3 SUPPLY        3.3 V
   5.0 SUPPLY        5.0 V
  15.0 SUPPLY       15.0 V
  24.0 SUPPLY       24.1 V
  -3.3 SUPPLY       -3.3 V


OPER   MODE   DIAGS ALARM
```

Interface Board Voltages

The Interface Board screen (read only) is used to display the current voltage readings on the interface board.

● In the Main Menu, choose Diagnostics > Voltages > **Interface Board Voltages**.

```
INTERFACE BOARD VOLTAGES:
>   3.3 SUPPLY        3.3 V
    5.0 SUPPLY        5.0 V
   15.0 SUPPLY       15.0 V
  -15.0 SUPPLY      -15.0 V
   24.0 SUPPLY       24.0 V
  PHOTOMTR          12.0 V
  O3 LAMP           11.6 V↓
OPER   MODE   DIAGS ALARM
```

I/O Board Voltages

The I/O Board screen (read only) is used to display the current voltage readings on the I/O expansion board. This menu is only displayed if the I/O expansion board option is installed.

● In the Main Menu, choose Diagnostics > Voltages > **I/O Board Voltages**.

```
I/O BOARD VOLTAGES:
   3.3 SUPPLY        3.3 V
   5.0 SUPPLY        5.0 V
  15.0 SUPPLY       15.0 V
  24.0 SUPPLY       24.0 V
  -3.3 SUPPLY       -3.3 V


OPER   MODE   DIAGS ALARM
```

Flows   The Flows screen (read only) displays the current flow controller readings. The flow is measured by internal flow sensors.

● In the Main Menu, choose Diagnostics > **Flows**.

```
FLOWS:
 ZERO TARGET      8000 SCCM
 ZERO ACTUAL      7997 SCCM
 GAS TARGET      50.00 SCCM
 GAS ACTUAL      50.02 SCCM



  OPER   MODE   DIAGS ALARM
```

Temperatures   The Temperatures screen (read only) displays the current ambient temperature, bench temperature, bench lamp temperature, ozone lamp temperature, and permeation oven temperature.

● In the Main Menu, choose Diagnostics > **Temperatures**.

```
TEMPERATURES:
 AMBIENT          30.6  °C
 BENCH            30.7  °C
 BENCH LAMP       54.0  °C
 O3 LAMP          67.0  °C
 PERM OVEN GAS    40.0  °C
 PERM OVEN HTR    40.0  °C

  OPER   MODE   DIAGS ALARM
```

Pressure   The Pressure screen (read only) displays the current pressure reading. The pressure is measured by a pressure transducer.

● In the Main Menu, choose Diagnostics > **Pressure**.

```
PRESSURE:       743.0 mmHg




  OPER   MODE   DIAGS ALARM
```

Analog Input Readings

The Analog Input Readings screen (read only) displays the 8 current user-scaled analog readings (if the I/O expansion board option is installed).

● In the Main Menu, choose Diagnostics > **Analog Input Readings**.

```
ANALOG INPUT READINGS:
>CO              10.2 PPM
 SO2             18.2 PPB
 CO2              250 PPM
 FL1            20.42 LPM
 WND             9.86   V
 FL2            1.865 LPM
 IO7              0.0V    ↓

 OPER   MODE   DIAGS ALARM
```

Analog Input Voltages

The Analog Input Voltages screen (read only) displays the 8 raw analog voltage readings (if the I/O expansion board option is installed).

● In the Main Menu, choose Diagnostics > **Analog Input Voltages**.

```
ANALOG INPUT VOLTAGES:
>ANALOG IN 1      6.24  V
 ANALOG IN 2      4.28  V
 ANALOG IN 3      0.00  V
 ANALOG IN 4      0.00  V
 ANALOG IN 5      0.00  V
 ANALOG IN 6      0.00  V
 ANALOG IN 7      0.00  V↓

 OPER   MODE   DIAGS ALARM
```

Digital Inputs

The Digital Inputs screen (read only) displays the state of the 16 digital inputs.

● In the Main Menu, choose Diagnostics > **Digital Inputs**.

```
DIGITAL INPUTS:
>INPUT 1              1
 INPUT 2              1
 INPUT 3              1
 INPUT 4              1
 INPUT 5              1
 INPUT 6              1
 INPUT 7              1↓

 OPER   MODE   DIAGS ALARM
```

Relay States   The Relay States screen displays the state of the 10 digital outputs and
                          allows toggling of the state to either on (1) or off (0). The relays are
                          restored to their original states upon exiting this screen.

● In the Main Menu, choose Diagnostics > **Relay States**.

```
RELAY STATE:
>OUTPUT    1                0
 OUTPUT    2                0
 OUTPUT    3                0
 OUTPUT    4                1
 OUTPUT    5                0
 OUTPUT    6                0
 OUTPUT    7                0↓

  OPER   MODE   DIAGS ALARM
```

Solenoid States   The Solenoid State screen displays the state of the 10 digital outputs and
                          allows toggling of the state to either on (1) or off (0). The solenoids are
                          restored to their original states upon exiting this screen.

● In the Main Menu, choose Diagnostics > **Solenoid States**.

```
SOLENOID STATE:
>SOLENOID   1               1
 SOLENOID   2               0
 SOLENOID   3               0
 SOLENOID   4               0
 SOLENOID   5               0
 SOLENOID   6               0
 SOLENOID   7               0↓

  OPER   MODE   DIAGS ALARM
```

Test Analog Outputs   The Test Analog Outputs menu contains a number of digital to analog
                          converter (DAC) calibration items. Channel choices include all analog
                          outputs, 6 voltage channels, and 6 current channels (if the I/O expansion
                          board option is installed).

● In the Main Menu, choose Diagnostics > **Test Analog Outputs**.

```
TEST ANALOG OUTPUTS:
>ALL
 VOLTAGE CHANNEL 1
 VOLTAGE CHANNEL 2
 VOLTAGE CHANNEL 3
 VOLTAGE CHANNEL 4
 VOLTAGE CHANNEL 5
 VOLTAGE CHANNEL 6

 OPER   MODE   DIAGS ALARM
```

Set Analog Outputs   The Set Analog Outputs screen contains three choices: Set to full-scale, set to zero, or reset to normal. Full-scale sets the analog outputs to the full-scale voltage, zero sets the analog outputs to 0 volts, and normal operation. The example below shows the selected output state "ALL" is set to normal.

● In the Main Menu, choose Diagnostics > Test Analog Outputs > **ALL, Voltage Channel 1-6,** or **Current Channel 1-6**.

```
SET ANALOG OUTPUTS:
 SETTING:              ALL
 OUTPUT SET TO:     NORMAL
 ↑ SET TO FULL SCALE
 ↓ SET TO ZERO
 ← RESET TO NORMAL

 OPER   MODE   DIAGS ALARM
```

Instrument Configuration   The Instrument Configuration screen displays information on the hardware configuration of the instrument.

Note If the analyzer is in service mode, pressing ⏎ on the item will toggle it yes or no (with the exception of purchased options). ▲

● In the Main Menu, choose Diagnostics > **Instrument Configuration**.

```
 INSTRUMENT CONFIGURATION:
>I/O EXPANSION BOARD   YES
 GAS VALVES              6
 OZONATOR              YES
 PHOTOMETER             NO
 PERMEATION OVEN        NO



 OPER   MODE   DIAGS ALARM
```

Contact Information

The Contact Information screen displays the customer service information.

● In the Main Menu, choose Diagnostics > **Contact Information**.

```
 CONTACT INFORMATION:

  CALL CENTER: 508-520-0430

  WEB:        WWW.THERMO.COM

 OPER   MODE   DIAGS ALARM
```

Alarms Menu

The Alarms menu displays a list of items that are monitored by the instrument. 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. If the alarm is not a level alarm, the status will go from "OK" to "FAIL". The number of alarms detected is displayed to indicate 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 [←].

Items displayed are determined by the options installed. The motherboard status, interface board status, and I/O Expansion board status (if installed) indicate that the power supplies are working and connections are successful. There are no setting screens for these alarms.

● In the Main Menu, choose **Alarms**.

```
ALARMS:
 ALARMS DETECTED        0
>AMBIENT  TEMP          OK
 O3 LAMP TEMP           OK
 PERM OVEN TEMP         OK
 PRESSURE               OK
 PHOT BENCH TEMP        OK
 PHOT LAMP TEMP         OK↓

 OPER   MODE   DIAGS ALARM
```

```
 PHTO INTENSITY         OK
 MOTHERBOARD STATUS     OK
 INTERFACE STATUS       OK
 I/O EXP STATUS         OK
```

Ambient Temperature

The Ambient Temperature screen displays the current ambient temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 8 to 47 °C. If the ambient temperature reading goes beyond either the minimum or maximum alarm limit, an alarm is activated. The word "ALARM" appears in the Run screen and in the Main Menu.

● In the Main Menu, choose Alarms > **Ambient Temp**.

```
AMBIENT TEMPERATURE:
 ACTUAL          30.1 °C
>MIN             15.0 °C
 MAX             45.0 °C




 OPER   MODE   DIAGS ALARM
```

Min and Max Ambient Temperature Limits

The Minimum Ambient Temperature alarm limit screen is used to change the minimum ambient temperature alarm limit. The minimum and maximum ambient temperature screens function the same way.

● In the Main Menu, choose Alarms > Ambient Temp > **Min** or **Max**.

```
AMBIENT TEMPERATURE:
 ACTUAL MIN:    15.0  °C
 SET MIN TO:    15.1  °C     ?


            ⬆⬇ INC/DEC
             ↵ SAVE VALUE

 OPER   MODE   DIAGS ALARM
```
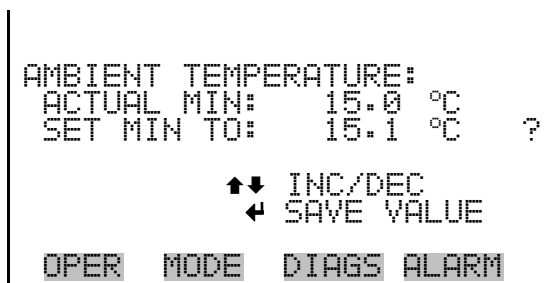
O₃ Lamp Temperature

The O₃ Lamp Temperature screen displays the current ozonator lamp temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 55 to 85 °C. If the O₃ lamp temperature reading goes beyond either the minimum or maximum alarm limit, an alarm is activated. The word "ALARM" appears in the Run screen and in the Main Menu.

● In the Main Menu, choose Alarms > **O3 Lamp Temp**.

```
O3 LAMP TEMPERATURE:
 ACTUAL           68.8  °C
>MIN              60.0  °C
 MAX              80.0  °C




 OPER   MODE   DIAGS ALARM
```

Min and Max O₃ Lamp Temperature Limits

The Minimum O₃ Lamp Temperature alarm limit screen is used to change the minimum O₃ lamp temperature alarm limit. The minimum and maximum O₃ lamp temperature screens function the same way.

● In the Main Menu, choose Alarms > O3 Lamp Temp > **Min** or **Max**.

```
O3 LAMP TEMPERATURE:
 ACTUAL MIN:    60.0  °C
 SET MIN TO:    68.0  °C    ?


            ⬆⬇ INC/DEC
             ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```
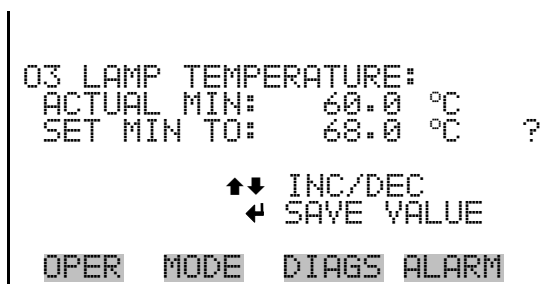
Permeation Oven Temperature

The Permeation Oven Temperature displays the current permeation gas temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from25 to 50 °C. If the permeation oven temperature reading goes beyond either the minimum or maximum limit, an alarm is activated. The word "ALARM" appears in the Run screen and in the Main Menu.

● In the Main Menu, choose Alarms > **Perm Oven Temp**.

```
POVEN GAS TEMPERATURE:
 ACTUAL          48.4  °C
>MIN             40.0  °C
 MAX             50.0  °C




 OPER   MODE   DIAGS ALARM
```

Min and Max Permeation Oven Temperature Limits

The Minimum Permeation Oven Temperature alarm limit screen is used to change the minimum bench temperature alarm limit. The minimum and maximum permeation oven temperature screens function the same way.

● In the Main Menu, choose Alarms > Perm Oven Temp > **Min** or **Max**.

```
POVEN GAS EMPERATURE:
 ACTUAL MIN:   40.0  °C
 SET MIN TO:   44.0  °C    ?

              ↑↓ INC/DEC
              ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```

Pressure

The Pressure screen displays the current reaction chamber pressure reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 200 to 1,000 mmHg. If the pressure reading goes beyond either the minimum or maximum limit, an alarm is activated. The word "ALARM" appears in the Run screen and in the Main Menu.

● In the Main Menu, choose Alarms > **Pressure**.

```
PRESSURE:
 ACTUAL            746.9 mmHg
>MIN               200.0 mmHg
 MAX              1000.0 mmHg



  OPER   MODE   DIAGS ALARM
```

Min and Max Pressure Limits

The Minimum Pressure alarm limit screen is used to change the minimum temperature alarm limit. The minimum and maximum pressure screens function the same way.

● In the Main Menu, choose Alarms > Pressure > **Min** or **Max**.

```
PRESSURE:
 ACTUAL MIN:   200.0 mmHg
 SET MIN TO:   250.0 mmHg ?

        ↑↓ INC/DEC
         ↵ SAVE VALUE
  OPER   MODE   DIAGS ALARM
```

Photometer Bench Temperature

The Photometer Bench Temperature screen displays the current bench temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 10 to 50 °C. If the bench temperature reading goes beyond either the minimum or maximum limit, an alarm is activated. The word "ALARM" appears in the Run screen and in the Main Menu.

● In the Main Menu, choose Alarms > **Phot Bench Temp**.

```
PHOT BENCH TEMPERATURE:
 ACTUAL             32.3 °C
>MIN                15.0 °C
 MAX                45.0 °C



  OPER   MODE   DIAGS ALARM
```

Min and Max Photometer Bench Temperature Limits

The Minimum Photometer Bench Temperature alarm limit screen is used to change the minimum bench temperature alarm limit. The minimum and maximum bench temperature screens function the same way.

● In the Main Menu, choose Alarms > Phot Bench Temp > **Min** or **Max**.

```
BENCH TEMPERATURE:
 ACTUAL MIN:    15.0  °C
 SET MIN TO:    16.0  °C     ?

          ↑↓  INC/DEC
           ↵  SAVE VALUE

 OPER   MODE   DIAGS ALARM
```
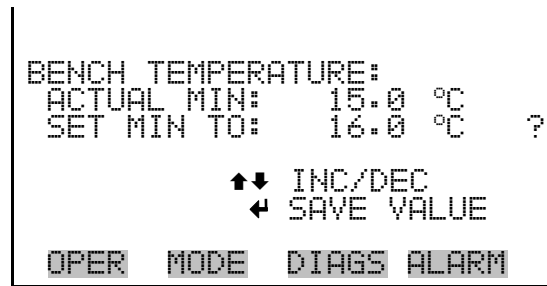
Photometer Lamp Temperature

The Photometer Lamp Temperature screen displays the current lamp temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 45 to 65 °C. If the bench temperature reading goes beyond either the minimum or maximum limit, an alarm is activated. The word "ALARM" appears in the Run screen and in the Main Menu.

● In the Main Menu, choose Alarms > **Phot Lamp Temp**.

```
PHOT LAMP TEMPERATURE:
 ACTUAL           32.3 °C
>MIN              50.0 °C
 MAX              60.0 °C




 OPER   MODE   DIAGS ALARM
```
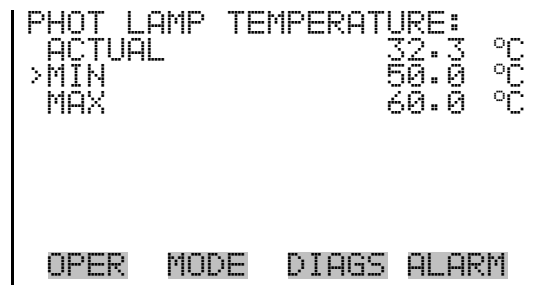
Min and Max Photometer Lamp Temperature Limits

The Minimum Photometer Lamp Temperature alarm limit screen is used to change the minimum lamp temperature alarm limit. The minimum and maximum lamp temperature screens function the same way.

● In the Main Menu, choose Alarms > Sample Flow > **Min** or **Max**.

```
PHOT LAMP TEMPERATURE:
 ACTUAL MIN:    50.0 °C
 SET MIN TO:    52.0 °C    ?

             ↑↓ INC/DEC
              ↵ SAVE VALUE

 OPER   MODE   DIAGS ALARM
```
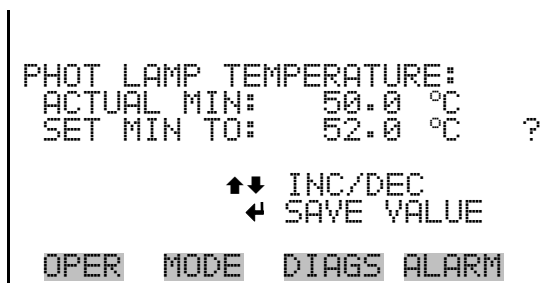
Photometer Intensity

The Photometer Intensity screen displays the current lamp intensity and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 0 to 300,000 Hertz. If the intensity reading goes beyond either the minimum or maximum limit, an alarm is activated. The word "ALARM" appears in the Run screen and in the Main Menu.

● In the Main Menu, choose Alarms > **Phot Intensity**.

```
PHOTOMETER INTENSITY:
 ACTUAL           98425 Hz
>MIN              45000 Hz
 MAX             150000 Hz




 OPER   MODE   DIAGS ALARM
```
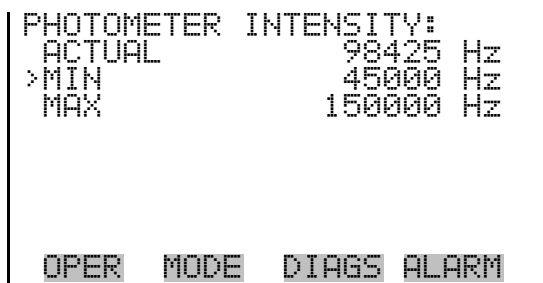
Min and Max Photometer Intensity Limits

The Minimum Photometer Intensity alarm limit screen is used to change the minimum intensity alarm limit. The minimum and maximum photometer intensity screens function the same way.

● In the Main Menu, choose Alarms > Sample Flow > **Min** or **Max**.

```
PHOTOMETER INTENSITY:
 ACTUAL MIN:    45000 Hz
 SET MIN TO:    55000 Hz ?

             ↑↓ INC/DEC
              ↵ SAVE VALUE
 OPER   MODE   DIAGS ALARM
```
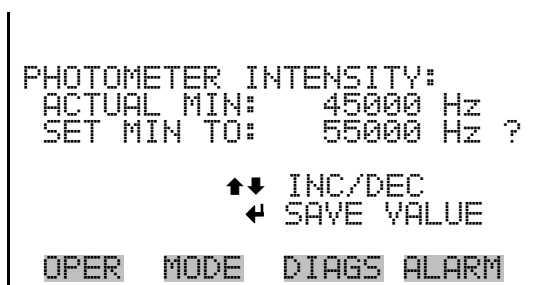
Service Menu   The Service menu appears only when the instrument is in the service mode. To put the instrument into the service mode:

●   In the Main Menu, choose Instrument Controls > **Service Mode**.

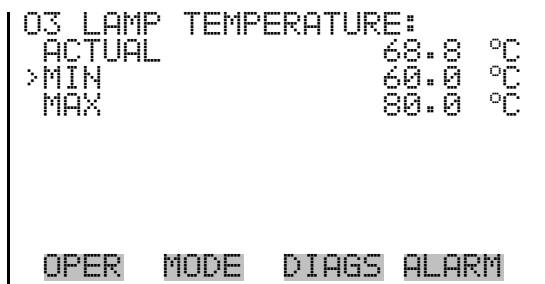Advanced diagnostic functions are included in the service mode. Meaningful data should not be collected when the instrument is in the service mode.

●   In the Main Menu, choose **Service**.

```
SERVICE:
>FLOW CONTROL SELECTION
 CALIBRATION PRES/TEMP
 ZERO FLOW CALIBRATION
 GAS FLOW CALIBRATION
 PRESSURE CALIBRATION
 AMBIENT TEMP CALIBRATION
 BENCH TEMP CALIBRATION  ↓

 OPER   MODE   DIAGS ALARM
```

```
 ANALOG OUT CALIBRATION
 ANALOG INPUT CALIBRATION
 PERM OVEN SETTINGS
 LAMP SETTING
 INTENSITY CHECK
 O3 RESPONSE COEFFICIENT
 DISPLAY PIXEL TEST
 RESTORE USER DEFAULTS
```

Flow Control Selection   The Flow Control Selection menu is used to select the installed zero-air controller and gas controller. The zero-air and gas controller screens are used when installing new mass flow controllers (for example, when installing controllers other than the standard 10 slm for zero-air, or 100 sccm for gas). The flow control selection is visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in this chapter.

●   In the Main Menu, choose Service > **Flow Control Selection.**

```
FLOW CONTROLLER SELECTION:
>ZERO SCALE        10  SLM
 GAS              100 SCCM




   OPER   MODE   DIAGS ALARM
```
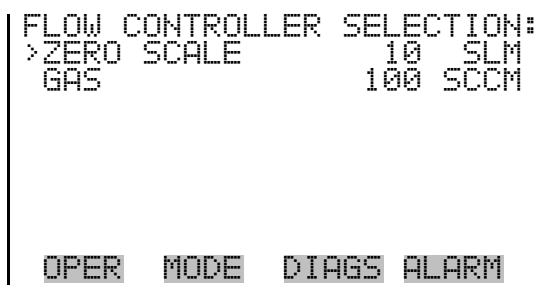
Zero-Air Flow Controller

The Zero-Air Flow Controller screen is used to select the zero-air controller. Allowable selections are: 5, 10, 15, and 20 slm. The zero-air flow controller calibration points are reset to defaults when a new controller is selected.

Note Changing the flow controller selection may affect allowable limits for span concentration and total flow. If is advisable to check these settings. ▲

The mass flow controllers are accurate to only ±2% upon delivery from the manufacturer. The instrument includes factory-set calibration curves to improve this accuracy. To achieve an equivalent accuracy when installing new controllers, see "Zero Flow Calibration" later in this chapter. ▲

● In the Main Menu, choose Service > Flow Control Selection > **Zero Scale.**

```
ZERO AIR FLOW CONTROLLER:
 CURRENTLY:       5 SLM
   SET TO:       20 SLM  ?

           ↑↓ CHANGE VALUE
           ↵ SAVE VALUE
   OPER   MODE   DIAGS ALARM
```
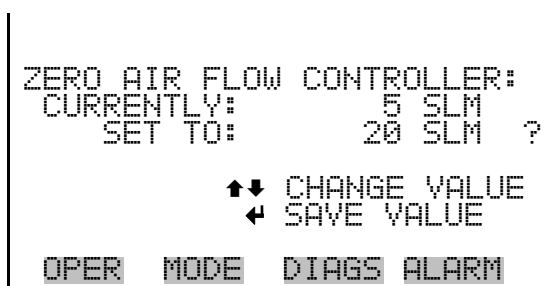
Gas Flow Controller

The Gas Flow Controller screen is used to select the gas controller. Allowable selections are: 25, 50, 100, 200, and 500 sccm. The gas flow controller calibration points are reset to defaults when a new controller is selected.

Note Changing the flow controller selection may affect allowable limits for span concentration and total flow. If is advisable to check these settings. ▲

The mass flow controllers are accurate to only ± 2% upon delivery from the manufacturer. The instrument includes factory-set calibration curves to improve this accuracy. To achieve an equivalent accuracy when installing new controllers, see "Gas Flow Calibration" later in this chapter. ▲

● In the Main Menu, choose Service > Flow Control Selection > **Gas.**

```
GAS FLOW CONTROLLER:
  CURRENTLY:          25 SCCM
      SET TO:        200 SCCM?

                  ↑↓ CHANGE VALUE
                   ↵ SAVE VALUE

 OPER   MODE   DIAGS ALARM
```
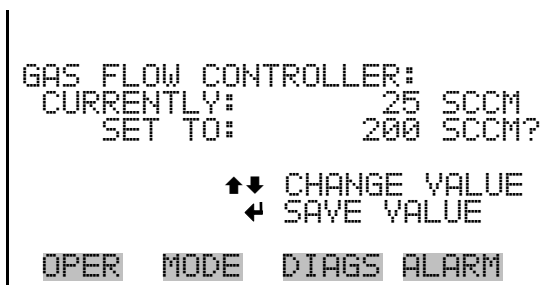
Calibration Pressure/Temperature The Calibrate Pressure/Temperature screen is used only prior to calibrating the flow controllers. These values are used to convert from volumetric flow to standard flow in the flow controller calibration screens. The flow controllers are calibrated prior to shipment. However, if you need to re-calibrate the flow controllers, you can use this screen to enter the pressure and temperature that existed during re-calibration.

Note When calibrating the flow controller, the pressure and temperature of the area immediately around the external flow sensor must be entered for an accurate calibration. The pressure is in millimetres mercury and the temperature is degrees Celsius. ▲

This adjustment should only be performed by an instrument service technician. ▲

● In the Main Menu, choose Service > **Calibration Pres/Temp.**

```
ENTER PRESS AND TEMP:
    PRESSURE: 760.0   mmHg
TEMPERATURE:   25.0   °C ?


          ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ↵ SAVE

  OPER   MODE   DIAGS ALARM
```
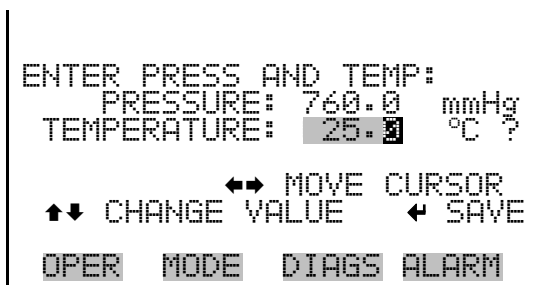
Zero Flow Calibration

The Zero Flow Calibration menu is used to calibrate the zero-air flow controller at 5, 20, 35, 50, 65, 80, and 95 percent of full-scale. Using a NIST traceable flow meter, the accuracy of the controller can be calibrated to about ± 1%, as opposed to the ± 2% accuracy rating when shipped from the manufacturer. The zero flow calibration is visible only when the instrument is in service mode. For more information of the service mode, see "Service Mode" earlier in the chapter.

Note This adjustment should only be performed by an instrument service technician. ▲

● In the Main Menu, choose Service > **Zero Flow Calibration.**

```
ZERO AIR FLOW CAL:
> 5% FS             0.500 SLM
 20% FS             2.000 SLM
 35% FS             3.500 SLM
 50% FS             5.000 SLM
 65% FS             6.500 SLM
 80% FS             8.000 SLM
 95% FS             9.500 SLM

  OPER   MODE   DIAGS ALARM
```

Zero Air Drive

The Zero Air Drive 20 screen is used to calibrate the zero-air mass flow controller using a NIST traceable flow meter as a reference. The zero drive 5, 35, 50, 65, 80, and 95% FS screens function the same way.

● In the Main Menu, choose Service > Zero Flow Calibration > **5, 20, 35, 50, 65, 80, or 95% FS.**

```
ZERO AIR DRIVE 5%:
 STD FLOW :    00.500 SLM
 VOL FLOW:     00.50█ LPM ?

              ←→  MOVE  CURSOR
    ↑↓ CHANGE VALUE    ↵ SAVE

   OPER   MODE   DIAGS ALARM
```

Gas Flow Calibration

The Gas Flow Calibration menu is used to calibrate the gas flow controller at 5, 20, 35, 50, 65, 80, and 95 percent of full-scale. Using a NIST traceable flow meter, the accuracy of the controller can be calibrated to about ± 1%, as opposed to the ± 2% accuracy rating when shipped from the manufacturer. The gas flow calibration is visible only when the instrument is in service mode. For more information of the service mode, see "Service Mode" earlier in the chapter.

Note This adjustment should only be performed by an instrument service technician. ▲

● In the Main Menu, choose Service > **Gas Flow Calibration.**

```
GAS FLOW CAL:
>SOLENOID               A
  5% FS           0.500 SCCM
 20% FS           2.000 SCCM
 35% FS           3.500 SCCM
 50% FS           5.000 SCCM
 65% FS           6.500 SCCM
 80% FS           8.000 SCCM

  OPER   MODE   DIAGS ALARM

 95% FS           9.500 SCCM
```
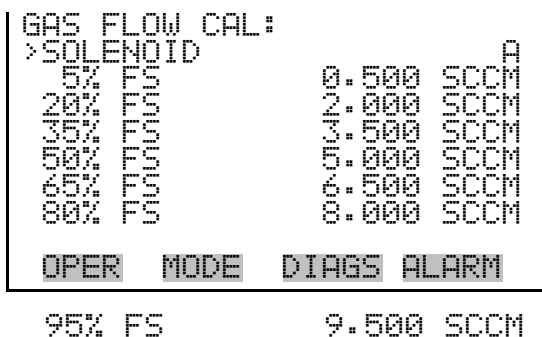
Gas Flow Calibration Solenoid Select

The Gas Flow Calibration Solenoid Select is used to select the solenoid that is active during the gas flow controller calibration. Solenoid choices include: Solenoid A, B, or C, and Solenoid D, E, or F (if installed).

● In the Main Menu, choose Service > Gas Flow Calibration > **Solenoid.**

```
┌─────────────────────────────────────┐
│ GAS FLOW CAL SOL SELECT:             │
│  CURRENTLY:   SOLENOID A             │
│      SET TO:   SOLENOID B ?          │
│                                      │
│              ↑↓ CHANGE VALUE         │
│               ↵ SAVE VALUE           │
│                                      │
│  OPER   MODE   DIAGS ALARM           │
└─────────────────────────────────────┘
```

Gas Drive   The Gas Drive screen is used to calibrate the gas-air mass flow controller using a NIST traceable flow meter as a reference. The zero drive 5, 35, 50, 65, 80, and 95% FS screens function the same way.

● In the Main Menu, choose Service > Gas Flow Calibration > **5, 20, 35, 50, 65, 80, or 95% FS.**

```
┌─────────────────────────────────────┐
│                                      │
│ GAS DRIVE 5%:                        │
│  STD FLOW :   010.22 SCCM            │
│  VOL FLOW :   010.24 SCCM ?          │
│                                      │
│              ←→ MOVE CURSOR          │
│   ↑↓ CHANGE VALUE      ↵ SAVE        │
│                                      │
│  OPER   MODE   DIAGS ALARM           │
└─────────────────────────────────────┘
```
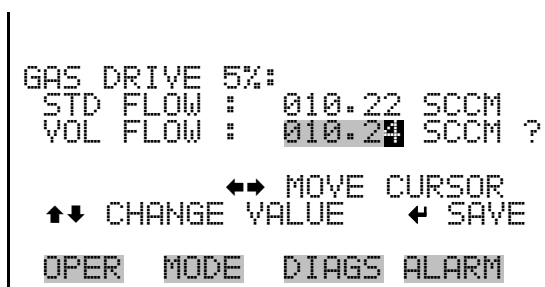
Pressure Calibration   The Pressure Calibration menu is used to calibrate the pressure sensor to zero, span, or restore factory default values. The pressure calibration is visible only if the photometer option is installed and when the calibrator is in service mode. For more information on the service mode, see "Service Mode" earlier in this chapter.

The pressure sensor's zero counts and span slope are displayed on the menu.

Note This adjustment should only be performed by an instrument service technician. ▲

● In the Main Menu, choose Service > **Pressure Calibration**.

```
PRESSURE SENSOR CAL:
>ZERO                  72
 SPAN              1.1447
 SET DEFAULTS




 OPER   MODE   DIAGS ALARM
```

Calibrate Pressure Zero

The Calibrate Pressure Zero screen calibrates the pressure sensor at zero pressure.

Note A vacuum pump must be connected to the pressure sensor before performing the zero calibration. ▲

● In the Main Menu, choose Service > Pressure Calibration > **Zero**.

```
CALIBRATE PRESSURE ZERO:
 CURRENTLY:    753.0 mmHg
    SET TO:      0.0 mmHg

 CONNECT VACUUM PUMP AND
   ↵ SAVE ZERO PRESSURE
 OPER   MODE   DIAGS ALARM
```

Calibrate Pressure Span

The Calibrate Pressure Span screen is used to view and set the pressure sensor calibration span point.

Note The plumbing going to the pressure sensor should be disconnected so the sensor is reading ambient pressure before performing the span calibration. The operator should use an independent barometer to measure the ambient pressure and enter the value on this screen before calibrating. ▲

● In the Main Menu, choose Service > Pressure Calibration > **Span**.

```
CALIBRATE PRESSURE SPAN:
 CURRENTLY:   753.0 mmHg
    SET TO:   760.0 mmHg ?

          ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ← SAVE

 OPER   MODE  DIAGS ALARM
```
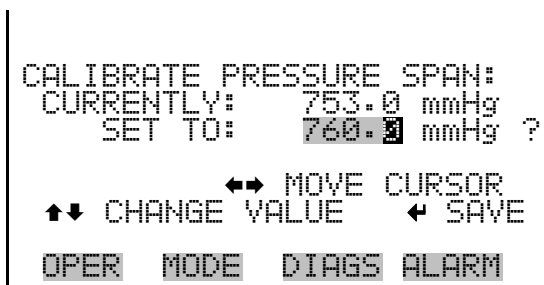
Restore Default Calibration

The Restore Default Calibration screen is used to reset the pressure calibration configuration values to factory defaults.

● In the Main Menu, choose Service > Pressure Calibration > **Set Defaults**.

```
RESTORE USER DEFAULTS:

              ← RESTORE




 OPER   MODE  DIAGS ALARM
```

```
RESTORE USER DEFAULTS:

              ← RESTORE
ARE YOU SURE YOU WANT TO?
PRESS → TO CONFIRM RESTORE


 OPER   MODE  DIAGS ALARM
```
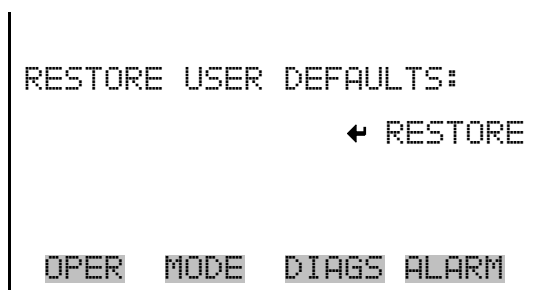
Ambient Temperature Calibration

The Ambient Temperature Calibration screen is used to view and set the ambient temperature sensor calibration. The ambient temperature calibration is visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

Note This adjustment should only be performed by an instrument service technician. ▲
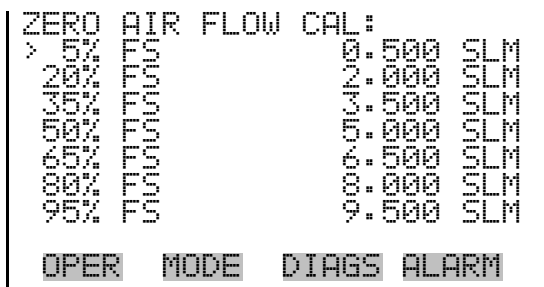
● In the Main Menu, choose Service > **Ambient Temp Calibration**.

```
CALIBRATE AMBIENT TEMP:
 CURRENTLY:      32.3 °C
    SET TO:     030.█ °C    ?

            ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ← SAVE

  OPER   MODE   DIAGS ALARM
```
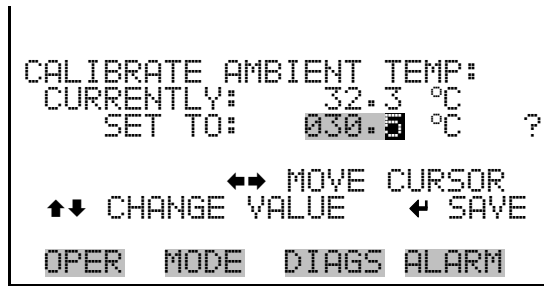
Bench Temperature Calibration

The Bench Temperature Calibration screen is used to view and set the bench temperature sensor calibration. This temperature is used for compensation of the photometer option's ozonator measurement. The temperature calibration is visible only if the photometer option is installed and when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

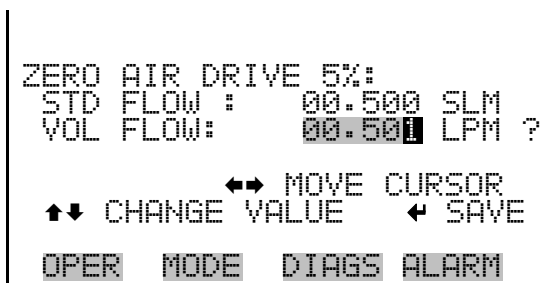**Note** This adjustment should only be performed by an instrument service technician. ▲

● In the Main Menu, choose Service > **Bench Temp Calibration**.

```
CALIBRATE BENCH TEMP:
 CURRENTLY:      32.3 °C
    SET TO:     032.█ °C    ?

            ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ← SAVE

  OPER   MODE   DIAGS ALARM
```
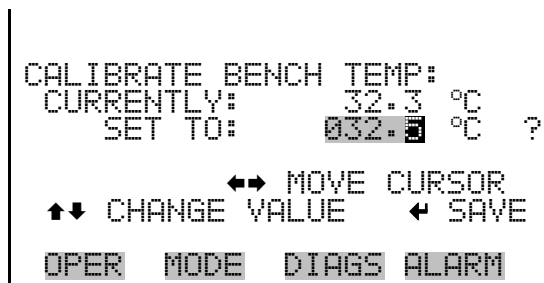
Analog Output Calibration

The Analog Output Calibration menu is a selection of 6 voltage channels and 6 current channels (if I/O expansion board option is installed) to calibrate, and allows the user to select the calibration action zero or span. The analog output calibration is visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

Note This adjustment should only be performed by an instrument service technician. ▲
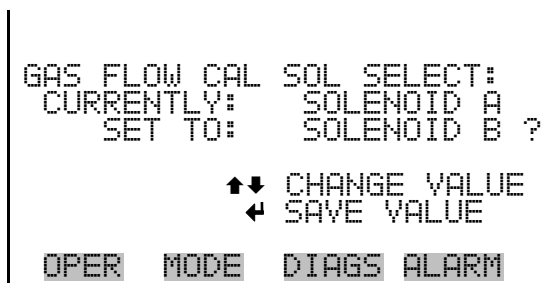
● In the Main Menu, choose Service > **Analog Out Calibration**.

```
 ANALOG OUTPUT CAL:
>VOLTAGE CHANNEL 1
 VOLTAGE CHANNEL 2
 VOLTAGE CHANNEL 3
 VOLTAGE CHANNEL 4
 VOLTAGE CHANNEL 5
 VOLTAGE CHANNEL 6
 CURRENT CHANNEL 1            ↓
 ▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬
 OPER   MODE   DIAGS ALARM
```

```
 ANALOG OUTPUT CAL:
>CALIBRATE ZERO
 CALIBRATE FULL SCALE



 ▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬
 OPER   MODE   DIAGS ALARM
```

Analog Output Calibrate Zero
The Analog Output Calibrate Zero screen is used to calibrate the zero state of the selected analog output. The operator must connect a meter to the output and adjust the output until it reads 0.0 V on the meter.

● In the Main Menu, choose Service > Analog Out Calibration > Select Channel > **Calibrate Zero**.

```
 ANALOG OUTPUT CAL:    ZERO
 CONNECT METER TO OUTPUT!
  SELECTED OUTPUT:      V1
  SET TO:              100
 ↵ SAVE VALUE   ↑↓ INC/DEC
 SET OUTPUT TO:      0.0 V
 ▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬
 OPER   MODE   DIAGS ALARM
```

Analog Output Calibrate Full-Scale
The Analog Output Calibrate Full-Scale screen is used to calibrate the full-scale state of the selected analog output. The operator must connect a meter to the output and adjust output until it reads the value shown in the set output to: field.

● In the Main Menu, choose Service > Analog Out Calibration > Select Channel > **Calibrate Full Scale**.

```
ANALOG OUTPUT CAL:    SPAN
 CONNECT METER TO OUTPUT!
   SELECTED OUTPUT:      V1
   SET TO:             3976
 ← SAVE VALUE   ↑↓ INC/DEC
 SET OUTPUT TO:       10 V

 OPER   MODE   DIAGS ALARM
```

Analog Input Calibration

The Analog Input Calibration menu is a selection of 8 analog inputs (if the I/O expansion board option is installed) to calibrate, and allows the user to select the calibration action zero or span. The analog input calibration is visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

Note This adjustment should only be performed by an instrument service technician. ▲

● In the Main Menu, choose Service > **Analog Input Calibration**.

```
ANALOG INPUT CAL:
>INPUT CHANNEL 1
 INPUT CHANNEL 2
 INPUT CHANNEL 3
 INPUT CHANNEL 4
 INPUT CHANNEL 5
 INPUT CHANNEL 6
 INPUT CHANNEL 7            ↓

 OPER   MODE   DIAGS ALARM
```

```
ANALOG INPUT CAL:
>CALIBRATE ZERO
 CALIBRATE FULL SCALE




 OPER   MODE   DIAGS ALARM
```

Analog Input Calibrate Zero

The Analog Input Calibrate Zero screen is used to calibrate the zero state of the selected analog input.

● In the Main Menu, choose Service > Analog Input Calibration > Select Channel > **Calibrate Zero**. (Hook up a voltage source of 0 V to the analog input channel.)

```
ANALOG INPUT CAL:     ZERO
DISCONNECT SELECTED INPUT!
 SELECTED INPUT:    INPUT 1
 CURRENTLY:          0.12 V ?

 ↵ CALIBRATE INPUT TO ZERO

OPER   MODE   DIAGS ALARM
```

Analog Input Calibrate Full-Scale

The Analog Input Calibration Full-Scale screen is used to calibrate the full-scale state of the selected analog input.

● In the Main Menu, choose Service > Analog Input Calibration > Select Channel > **Calibrate Full Scale**. (Hook up a voltage source of 10 V to the analog input channel.)

```
ANALOG INPUT CAL:     SPAN
PROVIDE VOLTAGE TO INPUT!
 SELECTED INPUT:    INPUT 1
 CURRENTLY:         6.24 V
    SET TO:        10.0█ V ?
 ↵ CALIBRATE INPUT TO ZERO

OPER   MODE   DIAGS ALARM
```

Permeation Oven Settings

The Permeation Oven Settings menu is used for setting up and calibrating the permeation oven option. The permeation oven settings are visible only if the permeation oven option installed and when the calibrator is in service mode. For more information on the service mode, see "Service Mode" earlier in this chapter.

● In the Main Menu, choose Service > **Perm Oven Settings**.

Note This adjustment should only be performed by an instrument service technician. ▲

```
PERM OVEN SETTINGS:
>CAL GAS THERMISTOR
 CAL OVEN THERMISTOR
 PERM OVEN SELECTION
 FACTORY CAL GAS THERM
 FACTORY CAL OVEN THERM



 OPER   MODE   DIAGS ALARM
```

Calibrate Gas Thermistor   The Calibrate Gas Thermistor menu is used for calibrating the permeation oven gas thermistor using a water bath or known resistance.

● In the Main Menu, choose Service > Perm Oven Settings > **Cal Gas Thermistor**.

```
CALIBRATE GAS THERMISTOR:
>WATER BATH
 KNOWN RESISTOR






 OPER   MODE   DIAGS ALARM
```

Water Bath   The Calibrate Gas Thermistor Water Bath screen is used to view and set the permeation oven gas temperature to a known temperature value.

● In the Main Menu, choose Service > Perm Oven Settings > Cal Gas Thermistor > **Water Bath**.

```
CAL GAS THERM (BATH):
 CURRENTLY:      45.80  °C
    SET TO:      45.0█  °C

            ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ↵ SAVE
 OPER   MODE   DIAGS ALARM
```

Resistor

The Calibrate Gas Thermistor Resistor screen is used to view and set the permeation oven gas thermistor resistance to a known resistor value.

● In the Main Menu, choose Service > Perm Oven Settings > Cal Gas Thermistor > **Known Resistor**.

```
CAL GAS THERM (RESISTOR):
 CURRENTLY:      3850 Ohms
    SET TO:     04000 Ohms

              ◄► MOVE CURSOR
  ▲▼ CHANGE VALUE    ↵ SAVE

 OPER   MODE   DIAGS ALARM
```
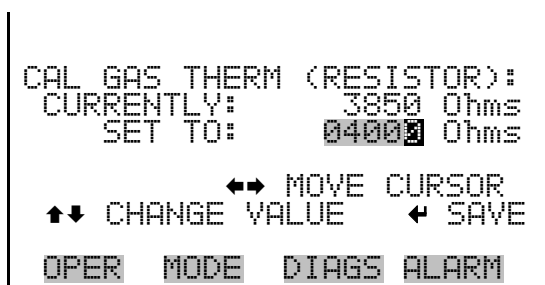
Calibrate Oven Thermistor

The Calibrate Oven Thermistor screen is used to view and set the permeation oven thermistor resistance to a known resistor value.

● In the Main Menu, choose Service > Perm Oven Settings > **Cal Oven Thermistor**.

```
CAL OVEN THERM (RESISTOR):
 CURRENTLY:      3850 Ohms
    SET TO:     04000 Ohms

              ◄► MOVE CURSOR
  ▲▼ CHANGE VALUE    ↵ SAVE

 OPER   MODE   DIAGS ALARM
```
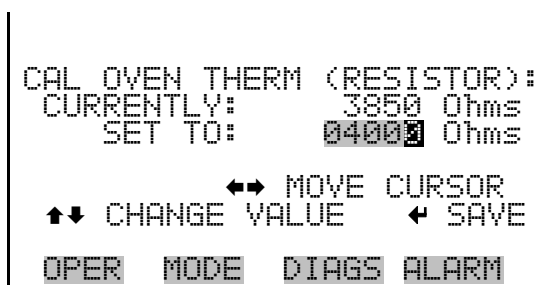
Permeation Oven Selection

The Permeation Oven Setpoint screen is used to select the permeation oven state to not present, or the desired temperature choice of 30, 35, and 45 °C.

● In the Main Menu, choose Service > Perm Oven Settings > **Perm Oven Selection**.

```
PERM OVEN SETPOINT:
 CURRENTLY:  NOT PRESENT
     SET TO:      45  °C ?

              ←➡ MOVE CURSOR
  ↑↓ CHANGE VALUE   ↵ SAVE
 OPER   MODE   DIAGS ALARM
```

Factory Calibrate Gas Thermistor   The Factory Calibrate Gas Thermistor menu is used for calibrating the permeation oven gas thermistor to either low point, high point, or set defaults.

● In the Main Menu, choose Service > Perm Oven Settings > **Factory Cal Gas Therm**.

```
FACTORY CAL GAS THERM:
>LOW POINT
 HIGH POINT
 SET DEFAULTS




 OPER   MODE   DIAGS ALARM
```

Low and High Points   The Calibrate Gas Thermistor Low Point screen is used to view and set the permeation oven thermistor resistance. The low and high point screens function the same way.

● In the Main Menu, choose Service > Perm Oven Settings > Factory Cal Gas Therm > **Low** or **High Point**.

```
CAL GAS THERM LOW POINT:
 CURRENTLY:  0= 3850 Ohms
    SET TO:     04005 Ohms

              ←➡ MOVE CURSOR
  ↑↓ CHANGE VALUE   ↵ SAVE
 OPER   MODE   DIAGS ALARM
```

Set Defaults   The Set Defaults screen is used to reset the configuration values to factory defaults.

● In the Main Menu, choose Service > Perm Oven Settings > Factory Cal Gas Therm > **Set Defaults**.

```
RESTORE DEFAULT SETTINGS:        RESTORE DEFAULT SETTINGS:
 FOR PERM OVEN GAS THERM          FOR PERM OVEN GAS THERM
               ↵ RESTORE                       ↵ RESTORE
                                 ARE YOU SURE YOU WANT TO?
                                 PRESS  ➜  TO CONFIRM RESTORE


 OPER   MODE   DIAGS ALARM        OPER   MODE   DIAGS ALARM
```

Factory Calibrate Oven   The Factory Calibrate Oven Thermistor menu is used for calibrating the
Thermistor   permeation oven heater thermistor to either low point, high point, or set defaults.

● In the Main Menu, choose Service > Perm Oven Settings > **Factory Cal Oven Therm**.

```
FACTORY CAL OVEN THERM:
>LOW POINT
 HIGH POINT
 SET DEFAULTS




 OPER   MODE   DIAGS ALARM
```
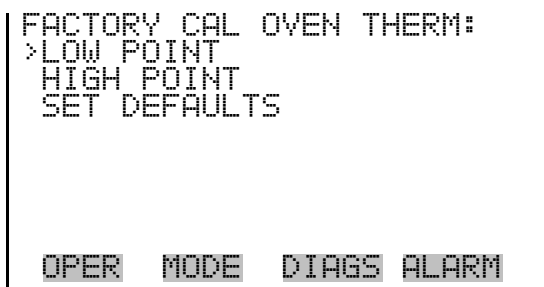
Low and High Points   The Calibrate Oven Thermistor Low Point screen is used to view and set the permeation oven thermistor resistance. The low and high point screens function the same way.

● In the Main Menu, choose Service > Perm Oven Settings > Factory Cal Oven Therm > **Low** or **High Point**.
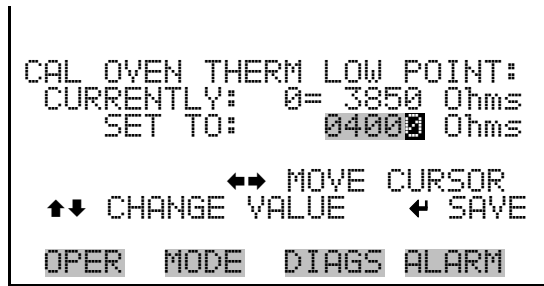
```
CAL OVEN THERM LOW POINT:
 CURRENTLY:   0= 3850 Ohms
    SET TO:      04005 Ohms

          ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ← SAVE
 OPER   MODE   DIAGS ALARM
```

Set Defaults   The Set Defaults screen is used to reset the configuration values to factory defaults.

●   In the Main Menu, choose Service > Perm Oven Settings > Factory Cal Oven Therm > **Set Defaults**.

```
RESTORE DEFAULT SETTINGS:
 FOR PERM OVEN HTR THERM
             ← RESTORE



 OPER   MODE   DIAGS ALARM
```

```
RESTORE DEFAULT SETTINGS:
 FOR PERM OVEN HTR THERM
             ← RESTORE
ARE YOU SURE YOU WANT TO?
PRESS  ➡ TO CONFIRM RESTORE

 OPER   MODE   DIAGS ALARM
```
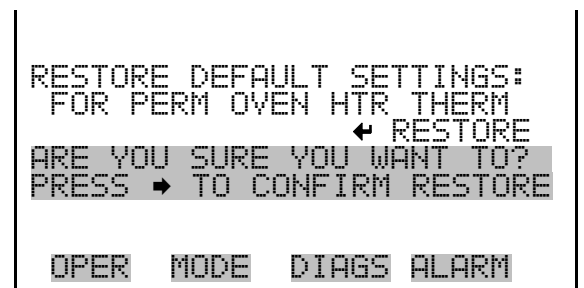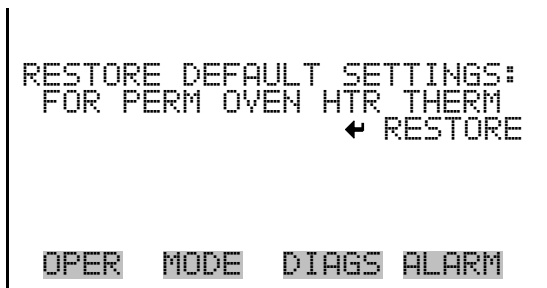
Lamp Setting   The Lamp Setting screen is used to adjust the photometer lamp drive. The intensity and current lamp drive settings are displayed. Adjust the lamp setting until the intensity is about 10000 Hz. The lamp setting is visible only if the photometer option is installed and when the calibrator is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

●   In the Main Menu, choose Service > **Lamp Setting.**

```
BENCH LAMP SETTING:
 INT:          100246 Hz
LAMP SETTING:    61.1 %

          ↑↓ CHANGE VALUE
          ← SAVE VALUE
 OPER   MODE   DIAGS ALARM
```
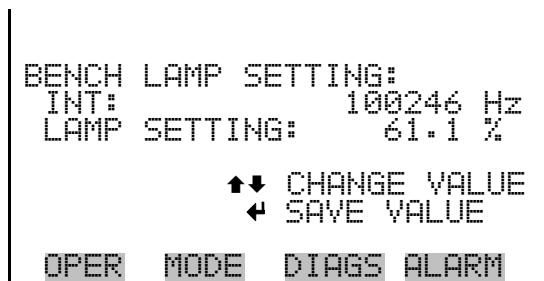
Intensity Check   The Intensity Check menu is used to manually control the flow of reference of sample gas through the photometer. This enables the intensity and noise reading of the detector to be determined with either reference or sample gas flow. Selecting any of these menu choices will disturb the analog outputs. The intensity check is visible only if the photometer option is installed and when the calibrator is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

● In the Main Menu, choose Service > **Intensity Check**.

```
INTENSITY CHECK:
>REFERENCE GAS
 SAMPLE GAS




 OPER   MODE   DIAGS ALARM
```

Reference Gas   The Reference Gas screen (read only) sets the valves to route the reference gas through the photometer and displays the intensity and noise.

● In the Main Menu, choose Service > Intensity Check > **Reference Gas**.

```
PHOTOMETER REFERENCE GAS:
  INTENSITY:      98425 Hz
     NOISE:          1.4



 OPER   MODE   DIAGS ALARM
```

Sample Gas   The Sample Gas screen (read only) sets the valves to route the sample gas through the photometer and displays the intensity and noise.

● In the Main Menu, choose Service > Intensity Check > **Sample Gas**.

```
┌─────────────────────────────────────┐
│                                     │
│  PHOTOMETER SAMPLE GAS:             │
│    INTENSITY:        98425 Hz       │
│       NOISE:           1.4          │
│                                     │
│                                     │
│                                     │
│   OPER   MODE   DIAGS ALARM         │
└─────────────────────────────────────┘
```
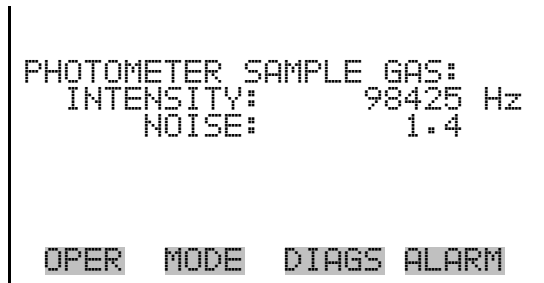
O₃ Response Coefficient

The O₃ Response Coefficient screen is used to manually adjust the O₃ response coefficient for the photometer option. The value is used to adjust how fast the ozonator drive is changed when under photometer control and should usually be left at 1.000. The O₃ response coefficient is visible only if the photometer option is installed and when the calibrator is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

● In the Main Menu, choose Service > **O3 Response Coefficient**.

```
┌─────────────────────────────────────┐
│                                     │
│  O3 RESPONSE COEFFICIENT:           │
│    CURRENTLY:         1.000         │
│       SET TO:        1.250?         │
│                                     │
│            ↑↓ CHANGE VALUE          │
│             ↵ SAVE VALUE            │
│   OPER   MODE   DIAGS ALARM         │
└─────────────────────────────────────┘
```
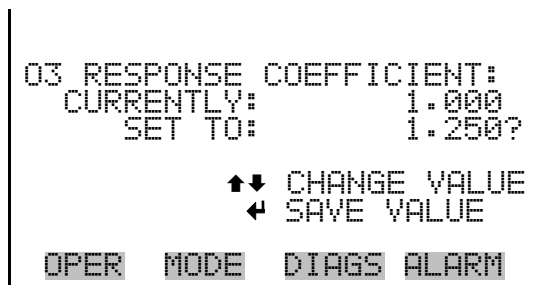
Display Pixel Test

The Display Pixel Test is used to test the LCD display. The display pixel test is visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

● In the Main Menu, choose Service > **Display Pixel Test**.

```
┌─────────────────────────────────────┐
│                                     │
│  DISPLAY PIXEL TEST:                │
│  DURING TEST PRESS ▤ OR  ▶          │
│  TO EXIT,  ↵ TO TOGGLE              │
│                                     │
│             ↵ BEGIN TEST            │
│             ▤ GO BACK TO MENU       │
│   OPER   MODE   DIAGS ALARM         │
└─────────────────────────────────────┘
```
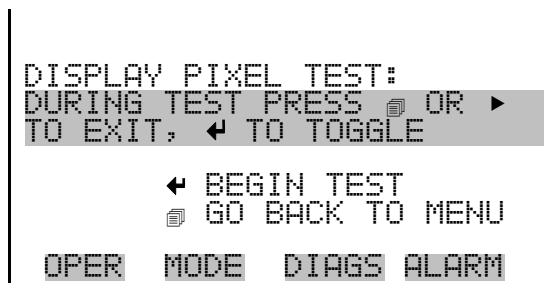
Restore User Defaults

The Restore User Defaults screen is used to reset the user calibration and configuration values to factory defaults. The restore default user is visible only when the instrument is in service mode. For more information on the service mode, see "Service Mode" earlier in the chapter.

● In the Main Menu, choose Service > **Restore User Defaults.**

```
RESTORE USER DEFAULTS:              RESTORE USER DEFAULTS:

                    ↵ RESTORE                           ↵ RESTORE
                                    ARE YOU SURE YOU WANT TO?
                                    PRESS ➧ TO CONFIRM RESTORE


OPER   MODE   DIAGS ALARM           OPER   MODE   DIAGS ALARM
```

Password

The Password menu allows the user to configure password protection. If the instrument is locked, none of the settings may be changed via the front panel user interface. The items visible under the password menu are determined by the instrument's password status.

● In the Main Menu, choose **Password**.

```
PASSWORD MENU:
>SET PASSWORD
 LOCK INSTRUMENT
 CHANGE PASSWORD
 REMOVE PASSWORD
 UNLOCK INSTRUMENT


OPER   MODE   DIAGS ALARM
```

Set Password

The Set Password screen is used to set the password to unlock the front panel. The set password is shown if the instrument is unlocked and the password is set.

● In the Main Menu, choose Password > **Set Password.**

```
ENTER NEW PASSWORD:
          ▉

          ▉BCDEFGHIJKLMN   BKSP
          OPQRSTUVWXYZ     PAGE
          0123456789 ./-   SAVE

   OPER   MODE   DIAGS ALARM
```

Lock Instrument

The Lock Instrument screen is used to lock the instrument's front panel so users can not change any settings from the front panel. The lock instrument is shown if the instrument is unlocked and the password is set.

● In the Main Menu, choose Password > **Lock Instrument.**

```
LOCK FRONT PANEL:
     PRESSING ENTER WILL
PREVENT USER FROM CHANGING
CONFIG FROM FRONT PANEL
   ↵ LOCK AND RETURN TO RUN

   OPER   MODE   DIAGS ALARM
```

Change Password

The Change Password is used to change the password used to unlock the instrument's front panel. The change password is shown if the instrument is unlocked.

● In the Main Menu, choose Password > **Change Password.**

```
ENTER NEW PASSWORD:
          ▉

          ▉BCDEFGHIJKLMN   BKSP
          OPQRSTUVWXYZ     PAGE
          0123456789 ./-   SAVE

   OPER   MODE   DIAGS ALARM
```

Remove Password

The Remove Password screen is used to erase the current password and disable password protection. The remove password is shown if the instrument is unlocked and the password set.

● In the Main Menu, choose Password > **Remove Password.**

```
REMOVE PASSWORD:
     PRESSING ENTER WILL
 REMOVE CURRENT PASSWORD
    AND DISABLE LOCKING
       ↵ REMOVE PASSWORD

  OPER   MODE   DIAGS ALARM
```

Unlock Instrument

The Unlock Instrument screen is used to enter the password to unlock the front panel. The unlock instrument is shown if the instrument is locked.

● In the Main Menu, choose Password > **Unlock Instrument.**

```
ENTER NEW PASSWORD:
               ■

    ■BCDEFGHIJKLMN   BKSP
    OPQRSTUVWXYZ     PAGE
    0123456789 ./-  SAVE
  OPER   MODE   DIAGS ALARM
```

Chapter 4 Calibration

Mass Flow Controllers

In order to calibrate the mass flow meter section of the zero or gas mass flow controller, a NIST traceable flow meter is required. The term calibration means determining the actual flow versus the flow setting for seven equally spaced flows along the range of the device. The Model 146*i* then corrects the output according to an internal algorithm.

Calibration may be done with a properly calibrated flow meter. For the most accurate calibration procedure, use a volumetric NIST traceable calibrator with the following step-by-step calibration procedure.

1. Connect a source of clean, dry air to the inlet of the mass flow controller.

2. Measure barometric pressure and room temperature.

3. Connect a suitable flow meter to the mass flow controller outlet.

4. Set Model 146*i* to Gas Drive or Zero Air Flow Calibration as described in the "Operation" chapter.

5. Set flow controller to 95 percent of full scale, then wait until flow meter reading stabilizes.

6. Enter the flow meter reading using the flow input screen.

7. Repeat Steps 5 and 6 for the remaining flow settings.

If difficulty is encountered due to a flow controller malfunction, contact Thermo Fisher Scientific.

Photometer Calibration

The ozone generator used on the Model 146*i* qualifies as a transfer standard under current U.S. Environmental Protection Agency requirements. In order to use it as a transfer standard, the user must certify the generator, following the procedures published in the technical assistance document for the calibration of ozone transfer standards.

In order to determine a calibration curve for the ozone generator, an ozone primary standard must be used. If an ozone analyzer is also available, the generation of the calibration curve becomes easier. A procedure for both is given below.

Calibration Using a Model 49*i* PS

Use the following procedure to calibrate the Model 146*i* using a Model 49*i* PS. Refer to the Photometer Calibration Flow Schematic (Figure 4-1).

1. Connect the 49*i* PS OUTPUT to the 146*i* EXTERNAL SAMPLE port.

2. Set flow of the 49*i* PS to the desired level.

3. Determine the ozone concentration at different ozone level settings on the 146*i*.

4. Determine a calibration curve by plotting the results of Step 3.

5. Change to the 146*i* Photometer Calibration Span.

6. For highest confidence, reconnect the 49*i* PS to the 146*i* and recheck the ozone calibrations.
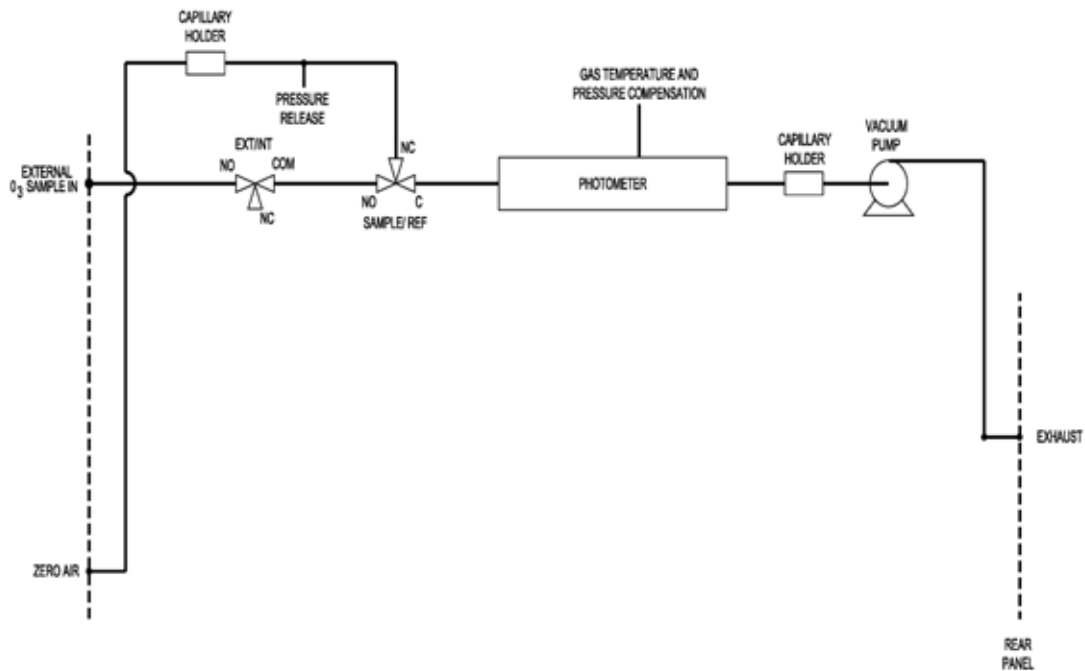
Figure 4-1. Photometer Calibration Flow Schematic

Ozonator Control Check

Use the following procedure to perform an ozonator control check. Refer to the ozonator control check flow schematic (Figure 4-2).

1. Connect the 146*i* OUTPUT port to the 49*i* PS INPUT port.

2. Set ozone concentration at different levels.

3. Compare the ozone concentration readings on the 146*i* and 49*i* PS.
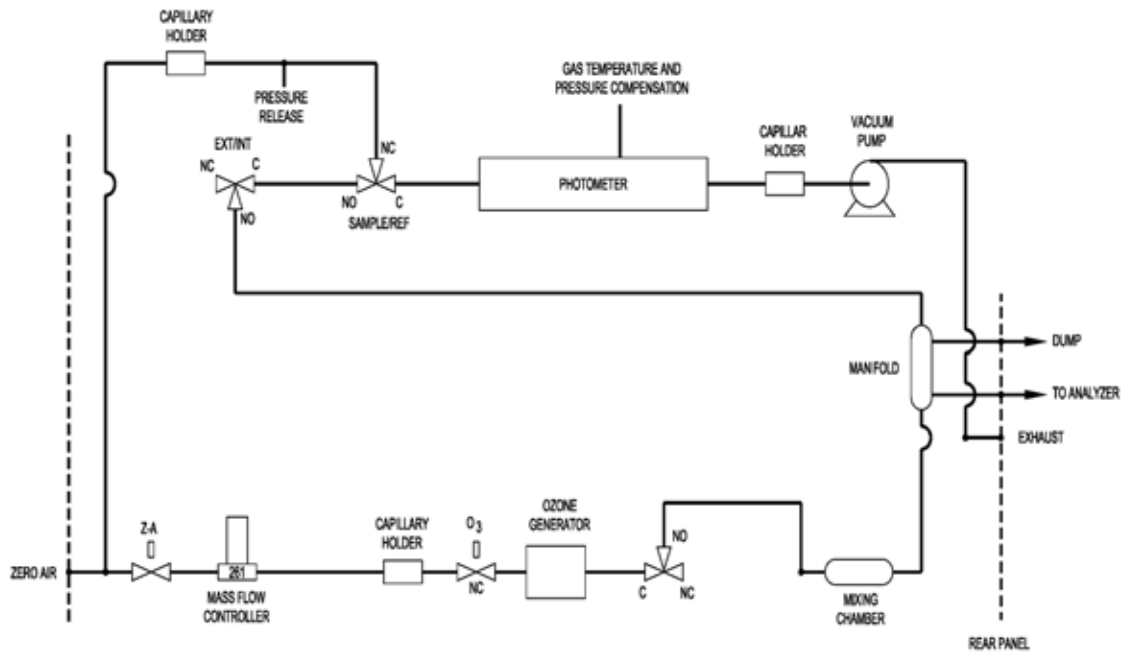
Figure 4-2. Ozonator Control Check Flow Schematic

Chapter 5 **Preventive Maintenance**

This chapter describes the periodic maintenance procedures that should be performed on the instrument to ensure proper operation.

Since usage and environmental conditions vary greatly, you should inspect the components frequently until an appropriate maintenance schedule is determined. This includes the sample pump and solenoid valves which have a limited life.

Other operations such as cleaning the optics and checking the pressure calibration should be performed on a regular basis.

This chapter includes the following maintenance information and replacement procedures:

- "Safety Precautions" on page 5-2

- "Replacement Parts" on page 5-2

- "Accessing the Service Mode" on page 5-2

- "Outside Case Cleaning" on page 5-2

- "Fan Filter Inspection and Cleaning" on page 5-3

- "Photometer Cleaning" on page 5-3

- "Monitoring Detector Frequency and Noise" on page 5-4

- "Capillary Service" on page 5-5

- "Ozonator Capillary Replacement (Ozonator option)" on page 5-6

- "Pressure Regulator Capillary Replacement" on page 5-7

- "Pump Capillary Replacement (Photometer option)" on page 5-8

- "Pump Rebuilding" on page 5-9

Safety Precautions

Read the safety precautions before beginning any procedures in this chapter.

WARNING If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲

Equipment Damage 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 the "Servicing" chapter. ▲

Replacement Parts

See "Replacement Parts List" on page 7-5 in the "Servicing" chapter for a list of replacement parts.

Accessing the Service Mode

If the Service is not displayed on the Main Menu, use the following procedure to display it.

1. At the Main Menu, press (↓) to scroll to Instrument Controls > press (↵) > (↓) to scroll to **Service Mode** > and press (↵).

   The Service Mode screen appears.

2. Press (↵) to toggle the Service Mode to ON.

3. Press (■) > (■) to return to the Main Menu.

4. Return to the procedure.

Outside Case Cleaning

Clean the outside case using a damp cloth being careful not to damage the labels on the case.

Equipment Damage Do Not use solvents or other cleaning products to clean the outside case. ▲

Fan Filter Inspection and Cleaning

Use the following procedure to inspect and clean the fan filter (Figure 5-1).

1. Remove the two fan guards from the fans and remove the filters.

2. Flush the filter with warm water and let dry (a clean, oil-free purge will help the drying process) or blow the filter clean with compressed air.

3. Re-install the filter and fan guards.
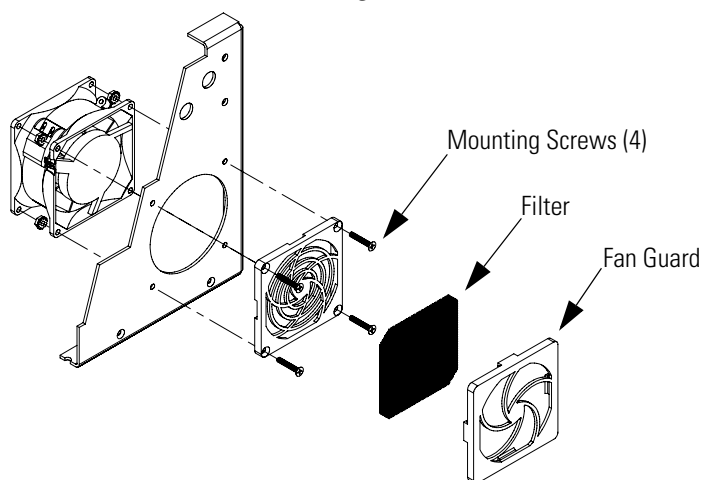
Figure 5-1. Inspecting and Cleaning the Fan Filter

Photometer Cleaning

Best results are obtained when the photometer is cleaned prior to recalibration. The cleanliness of the photometer should also be checked any time the detector frequency drops 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.

Use the following procedure to clean the photometer (Figure 7-12).

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 the "Servicing" chapter. ▲

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect the plumbing and electrical connections.

3. Loosen the Allen screws (4) securing the photometer to the floor plate (Figure 7-12) and remove the photometer.

4. Remove four (4) mounting screws on the lamp heater and remove the heater.

5. Remove the lamp housing (Figure 7-12) and the associated components.

6. Remove the detector. Refer to "Detector Replacement (Photometer option)" on page 7-35.

7. Remove the detector housing (Figure 7-12) and the associated components.

8. Push a piece of lens paper down the tube using a 1/4-inch 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.

9. Replace the photometer components following the previous steps in reverse.

Note It is recommended that the Model 146*i* be recalibrated if the photometer has been completely disassembled. Always check for leaks after replacing any component. Refer to "Leak Test and Pump Checkout" in the "Servicing" chapter. ▲

10. Re-install the instrument cover.

Monitoring Detector Frequency and Noise

The Model 146*i* 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 Intensity Check menu in the Service menu.

The Intensity Check menu is used to manually control the flow of reference or sample gas through the photometer. This enables the detector intensity and noise reading to be determined with either reference or sample gas.

Note Selecting these menu choices will affect the analog outputs. ▴

1. Press [■] to display the Main Menu.

2. Use [↑] [↓] to scroll to Service, press [↵] > [↓] to scroll to **Intensity Check** and press [↵].

   The Intensity Check menu appears.

Note If Service is not displayed, refer to ""Accessing the Service Mode" on page 5-2, then return to the beginning of this step. ▴

3. Select either Reference Gas or Sample Gas.

   Either the Photometer Reference Gas screen appears or the Photometer Sample Gas screen.

   The noise value displayed after 20 seconds should be below 4.0 Hz for a fully warmed-up lamp (see "Troubleshooting Guides" on page 6-2 in the "Troubleshooting" chapter if the noise is excessive).

Degradation of detector frequency to below 65 kHz indicates either a dirty cell or low lamp output. In addition to degrading the measured detector frequency, dirt in the cell can decompose the ozone and give erroneous readings. Therefore, the cell should first be cleaned and the frequency re-measured.

Capillary Service

The Model 146*i* includes the following capillaries (depending on the instrument options).

Ozonator capillary

Photometer capillary

Pressure gauge capillary

Pump capillary

If there are indications that a capillary may be blocked, perform the following procedures as appropriate. See the associated capillary replacement procedure for a description of how to remove the capillary for inspection and cleaning.

- Check the ends of the capillary for an obvious obstruction and remove the obstruction.

- Clear any internal blockage using an appropriate wire for the particular capillary. Refer to Table 5-1.

- If a restriction cannot be cleared, replace the capillary. Refer to the appropriate capillary replacement procedure that follows.

Table 5-1. Capillary Cleaning Wire Sizes

Capillary	Wire Diameter
Ozonator	8 mil
Photometer	8 mil
Pressure Gauge	8 mil
Pump	20 mil

Refer to "Component Layout" on page 7-8 to locate these capillaries within the instrument. If you need the capillary part number, refer to the "Replacement Parts List" on page 7-5.

Ozonator Capillary Replacement (Ozonator option)

Use the following procedure to replace the ozonator capillary (Figure 5-2).

Equipment Required:

    Ozonator capillary

Equipment Damage 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unscrew the knurled fitting, separate the components, and remove the capillary (Figure 5-2).

3. Insert the new capillary and reconnect the fittings.
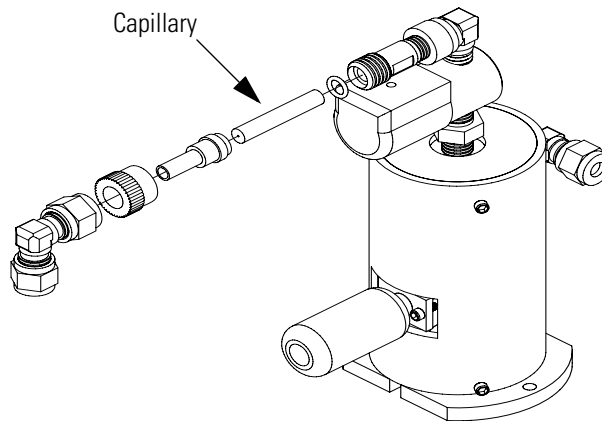
Capillary

Figure 5-2. Replacing the Ozonator Capillary

Pressure Regulator Capillary Replacement

Use the following procedure to replace the pressure regulator capillary (Figure 5-3).

Equipment Required:

Pressure regulator capillary

Equipment Damage 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unscrew the knurled fitting, separate the components, and remove the capillary (Figure 5-3).

3. Insert the new capillary and reconnect the fittings.
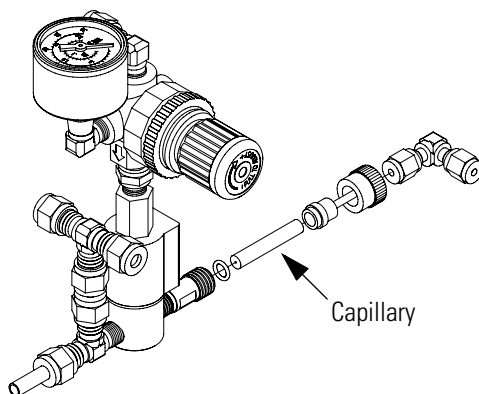
Capillary

Figure 5-3. Replacing the Pressure Regulator Capillary

Pump Capillary Replacement (Photometer option)

For instruments with the photometer option, use the following procedure to replace the pump capillary (Figure 5-4).

Equipment Required:

Pump capillary

Equipment Damage 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Loosen the fitting connecting the capillary to the pump and remove the capillary. (Figure 5-4).

3. Insert the new capillary and tighten the fitting.
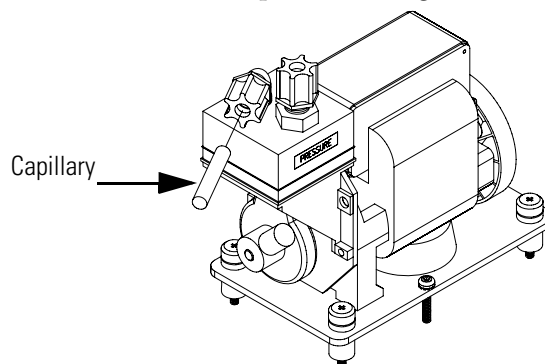
Capillary

Figure 5-4. Replacing the Pump Capillary

Pump Rebuilding

Use the following procedure to rebuild the pump (Figure 5-5). To replace the pump, see "Pump Replacement (Photometer option)" on page 7-16 in the "Servicing" chapter.

Equipment Required:

Flatblade screwdriver

Pump rebuild kit (flapper valve and diaphragm)

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Loosen the fittings and remove both lines going to the pump.

3. Remove the four screws from the top plate, remove top plate, flapper valve, and the bottom plate.

Top Plate

Flapper Plate

Bottom Plate
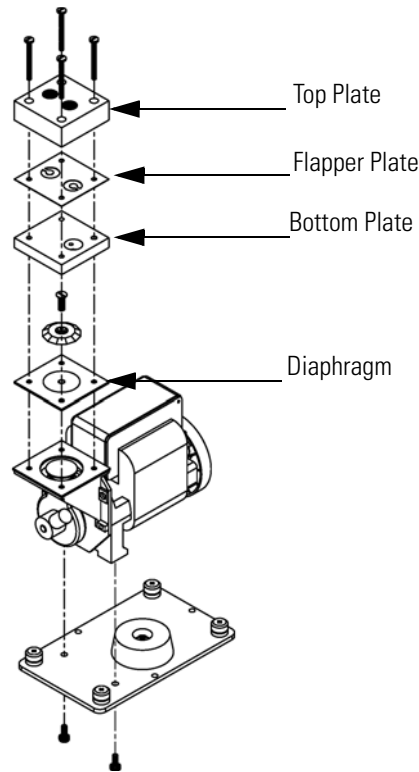
Diaphragm

Figure 5-5. Rebuilding the Pump

4. Remove the screw the securing the diaphragm to piston and remove diaphragm.

5. Assemble the pump by following the previous steps in reverse, make sure the Teflon® (white) side of the diaphragm is facing up and that the flapper valves cover the holes of the top and bottom plate.

6. Test the pump for leaks. Refer to "Leak Test and Pump Checkout" in the "Servicing" chapter.

Chapter 6 Troubleshooting

This instrument has been designed to achieve a high level of reliability. In the event of problems or failure, the troubleshooting guidelines, board-level connection diagrams, connector pin descriptions, and testing procedures presented in this chapter should be helpful in isolating and identifying problems.

For additional fault location information refer to the "Preventive Maintenance" chapter in this manual.

The service mode in the "Operation" chapter includes parameters and functions that are useful when making adjustments or diagnosing problems. The service mode includes some of the same information found in the Diagnostic menu, however, readings are updated every second in the service mode compared with every 10 seconds in the Diagnostics menu.

The Technical Support Department at Thermo Fisher Scientific can also be consulted in the event of problems. See "Service Locations" at the end of this chapter for contact information. In any correspondence with the factory, please note both the serial number and program number of the instrument.

This chapter provides the following troubleshooting and service support information:

Safety Precautions

Read the safety precautions in the Preface and the "Servicing" chapter before performing any actions listed in this chapter.

Troubleshooting Guides

The troubleshooting guides presented in this chapter are designed to help isolate and identify instrument problems.

Table 6-1 provides general troubleshooting information and indicates the checks that you should perform if you experience an instrument problem.

Table 6-2 lists all the alarm messages you may see on the graphics display and provides recommendations about how to resolve the alarm condition.

Table 6-1. Troubleshooting - General 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 power supply voltages.
Flow controller unstable	Leak	Perform a leak check (see "Servicing" chapter).
	Flow controller malfunction	Replace Flow Controller.
Solenoid not switching in local mode	Instrument in remote mode	Put instrument in local mode.
	Solenoid malfunction	Check 24 VDC on solenoid connector.
		Check solenoid cable.
		Check solenoid for continuity and replace as necessary.
	Defective cable	Replace cable.
	Defective connector	Replace connector.
	Defective solenoid connector board	Replace solenoid connector board.
	Defective measurement interface board	Replace measurement interface board.
Solenoid not switching in remote mode	Instrument in local mode	Put instrument in remote mode.
	Defective solenoid connector board	Replace solenoid connector board.
	Defective measurement interface board	Replace measurement interface board.
	Defective cable	Replace cable.

Table 6-1. Troubleshooting - General Guide, continued

Malfunction	Possible Cause	Action
	Defective connector	Replace connector.
Calibration as measured at output of mass flow controller does not agree with calibration as measured at output of instrument	Leak	Perform a leak check (see "Servicing" chapter).
	Mass flow controller not calibrated	Calibrate mass flow controller
No ozone output	Lamp failure	Check for blue light when removing ozone lamp from ozonator and replace lamp if light not visible.
	Ozonator heater failure	Check to see that ozonator is warm (>50 °C). If not warm, replace heater or heat power supply (see "Servicing" chapter).
	Ozonator board failure	Replace ozonator board (see "Servicing" chapter).
Low ozonator output	Leak in ozonator or distribution manifold	Check for leaks in ozonator and manifold system (see "Servicing" chapter) and repair leak.
	Flow excessively high	Check zero air flow valve and reduce flow.
	Ozonator board failure	Replace ozonator board (see "Servicing" chapter).
	Weak lamp	Check to see that there is a bright blue light when removing the ozone lamp from ozonator, with ozonator level set to 100%. If not, replace lamp (see "Servicing" chapter).
Unstable ozone output	Failure of analyzer measuring ozone	Repair analyzer.
	Leak in system	Check for leaks and repair (see "Servicing" chapter).
	Zero air flow unstable	Check zero air flow meter.
	Lamp failure	Replace lamp. (see "Servicing" chapter).
	Defective ozonator board	Replace ozonator board (see "Servicing" chapter).

Table 6-1. Troubleshooting - General Guide, continued

Malfunction	Possible Cause	Action
Permeation oven fails to warm up	Oven not ON	Turn oven ON.
	Not enough time has elapsed since turning oven ON	Wait one hour from powering up instrument.
	Loose cable/connections	Check cable/connections.
	Oven heater defective	Replace oven.
	Control circuit malfunction	Replace measurement interface board (see "Servicing" chapter).
Temperature display erratic	Flow through permeation tube oven not constant	Clean capillary, readjust regulator (see "Preventive Maintenance" chapter).
Cell frequency high	Light setting too high	Lower lamp setting (Service Mode > Lamp Setting).
	Defective detector	Replace detector module.
	Defective photometer board	Replace photometer board.
	Defective measurement interface board	Replace measurement interface board.
Cell frequency low or zero	Light setting too low	Raise lamp setting (Service Mode > Lamp Setting).
	Contaminated cell	Clean cell.
	Defective detector	Replace detector module.
	Defective photometer board	Replace photometer board.
	Defective measurement interface board	Replace measurement interface board.
Cell noise excessive	Contaminated cell	Clean cell.
	Defective detector	Replace detector module.
	Lamp failure	Replace lamp.
Pressure transducer does not hold calibration	Plumbing leak or bad electrical connection	Check plumbing and electrical connections.
	Defective pressure transducer	Replace pressure transducer.
	Defective measurement interface board	Replace measurement interface board.
Output signal noisy	Defective recorder	Replace or repair recorder.
	Sample is varying	Run instrument on stable ozone source, if quiet, no malfunction.

Table 6-1. Troubleshooting - General Guide, continued

Malfunction	Possible Cause	Action
	Contaminated cell	Clean cell.
	Sticky solenoid valve	Replace with known good solenoid valve.
Photometer does not calibrate properly	Leak	Perform leak test (see "Servicing" chapter.
	Bench thermistor defective	Replace bench thermistor.
	Pressure transducer out of calibration	Recalibrate pressure transducer.
	Dirty system	Clean cells and flow components.
	Defective solenoid	Replace solenoid.
	Lamp intensity unstable	Replace detector or photometer board.
Slow response	Averaging time	Verify averaging time is set properly.
	Leak	Perform leak test (see "Servicing" chapter).
	Contaminated optical bench	Clean bench and then condition system overnight.

Table 6-2. Troubleshooting - Alarm Messages

Alarm Message	Possible Cause	Action
Alarm - O_3 Lamp Temp	Defective ozonator board	Replace ozonator board.
	Defective ozonator lamp heater	Replace ozonator lamp heater.
Alarm - Lamp Temp	Defective photometer board	Replace photometer board.
	Defective photometer lamp heater	Replace photometer lamp heater.
Alarm - Bench Temp	Defective fan	Check for 24 VDC on fan connector and replace fan if 24 VDC is applied to fan.
	Check fan filter	Clean or replace foam filter (see "Preventive Maintenance" chapter).

Table 6-2. Troubleshooting - Alarm Messages, continued

Alarm Message	Possible Cause	Action
Alarm - Pressure	High pressure indication	Check the pump for a tear in the diaphragm, replace with pump repair kit if necessary. Refer to "Preventive Maintenance" chapter. Check that capillaries are properly installed and O-rings are in good shape. Replace if necessary. Check flow system for leaks. See the "Servicing" chapter.
Alarm - Intensity	Defective detector	Replace detector.
	Defective measurement interface board	Replace measurement interface board.
	See "Cell Frequency High" and "Cell Frequency Low or Zero" in Table 6-1.	See "Cell Frequency High" and "Cell Frequency Low or Zero" in Table 6-1.
Alarm - Oz Level 1 Check (Opt)	Does not reach the level 1 setting	See Table 6-1 for troubleshooting information.
Oz Level 2 Check (Opt)	Does not reach the level 2 setting	See Table 6-1 for troubleshooting information.
Oz Level 3 Check (Opt)	Does not reach the level 3 setting	See Table 6-1 for troubleshooting information.
Oz Level 4 Check (Opt)	Does not reach the level 4 setting	See Table 6-1 for troubleshooting information.
Alarm - O_3 Conc.	Concentration has exceeded range limit	Check to insure range corresponds with expected value. If not select proper range.
	Concentration low	Check user-defined low set point, set to zero.
Alarm - Motherboard Status	Internal cables not connected properly	Check that all internal cables are connected properly.
	Defective motherboard	Recycle AC power to instrument. If still alarming, replace board.
Alarm - Interface Status	Internal cables not connected properly	Check that all internal cables are connected properly.
	Defective measurement interface board	Recycle AC power to instrument. If still alarming, replace board.
Alarm - I/O Exp Status	I/O expansion board was installed, but is not currently installed.	Re-install board, if desired, and recycle power.

Table 6-2. Troubleshooting - Alarm Messages, continued

Alarm Message	Possible Cause	Action
	Malfunctioning external device	Disconnect external devices from board, and recycle power. If alarm persists, replace board.
	Internal cables not connected properly	Check that all internal cables are connected properly.
	Defective optional I/O expansion board	Replace board.

Board-Level Connection Diagrams

Figure 6-1 and Figure 6-2 are board-level connection diagrams for the common electronics and measurement system. These illustrations can be used along with the connector pin descriptions in Table 6-3 through Table 6-10 to troubleshoot board-level faults.
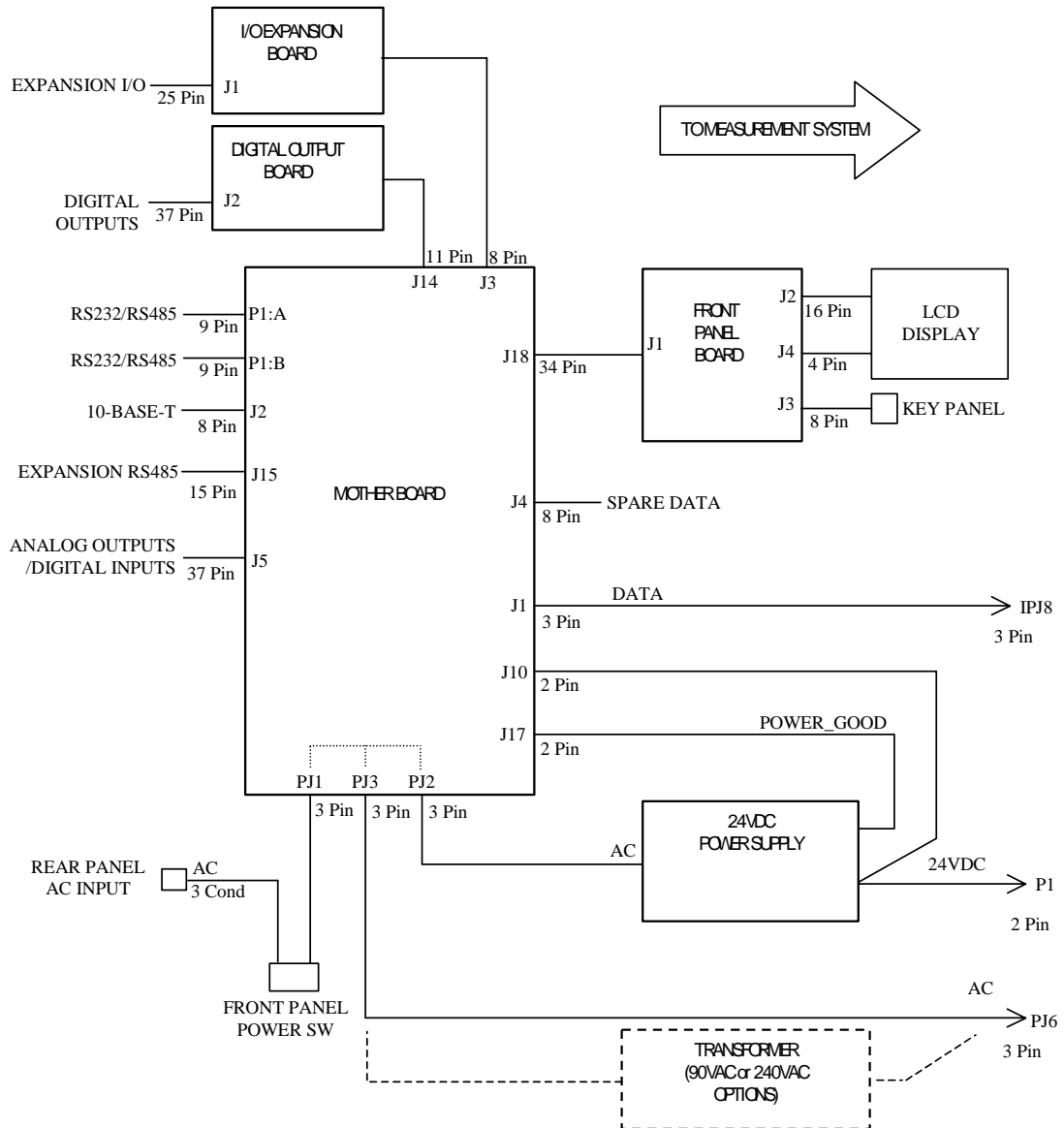
Figure 6-1. Board-Level Connection Diagram - Common Electronics
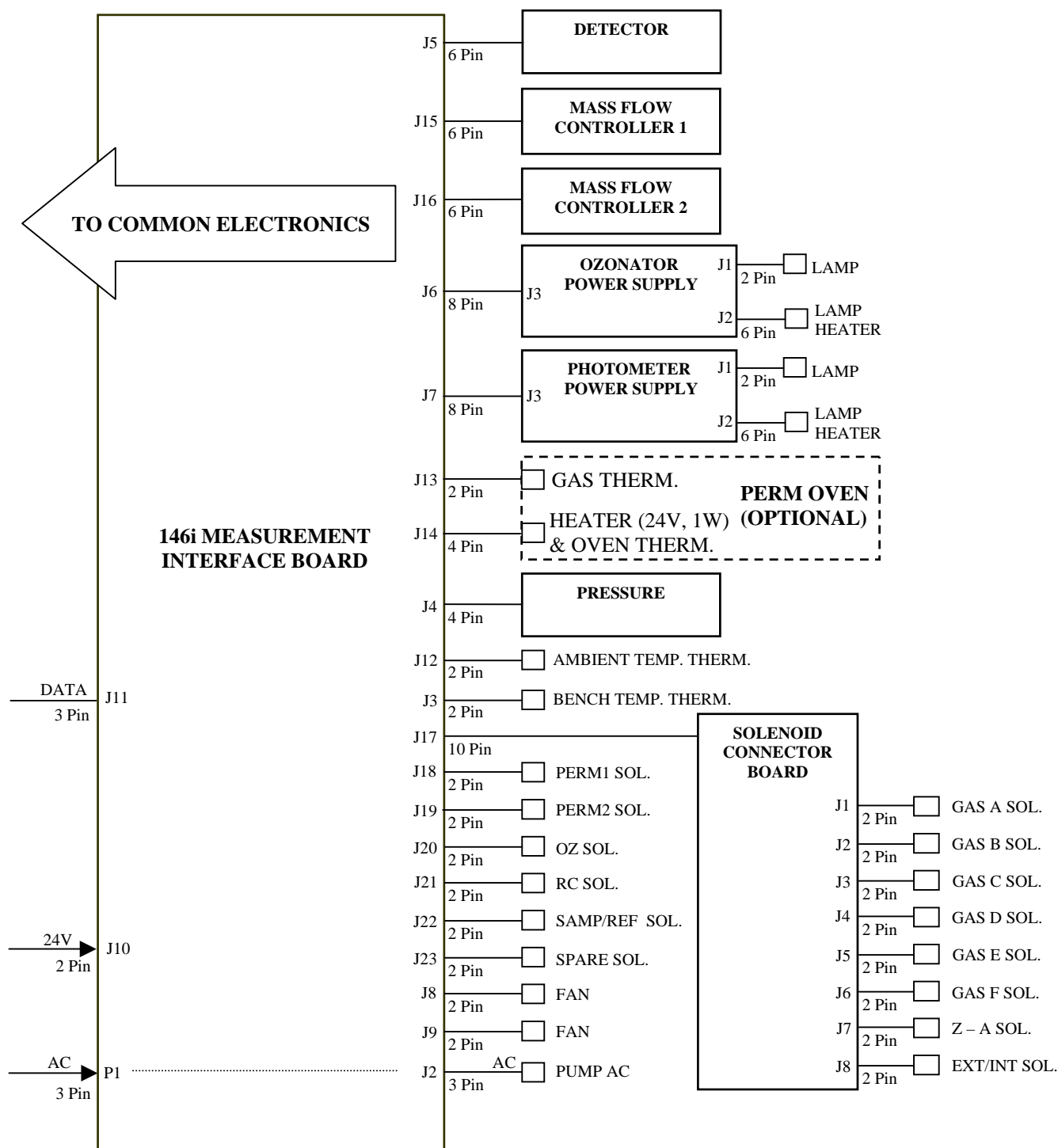
Figure 6-2. Board-Level Connection Diagram - Measurement System

Connector Pin Descriptions

The connector pin descriptions in Table 6-3 through Table 6-10 can be used along with the board-level connection diagrams to troubleshoot board-level faults.

Table 6-3. Motherboard Connector Pin Descriptions

Connector Label	Reference Designator	Pin	Signal Description
INTF DATA	J1	1	Ground
		2	+RS485 to Interface Board
		3	-RS485 to Interface Board
10-BASE-T	J2	1	Ethernet Output (+)
		2	Ethernet Output (-)
		3	Ethernet Input (+)
		4	NC
		5	NC
		6	Ethernet Input (-)
		7	NC
		8	NC
INTF DATA	J1	1	Ground
		2	+RS485 to Interface Board
		3	-RS485 to Interface Board
10-BASE-T	J2	1	Ethernet Output (+)
		2	Ethernet Output (-)

Table 6-3. Motherboard Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		3	Ethernet Input (+)
		4	NC
		5	NC
		6	Ethernet Input (-)
		7	NC
		8	NC
EXPANSION BD	J3	1	+5V
		2	+24V
		3	+24V
		4	Ground
		5	Ground
		6	Ground
		7	+RS485 to Expansion Board
		8	-RS485 to Expansion Board
SPARE DATA	J4	1	+5V
		2	+24V
		3	+24V
		4	Ground
		5	Ground
		6	Ground
		7	+RS485 to Spare Board
		8	-RS485 to Spare Board
I/O	J5	1	Power Fail Relay N.C. Contact
		2	Ground
		3	TTL Input 1
		4	TTL Input 2
		5	Ground
		6	TTL Input 5
		7	TTL Input 7
		8	TTL Input 8
		9	TTL Input 10
		10	Ground
		11	TTL Input 13

Table 6-3. Motherboard Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		12	TTL Input 15
		13	Ground
		14	Analog Voltage Output 1
		15	Analog Voltage Output 3
		16	Ground
		17	Analog Voltage Output 5
		18	Ground
		19	Ground
		20	Power Fail Relay COM
		21	Power Fail Relay N.O. Contact
		22	Ground
		23	TTL Input 3
		24	TTL Input 4
		25	TTL Input 6
		26	Ground
		27	TTL Input 9
		28	TTL Input 11
		29	TTL Input 12
		30	TTL Input 14
		31	TTL Input 16
		32	Ground
		33	Analog Voltage Output 2
		34	Analog Voltage Output 4
		35	Ground
		36	Analog Voltage Output 6
		37	Ground
SER EN	J7	1	Serial Enable Jumper
		2	+3.3V
24V IN	J10	1	+24V
		2	Ground
DIGITAL I/O	J14	1	+5V
		2	+24V
		3	+24V

Table 6-3. Motherboard Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		4	Ground
		5	Ground
		6	Ground
		7	SPI Reset
		8	SPI Input
		9	SPI Output
		10	SPI Board Select
		11	SPI Clock
EXT. RS485	J15	1	-RS485 to Rear Panel
		2	+RS485 to Rear Panel
		3	+5V
		4	+5V
		5	+5V
		6	Ground
		7	Ground
		8	Ground
		9	NC
		10	NC
		11	+24V
		12	+24V
		13	+24V
		14	+24V
		15	+24V
24V MONITOR	J17	1	24V Power Monitor
		2	Ground
FRONT PANEL BD	J18	1	Ground
		2	Ground
		3	LCLK – LCD Signal
		4	Ground
		5	Ground
		6	LLP – LCD Signal
		7	LFLM – LCD Signal

Table 6-3. Motherboard Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		8	LD4 – LCD Signal
		9	LD0 – LCD Signal
		10	LD5 – LCD Signal
		11	LD1 – LCD Signal
		12	LD6 – LCD Signal
		13	LD2 – LCD Signal
		14	LD7 – LCD Signal
		15	LD3 – LCD Signal
		16	LCD Bias Voltage
		17	+5V
		18	Ground
		19	Ground
		20	LCD_ONOFF – LCD Signal
		21	Keypad Row 2 Input
		22	Keypad Row 1 Input
		23	Keypad Row 4 Input
		24	Keypad Row 3 Input
		25	Keypad Col 2 Select
		26	Keypad Col 1 Select
		27	Keypad Col 4 Select
		28	Keypad Col 3 Select
		29	Ground
		30	Ground
		31	Ground
		32	Ground
		33	+24V
		34	+24V
RS232/RS485:A	P1:A	1	NC
		2	Serial Port 1 RX (-RS485 IN)
		3	Serial Port 1 TX (-RS485 OUT)
		4	NC
		5	Ground
		6	NC

Table 6-3. Motherboard Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		7	Serial Port 1 RTS (+RS485 OUT)
		8	Serial Port 1 CTS (+RS485 IN)
		9	NC
RS232/RS485:B	P1:B	1	NC
		2	Serial Port 2 RX (-RS485 IN)
		3	Serial Port 2 TX (-RS485 OUT)
		4	NC
		5	Ground
		6	NC
		7	Serial Port 2 RTS (+RS485 OUT)
		8	Serial Port 2 CTS (+RS485 IN)
		9	NC
AC IN	PJ1	1	AC-HOT
		2	AC-NEUT
		3	AC-Ground
AC 24VPWR	PJ2	1	AC-HOT
		2	AC-NEUT
		3	AC-Ground
AC INTF BD	PJ3	1	AC-HOT
		2	AC-NEUT
		3	AC-Ground

Table 6-4. Front Panel Board Connector Pin Diagram

Connector Label	Reference Designator	Pin	Signal Description
MOTHER BOARD	J1	1	Ground
		2	Ground
		3	LCLK – LCD Signal
		4	Ground
		5	Ground
		6	LLP – LCD Signal

Table 6-4. Front Panel Board Connector Pin Diagram, continued

Connector Label	Reference Designator	Pin	Signal Description
		7	LFLM – LCD Signal
		8	LD4 – LCD Signal
		9	LD0 – LCD Signal
		10	LD5 – LCD Signal
		11	LD1 – LCD Signal
		12	LD6 – LCD Signal
		13	LD2 – LCD Signal
		14	LD7 – LCD Signal
		15	LD3 – LCD Signal
		16	LCD Bias Voltage
		17	+5V
		18	Ground
		19	Ground
		20	LCD_ONOFF – LCD Signal
		21	Keypad Row 2 Input
		22	Keypad Row 1 Input
		23	Keypad Row 4 Input
		24	Keypad Row 3 Input
		25	Keypad Col 2 Select
		26	Keypad Col 1 Select
		27	Keypad Col 4 Select
		28	Keypad Col 3 Select
		29	Ground
		30	Ground
		31	Ground
		32	Ground
		33	+24V
		34	+24V
LCD DATA	J2	1	LFLM_5V – LCD Signal
		2	LLP_5V – LCD Signal
		3	LCLK_5V – LCD Signal
		4	LCD_ONOFF_5V – LCD Signal
		5	+5V

Table 6-4. Front Panel Board Connector Pin Diagram, continued

Connector Label	Reference Designator	Pin	Signal Description
		6	Ground
		7	LCD Bias Voltage
		8	LD0_5V – LCD Signal
		9	LD1_5V – LCD Signal
		10	LD2_5V – LCD Signal
		11	LD3_5V – LCD Signal
		12	LD4_5V – LCD Signal
		13	LD5_5V – LCD Signal
		14	LD6_5V – LCD Signal
		15	LD7_5V – LCD Signal
		16	Ground
KEYBOARD	J3	1	Keypad Row 1 Input
		2	Keypad Row 2 Input
		3	Keypad Row 3 Input
		4	Keypad Row 4 Input
		5	Keypad Col 1 Select
		6	Keypad Col 2 Select
		7	Keypad Col 3 Select
		8	Keypad Col 4 Select
LCD BACKLIGHT	J4	1	LCD Backlight Voltage 1
		2	NC
		3	NC
		4	LCD Backlight Voltage 2

Table 6-5. I/O Expansion Board (Optional) Connector Pin Descriptions

Connector Label	Reference Designator	Pin	Signal Description
EXPANSION I/O	J1	1	Analog Voltage Input 1
		2	Analog Voltage Input 2
		3	Analog Voltage Input 3
		4	Ground
		5	Analog Voltage Input 4

Table 6-5. I/O Expansion Board (Optional) Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		6	Analog Voltage Input 5
		7	Analog Voltage Input 6
		8	Ground
		9	Analog Voltage Input 7
		10	Analog Voltage Input 8
		11	Ground
		12	NC
		13	NC
		14	Ground
		15	Current Output 1
		16	Current Output Return
		17	Current Output 2
		18	Current Output Return
		19	Current Output 3
		20	Current Output Return
		21	Current Output 4
		22	Current Output Return
		23	Current Output 5
		24	Current Output Return
		25	Current Output 6
MOTHER BD	J2	1	+5V
		2	+24V
		3	+24V
		4	Ground
		5	Ground
		6	Ground
		7	+RS485 to Motherboard
		8	-RS485 to Motherboard

Table 6-6. Digital Output Board Connector Pin Descriptions

Connector Label	Reference Designator	Pin	Signal Description
MOTHER BD	J1	1	+5V
		2	+24V
		3	+24V
		4	Ground
		5	Ground
		6	Ground
		7	SPI Reset
		8	SPI Input
		9	SPI Output
		10	SPI Board Select
		11	SPI Clock
DIGITAL OUTPUTS	J2	1	Relay 1 Contact a
		2	Relay 2 Contact a
		3	Relay 3 Contact a
		4	Relay 4 Contact a
		5	Relay 5 Contact a
		6	Relay 6 Contact a
		7	Relay 7 Contact a
		8	Relay 8 Contact a
		9	Relay 9 Contact a
		10	Relay 10 Contact a
		11	NC
		12	Solenoid Drive Output 1
		13	Solenoid Drive Output 2
		14	Solenoid Drive Output 3
		15	Solenoid Drive Output 4
		16	Solenoid Drive Output 5
		17	Solenoid Drive Output 6
		18	Solenoid Drive Output 7
		19	Solenoid Drive Output 8
		20	Relay 1 Contact b

Table 6-6. Digital Output Board Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		21	Relay 2 Contact b
		22	Relay 3 Contact b
		23	Relay 4 Contact b
		24	Relay 5 Contact b
		25	Relay 6 Contact b
		26	Relay 7 Contact b
		27	Relay 8 Contact b
		28	Relay 9 Contact b
		29	Relay 10 Contact b
		30	+24V
		31	+24V
		32	+24V
		33	+24V
		34	+24V
		35	+24V
		36	+24V
		37	+24V

Table 6-7. Measurement Interface Board Connector Pin Descriptions

Connector Label	Reference Designator	Pin	Signal Description
AC IN	J1	1	AC-HOT
		2	AC-NEUT
		3	AC-Ground
AC PUMP	J2	1	AC-HOT
		2	AC-NEUT Switched
		3	AC-Ground
BENCH TEMP	J3	1	Bench Temperature Thermistor
		2	Ground
PRES	J4	1	Pressure Sensor Input
		2	Ground
		3	+15V

Table 6-7. Measurement Interface Board Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		4	-15V
DET	J5	1	Frequency Input 1
		2	+15V
		3	Ground
		4	Frequency Input 2
		5	-15V
		6	Ground
OZONATOR	J6	1	Ozonator Lamp Intensity Control Voltage Output
		2	Ozonator Lamp Intensity Control Voltage Input
		3	Ozonator Heater Thermistor
		4	+24V
		5	Ground
		6	Ozonator Lamp On/off Control
		7	Ground
		8	Ground
PHOTOMETER	J7	1	Photometer Lamp Intensity Control Voltage Output
		2	Photometer Lamp Intensity Control Voltage Input
		3	Photometer Heater Thermistor
		4	+24V
		5	Ground
		6	Photometer Lamp On/Off Control
		7	Ground
		8	Ground
FAN	J8	1	+24V (Fused)
		2	Ground
FAN	J9	1	+24V (Fused)
		2	Ground
24V IN	J10	1	+24V
		2	Ground
DATA	J11	1	Ground

Table 6-7. Measurement Interface Board Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		2	+RS485 from Motherboard
		3	-RS485 from Motherboard
AMB TEMP	J12	1	Ambient Temperature Thermistor
		2	Ground
PERM TEMP	J13	1	Perm Oven Gas Thermistor
		2	Ground
PERM OVEN	J14	1	Perm Oven Heater On/Off
		2	+24V
		3	Perm Oven Thermistor
		4	Ground
MFC1	J15	1	Mass Flow Controller 1 Input
		2	Mass Flow Controller 1 Output
		3	Ground
		4	+15V
		5	-15V
		6	Ground
MFC2	J16	1	Mass Flow Controller 2 Input
		2	Mass Flow Controller 2 Output
		3	Ground
		4	+15V
		5	-15V
		6	Ground
CONNECTOR BD	J17	1	Gas A Solenoid Control
		2	Gas C Solenoid Control
		3	+24V
		4	Gas E Solenoid Control
		5	Z – A Solenoid Control
		6	Gas B Solenoid Control
		7	Gas D Solenoid Control
		8	+24V
		9	Gas F Solenoid Control
		10	EXT/INT Solenoid Control
PERM 1	J18	1	+24V

Table 6-7. Measurement Interface Board Connector Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		2	Perm 1 Solenoid Control
PERM 2	J19	1	+24V
		2	Perm 2 Solenoid Control
OZ	J20	1	+24V
		2	Ozonator Solenoid Control
RC	J21	1	+24V
		2	Reaction Chamber Solenoid Control
SAMP/REF	J22	1	+24V
		2	Sample/Reference Solenoid Control
SPARE	J23	1	+24V
		2	Spare Solenoid Control

Table 6-8. Solenoid Connector Board Pin Descriptions

Connector Label	Reference Designator	Pin	Signal Description
BRN	-	-	Gas A Solenoid Control
ORG	-	-	Gas C Solenoid Control
RED	-	-	+24V
GRN	-	-	Gas E Solenoid Control
VIO	-	-	Z – A Solenoid Control
WHT	-	-	Gas B Solenoid Control
YEL	-	-	Gas D Solenoid Control
RED	-	-	+24V
BLU	-	-	Gas F Solenoid Control
GRA	-	-	EXT/INT Solenoid Control
GAS A	J1	1	+24V
		2	Gas A Solenoid Control
GAS B	J2	1	+24V
		2	Gas B Solenoid Control
GAS C	J3	1	+24V
		2	Gas C Solenoid Control
GAS D	J4	1	+24V

Table 6-8. Solenoid Connector Board Pin Descriptions, continued

Connector Label	Reference Designator	Pin	Signal Description
		2	Gas D Solenoid Control
GAS E	J5	1	+24V
		2	Gas E Solenoid Control
GAS F	J6	1	+24V
		2	Gas F Solenoid Control
Z – A	J7	1	+24V
		2	Z – A Solenoid Control
EXT/INT	J8	1	+24V
		2	EXT/INT Solenoid Control

Table 6-9. Ozonator Power Supply Connector Pin Descriptions

Connector Label	Reference Designator	Pin	Signal Description
LAMP	J1	1	Ozonator Lamp Voltage Out
		2	Ozonator Lamp Voltage Return
LAMP HEATER	J2	1	Ground
		2	Ozonator Lamp Thermistor 1
		3	Ozonator Lamp Heater Control
		4	Ground
		5	+24V Heater Current Sense
		6	Ozonator Lamp Thermistor 2
INTF	J3	1	Ozonator Lamp Intensity Control Voltage Input
		2	Ozonator Lamp Intensity Control Voltage Output
		3	Ozonator Heater Thermistor
		4	+24V
		5	Ground
		6	Ozonator Lamp On/off Control
		7	Ground
		8	Ground

Table 6-10. Photometer Power Supply Connector Pin Descriptions

Connector Label	Reference Designator	Pin	Signal Description
LAMP	J1	1	Photometer Lamp Voltage Out
		2	Photometer Lamp Voltage Return
LAMP HEATER	J2	1	Ground
		2	Photometer Lamp Thermistor 1
		3	Photometer Lamp Heater Control
		4	Ground
		5	+24V Heater Current Sense
		6	Photometer Lamp Thermistor 2
INTF	J3	1	Photometer Lamp Intensity Control Voltage Input
		2	Photometer Lamp Intensity Control Voltage Output
		3	Photometer Heater Thermistor
		4	+24V
		5	Ground
		6	Photometer Lamp On/off Control
		7	Ground
		8	Ground

Service Locations

For additional assistance, service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

Chapter 7 Servicing

This chapter explains how to replace the Model 146*i* subassemblies. It assumes that a subassembly has been identified as defective and needs to be replaced.

For fault location information refer to the "Preventive Maintenance" chapter and the "Troubleshooting" chapter in this manual.

The service mode in the "Operation" chapter also includes parameters and functions that are useful when making adjustments or diagnosing problems.

For additional service assistance, see "Service Locations" on page 7-54 at the end of this chapter.

This chapter includes the following parts information, testing, adjustment, and calibration procedures, and component replacement procedures:

"Safety Precautions" on page 7-3

"Firmware Updates" on page 7-4

"Replacement Parts List" on page 7-5

"Cable List" on page 7-6

"External Device Connection Components" on page 7-7

"Removing the Measurement Bench and Lowering the Partition Panel" on page 7-9

"Fuse Replacement" on page 7-10

"Leak Test and Pump Checkout - with Photometer Option" on page 7-11

"Mass Flow Controller Replacement" on page 7-14

"Pump Replacement (Photometer option)" on page 7-16

"Fan Replacement - Rear Panel" on page 7-17

Safety Precautions

Read the safety precautions before beginning any procedures in this chapter.

WARNING The service procedures in this manual are restricted to qualified service representatives. ▲

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲

⚠ **Equipment Damage** 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 (Figure 7-1). If an antistatic wrist strap is not available, be sure to touch a grounded metal object before touching any internal components. When the instrument is unplugged, the chassis is not at earth ground. ▲

Handle all printed circuit boards by the edges. ▲

Do not remove the LCD panel or frame from the LCD module. ▲

The polarizing plate is very fragile, handle it carefully. ▲

Do not wipe the polarizing plate with a dry cloth, it may easily scratch the plate. ▲

Do not use alcohol, acetone, MEK or other Ketone based or aromatic solvents to clean the module, use a soft cloth moistened with a naphtha cleaning solvent. ▲

Do not place the module near organic solvents or corrosive gases. ▲

Do not shake or jolt the module. ▲
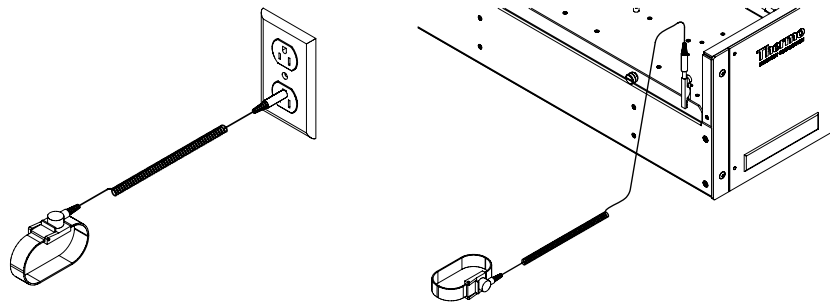
Figure 7-1. Properly Grounded Antistatic Wrist Strap

Firmware Updates

The firmware can be updated by the user in the field via the serial port or over the Ethernet. This includes both the main processor firmware and the firmware in all low-level processors. Refer to the *i-Port* manual for the firmware update procedure.

Replacement Parts List

Table 7-1 lists the replacement parts for the Model 146*i* major subassemblies. Refer to Figure 7-2 to identify the component location.

Table 7-1. Model 146*i* Replacement Parts

Part Number	Description
100480-00	Front Panel Pushbutton Board
101491-00	Processor Board
100533-00	Motherboard
100539-00	Digital Output Board
102014-00	I/O Expansion Board (Optional)
102340-00	Front Panel Connector Board
102496-00	Front Panel Display
101681-00	DC Power Supply
101399-00	Transformer, 220-240VAC (Optional)
101863-00	Transformer, 100VAC (Optional)
100880-00	Measurement Interface Board
102590-00	Ozonator
102775-00	Ozonator Lamp
100895-00	Ozonator Board
101023-00	Pressure Transducer
102455-00	Air Regulator Assembly (Optional)
103209-00	Detector Assembly
102351-00	Photometer Lamp Heater Assembly
102570-00	Photometer
8540	Photometer Lamp
102554-00	Photometer Board
101426-00	Pump
102464-01	Pump, Zero Air Supply 110V (Optional)
102464-02	Pump, Zero Air Supply 220V (Optional)
101055-00	AC Receptacle Assembly
100907-00	Fan
8630	Fan Filter
4510	Fuse, 250VAC, 3.0 Amp, SloBlow (for 100VAC and 110VAC models)
14007	Fuse, 250VAC, 1.60 Amp, SloBlow (for 220-240VAC models)
103075-00	Back Pressure Regulator
102604-00	Pressure Regulator

Table 7-1. Model 146*i* Replacement Parts, continued

Part Number	Description
102589-00	Reaction Chamber
102030-00	Permeation Oven
49P766	Mixing Chamber
49P501	Manifold
8095	Mass Flow Controller, 50 sccm
8096	Mass Flow Controller, 100 sccm
8097	Mass Flow Controller, 200 sccm
8092	Mass Flow Controller, 5 slpm
8093	Mass Flow Controller, 10 slpm
8094	Mass Flow Controller, 20 slpm
4120	Capillary, photometer
4121	Capillary, ozonator
4121	Capillary, pressure gauge
4127	Capillary, pump
103199-00	Solenoid, sample/reference
103205-00	Solenoid, ozonator
103334-00	Solenoid, perm 1
103200-00	Solenoid, perm 2
103207-00	Solenoid, reaction chamber
8130	Solenoid, zero air
103125-00	Solenoid, external/internal
103206-00	Solenoid, span gas
4291	Charcoal scrubber assembly (external)

Cable List

Table 7-2 describes the Model 146*i* cables. See the "Troubleshooting" chapter for associated connection diagrams and board connector pin descriptions.

Table 7-2. Model 146*i* Cables

Part Number	Description
101036-00	DC Power Supply, 24V Output
101037-00	115VAC Supply to Measurement Interface Board
101048-00	RS-485/Data
101038-00	AC to Motherboard

Table 7-2. Model 146*i* Cables, continued

Part Number	Description
101364-00	DC Power Supply Status Monitor
101054-00	Motherboard to Front Panel Board
101035-00	DC Power Supply AC Input
101033-00	AC from Receptacle
101377-00	AC to Power Switch
101055-00	Main AC Receptacle Assembly
101706-00	Measurement Interface Board to Photometer Board
102446-00	Measurement Interface Board to Ozonator Board
101267-00	Fan Power Cable
49P747	Mass Flow Controller Cable Assembly

External Device Connection Components

Table 7-3 lists the standard and optional cables and components used for connecting external devices such as PCs and data loggers to an *i*Series instrument.

Table 7-3. External Device Connection Components

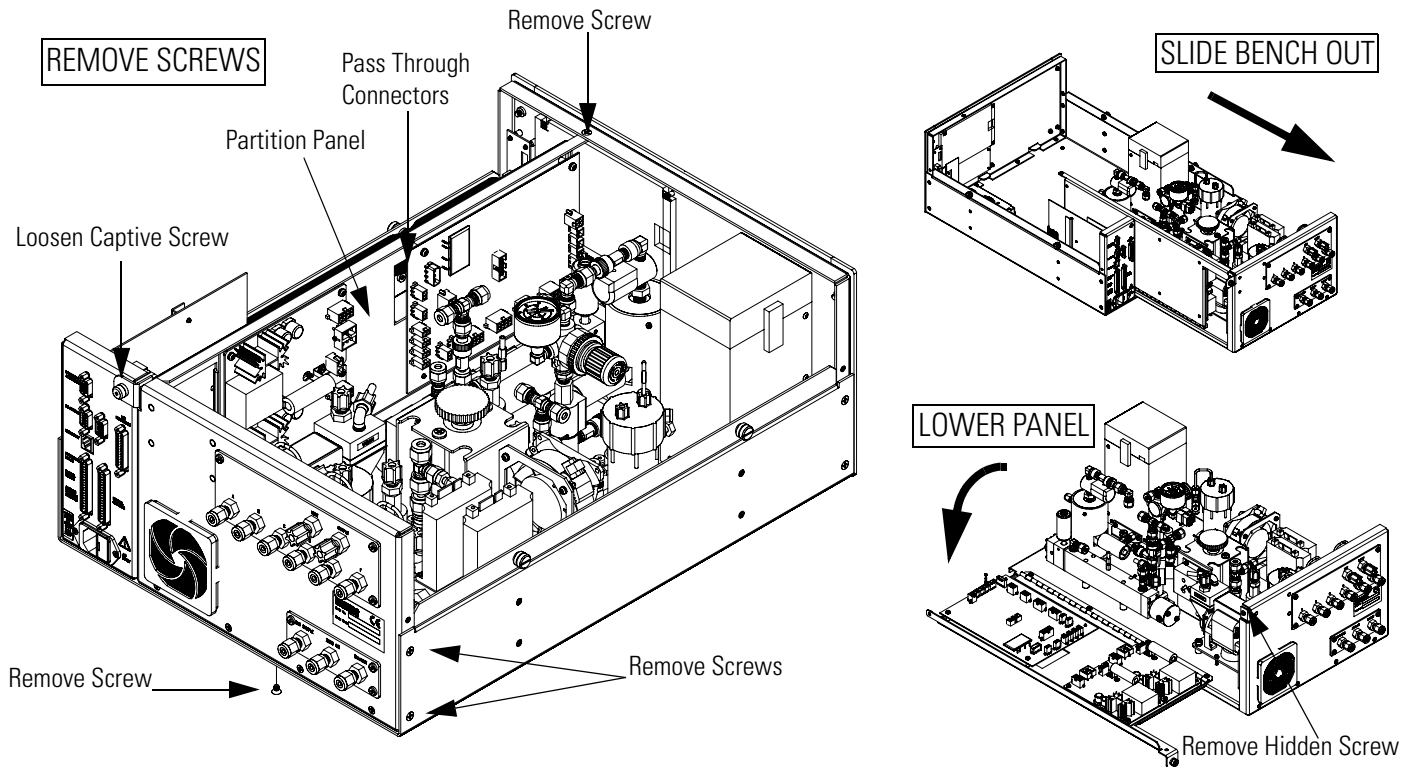| Part Number	Description
101562-00	Terminal Block and Cable Kit (DB25) (optional)
101556-00	Terminal Block and Cable Kit (DB37) (optional)
102645-00	Cable, DB37M to Open End Cable, Six Feet (optional)
102646-00	Cable, DB37F to Open End, Six Feet (optional)
102659-00	Cable, DB25M to Open End, Six Feet (optional)
6219	Cable, RS-232 (optional)
102888-00	Terminal Board PCB Assembly, DB37F (standard with all instruments)
102891-00	Terminal Board PCB Assembly, DB37M (standard with all instruments)
103084-00	Terminal Board PCB Assembly, DB25M (included with optional I/O Expansion Board in all instruments)
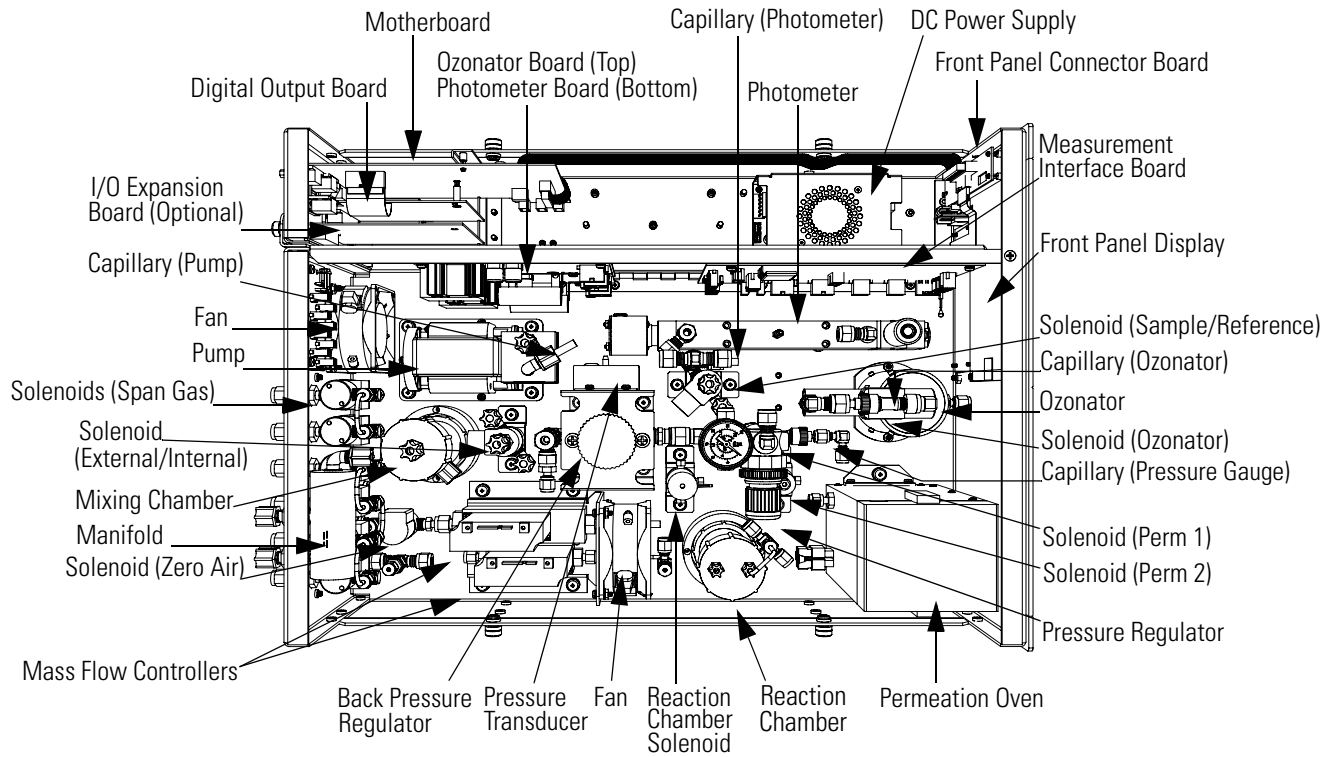
Figure 7-2. Component Layout

Removing the Measurement Bench and Lowering the Partition Panel

The measurement bench can be removed and the partition panel can be lowered to improve access to connectors and components. Refer to the following steps when a procedure requires lowering the partition panel (see Figure 7-3).

REMOVE SCREWS

Remove Screw

Pass Through Connectors

Partition Panel

Loosen Captive Screw

Remove Screw

Remove Screws

SLIDE BENCH OUT

LOWER PANEL

Remove Hidden Screw

Figure 7-3. Removing the Measurement Bench and Lowering the Partition Panel

Equipment Required:

Philips screwdriver

Equipment Damage 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. Turn instrument OFF and unplug the power cord.

2. Disconnect the plumbing connections at the rear of the measurement bench.

3. If the instrument is mounted in a rack, remove it from the rack.

4. Remove the cover.

5. Disconnect the connectors that pass through the center of the partition panel.

6. Remove two screws from the left side of the case.

7. Remove one screw from the bottom rear of the case.

8. Remove one screw from the top front of the partition panel.

9. While holding the case securely, loosen the captive screw at the rear of the measurement bench, and pull the measurement bench from the rear of the case.

10. Remove the screw at the top rear of the partition panel securing the top of partition panel to the measurement bench, and lower the panel being careful not to put excessive tension on the cables.

11. Replace the measurement bench by following the previous steps in reverse.

Fuse Replacement

Use the following procedure to replace the fuse.

Equipment Required:

Replacement fuses:

250VAC, 3 Amp, SlowBlow (for 100VAC and 110VAC models)

250VAC, 1.60 Amp, SlowBlow (for 220-240VAC models)

1. Turn instrument OFF and unplug the power cord.

2. Remove fuse drawer, located on the AC power connector.

3. If either fuse is blown, replace both fuses.

4. Insert fuse drawer and reconnect power cord.

Accessing the Service Mode

If the Service is not displayed on the Main Menu, use the following procedure to display it.

1. At the Main Menu, press [↓] to scroll to Instrument Controls > press [↵] > [↓] to scroll to **Service Mode** > and press [↵].

   The Service Mode screen appears.

2. Press [↵] to toggle the Service Mode to ON.

3. Press [■] > [■] to return to the Main Menu.

4. Return to the procedure.

Leak Test and Pump Checkout - with Photometer Option

Use the following procedure to check for leaks in the system and to leak test the pump. This procedure is for Model 146*i* instruments that have the photometer option. For Model 146*i* instruments that do not have the photometer option, refer to "Leak Test and Pump Checkout - without Photometer Option."

⚠ **WARNING** The service procedures in this manual are restricted to qualified service representatives. ▲

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲

⚠ **Equipment Damage** 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. Disconnect the external SAMPLE input line and plug the external SAMPLE fitting.

2. Disconnect the ZERO AIR input lines and plug.

3. Plug the VENT and OUTPUT.

4. Press [■] to display the **Main Menu**.

5. At Operation, press [↵] to display the Operation screen.

6. Use [↓] to scroll to PHOT (EXT/CTL/OFF or INT), use [→] to change the choice to PHOTO INT, if necessary, and press [↵] to save the setting.

7. Press [■] to display the **Main Menu**.

8. Press [↓] to scroll to Diagnostics and press [↵] to display the **Diagnostics** menu.

9. Use [↓] to scroll to **Pressure** and press [↵] to display the Pressure screen.

   The pressure reading should drop to less than 250 mm Hg.

   If the pump diaphragm is in good condition and the capillary is not blocked, it should take less than 20 seconds from the time the inlet is plugged to the time the reading drops below 250 mm Hg.

   If a leak is suspected, carefully tighten each fitting until the leak is found and check to see that none of the input lines are cracked or broken.

Leak Test and Pump Checkout - without Photometer Option

Use the following procedure to check for leaks in the system and to leak test the pump. This procedure is for Model 146*i* instruments that do not have the photometer option. For Model 146*i* instruments that have the photometer option, refer to "Leak Test and Pump Checkout - with Photometer Option."

Equipment Required:

Vacuum pump

Vacuum gauge

Shut-off valve

⚠ **WARNING** The service procedures in this manual are restricted to qualified service representatives. ▲

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲

⚠ **Equipment Damage** 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. Remove the cover.

2. With the instrument running, cap all external ports on the rear panel except the EXHAUST port.

3. If the instrument is equipped with a permeation oven, activate the permeation oven from the front panel controls. Refer to the "Operation" chapter for additional permeation oven operation information, if necessary.

4. Connect a shutoff valve between the external vacuum pump intake and the vacuum gauge.

5. Attach the external vacuum pump/vacuum gauge assembly with the vacuum gauge side to the calibrator EXHAUST port.

6. Apply vacuum until the gauge stabilizes, then trap the vacuum with the shut-off valve.

7. Verify that the pressure drops below 180 mm Hg by reading the vacuum gauge attached to the pump assembly.

8. If the instrument does not meet the previously described conditions, begin troubleshooting beginning at the top of this procedure.

Mass Flow Controller Replacement

Use the following procedure to replace a mass flow controller (Figure 7-4).

Equipment required:

Wrenches, 7/16 and 9/16

Philips screwdrivers, #1 and #2

Flatblade screwdriver

New mass flow controller

Equipment Damage 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Loosen all four fittings to mass flow controllers.

3. Disconnect electrical connections from the top of the flow controllers noting their positions for reconnection (Figure 7-4).
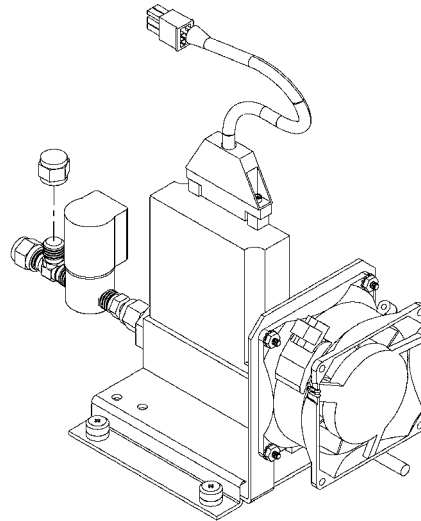
Figure 7-4. Replacing a Mass Flow Controller

4. Remove plumbing from flow controllers.

5. Disconnect fan electrical connector.

6. Remove four screws holding flow controller bracket to floor plate.

7. Remove flow controller assembly.

8. Remove defective flow controller from bracket by removing the two screws holding flow controller to bracket.

9. Install new flow controller by following the above directions in reverse.

10. Leak check system and recalibrate. Refer to "Leak Test and Pump Checkout" in this chapter.

Pump Replacement (Photometer option)

For instruments with the photometer option, use the following procedure to replace the pump (see Figure 7-5). To rebuild the pump, see "Pump Rebuilding" on page 5-9 in the "Preventive Maintenance" chapter.

Equipment Required:

110V pump

Philips screwdriver

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect pump power line from AC PUMP connector on the measurement interface board.

Figure 7-5. Replacing the Pump

3. Remove both lines from pump.

4. Loosen the four captive screws holding the pump to the mounting plate and remove the pump.

5. Install the new pump by following the previous steps in reverse.

Fan Replacement - Rear Panel

Use the following procedure to replace the rear panel fan (Figure 7-6).

Equipment Required:

Fan
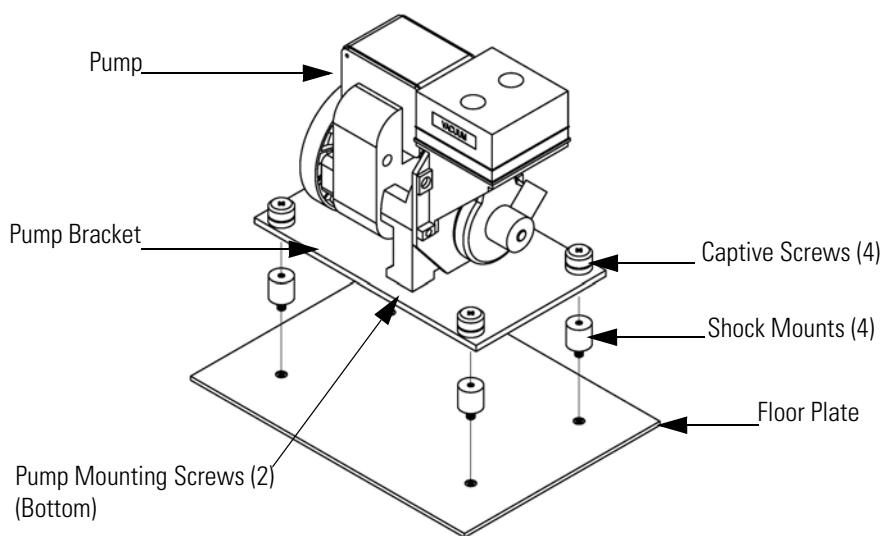
Philips screwdriver

Equipment Damage 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the measurement bench. Refer to "Removing the Measurement Bench and Lowering the Partition Panel" on page 7-9.

3. Pull the power connector off the fan.

4. Remove the fan guard from the fan and remove the filter.

5. Remove the four fan mounting screws and remove the fan.

6. Install a new fan following the previous steps in reverse.

7. Replace the measurement bench.

Mounting Screws (4)

Filter

Fan Guard

Figure 7-6. Replacing the Rear Panel Fan

Fan Replacement - Mass Flow Controllers

Use the following procedure to replace the cooling fan for the mass flow controllers (Figure 7-6).
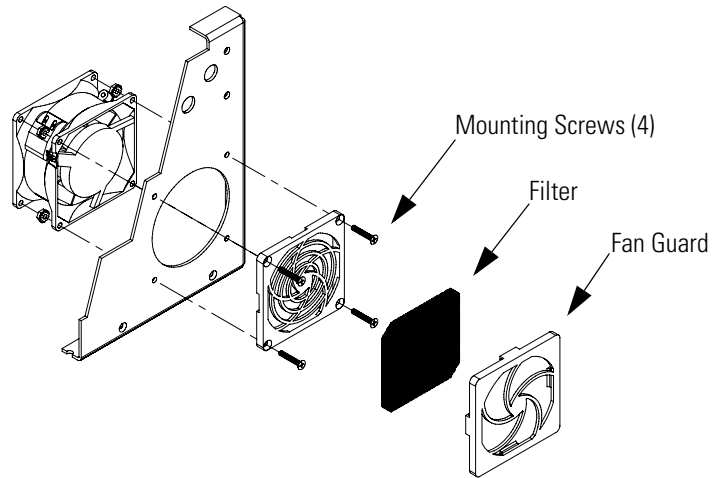
Equipment Required:

Fan

Philips screwdriver

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the mass flow controllers. Refer to "Mass Flow Controller Replacement" on page 7-14.

3. Disconnect the electrical connection from the fan.

4. Remove the fan mounting screws (4) and nuts and remove the fan.

5. Install the new fan using the previous steps in reverse.

6. Reinstall the mass flow controllers.

Analog Output Testing

The analog outputs should be tested if the concentration value on the front panel display disagrees with the analog outputs. To check the analog outputs, you connect a meter to an analog output channel (voltage or current) and compare the meter reading with the output value displayed on the Test Analog Outputs screen.

Equipment Required:

Multimeter

Use the following procedure to test the analog outputs.

1. Connect a meter to the channel to be tested. Figure 7-7 shows the analog output pins and Table 7-4 identifies the associated channels.

2. From the Main Menu, press (↓) to scroll to Diagnostics, press (↵) > (↓) to scroll to **Test Analog Outputs**, and press (↵).

    The Test Analog Outputs screen appears.

3. Press (↓) to scroll to the channel corresponding to the rear panel terminal pins where the meter is connected, and press (↵).

    The Set Analog Outputs screen appears.

4. Press (↓) to set the output to zero.

    The Output Set To line displays Zero.

5. Check that the meter is displaying a zero value. If the meter reading differs by more than one percent, the analog outputs should be adjusted. Refer to the "Analog Output Calibration" procedure that follows.

6. Press (↑) to set the output to full scale.

    The Output Set To line displays Full Scale.

7. Check that the meter is displaying the full scale value. If the meter reading differs by more than one percent, the analog outputs should be adjusted. Refer to the "Analog Output Calibration" procedure that follows.

8. Press [←] to reset the analog outputs to normal.
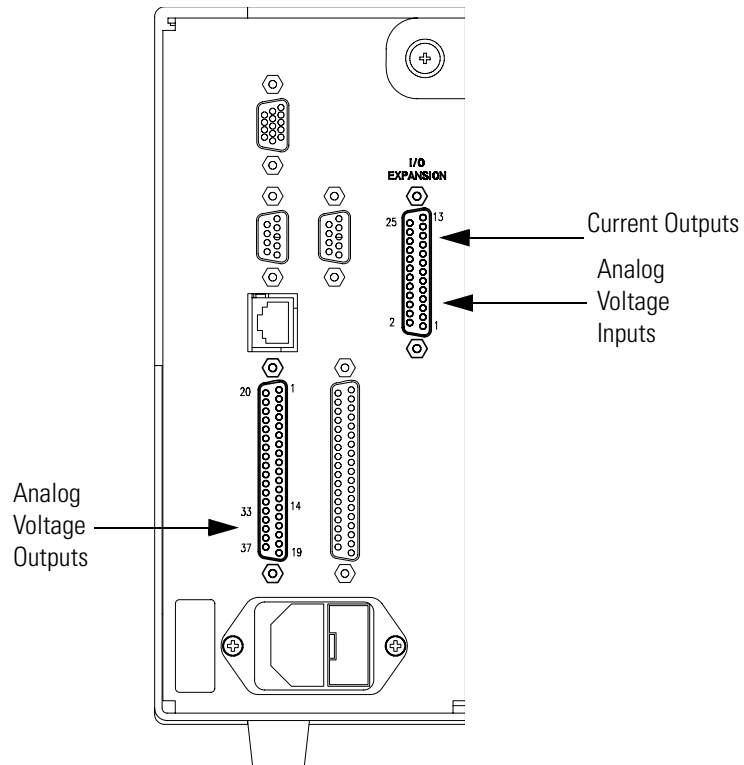
Figure 7-7. Rear Panel Analog Input and Output Pins

Table 7-4. Analog Output Channels and Rear Panel Pin Connections

Voltage Channel	Pin	Current Channel	Pin
1	14	1	15
2	33	2	17
3	15	3	19
4	34	4	21
5	17	5	23
6	36	6	25

Table 7-4. Analog Output Channels and Rear Panel Pin Connections, continued

Voltage Channel	Pin	Current Channel	Pin
Ground	16, 18, 19, 35, 37	Current Output Return	16, 18, 20, 22, 24

Table 7-5. Analog Input Channels and Rear Panel Pin Connections

Input Channel	Pin
1	1
2	2
3	3
4	5
5	6
6	7
7	9
8	10
Ground	4, 8, 11

Analog Output Calibration

Use the following procedure to calibrate the analog outputs if a meter reading in the "Analog Output Testing" procedure differed by more than one percent or after replacing the optional I/O expansion board.

Equipment Required:

Multimeter

1. Connect a meter to the channel to be adjusted and set to voltage or current as appropriate. Figure 7-7 shows the analog output pins and Table 7-4 identifies the associated channels.

2. From the Main Menu, press [↓] to scroll to Service, press [↵] > [↓] to scroll to **Analog Out Calibration,** and press [↵].

   The Analog Output Cal screen appears.

   Note If Service is not displayed, refer to ""Accessing the Service Mode" on page 7-11, then return to the beginning of this step. ▲

3. At the Analog Output Cal screen, press ⬇ to scroll to the voltage channel or current channel corresponding to the rear panel terminal pins where the meter is connected, then press ↵.

4. With the cursor at **Calibrate Zero**, press ↵.

   The Analog Output Cal line displays Zero

   Note When calibrating the analog output, always calibrate zero first and then calibrate full scale. ▲

5. Use ⬆ ⬇ until the meter reads the value shown in the Set Output To line, then press ↵ to save the value.

6. Press ■ to return to the previous screen.

7. Press ⬇ ↵ to select **Calibrate Full Scale**.

8. Use ⬆ ⬇ until the meter reads the value shown in the Set Output To line, then press ↵ to save the value.

Analog Input Calibration

Use the following procedures to calibrate the analog inputs after replacing the optional I/O expansion board. These procedures include selecting analog input channels, calibrating them to zero volts, and then calibrating them to full scale using a known voltage source.

Calibrating the Input Channels to Zero Volts

Use the following procedure to calibrate the input channels to zero volts.

1. From the Main Menu, press ⬇ to scroll to Service, press ↵ > ⬇ to scroll to **Analog Input Calibration,** and press ↵.

   The Analog Input Cal screen appears.

   Note If Service is not displayed, refer to ""Accessing the Service Mode" on page 7-11, then return to the beginning of this step. ▲

2. At the Analog Input Cal screen, press [↓] to scroll to a channel, and press [↵].

3. With the cursor at **Calibrate Zero**, press [↵].

   The screen displays the input voltage for the selected channel.

4. Make sure that nothing is connected to the channel input pins and press [↵] to calibrate the input voltage on the selected channel to zero volts.

   The screen displays 0.00 V as the voltage setting.

5. Press [■] > [■] to return to the Analog Input Cal screen and repeat Steps 2 through 4 to calibrate other input channels to zero as necessary.

6. Continue with the "Calibrating the Input Channels to Full Scale" procedure that follows.

Calibrating the Input Channels to Full Scale

Use the following procedure to calibrate the input channels to full scale by applying a known voltage to the channels.

Equipment Required:

   DC voltage source (greater than 0 volts and less than 10 volts)

1. Connect the known DC voltage source to the input channel (1-8) to be calibrated. Figure 7-7 shows the analog input pins and Table 7-5 identifies the associated channels.

2. From the Main Menu, press [↓] to scroll to Service, press [↵] > [↓] to scroll to **Analog Input Calibration,** and press [↵].

   The Analog Input Cal screen displays input channels 1-8.

   Note If Service is not displayed, refer to ""Accessing the Service Mode" on page 7-11, then return to the beginning of this step. ▲

3. At the Analog Input Cal screen, press [↓] to scroll to the channel selected in Step 1, and press [↵].

4. Press [↓] to scroll to **Calibrate Full Scale**, and press [↵].

    The screen displays the current input voltage for the selected channel.

5. Use [←][→] and [↑][↓] to enter the source voltage, and press [↵] to calibrate the input voltage for the selected channel to the source voltage.

6. Press [■] > [■] to return to the input channels display and repeat Steps 3-5 to calibrate other input channels to the source voltage as necessary.

I/O Expansion Board Replacement (Optional)

Use the following procedure to replace the optional I/O expansion board (Figure 7-8).

Note After replacing the optional I/O expansion board, calibrate the current outputs and the analog voltage inputs. See the "Analog Output Calibration" on page 7-21 and the "Analog Input Calibration" on page 7-22 in this chapter. ▲

Equipment Required:

   I/O expansion board

   Nut driver, 3/16-inch

⚠

Equipment Damage 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unplug the I/O expansion board cable from the EXPANSION BD connector on the motherboard.

3. Remove the two standoffs holding the I/O expansion board connector to the rear panel (Figure 7-9).

4. Pop off the board from the mounting studs and remove the board.

5. To install the I/O expansion board, follow previous steps in reverse.

Figure 7-8. Replacing the I/O Expansion Board (Optional)

Figure 7-9. Rear Panel Board Connectors

Digital Output Board Replacement

Use the following procedure to replace the digital output board (Figure 7-8).

Equipment Required:

Digital output board

Nut driver, 3/16-inch

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the I/O expansion board (optional), if used. See the "I/O Expansion Board Replacement" procedure in this chapter.

3. Disconnect the digital output board ribbon cable from the motherboard.

4. Using the nut driver, remove the two standoffs securing the board to the rear panel (Figure 7-9).

5. Pop off the digital output board from the mounting studs and remove the board.

6. To install the digital output board, follow previous steps in reverse.

Motherboard Replacement

Use the following procedure to replace the motherboard (Figure 7-8).

Equipment Required:

Motherboard

Philips screwdriver

Nut driver, 3/16-inch

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the I/O expansion board (optional), if used. See the "I/O Expansion Board Replacement" procedure in this chapter.

3. Remove the digital output board. See the "Digital Output Board Replacement" procedure in this chapter.

4. Unplug all connectors from the motherboard. Note connector locations to facilitate reconnection.

5. Using the nut driver, remove the six standoffs securing the board to the rear panel.

6. Pop off the motherboard from motherboard support bracket, and remove the motherboard.

7. To install the motherboard, follow previous steps in reverse.

Measurement Interface Board Replacement

Use the following procedure to replace the measurement interface board (Figure 7-10).

Equipment Required:

Measurement interface board

Philips screwdriver

⚠ **Equipment Damage** 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. Refer to "Removing the Measurement Bench and Lowering the Partition Panel" on page 7-9 to lower the partition panel, then proceed to the next step below.

2. Unplug all connectors. Note the locations of the connectors to facilitate reconnection.

3. Remove the two retaining screws from the top of the board.

4. Pop off the measurement interface board from the two mounting studs at the bottom of the board and remove the board.

Figure 7-10. Replacing the Measurement Interface Board

5. To install the measurement interface board, follow previous steps in reverse.

6. Re-install the measurement bench. Refer to "Removing the Measurement Bench and Lowering the Partition Panel" on page 7-9.

Front Panel Board Replacement

Use the following procedure to replace the front panel board (Figure 7-11).

Equipment Required:

Front panel board

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the three ribbon cables and the two-wire connector from the front panel board.

3. Pop off the board from the two top mounting studs and remove the board by lifting it up and off the slotted bottom support.

4. Replace the front panel board by following previous steps in reverse.

Figure 7-11. Replacing the Front Panel Board and the LCD Module

LCD Module Replacement

Use the following procedure to replace the LCD module (Figure 7-11).

Equipment Required:

LCD module

Philips screwdriver

⚠ **CAUTION** If the LCD panel breaks, do not to let the liquid crystal contact your skin or clothes. If the liquid crystal contacts your skin or clothes, wash it off immediately using soap and water. ▲

⚠ **Equipment Damage** 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. ▲

Do not remove the panel or frame from the module. ▲

The polarizing plate is very fragile, handle it carefully. ▲

Do not wipe the polarizing plate with a dry cloth, it may easily scratch the plate. ▲

Do not use alcohol, acetone, MEK or other Ketone based or aromatic solvents to clean the module, use a soft cloth moistened with a naphtha cleaning solvent. ▲

Do not place the module near organic solvents or corrosive gases. ▲

Do not shake or jolt the module. ▲

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the two screws from right side of LCD module (viewed front front).

3. Disconnect the ribbon cable and the two-wire connector from the front panel board.

4. Loosen left-side retaining screw (viewed from front) and slide the LCD module out towards the right and rear of the instrument.

5. Replace the LCD module by following previous steps in reverse.

Photometer Lamp Replacement (Photometer option)

The lamp control system of the Model 146*i* Photometer option 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 occur:

• 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 the "Troubleshooting" chapter).

Note It is not necessary to recalibrate the Model 146*i* since it is a ratio instrument and replacing the lamp does not affect the calibration. However, after replacing the photometer lamp, you must adjust the photometer lamp voltage to ensure proper operation. Refer to the "Photometer Lamp Voltage Adjustment" procedure that follows to adjust the photometer lamp voltage ▲

Use the following procedure to replace the photometer lamp (Figure 7-12).

Equipment required:

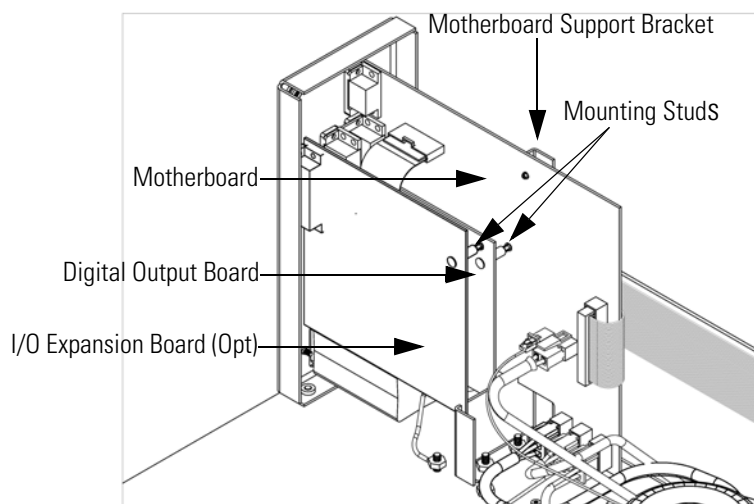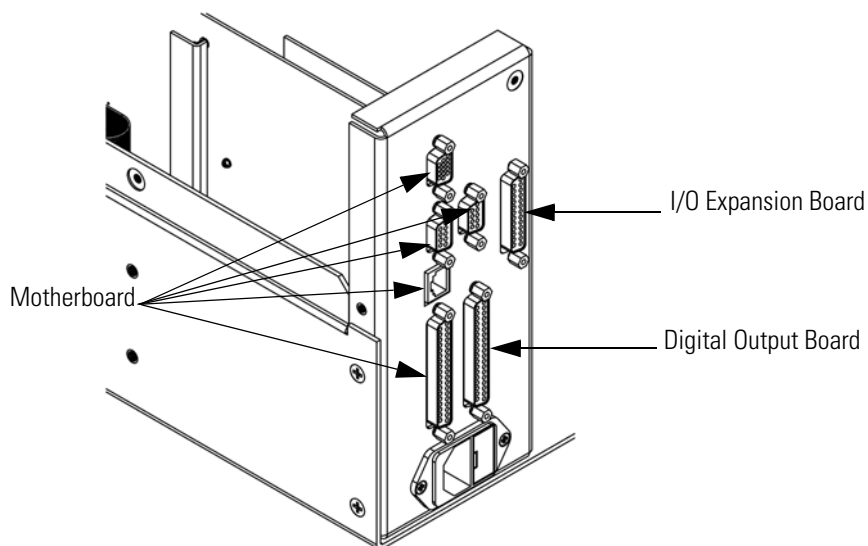Allen wrench, 1/16-inch

Equipment Damage 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. ▲

Use the following procedure to replace the photometer lamp.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect the photometer lamp cable from the LAMP connector on the photometer board.

3. Slide the insulation off the end of the lamp.

4. Loosen the Allen screw on the lamp clamp.

Figure 7-12. Photometer Components

5. Carefully slide the lamp out of the photometer.

6. Carefully slide new lamp into place until it bottoms and tighten the lamp clamp screw.

7. Plug the new photometer lamp cable into the LAMP connector on the photometer board.

8. Re-install the instrument cover.

9. Reconnect power and turn instrument ON.

10. After lamp has stabilized (approximately 15 minutes), refer to the "Photometer Lamp Voltage Adjustment" procedure that follows to adjust the photometer lamp voltage.

Photometer Lamp Voltage Adjustment (Photometer option)

Use the following procedure to adjust the photometer lamp intensity to approximately 100,000 Hz.

Note After turning power ON, wait for the lamp to stabilize (approximately 15 minutes) before beginning the following lamp voltage adjustment procedure. ▲

1. From the Main Menu, press [↓] to scroll to Service > press [↵] > [↓] to scroll to **Lamp Setting** > and press [↵].

    The Photometer Lamp Setting screen appears.

    Note If Service is not displayed, refer to ""Accessing the Service Mode" on page 7-11, then return to the beginning of this step. ▲

2. At the Photometer Lamp Setting screen, use [↑][↓] to increment/decrement the Lamp Setting % until Intensity indicates approximately 100,000 Hz.

3. Press [↵] to save the setting.

Photometer Lamp Heater Replacement

Use the following procedure to replace the photometer lamp heater (Figure 7-12).

Equipment required:

Photometer lamp heater
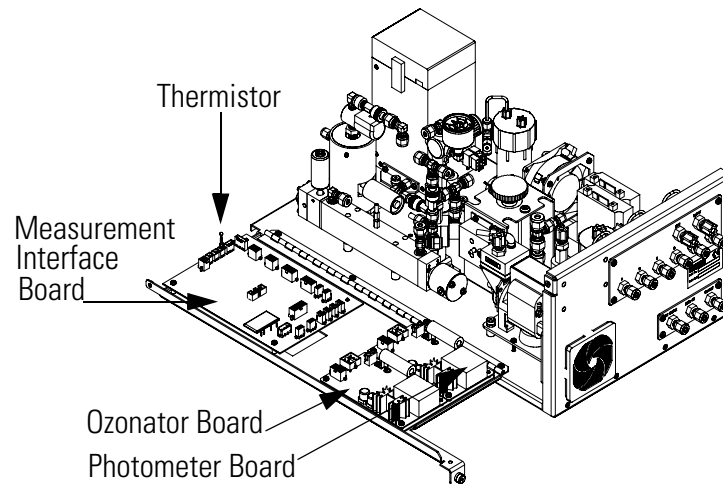
Allen wrench, 7/64-inch

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect the plumbing and electrical connections.

3. Loosen the Allen screws (4) securing the photometer to the floor plate (Figure 7-12) and remove the photometer.

4. Remove four (4) mounting screws on the lamp heater and remove the heater.

5. Install the new lamp heater and secure with the four (4) mounting screws.

Photometer Replacement (Photometer option)

Use the following procedure to replace the photometer (Figure 7-12).

Equipment required:

Photometer

Allen wrench, 7/64-inch

Open-end wrench, 9/16-inch

⚠ **Equipment Damage** 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. ▲

Use the following procedure to replace the photometer.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect the plumbing and electrical connections.

3. Loosen the four (4) socket head retaining screws securing the photometer to the floor plate (Figure 7-12) and remove the photometer.

4. Perform the previous steps in reverse to install the new photometer.

5. Calibrate the instrument. Refer to the "Calibration" chapter in this manual.

Photometer Board Replacement (Photometer option)

Use the following procedure to replace the photometer board (Figure 7-10).

Equipment required:

Photometer board

Philips screwdriver
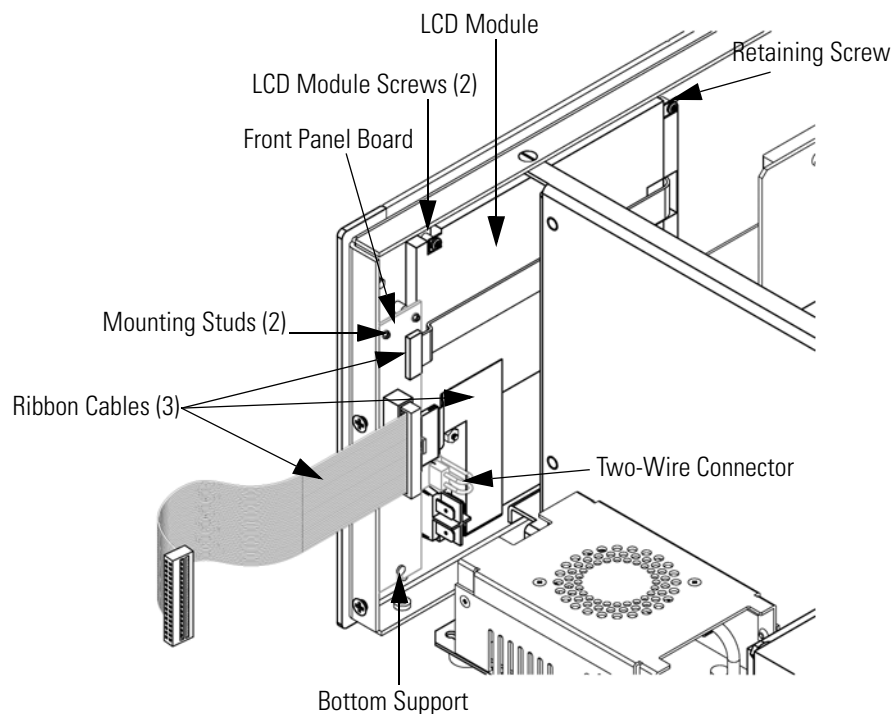
⚠ **Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

Use the following procedure to replace the photometer board.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the ozonator board. Refer to "Ozonator Board Replacement (Ozonator option)" on page 7-45.

3. Remove the cables from the board.

4. Remove the two screws from the top of the board.

5. Pop off the board from the bottom mounting studs and remove the board.

6. To install the new photometer board, follow previous steps in reverse.

7. Reinstall the ozonator board.

Detector Replacement (Photometer option)

Use the following procedure to replace the photometer detector (Figure 7-12).

Equipment Required:

Detector assembly

Allen wrench, 1/16-inch

⚠️ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect the plumbing and electrical connections.

3. Loosen the captive screws (4) securing the photometer to the floor plate (Figure 7-12) and remove the photometer.

4. Loosen the Allen screw securing the detector in detector block and remove the detector.

5. Install the new detector by following the above steps in reverse.

6. Adjust the photometer lamp intensity, if necessary via Service > Lamp Setting.

Photometer Thermistor Replacement

Use the following procedure to replace the photometer thermistor (Figure 7-12).

Equipment Required:

Photometer thermistor

Wrench, 1/4-inch

⚠️ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect the thermistor electrical connection.

3. Remove the thermistor and replace it with the new thermistor.

4. Connect the thermistor electrical connection.

Photometer Temperature Calibration (Photometer option)

Use the following procedure to calibrate the photometer temperature.

Equipment Required:

Calibrated thermometer or 10K ±1% Resistor

⚠ **WARNING** The service procedures in this manual are restricted to qualified service representatives. ▲

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲
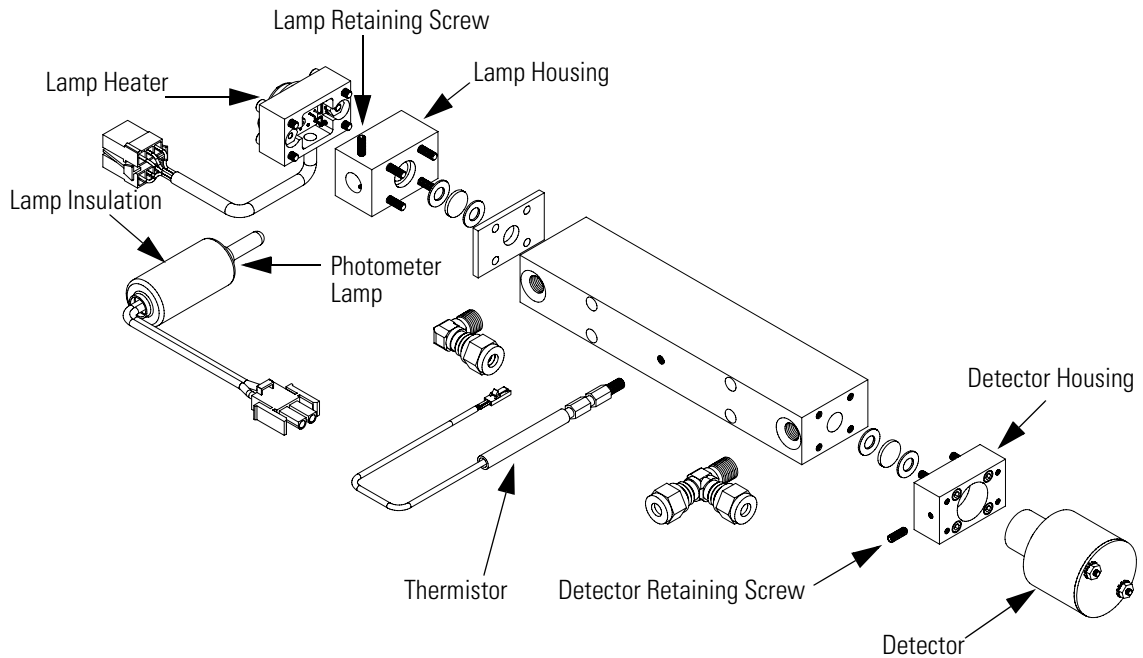
⚠ **Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

1. Remove the instrument cover.

2. Tape the thermistor (Figure 7-12) to a calibrated thermometer.

Note Since the thermistors are interchangeable to an accuracy of ±0.2 °C, and have a value of 10K ohms at 25 °C, an alternate procedure is to connect an accurately known 10K resistor to the thermistor input (TEMP) on the measurement interface board, and enter the temperature reading. ▲

A 1 °C change corresponds to a ±5% change in resistance, thus this alternative procedure can be quite accurate as a check; however, it clearly is not NIST traceable. ▲

3. From the Main Menu, press ⬇ to scroll to Service > press ↵ > ⬇ to scroll to **Temperature Calibration** > and press ↵.

The Calibrate Bench Temp screen appears.

Note If Service is not displayed, refer to ""Accessing the Service Mode" on page 7-11, then return to the beginning of this step. ▲

4. Wait at least 10 seconds for the reading to stabilize, use ⬅ ➡ and ⬆ ⬇ to enter the known temperature, and press ⏎ to save the temperature value.

5. Install the cover.

Solenoid Replacement

The Model 146*i* includes the following solenoids. Refer to "Component Layout" on page 7-8 to locate these solenoids within the instrument. If you need the solenoid part number, refer to the "Replacement Parts List" on page 7-5.

*   External/Internal solenoid

*   Ozonator solenoid

*   Perm1 and Perm 2 solenoids

*   Reaction chamber solenoid

*   Sample/Reference solenoid

*   Span gas solenoids

*   Zero air solenoid

⚠ **Equipment Damage** 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. ▲

Use the following general replacement procedure to replace a solenoid.

Equipment required:

Solenoid

Open-end wrenches, 5/16, 1/2, 9/16, and 5/8-inch

Flatblade screwdriver

Philips screwdriver

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unplug the solenoid electrical cable.

3. Disconnect all lines from defective solenoid.

4. Remove the solenoid and replace with the new solenoid.

5. Reconnect the electrical connection and the lines.

6. Check for leaks after replacing any solenoid. Refer to "Leak Test and Pump Checkout" in this chapter.

Pressure Transducer Replacement (Photometer option)

Use the following procedure to replace the pressure transducer. Refer to "Component Layout" on page 7-8 to locate the pressure transducer within the instrument, and refer to "Replacement Parts List" on page 7-5 if you need the pressure transducer part number.

Equipment Required:

Pressure transducer assembly

Philips screwdriver, short

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect plumbing from the pressure transducer assembly. Note the plumbing connections to facilitate reconnection.

3. Disconnect the pressure transducer PRESS connector from the measurement interface board.

4. Remove the two pressure transducer retaining screws and remove the pressure transducer.

5. Install the new pressure transducer assembly by following the previous steps in reverse.

6. Calibrate the pressure transducer. Refer to the "Pressure Transducer Calibration" procedure that follows.

Pressure Transducer Calibration (Photometer option)

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.

Use the following procedure to calibrate the pressure transducer.

Equipment Required:

    Vacuum pump

WARNING The service procedures in this manual are restricted to qualified service representatives. ▲

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲

Equipment Damage 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. Remove the cover.

2. Disconnect the tubing from the pressure transducer and connect a vacuum pump known to produce a vacuum less than 1 mm Hg.

3. From the Main Menu, press [↓] to scroll to Service > press [←] > [↓] to scroll to **Pressure Calibration** > and press [←].

   The Pressure Sensor Cal screen appears.

   Note If Service is not displayed, refer to ""Accessing the Service Mode" on page 7-11, then return to the beginning of this step. ▲

4. At the Pressure Sensor Cal screen, press [←] to select **Zero**.

   The Calibrate Pressure Zero screen appears.

5. Wait at least 10 seconds for the zero reading to stabilize, then press [←] to save the zero pressure value.

6. Disconnect the pump from the pressure transducer.

7. Press [■] to return to the Pressure Sensor Cal screen.

8. At the Pressure Sensor Cal screen, press [↓] [←] to select **Span**.

   The Calibrate Pressure Span screen appears.

9. Wait at least 10 seconds for the ambient reading to stabilize, use [←] [→] and [↑] [↓] to enter the known barometric pressure, and press [←] to save the pressure value.

10. Reconnect the tubing to the pressure transducer.

11. Install the cover.

Ozonator Lamp Replacement (Ozonator option)

Use the following procedure to replace the ozonator lamp (Figure 7-13).

Equipment Required:

Ozonator lamp

Allen wrench, 3/32-inch

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unplug the ozonator lamp cable from the LAMP connector on ozonator board (Figure 7-10).

3. Slide insulation off the lamp handle onto the lamp cord.

4. Loosen both lamp clamp screws.

5. Carefully slide lamp out of ozonator housing.

6. Slide insulation off of old lamp and slide onto new lamp cord.

7. Carefully insert new lamp into ozonator housing until it bottoms. Pull lamp out approximately 1/16-inch (to allow for expansion when the lamp warms up) and tighten the Allen screws on the clamp.

8. Slide the lamp insulation against the ozonator.

9. Re-connect the ozonator LAMP connector to the ozonator board.

10. Replace the cover and reconnect power.

Ozonator Lamp Heater Replacement (Ozonator option)

Use the following procedure to replace the ozonator lamp heater.

Equipment Required:

Ozonator lamp heater

Allen wrench, 3/32-inch and 7/64-inch

Philips screwdriver

Heat conductive compound

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unplug heater cable from the LAMP HEATER and LAMP connectors on the ozonator board (Figure 7-10).

3. Disconnect plumbing from the ozonator.

4. Remove the ozonator by removing the two screws securing the ozonator to the floor plate and lifting the ozonator straight up.

5. Remove the ozonator flange by removing three screws securing the bottom flange and pulling the flange off.

6. Remove the ozonator lamp heater block from the ozonator by removing four Allen screws.

7. Coat new lamp heater block with thin film of heat conductive compound.

8. Install new ozonator lamp heater block by following the above procedure in reverse.

9. Re-install the instrument cover.

Ozonator Replacement (Ozonator option)

Use the following procedure to replace the ozonator (Figure 7-13).

Equipment Required:

Wrenches, 7/16 and 9/16-inch

Philips screwdriver

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unplug heater cable from the LAMP HEATER and LAMP connectors on the ozonator board (Figure 7-10).

3. Disconnect plumbing from the ozonator.

4. Remove the ozonator by removing the two screws securing the ozonator to the floor plate and lifting the ozonator straight up.

5. Install new ozonator by following the above procedure in reverse. Ensure all fittings are tight.

6. Perform a leak test. Refer to "Leak Test and Pump Checkout" in this chapter.

7. Re-install the instrument cover.

Capillary
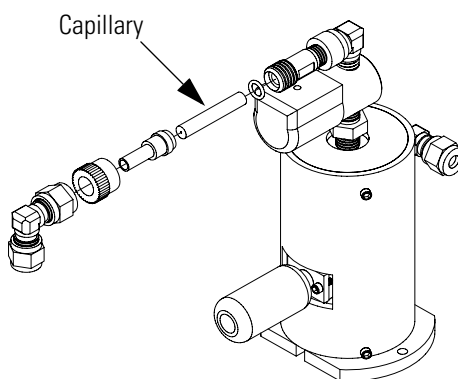
Figure 7-13. Replacing the Ozonator

Ozonator Board Replacement (Ozonator option)

Use the following procedure to replace the ozonator board (Figure 7-10).

Equipment Required:

Ozonator board

Philips screwdriver

⚠️ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the connection cables from the board.

3. Remove the two screws from the top of the board.

4. Pop off the board from the bottom mounting studs and remove the board.

5. To install the new ozonator board, follow previous steps in reverse.

Permeation Oven Replacement

Use the following procedure to replace the permeation oven.

Equipment Required:

Permeation oven

Flatblade screwdriver

Wrenches, 1/4-inch and 7/16-inch

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect all electrical connections.

3. Disconnect the gas fittings.

4. Remove the two (2) screws holding the oven to the floor plate and remove the oven.

5. Remove oven glass chamber from oven and install in new oven.

   a. Release the latches on the sides of the oven cover and remove cover.

   b. Remove glass chamber assembly by loosening (not removing) knurled screw, located at the top of the chamber, and gently pulling assembly upward. Completely remove assembly from oven (Figure 7-14).

   c. Separate glass chamber from top assembly by twisting and gently pulling glass away from top (Figure 7-14). Keep glass clean by using Kimwipes or similar material to handle glass.

   d. Place permeation tube in chamber.

   e. Attach glass chamber to top assembly by gently pushing together with a slight twisting motion (Figure 7-14).

   f. Replace glass chamber assembly into oven until top of assembly is flush or slightly below oven top (Figure 7-15).

g. Tighten knurled screw finger tight. Do not use tools to tighten.

h. Replace oven cover, being careful to place tubing and wire in slot of cover.

6. Install the new oven by following the previous steps in reverse.

7. Check the system for leaks. Refer to "Leak Test and Pump Checkout" in this chapter.
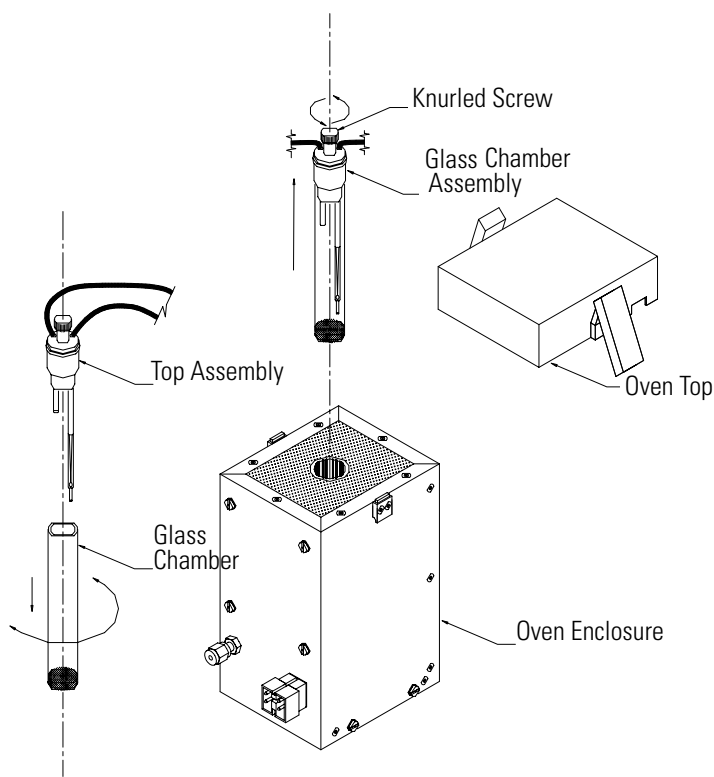
Figure 7-14. Removing the Glass Chamber Assembly

Figure 7-15. Replacing the Glass Chamber Assembly

Reaction Chamber/Mixing Chamber Replacement

Use the following procedure to replace the reaction chamber or mixing chamber.

Equipment Required:

Reaction chamber or mixing chamber

Allen wrench, 7/64-inch

Philips screwdriver

Equipment Damage 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the plumbing.

3. Remove two (2) Allen screws from the top of the holder assembly.

4. Remove two (2) Allen screws from the side of the holder assembly.

5. Remove the chamber and replace with new chamber.

Pressure Regulator Replacement

Use the following procedure to replace the pressure regulator (Figure 7-16).

Equipment Required:

Pressure regulator

Wrenches, 7/16 and 9/16-inch

⚠ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove plumbing.

3. Remove fitting from bottom of the pressure regulator by holding the assembly in place with a 9/16-inch wrench as shown in Figure 7-16 and loosening the pressure regulator fitting.
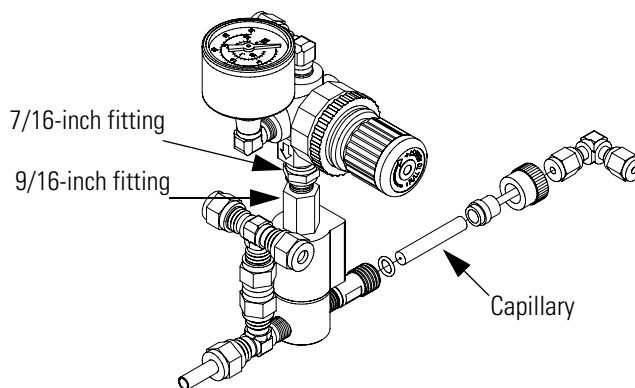
Figure 7-16. Replacing the Pressure Regulator

4. Remove the pressure regulator and replace with a new unit.

5. Reconnect plumbing and check for leaks. Refer to "Leak Test and Pump Checkout" in this chapter.

Back Pressure Regulator Replacement

Use the following procedure to replace the back pressure regulator.

Equipment Required:

Back pressure regulator

Wrenches, 5/32 and 1/2-inch

Flatblade screwdriver

Philips screwdriver

⚠️ **Equipment Damage** 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. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove plumbing.

3. Loosen four (4) captive screws and remove the assembly.

4. Remove the pressure transducer.

5. Remove the back pressure regulator handle.

6. Remove two (2) screws holding the regulator to the bracket.

7. Remove the back pressure regulator.

8. Install a new back pressure regulator and calibrate.

9. After calibration, tighten the locking nut securing the position of the back pressure regulator handle.

10. Remove flow controller assembly.

11. Remove defective flow controller from the bracket by removing the two retaining screws.

12. Install the new flow controller by following the previous steps in reverse.

13. Check the system for leaks. Refer to "Leak Test and Pump Checkout" in this chapter.

14. Recalibrate.

Pressure Regulator(s) Adjustment

Use the following procedure to adjust the pressure regulator and the back pressure regulator.

Equipment required:

Digital flow meter capable of measuring 150 sccm

WARNING The service procedures in this manual are restricted to qualified service representatives. ▲

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲

Equipment Damage 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. Configure a digital flow meter (capable of measuring 150 sccm) with a 0.01-inch capillary restricting the meter input.

2. For instruments equipped with the ozonator option, attach the digital flow meter to the gas line immediately preceding the ozonator capillary holder (attached to the solenoid valve on the ozonator).

   For instruments equipped with only the permeation oven option, attach the digital flow meter in place of the tee fitting between the back pressure regulator input and the Perm 1 solenoid valve.

3. Connect a source of zero air to the zero air bulkhead connector and the GAS A bulkhead fitting (located on the rear panel).

4. Activate the Service mode. Refer to "Accessing the Service Mode" on page 7-11, then return to the next step in this procedure.

5. From the Main Menu, press (↓) to scroll to Diagnostics, press (↵), scroll to **Instrument Configuration,** press (↵), and enable all appropriate options.

6. Set all parameters that apply as follows:

GAS A	Maximum flow (see Note)
ZERO	0.000 PPM
PERM OFF	0.000 PPM
OZONE OFF	0.0%
PHOT OFF	

    Note To acquire maximum flow setting, go to Service > Flow Control Selection > **Zero Scale**, and use the zero flow controller zero scale value listed as the appropriate input for GAS A. ▲

7. If the instrument includes an output pressure regulator, reduce the output pressure to zero on the gauge.

8. Set the back pressure regulator to indicate a flow of 150 sccm on the digital flow meter.

9. Change the GAS A flow rate to 400 sccm and observe the digital flow meter to verify that the flow rate remains greater than 125 sccm.

10. Disconnect the digital flow meter and all associated plumbing, reconnect the instrument plumbing and tighten securely.

11. Set GAS A to OFF and set the output pressure regulator to 10 psig.

12. Tighten the locknut on the back pressure regulator and set the lock on the pressure adjust knob on the output pressure regulator.

Ambient Temperature Calibration

Use the following procedure to calibrate the ambient internal temperature for the instrument.

Equipment Required:

Calibrated thermometer or 10K ±1% resistor

WARNING The service procedures in this manual are restricted to qualified service representatives. ▲

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲

Equipment Damage 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. Remove the instrument cover.

2. Tape the thermistor (Figure 7-3) to a calibrated thermometer.

Note Since the thermistors are interchangeable to an accuracy of ±0.2 °C, and have a value of 10K ohms at 25 °C, an alternate procedure is to connect an accurately known 10K resistor to the thermistor input (AMB TEMP) on the measurement interface board, and enter the temperature reading. ▲

A 1 °C change corresponds to a ±5% change in resistance, thus this alternative procedure can be quite accurate as a check; however, it clearly is not NIST traceable. ▲

3. From the Main Menu, press [↓] to scroll to Service, press [↵] > [↓] to scroll to **Temperature Calibration**, and press [↵].

The Calibrate Ambient Temperature screen appears.

> **Note** If Service is not displayed, refer to ""Accessing the Service Mode" on page 7-11, then return to the beginning of this step. ▲

4. Wait at least 10 seconds for the ambient reading to stabilize, use ⟵ and ⟶ and ⬆ ⬇ to enter the known temperature, and press ⏎ to save the temperature value.

5. Install the cover.

Service Locations

For additional assistance, Thermo Fisher Scientific has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

Chapter 8 System Description

This chapter describes the function and location of the system components, provides an overview of the software structure, and includes a description of the system electronics and input/output connections and functions.

- "Hardware" on page 8-1 describes the analyzer components.

- "Software" on page 8-7 provides an overview of the software organization and detailed information on the software tasks.

- "Electronics" on page 8-8 describes the system boards, assemblies, and connectors.

- "I/O Components" on page 8-11 describes the input and output communication functions and components.

Hardware

The Model 146*i* components include (Figure 8-1):

- Flow system

- Photometer with photometer lamp (optional)

    - Pressure transducer

    - Photometer lamp power supply

    - Photometer temperature thermistor

    - Pump

    - Sample/Reference Solenoid Valves

- Ozonator assembly (optional)

    - Ozonator lamp power supply

- Permeation oven (optional)
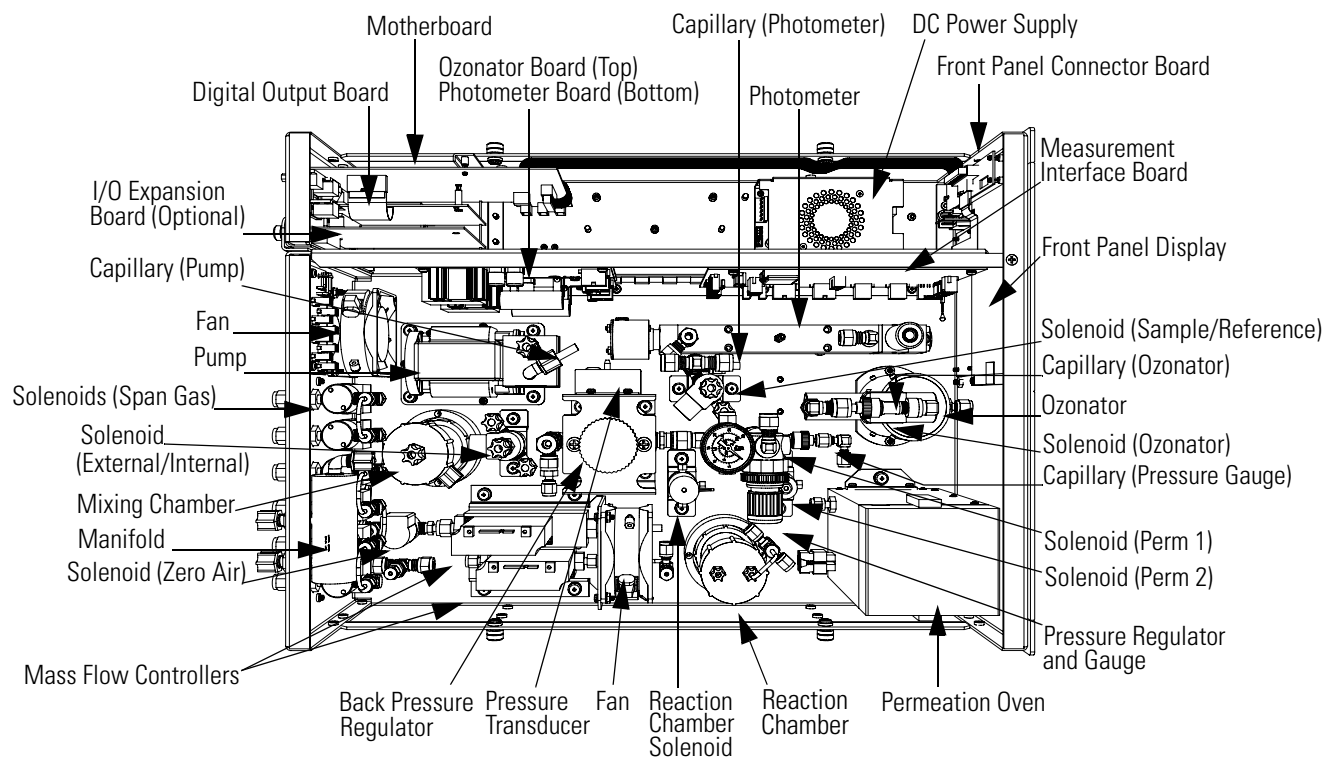
Figure 8-1. Hardware Components

Flow System

The Model 146i Dynamic Gas Calibrator can produce up to four different flow streams, using three hardware modules. The basic unit contains only the dilution module. There are two optional modules, either or both of which can be added to the basic instrument. These optional modules are:

- the ozonator generating module which produces an ozone flow or gas phase titration (GPT) with the addition of an NO cylinder.

- the permeation tube oven module

The flow for each module is governed by mass flow controllers and solenoids. Each system is described independently. While many of the components are shared, they may only be necessary for one or two functions. These components are only described when the system that requires them is being used.

Precision Gas Dilution

Gas dilution is achieved by using two accurate mass flow controllers. One governs high flow (typically 10 LPM fullscale) to control the diluting zero air, the other governs low flow (typically 100 sccm) for controlling the gas to be diluted. The two components are mixed in a Teflon mixing chamber.

Since the mass flow controllers used do not have a positive shutoff, a zero air solenoid shuts off zero air when the system is in standby to reduce zero air use.

The Model 146i uses as many as six different independent gas inlets which are individually controlled by gas solenoids A through F depending on the mode being commanded.

Ozone Generation

The Model 146i produces ozone by exposing air to light at 185 nm. The ozone level can be changed by changing the flow through the ozone generator or by changing the light intensity. In the Model 146i, the selected light intensity level is held constant by temperature controlling the lamp and by using a highly stable lamp power supply. The flow is held constant by the mass flow controller.

Gas Phase Titration

Gas phase titration in the Model 146i is accomplished by combining the outputs of the precision gas dilution system with that of the ozone generating source. The gas dilution system is used to produce an accurately known concentration of NO from a known concentration gas cylinder. The amount of NO_2 formed is determined by mixing the NO concentration with ozone and measuring the loss of NO, (it is equal to the NO loss).

The only caution that must be used in performing the gas phase titration is to ensure the $NO-O_3$ reaction has been completed. Empirically, certain dynamic parameter constraints have been derived to ensure completion of the reaction. These conditions dictate that the residence time in the reaction chamber, the gas flow rate and reaction chamber volumes meet the following conditions:

Condition 1: $\quad P_R = [NO]_{RC} \times t_R \geq 2.75 \text{ ppm - min}$

Condition 2: $\quad [NO]_{RC} = [NO]_{STD} \times \dfrac{F_{NO}}{F_O + F_{NO}}$

Condition 3: $\quad t_R = \dfrac{V_{RC}}{F_O + F_{NO}} \leq 2\text{min}$

where:

P_R	=	the dynamic specification, determined empirically, to ensure complete reaction of the available O3, ppm-min
$[NO]_{RC}$	=	the NO concentration in the reaction chamber, ppm
t_R	=	the residence time in the reaction chamber, min
$[NO]_{STD}$	=	the concentration of the NO gas cylinder, ppm
F_{NO}	=	the NO flow rate, sccm
F_O	=	the O3 generator air flow rate, sccm
V_{RC}	=	the volume of the reaction chamber

The flows through the Model 146*i* satisfy these requirements. The reaction chamber volume is 150 cc. Flow through the ozonator is approximately 150 sccm using the back pressure regulator (set to approximately 3 psi) and the capillary. All excess zero air flow bypasses the ozone generator. The dynamic parameter conditions are met for any reasonable NO flow (12.5-100 sccm) and [NO]STD (40-60 ppm).

The reaction chamber is only in the system during gas phase titration. This is because the reaction chamber is only needed during gas phase titration, the flush time (residence time) is approximately less than one minute, and three flush times are necessary for a response of 95 percent.

Permeation Tube Oven

Gas flow through the oven is low (approximately 150 sccm) to stabilize the permeation tube oven temperature. The major portion of the flow bypasses the oven and is directed to the mixing chamber with the stream from the oven. This is achieved by using the same back pressure regulator described above for gas phase titration with a capillary of identical size.

During standby operation, a continuous flow of gas is necessary through the oven. The standby flow and operating flow should be the same to +10 percent. This is achieved by setting the pressure regulator to the same pressure setting as the back pressure regulator. In practice, rather than measuring the pressure, it is the actual flows that are measured while adjusting the pressure regulator. Two solenoids are used to change the flow of gas going through the oven to the main stream or to vent.

Photometer

The photometer has an airtight chamber that contains the sample and reference gases and includes a photometer lamp at one end and a detector at the other end.

Detector System

The photo tube in the detector transmits light intensity information to the measurement interface board for sample measurement computations.

Pressure Transducer

The pressure transducer measures the pressure of the sample gas.

Ozonator

The internal ozonator operates on the photolytic principle and 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.

Ozonator Lamp Power Supply

The ozonator lamp power supply generates high voltage AC and contains heater control circuits for the ozonator lamp.

Photometer Lamp Power Supply

The photometer lamp power supply generates high voltage AC and contains heater control circuits for the photometer lamp.

Photometer Temperature Thermistor

The photometer temperature thermistor is used for controlling the photometer at a consistent temperature.

Pump

The pump draws the sample gas through the photometer.

Sample/Reference Solenoid Valves

The sample/reference solenoid valves allow sample gas or reference (zero) gas to pass through the cell.

Ozonator Solenoid   Controls gas flow though the ozonator.

Perm 1 Solenoid   Controls gas flow though the permeation oven.

Perm 2 Solenoid   Directs gas flow to the reaction chamber or to exhaust.

Reaction Chamber Solenoid   Directs gas flow to the reaction chamber or to exhaust.

Zero Air Solenoid   Shuts off zero air when the system is in standby to minimize zero air usage.

External/Internal Solenoid   Used to select either the external ozone sample or the internal ozone sample for measurement.

Span Gas Solenoids   Control flow through independent gas inlets depending on the mode being controlled.

Photometer Capillary   Reduces gas flow to the photometer.

Ozonator Capillary   Reduces gas flow to the ozonator.

Pressure Gauge Capillary   Used in conjunction with the pressure regulator to control flow through the ozonator.

Pump Capillary   Controls flow pressure on the photometer.

Mixing Chamber   Mixes the gas dilutions provided the mass flow controllers.

Manifold   Distributes gas from various sources to an analyzer.

Mass Flow Controllers   Governs high gas flow to control diluting zero air and governs low gas flow for controlling gas to be diluted.

Back Pressure Regulator

Controls back pressure flow through the system.

Reaction Chamber

The reaction chamber is where the sample reacts with ozone and produces excited NO_2 that gives off a photon of energy when it decays.

The reaction chamber is heated and controlled to approximately 50 °C to ensure optimum instrument stability.

Pressure Regulator and Gauge

Regulates and measures gas flow through the system.

Software

The processor software tasks are organized into four areas:

- Instrument Control

- Monitoring Signals

- Measurement Calculations

- Output Communication

Instrument Control

Low-level embedded processors are used to control the various functions on the boards, such as analog and digital I/O and heater control. These processors are controlled over a serial interface with a single high-level processor that also controls the front-panel user interface. The low-level processors all run a common piece of firmware that is bundled with the high-level firmware and loaded on power-up if a different version is detected.

Each board has a specific address that is used to identify to the firmware what functions are supported on that board. This address is also used for the communications between the low-level processors and the high-level processor.

Every tenth of a second the frequency counters, analog I/O, and digital I/O are read and written to by the low-level processor. The counters are accumulated over the past second and the analog inputs are averaged over that second. The high-level processor polls the low-level processors once per second to exchange the measurement and control data.

Monitoring Signals

The instrument includes a sample solenoid valve and a reference solenoid valve. The instrument can be configured to measure O_3 every ten seconds (standard cycle) or every four seconds (fast cycle). Every cycle, the two solenoid valves switch the sample gas and reference gas streams between the two cells. One cell contains sample gas, the other cell contains reference gas and vice versa.

During a standard cycle, the cells are purged for seven seconds and measurements are taken for three seconds. During a fast cycle, the cells are purged for three seconds and measurements are taken for one second.

Measurement Calculations

During every cycle, the instrument calculates the natural logarithm of the sample gas frequency to reference gas frequency ratio in each cell and averages these results to optimize instrument accuracy. These logarithms provide the basis for calculating the ozone concentrations. The logarithms are stored in a rolling stack of 30 logarithms which are averaged by the instrument's averaging time function.

The background values for O_3 are corrected for temperature, pressure, and span and are subtracted from the ozone calculated to yield a corrected value.

Output Communication

The front panel display, serial and Ethernet data ports, and analog outputs are used to communicate the results of the measurement calculations. The front panel displays the O_3 concentration. The display is updated every ten seconds (standard cycle) or every four seconds (fast cycle).

The analog output ranges are user selectable via software. The analog outputs are defaulted based on the measurement range. The defaults are calculated by dividing the data values by the full-scale range for each of the three parameters and then multiplying each result by the user-selected output range. Negative concentrations can be represented as long as they are within -5% of full-scale. The zero and span values may be set by the user to any desired value.

Electronics

All electronics operate from a universal switching supply, which is capable of auto-sensing the input voltage and working over the entire operating range.

Internal pumps and heaters all operate on 110VAC. An optional transformer is required if operating on the 210-250VAC or 90-110VAC ranges.

An on/off switch controls all power to the instrument, and is accessible on the front panel.

Motherboard   The motherboard contains the main processor, power supplies, a sub-processor and serves as the communication hub for the instrument. The motherboard receives operator inputs from the front panel mounted function key panel and/or over I/O connections on the rear panel and sends commands to the other boards to control the functions of the instrument and to collect measurement and diagnostic information. The motherboard outputs instrument status and measurement data to the front-panel mounted graphics display and to the rear-panel I/O. The motherboard also contains I/O circuitry and the associated connector to monitor external digital status lines and to output analog voltages that represent the measurement data. Connectors located on the motherboard include:

External Connectors   External connectors include:

- External Accessory

- RS-232/485 Communications (two connectors)

- Ethernet Communications

- I/O connector with Power Fail Relay, 16 Digital Inputs, and 6 Analog Voltage Outputs.

Internal Connectors   Internal connectors include:

- Function key panel and Display

- Measurement Interface Board Data

- I/O Expansion Board Data

- Digital Output Board

- AC distribution

Measurement Interface Board   The measurement interface board serves as a central connection area for all measurement electronics in the instrument. It contains power supplies and interface circuitry for sensors and control devices in the measurement system. It sends status data to the motherboard and receives control signals from the motherboard.

Measurement Interface Board Connectors   Connectors located on the measurement interface board include:

- Data communication with the motherboard

- 24V and 120VAC power supply inputs

- Fan and solenoid outputs

- 120VAC outputs for the photometer pump

- Two mass flow controllers

- Pressure sensor inputs

- Detector board inputs

- Internal temperature thermistor

- Photometer temperature thermistor

- Ozonator lamp power supply

- Photometer lamp power supply

- Permeation oven temperature thermistor and heater control

Pressure Sensor Assembly   The pressure sensor assembly consists of a board containing an instrumentation amplifier and a pressure transducer with a gas input fitting. The pressure transducer output is produced by measuring the pressure difference between the sample gas pressure and ambient air pressure.

Ozonator Lamp Power Supply   The ozonator lamp power supply board includes the circuits that generate high voltage AC to control the lamp heater. A transformer outputting high voltage at approximately 15 kHz drives the lamp. A resistor in series with the output limits the lamp current. The voltage output is adjustable under software control for lamp intensity control. The ozonator lamp can be switched on and off under software control.

The lamp is heated to a specific temperature to ensure reliable operation. The oscillator circuit that drives the high voltage output is inhibited until this operating temperature is reached. A power transistor is used to heat the lamp housing. Thermistors sense the housing temperature for heater control and for status information.

Photometer Lamp Power Supply

The photometer lamp power supply is similar to the ozonator power supply except for the operating temperature set point and the value of the resistor in series with the output. The photometer is always "on" when the operating temperature is reached. Software on/off control is not required.

Digital Output Board

The digital output board connects to the motherboard and provides solenoid driver outputs and relay contact outputs to a connector located on the rear panel of the instrument. Ten relay contacts normally open (with power off) are provided which are electrically isolated from each other. Eight solenoid driver outputs (open collector) are provided along with a corresponding +24VDC supply pin on the connector.

I/O Expansion Board (Optional)

The I/O expansion board connects to the motherboard and adds the capability to input external analog voltage inputs and to output analog currents via a connector located on the rear panel of the instrument. It contains local power supplies, a DC/DC isolator supply, a sub-processor and analog circuits. Eight analog voltage inputs are provided with an input voltage range of 0V to 10VDC. Six current outputs are provided with a normal operating range of 0 to 20 mA.

Front Panel Connector Board

The front panel connector board interfaces between the motherboard and the front panel mounted function key panel and Graphics display. It serves as central location to tie the three connectors required for the function key panel, the graphics display control lines, and the graphics display backlight to a single ribbon cable extending back to the motherboard. This board also includes signal buffers for the graphics display control signals and a high voltage power supply for the graphics display backlight.

I/O Components

External I/O is driven from a generic bus that is capable of controlling the following devices:

- Analog output (voltage and current)

- Analog input (voltage)

- Digital output (TTL levels)

- Digital input (TTL levels)

Note The instrument has spare solenoid valve drivers and I/O support for future expansion. ▲

Analog Voltage Outputs

The instrument provides six analog voltage outputs. Each may be software configured for any one of the following ranges, while maintaining a minimum resolution of 12 bits:

- 0-100mV

- 0-1V

- 0-5V

- 0-10V

The user can calibrate each analog output zero and span point through firmware. At least 5% of full-scale over and under range are also supported.

The analog outputs may be assigned to any measurement or diagnostic channel with a user-defined range in the units of the selected parameter. The voltage outputs are independent of the current outputs.

Analog Current Outputs (Optional)

The optional I/O Expansion board includes six isolated current outputs. These are software configured for any one of the following ranges, while maintaining a minimum resolution of 11 bits:

- 0-20 mA

- 4-20 mA

The user can calibrate each analog output zero and span point through firmware. At least 5% of full-scale over and under range are also supported.

The analog outputs may be assigned to any measurement or diagnostic channel with a user-defined range in the units of the selected parameter. The current outputs are independent of the voltage outputs. The current outputs are isolated from the instrument power and ground, but they share a common return line (Isolated GND).

Analog Voltage Inputs (Optional)

The optional I/O expansion board includes eight analog voltage inputs. These inputs are used to gather measurement data from third-party devices such as meteorological equipment. The user may assign a label, unit, and a voltage to user-defined unit conversion table (up to 16 points). All voltage inputs have a resolution of 12 bits over the range of 0 to 10 volts.

Digital Relay Outputs

The instrument includes one power fail relay on motherboard and ten digital output relays on the digital output board. These are reed relays rated for at least 500 mA @ 200VDC.

The power fail relay is Form C (both normally opened and normally closed contacts). All other relays are Form A (normally opened contacts) and are used to provide alarm status and mode information from the analyzer, as well as remote control to other devices, such as for controlling valves during calibration. The user may select what information is sent out each relay and whether the active state is opened or closed.

Digital Inputs

Sixteen digital inputs are available which may be programmed to signal instrument modes and special conditions including:

* Zero Gas Mode

* Span Gas Mode

The actual use of these inputs will vary based on instrument configuration.

The digital inputs are TTL level compatible and are pulled up within the analyzer. The active state can be user defined in firmware.

Serial Ports

Two serial ports allow daisy chaining so that multiple analyzers may be linked using one PC serial port.

The standard bi-directional serial interface can be configured for either RS-232 or RS-485. The serial baud rate is user selectable in firmware for standard speeds from 1200 to 19,200 baud. The user can also set the data bits, parity, and stop bits. The following protocols are supported:

* C-Link

* Streaming Data

* Modbus Slave

The Streaming Data protocol transmits user-selected measurement data via the serial port in real-time for capture by a serial printer, data logger, or PC.

RS-232 Connection

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 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, 9600, 19200, 38400, 57600, or 115200 BAUD

8 data bits

1 stop bit

no parity

All responses are terminated with a carriage return (hex 0D)

Refer to Table 8-1 for the DB9 connector pin configuration.

Table 8-1. RS-232 DB Connector Pin Configurations

DB9 Pin	Function
2	RX
3	TX
7	RTS
8	CTS
5	Ground

RS-485 Connection

The instrument uses a four wire RS-485 configuration with automatic flow control (SD). Refer to Table 8-2 for the DB9 connector pin configuration.

Table 8-2. RS-485 DB Connector Pin Configuration

DB9 Pin	Function
2	+ receive
8	- receive
7	+ transmit
3	- transmit
5	ground

Ethernet Connection   An RJ45 connector is used for the 10Mbs Ethernet connection supporting TCP/IP communications via standard IPV4 addressing. The IP address may be configured for static addressing or dynamic addressing (set using a DHCP server).

Any serial port protocols may be accessed over Ethernet in addition to the serial port.

External Accessory Connector   The external accessory connector is not used in the Model 146*i* calibrator.

This port is used in other models to communicate with smart external devices that may be mounted hundreds of feet from the analyzer using an RS-485 electrical interface.

Chapter 9 Optional Equipment

The Model 146*i* is available with the following options:

- "Ozonator" on page 9-1

- "Photometer" on page 9-1

- "Zero Air Source" on page 9-1

- "Permeation Oven" on page 9-2

- "Six Span Inputs" on page 9-10

- "Span Gas Mass Flow Controller" on page 9-10

- "Zero Gas Mass Flow Controller" on page 9-10

- "I/O Expansion Board Assembly" on page 9-10

- "Terminal Block and Cable Kits" on page 9-11

- "Cables" on page 9-11

- "Mounting Options" on page 9-13

Ozonator The internal ozone generator provides easy determination of zero, precision, and Level 1 span checks. 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.

Photometer The photometer measures ozone concentration and is used to control ozone output.

Zero Air Source The zero air source option is a convenient system for generating pollutant free zero gas for O_3 monitoring requirements. This option includes the pump, filter, filter holder, and Silastic tubing.

Permeation Oven

Since the temperature of the permeation tube oven should be stable, the gas flow through the oven is small (approximately 150 sccm). The major portion of the flow bypasses the oven, and is directed to the mixing chamber with the stream from the oven. This is achieved by using the same backpressure regulator described above for gas phase titration, with a capillary of identical size.

During standby operation, a continuous flow of gas is necessary through the oven. The standby flow and operating flow should be the same to +10 percent. This is achieved by setting the pressure regulator to the same pressure setting as the backpressure regulator. In practice, rather than measuring the pressure, it is the actual flows that are measured while adjusting the pressure regulator. Two solenoids, under control of the microcomputer, are used to change the flow of gas going through the oven to the main-stream or to vent.

Permeation Tube Installation

Use the following procedure to install the permeation tube.

1. Remove the oven cover.

2. Remove the glass chamber assembly by loosening the white plastic retaining collar, loosening (not removing) the knurled screw, and gently pulling the assembly upward. Completely remove the oven.

3. Separate the glass chamber from the top assembly by twisting and gently pulling the glass away from the top.

Note Keep the glass clean when handling it. ▲

4. Place the permeation tube(s) in the glass chamber.

5. Attach the glass chamber to the top assembly by gently pushing the two together with a slight twisting motion.

6. Replace the glass chamber assembly into the oven until the top of the assembly is flush or slightly below the top of the oven.

⚠️ **Equipment Damage** Do not use tools to tighten the knurled screw in the following step. ▲

7. Tighten the knurled screw finger tight. Do not use tools to tighten.

8. Tighten the white plastic retaining collar.

9. Replace the oven cover being careful to place the tubing and wiring into the cover slot.

Computation of Concentrations

The computation of the gas output level is shown in the following information. Note that is assumed that all devices are properly calibrated and that all flows are corrected to 25 °C and 1 atm.

Permeation Tube:

$$Output\,(ppm) = \frac{(R)(K)}{Q_o}$$

Where:

R = permeation rate in ng/min

Q_0 = flow rate of gas (scc/min) into the charcoal scrubber during span mode

K = constant for the specific permeant = 24.45 / MW

MW = molecular weight

Oven Installation and Configuration

Use the following procedure to install and configure the permeation oven.

1. Physically install the permeation oven and valves into the instrument and connect the cables and plumbing.

2. From the Perm Oven Settings menu in the Service menu, select **Perm Oven Selection**, then select **45 °C**.

3. Remove the thermistor from POJ1 on the measurement interface board.

4. Connect a resistance of approximately 3.8 KΩ across pins 1 and 2 of POJ1.

5. Go to the Factory Cal Gas Therm menu from the Perm Oven Settings menu in the Service menu. Select **Low Point**, enter the exact value of the resistor and press ⏎ to calibrate the low resistance point.

6. Press ■ to return to the Factory Cal Gas Therm menu.

7. Connect a resistance of approximately 5 KΩ across pins 1 and 2 of POJ1.

8. Go to the High Point screen, enter the exact value of the resistor and press ⏎ to calibrate the high resistance point.

9. Press ■ to return to the Factory Cal Gas Therm menu.

10. Remove resistor from POJ1 and re-attach the gas thermistor.

11. Connect a resistance of approximately 3.8 KΩ across pins 3 and 4 of POJ3.

12. Go to the Factory Cal Oven Therm menu from the Perm Oven Settings menu in the Service menu. Select **Low Point**, enter the exact value of the resistor and press ⏎ to calibrate the low resistance point.

13. Press ■ to return to the Factory Cal Oven Therm menu.

14. Connect a resistance of approximately 5 KΩ across pins 3 and 4 of POJ3.

15. Go to the High Point screen, enter the exact value of the resistor and press 〔 ⏎ 〕 to calibrate the high resistance point.

16. Press 〔 ▪ 〕 to return to the Factory Cal Oven Therm menu.

17. Remove resistor from POJ3 and re-attach the permeation oven.

18. Perform a thermistor calibration using the "Permeation Tube Oven Calibration" procedure that follows.

Permeation Tube Oven Calibration

There are two general approaches that can be used to calibrate the permeation tube oven. The first is to calibrate the temperature indicator very accurately (to better than 0.02 °C) and to use a permeation tube whose weight loss has been previously determined at that temperature.

Note An error of approximately 0.1 °C corresponds to an error of 1% in release rate. ▲

The second approach is to note that the thermistors used to measure temperature are interchangeable to better than ±0.2 °C. Thus a 1% resistor of the proper value (4.369 KΩ for 45 °C) can be used to set the span on the measurement interface board. The release rate for the permeation tube is then determined by weight loss in the actual oven being used.

Setting Perm Oven Temperature

You can use either of the two calibration methods presented here. One method involves performing the "Setting Perm Oven Temperature" procedure and then continuing with the "Setting Temperature with Water Bath" procedure.

Alternatively, you can perform the "Setting Perm Oven Temperature" procedure and then continue with the "Setting Temperature with Known Resistance" procedure.

In either case, use the following procedure for setting the perm oven temperature.

1. Unplug POJ3 from the measurement interface board. Place a 4.369 KΩ resistor across pins 3 and 4 on the board.

2. From the Permeation Oven menu in the Service menu, select **Cal Oven Thermistor** (Figure 9-1).

```
SAMPLE        12:34      ALARM


CAL OVEN THERM (RESISTOR):
 CURRENTLY:        4369 Ohms
    SET TO:       04369 Ohms

        ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE   AVG    DIAGS ALARM
```
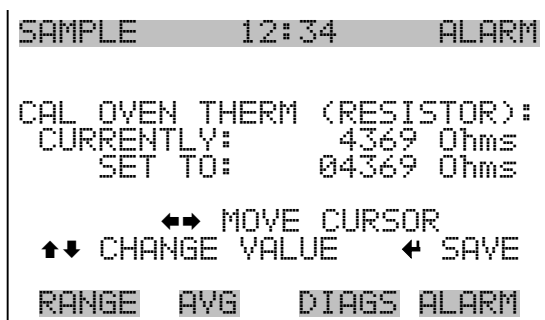
Figure 9-1. Cal Oven Therm Resistor Screen

3. Enter the exact value of the attached resistor and press ⏎ to save the offset.

4. Press ■ to return to the Permeation Oven menu.

5. Remove the resistor and re-attach the permeation oven to POJ3.

Setting Temperature with Water Bath

Use the following procedure for setting the measure temperature with water bath.

1. Remove the thermistor from the permeation tube oven, but leave the thermistor connected to the measurement interface board. Insert the thermistor into the water bath next to an NIST traceable thermometer (if necessary, use an extension cable to reach).

2. Turn on the power to the water bath. Using an NIST traceable thermometer with a resolution of ±0.01 °C, adjust the water bath to 45 °C.

3. From the Permeation Oven menu, in the Service menu, select Cal Gas Thermistor > **Water Bath**. Enter the thermistor temperature from the thermometer and press ⌐ ↵ ⌐ (Figure 9-2).

```
SAMPLE        12:34     ALARM


CAL GAS THERM (BATH):
 CURRENTLY:        45.80  °C
    SET TO:        45.0█  °C

            ←→ MOVE CURSOR
  ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE   AVG    DIAGS ALARM
```
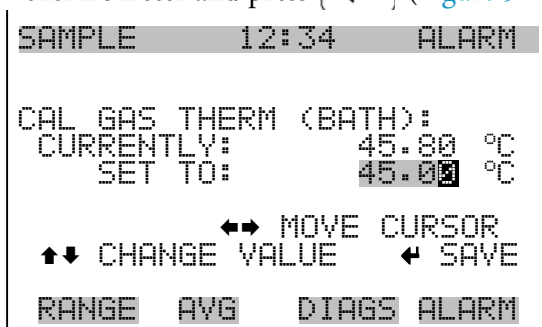
Figure 9-2. Cal Gas Therm Bath Screen

4. Remove the thermistor from the water bath, dry, and replace into the permeation tube oven.

5. Make sure the charcoal scrubber is connected to the ZERO bulkhead on the rear panel.

6. Wait for the permeation gas temperature reading to stabilize.

Setting Temperature with Known Resistance

Use the following procedure to set the gas temperature with an accurate known resistance.

1. Remove the thermistor from POJ1 on the measurement interface board.

1. Connect a 4.369 KΩ resistor across pins 1 and 2 of POJ1 (use a resistance substitution box and an accurate meter, if necessary).

2. From the Permeation Oven menu, select **Cal Gas Thermistor**, then select known resistor (Figure 9-3).

```
SAMPLE      12:34      ALARM


CAL GAS THERM (RESISTOR):
 CURRENTLY:       4369 Ohms
   SET TO:      04369 Ohms

         ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ← SAVE

 RANGE   AVG    DIAGS ALARM
```
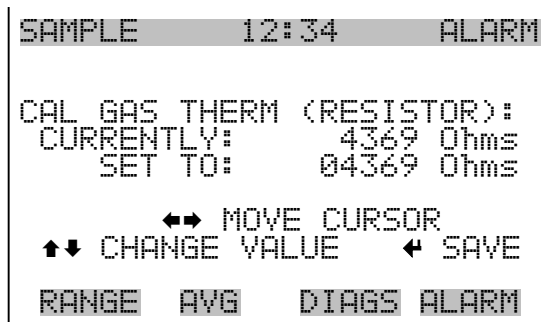
Figure 9-3. Cal Gas Therm Resistor Screen

3. Enter the exact value of the attached resistor and press ⏎ to save the offset.

4. Remove the resistor and reconnect the gas thermistor.

5. Make sure the charcoal scrubber is connected to the ZERO bulkhead on the rear panel.

6. Wait for the permeation gas temperature reading to stabilize.

Determining Permeation Rate by Weight Loss

Use the following procedure to determine the permeation rate by weight loss.

1. Make sure the oven has been calibrated as described in the "Permeation Tube Oven Calibration" procedure described previously.

2. Insert the permeation tube carefully. Do not touch with fingers.

3. Turn on the instrument.

4. Wait 48-72 hours for the permeation tube to stabilize.

5. Carefully remove the permeation tube from the oven and weigh to an accuracy of 0.1mg. Perform this measurement as quickly as possible.

6. Replace the permeation tube into the oven of the instrument.

7. Repeat Steps 5 and 6 after two weeks.

8. Compute the weight loss of the permeation tube from the values determined in Steps 5 through 7.

9. Repeat Steps 5 through 8 until the weight loss has been determined to a precision of 1-2%.

10. For the most accurate work, use the permeation tube in the same oven that was used to determine the weight loss of permeation tube.

Determining Release Rate by Transfer Standard

Use the following procedure to determine the release rate by transfer standard.

1. Make sure the oven has been calibrated as described in the "Permeation Tube Oven Calibration" procedure described previously. Also make sure that the Transfer Standard has been properly calibrated.

2. Determine the permeation rate for the permeation tube in the Transfer Standard, or install a certified permeation tube.

3. Allow the permeation tubes in both the 146*i* and the Transfer Standard to stabilize for at least 48 hours.

4. Carefully calibrate the 146*i* using the Transfer Standard. The output of the Transfer Standard should be connected to the SAMPLE bulkhead on the rear panel of the 146*i*.

5. Switch the calibrated 146*i* into the span mode.

6. Measure the flow rate into the ZERO bulkhead on the rear panel of the 146*i*. Be sure that the charcoal scrubber is connected. Note the flow and measured gas concentration.

7. From the flow and measured concentration, compute the permeation tube release rate.

Six Span Inputs

The six span input option increases the number of span ports from three (standard) to six.

Span Gas Mass Flow Controller

The span gas mass flow controller governs low gas flow to control gas being diluted. Span gas mass flow controllers include:

• 25 SCCM

• 50 SCCM

• 100 SCCM (standard)

• 200 SCCM

• 500 SCCM

Zero Gas Mass Flow Controller

The zero gas mass flow controller governs high gas flow to control zero air. Zero gas mass flow controllers include:

• 5 SLPM

• 10 SLPM (standard)

• 15 SLPM

• 20 SLPM

I/O Expansion Board Assembly

The I/O expansion board provides six analog current output channels (0-20 mA or 4-20 mA) and eight analog voltage inputs (0-10V). The DB25 connector on the rear panel provides the interface for these inputs and outputs.

25-Pin Terminal Board Assembly

The 25-pin terminal board assembly is included with the optional I/O expansion board. Refer "Terminal Board PCB Assemblies" in the "Installation" chapter for information on attaching the cable to the connector board. For associated part numbers, refer to "External Device Connection Components" in the "Servicing" chapter.

Terminal Block and Cable Kits

The optional terminal block and cable kits provide a convenient way to connect devices to the instrument. These kits break out the signals on the rear panel connector to individual numbered terminals.

Two types of terminal block and cable kits are available. One kit is for the DB37 connectors and can be used for either the analog output connector or the relay output connector. The other kit is for the DB25 connector and can be used for the optional I/O expansion board. For associated part numbers, refer to "External Device Connection Components" in the "Servicing" chapter.

Each kit consists of:

• one six-foot cable

• one terminal block

• one snap track

Note Supporting all of the connections on units with the optional I/O expansion board requires:

• two DB37 kits

• one DB25 kit

Cables

Table 9-1 identifies the optional individual cables that are available for the instrument and Table 9-2 provides the cable color codes. For associated part numbers, refer to "External Device Connection Components" in the "Servicing" chapter.

Note Table 9-2 provides the color coding for both 25-pin cables and 37-pin cables. Color codes for pins 1-25 are for 25-pin cables; color codes for pins 1-37 are for 37-pin cables. ▲

Table 9-1. Cable Options

Description	Cable Length
DB37M to open end	Six feet
DB37F to open end	Six feet
DB25M to open end	Six feet
RS-232	

Table 9-2. Color Codes for 25-Pin and 37-Pin Cables

Pin	Color	Pin	Color
1	BLACK	20	RED/BLACK
2	BROWN	21	ORANGE/BLACK
3	RED	22	YELLOW/BLACK
4	ORANGE	23	GREEN/BLACK
5	YELLOW	24	GRAY/BLACK
6	GREEN	25	PINK/BLACK
7	BLUE	End color codes for 25-pin cables continue for 37-pin cables.	
8	VIOLET	26	PINK/GREEN
9	GRAY	27	PINK/RED
10	WHITE	28	PINK/VIOLET
11	PINK	29	LIGHT BLUE
12	LIGHT GREEN	30	LIGHT BLUE/BROWN
13	BLACK/WHITE	31	LIGHT BLUE/RED
14	BROWN/WHITE	32	LIGHT BLUE/VIOLET
15	RED/WHITE	33	LIGHT BLUE/BLACK
16	ORANGE/WHITE	34	GRAY/GREEN
17	GREEN/WHITE	35	GRAY/RED
18	BLUE/WHITE	36	GRAY/VIOLET
19	VIOLET/WHITE	37	LIGHT GREEN/BLACK

Mounting Options

The analyzer can be installed in the configurations described in Table 9-3 and shown in Figure 9-4 through Figure 9-7.

Table 9-3. Mounting Options

Mounting Type	Description
Bench	Positioned on bench, includes mounting feet, and front panel side-trim ears.
EIA rack	Mounted in an EIA-style rack, includes mounting slides, and front panel EIA-rack mounting ears.
Retrofit rack	Mounted in a Thermo non-EIA rack, includes mounting slides, and retrofit front panel rack-mounting ears.

EXTENDER BRACKET
OPTION 211I

17.81 [452.42]
RAIL CLEARANCE

BAR NUT SHOULD BE
ASSEMBLED WITH
OFF-CENTERED
TAPPED HOLE AWAY
FROM INSTRUMENT AS
SHOWN.

22.00 TO 28.75
REQUIRED

RACK MTG RAIL

REAR MTG BRACKET
FOR SLIDES

INSTRUMENT CASE

22.00 [558.80]
REQUIRED

RACK SLIDE
P/N 5225
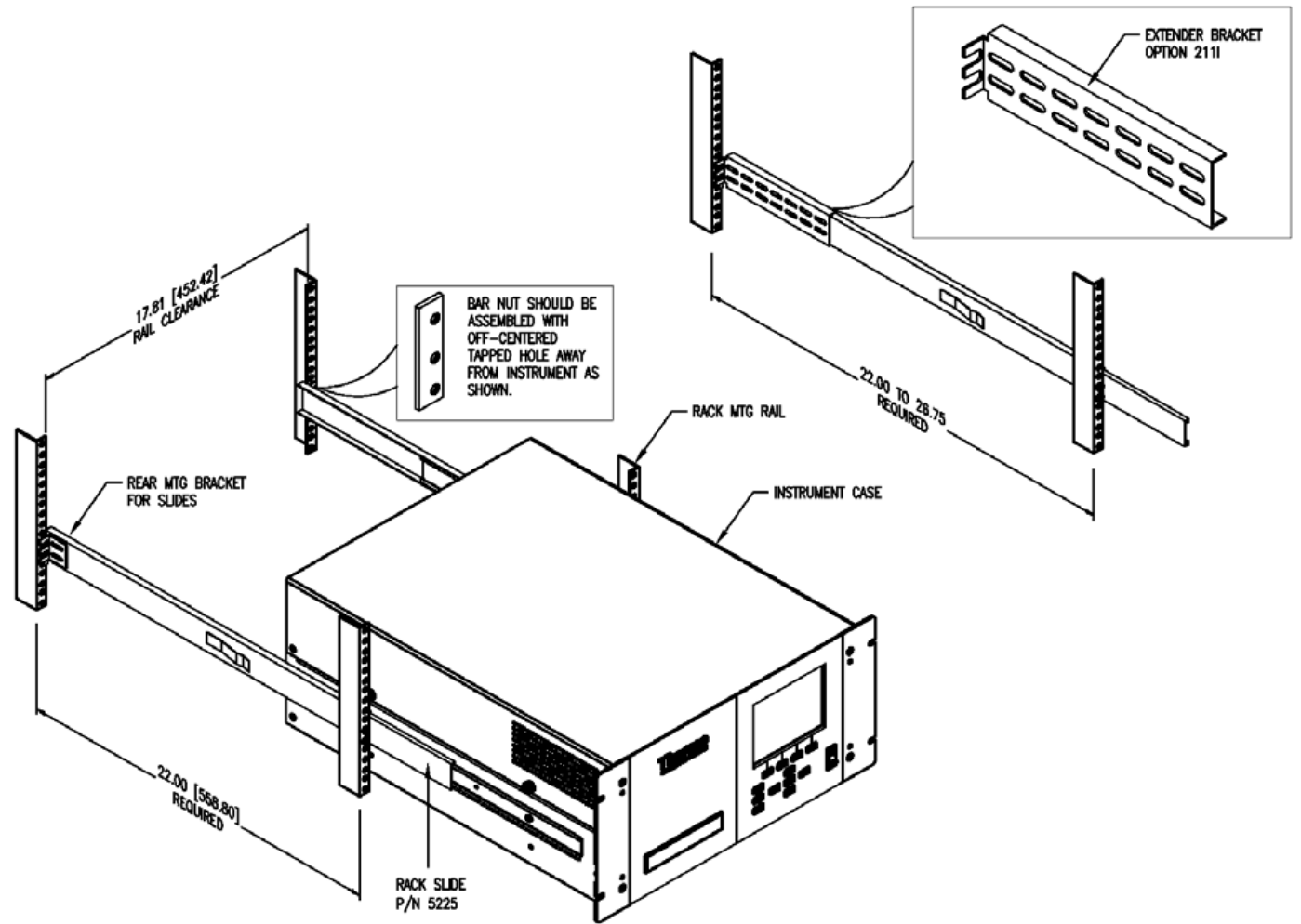
Figure 9-4. Rack Mount Option Assembly
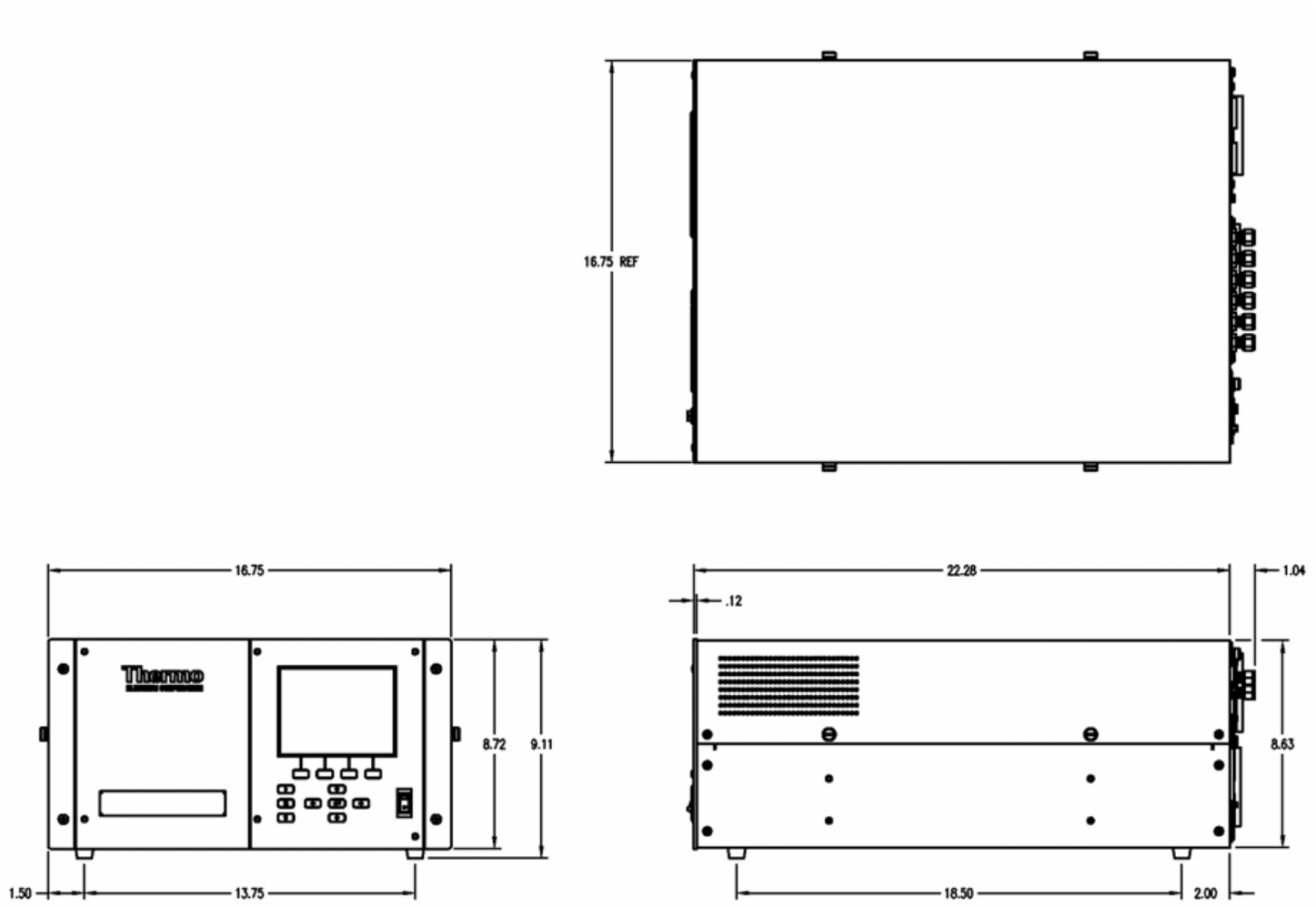
Figure 9-5. Bench Mounting
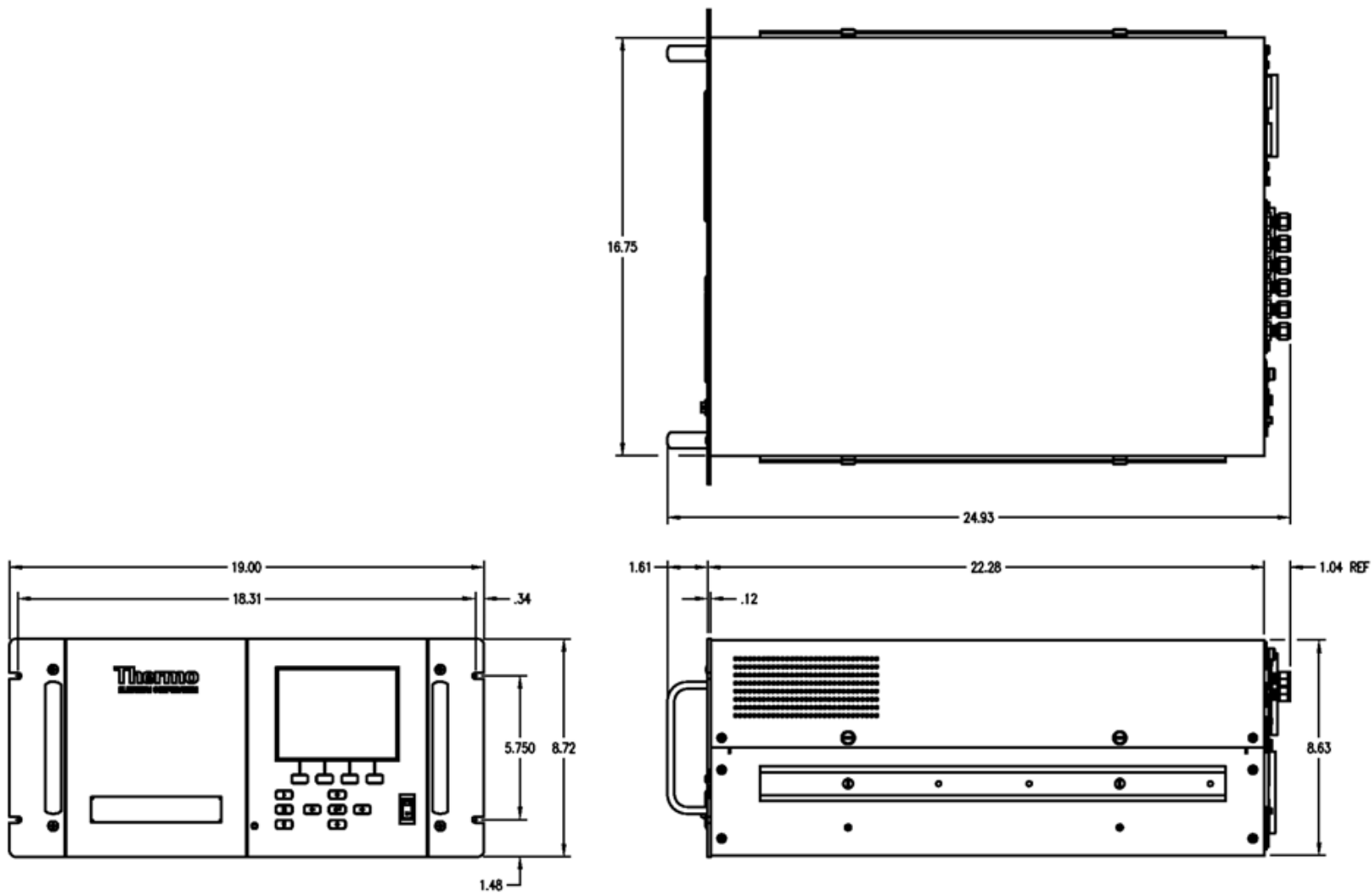
Figure 9-6. EIA Rack Mounting
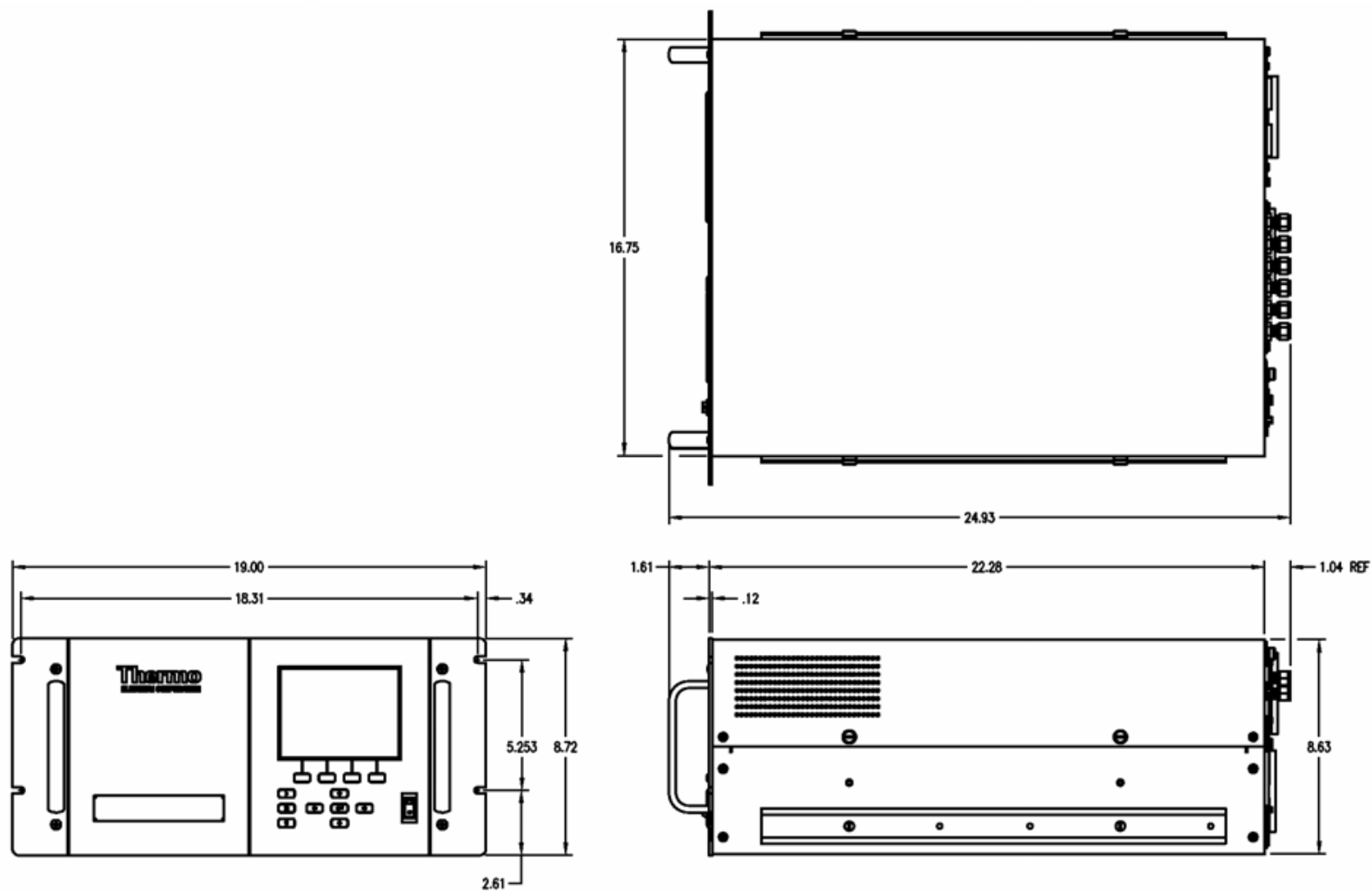
Figure 9-7. Retrofit Rack Mounting

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.

Appendix B
C-Link Protocol Commands

This appendix provides a description of the C-Link protocol commands that can be used to remotely control a Model 146*i* analyzer using a host device such as a PC or a datalogger. C-Link protocol may be used over RS-232, RS-485, or Ethernet. C-Link functions can be accessed over Ethernet using TCP/IP port 9880. For details, see the following topics:

Instrument Identification Number

Each command sent to the instrument must begin with the American Standard Code for Information Interchange (ASCII) symbol or byte value equivalent of the instrument's identification number plus 128. For example, if the instrument ID is set to 25, then each command must begin with the ACSII character code 153 decimal. The analyzer ignores any command that does not begin with its instrument identification number. If the instrument ID is set to 0, then this byte is not required. For more information on changing Instrument ID, see Chapter 3, "Operation".

Commands

The instrument must be in the remote mode in order to change instrument parameters via remote. However, the command "set mode remote" can be sent to the analyzer to put it in the remote mode. Report commands (commands that don't begin with "set") can be issued either in the remote or local mode. For information on changing modes, see Chapter 3, "Operation".

The commands can be sent in either uppercase or lowercase characters. Each command must begin with the proper instrument identification number (ASCII) character. The command in the example below begins with the ASCII character code 179 decimal, which directs the command to the Model 146*i*, and is terminated by a carriage return "CR" (ASCII character code 13 decimal).

<ASCII 179>	T	I	M	E	<CR>

If an incorrect command is sent, a "bad command" message will be received. The example below sends the incorrect command "set unit ppm" instead of the correct command "set gas unit ppm."

```
Send:         set unit ppm
Receive:      set unit ppm bad cmd
```

The "save" and "set save params" commands stores parameters in FLASH. 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.

Commands List

Table B–1 lists the 146*i* C-Link protocol commands. The interface will respond to the command strings outlined below.

Table B–1. C-Link Protocol Commands

Command	Description	Page
addr dns	Reports/sets domain name server address for Ethernet port	B-39
addr gw	Reports/sets default gateway address for Ethernet port	B-39
addr ip	Reports/sets IP address for Ethernet port	B-39
addr nm	Reports/sets IP netmask address for Ethernet port	B-40
alarm bench lamp temp max	Reports/sets photometer bench lamp temperature alarm maximum value	B-10

Command	Description	Page
alarm bench lamp temp min	Reports/sets photometer bench lamp temperature alarm minimum value	B-10
alarm bench temp max	Reports/sets photometer bench temperature alarm maximum value	B-11
alarm bench temp min	Reports/sets photometer bench temperature alarm minimum value	B-11
alarm conc o3 max	Reports/sets photometer O_3 concentration alarm maximum value	B-11
alarm conc o3 min	Reports/sets photometer O_3 concentration alarm minimum value	B-11
alarm intensity max	Reports/sets photometer intensity alarm maximum value	B-11
alarm intensity min	Reports/sets photometer intensity alarm minimum value	B-11
alarm internal temp max	Reports/sets ambient temperature alarm maximum value	B-12
alarm internal temp min	Reports/sets ambient temperature alarm minimum value	B-12
alarm o3 lamp temp max	Reports/sets ozonator lamp temperature alarm maximum value	B-12
alarm o3 lamp temp min	Reports/sets ozonator lamp temperature alarm minimum value	B-12
alarm pressure max	Reports/sets photometer pressure alarm maximum value	B-13
alarm pressure min	Reports/sets photometer pressure alarm minimum value	B-13
alarm trig conc o3	Reports/sets O_3 concentration low alarm trigger value	B-13
analog iout range	Reports/sets analog current output range per channel	B-43
analog vin	Retrieves analog voltage input data per channel	B-43
analog vout range	Reports/sets analog voltage output range per channel	B-44
avg time	Reports/sets averaging time	B-8
baud	Reports/sets baud rate	B-40
cal o3 bkg	Sets/auto-calibrates O_3 background	B-23
cal o3 coef	Sets/auto-calibrates O_3 coefficient	B-23
clr lrecs	Clears away only long records that have been saved	B-16
clr records	Clears away all logging records that have been saved	B-16
clr srecs	Clears away only short records that have been saved	B-16
contrast	Reports/sets current front-panel screen contrast	B-37
copy lrec to sp	Copies current lrec selection into the scratch pad	B-21
copy sp to lrec	Copies current selections in scratch pad into lrec list	B-21
copy sp to srec	Copies current selections in scratch pad into srec list	B-21

Command	Description	Page
copy sp to stream	Copies current selections in scratch pad into stream list	B-21
copy srec to sp	Copies current srec selection into the scratch pad	B-21
copy stream to sp	Copies current streaming data selection into the scratch pad	B-21
custom	Reports/sets defined custom range concentration	B-36
date	Reports/sets current date	B-38
default params	Sets parameters to default values	B-38
dhcp	Reports/sets state of use of DHCP on Ethernet port	B-40
diag volt iob	Reports diagnostic voltage levels for I/O expansion board	B-14
diag volt mb	Reports diagnostic voltage levels for motherboard	B-14
diag volt mib	Reports diagnostic voltage levels for measurement interface board	B-14
dig in	Reports status of the digital inputs	B-44
din	Reports/sets active logic state for the digital input channel	B-44
do (down)	Simulates pressing down pushbutton	B-25
dout	Reports/sets active logic state for the digital output channel	B-45
dtoa	Reports outputs of the digital to analog converters per channel	B-45
en (enter)	Simulates pressing enter pushbutton	B-25
er	Returns a brief description of the main operating conditions in the format specified in the commands	B-17
erec	Returns a brief description of the main operating conditions in the format specified in the command	B-18
erec format	Reports/sets erec format (ASCII or binary)	B-19
erec layout	Reports current layout of erec data	B-19
event params	Reports current event that is being executed	B-14
event status	Reports the parameters programmed for the specified event	B-14
flags	Reports 8 hexadecimal digits (or flags) that represent the status of the instrument	B-9
format	Reports/sets current reply termination format	B-41
gas conc	Returns current concentration of gas being supplied by the instrument.	B-8
gas index	Reports/sets the gas index value	B-28
gas man	Selects manual preset level for gas	B-28
gas name	Sets the gas name	B-29
gas off	Selects gas off	B-29
gas params	Returns parameters for gas (tank conc, span, flow)	B-29

Command	Description	Page
gas solenoid	Reports/sets solenoid used when gas selected	B-29
gas span	Selects gas span level 0, 1, 2, 3, 4, or 5	B-30
gas span conc	Reports/sets target concentration for specified gas and span level	B-30
gas span flow	Reports/sets target total flow for specified gas and span level	B-31
gas tank conc	Reports/sets concentration of cylinder connected as specified gas	B-31
gflow	Reports flow through gas flow controller	B-8
he (help)	Simulates pressing help pushbutton	B-25
host name	Reports/sets host name string for Ethernet port	B-41
instr name	Reports instrument name	B-42
instrument id	Reports/sets instrument id	B-42
intensity	Reports photometer detector intensity in Hz	B-9
intern temp	Reports current internal instrument temperature	B-15
isc (iscreen)	Retrieves framebuffer data used for the display	B-26
l1	Reports/sets custom level 1 setting of ozonator lamp drive	B-32
l1 conc	Reports/sets custom level 1 concentration for photometer control of ozonator lamp drive	B-32
l2	Reports/sets custom level 2 setting of ozonator lamp drive	B-32
l2 conc	Reports/sets custom level 2 concentration for photometer control of ozonator lamp drive	B-32
l3	Reports/sets custom level 3 setting of ozonator lamp drive	B-32
l3 conc	Reports/sets custom level 3 concentration for photometer control of ozonator lamp drive	B-32
l4	Reports/sets custom level 4 setting of ozonator lamp drive	B-32
l4 conc	Reports/sets custom level 4 concentration for photometer control of ozonator lamp drive	B-32
l5	Reports/sets custom level 5 setting of ozonator lamp drive	B-32
l5 conc	Reports/sets custom level 5 concentration for photometer control of ozonator lamp drive	B-32
lamp	Reports/sets photometer lamp drive setting	B-23
lamp setting	Reports photometer lamp drive setting	B-24
lamp temp	Reports photometer lamp temperature	B-15
lamp voltage bench	Reports photometer bench lamp voltage in volts	B-15
lamp voltage o3	Reports ozonator lamp voltage in volts	B-15

Command	Description	Page
layout ack	Disables CLINK stale layout/layout changed indicator ('*')	B-43
le (left)	Simulates pressing left pushbutton	B-25
level	Sets the ozonator to level 1, 2, 3, 4, or 5	B-33
list din	Lists current selection for digital input	B-16
list dout	Lists current selection for digital output	B-16
list lrec	Lists current selection lrec logging data	B-17
list sp	Lists current selection in the scratchpad list	B-17
list srec	Lists current selection srec logging data	B-17
list stream	Lists current selection streaming data output	B-17
list var aout	Reports list of analog output, index numbers, and variables	B-46
list var din	Reports list of digital input, index numbers, and variables	B-46
list var dout	Reports list of digital output, index numbers, and variables	B-46
lr	Outputs long records in the format specified in the command	B-17
lrec	Outputs long records	B-18
lrec format	Reports/sets output format for long records (ASCII or binary)	B-19
lrec layout	Reports layout of lrec data	B-19
lrec mem size	Reports maximum number of long records that can be stored	B-20
lrec per	Reports/sets long record logging period	B-20
malloc lrec	Reports/sets memory allocation for long records	B-21
malloc srec	Reports/sets memory allocation for short records	B-21
man gas gflow	Reports/sets gas flow controller manual flow rate	B-33
man gas zflow	Reports/sets zero flow controller manual flow rate	B-33
man ozon level	Reports/sets ozonator drive level for manual mode	B-33
man ozon zflow	Reports/sets zero flow controller manual flow rate when ozonator is active	B-33
me (menu)	Simulates pressing menu pushbutton	B-25
mode	Reports/sets operating mode in local, service, or remote	B-42
no of lrec	Reports/sets number of long records stored in memory	B-20
no of srec	Reports/sets number of short records stored in memory	B-20
o3	Reports ozone concentration measured by photometer	B-9
o3 bkg	Reports/sets photometer O_3 background	B-24
o3 coef	Reports/sets photometer O_3 coefficient	B-24
o3 conc	Sets ozonator target concentration under photometer control	B-34
o3 setting	Reports ozonator target concentration under photometer	B-35

Command	Description	Page
	control	
oz lamp temp	Reports ozonator lamp temperature	B-15
ozon	Sets ozonator output level	B-34
ozon perm off	Sets both ozonator and permeation oven output to zero	B-34
perm	Reports/sets permeation oven output level	B-34
photometer temp	Reports photometer bench temperature	B-15
pres	Reports photometer pressure	B-9
pres comp	Reports/sets photometer pressure compensation on or off	B-36
program	Reports/sets program on or off	B-16
program no	Reports instrument program number	B-42
push	Simulates pressing a key on the front panel	B-25
range	Reports/sets photometer O_3 range	B-35
relay	Reports/sets relay logic status of designated relay(s)	B-46
relay stat	Reports relay logic status for the designated relay(s)	B-46
resp coef	Reports/sets photometer control response coefficient	B-25
ri (right)	Simulates pressing right pushbutton	B-26
ru (run)	Simulates pressing run pushbutton	B-26
save	Stores parameters in FLASH	B-38
save params	Stores parameters in FLASH	B-38
sc (screen)	C-series legacy command that reports a generic response (Use iscreen instead)	B-27
sp conc	Reports/sets photometer span concentration for calibration	B-25
sp field	Reports/sets item number and name in scratch pad list	B-22
span index	Reports/sets span gas level	B-36
sr	Reports last short record stored	B-17
srec	Reports maximum number of short records	B-18
srec format	Reports/sets output format for short records (ASCII or binary)	B-19
srec layout	Reports current layout of short record data	B-19
srec mem size	Reports maximum number of short records	B-20
srec per	Reports/sets short record logging period	B-20
status	Reports gas and span selections	B-9
stream per	Reports/sets current set time period for streaming data	B-22
stream time	Reports/sets a time stamp to streaming data or not	B-22
temp comp	Reports/sets photometer temperature compensation on or off	B-37

Command	Description	Page
time	Reports/sets current time (24-hour time)	B-38
up	Simulates pressing up pushbutton	B-26
zflow	Reports flow through zero air flow controller	B-8

Measurements

avg time

This command reports the photometer averaging time in seconds. The example below shows that the averaging time is 300 seconds, according to Table B–2. This command is only available if the photometer option is installed.

```
Send:        avg time
Receive:     avg time 5:300 sec
```

set avg time *selection*

This command sets the averaging time according to Table B–2. The example below sets the averaging time to 120 seconds. This command is only available if the photometer option is installed.

```
Send:        set avg time 2
Receive:     set avg time 2 ok
```

Table B–2. Averaging Times

Selection	Averaging Time (seconds)
0	60 seconds
1	90
2	120
3	180
4	240
5	300

gas conc

This command reports the current concentration of gas being supplied by the Model146*i*.

```
Send:        gas conc
Receive:     gas conc actual 100.000 target 1.600 ppm
```

gflow
zflow

These commands report the current zero air or gas flow.

```
Send:        gflow
Receive:     gflow actual 15.68 target 16.00 sccm
```

intensity

This command reports the photometer detector intensity. This command is only available if the photometer option is installed.

```
Send:        intensity
Receive:     intensity 101286 Hz
```

o3

This command reports the O_3 concentration measured by the photometer. The example below shows that the O_3 concentration is 5 ppm. This command is only available if the photometer option is installed.

```
Send:        o3
Receive:     o3 5.000E+00 ppb
```

pres

This command reports the photometer bench 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 mmHg is used as default pressure even though the actual pressure is 753.4 mmHg. The example below shows that the actual reaction chamber pressure is 753.4 mmHg. This command is only available if the photometer option is installed.

```
Send:        pres
Receive:     pres 753.4 mmHg, actual 753.4
```

status

This command returns the gas and span status of the Model 146*i*.

```
Send:        status
Receive:     status remote gas A span 4
```

flags

This reports 8 hexadecimal digits (or flags) that represent the status of the pressure and temperature compensation status, flow mode, and alarms. To decode the flags, each hexadecimal digit is converted to binary as shown in the Figure B–1. It is the binary digits that define the status of each parameter. In the example below, the instrument is reporting that it is in span 1 with no gases currently selected.

```
Send:        flags
Receive:     flags 00008000
```
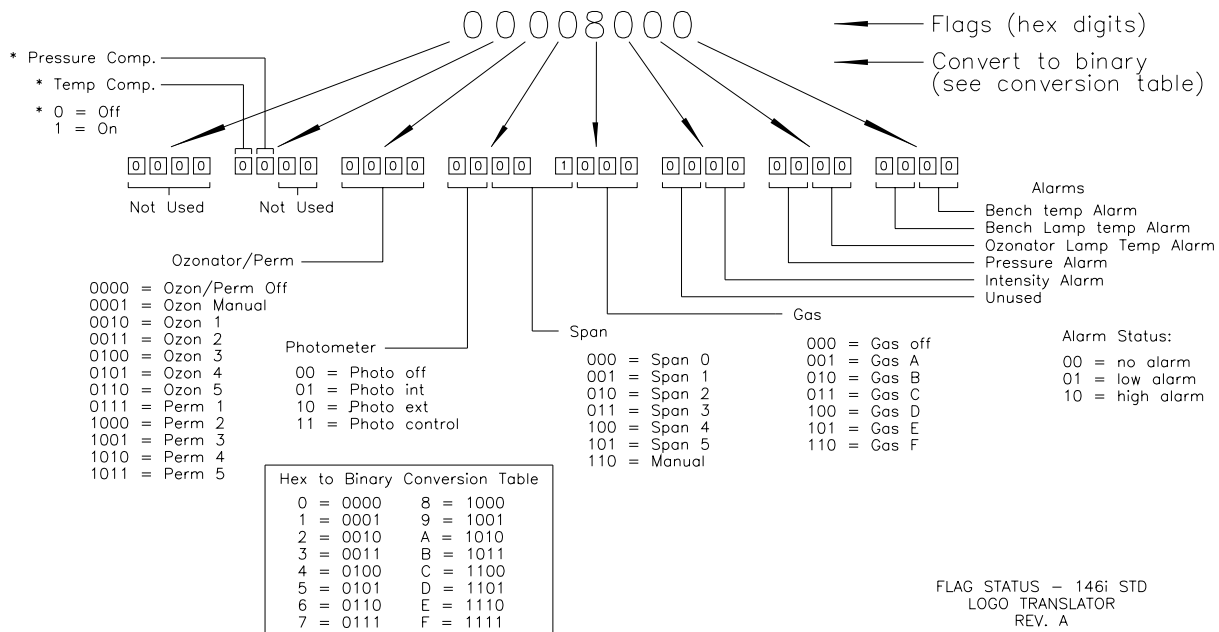
Figure B–1. Flags

Alarms

alarm bench lamp temp min
alarm bench lamp temp max
These commands report the photometer bench lamp temperature alarm minimum and maximum value current settings. The example below reports the bench lamp temperature alarm minimum value is 52 °C. These commands are only available if the photometer option is installed.

```
Send:          alarm bench lamp temp min
Receive:       alarm bench lamp temp min 52.0 deg C
```

set alarm bench lamp temp min *value*
set alarm bench lamp temp max *value*
These commands set the photometer bench lamp temperature minimum and maximum values to *value*, where *value* is a floating-point number representing bench lamp temperature alarm limits in degrees C. The example below sets the bench lamp temperature alarm maximum value to 58 °C. These commands are only available if the photometer option is installed.

```
Send:          set alarm bench lamp temp max 58
Receive:       set alarm bench lamp temp max 58 ok
```

alarm bench temp min
alarm bench temp max
These commands report the photometer bench temperature alarm
minimum and maximum value current settings. The example below reports
the bench temperature alarm minimum value is 15.0 °C. These commands
are only available if the photometer option is installed.

```
Send:        alarm bench temp min
Receive:     alarm bench temp min 15.0
```

set alarm bench temp min *value*
set alarm bench temp max *value*
These commands set the photometer bench temperature minimum and
maximum values to *value*, where *value* is a floating-point number
representing bias voltage alarm limits in degrees C. The example below sets
the bench temperature alarm maximum value to 35 °C. These commands
are only available if the photometer option is installed.

```
Send:        set alarm bench temp max 35
Receive:     set alarm bench temp max 35 ok
```

alarm conc o3 min
alarm conc o3 max
These commands report the photometer O_3 concentration alarm minimum
and maximum value current setting. The example below reports the O_3
concentration alarm minimum is .20 ppb. These commands are only
available if the photometer option is installed.

```
Send:        alarm conc o3 min
Receive:     alarm conc o3 min 20.0 ppm
```

set alarm conc o3 min *value*
set alarm conc o3 max *value*
These commands set the photometer O_3 concentration minimum and
maximum values to *value*, where *value* is a floating-point representation of
the concentration alarm limits in ppb. The example below sets the O_3
concentration alarm maximum value to 5. These commands are only
available if the photometer option is installed.

```
Send:        set alarm conc o3 max 5
Receive:     set alarm conc o3 max 5 ok
```

alarm intensity min
alarm intensity max
These commands report the photometer detector intensity alarm minimum
and maximum value current settings. The example below reports the
intensity alarm minimum value is 45000 Hz. These commands are only
available if the photometer option is installed.

```
Send:        alarm intensity min
Receive:     alarm intensity min 45000 Hz
```

set alarm intensity min *value*
set alarm intensity max *value*
These commands set the photometer detector intensity minimum and maximum values to *value*, where *value* is a floating-point number representing intensity alarm limits in hertz. The example below sets the intensity alarm maximum value to 150000 Hz. These commands are only available if the photometer option is installed.

```
Send:        set alarm intensity max 150000
Receive:     set alarm intensity max 150000 ok
```

alarm internal temp min
alarm internal temp max
These commands report the ambient temperature alarm minimum and maximum values. The example below reports the internal temperature alarm minimum value is 15.0 °C.

```
Send:        alarm internal temp min
Receive:     alarm internal temp min 15.0 deg C
```

set alarm internal temp min *value*
set alarm internal temp max *value*
These commands set the internal temperature minimum and maximum values to *value*, where *value* is a floating-point number representing ambient temperature alarm limits in degrees C. The example below sets the internal temperature alarm maximum value to 45.0 °C.

```
Send:        set alarm internal temp max 45
Receive:     set alarm internal temp max 45 ok
```

alarm o3 lamp temp min
alarm o3 lamp temp max
These commands report the ozonator lamp temperature alarm minimum and maximum values. The example below reports the ozonator lamp temperature alarm minimum value is 52 °C. These commands are only available if the photometer option is installed.

```
Send:        alarm o3 lamp temp min
Receive:     alarm o3 lamp temp min 52.0 deg C
```

set alarm o3 lamp temp min *value*
set alarm o3 lamp temp max *value*
These commands set the ozonator lamp temperature alarm minimum and maximum values to *value*, where *value* is a floating-point number representing ozonator lamp temperature alarm limits in degrees C. The

example below sets the ozonator lamp temperature alarm maximum value to 58 °C. These commands are only available if the photometer option is installed.

```
Send:          set alarm o3 lamp temp max 58.0
Receive:       set alarm o3 lamp temp max 58.0 ok
```

alarm pressure min
alarm pressure max
These commands report the photometer bench pressure alarm minimum and maximum value current settings. The example below reports that the pressure alarm minimum value is 200 mmHg. These commands are only available if the photometer option is installed.

```
Send:          alarm pressure min
Receive:       alarm pressure min 200 mm_Hg
```

set alarm pressure min *value*
set alarm pressure max *value*
These commands set the photometer bench pressure alarm minimum and maximum values to *value*, where *value* is a floating-point number representing pressure alarm limits in millimeters of mercury. The example below sets the pressure alarm maximum value to 1000 mmHg. These commands are only available if the photometer option is installed.

```
Send:          set alarm pressure max 1000
Receive:       set alarm pressure max 1000 ok
```

alarm trig conc o3
This command reports the photometer O_3 concentration alarm trigger action for minimum alarm to either floor or ceiling. The example below shows the O_3 concentration minimum alarm trigger to ceiling, according to Table B–3. These commands are only available if the photometer option is installed.

```
Send:          alarm trig conc o3
Receive:       alarm trig conc o3 1
```

set alarm trig conc o3 *value*
These commands set the photometer O_3 concentration alarm trigger action for the minimum alarm to *value*, where *value* is set to either floor or ceiling, according to Table B–3. The example below sets the O_3 concentration minimum alarm trigger to floor. These commands are only available if the photometer option is installed.

```
Send:          set alarm trig conc 0
Receive:       set alarm trig conc 0 ok
```

Table B–3. Alarm Trigger Values

Value	Alarm Trigger
0	Floor
1	Ceiling

Diagnostics

diag volt mb
This command reports the diagnostic voltage measurements on the motherboard. The sequence of voltages is: Positive 24, positive 15, positive 5, positive 3.3, and negative 3.3. Each voltage value is separated by a space.

```
Send:       diag volt mb
Receive:    diag volt mb 24.1 14.9 4.9 3.2 -3.2
```

diag volt mib
This command reports the diagnostic voltage measurements on the measurement interface board. The sequence of voltages is: Positive 24, positive 15, negative 15, positive 5, positive 3.3. Each voltage value is separated by a space.

```
Send:       diag volt mib
Receive:    diag volt mib 24.1 14.9 -14.9 4.9 3.2
```

diag volt iob
This command reports the diagnostic voltage measurements on the I/O expansion board. The sequence of voltages is: Positive 24, positive 5, positive 3.3, and negative 3.3. Each voltage value is separated by a space.

```
Send:       diag volt iob
Receive:    diag volt iob 24.1 4.9 3.2 -3.2
```

event *event* **params**
event = 1-32

This command reports the parameters programmed for the specified event *event*.

```
Send:       event 1 params
Receive:    event 1 params gas A span 1 ozon 3 perm 1 photo
            internal
```

event status
This command reports the current event that is being executed 1-32. A 0 response indicates no event is currently running.

```
Send:       event status
Receive:    event status 1
```

intern temp

This command reports the current internal instrument temperature, in degrees C. The example below shows that temperature compensation is on and that the internal temperature is 27.2 °C.

```
Send:          intern temp
Receive:       intern temp 27.2 deg C
```

lamp temp

This command reports the photometer bench lamp temperature. The example below reports the current bench lamp temperature is 55.2 °C. This command is only available if the photometer option is installed.

```
Send:          lamp temp
Receive:       lamp temp 55.2 deg C
```

lamp voltage bench

This command reports the photometer bench lamp voltage in volts. This command is only available if the photometer option is installed.

```
Send:          lamp voltage bench
Receive:       lamp voltage bench 10.3 V
```

lamp voltage o3

This command reports the ozonator lamp voltage in volts. This command is only available if the photometer option is installed.

```
Send:          lamp voltage o3
Receive:       lamp voltage o3 12.3 V
```

oz lamp temp

This command reports the current ozonator lamp temperature. The example below shows the current ozonator temperature is 68.7 °C. This command is only available if the photometer option is installed.

```
Send:          oz lamp temp
Receive:       oz lamp temp 68.7 deg C
```

photometer temp

This command reports the current photometer bench temperature. The first 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 0.0 °C is shown as the default temperature even though the actual internal temperature is 31.2 °C The example below shows that temperature compensation is on and that the internal temperature is 31.2 °C.

```
Send:         photometer temp
Receive:      photometer temp 31.2 deg C, actual 31.2
```

program
This command reports programmed events status.

```
Send:         program
Receive:      program on
```

set program *onoff*
This command sets programmed events *on* or *off*. If set to *off*, programmed events will not be triggered at their normal interval and if programmed events are currently running, they will be aborted. All the other set commands will be disabled if the programmed events are running, except for this command. If set to *on*, programmed events will be triggered at their normal interval.

```
Send:         set program on
Receive:      set program on ok
```

Datalogging

clr records
This command will clear all long and short records that have been saved.

```
Send:         clear records
Receive:      clear records ok
```

set clr lrecs
set clr srecs
These commands will clear only the long records or only the short records that have been saved. The example below clears short records.

```
Send:         set clr srecs
Receive:      set clr srecs ok
```

list din
list dout
These commands report the current selection for the digital outputs in the format. Output no Index number variable name active state. The active state for digital outputs is open or closed. The active state for digital inputs is high or low.

```
Send:         list dout
Receive:      list dout
              output index variable state
              1 1 GAS BIT 1 open
              2 2 GAS BIT 2 open
              3 3 GAS BIT 3 open
              4 4 SPAN BIT 1 open
```

```
5 5 SPAN BIT 2 open
6 6 SPAN BIT 3 open
7 7 O3/PERM BIT 1 open
8 8 O3/PERM BIT 2 open
9 9 O3/PERM BIT 3 open
10 10 O3/PERM BIT 4 open
sum 462d
```

list lrec
list srec
list stream
list sp
These commands report the list of current selections for long record logging data, short record logging data, streaming data output, or the scratch pad (sp) list. The example below shows the list for streaming data output.

```
Send:        list stream
Receive:     list stream
             field index variable
             x x time
             1 1 conc
             2 2 tgflo
             3 3 agflo
             4 4 tzflo
             5 5 azflo
             6 6 ttgflo
             7 7 atflo
             sum 242d
```

er *xy*
lr *xy*
sr *xy*
x = | 0 | 1 | : Reply termination format (see "set format *format*" command)
y = | 0 | 1 | 2 | : Output format (see "set erec/lrec/srec format *format*" command)

These commands report the last long and short records stored or the dynamic data record. In the example below, the command requests a long record with no checksum, in ASCII format with text. For details on how to decode the flag fields within these records, see the "flags" command.

```
Send:        lr11
Receive:     lr11
             11:00 12-12-05 flags C0012C9 conc 533.746 tgflo 25.000
             agflo 26.689 tzflo 4975.000 azflo 4970.950 ttflo
             5000.000 atflo 4997.640 pres 741.699
             sum 2583
```

erec

This command returns a brief description of the main operating conditions at the time the command is issued (i.e. dynamic data). The example below shows a typical response. The format is defined by the current settings of "format" and "erec format" commands. For details on how to decode the flag fields within these records, see the "flags" command.

```
Send:        erec
Receive:     erec
             14:08 12-15-05 C000000 0.000 4.999.900 999.900 999.900
             999.900 50.000 0.000 0.000 0.000 0.000 1.000 90 6.000 1
             1 0.000 1 0 0.000 0 0 0.000
```

lrec
srec
lrec *xxxx yy*
srec *xxxx yy*
lrec *aa:bb oo-pp-qq yy*
srec *aa:bb oo-pp-qq yy*
xxxx = the number of past records
yy = the number of records to return (1 to 10)
aa = hours (01 to 24)
bb = minutes (01 to 59)
oo = month (01 to 12)
pp = day (01 to 31)
qq = year

These commands output long or short records. The output format is determined by the "set lrec format" and "set srec format" commands. The logging time is determined by the "set lrec per" and "set srec per" commands.

In the following example, there are 740 long records currently stored in memory. When the command lrec 100 5 is sent, the instrument counts back 100 records from the last record collected (record 740), and then returns 5 records: 640, 641, 642, 643, and 644. For details on how to decode the flag fields within these records, see the "flags" command.

```
Send:        lrec 5
Receive:     lrec 100 5
             10:00 12-15-05 flags C000000 conc 0.000 tgflo 30.000
             agflo 0.000 tzflo 1000.000 azflo 0.000 ttflo 1030.000
             atflo 0.000 pres 0.000
             11:00 12-15-05 flags C000000 conc 0.000 tgflo 30.000
             agflo 0.000 tzflo 1000.000 azflo 0.000 ttflo 1030.000
             atflo 0.000 pres 0.000
             12:00 12-15-05 flags C000000 conc 0.000 tgflo 30.000
             agflo 0.000 tzflo 1000.000 azflo 0.000 ttflo 1030.000
             atflo 0.000 pres 0.000
```

```
13:00 12-15-05 flags C000000 conc 0.000 tgflo 30.000
agflo 0.000 tzflo 1000.000 azflo 0.000 ttflo 1030.000
atflo 0.000 pres 0.000
14:00 12-15-05 flags C000000 conc 0.000 tgflo 30.000
agflo 0.000 tzflo 1000.000 azflo 0.000 ttflo 1030.000
atflo 0.000 pres 0.000
```

erec format
lrec format
srec format
These commands report the output format for long and short records, and
dynamic data in various formats such as ASCII without text, ASCII with
text, or binary. The example below shows the output format for long
records is ASCII with text, according to Table B-4.

```
Send:        lrec format
Receive:     lrec format 01
```

set erec format *format*
set lrec format *format*
set srec format *format*
These commands set the output format for long and short records, and
dynamic data, according to Table B-4. The example below sets the long
record output format to ASCII with text.

```
Send:        set lrec format 1
Receive:     set lrec format 1 ok
```

Table B–4. Record Output Formats

Format	Output Format
0	ASCII no text
1	ASCII with text
2	Binary data

erec layout
lrec layout
srec layout
These commands report the layout (string indicating the data formats) for
data that is sent out in response to the erec, lrec, srec, and related
commands. For details on how to interpret the strings, see "Record Layout
Definition" later in this appendix.

```
Send:          lrec layout
Receive:       lrec layout %s %s %lx %f %f %f %f
               t D L ffff
               flags conc tgflo agflo tzflo azflo ttflo atflo pres
```

lrec mem size
srec mem size
These commands report the long and short records that can be stored with the current settings and the number of blocks reserved for long and short records. To calculate the number of short records per block, add 2 to the number of records, and then divide by the number of blocks. The example below shows that 10 blocks were reserved for long records, and the maximum number of long records that can be stored in memory is 2038.

```
Send:          lrec mem size
Receive:       lrec mem size 2038 recs, 10 blocks
```

lrec per
srec per
These commands report the long and short records logging period. The example below shows that the short record logging period is 5 minutes.

```
Send:          srec per
Receive:       srec per 5 min
```

set srec per *value*
set srec per *value*
value = | 1 | 5 | 15 | 30 | 60 |

These commands set the long and short records logging period to *value* in minutes. The example below sets the long record logging period to 15 minutes.

```
Send:          set lrec per 15
Receive:       set lrec per 15 ok
```

no of lrec
no of srec
These commands report the number of long and short records stored in the long and short records memory. The example below shows that 50 long records have been stored in the memory.

```
Send:          no of lrec
Receive:       no of lrec 50 recs
```

malloc lrec
malloc srec
These commands report the currently set memory allocation for long and short records in percent of total memory.

```
Send:          malloc lrec
Receive:       malloc lrec 10%
```

set malloc lrec *value*
set malloc srec *value*
value = 0 to 100

These commands set the percent of memory space allocated for long and short records to *value*, where *value* is a floating-point number representing percent. The example below sets the memory allocation for long records to 10.

Note Issuing these commands will clear all the logging data memory. All the existing records should be retrieved using appropriate commands, if required. ▲

```
Send:          set malloc lrec 10
Receive:       set malloc lrec 10 ok
```

set copy sp to lrec
set copy sp to srec
set copy sp to stream
These commands copy the current selections in scratch pad (sp) into the long record, short record, or streaming data list. The example below copies the current list in scratch pad into the long records list.

```
Send:          set copy sp to lrec
Receive:       set copy sp to lrec ok
```

set copy lrec to sp
set copy srec to sp
set copy stream to sp
These commands copy the current contents of the long record, short record, or streaming data list into the scratch pad (sp). These commands are useful in easy modification of current long record, short record, or streaming data lists. The example below copies the current list of long records into the scratch pad.

```
Send:          set copy lrec to sp
Receive:       set copy lrec to sp ok
```

sp field *number*
This command reports the variable *number* and name stored at index in the scratch pad list. The example below shows that the field 5 in the scratch pad is set to index number 13, which is for the variable pressure.

```
Send:          sp field 5
Receive:       sp field 5 13 pres
```

set sp field *number value*
number = 1-32 is the maximum number of fields in long and short record lists.
number = 1-18 is for streaming data lists.

This command sets the scratch pad field *number* (item number in scratch pad list) to *value*, where *value* is the index number of a variable in the analog out variable list. Available variables and their corresponding index numbers may be obtained using the command "list var aout". The "set sp field" command is used to create a list of variables which can then be transferred into the long record, short record, or streaming data lists, using the "set copy sp to lrec", "set copy sp to srec", or "set copy sp to stream" commands.

```
Send:          set sp field 1 34
Receive:       set sp field 1 34 ok
```

stream per
This command reports the currently set time interval in seconds for streaming data.

```
Send:          stream per
Receive:       stream per 10
```

set stream per *number value*
number value = | 1 | 2 | 5 | 10 | 20 | 30 | 60 | 90 |120 | 180 | 240 | 300 |

This command sets the time interval between two consecutive streaming data strings to *number value* in seconds. The example below sets the number value to 10 seconds.

```
Send:          set stream per 10
Receive:       set stream per 10 ok
```

stream time
This command reports if the streaming data string will have a time stamp attached to it or not, according to Table B–5.

```
Send:          stream time
Receive:       stream time 0
```

set stream time *value*
This command enables *value*, where *value* is to attach or disable time stamp to streaming data string, according to Table B–5. The example below attaches a time stamp to streaming data.

```
Send:        set stream time 0
Receive:     set stream time 0 ok
```

Table B–5. Stream Time Values

Value	Stream Time
00	Attaches time stamp to streaming data string
01	Disables time stamp to streaming data string

Calibration

set cal o3 bkg
This command will auto-calibrate the O_3 background. The example below shows a successful auto-calibration of the O_3 background. This command is only available if the photometer option is installed.

```
Send:        set cal o3 bkg
Receive:     set cal o3 bkg ok
```

set cal o3 coef
This command will auto-calibrate O_3 coefficients based on O_3 span gas concentrations. If the mode is incorrect, the instrument responds with "can't, wrong settings". The example below shows a successful auto-calibration of the O_3 coefficient. This command is only available if the photometer option is installed.

```
Send:        set cal o3 coef
Receive:     set cal o3 coef ok
```

lamp
This command reports the current photometer lamp setting in percent. The example below shows that the lamp setting is 10.0%. This command is only available if the photometer option is installed.

```
Send:        lamp
Receive:     lamp 10.0 %
```

set lamp *value*
This command sets the photometer lamp setting to *value*, where *value* is a floating point number representing a percentage of the photometer lamp setting. The example below sets the photometer lamp to 10.0%. This command is only available if the photometer option is installed.

```
Send:          set lamp 10.0
Receive:       set lamp 10.0 ok
```

lamp setting
This command reports the current photometer lamp setting. The example below shows the lamp setting is 10.0%. This command is only available if the photometer option is installed.

```
Send:          lamp
Receive:       lamp 10.0 %
```

o3 coef
This command reports O_3 coefficients. If the mode is incorrect, the instrument responds with "can't, wrong settings". The example below reports that the O_3 coefficient is 1.000. This command is only available if the photometer option is installed.

```
Send:          o3 coef
Receive:       o3 coef 1.000
```

set o3 coef *value*
This command sets the O_3 coefficients to user-defined values to *value*, where *value* is a floating-point representation of the coefficient. The example below sets the O_3 coefficient to 1.005. This command is only available if the photometer option is installed.

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

o3 bkg
This command reports the current O_3 background. The example below reports that the O_3 background is 1.005 ppm. This command is only available if the photometer option is installed.

```
Send:          o3 bkg
Receive:       o3 bkg 1.005 ppb
```

set o3 bkg *value*
This command is used to set O_3 background to user-defined values to *value*, where *value* is a floating-point representation of the background in ppm. The example below sets the O_3 background to 15 ppb. This command is only available if the photometer option is installed.

```
Send:          set o3 bkg 15
Receive:       set o3 bkg 15 ok
```

resp coef

This command reports the current ozonator response coefficient when under photometer control. The example below reports that the ozonator response coefficient is 1.000. This command is only available if the photometer option is installed.

```
Send:        resp coef
Receive:     resp coef 1.000
```

set resp coef *value*

This command sets the ozonator response coefficient to user-defined values to *value*, where *value* is a floating-point representation of the coefficient. The example below sets the ozonator response coefficient to 1.500. This command is only available if the photometer option is installed.

```
Send:        set resp coef 1.500
Receive:     set resp coef 1.500 ok
```

sp conc

This command reports photometer span concentration. If the mode is incorrect, the instrument responds with "can't, wrong settings". The example below reports the span gas concentration of 50 ppb. This command is only available if the photometer option is installed.

```
Send:        sp conc
Receive:     sp conc 5.000E+01 ppb
```

set sp conc *value*

This command sets the span concentrations to user-defined values to *value*, where *value* is a floating-point representation of the span concentration in ppb. The example below sets the span concentration to 50 ppb. This command is only available if the photometer option is installed.

```
Send:        set sp conc 50
Receive:     set sp conc 50 ok
```

Keys/Display

push *button*
do
down
en
enter
he
help
le
left
me

menu
ri
right
ru
run
up
1
2
3
4
button = | do | down | en | enter | he | help | le | left | me | menu | ri | right |
ru | run | up | 1 | 2 | 3 | 4 |

These commands simulate pressing the front panel pushbuttons. The
numbers represent the front-panel soft keys, from left to right.

```
Send:        push enter
Receive:     push enter ok
```

---

isc
iscreen

This command retrieves the framebuffer data used for the display on the
*i*Series instrument. It is 19200 bytes in size, 2-bits per pixel, 4 pixels per
byte arranged as 320 by 240 characters. The data is sent in RLE encoded
form to save time in transmission. It is sent as a type '5' binary c_link
response with no checksum.

The RLE encoding consists of a 0 followed by an 8-bit count of
consecutive 0xFF bytes. The following 'c' code will expand the incoming
data.

```
void    unpackDisplay ( void far* tdib, unsigned char far* rlescreen )
{
int i,j,k;
unsigned char far *sc4bpp, *sc2bpp, *screen, *ptr;

        ptr = screen = (unsigned char far *)malloc(19200);
        //RLE decode the screen
          for (i=0; i<19200 && (ptr - screen) < 19200; i++)
          {
                *(ptr++) = *(rlescreen + i);
                if (*(rlescreen + i) == 0)
                {
                unsigned char rlecount = *(unsigned char *)(rlescreen + ++i);
                        while (rlecount)
                        {
                                *(ptr++) = 0;
                                rlecount--;
                        }
                }
                else if (*(rlescreen + i) == 0xff)
                {
                 unsigned char rlecount = *(unsigned char *)(rlescreen + ++i);

                 while (rlecount)
                {
                        *(ptr++) = 0xff;
                        rlecount--;
                }
            }
        }
    }
```

To convert this data into a BMP for use with windows, it needs to be
turned into a 4BPP as that is the smallest windows can display. Also note
that BMP files are upside down relative to this data, i.e. the top display line
is the last line in the BMP.

---

sc
screen
This command is meant for backward compatibility on the C series. Screen
information is reported using the "iscreen" command above.

```
Send:       screen
Receive:    screen
            This is an I series
            Instrument. Screen
            Information not
            available
```

Measurement Configuration

gas index
This command reports the current gas index. This selects the gas that will be diluted, according to Table B-6. The example below reports that Gas A is currently selected.

```
Send:       gas index
Receive:    gas index 1
```

set gas index *index*
index = 0-6

This command sets the current gas index value to *index*. The example below selects Gas D, according to Table B-6.

```
Send:       set gas index 4
Receive:    set gas index 4 ok
```

Table B–6. Gas Index Values

Value	Gas Index
0	None
1	Gas A
2	Gas B
3	Gas C
4	Gas D
5	Gas E
6	Gas F

sel gas *gas* **man**
gas = | a | b | c | d | e | f |

This command selects the gas at the level preset for manual.

```
Send:       sel gas a man
Receive:    sel gas a man ok
```

gas name *gas*
gas = | a | b | c | d | e | f |

This command reports the gas name for gas *gas*.

```
Send:          gas a name
Receive:       gas a name abcd
```

set gas name *gas name*
gas = | a | b | c | d | e | f |
name = 5 character string

This command sets the gas name for gas *gas* to a *name*. 1-5 characters are allowed.

```
Send:          set gas a name abcd
Receive:       set gas a name abcd ok
```

sel gas off
This command turns off all gas solenoids.

```
Send:          sel gas off
Receive:       sel gas off ok
```

gas *gas* **params**
gas = | a | b | c | d | e | f |

This command returns the parameters for the specified *gas*.

```
Send:          gas a params
Receive:       gas a params
               tank ppm 10.000
               span 0 zflow 1800.000
               span 1 tflow 1000.000 ppm 0.400
               span 2 tflow 1000.000 ppm 0.800
               span 3 tflow 1000.000 ppm 1.200
               span 4 tflow 1000.000 ppm 1.600
               span 5 tflow 1000.000 ppm 0.400
               manual zflow 1000.000 gflow 30.50
```

gas *gas* **solenoid**
gas = | a | b | c | d | e | f |

This command reports the solenoid number, according to Table B-7, which is used when the gas *gas* is selected. The example below shows that solenoid A is associated with gas A.

```
Send:          gas a solenoid
Receive:       gas a solenoid 1
```

set gas *gas* **solenoid** *number*
gas = | a | b | c | d | e | f |
number = 1-6

This command selects the solenoid *number* to be used when gas *gas* is selected. The tank for the specified gas should be connected to the specified bulkhead fitting. The example below shows that solenoid C is set for gas A, according to Table B-7.

```
Send:        set gas a solenoid 1
Receive:     set gas a solenoid 1 ok
```

Table B–7. Solenoid Number Values

Value	Solenoid Value
1	Solenoid A
2	Solenoid B
3	Solenoid C
4	Solenoid D
5	Solenoid E
6	Solenoid F

sel gas *gas* **span**
gas = | a | b | c | d | e | f |

This command sets the gas *gas* to span levels 0, 1, 2, 3, 4, or 5. The example below sets gas A to span level 1.

```
Send:        sel gas a span 1
Receive:     set gas a span 1 ok
```

gas *gas* **span conc** *spanindex*
gas = | a | b | c | d | e | f |
spanindex = span index 0-6 (1-5 reports the span concentration for each span level and 6 reports the span concentration for manual mode)

This command reports the target span concentration for the specified gas *gas* and the span level *spanindex*. The concentration reported is in ppb.

```
Send:        gas a span conc 1
Receive:     gas a span conc 1 123.45
```

set gas *gas* **span conc** *spanindex value*
gas = | a | b | c | d | e | f |
spanindex= span index 0-6 (1-5 reports the span concentration for each span level and 6 reports the span concentration for manual mode)
value = float

This command sets the target span concentration *value* for the specified gas *gas* and the span level *spanindex.* The concentration *value* is in ppb.

Note Changing span concentration may affect allowable limits for gas span flow. It is advisable to check this setting. ▲

```
Send:        set gas a span conc 1 123.45
Receive:     set gas a span conc 1 123.45 ok
```

---

gas *gas* **span flow**
gas = | a | b | c | d | e | f |
spanindex = span index 0-6 (0 is for zero flow)

This command reports the target total flow for the specified gas *gas* and span level *spanindex.*

```
Send:        gas a span flow 1
Receive:     gas a span flow 1 123.45
```

set gas *gas* **span flow** *value*
gas = | a | b | c | d | e | f |
spanindex = span index 0-6 (0 is for zero flow)
value = float

This command sets the target total flow *value* for the specified gas *gas* and span level *spanindex.*

```
Send:        set gas a span flow 1 123.45
Receive:     set gas a span flow 1 123.45 ok
```

---

gas *gas* **tank conc**
gas = | a | b | c | d | e | f |

This command reports the tank concentration for gas *gas.* Here concentration is reported in ppb.

```
Send:        gas a tank conc
Receive:     gas a tank conc 123.45
```

set gas *gas* **tank conc** *conc*
gas = | a | b | c | d | e | f |
conc = float

This command sets the tank concentration for gas *gas*. Here *conc* is stored in ppb.

Note Changing this value may affect allowable limits for gas span concentration and gas span flow. It is advisable to check these settings. ▲

```
Send:          set gas a tank conc 123.45
Receive:       set gas a tank conc 123.45 ok
```

---

l1
l2
l3
l4
l5
These commands report the percentage of the ozonator lamp drive for each of the five custom levels. The example below shows that custom level 1 is 10%. This command is only available if the ozonator option is installed. Also, if the photometer option is installed, it must be configured for internal or external measurement mode.

```
Send:          l1
Receive:       l1 10%
```

set l1 *value*
set l2 *value*
set l3 *value*
set l4 *value*
set l5 *value*
These commands set the percentage of the ozonator lamp drive for each of the five custom levels. The example below sets the custom level 1 to 10%. This command is only available if the ozonator option is installed. Also, if the photometer option is installed, it must be configured for internal or external measurement mode.

```
Send:          set l1 10
Receive:       set l1 10 ok
```

---

l1 conc
l2 conc
l3 conc
l4 conc
l5 conc
These commands report the concentration setting of each of the five custom levels. The example below shows that custom level 1 is 500 ppb. This command is only available if the ozonator and photometer options are installed and the photometer is configured for ozonator control mode.

```
Send:          l1 conc
Receive:       l1 conc 500 ppb
```

set l1 *value*
set l2 *value*
set l3 *value*
set l4 *value*
set l5 *value*
These commands set the concentration for each of the five custom levels.
The example below sets the custom level 1 to 500 ppb. The example below
shows that custom level 1 is 500 ppb. This command is only available if the
ozonator and photometer options are installed and the photometer is
configured for ozonator control mode.

```
Send:          set level 1 500
Receive:       set level 1 500 ok
```

set level *level*
This command sets the ozonator output to *level*, where *level* represents
custom levels 1, 2, 3, 4, or 5. The example below sets level 1.

```
Send:          set level 1
Receive:       set level 1 ok
```

man gas *gas* **gflow** *value*
man gas *gas* **zflow** *value*
gas = | a | b | c | d | e | f |
value = float

These commands set the manual level for zero and gas flows for gas *gas* in
sccm. The set command is optional.

```
Send:          set man gas a gflow 202.00
Receive:       set man gas a gflow 202.00
```

man ozon level *value*
This command sets the ozone drive level for the manual level to *value* in %
or ppb. The set command is optional. This command is only available if
the ozonator option is installed.

```
Send:          man ozon level 20
Receive:       man ozon level 20 ok
```

man ozon zflow *value*
This command sets the ozone zero air flow for the ozone manual level to
value, where *value* is a floating point in sccm. The set command is optional.
This command is only available if the ozonator option is installed.

```
Send:        set man ozon zflow 1000
Receive:     set man ozon zflow 1000 ok
```

sel ozon *level*

This command selects the ozonator output levels 1, 2, 3, 4 or 5.

```
Send:        sel ozon 1
Receive:     sel ozon 1 ok
```

sel ozon *level*
set ozon *level*
This command selects the ozonator output levels 0, 1, 2, 3, 4, 5, or man. 0 shuts off the ozonator and man puts it into manual mode. The example below sets the ozonator output level 1. This command is only available if the ozonator option is installed.

```
Send:        sel ozon 1
Receive:     sel ozon 1 ok
```

sel ozon perm off
This command turns off the ozonator and permeation oven if these options are present.

```
Send:        set ozon perm off
Receive:     set ozon perm off ok
```

perm
This command reports the current permeation oven output level, where 0 is off. This command is only available if the permeation oven option is installed.

```
Send:        perm
Receive:     perm 1
```

sel perm *index*
set perm *index*
index = 0-5

This command selects preset permeation oven levels to *index*. This command is only available if the permeation oven option is installed.

```
Send:        sel perm 1
Receive:     set perm 1 ok
```

set o3 conc *value*

This command sets the ozonator target concentration under photometer control, in ppb. This command is only available if the photometer option is installed.

```
Send:           set o3 conc 500
Receive:        set o3 conc 500 ok
```

o3 setting
This command reports the ozonator target concentration under photometer control, in ppb. The example below reports a setting of 100 ppb. This command is only available if the photometer option is installed.

```
Send:           o3 setting
Receive:        o3 setting 1.000E+02 ppb
```

range
This commands report photometer O_3 range. If the mode is incorrect, the instrument responds with "can't, wrong settings". The example below reports that the O_3 full-scale range is set to 5.0 ppm, according to Table B–8. This command is only available if the photometer option is installed.

```
Send:           range
Receive:        range 6: 500E+03 ppb
```

set range *selection*
This command selects the O_3 full-scale ranges, according to Table B–8. The example below sets the O_3 full-scale range to 2.0 ppm.

```
Send:           set range 5
Receive:        set range 5 ok
```

Table B–8. Standard Ranges

Selection	ppm
0	0.05
1	0.1
2	0.2
3	0.5
4	1.0
5	2.0
6	5.0
7	C1
8	C2
9	C3

custom *range*
range = │ 1 │ 2 │ 3 │

This command reports the user-defined value of custom *range* 1, 2, or 3.
The example below reports that custom range 1 is defined to 4.50 ppm.
This command is only available if the photometer option is installed.

```
Send:          custom 1
Receive:       custom 1 4.500E+03 ppb
```

set custom *range* **range** *value*
set custom 1 range *value*
set custom 2 range *value*
set custom 3 range *value*
These commands are used to set the maximum concentration for any of the
three custom *ranges* 1, 2, or 3 to range *value*, where *value* is a floating-point
number representing concentration in ppm. The example below sets the
custom 1 range to 4.5 ppm.

```
Send:          set custom 1 range 4.5
Receive:       set custom 1 range 4.5 ok
```

pres comp
This command reports whether pressure compensation is on or off. The
example below shows that pressure compensation is on. This command is
only available if the photometer option is installed.

```
Send:          pres comp
Receive:       pres comp on
```

set pres comp *onoff*
These commands turn the pressure compensation *on* or *off*. The example
below turns pressure compensation off. This command is only available if
the photometer option is installed.

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

span index
This command reports the current span index, where 0 is zero air, 1-5 are
pre-set span levels, and 6 is manual span level.

```
Send:          span index
Receive:       span index 1
```

set span index *index*
index = 0-6

This command sets the span index value to *index*.

```
Send:          set span index 1
Receive:       set span index 1 ok
```

temp comp
This command reports whether temperature compensation is on or off. The example below shows the temperature compensation is off. This command is only available if the photometer option is installed.

```
Send:          temp comp
Receive:       temp comp off
```

set temp comp *onoff*
These commands turn the temperature compensation *on* or *off*. The example below turns temperature compensation off. This command is only available if the photometer option is installed.

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

Hardware Configuration

contrast
This command reports the screen's level of contrast. The example below shows the screen contrast is 50%, according to Table B–9.

```
Send:          contrast
Receive:       contrast 5:50%
```

set contrast *level*
This command sets the screen's *level* of contrast, according to Table B–9. The example below sets the contrast level to 50%.

```
Send:          set contrast 5
Receive:       set contrast 5 ok
```

Table B–9. Contrast Levels

Level	Contrast Level
0	0%
1	10%
2	20%
3	30%
4	40%
5	50%
6	60%

Level	Contrast Level
7	70%
8	80%
9	90%
10	100%

date
This command reports the current date. The example below reports the date as December 1, 2004.

```
Send:       date
Receive:    date 12-01-04
```

set date *mm-dd-yy*
mm = month
dd = day
yy = year

This command sets the date of the analyzer's internal clock. The example below sets the date to December 1, 2004.

```
Send:       set date 12-01-04
Receive:    set date 12-01-04 ok
```

set default params
This command sets all the parameters to their default values. This does not affect the factory-calibrated parameters.

```
Send:       set default params
Receive:    set default params ok
```

save
set save params
This command stores all current parameters in FLASH memory. 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 FLASH memory.

```
Send:       set save params
Receive:    set save params ok
```

time
This command reports the current time (24-hour 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

This command sets the internal clock (24-hour time). The example below sets the internal time to 2:15 pm.

Note If seconds are omitted, the seconds default to 00. ▲

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

Communications Configuration

addr dns
This command reports the TCP/IP address for the domain name server.

```
Send:           addr dns
Receive:        addr dns 192.168.1.1
```

set addr dns *address*
This command sets the dns *address*, where *address* consists of four numbers ranging from 0-255 inclusive, separated by ".".

```
Send:           set addr dns 192.168.1.1
Receive:        set addr dns 192.168.1.1 ok
```

addr gw
This command reports the default TCP/IP gateway address.

```
Send:           addr gw
Receive:        addr gw 192.168.1.1
```

set addr gw *address*
This command sets the default gateway *address*, where *address* consists of four numbers ranging from 0-255 inclusive, separated by ".".

```
Send:           set addr gw 192.168.1.1
Receive:        set addr gw 192.168.1.1 ok
```

addr ip
This command reports the IP address of the analyzer.

```
Send:           addr ip
Receive:        addr ip 192.168.1.200
```

set addr ip *address*
This command sets the analyzer's IP *address*, where *address* consists of four
numbers ranging from 0-255 inclusive, separated by ".".

```
Send:        set addr ip 192.168.1.200
Receive:     set addr ip 192.168.1.200 ok
```

addr nm
This command reports the IP netmask.

```
Send:        addr nm
Receive:     addr nm 255.255.255.0
```

set addr nm *address*
This command sets the nm *address*, where *address* consists of four numbers
ranging from 0-255 inclusive, separated by ".".

```
Send:        set addr nm 255.255.255.0
Receive:     set addr nm 255.255.255.0 ok
```

baud
This command reports the current baud rate for the serial port
(RS232/RS485). The example below reports that the current baud rate is
9600 baud.

```
Send:        baud
Receive:     baud 9600
```

set baud rate
rate = | 1200 | 2400 | 4800 | 9600 | 19200 | 38400 | 57600 | 115200 |

This command sets the instrument baud rate. The example below sets the
instrument's baud rate to 9600.

Note After the command is sent, the baud rate of the sending device must
be changed to agree with the instrument. ▲

```
Send:        set baud 9600
Receive:     set baud 9600 ok
```

dhcp
This command reports the current state of use of DHCP on or off. DHCP
is used to assign an IP address to the analyzer automatically. The example
below shows that DHCP is on.

```
Send:        dhcp
Receive:     dhcp on
```

set dhcp *onoff*

These commands enables and disables the DHCP service by either *on* or *off*. Changes to this parameter will only take effect when the analyzer is powered up. The example below sets the DHCP service on.

Note When DHCP is set to on, the user-supplied addr gw, addr dns, addr ip, and addr nm parameters are not used. ▲

```
Send:        set dhcp on
Receive:     set dhcp on ok
```

format

This command reports the current reply termination format. The example below shows that the reply format is 00, which means reply with no checksum, according to Table B–10.

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

set format *format*

This command sets the reply termination *format*, where *format* is set according to Table B–10. The example below sets the reply termination format to checksum.

```
Send:        set format 01
Receive:     set format 01 ok
```

Table B–10. Reply Termination Formats

Format	Reply Termination
00	<CR>
01	<NL> sum xxxx <CR>

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

host name

This command reports the host name string.

```
Send:        host name
Receive:     host name analyzer01
```

set host name *string*

This command sets the host name *string*, where *string* is 1-13 alphanumeric characters.

```
Send:          set host name analyzer01
Receive:       set host name analyzer01 ok
```

instr name
This command reports the instrument name.

```
Send:          instr name
Receive:       instr name
               Dynamic Gas Calibrator
               Dynamic Gas Calibrator
```

instrument id
This command reports the instrument id.

```
Send:          instrument id
Receive:       instrument id 51
```

set instrument id *value*
This command sets the instrument id to *value*, where *value* is a decimal
number between 0 and 127 inclusive.

Note sending this command via RS-232 or RS-485 will require the host to
use the new id for subsequent commands. 5

```
Send:          set instrument id 52
Receive:       set instrument id 52 ok
```

mode
This command reports what operating mode the instrument is in: local,
service, 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
```

program no
This command reports the analyzer's model information and program
version number, which will be dependant on the current version.

```
Send:          program no
Receive:       program no iSeries 146i 01.00.00.100
```

set layout ack
This command disables the stale layout/layout change indicator ('*') that is attached to each response if the layout has changed.

```
Send:          set layout ack
Receive:       set layout ack ok
```

I/O Configuration

analog iout range *channel*
This command reports the analog current output range setting for *channels*, where *channel* must be between 1 and 6, inclusive. The example below reports current output channel 4 to the 4-20 mA range, according to Table B–11. This command responds with "feature not enabled" if the I/O expansion board is not detected.

```
Send:          analog iout range 4
Receive:       analog iout range 4 2
```

set analog iout range *channel range*
This command sets analog current output *channel* to the *channel range* where *channel* is between 1 and 6 inclusive, and *range* is set according to Table B–11. The example below sets current output channel 4 to the 0-20 mA range. This command responds with "feature not enabled" if the I/O expansion board is not detected.

```
Send:          set analog iout range 4 1
Receive:       set analog iout range 4 1 ok
```

Table B–11. Analog Current Output Range Values

Range	Output Range
1	0-20 mA
2	4-20 mA
0 [cannot be set to this, but may report]	Undefined

analog vin *channel*
This command retrieves the analog voltage input *channel* data, both the calculated value and the actual voltage. In the example below, the "calculated" value of channel 1 is 75.325 degrees F, volts are 2.796. This command responds with "feature not enabled" if the I/O expansion board is not detected.

```
Send:          analog vin 1
Receive:       analog vin 1 75.325 2.796
```

analog vout range *channel*
This command reports the analog voltage output *channel* range, where *channel* is between 1 and 6 inclusive, according to Table B–12.

```
Send:          analog vout range 2
Receive:       analog vout range 2 3
```

set analog vout range *channel range*
This command sets analog voltage output *channel* to the range, where *channel* is between 1 and 6 inclusive, and *range* is set according to Table B–12. The example below sets channel 2 to the 0-10 V range.

```
Send:          set analog vout range 2 3
Receive:       set analog vout range 2 3 ok
```

Table B–12. Analog Voltage Output Range Values

Range	Output Range
1	0-1 V
2	0-100 mV
3	0-10 V
4	0-5 V
0 [cannot be set to this, but may report]	Undefined

dig in
This command reports the status of the digital inputs as a 4-digit hexadecimal string with the most significant bit (MSB) being input 16.

```
Send:          dig in
Receive:       dig in 0xff7f
```

din *channel*
This command reports the action assigned to input *channel* and the corresponding active state. The example below reports the input 1 to be assigned an index number 3 corresponding to action of "set background" mode with the active state being high.

```
Send:          din 1
Receive:       din 1 3 SET BACKGROUND high
```

set din *channel index state*

This command assigns digital input *channel* (1-16) to activate the action indicated by *index* (1-35), when the input transitions to the designated *state* (high or low). Use "list din var" command to obtain the list of supported *index* values and corresponding actions.

```
Send:          set din 5 9 high
Receive:       set din 1 9 high ok
```

dout *channel*
This command reports the index number and output variable and the active state assigned to output *channel*. The example below reports the input 2 to be assigned an index number 2 corresponding to "local/remote" with the active state being open.

```
Send:          dout 2
Receive:       dout 2 2 LOCAL/REMOTE open
```

set dout *channel index state*
This command assigns digital output *channel* to be assigned to the action associated with *index*, and assigns it an active state of *state* (open or closed).

```
Send:          set dout 2 2 open
Receive:       set dout 2 2 open ok
```

dtoa *channel*
This reports the outputs of the 6 or 12 Digital to Analog converters, according to Table B–13. The example below shows that the D/A #1 is 97.7% full-scale.

```
Send:          dtoa 1
Receive:       dtoa 1 97.7%
```

Note All channel ranges are user definable. If any customization has been made to the analog output configuration, the default selections may not apply. ▲

Table B–13. Default Output Assignment

D to A	Function	Single Range	Dual Range	Auto Range
1	Voltage Output	O_3	Not Used	Not Used
2	Voltage Output	O_3	Not Used	Not Used
3	Voltage Output	Not Used	Not Used	Not Used
4	Voltage Output	Not Used	Not Used	Not Used
5	Voltage Output	Not Used	Not Used	Not Used
6	Voltage Output	Not Used	Not Used	Not Used

D to A	Function	Single Range	Dual Range	Auto Range
7	Current Outputs	O_3	Not Used	Not Used
8	Current Outputs	O_3	Not Used	Not Used
9	Current Outputs	Not Used	Not Used	Not Used
10	Current Outputs	Not Used	Not Used	Not Used
11	Current Outputs	Not Used	Not Used	Not Used
12	Current Outputs	Not Used	Not Used	Not Used

list var aout
list var dout
list var din
These commands report the list of index numbers, and the variables
(associated with that index number) available for selection in the current
mode (determined by single/dual/auto, gas mode) for analog output, digital
output and digital inputs. The index number is used to insert the variable
in a field location in a list using "set sp *field index*". The example below
reports the list of analog output, index numbers, and variables.

```
Send:       list var aout
Receive:    list var aout
            index variable
            0 none
            1 conc
            2 tgflo
            3 agflo
            4 tzflo
            5 azflo
            6 ttflo
            7 atflo
            8 ozone
            9 perm
            10 pres
            11 bncht
            12 lmpt
            13 o3lt
            14 int
            15 noise
            sum 311a
```

relay
relay stat
This command reports the current relay logic normally "open" or normally
"closed," if all the relays are set to same state, that is all open or all closed.
The example below shows that the status when all the relays logic is set to
normally "open".

```
Send:          relay stat
Receive:       relay stat open
```

Note If individual relays have been assigned different logic then the response would be a 4-digit hexadecimal string with the least significant byte (LSB) being relay no 1. ▲

For example:

```
Receive:       relay stat 0x0001 (indicates relay no 1 is set to
               normally open logic, all others are normally closed)
Receive:       relay stat 0x0005 (indicates relay no 1 and 3 are set
               to be normally open logic, all others are normally
               closed)
```

set relay open
set relay open *value*
set relay closed
set relay closed *value*
These commands set the relay logic to normally open or closed for relay number *value*, where *value* is the relay between 1 and 16. The example below sets the relay no 1 logic to normally open.

Note If the command is sent without an appended relay number then all the relays are assigned the set logic of normally open/closed. 5

```
Send:          set relay open 1
Receive:       set relay open 1 ok
```

Record Layout Definition

The Erec, Lrec Srec layouts contain the following:

● A format specifier for parsing ASCII responses

● A format specifier for parsing binary responses

In addition to these the Erec Layout contains:

● A format specifier for producing the front-panel displays

Values are read in using either the ASCII or binary format specifiers and converted to uniform internal representations (32-bit floats or 32-bit integers). These values are converted into text for display on the screen using the format specifier for the front-panel display. Normally, the specifier used to parse a particular datum from the input stream will be strongly related to the specifier used to display it (such as, all of the floating

point inputs will be displayed with an 'f' output specifier, and all of the integer inputs will be displayed with a 'd' specifier).

Format Specifier for ASCII Responses

The first line of the Layout response is the scanf-like parameter list for parsing the fields from an ASCII ERec response. Parameters are separated by spaces and the line is terminated by a \n (the normal line separator character). Valid fields are:

%s - parse a string
%d - parse a decimal number
%ld - parse a long (32-bit) decimal number
%f - parse a floating point number
%x - parse a hexadecimal number
%lx - parse a long (32-bit) hex number
%* - ignore the field

Note Signed versus unsigned for the integer values does not matter; it is handled automatically. ▲

Format Specifier for Binary Responses

The second line of the Layout response is the binary parameter list for parsing the fields from a binary response. Parameters MUST be separated by spaces, and the line is terminated by a '\n'. Valid fields are:

t - parse a time specifier (2 bytes)
D - parse a date specifier (3 bytes)
i - ignore one 8-bit character (1 byte)
e - parse a 24-bit floating point number (3 bytes: n/x)
E - parse a 24-bit floating point number (3 bytes: N/x)
f - parse a 32-bit floating point number (4 bytes)

c - parse an 8-bit   signed number (1 byte)
C - parse an 8-bit unsigned number (1 byte)
n - parse a 16-bit   signed number (2 bytes)
N - parse a 16-bit unsigned number (2 bytes)
m - parse a 24-bit   signed number (3 bytes)
M - parse a 24-bit unsigned number (3 bytes)
l - parse a 32-bit   signed number (4 bytes)
L - parse a 32-bit unsigned number (4 bytes)

There is an optional single digit d which may follow any of the numeric fields which indicates that after the field has been parsed out, the resulting value is to be divided by 10^d. Thus the 16-bit field 0xFFC6 would be interpreted with the format specifier 'n3' as the number -0.058.

Format Specifier for Front-Panel Layout

The subsequent lines in the ERec Layout response describe the appearance of the full panel. The full instrument panel as it appears on the screen has two columns of lines. Each line is composed of three major components: (1) a text field, (2) a value field, and (3) a button. None of these three components is required. The text field contains statically displayed text.

The value field displays values which are parsed out of the response to a DATA/ERec command. It also displays, though background changes, alarm status. The button, when pressed, triggers input from either a dialog box or a selection list. There are five kinds of buttons, B, I, L, T, and N.

Each line in the layout string corresponds to one line on the display. The layout string describes each of the three major fields as well as translation mechanisms and corresponding commands.

Text

The first field in the layout string is the text. It is delimited by a ':'. The string up to the first ':' will be read and inserted in the text field of the line.

Value String

This is followed by a possible string enclosed in quotes that is used to place a string into the value field.

Value Source

The value source, which is the item (or word) number in the DATA/ERec response, appears next. This is followed by an optional bitfield designator. The datum identified by the value source can be printed as a string 's', hexadecimal 'x', decimal 'd', or floating point 'f', or binary 'b' number. Typically, bitfield extractions are only done for decimal or hexadecimal numbers.

Floating-point numbers can be followed with an optional precision specifier which will be used as an argument to printf's %f format (e.g., a field of '4' would be translated into the printf command of '%.3f'). Alternately, the special character '*' can precede the precision specifier; this causes an indirection on the precision specifier (which now becomes a field number).

This is useful when formatting, for example, numbers which have varying precision depending on the mode of the instrument.

Binary numbers can also have an optional precision specifier which is used to determine how many bits to print. For example, the specifier 'b4' will print the lowest four bits of the parsed number.

There are serious restrictions on where an 's' field may appear: currently sources 1 and 2 must be 's', and no others may be 's'.

Alarm Information   The value source is followed by optional alarm information, indicated by a commercial at sign '@' with a source indicator and a starting bit indicator. All alarm information is presumed to be two bits long (low and high). The bitfield extraction is performed on the integer part of the source. Typical alarm information would appear as '@6.4'.

Translation Table   Then, there appears an optional translation table within braces '{}'. This is a string of words separated by spaces. An example translation table would be '{Code_0 Code_1 Code_2 Code_3}'. The value, once extracted is used as a zero-based index into the translation table to determine the string to display.

Selection Table   Then there appears an optional selection table within parentheses '(...)'. This is a string of numbers separated by spaces '(0 1)'. The selection table lists the translation table entries which the user may select from when setting the parameter. This is not necessarily the same as the entries which may be displayed.

Button Designator   Then there appears an optional button designator. This will be one of 'B', 'I', 'L', 'T', or 'N'.

B- Indicates a button which pops up an input dialog prompting the user for a new value using the designated input format. The input format is specified from the 'B' through the subsequent semicolon.

I—Indicates a button which pops up a selection list with input translation. That is, the values read are translated before they are compared to the selection list options.

L—Indicates a button which pops up a selection list without any translation. The output value is number of the selected option.

T—Indicates a button which pops up a selection list with output translation. The number of the option selected is used as an index into the translation table to generate an output string.

N—Indicates a button which only sends the subsequent command to the instrument. No user-prompting happens.

The following string through an optional '|' or the end of the line is the command which is to be sent to the instrument upon the completion of the button selection. The command string should normally contain print-style formatting to include the user input. If a '|' is present, it indicates a command which is sent to the instrument upon successful completion of the button command to update the value field.

This is not currently used.

Examples   Some examples ('\n' is the C syntax for an end-of-line character):

      'Concentrations\n'

This is a single text-only line.

      '\n'

This is a single blank line.

      ' NO:3s\n'

This is a line which appears slightly indented. The text field is 'NO', the value is taken from the third element of the data response, and interpreted as a string.

      ' NO:18sBd.ddd;set no coef %s\n'

This is a line which also appears slightly indented. The next field is also 'NO', but the value is taken from the eighteenth element of the data response, again interpreted as a string. A button appears on this line which, when pressed, pops up an input dialog which will state "Please enter a new value for NO using a d.ddd format." The string entered by the user is used to construct the output command. If the user enters, for example, '1.234', the constructed command will be 'set no coef 1.234'.

      ' NO:21f{Code_0 Code_1 Code_2 Code_3 Code_4 Code_5 Code_6
      Code_7 Code_8 Code_9 Code_10 Code_11}Lset range no %d\n'

This is a line which appears slightly indented, the title is again 'NO', and the value the twenty-first element of the data response, interpreted as a floating-point number. There is a no-translation button which creates a

selection list of twelve "Code nn" options. The number of the user selection is used to create the output command.

```
'Mode:6.12-13x{local remote service service}(0 1)Tset mode
%s\n'
```

This is a line which has a title of 'Mode', and value taken from the sixth field of the data response. There is a bitfield extraction of bits 12 through 13 from the source (the value type is not important here because the value is being translated to an output string). Once the bits have been extracted, they are shifted down to the bit-zero position. Thus, the possible values of this example will be 0 through 3. The translation list shows the words which correspond to each input value, the zeroth value appearing first (0 -> local, 1 -> remote, etc.). The selection list shows that only the first two values, in this case, are to be shown to the user when the button is pressed. The 'T' button indicates full translation, input code to string, and user selection number to output string.

```
'\xC'
```

This is a line that starts a new column (the \xC or ^L).

```
' Comp:6.11x{off on}Tset temp comp %s\n'
```

This shows that the bitfield end (the second part of a bitfield specification) is optional. The bitfield will be one bit long, starting in this case at the eleventh bit.

```
'Background:7f*8Bd.ddd;set o3 bkg %s\n'
```

This shows the use of indirect precision specifiers for floating point displays. The background value is taken from the 7th element, and the precision specifier is taken from the 8th. If the asterisk were not present, it would indicate instead that 8 digits after the decimal point should be displayed.

Appendix C
MODBUS Protocol

This appendix provides a description of the MODBUS Protocol Interface and is supported both over RS-232/485 (RTU protocol) as well as TCP/IP over Ethernet.

The MODBUS Commands that are implemented are explained in detail in this document. The MODBUS protocol support for the *i*Series enables the user to perform the functions of reading the various concentrations and other analog values or variables, read the status of the digital outputs of the analyzer, and to trigger or simulate the activation of a digital input to the instrument. This is achieved by using the supported MODBUS commands listed below.

For details of the Model 146*i* MODBUS Protocol specification, see the following topics:

- "Serial Communication Parameters" on page C-1
- "TCP Communication Parameters" on page C-2
- "Application Data Unit Definition" on page C-2
- "Function Codes" on page C-3
- "MODBUS Commands Supported" on page C-8

Additional information on the MODBUS protocol can be obtained at http://www.modbus.org. References are from MODBUS Application Protocol Specification V1.1a MODBUS-IDA June 4, 2004.

Serial Communication Parameters

The following are the communication parameters that are used to configure the serial port of the *i*Series to support MODBUS RTU protocol.

Number of Data bits	: 8
Number of Stop bits	: 1
Parity	: None
Date rate	: from 1200-115200 Baud (9600 is default)

TCP Communication Parameters

*i*Series Instruments support the MODBUS/TCP protocol. The register definition is the same as for the serial interface.

TCP connection port for MODBUS : 502

Application Data Unit Definition

Here are the MODBUS ADU (Application Data Unit) formats over serial and TCP/IP:

Serial:	Slave Address	Function Code	Data	Error Check
TCP/IP:	MBAP Header	Function Code	Data	

Slave Address

The MODBUS save address is a single byte in length. This is the same as the instrument ID used for C-Link commands and can be between 1 and 127 decimal (i.e. 0x01 hex to 0x7F hex). This address is only used for MODBUS RTU over serial connections.

Note Device ID '0' used for broadcast MODBUS commands, is not supported. Device IDs 128 through 247 (i.e. 0x80 hex to 0xF7 hex) are not supported because of limitations imposed by C-Link. ▲

MBAP Header

In MODBUS over TCP/IP, a MODBUS Application Protocol Header (MBAP) is used to identify the message. This header consists of the following components:

Transaction Identifier	2 Bytes	0x0000 to 0xFFFF (Passed back in response)
Protocol Identifier	2 Bytes	0x00 (MODBUS protocol)
Length	2 Bytes	0x0000 to 0xFFFF (Number of following bytes)
Unit Identifier	1 Byte	0x00 to 0xFF (Passed back in response)

A Slave address is not required in MODBUS over TCP/IP because the higher-level protocols include device addressing. The unit identifier is not used by the instrument.

Function Code

The function code is a single byte in length. The following function codes are supported by the instrument:

Read Coils	:	0x01
Read Inputs	:	0x02
Read Holding Registers	:	0x03
Read Input Registers	:	0x04
Force (Write) Single Coil	:	0x05
Read Exception Status	:	0x06

If a function code is received that is not in this list, an invalid function exception is returned.

Data

The data field varies depending on the function. For more description of these data fields, see "Function Codes" below.

Error Check

In MODBUS over Serial an error check is included in the message. This is not necessary in MODBUS over TCP/IP because the higher-level protocols ensure error-free transmission. The error check is a two-byte (16 bit) CRC value.

Function Codes

This section describes the various function codes that are supported by the Model 146*i*.

(0x01/0x02) Read Coils / Read Inputs

Read Coils / Inputs read the status of the digital outputs (relays) in the instrument. Issuing either of these function codes will generate the same response.

These requests specify the starting address, i.e. the address of the first output specified, and the number of outputs. The outputs are addressed starting at zero. Therefore, outputs numbered 1–16 are addressed as 0–15.

The outputs in the response message are packed as one per bit of the data field. Status is indicated as 1 = Active (on) and 0 – Inactive (off). The LSB of the first data byte contains the output addressed in the query. The other outputs follow toward the high end of this byte, and from low order to

high order in subsequent bytes. If the returned output quantity is not a multiple of eight, the remaining bits in the final data byte will be padded with zeros (toward the high order end of the byte). The Byte Count field specifies the quantity of complete bytes of data.

Note The values reported may not reflect the state of the actual relays in the instrument, as the user may program these outputs for either active closed or open. ▲

Request

Function code	1 Byte	0x01 or 0x02
Starting Address	2 Bytes	0x0000 to maximum allowed by instrument
Quantity of outputs	2 Bytes	1 to maximum allowed by instrument
Unit Identifier	1 Byte	0x00 to 0xFF (Passed back in response)

Response

Function code	1 Byte	0x01 or 0x02
Byte count	1 Byte	N*
Output Status	n Byte	N = N or N+1

*N = Quantity of Outputs / 8, if the remainder not equal to zero, then N=N+1

Error Response

| Function code | 1 Byte | 0x01 or 0x02 |
| Exception code | 1 Byte | 01=Illegal Function, 02=Illegal Address, 03=Illegal Data, 04=Slave Device Failure |

Here is an example of a request and response to read outputs 2–15:

Request

Field Name	*(Hex)*
Function	0x01
Starting Address Hi	0x00
Starting Address Lo	0x02
Quantity of Outputs Hi	0x00
Quantity of Outputs Lo	0x0D

Response

Field Name	(Hex)
Function	0x01
Byte Count	0x03
Output Status 2–10	0xCD
Output Status 11–15	0x0A

The status of outputs 2–10 is shown as the byte value 0xCD, or binary 1100 1101. Output 10 is the MSB of this byte, and output 2 is the LSB. By convention, bits within a byte are shown with the MSB to the left, and the LSB to the right. Thus, the outputs in the first byte are '10 through 2', from left to right. In the last data byte, the status of outputs 15-11 is shown as the byte value 0x0A, or binary 0000 1010. Output 15 is in the fifth bit position from the left, and output 11 is the LSB of this byte. The four remaining high order bits are zero filled.

(0x03/0x04) Read Holding Registers / Read Input Registers

Read holding / input registers reads the measurement data from the instrument. Issuing either of these function codes will generate the same response. These functions read the contents of one or more contiguous registers.

These registers are 16 bits each and are organized as shown below. All of the values are reported as 32-bit IEEE standard 754 floating point format. This uses 2 sequential registers, least significant 16 bits first.

The request specifies the starting register address and the number of registers. Registers are addressed starting at zero. Therefore, registers numbered 1–16 are addressed as 1–15. The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

Request

Function code	1 Byte	0x03 or 0x04
Starting Address	2 Bytes	0x0000 to maximum allowed by instrument
Quantity of Registers	2 Bytes	1 to maximum allowed by instrument

Response

Function code	1 Byte	0x03 or 0x04
Byte count	1 Byte	2 x N*
Register value	N* x 2 Bytes	N = N or N+1

*N = Quantity of Registers

Error Response

Function code	1 Byte	Function code + 0x80
Exception code	1 Byte	01=Illegal Function, 02=Illegal Address,
		03=Illegal Data, 04=Slave Device Failure

Here is an example of a request and response to read registers 10–13:

Request

Field Name	(Hex)
Function	0x03
Starting Address Hi	0x00
Starting Address Lo	0x09
No. of Registers Hi	0x00
No. of Registers Lo	0x04

Response

Field Name	(Hex)
Function	0x03
Byte Count	0x06
Register value Hi (10)	0x02
Register value Lo (10)	0x2B
Register value Hi (11)	0x00
Register value Lo (11)	0x00
Register value Hi (12)	0x00
Register value Lo (12)	0x64
Register value Hi (13)	0x00
Register value Lo (13)	0x64

The contents of register 10 are shown as the two byte values of 0x02 0x2B. Then contents of registers 11–13 are 0x00 0x00, 0x00 0x64 and 0x00 0x64 respectively.

(0x05) Force (Write) Single Coil

The force (write) single coil function simulates the activation of the digital inputs in the instrument, which triggers the respective action.

This function code is used to set a single action to either ON or OFF. The request specifies the address of the action to be forced. Actions are addressed starting at zero. Therefore, action number 1 is addressed as 0. The requested ON/OFF state is specified by a constant in the request data field. A value of 0xFF00 requests the action to be ON. A value of 0x0000 requests it to be OFF. All other values are illegal and will not affect the output. The normal response is an echo of the request, returned after the state has been written.

Request

Function code	1 Byte	0x05
Starting Address	2 Bytes	0x0000 to maximum allowed by instrument
Output Value	2 Bytes	0x0000 or 0xFF00

Response

Function code	1 Byte	0x05
Starting Address	2 Bytes	0x0000 to maximum allowed by instrument
Output Value	2 Bytes	0x0000 or 0xFF00

Error Response

Function code	1 Byte	Function code + 0x80
Exception code	1 Byte	01=Illegal Function, 02=Illegal Address, 03=Illegal Data, 04=Slave Device Failure

Here is an example of a request to write Coil 5 ON:

Request

Field Name	(Hex)
Function	05
Output Address Hi	00
Output Address Lo	05

Output Value Hi	FF
Output Value Lo	00

Response

Field Name	(Hex)
Function	05
Output Address Hi	00
Output Address Lo	05
Output Value Hi	FF
Output Value Lo	00

MODBUS Commands Supported

The following Table C–1 through Table C–3 lists the MODBUS commands supported for the Model 146*i*.

Table C–1. Read Coils for 146*i*

Coil Number	Status
1	GAS BIT 1
2	GAS BIT 2
3	GAS BIT 3
4	SPAN BIT 1
5	SPAN BIT 2
6	SPAN BIT 3
7	O3/PERM BIT 1
8	O3/PERM BIT 2
9	O3/PERM BIT 3
10	O3/PERM BIT 4
11	PHOTO BIT 1
12	PHOTO BIT 2
13	GAS A
14	GAS B
15	GAS C
16	GAS D
17	GAS E
18	GAS F
19	OZONATOR

Coil Number	Status
20	PERM OVEN
21	USER 1
22	USER 2
23	USER 3
24	USER 4
25	USER 5
26	USER 6
27	USER 7
28	USER 8
29	GEN ALARM
30	AMBIENT TEMP
31	O3 LAMP TEMP
32	PERM GAS TEMP
33	PRESSURE
34	PHOT BENCH TEMP
35	PHOT LAMP TEMP
36	PHOT INTENSITY
37	O3 LEVEL

Table C–2. Read Registers for 146*i*

Register Number	Variable
40001&40002	GAS CONC
40003&40004	TARGET GFLOW
40005&40006	ACTUAL GFLOW
40007&40008	TARGET ZFLOW
40009&40010	ACTUAL ZFLOW
40011&40012	TARGET TFLOW
40013&40014	ACTUAL TFLOW
40015&40016	O3 CONC
40017&40018	PERM CONC
40019&40020	PRESSURE
40021&40022	BENCH TEMP
40023&40024	LAMP TEMP

Register Number	Variable
40025&40026	O3 LAMP TEMP
40027&40028	INTENSITY
40029&40030	NOISE
40031&40032	ANALOG 1
40033&40034	ANALOG 2
40035&40036	ANALOG 3
40037&40038	ANALOG 4
40039&40040	ANALOG 5
40041&40042	ANALOG 6
40043&40044	ANALOG 7
40045&40046	ANALOG 8

Table C–3. Write Coils for 146*i*

Coil Number	Action
101	GAS BIT 1
102	GAS BIT 2
103	GAS BIT 3
104	SPAN BIT 1
105	SPAN BIT 2
106	SPAN BIT 3
107	O3/PERM BIT 1
108	O3/PERM BIT 2
109	O3/PERM BIT 3
110	O3/PERM BIT 4
111	PHOTO BIT 1
112	PHOTO BIT 2
113	AOUTS TO ZERO
114	AOUTS TO FS