Model 48*i* Trace Level-Enhanced

Instruction Manual

Gas Filter Correlation CO Analyzer

Part Number 102948-00

27Apr2006

CE

Thermo
ELECTRON CORPORATION

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 Electron 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 Electron's compliance with these Directives, the recyclers in your country, and information on Thermo Electron 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 appendixes 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.
- Appendix A "Warranty" is a copy of the warranty statement.
- Appendix B "C-Link Protocol Commands" provides a description of the C-Link protocol commands that can be used to remotely control an analyzer using a host device such as a PC or datalogger.

- Appendix C "MODBUS Protocol" 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.
- Appendix D "Geysitech (Bayern-Hessen) Protocol" provides a description of the Geysitech (Bayern-Hessen or BH) Protocol Interface and is supported both over RS-232/485 as well as TCP/IP over Ethernet

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 calibrator 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	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 48*i* Trace Level-Enhanced is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated. ▲
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.

866-282-0430 Toll Free

508-520-0430 International

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Chapter 1
Introduction

The Model 48*i* Trace Level-Enhanced Analyzer measures CO concentration using Gas Filter Correlation (GFC). The Model 48*i* Trace Level-Enhanced combines proven detection technology, easy to use menu-driven software, and advanced diagnostics to offer unsurpassed flexibility and reliability. The Model 48*i* Trace Level-Enhanced has the following features:

- 320 x 240 graphics display
- Menu-driven software
- Field programmable ranges
- User-selectable single/dual/auto range modes
- Multiple user-defined analog outputs
- Analog input options
- High sensitivity
- Fast response time
- Linearity through all ranges
- Highly specific to CO
- Self-aligning optics
- Automatic temperature and pressure compensation
- User-selectable digital input/output capabilities
- Standard communications features include RS232/485 and Ethernet
- C-Link, MODBUS, Geysitech (Bayern-Hessen), and streaming data protocols

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

- "Principle of Operation" on page 1-2
- "Specifications" on page 1-3

Thermo Electron is pleased to supply this CO analyzer. We are committed to the manufacture of instruments exhibiting high standards of quality, performance, and workmanship. Service personnel are available for assistance with any questions or problems that may arise in the use of this analyzer. For more information on servicing, see Chapter 7 "Servicing".

Principle of Operation

The Model 48*i* Trace Level-Enhanced operates on the principle that carbon monoxide (CO) absorbs infrared radiation at a wavelength of 4.6 microns. Because infrared absorption is a non-linear measurement technique, it is necessary to transform the basic analyzer signal into a linear output. The Model 48*i* Trace Level-Enhanced uses an internally stored calibration curve to accurately linearize the instrument output over any range up to a concentration of 1000 ppm.

The sample is drawn into the Model 48*i* Trace Level-Enhanced through the sample bulkhead, as shown in Figure 1-1. The sample flows through the optical bench. Radiation from an infrared source is chopped and then passed through a gas filter alternating between CO and N_2. The radiation then passes through a narrow bandpass interference filter and enters the optical bench where absorption by the sample gas occurs. The infrared radiation then exits the optical bench and falls on an infrared detector.

The CO gas filter acts to produce a reference beam which cannot be further attenuated by CO in the sample cell. The N_2 side of the filter wheel is transparent to the infrared radiation and therefore produces a measurement beam, which can be absorbed by CO in the cell. The chopped detector signal is modulated by the alternation between the two gas filters with an amplitude related to the concentration of CO in the sample cell. Other gases do not cause modulation of the detector signal since they absorb the reference and measurement beams equally. Thus, the GFC system responds specifically to CO.

The Model 48*i* Trace Level-Enhanced outputs the CO concentration to the front panel display, the analog outputs, and also makes the data available over the serial or Ethernet connection.

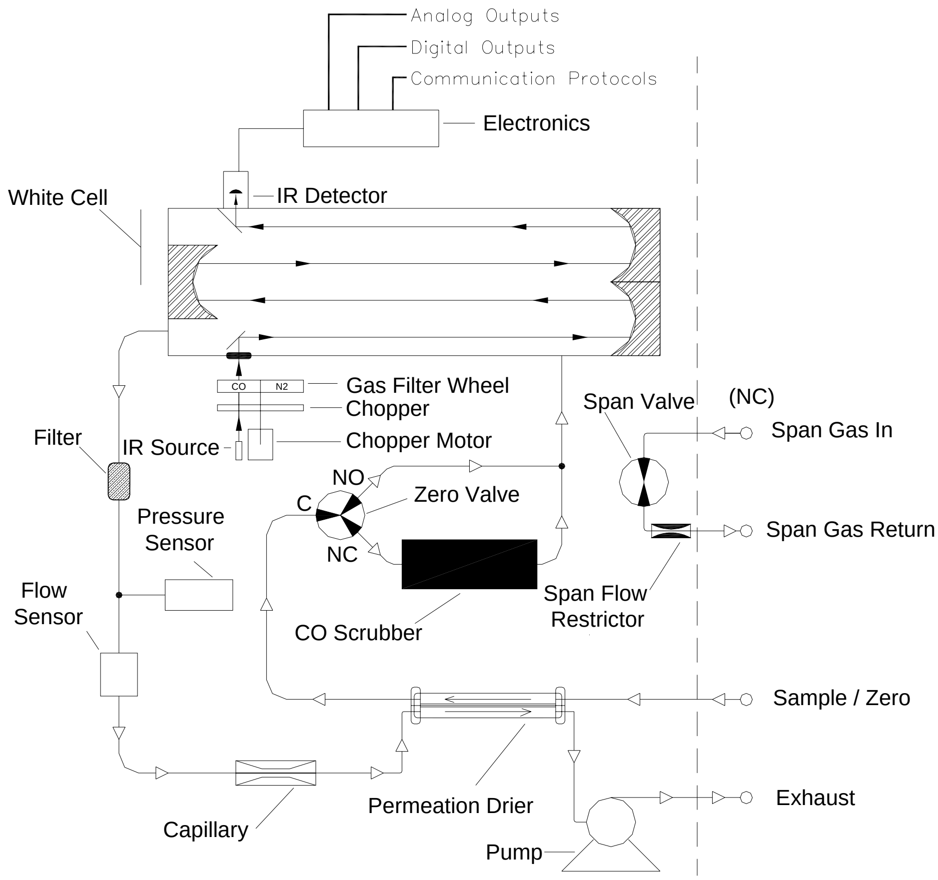


Figure 1–1. Model 48i Trace Level-Enhanced

Specifications

Table 1–1 lists the specifications for the Model 48*i* Trace Level-Enhanced.

Table 1–1. Model 48*i* Trace Level-Enhanced Specifications

Preset ranges	0-1, 2, 5, 10, 20, 50, 100, 200, 500, 1000 ppm or mg/m^3
Custom ranges	0-1 to 1000 ppm or mg/m^3
Zero roise	0.02 ppm RMS (30 second averaging time)
Lower detectable limit	0.04 ppm
Zero drift (24 hour)	< 0.1 ppm
Span drift (24 hour)	± 1% full-scale
Response time	60 seconds (30 second averaging time)
Linearity	± 1% full-scale or 0.04 ppm, whichever is greater
Sample flow rate	0.5 lpm

Operating temperature	20–30 °C (may be safely operated over the range of 5–40 °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 49 lbs.
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 programmable
Digital outputs	1 power fail relay Form C, 10 digital 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, Geysitech (Bayern-Hessen), and streaming data (all user selectable)
Ethernet connection	RJ45 connector for 10Mbs Ethernet connection, static or dynamic TCP/IP addressing

*In non-condensing environments. Standard specifications cannot be maintained for sample concentrations over 1,000 ppm. Performance specifications based on operation with 20–30 °C.

Chapter 2
Installation

Installing the Model 48*i* Trace Level-Enhanced includes the following recommendations and procedures:

- "Lifting" on page 2-1
- "Unpacking and Inspection" on page 2-1
- "Setup Procedure" on page 2-3
- "Connecting External Devices" on page 2-5
- "Startup" on page 2-9

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 48*i* Trace Level-Enhanced 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).

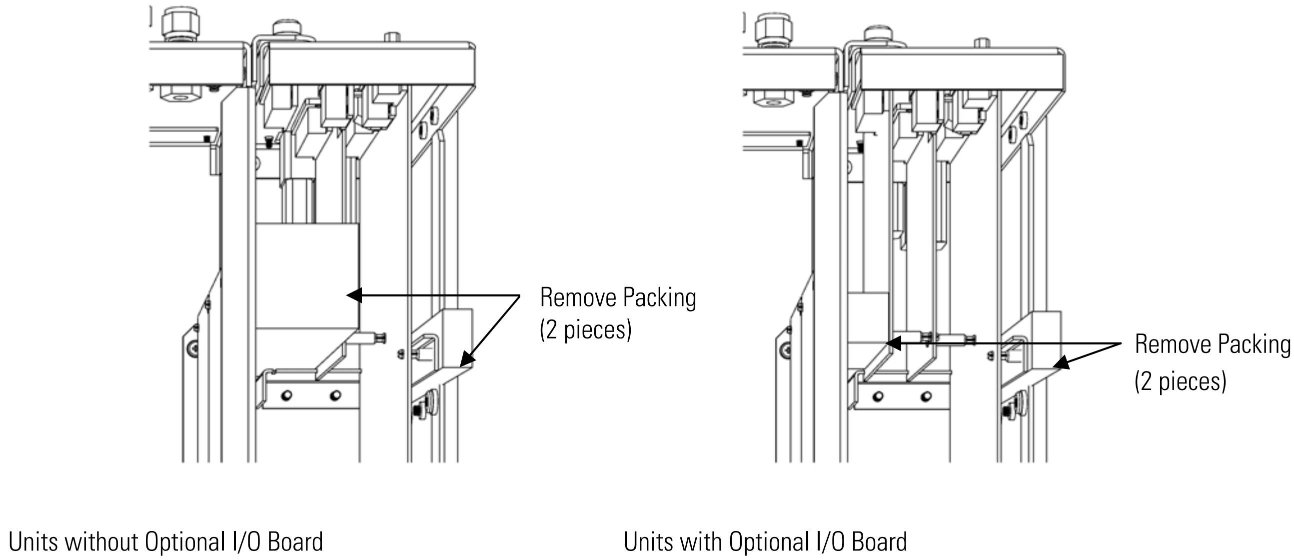


Figure 2–1. Remove the Packing Material

4. Remove the three shipping screws from the pump (Figure 2–2).

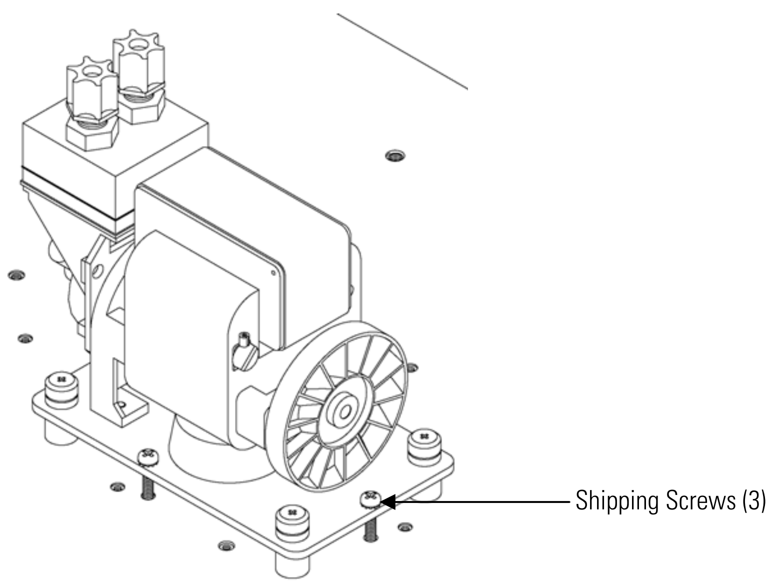


Figure 2–2. Removing the Shipping Screws

5. Check for possible damage during shipment.

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

7. Re-install the cover.

8. Remove any protective plastic material from the case exterior.

Setup Procedure

Use the following procedure to setup the instrument:

1. Connect the sample line to the SAMPLE bulkhead on the rear panel (Figure 2–3). Ensure that the sample line is not contaminated by dirty, wet, or incompatible materials. All tubing should be constructed of Teflon®, 316 stainless steel, borosilicate glass, or similar tubing with an OD of 1/4-inch and a minimum ID of 1/8-inch. The length of the tubing should be less than 10 feet.

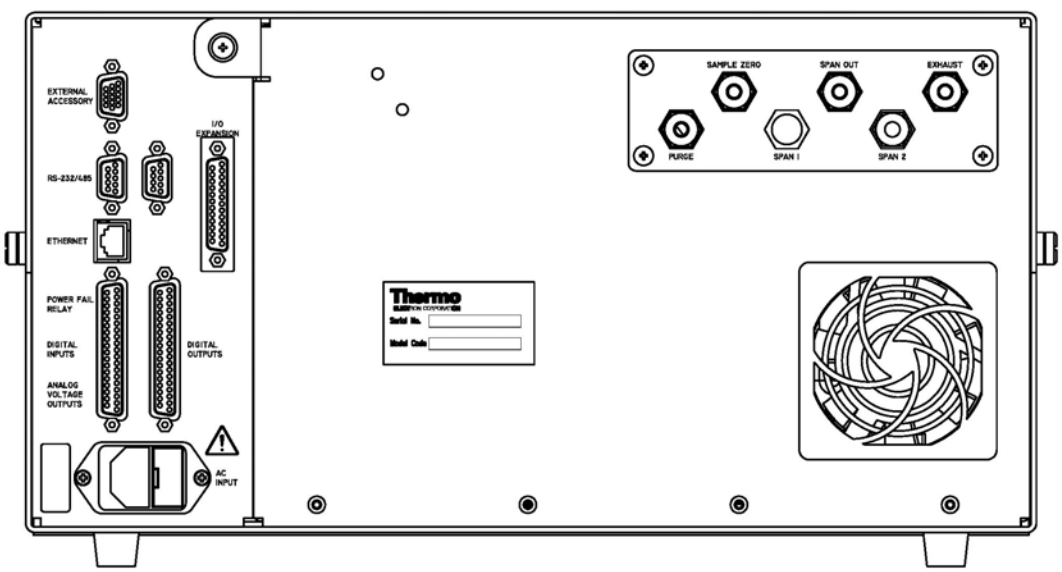


Figure 2–3. Model 48*i* Trace Level-Enhanced Rear Panel

Note Gas must be delivered to the instrument free of particulates. It may be necessary to use the Teflon particulate filter as described in "Teflon Particulate Filter" on page 9-1. ▲

Note Gas must be delivered to the instrument at atmospheric pressure. It may be necessary to use an atmospheric bypass plumbing arrangement as shown in Figure 2–4 if gas pressure is greater than atmospheric pressure. ▲

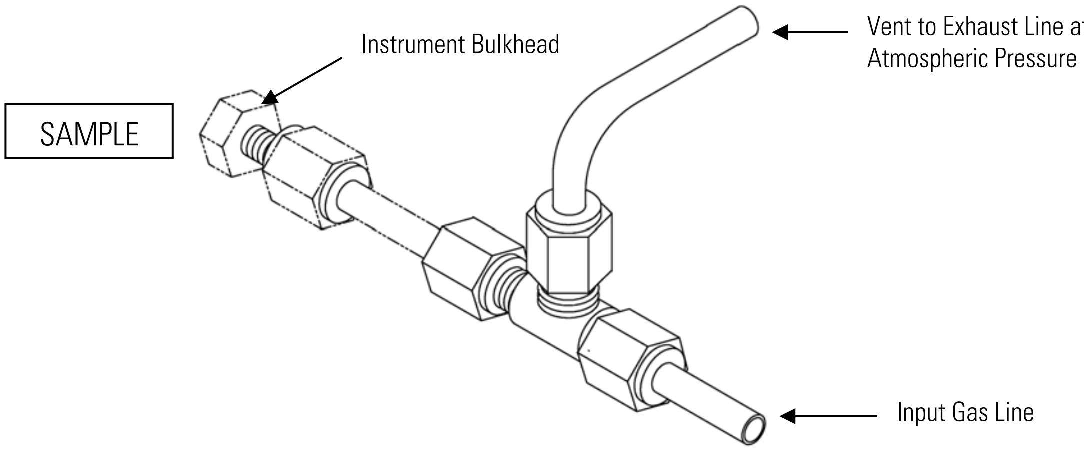


Figure 2–4. Atmospheric Dump Bypass Plumbing

2. 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.

3. Connect a source of CO span gas to the SPAN bulkhead. The span gas should contain CO in balance air, with the CO concentration similar to that of the sample.

   A constant filter wheel purge flow of approximately 140 cc/minute is recommended for optimum performance. This is produced by feeding a purge gas to the rear panel bulkhead at a constant pressure of 15 psig. A 0.006” glass capillary, mounted inside the capillary housing on the rear panel of the instrument will deliver the required 140 cc/minute purge flow. Flows greater than this are not recommended due to unstable cooling effects on the IR source.

   The stability of the purge gas is very important. Since this gas is in the same optical path as the sample, changes in the composition of the purge gas can change the calibration of the instrument. Therefore, either zero air or a non-toxic dry inert gas, such as nitrogen, is recommended for use in this option. Other than the effect of the purge gas, operation and calibration of the instrument is not affected by the addition of the purge housing.

4. 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 2-5

"External Device Connection Components" on page 7-5

"Terminal Block and Cable Kits" on page 9-1

"Instrument Controls Menu" on page 3-23

For detailed information about troubleshooting a connection, refer to "Analog Output Testing" on page 7-27.

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

WARNING The Model 48*i* Trace Level-Enhanced is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated. ▲

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 7-5.

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 2–5 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.

Note All of the I/O available in the instrument are not brought out on this terminal board, if more I/O is desired, an alternative means of connection is required. ▲

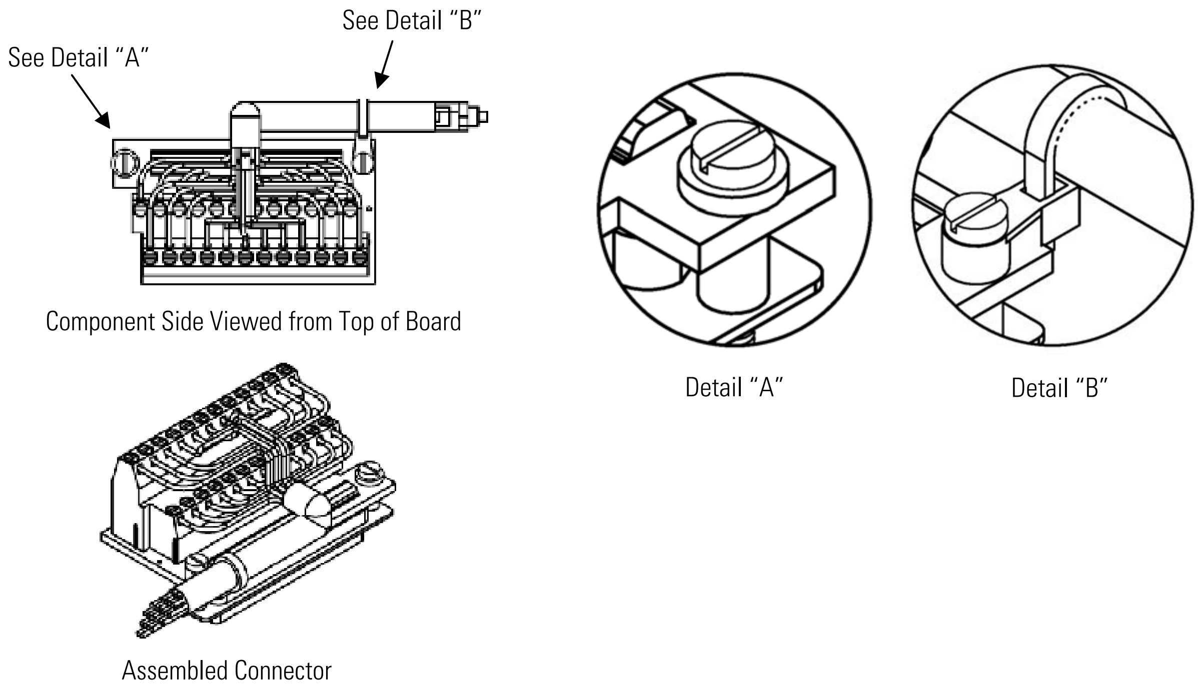


Figure 2–5. I/O Terminal Board Views

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 2–6 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.

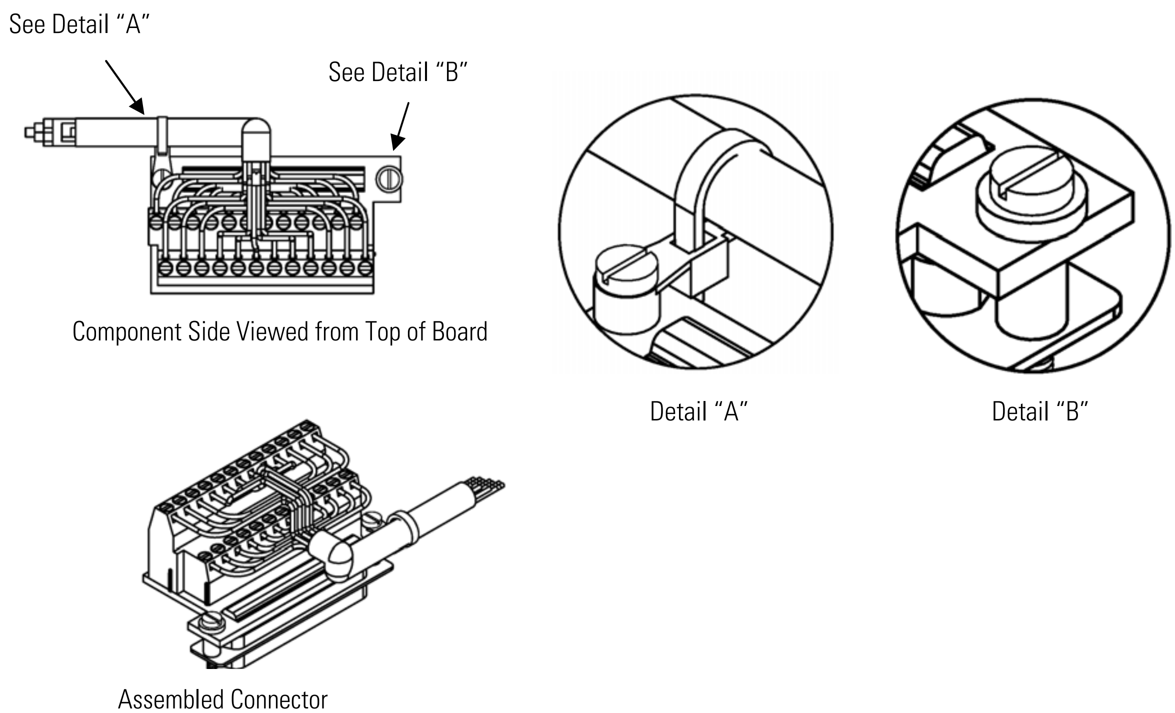


Figure 2–6. D/O Terminal Board Views

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.

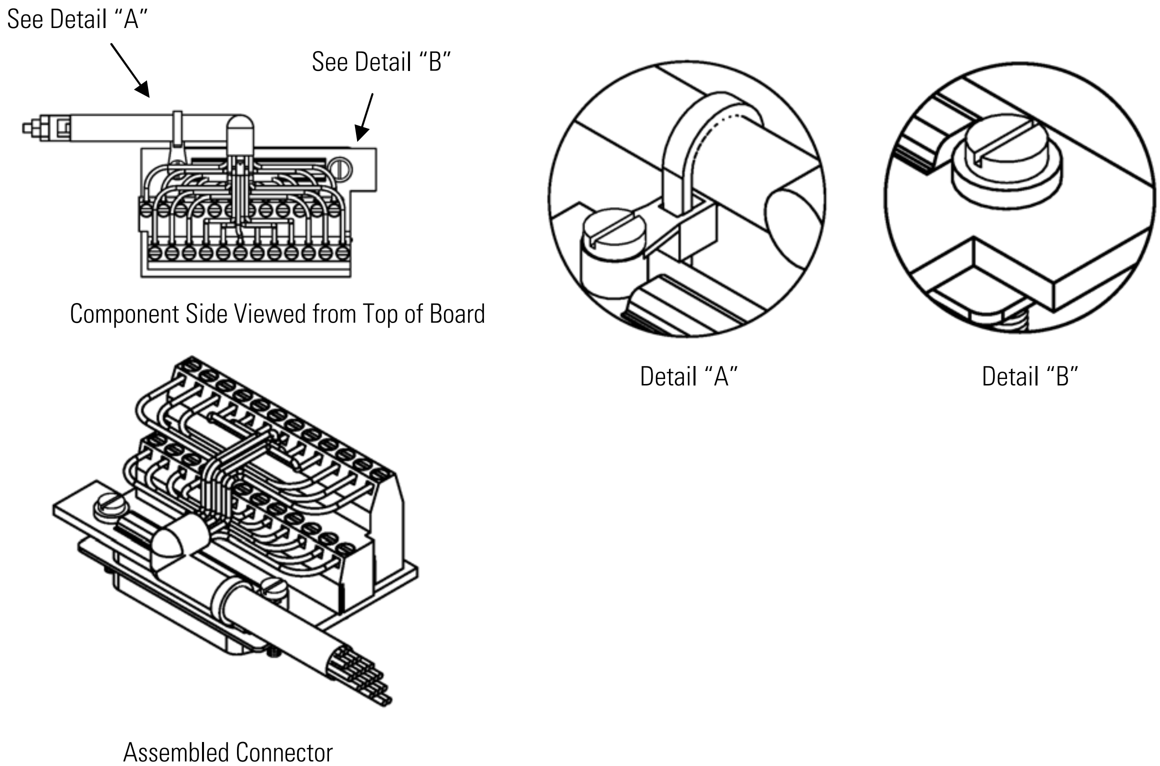


Figure 2–7. 25-Pin Terminal Board Views

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

Pin	Signal Description	Pin	Signal Description
1	IOut1	13	Analog_In1
2	Isolated ground	14	Analog_In2
3	IOut2	15	Analog_In3
4	Isolated ground	16	GNDD
5	IOut3	17	Analog_In4
6	Isolated ground	18	Analog_In5
7	IOut4	19	Analog_In6
8	Isolated ground	20	GNDD
9	IOut5	21	Analog_In7
10	Isolated ground	22	Analog_In8
11	IOut6	23	GNDD
12	Isolated ground	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 operating ranges and averaging times to appropriate settings. For more information about instrument parameters, see the "Operation" chapter.

4. Before beginning the actual monitoring, perform a multipoint calibration as described in the "Calibration" chapter.

Chapter 3
Operation

This chapter describes the 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.

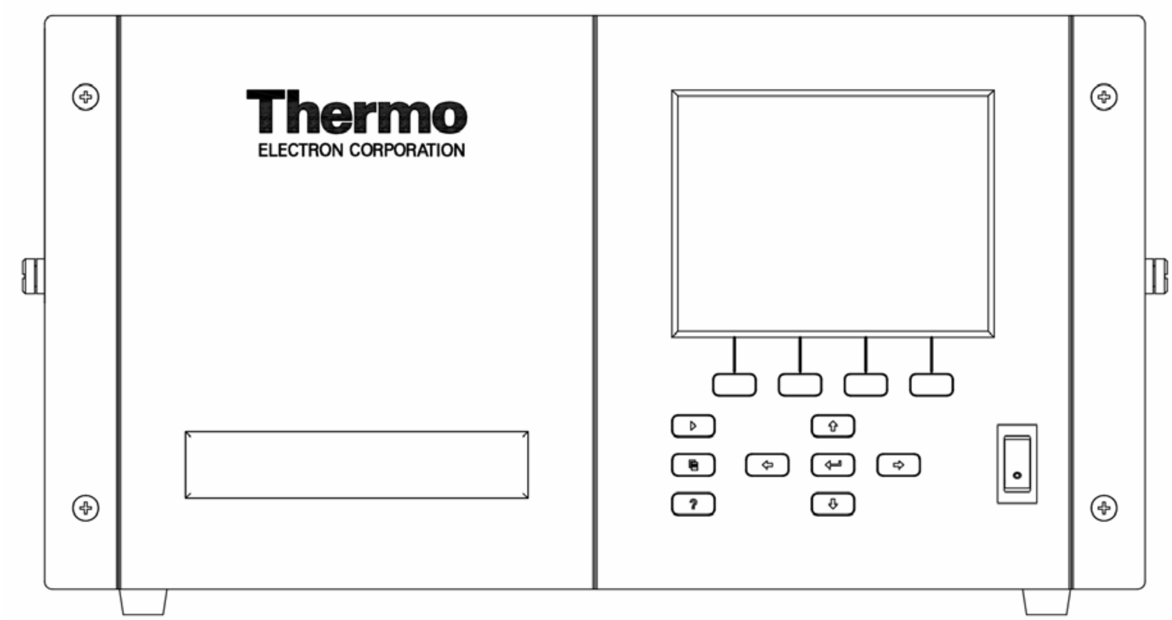


Figure 3–1. Front Panel Display

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.

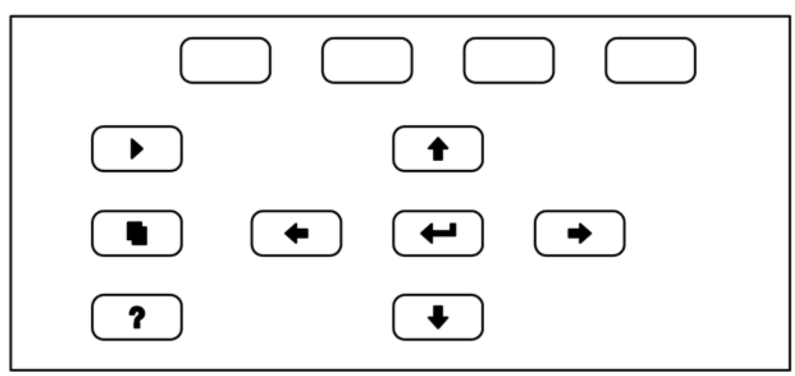


Figure 3–2. Front Panel Pushbuttons

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 CO concentration.
[■] = 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. ▲

Software Overview

The Model 48*i* Trace Level-Enhanced 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 each time the instrument is turned on. This screen is displayed while the instrument is warming up and performing self-checks. After the warm-up period, the Run screen is automatically displayed. The Run screen is the normal operating screen. It displays the CO concentration, depending on operating mode. 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 settings. This chapter describes each submenu and screen in detail. Refer to the appropriate sections for more information.

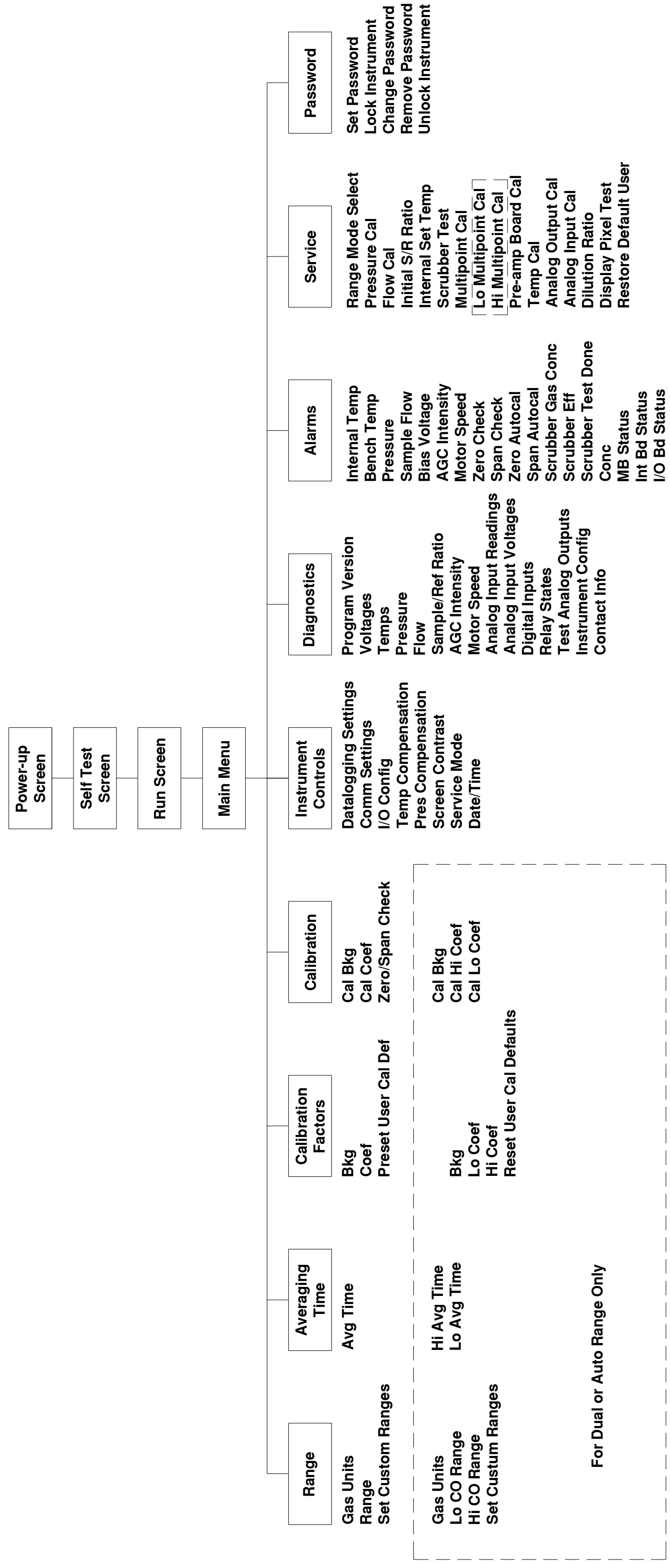
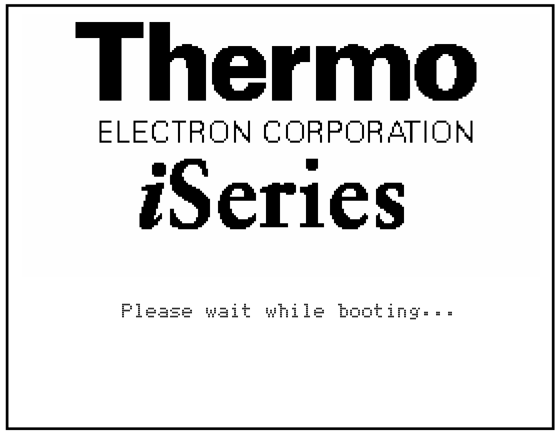


Figure 3–3. Flowchart of Menu-Driven Software

Power-Up Screen

The Power-Up screen is displayed on power up of the Model 48*i* Trace Level-Enhanced. The Self-Test is displayed while the internal components are warming up and diagnostic checks are performed.



Run Screen

The Run screen displays the CO concentration. The status bar displays zero/span sample solenoid valves, time, and alarm status. The word "SAMPLE" on the display indicates the analyzer is in "SAMPLE" mode. Other modes appear in the same area of the display as "ZERO" or "SPAN".

When operating in dual or auto range mode two sets of coefficients are used to calculate the CO "High" and "Low" concentrations. Also, two averaging times are used—one for each range. The title bar indicates which range concentrations are displayed. The words "LOW RANGE CONCENTRATION" on the top of the display indicates that the low concentration is displayed. In dual range mode, pressing the ↑ and ↓ arrows will toggle between high and low concentrations. The example below shows the Run screen in single range mode.

```
      CONCENTRATION

CO             25.5 PPM

 SAMPLE    12:34     ALARM
 RANGE   AVG   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 concentration appears above the main menu and submenus in every screen. 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 Main Menu or ▶ to return to the Run screen.

```
      CONCENTRATION
 CO             15.8 PPM
 SAMPLE    12:34     ALARM
MAIN MENU:
>RANGE
 AVERAGING TIME
 CALIBRATION FACTORS
 CALIBRATION
 INSTRUMENT CONTROLS
 DIAGNOSTICS
 ALARMS                    ↓
 RANGE   AVG   DIAGS  ALARM

 SERVICE
 PASSWORD
```

Range Menu

The Range menu allows the operator to select the gas units, CO ranges, and to set the custom ranges. The screens below show the range menu in single range mode and dual/auto range modes. The only difference between the screens are the words "HI" and "LO" to indicate which range is displayed. For more information about the single, dual and auto range modes, see "Single Range Mode", "Dual Range Mode", and "Auto Range Mode" below.

- In the Main Menu, choose **Range**

```
RANGE:
>GAS UNITS               PPM
 RANGE                    50
 SET CUSTOM RANGES



 RANGE   AVG   DIAGS ALARM
```

```
RANGE:
>GAS UNITS               PPM
 LO RANGE                 50
 HI RANGE                100
 SET CUSTOM RANGES



 RANGE   AVG   DIAGS ALARM
```

Single Range Mode

In the single range mode, there is one range, one averaging time, and one span coefficient.

By default, the two CO analog outputs are arranged on the rear panel connector as shown in Figure 3–4. See Table 3–2 for channels and pin connections. Single range mode may be selected from the "Range Mode Select" on page 3-71.

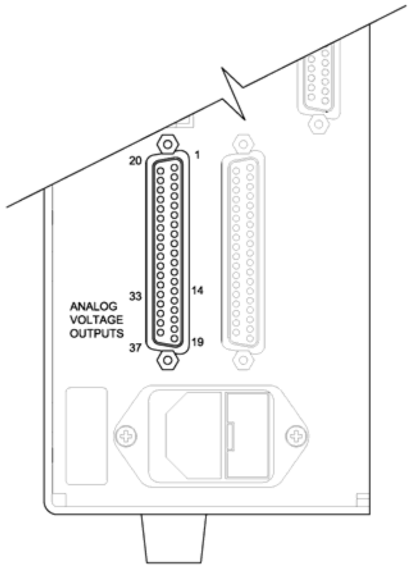


Figure 3–4. Pin-Out of Rear Panel Connector in Single Range Mode

Table 3–2. Default Analog Outputs in Single Range Mode

Channel	Connector Pin	I/O Terminal Pin	Description
1	14	1	CO Analog Output
2	33	3	CO Analog Output
3	15	5	None
4	34	7	None
5	17	9	None
6	36	11	None
Ground	16, 18, 19, 35, 37	2, 4, 6, 8, 10, 12	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. ▲

Dual Range Mode

In the dual range mode, there are two independent analog outputs. These are labeled simply as the "High Range" and the "Low Range". Each channel has its own analog output range, averaging time, and span coefficient.

This enables the sample concentration reading to be sent to the analog outputs at two different ranges. For example, the low CO analog output can be set to output concentrations from 0 to 50 ppm and the high CO analog output set to output concentrations from 0 to 100 ppm.

In addition, each CO analog output has a span coefficient. There are two span coefficients so that each range can be calibrated separately. This is necessary if the two ranges are not close to one another. For example, the low CO range is set to 0–50 ppm and the high CO range is set to 0–1000 ppm.

By default, in the dual range mode, the analog outputs are arranged on the rear panel connector as shown in Figure 3–5. See Table 3–3 for channels and pin connections. Dual range mode may be selected from the "Range Mode Select" on page 3-71.

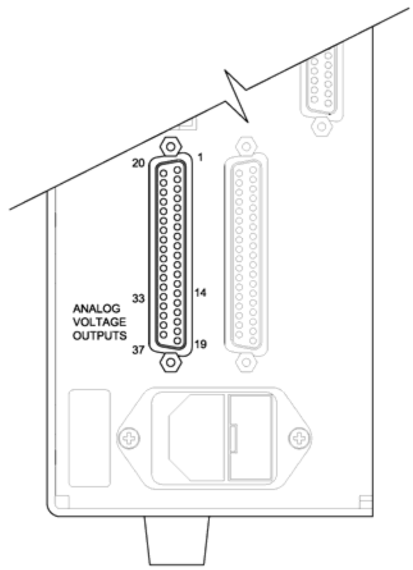


Figure 3–5. Pin-Out of Rear Panel Connector in Dual Range Mode

Table 3–3. Default Analog Outputs in Dual Range Mode

Channel	Connector Pin	I/O Terminal Pin	Description
1	14	1	CO High Range
2	33	3	CO Low Range
3	15	5	None
4	34	7	None
5	17	9	None
6	36	11	None
Ground	16, 18, 19, 35, 37	2, 4, 6, 8, 10, 12	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. ▲

Auto Range Mode

The auto range mode switches the CO analog outputs between high and low ranges, depending on the concentration level. The high and low ranges are defined in the Range menu.

For example, suppose the low range is set to 50 ppm and the high range is set to 100 ppm (Figure 3–6). Sample concentrations below 50 ppm are output based on low range selection and sample concentrations above 50 ppm are output based on high range selection. When the low range is active, the status output is at 0 volts. When the high range is active, the status output is at half of full-scale.

When the high range is active, the concentration must drop to 95% of the low CO range for the low range to become active.

In addition, each CO analog output has a span coefficient. There are two span coefficients so that each range can be calibrated separately. This is necessary if the two ranges are not close to one another. For example, the low CO range is set to 0–50 ppm and the high CO range is set to 0–1000 ppm.

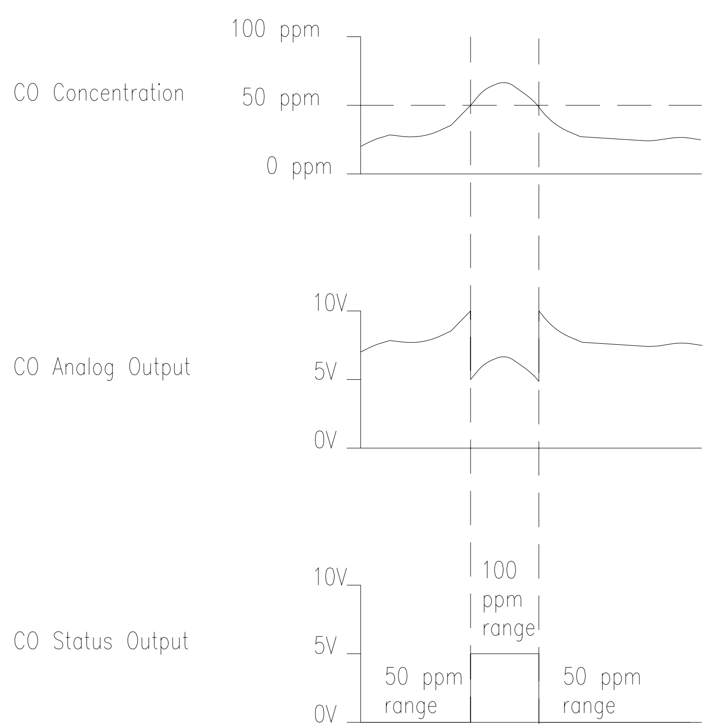


Figure 3–6. Analog Output in Auto Range Mode

By default, in the auto range mode, the analog outputs are arranged on the rear panel connector as shown in Figure 3–7. See Table 3–4 for channels and pin connections. Auto range mode may be selected from the "Range Mode Select" on page 3-71.

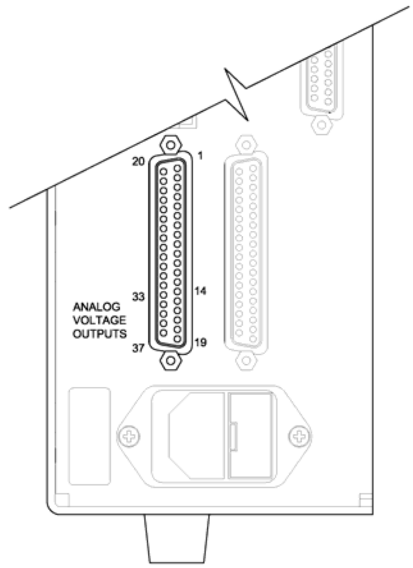


Figure 3–7. Pin-Out of Rear Connector in Auto Range Mode

Table 3–4. Default Analog Outputs in Auto Range Mode

Channel	Connector Pin	I/O Terminal Pin	Description
1	14	1	CO Analog Output
2	33	3	Range Status: half-scale = high range zero scale = low range
3	15	5	None
4	34	7	None
5	17	9	None
6	36	11	None
Ground	16, 18, 19, 35, 37	2, 4, 6, 8, 10, 12	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. ▲

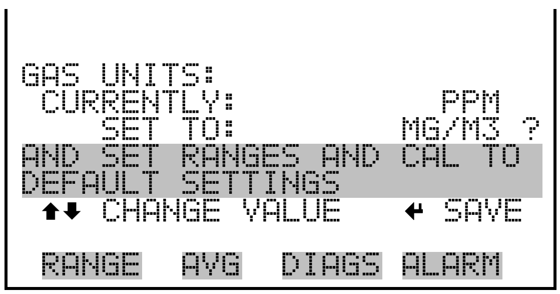
Gas Units

The Gas Units screen defines how the CO concentration readings are expressed. Gas units of parts per million (ppm) and milligrams per cubic meter (mg/m^3) are available. The mg/m^3 gas concentration mode is calculated using a standard pressure of 760 mmHg and a standard temperature of 20 °C.

When switching from ppm to mg/m^3, the analog ranges all default to the highest range in that mode. For example, when switching from mg/m^3 to ppm, all the ranges default to 1000 ppm. Therefore, whenever you change units, you should also check the range settings.

- In the Main Menu, choose Range > **Gas Units**.

Note If the units change from ppm to mg/m^3 or vice versa, the instrument should be re-calibrated, particularly if the user's standard temperature is different from 20 °C. A display warning will appear that ranges will be defaulted and calibration parameters reset. ▲



CO Range

The CO Range screen defines the concentration range of the analog outputs. For example, a CO range of 0–50 ppm restricts the analog output to concentrations between 0 and 50 ppm.

The display shows the current CO range. The next line of the display is used to change the range. The range screen is similar for the single, dual, and auto range modes. The only difference between the screens are the words "High" or "Low" displayed to indicate which range is displayed. The example below shows the CO range screen in single mode. For more information about the dual and auto range modes, see "Single Range Mode", "Dual Range Mode", and "Auto Range Mode" earlier in this chapter.

Table 3–5 lists the available standard ranges.

- In the Main Menu, choose Range > **Range**.

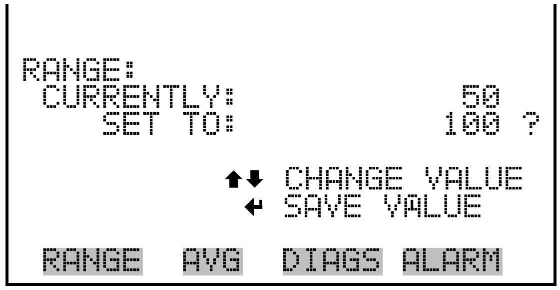


Table 3–5. Available Operating Ranges

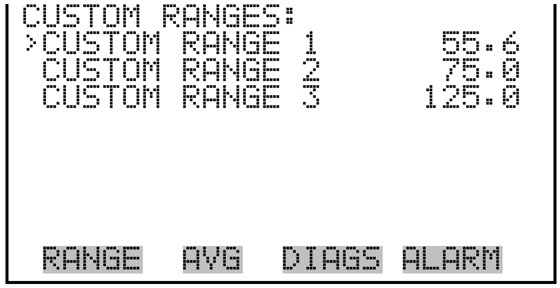
ppm	mgm³
1	1
2	2
5	5
10	10
20	20
50	50
100	100
200	200
500	500
1000	1000
C1	C1
C2	C2
C3	C3

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

Set Custom Ranges

The Custom Ranges Menu lists three custom ranges: C1, C2, and C3. Custom ranges are user-defined ranges. In the ppm or mg/m³ mode, any value between 1 and 1000 ppm can be specified as a range.

- In the Main Menu, choose Range > **Set Custom Ranges**.

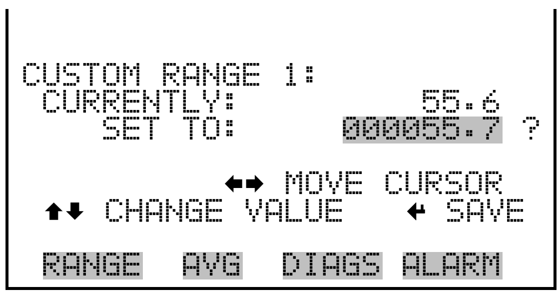


Custom Ranges

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 CO Ranges screen. For more information about selecting ranges, see "CO Range" above.

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

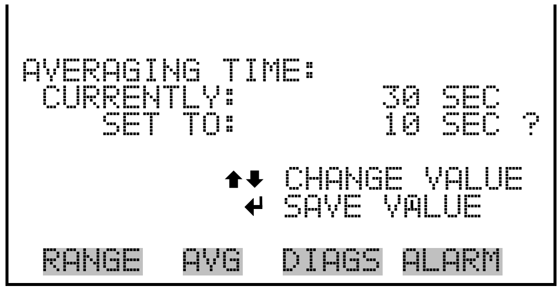


Averaging Time

The Averaging Time defines a time period (1 to 300 seconds) during which CO measurements are taken. The average concentration of the readings are calculated for that time period. The front panel display and analog outputs are updated every 10 seconds for averaging times between 10 and 300 seconds. For averaging times of 1, 2, and 5 seconds, the front panel display and analog outputs are updated every second. An averaging time of 10 seconds, for example, means that the average concentration of the last 10 seconds will be output at each update. An averaging time of 300 seconds means that the moving average concentration of the last 300 seconds will be output at each update. Therefore, the lower the averaging time the faster the front panel display and analog outputs respond to concentration changes. Longer averaging times are typically used to smooth output data.

The Averaging Time screen for the single range mode is shown below. In the dual and auto range modes, an Averaging Time Menu is displayed before the averaging time screens. This menu is needed because the dual and auto range modes have two averaging times (high and low). The Averaging Time screen functions the same way in the single, dual, and auto range modes. The following averaging times are available: 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds.

- In the Main Menu, choose **Averaging Time**.



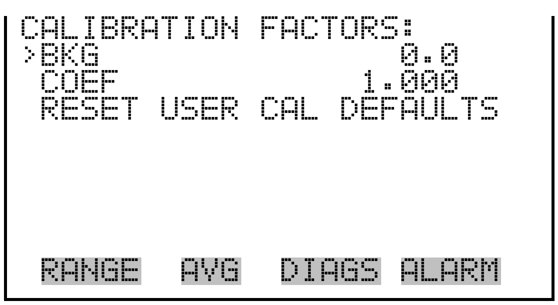
Calibration Factors Menu

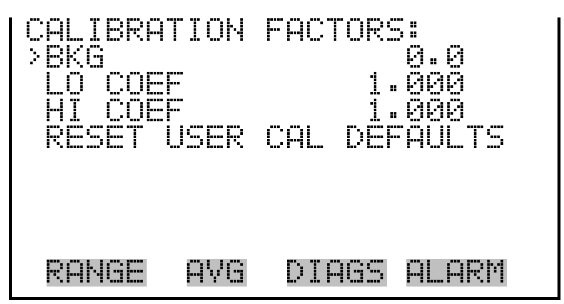
Calibration factors are used to correct the CO concentration readings that the instrument generates using its own internal calibration data. The Calibration Factors menu displays the calibration factors. The screens below show the calibration factors menu in single mode and dual/auto range modes. The only difference between the screens are the words “LO” and “HI” to indicate which range is displayed.

Normally, the instrument is calibrated automatically using the Calibration menu described in “Calibration Menu” later in this chapter. However, the instrument can also be calibrated manually using the Calibration Factors menu.

To manually calibrate the instrument, see “CO Background” and “CO Coefficient” below for more information.

- In the Main Menu, choose **Calibration Factors**.





CO Background

The CO background correction is determined during zero calibration. The CO background is the amount of signal read by the analyzer while sampling zero air. The background signal is electrical noise. Before the analyzer sets the CO reading to zero, it stores this value as the CO background correction.

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

In the example below, the analyzer is reading 1.4 ppm of CO while sampling zero air. The CO background correction is 0.0 ppm. That is, the analyzer is not applying a zero background correction. The question mark is used as a prompt to change the background correction. In this case the background correction must be increased to 1.4 ppm in order for the CO reading to be at 0 ppm.

To set the CO reading in the example below to zero, use ↑ to increment the CO background correction to 1.4 ppm. As the CO background correction is increased, the CO concentration is decreased. At this point, however, no real changes have been made. To escape this screen without making any changes, press ■ to return to the Calibration Factors menu or ▶ to return to the Run screen. Press ↵ to actually set the CO reading to 0 ppm and store the background correction of 1.4 ppm.

- In the Main Menu, choose Calibration Factors > **Bkg**.

```
CO BACKGROUND:
          CO:         1.4
 SET BKG TO:          0.0

             ↑↓ INC/DEC
              ↵ SAVE VALUE

 RANGE  AVG  DIAGS ALARM
```

CO Coefficient

The CO span coefficient is usually calculated by the instrument processor during calibration. The span coefficients are used to correct the CO readings and normally has a value near 1.000.

The CO Coefficient screen enables the CO span coefficient to be manually changed while sampling span gas of known concentration.

The display shows the current CO concentration reading. The next line of the display shows the CO span coefficient that is stored in memory and is being used to correct the CO concentration. Notice that as the span coefficient value is changed, the current CO concentration reading above also changes. However, no real changes are made until ↵ is pressed. Only proposed changes, as indicated by a question mark prompt, are displayed until ↵ is pressed.

In dual or auto range modes, “HIGH” or “LOW” is displayed to indicate the calibration of the high or low coefficient.

The example below shows the coefficient screen in dual/auto range mode.

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). ▲

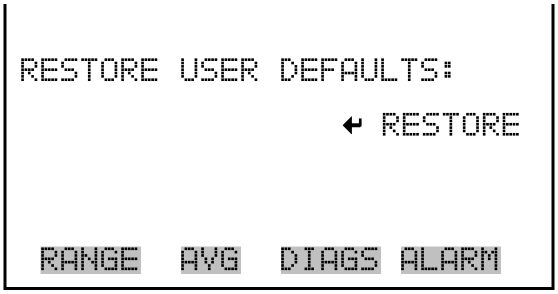
- In the Main Menu, choose Calibration Factors > **Hi Coef**.

```
HIGH CO COEFFICIENT:
     HIGH CO:        51.4
 SET COEF TO:       1.000

            ↑↓ INC/DEC
             ↵ SAVE VALUE
 RANGE  AVG  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 Service > Calibration Factors > **Reset User Cal Defaults**.



Calibration Menu

The Calibration menu is used to calibrate zero and span. The calibration menu is similar for the single, dual, and auto range mode as shown below. The only difference between the screens are the words "HI" and "LO" to indicate which range is displayed. The dual and auto range modes have two CO span factors (high and low). This allows each range to be calibrated separately. This is necessary if the two ranges used are not close to one another. For example, a low CO range of 50 ppm and a high CO range of 1000 ppm. For more information about calibration, see Chapter 4, "Calibration".

- In the Main Menu, choose **Calibration**.

Calibrate CO Background

The Calibrate CO Background screen is used to adjust the CO 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. For more information about calibration, see Chapter 4, "Calibration".

- In the Main Menu, choose Calibration > **Cal CO Background**.

```
CO BACKGROUND:
        CO:              1.4
 CURRENTLY:              0.0 ?

        ↵ SET CO TO ZERO

 RANGE  AVG  DIAGS ALARM
```

Calibrate CO Coefficient

The Calibrate CO Coefficient screen is used to adjust the CO coefficient and enter the span concentration. The display shows the current CO concentration reading. The next line of the display is where the CO calibration gas concentration is entered.

The CO span coefficient is calculated, stored, and used to correct the current CO reading. For more information about calibration, see Chapter 4, "Calibration". In dual or auto range modes, "HIGH" or "LOW" is displayed to indicate the calibration of the high or low coefficient.

- In the Main Menu, choose Calibration > **Cal Coefficient**.

```
CALIBRATE CO:
        CO:             79.1
 SPAN CONC:       000080.0 ?

           ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE
 RANGE  AVG  DIAGS ALARM
```

Zero/Span Check

The Zero/Span Check menu is used to program the instrument to perform fully automated zero and span checks or adjustments. Total Duration Hour is the sum of zero, span, and purge duration minutes. Zero and Span Calibration Reset are toggle items that change between yes or no when selected, and displayed if auto calibration is installed.

- In the Main Menu, choose Calibration > **Zero/Span Check**.

```
ZERO/SPAN CHECK:
>NEXT TIME 01Jan05 12:00
 PERIOD HR              24
 TOTAL DURATION HR     2.5
 ZERO DURATION MIN      30
 SPAN DURATION MIN      30
 PURGE DURATION MIN     30
 ZERO/SPAN AVG SEC      60 ↓

 RANGE  AVG  DIAGS ALARM

 ZERO CAL RESET         ON
 SPAN CAL RESET        OFF
 ZERO/SPAN RATIO         1
```

Next Time The Next Time screen is used to view and set the next zero/span check date and time. Once the initial zero/span check is performed, the date and time of the next zero/span check is calculated and displayed.

- In the Main Menu, choose Calibration > Zero/Span Check > **Next Time**.

```
NEXT DATE AND TIME:
19 MAR 2005  12:34
PRESS ← TO EDIT



 RANGE  AVG  DIAGS ALARM
```

```
NEXT DATE AND TIME:
 19 MAR 2005  12:34:56

 SETTING: DAYS
            → SET MONTHS
           ↑↓ CHANGE VALUE
            ↵ SAVE VALUE
 RANGE  AVG  DIAGS ALARM
```

Period Hours The Zero/Span Period Hours screen defines the period or interval between zero/span checks. Periods between 0 and 999 hours are acceptable. To turn the zero/span check off, set the period to 0.

- In the Main Menu, choose Calibration > Zero/Span Check > **Period Hours**.

```
ZERO/SPAN PERIOD:
 CURRENTLY:      024 HRS
    SET TO:      025 HRS ?

          ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Zero/Span/Purge Duration Minutes

The Zero Duration Minutes screen defines how long zero air is sampled by the instrument. The span and purge duration screens look and function the same way as the zero duration screen, and are used to set how long the span gas and sample gas are sampled by the instrument. Durations between 0 and 60 minutes are acceptable. Each time a zero/span check occurs the zero check is done first, followed by the span check. To perform just a zero check, set the span and purge duration screens to 0 (off). The same applies to perform just a span or purge check.

- In the Main Menu, choose Calibration > Zero/Span Check > **Zero, Span** or **Purge Duration Min**.

```
ZERO DURATION:
 CURRENTLY:       30 MIN
    SET TO:       31 MIN ?

          ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Zero/Span Averaging Time

The Zero/Span Averaging Time screen allows the user to adjust the zero/span averaging time. The zero/span averaging time is used by the analyzer only when performing an automatic zero or span check or calibration. The analyzer's averaging time is used for all other functions. The following averaging times are available: 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds.

- In the Main Menu, choose Calibration > Zero/Span Check > **Zero/Span Avg Sec**.

```
ZERO/SPAN AVERAGING TIME:
  CURRENTLY:        60 SEC
     SET TO:        90 SEC ?

             ↑↓ CHANGE VALUE
              ↵ SAVE VALUE

  RANGE   AVG   DIAGS ALARM
```

Zero/Span Ratio

The Zero/Span Ratio screen is used to adjust the ratio of zeros to spans. For example, if this value is set to 1, a span check will follow every zero check. If this value is set to 3, there will be two zero checks between each zero/span check. This value may be set from 1 to 10, with 1 as default.

- In the Main Menu, choose Calibration > Zero/Span Check > **Zero/Span Ratio**.

```
ZERO/SPAN RATIO:
  CURRENTLY:          1:1
     SET TO:          2:1 ?

             ↑↓ CHANGE VALUE
              ↵ SAVE VALUE

  RANGE   AVG   DIAGS ALARM
```

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

  RANGE   AVG   DIAGS ALARM

  DATE/TIME
```

Datalogging Settings

The Datalogging Settings menu deals with datalogging.

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

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

 RANGE  AVG  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

 RANGE  AVG  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
 RANGE  AVG  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:
                  0000000
TOTAL LRECS:           20

           ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE
 RANGE  AVG  DIAGS ALARM
```

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

```
 time    date    flags
 10:01  06/20/05 FC0088900
 10:02  06/20/05 FC0088900
 10:03  06/20/05 FC0088900
 10:04  06/20/05 FC0088900
  ↑↓ PGUP/DN   ←→ PAN L/R
 RANGE  AVG  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

 RANGE  AVG  DIAGS ALARM
```

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

```
 time    date   flags
 10:01 06/20/05 FC0088900
 10:02 06/20/05 FC0088900
 10:03 06/20/05 FC0088900
 10:04 06/20/05 FC0088900
  ↑↓ PGUP/DN   ←→ PAN L/R
 RANGE  AVG  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



 RANGE  AVG  DIAGS ALARM
```

```
ERASE LREC LOG FILE DATA?
                ↵ ERASE
ARE YOU SURE YOU WANT TO?
PRESS → TO CONFIRM ERASURE

 RANGE  AVG  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              CO
 FIELD 2            HICO
 FIELD 3            INTT
 FIELD 4             CHT
 FIELD 5            PRES
 FIELD 6          SMPLFL
 FIELD 7            NONE ↓

 RANGE  AVG  DIAGS ALARM
```

Choose Item Type

The Choose Item Type submenu displays a list of data that can be loggd for the current field. Choices are Concentrations, Other Measurements, and Analog Inputs (if the I/O expansion board is installed).

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content > **Field 1-32**.

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




 RANGE  AVG  DIAGS ALARM
```

Note The ANALOG INPUTS item is only displayed if the I/O Expansion Board option is installed. ▲

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. Range status is visible only in auto range mode.

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

```
CONCENTRATIONS:
>NONE
 CO                     <--
 LO CO
 HI CO
 RANGE STATUS


 RANGE  AVG  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.

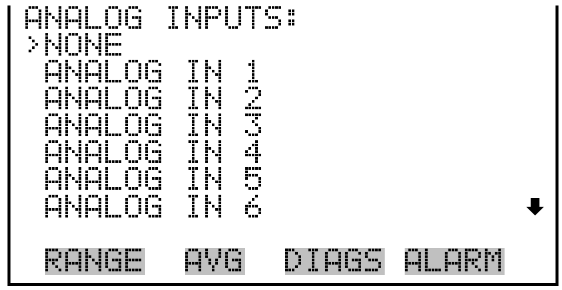
- In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content > Select Field > **Other Measurements**.

```
OTHER MEASUREMENTS:
>NONE
 S/R
 LO S/R
 HI S/R
 INT TEMP
 BENCH TEMP
 BENCH PRES             ↓
 RANGE  AVG  DIAGS ALARM

 SAMPLE FLOW
 INTENSITY
 MOTOR SPEED
 BIAS SUPPLY
 SCRUBBER EFF
```

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**.



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**.

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

 RANGE   AVG   DIAGS ALARM
```

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

 RANGE   AVG   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

 RANGE   AVG   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).

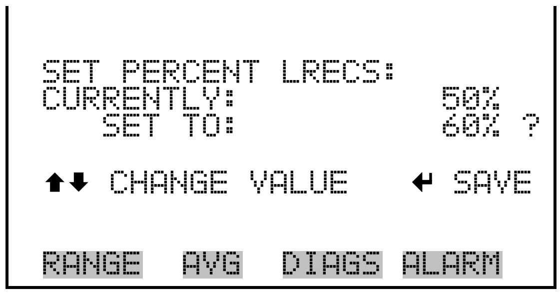
- In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > **Logging Period Min**.

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

 ⬆⬇ CHANGE VALUE    ↵ SAVE

 RANGE   AVG   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.

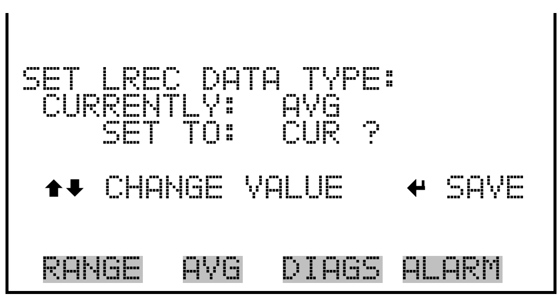
- In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > **Memory Allocation %**.



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 measured during the interval, or the current value (last value measured). 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**.



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

 RANGE   AVG   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
 RANGE   AVG   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 instrument are connected to one computer. Valid Instrument ID numbers are from 0 to 127. The Model 48*i* Trace Level-Enhanced has a default Instrument ID of 48. 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:           48
    SET TO:           50 ?

           ↑↓ CHANGE VALUE
            ↵ SAVE VALUE

 RANGE  AVG  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

 RANGE  AVG  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).

Note Add Labels and Prepend Timestamp are toggle items that change between yes or o when selected. ▲

- 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              HICO
 ITEM 2              INTT
 ITEM 3               CHT
 ITEM 4              NONE ↓

 RANGE  AVG  DIAGS ALARM
```

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




 RANGE  AVG  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

 RANGE  AVG  DIAGS ALARM
```

Choose Item Signal

The Choose Signal screen displays a submenu of the analog output signal group choices. Group choices are Concentrations, Other Measurements, and Analog Inputs (if the I/O expansion board is installed).

- In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > **Item 1-8**.

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



 RANGE  AVG  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 dual or auto range mode, "HI" or "LO" is displayed to indicate high or low concentrations. Range Status is also visible in auto range mode.

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

```
CONCENTRATIONS:
>NONE
 CO                 <--



 RANGE  AVG  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 dual or auto range mode, "HI" or "LO" is displayed to indicate high or low range concentrations.

- In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > Select Item > **Other Measurements**.

```
OTHER MEASUREMENTS:
>NONE
 S/R
 INT TEMP
 BENCH TEMP
 BENCH PRES
 SAMPLE FLOW
 INTENSITY                   ↓
 RANGE  AVG  DIAGS ALARM

 MOTOR SPEED
 BIAS SUPPLY
 SCRUBBER EFF
```

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                 ↓
 RANGE  AVG  DIAGS ALARM

 ANALOG IN 7
 ANALOG IN 8
```

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.

Equipment Damage 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

 RANGE  AVG  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

 RANGE  AVG  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      192.168.1.1
 HOST NAME        iSeries


 RANGE  AVG  DIAGS ALARM
```

Use DHCP

The Use DHCP screen is used to specify whether to use DHCP or not. When DHCP is enabled, the network dynamically provides an IP address for the instrument. The instrument's power must be cycled for a change to this parameter to take affect.

- 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

 RANGE  AVG  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: 192.168.1.200
  SET TO: 192.168.1.200 █
          ←→ MOVE CURSOR
          ↑↓ CHANGE VALUE
           ↵ SAVE VALUE

 RANGE  AVG  DIAGS ALARM
```

Netmask The Netmask screen is used to edit the netmask. The netmask is used to determine the subnet for which the instrument can directly communicate to other devices on. The netmask can only be changed when DHCP is OFF. For more information on DHCP, see “Use DHCP” in this chapter.

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

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

 RANGE  AVG  DIAGS ALARM
```

Default Gateway

The Default Gateway screen is used to edit the gateway address. The default gateway can only be changed when DHCP is OFF. For more information on DHCP, see “Use DHCP” in this chapter. Any traffic to addresses that are not on the local subnet will be routed through this address.

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

```
DEFAULT GATEWAY:
 CURRENT: 192.168.1.1
  SET TO: 192.168.1.1
          ←→ MOVE CURSOR
          ↑↓ CHANGE VALUE
           ↵ SAVE VALUE

 RANGE  AVG  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

 RANGE  AVG  DIAGS ALARM
```

I/O Configuration

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

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

Note Analog Input Config is only displayed if the optional I/O Expansion Board is installed. ▲

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

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



 RANGE  AVG  DIAGS ALARM
```

Output Relay Settings

The Output Relay Settings menu displays a list of the 10 digital 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      CONC ALARM
 2   NOP            NONE
 3   NOP           UNITS
 4   NOP       GEN ALARM
 5   NOP            NONE
 6   NOP            NONE
 7   NOP            NONE ↓
 RANGE  AVG  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





 RANGE  AVG  DIAGS ALARM
```

Instrument State

The Instrument State submenu allows the user to select the instrument state that is tied to the selected relay output. A submenu lists signal types of either alarm and 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





 RANGE  AVG  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**.

Note The I/O BD STATUS alarm is only present if the I/O expansion board is installed. ZERO CHK/CAL and SPAN CHK/CAL are only present if autozero/span check is enabled. ▲

```
ALARM STATUS ITEMS:
>NONE
 GEN ALARM
 CONC MAX
 CONC MIN
 INT TEMP
 BENCH TEMP
 PRESSURE                  ↓

 RANGE  AVG  DIAGS ALARM

 SAMPLE FLOW
 INTENSITY
 MOTOR SPEED
 BIAS VOLTAGE
 MB STATUS
 MIB STATUS
 I/O BD STATUS
 CONC ALARM             <--
 ZERO CHK/CAL
 SPAN CHK/CAL
```

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.

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

```
NON ALARM STATUS ITEMS:
>NONE
 AUTORANGE
 LOCAL/REMOTE
 SERVICE
 UNITS
 ZERO MODE
 SPAN MODE                   ↓

 RANGE  AVG  DIAGS ALARM

 SAMPLE MODE
 PURGE MODE
 SCRUB TST MODE
```

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   SET BACKGROUND
 2   NOP CAL TO  LO SPAN
 3   NOP   AOUTS TO ZERO
 4   NOP     AOUTS TO FS
 5   NOP            NONE
 6   NOP            NONE
 7   NOP            NONE ↓

 RANGE  AVG  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

 RANGE  AVG  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**.

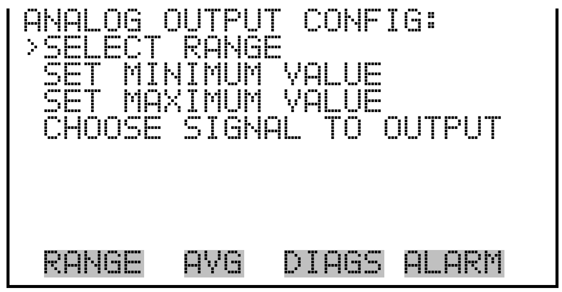
```
CHOOSE ACTION:
>NONE
 ZERO MODE
 SPAN MODE
 SET BACKGROUND       <--
 CAL TO LO SPAN
 AOUTS TO ZERO
 AOUTS TO FS
 RANGE  AVG  DIAGS ALARM

 CAL TO HI SPAN
 SCRUBBER TEST
```

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.

Note The current outputs are displayed only if the I/O expansion board option is installed. ▲

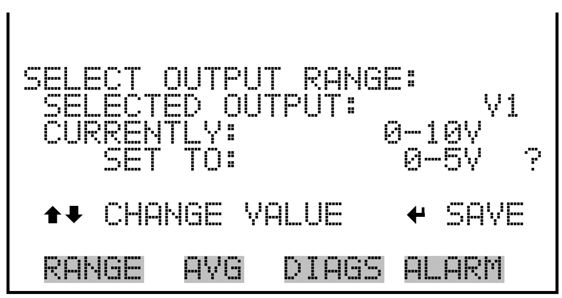
- In the Main Menu, choose Instrument Controls > I/O Configuration > **Analog Output Config**.



Select Output Range

The Select Output Range screen is used to select the hardware range for the selected analog voltage 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**.



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 3–6 for a list of choices. In dual or auto range mode, "HI" or "LO" is displayed to indicate high or low concentrations. Range Status is visible only in auto range mode. 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:     V1
 CURRENTLY:         N/A %
    SET TO:      0000.0 % ?

 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Table 3–6. Analog Output Zero to Full-Scale Table

Output	Zero % Value	Full-Scale 100% Value
CO	Zero (0)	Range Setting
LO CO	Zero (0)	Range Setting
HI CO	Zero (0)	Range Setting
Range Status	Recommend not to change the setting for this output	
Sample/Reference Ratio	0.0	1.2
LO Sample/Reference Ratio	0.0	1.2
HI Sample/Reference Ratio	0.0	1.2
Internal Temperature	User-set alarm min value	User-set alarm max value
Bench Temperature	User-set alarm min value	User-set alarm max value
Bench Pressure	User-set alarm min value	User-set alarm max value
Sample Flow	User-set alarm min value	User-set alarm max value
Intensity	User-set alarm min value	User-set alarm max value
Motor Speed	User-set alarm min value	User-set alarm max value
Bias Supply	User-set alarm min value	User-set alarm max value
Scrubber Efficiency	User-set alarm min value	User-set alarm max value
Everything Else	0 Units	10 Units

Choose Signal To Output

The Choose Signal 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. In dual or auto range mode, “HI” or “LO” is displayed to indicate high or low concentrations. Range Status is visible only in auto range mode. The Concentrations screen is shown below. See Table 3–7 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




 RANGE  AVG  DIAGS ALARM
```

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

 ↑↓ CHANGE VALUE   ↵ SAVE
 RANGE  AVG  DIAGS ALARM
```

Table 3–7. Signal Type Group Choices

Concentrations	Other Measurements	Analog Inputs
None	None	None
CO (single/auto range only)	Sample Reference (single/auto range only)	Analog Input 1
LO CO (dual range only)	LO Sample Reference (dual range only)	Analog Input 2
HI CO (dual range only)	HI Sample Reference (dual range only)	Analog Input 3
Range Status (auto range only)	Internal Temperature	Analog Input 4
	Bench Temperature	Analog Input 5
	Bench Pressure	Analog Input 6
	Sample Flow	Analog Input 7
	Intensity	Analog Input 8

Concentrations	Other Measurements	Analog Inputs
	Motor Speed	
	Bias Supply	
	Scrubber Efficiency	

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 2-10 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 1              IN2
 CHANNEL 1              IN3
 CHANNEL 1              IN4
 CHANNEL 1              IN5
 CHANNEL 1              IN6
 CHANNEL 1              IN7↓

 RANGE  AVG  DIAGS ALARM
```

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

 RANGE  AVG  DIAGS ALARM
```

Descriptor

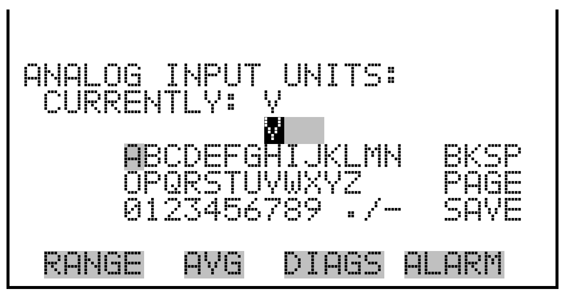
The Descriptor screen allows the user to enter the descriptor for the selected analog input channel. The descriptor is used in datalogging and streaming data to report what data is being sent out. The descriptor may be from 1 to 3 characters in length, and defaults to IN1 to IN8 (user input channel number).

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

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**.



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**.

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
 RANGE  AVG  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






 RANGE  AVG  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

 RANGE  AVG  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:     00000.00

          ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Temperature Compensation

Temperature compensation provides compensation for any changes to the instrument's output signal due to internal instrument temperature variations. The effects of internal instrument temperature changes on the analyzer's subsystems and output have been empirically determined. This empirical data is used to compensate for any changes in temperature.

When temperature compensation is on, the display shows the current internal instrument temperature (measured by a thermistor on the bench). When temperature compensation is off, the display shows the factory standard temperature of 30 °C.

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

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

             ↵ TOGGLE VALUE
 RANGE  AVG  DIAGS ALARM
```

Pressure Compensation

Pressure compensation provides compensation for any changes to the instrument's output signal due to reaction chamber pressure variations. The effects of reaction chamber pressure changes on the analyzer's subsystems and output have been empirically determined. This empirical data is used to compensate for any change in reaction chamber pressure.

When pressure compensation is on, the first line of the display represents the current pressure in the reaction chamber. 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
 RANGE  AVG  DIAGS ALARM
```

Screen Contrast

The Screen Contrast screen is used to change the contrast of the display. Values 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
 RANGE  AVG  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 48*i* Trace Level-Enhanced. 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
 RANGE  AVG  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



 RANGE  AVG  DIAGS ALARM
```

```
DATE AND TIME:
 19 MAR 2005  12:34:56   ?
 SETTING: DAYS
          ➡ SET MONTHS
         ↑↓ CHANGE VALUE
          ↵ SAVE VALUE
 RANGE  AVG  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 VERSIONS
 VOLTAGES
 TEMPERATURES
 PRESSURE
 FLOW
 SAMPLE/REF RATIO
 AGC INTENSITY            ↓

 RANGE  AVG  DIAGS ALARM

 MOTOR SPEED
 ANALOG INPUT READINGS
 ANALOG INPUT VOLTAGES
 DIGITAL INPUTS
 RELAY 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 and program version numbers.

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

```
PROGRAM VERSIONS:
   PRODUCT:  MODEL 48iTLE
   VERSION:  01.02.12.095
  FIRMWARE:       09.06.19

 RANGE   AVG   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

 RANGE   AVG   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

 RANGE   AVG   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
   24.0 SUPPLY       24.1 V
  -15.0 SUPPLY      -15.0 V
   18.0 IR SUPPLY    18.0 V
   18.0 MOT SUPPLY   18.0 V↓

 RANGE  AVG  DIAGS ALARM
```

```
 BIAS SUPPLY     -110.0 V
```

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
   24.0 SUPPLY       24.0 V
   -3.3 SUPPLY       -3.3 V



 RANGE  AVG  DIAGS ALARM
```

Temperatures

The Temperatures screen (read only) displays the current internal instrument temperature and bench temperature. The internal temperature is the air temperature measured by a sensor located on the interface board.

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

```
TEMPERATURES:
 INTERNAL          34.6 °C
 BENCH             49.7 °C





 RANGE  AVG  DIAGS ALARM
```

Pressure

The Pressure screen (read only) displays the current optical bench pressure. The pressure is measured by a pressure transducer in-line with the optical bench.

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

```
PRESSURE:       743.0 mmHg



 RANGE  AVG  DIAGS ALARM
```

Flow

The Flow screen (read only) displays the current sample flow rate. The flow is measured by an internal flow sensor.

- In the Main Menu, choose Diagnostics > **Flow**.

```
FLOW:            0.508 LPM



 RANGE  AVG  DIAGS ALARM
```

Sample/Reference Ratio

The Sample/Reference Ratio screen (read only) displays the ratio of the intensities of the light source through the sample wavelength and reference wavelength of the bandpass filter wheel. Normally, when zero air is being sampled, the sample/reference ratio is between 1.00 and 1.18. A ratio outside may indicate that the filter wheel is dirty or the infrared source is degraded.

- In the Main Menu, choose Diagnostics > **Sample/Ref Ratio**.

```
SAMPLE REFERENCE RATIO:
 S/R:            1.1611000


 RANGE  AVG  DIAGS ALARM
```

AGC Intensity

The AGC Intensity screen (read only) displays the intensity (in Hertz) of the reference channel Automatic Gain Control (AGC) circuit. The AGC circuit optimizes the noise and resolution levels of the Model 48*i* Trace Level-Enhanced. The AGC intensity reading should be about 200000 Hertz.

- In the Main Menu, choose Diagnostics > **AGC Intensity**.

```
AGC INTENSITY:
 INTENSITY:      198611 Hz


 RANGE  AVG  DIAGS ALARM
```

Motor Speed

The Motor Speed screen (read only) displays the status of the chopper motor. A reading of 100.0% means that the motor speed is correct. A reading other than 100.0% indicates that there is a problem with the chopper motor or power supply.

- In the Main Menu, choose Diagnostics > **Motor Speed**.

```
MOTOR SPEED:
 SPEED:           100.00 %


 RANGE  AVG  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↓

 RANGE  AVG  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↓

 RANGE  AVG  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↓

 RANGE  AVG  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**.

Press ↵ to toggle the relay state open and closed.

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

 RANGE  AVG  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

 RANGE  AVG  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

 RANGE  AVG  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 dilution ratio and auto calibration, which may only be enabled at the factory). ▲

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

```
INSTRUMENT CONFIGURATION:
>I/O EXPANSION BOARD  YES
 ZERO/SPAN VALVES     YES
 ZERO AIR SCRUBBER    YES
 WHEEL PURGE          YES
 DILUTION              NO
 AUTO CALIBRATION      NO

 RANGE  AVG  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

 RANGE  AVG  DIAGS ALARM
```

Alarms Menu

The alarms menu displays a list of items that are monitored by the analyzer. If the item being monitored goes outside the lower or upper limit, the status of that item will go from "OK" to either "LOW" or "HIGH", respectively. 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 ↵.

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
>INTERNAL TEMP           OK
 BENCH TEMP              OK
 PRESSURE                OK
 SAMPLE FLOW             OK
 BIAS VOLTAGE            OK
 AGC INTENSITY           OK↓

 RANGE  AVG  DIAGS  ALARM

 MOTOR SPEED             OK
 ZERO CHECK              OK
 SPAN CHECK              OK
 ZERO AUTOCAL            OK
 SPAN AUTOCAL            OK
 SCRUBBER GAS CONC       OK
 SCRUBBER EFF            OK
 SCRUBBER TEST DONE      OK
 CONCENTRATION           OK
 MOTHERBOARD STATUS      OK
 INTERFACE STATUS        OK
 I/O EXP STATUS          OK
```

Internal Temperature

The Internal Temperature screen displays the current internal temperature and sets the minimum and maximum alarm limits. The internal temperature in the Model 48*i* Trace Level-Enhanced is regulated by turning the fan on as the temperature gets too high and off as it gets too low. Acceptable alarm limits range from 38 to 43 °C. If the internal 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 > **Internal Temp**.

```
INTERNAL TEMPERATURE:
 ACTUAL            40.6 °C
>MIN               38.0 °C
 MAX               43.0 °C




 RANGE  AVG  DIAGS ALARM
```

Min and Max Internal Temperature Limits

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

- In the Main Menu, choose Alarms > Internal Temp > **Min** or **Max**.

```
INTERNAL TEMPERATURE:
 ACTUAL MIN:       38.0 °C
 SET MIN TO:       40.0 °C ?

            ↑↓ INC/DEC
             ↵ SAVE VALUE
 RANGE  AVG  DIAGS ALARM
```

Bench Temperature

The Bench Temperature screen displays the current bench temperature and sets the minimum and maximum alarm limits. The bench temperature is regulated at 50.0 degrees C. Acceptable alarm limits range from 40 to 59 °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 > **Bench Temp**.

```
BENCH TEMPERATURE:
 ACTUAL            48.4 °C
>MIN               40.0 °C
 MAX               59.0 °C




 RANGE  AVG  DIAGS ALARM
```

Min and Max Bench Temperature Limits

The Minimum 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 > Bench Temp > **Min** or **Max**.

```
BENCH TEMPERATURE:
 ACTUAL MIN:      40.0 °C
 SET MIN TO:      44.0 °C ?

           ↑↓ INC/DEC
            ↵ SAVE VALUE

 RANGE  AVG  DIAGS ALARM
```

Pressure

The Pressure screen displays the current bench pressure reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 250 to 1000 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            250.0 mmHg
 MAX           1000.0 mmHg




 RANGE  AVG  DIAGS ALARM
```

Min and Max Pressure Limits

The Minimum Pressure alarm limit screen is used to change the minimum pressure 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:    250.0 mmHg
 SET MIN TO:    500.0 mmHg?

           ↑↓ INC/DEC
            ↵ SAVE VALUE
 RANGE  AVG  DIAGS ALARM
```

Sample Flow

The Sample Flow screen displays the current sample flow reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 0 to 1.500 LPM. If the sample flow 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 > **Sample Flow**.

```
SAMPLE FLOW:
 ACTUAL         0.750 LPM
>MIN            0.300 LPM
 MAX            1.500 LPM




 RANGE  AVG  DIAGS ALARM
```

Min and Max Sample Flow Limits

The Minimum Sample Flow alarm limit screen is used to change the minimum sample flow alarm limit. The minimum and maximum sample flow screens function the same way.

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

```
SAMPLE FLOW:
 ACTUAL MIN:    0.300 LPM
 SET MIN TO:    0.400 LPM ?

           ↑↓ INC/DEC
            ↵ SAVE VALUE
 RANGE  AVG  DIAGS ALARM
```

Bias Voltage

The Bias Voltage screen displays the current bias voltage reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from -130 to -100 volts. If the bias voltage 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 > **Bias Voltage**.

```
BIAS VOLTAGE:
 ACTUAL            -110 V
>MIN               -130 V
 MAX               -100 V




 RANGE  AVG  DIAGS ALARM
```

Min and Max Bias Voltage Limits

The Minimum Bias Voltage alarm limit screen is used to change the minimum bias voltage alarm limit. The minimum and maximum bias voltage screens function the same way.

- In the Main Menu, choose Alarms > Bias Voltage > **Min** or **Max**.

```
BIAS VOLTAGE:
 ACTUAL MIN:    -130 V
 SET MIN TO:    -120 V    ?

          ↑↓ INC/DEC
           ↵ SAVE VALUE
 RANGE  AVG  DIAGS ALARM
```

AGC Intensity

The AGC Intensity screen displays the current AGC Intensity reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 150,000 to 300,000 Hz. If the AGC 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 > **AGC Intensity**.

```
AGC INTENSITY:
 ACTUAL          196646 Hz
>MIN             150000 Hz
 MAX             300000 Hz




 RANGE  AVG  DIAGS ALARM
```

Min and Max AGC Intensity Limits

The Minimum AGC Intensity alarm limit screen is used to change the minimum sample flow alarm limit. The minimum and maximum AGC Intensity screens function the same way.

- In the Main Menu, choose Alarms > AGC Intensity > **Min** or **Max**.

```

AGC INTENSITY:
 ACTUAL MIN:    150000 Hz
 SET MIN TO:    180000 Hz ?

             ↑↓ INC/DEC
              ↵ SAVE VALUE
 RANGE  AVG  DIAGS ALARM
```

Motor Speed

The Motor Speed screen (read only) displays the current motor speed. A reading other than 100.0% indicates a problem with either the motor or the power supply.

- In the Main Menu, choose Alarms > **Motor Speed**.

```
MOTOR SPEED:
 ACTUAL              100.0 %






 RANGE  AVG  DIAGS ALARM
```

Zero and Span Check

The Zero Span Check screen allows the user to view the status of the most recent zero check and set the maximum zero check offset.

- In the Main Menu, choose Alarms > **Zero** or **Span Check**.

```
ZERO CHECK:
     ALARM:             OK
   RESPONSE:           0.0
>MAX OFFSET           10.0



 RANGE  AVG  DIAGS ALARM
```

Max Zero and Span Offset

The Max Zero Check Offset screen is used to change the maximum zero check offset. The maximum zero and span offset screens function the same way.

- In the Main Menu, choose Alarms > Zero or Span Check > **Max Offset**.

```
MAX ZERO CHECK OFFSET:
  CURRENTLY:      10.0
    SET TO:     00010.00 ?

          ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE
 RANGE  AVG  DIAGS ALARM
```

Zero and Span Auto Calibration

The Zero Auto Calibration screen (read only) allows the user to view the status of the most recent auto background calibration. The zero and span auto calibration screens are visible only if the auto calibration option is enabled and function the same way.

- In the Main Menu, choose Alarms > **Zero** or **Span Autocal**.

```
ZERO AUTO CALIBRATION:
      ALARM:            OK
   RESPONSE:           5.0



 RANGE  AVG  DIAGS ALARM
```

Scrubber Gas Concentration

The Scrubber Gas Concentration screen displays the current scrubber gas concentration reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 5 to 100 ppm. If the scrubber gas concentration 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 > **Scrubber Gas Conc**.

```
SCRUBBER GAS CONC:
 ACTUAL                0.000
>MIN                    5.00
 MAX                   100.0




 RANGE  AVG  DIAGS ALARM
```

Min and Max Scrubber Gas Concentration Limits

The Minimum Scrubber Gas Concentration alarm limit screen is used to change the minimum scrubber gas concentration alarm limit. The minimum and maximum scrubber gas concentration screens function the same way.

- In the Main Menu, choose Alarms > Scrubber Gas Conc > **Min** or **Max**.

```

SCRUBBER GAS CONC:
 ACTUAL MIN:           5.00
 SET MIN TO:       00005.00 ?

               ←→ MOVE CURSOR
 ↑↓ INC/DEC   ↵ SAVE VALUE

 RANGE  AVG  DIAGS ALARM
```

Scrubber Efficiency

The Scrubber Efficiency screen displays the current scrubber efficiency reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 95 to 101 percent. If the scrubber efficiency 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. Last date (read only) displays the date and time of the last scrubber test done.

- In the Main Menu, choose Alarms > **Scrubber Eff**.

```
SCRUBBER EFFICIENCY:
 ACTUAL                0.0 %
>MIN                  95.0 %
 MAX                 101.0 %
 LAST TEST           NO DATA



 RANGE  AVG  DIAGS ALARM
```

Min and Max Scrubber Efficiency Limits

The Minimum Scrubber Gas Concentration alarm limit screen is used to change the minimum scrubber efficiency alarm limit. The minimum and maximum scrubber efficiency screens function the same way.

- In the Main Menu, choose Alarms > Scrubber Eff > **Min** or **Max**.

```
SCRUBBER EFFICIENCY:
 ACTUAL MIN:    95 %
 SET MIN TO:    96 %      ?

          ↑↓ INC/DEC
           ↵ SAVE VALUE
 RANGE  AVG  DIAGS ALARM
```

Concentration

The Concentration screen displays the current CO concentration and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 0 to 1000 ppm. The minimum alarm may be programmed as a floor trigger (alarm is triggered when the concentration falls below the minimum value) or a ceiling trigger (alarm is triggered when the concentration goes above the minimum value). If the CO concentration 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 > **Concentration**.

```
CONCENTRATION:
 ACTUAL                58.3
>MIN                   1000
 MAX                   1000
 MIN TRIGGER        CEILING



 RANGE  AVG  DIAGS ALARM
```

Min and Max Concentration Limits

The Minimum Concentration alarm limit screen is used to change the minimum concentration alarm limits. The minimum and maximum concentration alarm limit screens function the same way.

- In the Main Menu, choose Alarms > Concentration > **Min** or **Max**.

```
CONCENTRATION:
 ACTUAL MIN:            0.0
 SET MIN TO:     00010.00 ?

            ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Min Trigger Concentration

The Minimum Trigger screen allows the user to view and set the concentration alarm trigger type to either floor or ceiling. The minimum alarm may be programmed as a floor trigger (alarm is triggered when the concentration falls below the minimum value) or a ceiling trigger (alarm is triggered when the concentration goes above the minimum value).

- In the Main Menu, choose Alarms > Select Concentration > **MinTrigger**.

```
MIN TRIG(CEILING/FLOOR):
ACTUAL TRIGGER:  CEILING
SET TRIGGER TO:    FLOOR ?

  ↵ TOGGLE AND SAVE VALUE

 RANGE  AVG  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 dual or auto range modes, “LO” or “HI” multi-point calibration is displayed to indicate the calibration of the high or low concentrations.

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

```
SERVICE:
>RANGE MODE SELECT
 PRESSURE CALIBRATION
 FLOW CALIBRATION
 INITIAL S/R RATIO
 INTERNAL SET TEMP
 SCRUBBER TEST
 MULTIPOINT CAL              ↓

 RANGE  AVG  DIAGS ALARM

 PREAMP BOARD CAL
 TEMPERATURE CALIBRATION
 ANALOG OUT CAL
 ANALOG INPUT CAL
 DILUTION RATIO
 DISPLAY PIXEL TEST
 RESTORE USER DEFAULTS
```

Range Mode Select

The Range Mode Select screen is used to switch between the various range modes: single, dual, and auto range.

- In the Main Menu, choose Service > **Range Mode Select**.

```
SINGLE/DUAL/AUTO RANGE:
 CURRENTLY:        SINGLE
    SET TO:          DUAL ?

           ↑↓ CHANGE VALUE
            ↵ SAVE VALUE

 RANGE  AVG  DIAGS ALARM
```

Pressure Calibration

The Pressure Calibration submenu is used to calibrate the pressure sensor to zero, span, or restore factory default values. The pressure calibration is visible only when the instrument 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            1.1416
 SET DEFAULTS



 RANGE  AVG  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**.

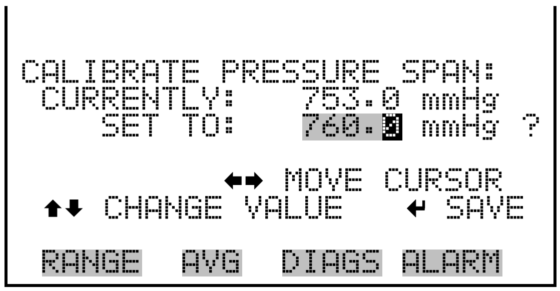
```
CALIBRATE PRESSURE ZERO:
 CURRENTLY:     10.0 mmHg
    SET TO:      0.0 mmHg

 CONNECT VACUUM PUMP AND
   ↵ SAVE ZERO PRESSURE

 RANGE  AVG  DIAGS ALARM
```

Calibrate Pressure Span

The Calibrate Pressure Span screen allows the user 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. ▲

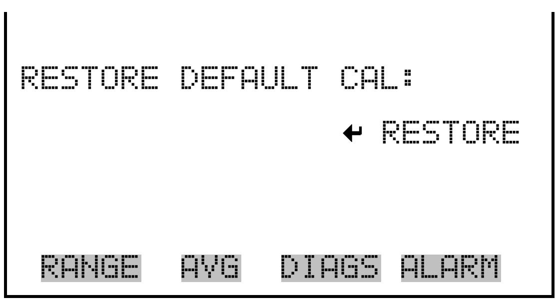
- In the Main Menu, choose Service > Pressure Calibration > **Span**.

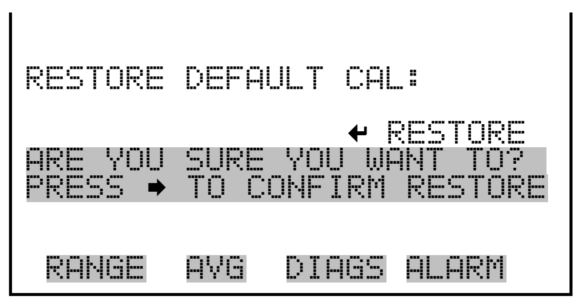


Restore Default Pressure Calibration

The Restore Default Pressure Calibration screen allows the user to reset the pressure calibration configuration values to factory defaults.

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





Flow Calibration

The Flow Calibration submenu is used to calibrate the flow sensor to zero, span, or restore factory default values. The flow 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 > **Flow Calibration**.

```
FLOW SENSOR CAL:
>ZERO                  121
 SPAN               1.0000
 SET DEFAULTS



 RANGE  AVG  DIAGS ALARM
```

Calibrate Flow Zero

The Calibrate Flow Zero screen calibrates the flow sensor at zero flow.

Note The pump must be disconnected before performing the zero calibration. ▲

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

```

CALIBRATE FLOW ZERO:
 CURRENTLY:   0.000 LPM
    SET TO:   0.000 LPM ?

   DISCONNECT PUMP AND
   ↵ SAVE CURRENT FLOW
 RANGE  AVG  DIAGS ALARM
```

Calibrate Flow Span

The Calibrate Flow Span screen allows the user to view and set the flow sensor calibrate span point.

Note An independent flow sensor is required to read the flow, then the operator enters the flow value on this screen to perform the calibration. ▲

- In the Main Menu, choose Service > Flow Calibration > **Span**.

```
CALIBRATE FLOW SPAN:
 CURRENTLY:    0.508 LPM
    SET TO:    0.501 LPM ?

           ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Restore Default Flow Calibration

The Restore Default Flow Calibration screen allows the user to reset the flow calibration configuration values to factory defaults.

- In the Main Menu, choose Service > Flow Calibration > **Set Defaults**.

```
RESTORE DEFAULT CAL:

                ↵ RESTORE



 RANGE  AVG  DIAGS ALARM
```

```
RESTORE DEFAULT CAL:

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

 RANGE  AVG  DIAGS ALARM
```

Initial Sample/Reference Ratio

The Initial Sample/Reference (S/R) Ratio screen displays both the initial S/R ratio and the current S/R ratio. The initial S/R ratio is determined at the factory, and is used to correct for the slight variations found from one correlation wheel to another. The only time the initial S/R ratio should be changed is when the correlation wheel is replaced or sample/reference is outside 0.90 to 1.20.

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

- In the Main Menu, choose Service > **Initial S/R Ratio**.

```
INITIAL S/R RATIO:
 CURRENTLY:      1.079620
  MEASURED:      1.130966
    SET TO:      1.131524 ?

           ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Internal Set Temperature

The Internal Set Temperature screen allows the user to set the operating point for internal set temperature (for fan control).

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

- In the Main Menu, choose Service > **Internal Set Temp**.

```
INTERNAL TEMP SETPOINT:
 CURRENTLY:       43.0 °C
    SET TO:       43.5 °C ?

           ↑↓ CHANGE VALUE
            ↵ SAVE VALUE

 RANGE  AVG  DIAGS ALARM
```

Scrubber Test

The Scrubber Test screen allows the user to initiate a scrubber efficiency test, or to stop a test that is currently in progress. Typically, the efficiency test should run for at least 10 minutes. When the efficiency test is initiated, a timer is started and the efficiency test will automatically shut off. The scrubber test results allow the user to view the current CO reading, the span gas concentration, and the scrubber effectiveness, expressed as a percent efficiency.

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

- In the Main Menu, choose Service > **Scrubber Test**.

```
SCRUBBER EFFICIENCY:
   TEST PHASE: SCRUBBER
 TEST GAS CONC:     0.000
  CURRENT CONC:     0.000
  % EFFICIENCY:       0.0%
                  ↵ START
 RANGE   AVG   DIAGS ALARM
```

```
SCRUBBER EFFICIENCY:
   TEST PHASE: SCRUBBER
 TEST GAS CONC:     0.000
  CURRENT CONC:     0.000
  % EFFICIENCY:       0.0%
 PHASE TIME: 599s ← ABORT
 RANGE   AVG   DIAGS ALARM
```

Multi-Point Calibration

Up to three gas concentrations (cal-points) for each range may be calibrated to using the following steps. Three cal-points will give the most accurate readings over the entire range. The calibration process is sequential and will work properly if all steps are followed in order. The example below shows the multi-point calibration screen in single range mode. In dual or auto range modes, "HI" or "LO" is displayed to indicate the calibration of the high or low concentrations and function the same way.

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

- In the Main Menu, choose Service > **Multipoint Calibration**.

```
MULTI-POINT CAL:
>CALIBRATE POINT 1
 CALIBRATE POINT 2
 CALIBRATE POINT 3
 COEFFICIENT
 DEFAULT COEFFICIENTS


 RANGE   AVG   DIAGS ALARM
```

Calibrate Point 1/2/3

The Calibrate Point 1 screen allows the user to view and set the selected calibration point. The calibrate 2 and calibrate 3 screens function the same way.

- In the Main Menu, choose Service > Multipoint Cal > **Calibrate 1, 2** or **3**.

```
SET CAL GAS POINT:
 RANGE:              10000
 CAL FACTOR 1:      1.0000
 CAL GAS 1:      0040.000 ?

          ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE  AVG  DIAGS ALARM
```

Coefficients

The Coefficients screen allows the user to view and re-calculate the calibration coefficients.

- In the Main Menu, choose Service > Multipoint Cal > Choose Cal Point > **Coefficients**.

```
COEFFICIENTS:
           1: 1.000000
           2: 1.000000
           3: 1.000000

           ↵ RECALCULATE?

 RANGE  AVG  DIAGS ALARM
```

Default Coefficients

The Default Coefficients screen allows the user to view and reset the calibration coefficients to default values.

- In the Main Menu, choose Service > Multipoint Cal > Choose Cal Point > **Coefficients**.

```
COEFFICIENTS:
           1: 1.000000
           2: 1.000000
           3: 1.000000
       ↵ SET TO DEFAULTS

 RANGE  AVG  DIAGS ALARM
```

Preamp Board Calibration

The Pre-amp Board Calibration screen is used to adjust the preamp board calibration parameters. The AGC circuitry is turned off while the preamp board is being calibrated. The value should be set so that the sample and reference values are around 150000 Hz.

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

- In the Main Menu, choose Service > **Preamp Calibration**.

```
PREAMP BOARD CAL:
    SAMPLE:     127807 Hz
 REFERENCE:     148256 Hz
    SET TO:         51    ?

           ↑↓ CHANGE VALUE
            ↵ SAVE VALUE

 RANGE   AVG   DIAGS ALARM
```

Temperature Calibration

The Temperature calibration screen allows the user to view and set the ambient temperature sensor calibration. The 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 > **Temperature Calibration**.

```
CALIBRATE AMBIENT TEMP:
 CURRENTLY:     32.3 °C
    SET TO:     032.3 °C ?

           ←→ MOVE CURSOR
 ↑↓ CHANGE VALUE    ↵ SAVE

 RANGE   AVG   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      ↓

 RANGE  AVG  DIAGS ALARM
```

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






 RANGE  AVG  DIAGS ALARM
```

Analog Output Calibrate Zero

The Analog Output Calibrate Zero screen allows the user 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

 RANGE  AVG  DIAGS ALARM
```

Analog Output Calibrate Full-Scale

The Analog Output Calibrate Full-Scale screen allows the user 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:             6397
 ↵ SAVE VALUE   ↑↓ INC/DEC
 SET OUTPUT TO:       10 V

 RANGE   AVG   DIAGS ALARM
```

Analog Input Calibration

The Analog Input Calibration menu is a selection of 8 analog inputs 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 screen is present only when the I/O expansion board is installed. ▲

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        ↓

 RANGE   AVG   DIAGS ALARM
```

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




 RANGE   AVG   DIAGS ALARM
```

Analog Input Calibrate Zero

The Analog Input Calibrate Zero screen allows the user 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:   INPUT1
 CURRENTLY:        0.24 V ?

 ↵ CALIBRATE INPUT TO ZERO
 RANGE   AVG   DIAGS ALARM
```

Analog Input Calibrate Full-Scale

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

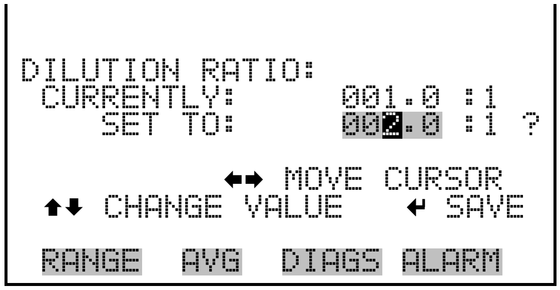
- In the Main Menu, choose Service > Analog Input Calibration > Select Channel > **Calibrate Full Scale**. (Hook up a voltage source of 10 V to the analog input channel.)

```
ANALOG INPUT CAL:    SPAN
PROVIDE VOLTAGE TO INPUT!
 SELECTED INPUT:   INPUT1
 CURRENTLY:        9.24 V
    SET TO:       10.00 V ?
 ↵ CALIBRATE INPUT TO ZERO
 RANGE   AVG   DIAGS ALARM
```

Dilution Ratio

The Dilution Ratio screen allows the user to view and set the dilution ratio. Acceptable values are 1–500: 1. The default is 1:1. When this value is set, the dilution ratio is applied to all concentration measurements. This screen is only accessible if the dilution ratio option is installed.

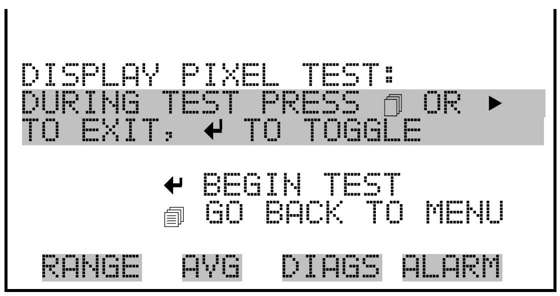
- In the Main Menu, choose Service > **Dilution Ratio**.



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.

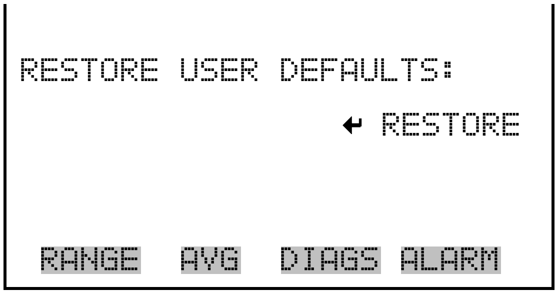
- In the Main Menu, choose Service > **Display Pixel Test**.

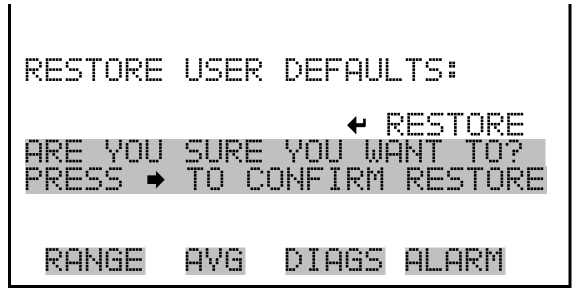


Restore User Defaults

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.**





Password Menu

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**.

Set Password

The Set Password screen is used to set the password to unlock the front panel. The set password screen is shown if the instrument is unlocked and the password is set.

- In the Main Menu, choose Password > **Set Password**

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 screen is shown if the instrument is unlocked and the password is set.

- In the Main Menu, choose Password > **Lock Instrument**

Change Password

The Change Password is used to change the password used to unlock the instrument's front panel. The change password screen is shown if the instrument is unlocked.

- In the Main Menu, choose Password > **Change Password**

Remove Password

The Remove Password screen is used to erase the current password and disable password protection. The remove password screen 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

 RANGE  AVG  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:


     ABCDEFGHIJKLMN  BKSP
     OPQRSTUVWXYZ    PAGE
     0123456789 ./-  SAVE
 RANGE  AVG  DIAGS ALARM
```

Chapter 4
Calibration

This chapter describes the procedures for calibrating the Model 48*i* Trace Level-Enhanced (TLE) analyzer. The information described here is more than adequate to perform the calibration. However, if greater detail is needed, please refer to the *Quality Assurance Handbook for Air Pollution Measurement Systems*[1].

Like most measurement systems, the Model 48 *i*Series CO analyzers require initial and periodic calibration to ensure that measurement results are accurate. Calibration is achieved by introducing a series of well-defined gas mixtures containing known concentrations of CO to the instrument, and verifying that the unit provides an accurate CO measurement. If the measurement results are not correct, the zero background and/or span factor are adjusted as necessary.

Depending on the application under consideration, there are two types of calibration that may be utilized. These are a single point internal calibration and a multipoint external calibration.

The single point calibration uses a zero gas and a single span point to adjust the instrument's internal calibration factors, as necessary, to provide accurate CO measurements. Although the relationship between CO concentration and IR absorbance is inherently non-linear, the relationship is predictable, and the instrument firmware features a linearization algorithm that compensates for that non-linearity. This compensation allows the instrument to provide accurate measurement results over the entire operating range using a calibration based on just a zero gas and a single span point.

Although the Model 48*i* Trace Level-Enhanced will meet all performance specifications with just the single point internal calibration, some air monitoring regulations require the operator to carry out an external multi-point calibration as well. An external multipoint calibration requires the operator to generate a series of test mixtures containing CO concentrations that range from zero up to approximately 90% of full scale. The test gases are sequentially introduced to the instrument through the sampling port or manifold, and the instrument reading for each test point is recorded from the instrument's analog output. A graph of CO concentration versus analog output signal is then created on paper, or preferably, using a computer. A "best-fit" line or equation representing the relationship between CO concentration and the instrument's analog signal can then be generated and used to interpret data taken during normal operation.

Although the Model 48*i* Trace Level-Enhanced will provide high quality data without using an external multi-point calibration, it is a regulatory requirement in many cases. In addition, the external calibration does provide an opportunity to verify the analyzer's accuracy over the entire measurement range. Moreover, if an instrument were to display a non-linearity in response, the external calibration could be used to correct for that error. Some further discussion of multi-point calibration is included in the following procedures. However, the operator should consult the *Quality Assurance Handbook for Air Pollution Measurement Systems*[1] referenced earlier for a more detailed explanation of the procedure.

The following sections discuss the required apparatus and procedure for calibrating the instrument.

Equipment Required

The following equipment is required to calibrate the instrument:

Calibration Standard (Span Gas)

A cylinder of CO in air containing an appropriate concentration of CO suitable for the selected operating range of the analyzer under calibration is necessary. For most applications, the span concentration should be about 80% of the full-scale range that will be used during normal operation. For example, if the instrument will be operated with the analog output set on a full-scale range of zero to 50 ppm, the span gas concentration should be about 40 ppm. Selection of the analog output's full-scale range will depend on the application, and in some cases the choice may be subject to regulatory considerations.

For legal reasons, the assay of the span cylinder must be traceable either to a National Institute of Standards and Technology (NIST) CO in Air Standard Reference Material (SRM), or a NIST/EPA approved gas manufacturer's Certified Reference Material (CRM).

A recommended protocol for certifying CO gas cylinders against an SRM or CRM is given in the *Quality Assurance Handbook*[1]. The CO gas cylinder should be recertified on a regular basis determined by the local quality control program.

CO Free Dilution Air (Required for multi-point calibration only)

Because the enhanced trace level instrument is equipped with an internal CO scrubber, a separate source of zero air is not required for routine single point calibration. However, a high quality CO-free air source may be needed to supply dilution air that can be used to generate span gas from a higher concentration cylinder, or to generate test gases containing varying concentrations of CO.

If a gas titration, or dilution, system will be used, the dilution air should contain <0.01 ppm CO. In addition, the dilution air should be dry (Dew point < 10°C) and free of oil mist and dust particles. Since the Model 48*i* Trace Level-Enhanced is virtually interference free, it is not necessary to include special scrubbers for removal of SO_2, NO_x, CO_2 or volatile organic compounds.

Zero air cylinders from scientific and commercial suppliers typically contain CO concentrations in the 0.1 - 0.3 ppm range. Thus, cylinder zero air may need to be scrubbed of the residual CO prior to its use as a dilution gas or as a zero standard in multi-point calibration.

If dilution air will be generated on-site, a commercial system such as the Thermo Electron *Model 1160 Zero Air Supply* is highly recommended. A dilution air system can also be built using the air-drying and CO removal techniques discussed below.

Compression

The zero air should be supplied at an elevated pressure to allow accurate and reproducible flow control and to aid in subsequent drying, oxidation, and scrubbing. An air compressor that gives an output of 30 to 40 psig is usually sufficient. In addition to supplying high-pressure air, a compressor equipped with condensation coils and a water trap can remove some water.

Drying

Several drying methods are available. Passing the compressed air through a bed of silica gel, using a heatless air dryer, or removing water vapor with a permeation dryer are three possible approaches to achieving a lower dew point. If a large volume or continuous flow of dry air is needed, silica gel or other similar drying agents will require frequent replacement. In those cases, a permeation dryer or heatless air dryer will usually be a better solution.

CO Removal

A platinum on alumina catalyst, operated at 250 °C, has been found to be a convenient oxidizer to convert CO to CO_2.

Gas Titration System (Required for multi-point calibration only)

If the analyzer is being calibrated with zero air and a single span gas, the internal scrubber can be used to provide the zero, and the span gas should be purchased at the appropriate concentration so that no dilution will be necessary. However, if the unit will be operated under regulations that require an external multi-point calibration, or if a multi-point accuracy test is planned, a gas titration system will be required. A high quality gas titration system, such as the Thermo Electron Model 146 Series Multigas Calibration System, is suggested for these applications. If a titration system must be assembled from individual components, as in Figure 4-1, the following issues must be considered.

Equipment Damage All connections between components in the system should be made with glass, Teflon®, or other non-reactive material. ▲

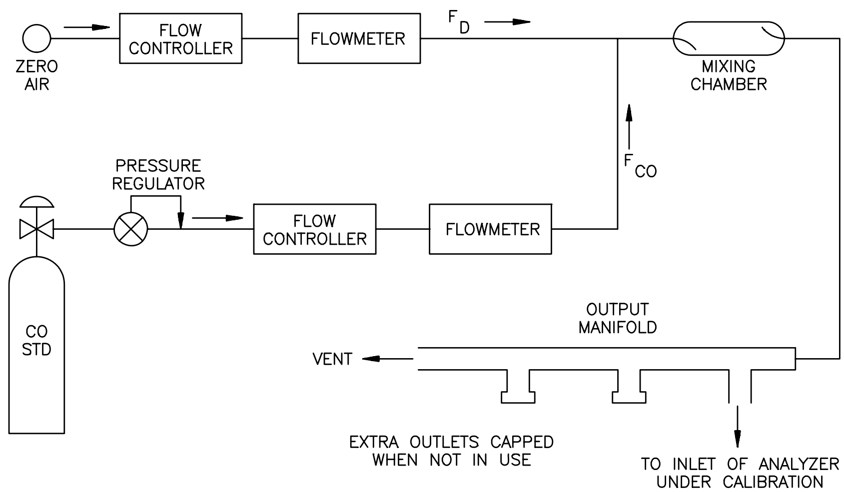


Figure 4–1. Dilution System Schematic

Flow Meter(s) and Controller(s)

In order to obtain an accurate dilution ratio, the flow rates must be regulated to 1% and be measured to an accuracy of at least 2%. The meter and controller can be two separate devices, or combined in one device. The user's manual for the meter should be consulted for calibration information.

Additional information on the calibration of flow devices can be found in the *Quality Assurance Handbook1*. It should be noted that all flows should be corrected to 25 °C and 760 mmHg, and that care should be exercised in correcting for water vapor content.

Pressure Regulator for CO Standard Cylinder

The regulator used must have a non-reactive diaphragm and internal parts, as well as a suitable delivery pressure.

Mixing Chamber

A chamber constructed of glass, Teflon®, or other nonreactive material, and designed to provide thorough mixing of CO and diluent air for the dilution needed.

Output Manifold

The output manifold should be constructed of glass, Teflon, or other nonreactive material, and should be of sufficient diameter to ensure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to ensure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold.

When using the gas dilution system, the total flow must exceed the total demand of the analyzer(s) connected to the output manifold to ensure that no ambient air is pulled into the manifold vent. The exact CO concentration is calculated from:

$$[CO]_{OUT} = \frac{([CO]_{STD} \times F_{CO})}{(F_D + F_{CO})}$$

Where:

$[CO]_{OUT}$ = diluted CO concentration at the output manifold, ppm

$[CO]_{STD}$ = concentration of the undiluted CO standard, ppm

F_{CO} = flow rate of CO standard corrected to 25 °C and 760 mmHg, LPM

F_D = flow rate of dilution air corrected to 25 °C and 760 mmHg, LPM

Calibration Procedures

Use the following procedures to calibrate the instrument.

Connect to and Configure the Calibration Gas System

Connect the instrument and configure the calibration gas system per the following.

Internal Valve System

In addition to the internal zero air scrubber, the Model 48*i* Trace Level-Enhanced is shipped standard with internal switching valves that provide the capability for fully automated calibration. The configuration of these valves is illustrated schematically in Figure 4-2. When designing the calibration system, it is important that the operator understand the instrument's internal valve configuration. If the calibration and/or sampling system is designed without considering the internal valves, there is a possibility of calibration errors that would invalidate monitoring data.

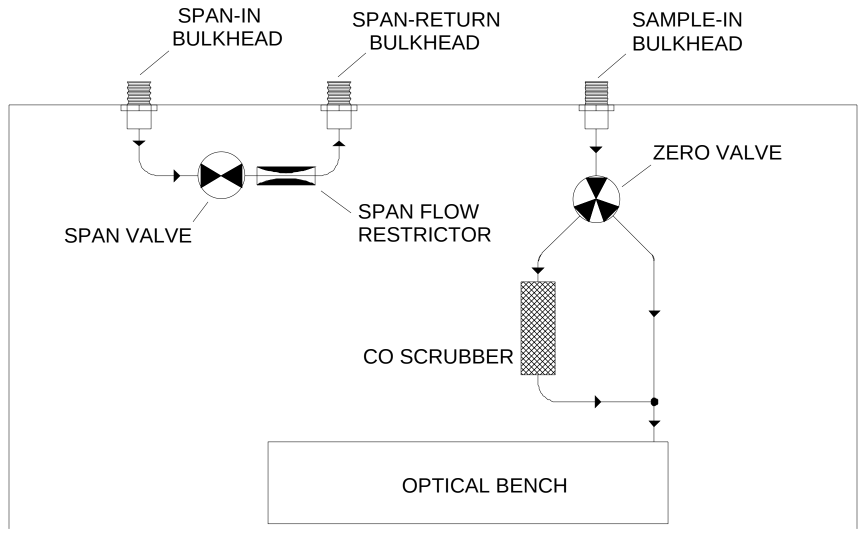


Figure 4–2. Internal Zero and Span Valve Plumbing

The internal span valve is a 2-way, normally-closed solenoid that shuts off the flow from a span gas cylinder connected to the Span-In bulkhead. When the solenoid is activated, during a span adjust, span check or scrubber efficiency test, the valve opens. Span gas flows through the span flow restrictor and back out the span-return bulkhead. A line should be run from the Span-Return bulkhead to an appropriate point in the sample inlet system, so that the span gas will follow the same path as the actual sample. The internal restrictor allows a flow rate of approximately 1 liter per minute at a pressure of 10 psi. The zero valve, located downstream of the Sample-In bulkhead, is a 3-way solenoid that routes sample flow either through or around the CO scrubber. During a zero adjustment, zero check or scrubber test, the valve activates to route the gas through the scrubber.

External Connections

Depending on the type of calibration that will be performed, and the overall design of the system, there are several possible options for connecting the instrument to the calibration system. The two most likely configurations are illustrated in Figures 4-3 and 4-4.

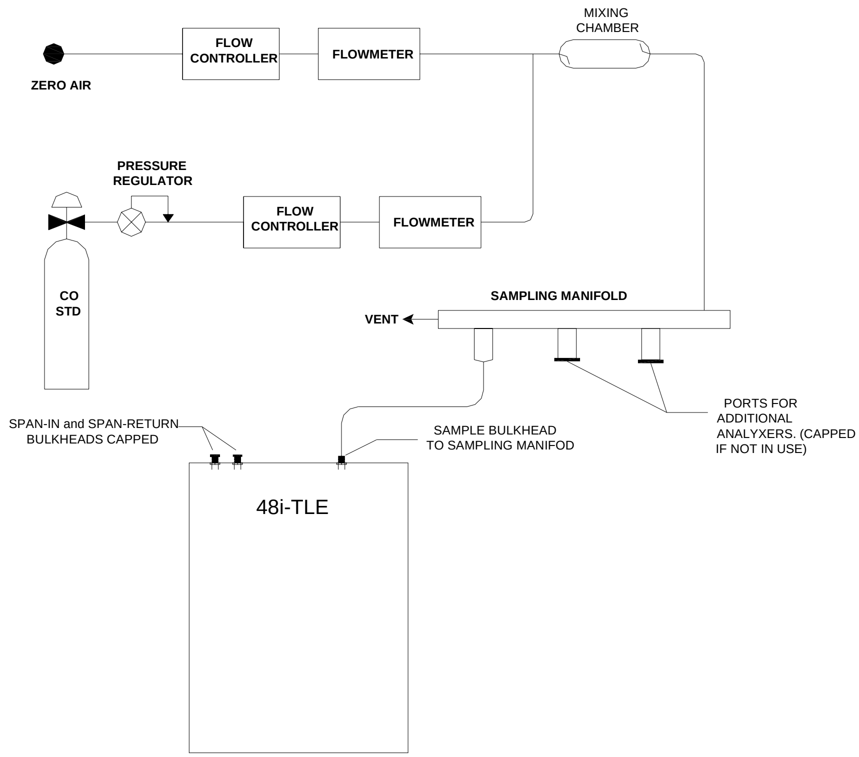


Figure 4–3. Plumbing Configuration for Mulit-Point External Calibration

If a gas titration system will be used to deliver the calibration gases, the span control valve located inside the 48*i* Trace Level-Enhanced cannot be used to control the gas flows. In this arrangement, delivery of span gas will be controlled by an external system. The internal CO scrubber will still be active, so automatic zero adjustments, which are discussed later in this chapter will still be possible.

Whatever configuration is selected, the operator must ensure that the calibration gases will be supplied at a flow rate that slightly exceeds the total flow required by the analyzer and any other flow demand connected to the delivery system. The design must also ensure that the calibration gases are supplied at atmospheric pressure. If the calibration gases are being supplied to an inlet manifold at elevated pressure, an atmospheric dump, or by-pass, must be provided. In addition, if an optional sample line filter is being used, the calibration should be performed through this filter to compensate for any leaks that the filter introduces.

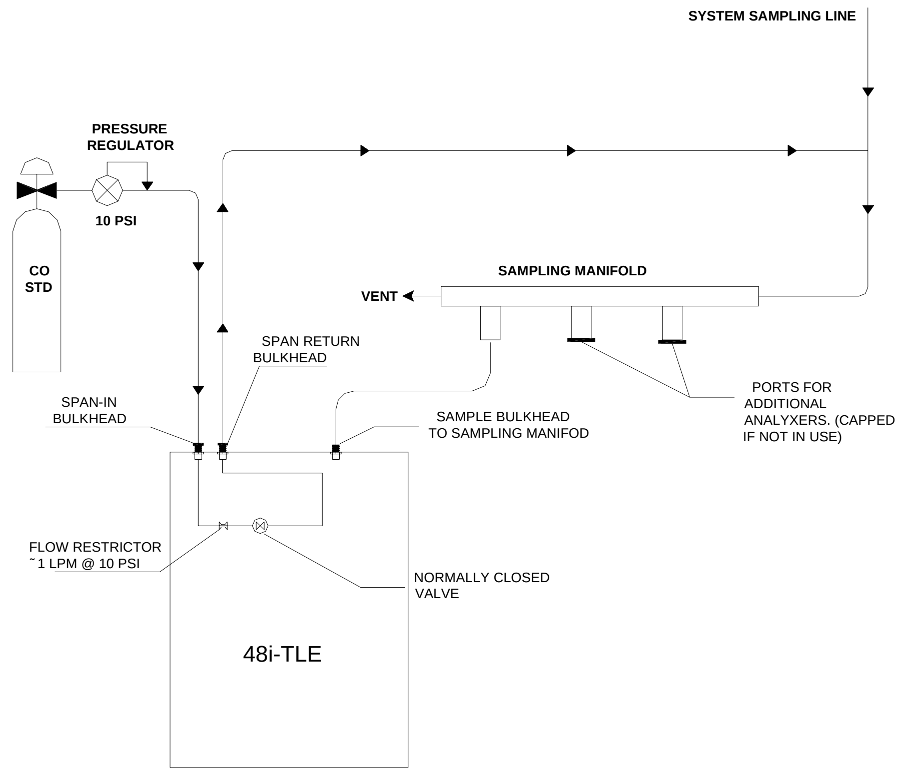


Figure 4–4. Plumbing Configuration for Single-Point Internal Calibration

In this configuration, only one span concentration is utilized. However, the calibration process can be fully automated because the 48*i* Trace Level-Enhanced internal span valve controls the flow span gas. Whenever the instrument is switched to span mode (check or adjust) the internal valve will open and allow span gas to flow into the sampling system. This arrangement also enables the automated scrubber efficiency test, which runs span gas through the CO scrubber.

Pre-Calibration

Prior to calibration, be sure the Model 48*i* Trace Level-Enhanced is operating properly. Turn on the instrument and allow it to stabilize for one hour. Perform the service checks of the "Preventive Maintenance" chapter. Set the operating range to an appropriate value for your application and the averaging time to 60 seconds.

Note The averaging time should be less than the zero duration and less than the span duration. ▲

The calibration and calibration check duration times should be long enough to account for the transition (purge) process when switching from sample to zero and from zero to span. This transition time is the time required to purge the existing air. ▲

Depending on the plumbing configuration and the instrument, data from approximately the first minute of a zero calibration or check should be disregarded because of residual sample air. Also, data from approximately the first minute of a span calibration or check should be disregarded because the span is mixing with the residual zero air. ▲

Single Point Internal Calibration

See the following procedures for a single point internal calibration.

Zero Adjust

Use the following procedure to set the CO reading to zero.

1. Allow the analyzer to sample ambient air for at least 5 minutes, or until a stable reading is obtained.

2. Press and choose Calibration > **Cal Background**.

3. Allow the instrument to run with the zero scrubber activated for at least 5 minutes, or until a stable signal is observed.

4. In the CO Background screen, press to set the CO reading to zero.

Span Adjust

Use the following procedure to adjust the span.

1. If necessary, open the main cylinder valve on the CO span gas and adjust the output pressure to 10 ± 2 psi.

2. Press and choose Calibration > **Cal Coefficient**.

   The display shows the current CO concentration reading. The next line of the display shows the CO concentration of the span gas cylinder.

3. If you have not already done so, verify that excess span gas is flowing out the "Span Out" bulkhead at 250 to 750 cc per minute.

4. Allow the instrument to sample span gas for at least 5 minutes or until the reading is fully stabilized.

5. Enter the CO calibration gas concentration using the pushbuttons to adjust the display value to match the cylinder concentration, and then press ↵ to set the CO reading to match the CO concentration of the span gas.

   Note that the procedures described above adjust the instrument readings to match the expected values by resetting the internal zero-offset and span-factor values. These values are used by the instrument firmware to convert the raw detector signal to a CO concentration. The new zero-offset and span-factor values can be seen by selecting "Calibration Factors" from the Main Menu.

Multi-Point External Calibration

Even if an external calibration curve will be used to interpret monitoring data, the operator should follow the zero adjust and span adjust instruction given below. This will bring the instrument's front panel readings into calibration and simplify general operation and trouble-shooting of the analyzer.

Zero Adjust

Use the following procedure to set the CO reading to zero.

1. Allow sufficient time for the analyzer to warm up and stabilize.

2. Adjust the gas titration system so CO-free zero air is present in the manifold.

   Since not all flow controllers have a positive shut off, it might be necessary to disconnect the CO input line and cap it.

3. Allow the analyzer to sample zero air until a stable reading is obtained.

4. Press and choose Calibration > **Cal Background**.

5. Allow the instrument another 5 minutes to fully stabilize.

6. In the CO Background screen, press ↵ to adjust the instrument's zero-offset and set the CO reading to zero.

   If a strip chart recorder is used to obtain a record of the analog output, it is recommended that the system be adjusted to obtain a zero trace at

5% of scale. This is to allow observation of zero drift and/or zero noise. Record the stable zero air response as Z.

Span Adjust

Use the following procedure to adjust the span.

1. Adjust the zero airflow and the CO flow from the standard CO cylinder to provide a diluted CO concentration of approximately 80% of the full-scale range that the unit will be operating under. For example, if the analyzer will be run on the 50 ppm range, the span gas concentration should be about 40 ppm.

2. Allow the analyzer to sample this CO concentration standard until a stable response is obtained.

3. Press and choose Calibration > **Cal Coefficient**.

   The display shows the current CO concentration reading. The next line of the display shows the actual CO concentration of the gas as calculated from the air and span flows.

4. Enter the CO calibration gas concentration using the pushbuttons to adjust the display value to match the actual concentration being delivered by the gas titration system, and then press to adjust the instrument's span-factor and force the CO reading to match the true CO concentration of the span gas.

   If a strip-chart recorder is being used to record the analog output, the recorder response should now be:

   recorder response (percent scale) = $(([CO]OUT \times 100)/URL) + Z_{CO}$

   Where:

   URL = nominal upper range limit of the analyzer's operating range

   Z_{CO} = analyzer's response to zero air, %scale

5. Record the CO concentration and the analyzer's response.

Additional Concentration Standards

Generate several additional concentrations (at least five others are suggested) by decreasing F_{CO} or increasing F_D. In each case, be sure the total flow exceeds the analyzer's total flow demand. For each concentration generated, calculate the exact CO concentration using Equation (1). Record the concentration and the response from the analyzer's analog output for each concentration.

Calibration Curve

Plot the analyzer's response versus the corresponding CO concentrations. Connect the experimental points using a straight line, preferably determined by linear regression techniques. The calibration curve is used to interpret, or reduce, subsequent measurement data.

Frequency of Calibration

In order to generate data of the highest confidence, it is recommended that a full calibration be performed:

- every three months
- any time major disassembly of components is performed
- any time a zero or span check gives results outside the limits described in the site's QA/QC program. Note that the QA/QC limits and frequency of calibration may also be controlled by regulatory mandates outside the scope of this manual.

Periodic Zero and Span Checks

In order to achieve data of the highest confidence, the instrument zero and span should be checked periodically. These checks can be performed by challenging the analyzer with zero air and span gas and comparing the instrument readings to the expected values.

If the span gas has been connected appropriately, the Model 48*i* Trace Level-Enhanced's internal CO scrubber and valve system allow the operator to manually switch the instrument between sample, zero, and span by simply pushing ▶ on the front panel. The currently active mode appears in the lower left-hand corner of the Run Screen. Repeated presses of ▶ will cause the instrument to cycle through the three possible states.

Zero Check

When running the zero check, the instrument should be connected to the normal inlet system and sampling ambient air. The unit must be allowed to stabilize for at least five minutes before taking data. If the test data is recorded directly from the front panel or from the digital interface (RS-232/485), the drift can simply be reported in units of ppm. If regulatory requirements call for zero drift to be reported as percent of range, the calculation will be made based on the range specified in the regulations.

If the data is being collected with a data logger or strip chart recorder attached to one of the analog outputs, the zero drift is typically reported as a percent of the upper range limit (URL) of the recorder or as the current full-scale setting of the analog output.

$$\text{Zero Drift (\%)} = ((A_0 - Z)/URL) \text{ X } 100$$

Where A_0 is the recorder response obtained for this test, Z is the recorder response obtained for zero air at the last calibration, URL is the upper range limit of the recorder, and Zero Drift is expressed as % of full-scale. In this case, there is no need to convert the analog signal to units of concentration. For example, if the instrument is configured for a 0-10 volt analog output, the output at the last zero adjustment was 0.1 volts and the output during this zero check is 0.3 volts, then the zero drift could be calculated as follows:

$$\text{Zero Drift (\%)} = ((0.3 \text{ volts} - 0.1 \text{ volt})/10 \text{ volts}) \text{ X } 100$$

$$\text{Zero Drift} = 2.0\ \%$$

Span Check

To run a span check, press ▶ until the word "SPAN" appears in the lower left corner of the display. The internal span valve will open, and if the span gas is plumbed as suggested, span gas will flow to the manifold or sampling line. The unit must be allowed to stabilize for at least five minutes before taking data.

As discussed elsewhere, the flow rate of span gas must be greater than the flow demand of the inlet system. In addition, the calibration system must be configured so that the span gas is being delivered at atmospheric pressure. For most applications, the span check should be run with a CO concentration that is approximately 80% of the instrument's current range setting. The simplest and most reliable source of span gas is a cylinder containing the span concentration of CO in air that has been certified against an SRM or CRM.

If the span check data is recorded directly from the front panel or from the digital interface (RS-232/485), the span drift can simply be reported in units of ppm, or as a percent of the actual span concentration. If regulatory requirements call for span drift to be reported as percent of range, the calculation will be made based on the range specified in the regulations.

If the data is being collected with a strip chart recorder attached to one of the analog outputs, the span error is typically reported as a percent of the upper range limit (URL) of the recorder. In this case, record the analyzer's response in % of scale as A_{80}, and compute the span error from the following equation:

Span Error, % = $(((A_{80} - Z)*(URL/100)) - [CO]) * (100 / [CO])$

Where:

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

[CO] = Span concentration

URL: The current full-scale range setting

For more information on regulatory requirements regarding reporting of zero and span errors, please consult the latest copy of the *Quality Assurance Handbook for Air Pollution Measurement Systems*[1] and for detailed guidance in setting up a quality assurance program, refer to the *Code of Federal Regulations* and the *EPA Handbook on Quality Assurance*.

Automatic Zero and Span Adjustment

While the gas-filter correlation IR measurement method used by this analyzer can provide highly specific, accurate and precise data, the ability to make continuous measurements at low ppm concentrations may be limited by gradual changes in electronic baseline, or zero background. This drift occurs primarily due to slight changes in environmental parameters, such as temperature. The enhanced trace level version of the 48*i* CO analyzer uses both hardware and software compensation to limit the impact of changes in the instrument's environment. One key feature that is included in the instrument design is an auto-zeroing function that allows the instrument to automatically check and adjust the zero background on a periodic basis.

The auto-zero feature includes a solenoid valve that re-routes the sample stream through an internal CO scrubber at an interval that is programmed by the operator. Typically, the auto-zero will have a duration of ten minutes and will be programmed to occur once every two hours.

While the auto-zero function greatly improves instrument stability, it is not intended to replace the routine calibration procedures described in this chapter.

In addition to the automatic zero function, the Model 48*i* Trace Level-Enhanced also includes the capability for fully automated span testing and/or adjustment. In order to use this feature, the span gas cylinder must be connected directly to the Span In bulkhead on the rear panel of the instrument. The span gas pressure should be set to 10 ± 2 psi and the operator should verify that the flow rate of span gas is enough to provide a small excess over what the instrument pump will draw.

Although the automatic zero and span functions are designed to operate from the same internal timer, the choice of whether to adjust or simply check each parameter is made independently. Thermo Electron suggests that the auto-zero should be programmed to make an actual adjustment every two hours, but that recommendation does not apply to the automatic span. In general, the span factor is less affected by changes in the operating environment and will hold stable for a period of weeks without any adjustment. In addition, some air monitoring regulations may prohibit automatic span adjustments.

Based on experience with the analyzer, the operator may decide to alter the zero adjustment frequency and whether to add automatic span checking or adjustment. For detailed instruction on programming the automatic zero and span checking or adjustment, see “Zero/Span Check” on page XX.

References

1. Section 12 of EPA-454/R-98-004, *Quality Assurance Handbook for Air Pollution Measurement Systems*, Volume II, Part 1, August 1998, available at www.epa.gov/ttn/amtic/qabook.html, and 40 CFR 50, Appendix C “Measurement Principle and Calibration Procedure for the Measurement of Carbon Monoxide in the Atmosphere (Non-Dispersive Infrared Photometry)”.

   Section 12 also provides information on “Calibration of Primary and Secondary Standards for Flow Measurements”.

   Specific information on certification of concentration standards is given in EPA-600/R93/224, *EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards*, 1993 Available from www.NTIS.gov (PB94130424).

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, solenoid valves, and IR source, which have a limited life.

Other operations such as cleaning the optics and checking the calibration of the pressure and temperature transducers should be performed on a regular basis.

This chapter includes the following maintenance information and replacement procedures:

- "Safety Precautions" on page 5-1
- "Replacement Parts" on page 5-2
- "Cleaning the Outside Case" on page 5-2
- "Cleaning the Optics" on page 5-2
- "Capillary Cleaning or Replacement" on page 5-3
- "IR Source Replacement" on page 5-4
- "Fan Filter Inspection and Cleaning" on page 5-4
- "Leak Test and Pump Check Out" on page 5-5
- "Pump Rebuilding" on page 5-6

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 Do not attempt to lift the instrument by the cover or other external fittings. ▲

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 the "Servicing" chapter for a list of replacement parts and the associated replacement procedures.

WARNING If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired Do not attempt to lift the instrument by the cover or other external fittings. ▲

Cleaning the Outside Case

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. ▲

Cleaning the Optics

Best results are obtained when the optics are cleaned prior to calibration. The cleanliness of the mirrors should be checked any time the AGC intensity is below 200000 Hz, since one cause of low output is light attenuation due to dirt on the mirrors.

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the "Servicing" chapter. ▲

Use the following procedure to clean the mirrors.

2. Turn off power and disconnect power line.

3. Remove the field mirror by removing the four Allen head screws holding it to the main bench (use a 9/64-inch Allen wrench).

4. Carefully clean each mirror using a cotton swab and methanol. Rinse with distilled or deionized water. Dry by blowing clean dry air over the mirror.

5. Reassemble following the above procedure in reverse. It is not necessary to realign any mirror following cleaning.

6. Calibrate the instrument. See the "Calibration" chapter in this manual.

Capillary Cleaning or Replacement

Use the following procedure to clean or replace the capillaries (Figure 5–1).

Equipment Required:

Wrench, 5/8-inch

Capillary

Capillary cleaning wire (smaller than 0.018-inch)

Capillary cleaning wire (smaller than 0.006-inch)

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 sample flow capillary from the inlet elbow fitting on the pump head and clean with a wire smaller than 0.018 diameter/or replace.

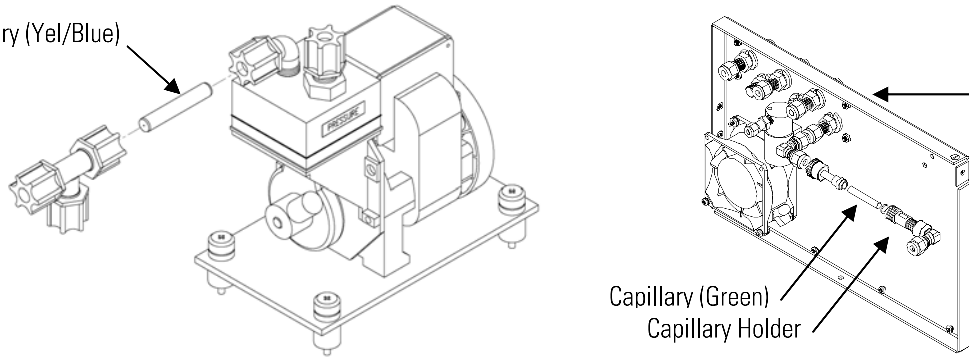


Figure 5–1. Cleaning or Replacing the Capillaries

3. Remove purge capillary from capillary holder on rear panel and clean with a wire smaller than 0.006-inch diameter/or replace.

4. Install the capillary by following the previous steps in reverse.

IR Source Replacement

The IR source control system has been designed to operate the wire wound resistor IR source conservatively in order to increase its life. Nevertheless, the IR source does have a finite life. Since the IR source is relatively inexpensive and easily replaced, it is recommended that the IR source be replaced after one year of continuous use. This will prevent loss of data due to IR source failure. If an IR source is to be replaced on an as needed basis, it should be replaced when:

- There is no light output
- After cleaning the optics, the IR light intensities remain below 100000 Hz

It is not necessary to recalibrate the Model 48*i* Trace Level-Enhanced after replacing the IR source since it is a ratio instrument, and replacing the IR source does not affect the calibration.

Fan Filter Inspection and Cleaning

Use the following procedure to inspect and clean the fan filter (Figure 5–2).

1. Remove the fan guard from the fan and remove the filter.

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 guard.

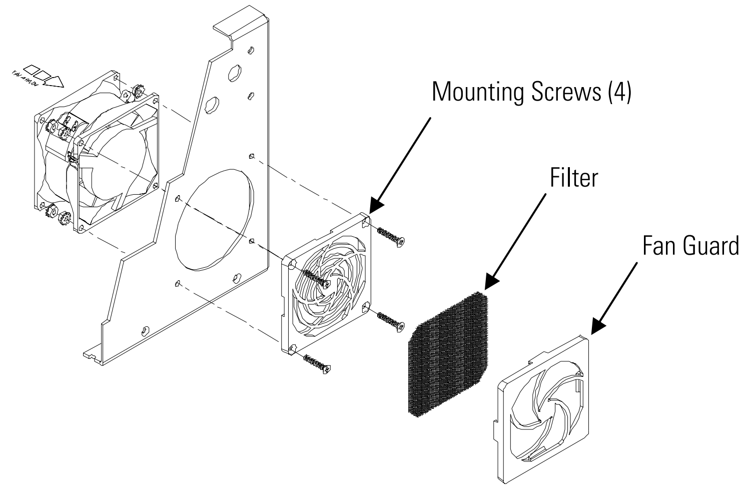


Figure 5–2. Inspection and Cleaning the Fan

Leak Test and Pump Check Out

There are two major types of leaks: external leaks and leaks across the optional zero/span solenoid valve seals.

External Leaks

Use the following procedure to test for external leaks.

1. Disconnect the sample input line and plug the SAMPLE fitting.

2. Press [MENU] to display the Main Menu.

3. Press [↓] to move the cursor to Diagnostics and press [↵] to display the Diagnostics menu.

4. Press [↓] to move the cursor to Flow and press [↵] to display the Sample Flow screen. The flow reading should indicate zero flow and the pressure reading should be less than 250 mmHg. If not, check to see that all fittings are tight and that none of the input lines are cracked or broken. For detailed information about this screen, refer to the "Operation" chapter.

If the pump diaphragm is in good condition and the capillary not blocked, it should take less than one minute from the time the inlet is plugged to the time the reading below 250 mmHg is obtained.

Leaks Across the Optional Zero/Span and Sample Solenoid Valves

In order to check for leaks across the optional valves, plug the SPAN inlet line, press ▶ until span appears in the status line and follow the "External Leaks" procedure.

If the pressure drops below 250 mmHg the valve associated with the span line is functioning normally. Repeat for the valve associated with the zero line by plugging the zero inlet, press ▶ until zero appears in the status line and follow the "External Leaks" procedure.

If the pressure drops below 250 mmHg, the valve associated with the zero line is functioning normally.

Pump Rebuilding

Use the following procedure to rebuild the pump (Figure 5–3). To replace the pump, see "Pump Replacement" on page 7-20.

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 ground 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. 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.

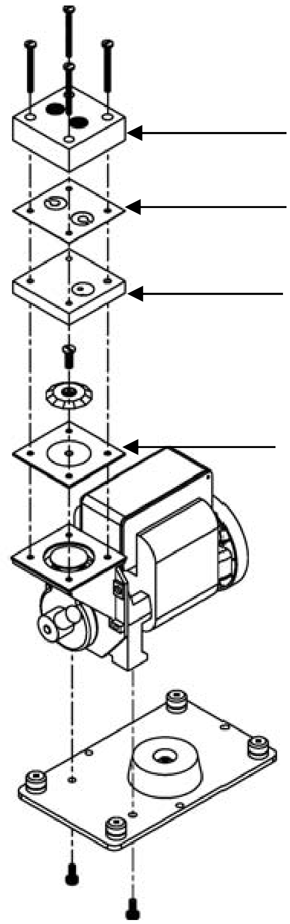


Figure 5–3. Rebuilding the Pump

4. Remove the screw 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. Perform the "Leak Test and Pump Check Out" on page 5-5.

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 Technical Support Department at Thermo Electron can also be consulted in the event of problems. See "Service Locations" on page 6-24 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 "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 troubleshooting information egarding power-up failures and indicates the checks that you should perform if you experience an instrument problem.

Table 6–2 provides troubleshooting information regarding calibration failures and indicates checks that you should perform if you experience a calibration problem.

Table 6–3 provides troubleshooting information regarding measurement failures and indicates checks that you should perform if you experience a calibration problem.

Table 6–4 Troubleshooting – Alarm Messages lists all the alarm messages you may see on the display and provides recommendations about how to resolve the alarm condition.

Table 6–1. Troubleshooting – Power-Up Failures

Malfunction	Possible Cause	Action
Does not start (The light on display does not come on and the pump motor is not running.	No power or wrong power configuration	Check the line to confirm that power is available and that it matches the voltage and frequency configuration of the instrument.
	Main fuse is blown or missing	Unplug the power cord, open the fuse drawer on the back panel, and check the fuses visually or with a multimeter.
	Bad switch or wiring connection	Unplug the power cord, disconnect the switch and check operation with a multimeter.
Display does not come on (Pump is running)	DC power supply failure	Check that the green LED on the back edge of the power supply is on. If not, the power supply has failed.
	DC power distribution failure	Check surface mount LEDs labelled “24V PWR” on the motherboard and measurement interface board. If lit, power is OK. Check for 24VDC from the power supply using a voltmeter. Unplug power cables to motherboard, measurement interface board and rear panel to determine where the fault is.
	Display failure	If possible, check instrument function through RS-232 or Ethernet. Contact Thermo Electron Service Deparment.

Malfunction	Possible Cause	Action
Power comes on and the display functions, but the pump is not running.	AC power is not reaching the pump.	Locate the three-pin connector on the interface board and use a voltmeter to check AC voltage across the two black wires (should read 110 - 120V, even on 220V or 100V instruments).
	Pump is jammed due to a new or stiff diaphragm.	Carefully rotate the pump fan to get past sticking point.
	Pump bearings have failed.	Disconnect AC power and remove the gas lines from the pump head, then try to rotate the pump fan. If it is jammed, or noisy, the motor bearings may have failed.

Table 6–2. Troubleshooting – Calibration Failures

Malfunction	Possible Cause	Action
Analyzer does not calibrate properly	System leak	Find and repair leak.
	Pressure or temperature transducer out of calibration	Recalibrate pressure and temperature transducer.
	Dirty system	Clean cells and flow components.
	Leaky correlation wheel	Replace with a known good wheel.
Cannot zero instrument or there is a high background signal when sampling zero air.	Zero air flow rate is inadequate.	Check by-pass or atmospheric pressure vent to verify that the zero air system is providing more flow than the instrument is drawing.
	Instrument is not drawing in span gas.	Check sample Flow and Pressure readings on the Diagnostics screen.
		Use an independent flow meter to check flows at the sample inlet and exhaust bulkheads (they should match).
		Perform a leak test, as described in the "Preventive Maintenance" chapter.

Malfunction	Possible Cause	Action
	Internal or external lines, filters, and other sample handling equipment are contaminated or dirty.	Replace inlet filter (if installed) and as much of the tubing as possible.
Instrument appears to zero, but there is weak or no response to span gas.	Span cylinder empty	Check the source pressure.
	Calibration system failure	Check solenoids or other hardware to be sure that span gas is being delivered.
	Flow rate of the diluted span mix is inadequate.	Check by-pass or atmospheric vent to verify that the zero air system is providing more flow than the instrument draws.
	Instrument is not drawing in span gas.	Check sample Flow and Pressure readings on the Diagnostics screen.
		Use an independent flow meter to check flows at the sample inlet and exhaust bulkheads (they should match).
		Perform a leak test, as described in the "Preventive Maintenance" chapter.
	IR Source has failed.	Check the IR Source intensity, replace source.
Zero or Span will not stabilize.	Flow rate of the diluted span mix is inadequate.	Check by-pass or atmospheric pressure vent to verify that the zero air system is providing more flow than the instrument is drawing.
	Instrument is not drawing in span gas.	Check sample Flow and Pressure readings on the Diagnostics screen.
		Use an independent flow meter to check flows at the sample inlet and exhaust bulkheads (they should match).
		Perform a leak test, as described in the "Preventive Maintenance" chapter.

Malfunction	Possible Cause	Action
	Averaging time is not set correctly.	Check the Averaging Time in Main Menu. If too high, the unit will be slow to stabilize. If too low, the signal may appear noisy.

Table 6–3. Troubleshooting – Measurement Failures

Malfunction	Possible Cause	Action
Reduced response or no response to sample gas with alarm(s) indicated.	Undefined electronic failure or pump failure	Check alarm screens and the diagnostic voltage screen to localize fault.
		Check the response to known span gas.
	Instrument is not drawing in sample as expected.	Check sample Flow and Pressure readings on the Diagnostics screen.
		Use an independent flow meter to check flows at the sample inlet and exhaust bulkheads (they should match).
		Perform a leak test, as described in the "Preventive Maintenance" chapter.
Reduced response or no response to sample gas with no alarms indicated.	Instrument is not drawing in sample as expected.	Check sample Flow and Pressure readings on the Diagnostics screen.
		Use an independent flow meter to check flows at the sample inlet and exhaust bulkheads (they should match).
		Perform a leak test, as described in the "Preventive Maintenance" chapter.
		Check the external plumbing for leaks or other problems.
	Instrument is not properly calibrated.	Go to the Calibration Factors menu and verify that the Background and Coefficient are set appropriately.

Malfunction	Possible Cause	Action
Span calibration coefficient outside acceptable limits of 0.5 – 2.0.	Bad span gas	Verify quality of span gas.
	System leak	Perform leak test.
	Insufficient calibrator flow	Verify calibrator is providing a flow of at least 1.0 LPM.
Excessive response time	Averaging time is not set correctly.	Go to Averaging Time (Main Menu) and verify setting.
	Instrument is not drawing in sample at normal flow rate.	Check sample Flow and Pressure readings on the Diagnostics screen.
		Use an independent flow meter to check flows at the sample inlet and exhaust bulkheads (they should match).
		Perform a leak test, as described in the "Preventive Maintenance" chapter.
Analog signal doesn't match expected value.	Software has not been configured.	Verify that the selected analog output has been properly configured to match the data system.
	Recorder is drawing down output.	Verify that the recorder or data logger input impedance meets minimum requirements.
Pressure transducer does not hold calibration or is noisy	Pressure transducer defective	Replace pressure transducer.
No output signal (or very low output)	No sample gas reaching the analyzer	Check input sample flow
	Ruptured pump diaphragm	Rebuild pump head
	Blocked sample capillary	Clean or replace capillary
Run output noisy	Recorder noise	Replace or repair recorder.
	Sample CO concentration varying	Run instrument on a span CO source - if quiet, there is no malfunction.
	Foreign material in optical bench	Clean optical bench.

Table 6–4. Troubleshooting – Alarm Messages

Malfunction	Possible Cause	Action
Alarm - Internal Temp	Instrument overheating	Replace fan if not operating properly.
		Clean or replace foam filter, refer to "Preventive Maintenance" chapter in this manual.
		Check 10K ambient thermistor mounted on the filter motor, replace if bad.
Alarm - Chamber Temp	Chamber temperature below set point of 48 °C	Check 10K ohm thermistor, replace if bad.
		Check measurement interface board to insure the bench heater LED is coming on. If not, measurement interface board could be defective.
	Heaters have failed	Check bench heater connector pins for continuity..
Alarm - Pressure	High pressure indication	Check plumbing for leaks.
		Check the pump for a tear in the diaphragm, replace with pump repair kit if necessary.
		Refer to "Preventive Maintenance" chapter in this manual. Check that capillaries are properly installed and O-rings are in good shape. Replace if necessary. Check flow system for leaks.
Alarm - Flow	Flow low	Check sample capillary for blockage. Replace as necessary.
		If using sample particulate filter make sure it is not blocked. Disconnect sample particulate filter from the sample bulkhead, if flow increases, replace the filter.
Alarm - Bias voltage	Defective measurement interface board	Replace measurement interface board.
	Defective pre-amp board	Replace pre-amp board.

Malfunction	Possible Cause	Action
Alarm - AGC intensity	Pre-amp Gain not set properly	Check Gain adjustment.
	Defective measurement interface board	Replace measurement interface board.
Alarm - Motor Speed	Defective measurement interface board	Replace measurement interface board.
	Defective chopper motor or cable	Check chopper motor cable. Replace chopper motor.
Alarm – Scrubber Gas Conc.	Test gas not good	Check test gas cylinder is attached correctly and not empty. Check gas supplier is working properly. Check test gas concentration is within set limits.
	System leak	Perform a leak test, as described in the "Preventive Maintenance" chapter.
Alarm – Scrubber Eff.	Scrubber failure	Replace/recharge the scrubber.
	System leak	Perform a leak test, as described in the "Preventive Maintenance" chapter.
Alarm – Scrubber Test Done	Test did not complete	Rerun test. Check test gas concentration (See Sscrubber Gas Conc. Alarm).
Alarm - CO 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 - Zero Check Alarm - Span Check	Instrument out of calibration	Recalibrate instrument.
Alarm - Zero Autocal Alarm - Span Autocal		Check gas supply. Perform manual calibration.
Alarm - Motherboard Status Alarm - Interface Status Alarm - I/O Exp Status	Internal cables not connected properly Board is defective	Check that all internal cables are connected properly. Recycle AC power to instrument. If still alarming, change 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 6–5 through Table 6–10 to troubleshoot board-level faults.

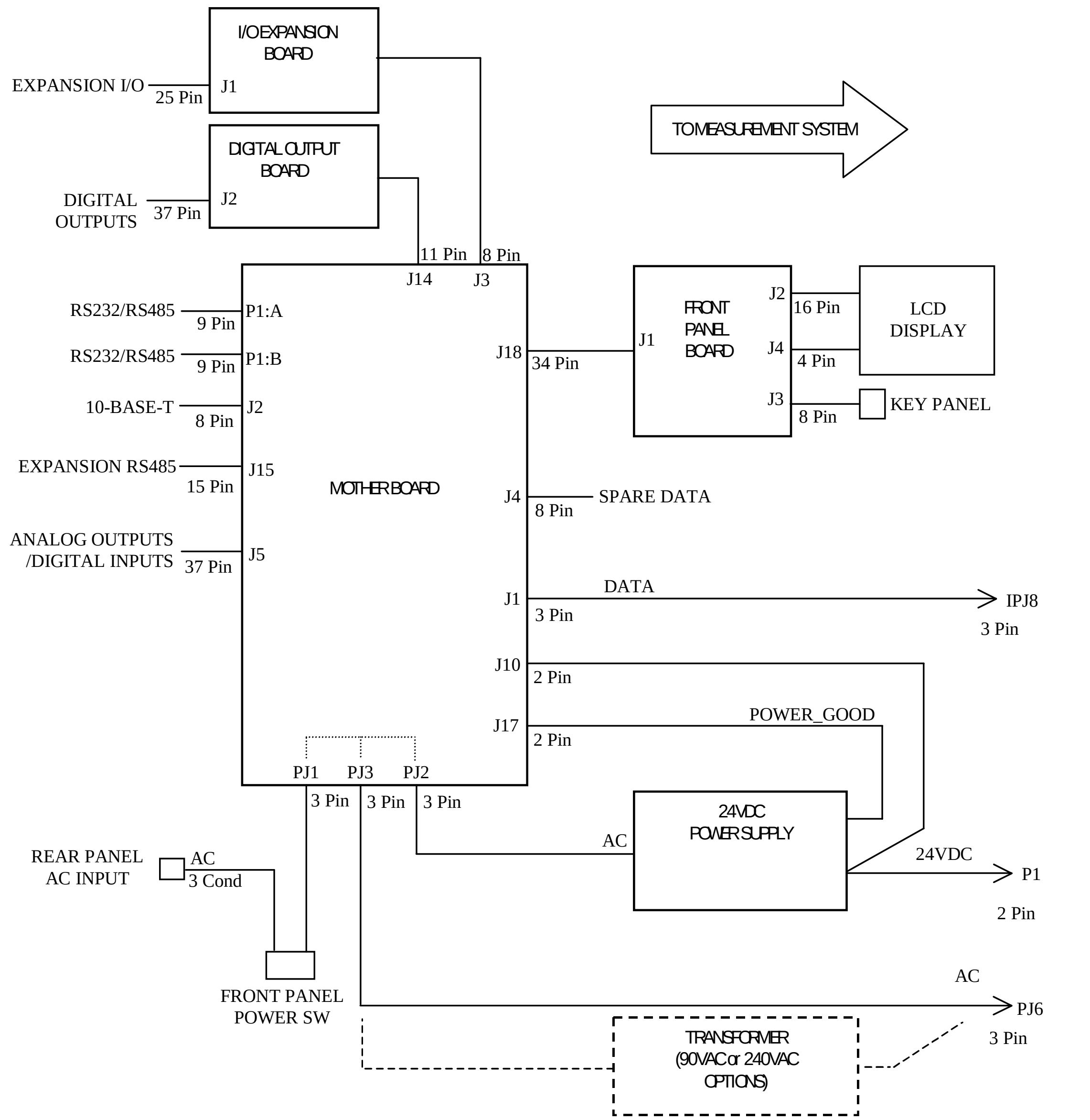


Figure 6–1. Board-Level Connection Diagram - Common Electronics

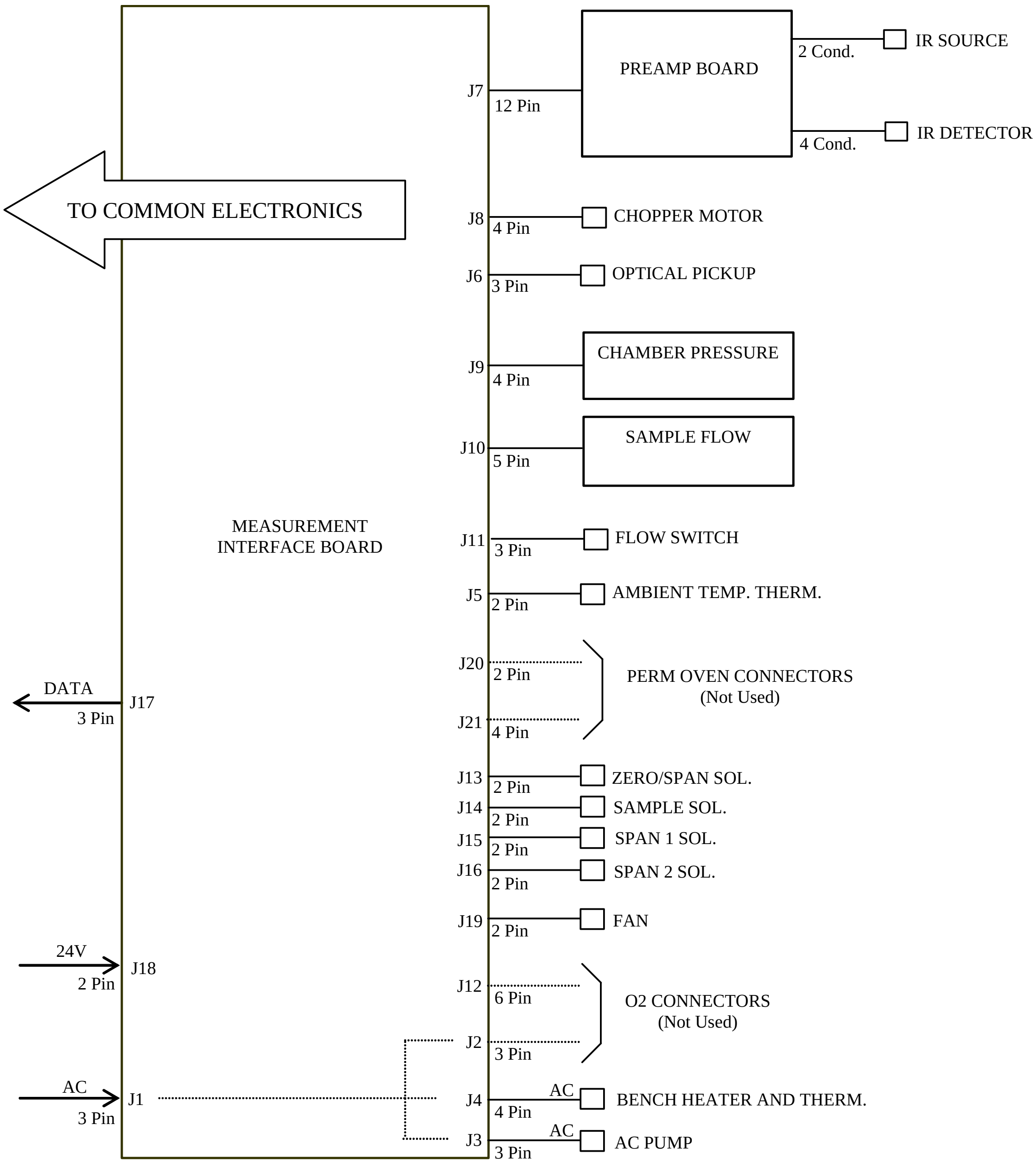


Figure 6–2. Board-Level Connection Diagram - Measurement System

Connector Pin Descriptions

The connector pin descriptions in Table 6–5 through Table 6–10 can be used along with the board-level connection diagrams to troubleshoot board-level faults.

"Motherboard Connector Pin Descriptions" on page 6-11

"Measurement Interface Board Connector Pin Descriptions" on page 6-16

"Front Panel Board Connector Pin Diagram" on page 6-18

"I/O Expansion Board (Optional) Connector Pin Descriptions" on page 6-20

"Digital Output Board Connector Pin Descriptions" on page 6-21

"Pre-amp Board Connector Pin Descriptions" on page 6-23

Table 6–5. 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 (-)
		3	Ethernet Input (+)
		4	NC
		5	NC

Connector Label	Reference Designator	Pin	Signal Description
		6	Ethernet Input (-)
		7	NC
		8	NC
EXPANSION BD	J2	1	+5V
		2	+24V
		3	+24V
		4	Ground
		5	Ground
		6	Ground
		7	+RS485 to Expansion Board
		8	-RS485 to Expansion Board
SPARE DATA	J12	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
		12	TTL Input 15
		13	Ground
		14	Analog Voltage 1
		15	Analog Voltage 3

Connector Label	Reference Designator	Pin	Signal Description
		16	Ground
		17	Analog Voltage 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 2
		34	Analog Voltage 4
		35	Ground
		36	Analog Voltage 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
		4	Ground
		5	Ground
		6	Ground
		7	SPI Reset
		8	SPI Input

Connector Label	Reference Designator	Pin	Signal Description
		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	+24
		12	+24
		13	+24
		14	+24
		15	+24
24 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
		8	LD4 – LCD Signal
		9	LD0 – LCD Signal
		10	LD5 – LCD Signal
		11	LD1 – LCD Signal
		12	LD6 – LCD Signal
		13	LD2 – LCD Signal

Connector Label	Reference Designator	Pin	Signal Description
		14	LD7 – LCD Signal
		15	LD3 – LCD Signal
		16	LCD Bias Voltagel
		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
		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

Connector Label	Reference Designator	Pin	Signal Description
		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	J1	1	AC-HOT
		2	AC-NEUT
		3	AC-Ground
AC INTF BD	PJ3	1	AC-HOT
		2	AC-NEUT
		3	AC-Ground

Table 6–6. Measurement Interface Board Connector Pin Descriptions

Connector Label	Reference Designator	Pin	Signal Description
DATA	J17	1	Ground
		2	+RS485 from Motherboard
		3	-RS485 from Motherboard
PREAMP BD	J7	1	Preamp Signal Input
		2	Ground for Shield
		3	Ground
		4	SPI – Data Out
		5	SPI - CLK
		6	SPI - CS
		7	+15V
		8	+5V
		9	+18V for IR Source
		10	Ground
		11	-100V
		12	-100V Return

Connector Label	Reference Designator	Pin	Signal Description
PRES	J9	1	Pressure Sensor Input
		2	Ground
		3	+15V
		4	-15V
FLOW	J10	1	Flow Sensor Input
		2	Ground
		3	+15V
		4	-15V
		5	Ground
AMB TEMP	J5	1	Ambient Temperature Thermistor
		2	Ground
O2 SENS	J2	1	Sensor Signal Input
		2	Ground
		3	Temperature Signal Input
		4	Ground
		5	+15V
		6	-15V
AC BENCH	J4	1	BENCH THERMISTOR
		2	Ground
		3	AC-HOT
		4	AC-BENCH HEATER
24V IN	J18	1	+24V
		2	Ground
FAN	J18	1	+24V
		2	Ground
AC PUMP	J3	1	AC-HOT
		2	AC-NEUT
		3	AC-Ground
Z/S SOL.	J13	1	+24V
		2	Zero/Span Solenoid Control
SAMPLE SOL.	J14	1	+24V
		2	Sample Solenoid Control
SPAN1 SOL.	J15	1	+24V
		2	Converter Solenoid Control

Connector Label	Reference Designator	Pin	Signal Description
SPAN2 SOL.	J16	1	+24V
		2	Span 2 Solenoid Control
AC O2	J3	1	AC-HOT
		2	AC-NEUT
		3	AC-Ground
PERM OVEN THERM	J20	1	Perm Oven Gas Thermistor
		2	Ground
PERM OVEN	J21	1	Perm Oven Heater On/Off
		2	+15V_PWR
		3	Perm Oven Thermistor
		4	Ground
FLOW SW	J11	1	N.C.
		2	Ground
		3	Purge Flow Signal Input
MOT DRV	J8	1	Motor Drive Voltage 1
		2	Motor Drive Voltage 2
		3	Motor Drive Voltage 3
		4	Motor Drive Voltage 4
OPT	J6	1	Optical Pickup Signal Input
		2	Ground
		3	Optical Pickup Power

Table 6–7. Front Panel Board Connector Pin Diagram

Connector Label	Reference Designator	Pin	Signal Description
MOTHERBOARD	J1	1	Ground
		2	Ground
		3	LCLK – LCD Signal
		4	Ground
		5	Ground
		6	LLP – LCD Signal
		7	LFLM – LCD Signal
		8	LD4 – LCD Signal

Connector Label	Reference Designator	Pin	Signal Description
		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 Voltagel
		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	LD0_5V – LCD Signal
		2	LD1_5V – LCD Signal
		3	LD2_5V – LCD Signal
		4	LD3_5V – LCD Signal
		5	LCD_ONOFF_5V – LCD Signal
		6	LFLM_5V – LCD Signal
		7	NC
		8	LLP_5V – LCD Signal

Connector Label	Reference Designator	Pin	Signal Description
		9	LCLK_5V – LCD Signal
		10	+5V
		11	Ground
		12	-25V
		13	LCD Bias Voltage
		14	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	+5 Supply
		2	NC
		3	Ground

Table 6–8. 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
		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

Connector Label	Reference Designator	Pin	Signal Description
		13	Current Output Return
		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 6–9. 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

Connector Label	Reference Designator	Pin	Signal Description
		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
		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

Connector Label	Reference Designator	Pin	Signal Description
		31	+24V
		32	+24V
		33	+24V
		34	+24V
		35	+24V
		36	+24V
		37	+24V

Table 6–10. Pre-amp Board Connector Pin Descriptions

Connector Label	Signal Description
OUT	Preamp Signal Output
SH	Ground for Shield
BLK	Ground
GRN	SPI – Data Out
ORG	SPI - CLK
VIO	SPI - CS
BLU	+15V
BRN	+5V
RED	+18V for IR Source
WHT	-100V
BLK	+18V for IR Source
YEL	IR Source Return
YEL	IR Detector Return
RED	IR Detector Cooler +
BLK	IR Detector Cooler -
WHT	IR Detector
WHT	IR Detector

Service Locations

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

866-282-0430 Toll Free

508-520-0430 International

Chapter 7
Servicing

This chapter explains how to replace the Model 48*i* Trace Level-Enhanced 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 "Operation" chapter in this manual.

The service mode described 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 7-39.

This chapter includes the following parts information and component replacement procedures:

Safety Precautions

Read the safety precautions before beginning any procedures in this chapter.

WARNING The service procedures in this manual are restricted to qualified representatives. ▲

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲

CAUTION Carefully observe the instructions in each procedure. ▲

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 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. ▲

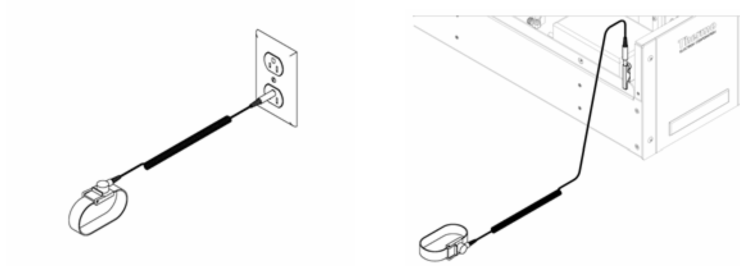


Figure 7–1. Properly Grounded Antistatic Wrist Strap

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 *iPort* manual for the firmware update procedure.

Accessing the Service Mode

If the Service Mode 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.

Replacement Parts List

Table 7–1 lists the replacement parts for the Model 48*i* Trace Level-Enhanced major subassemblies. Refer to Table 7–2 to identify the component location.

Table 7–1. Model 48*i* Trace Level-Enhanced Replacement Parts

Part Number	Description
100480-00	Front Panel Pushbutton Board
101491-12	Processor Board
100533-00	Motherboard
100539-00	Digital Output Board
100542-00	I/O Expansion Board (Optional)
102340-00	Front Panel Connector Board
102496-00	Front Panel Display
100399-00	Transformer, 220-240VAC (Optional)
101863-00	Transformer, 100VAC (Optional)
100868-00	Measurement Interface Board
101780-00	Detector Assembly
101686-00	Heater Board Assembly
101023-00	Pressure Transducer
102055-00	Flow Transducer (Sample)
101390-00	Solenoid Valve
101426-00	Pump 110 VAC w/Plate and Fittings
8606	Pump Repair Kit (for 101426-00)
101055-00	AC Receptacle Assembly
101681-00	Power Supply Assembly, 24VDC, w/Base Plate and Screws
100907-00	Fan, 24VDC
4510	Fuse, 250VAC, 3.0 Amp, SlowBlow (for 100VAC and 110VAC models)
14007	Fuse, 250VAC, 1.60 Amp, SlowBlow (for 220-240VAC models)
8919	Capillary, 0.018-inch ID (Yel/Blue)
4115	Capillary, 0.006-inch ID (Green)

Part Number	Description
8630	Filter Guard Assembly (w/foam)
7361	I/R Source
101424-00	Optical Switch
7193	Relay Mirror
7194	Field Mirror
7195	Entrance Mirror
7196	Exit Mirror
7358	Filter, Wheel Assembly
101427-00	Chopper Motor
102949-00	Ambient Temperature Sensor Assembly
102418-00	CO Scrubber

Cable List

Table 7–2 describes the Model 48*i* Trace Level-Enhanced cables. See the "Troubleshooting" chapter for associated connection diagrams and board connector pin descriptions.

Table 7–2. Model 48*i* Trace Level-Enhanced 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	Power Switch to Motherboard
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
101267-00	Fan Power Cable

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 (optional) Included with optional I/O Board in all instruments.

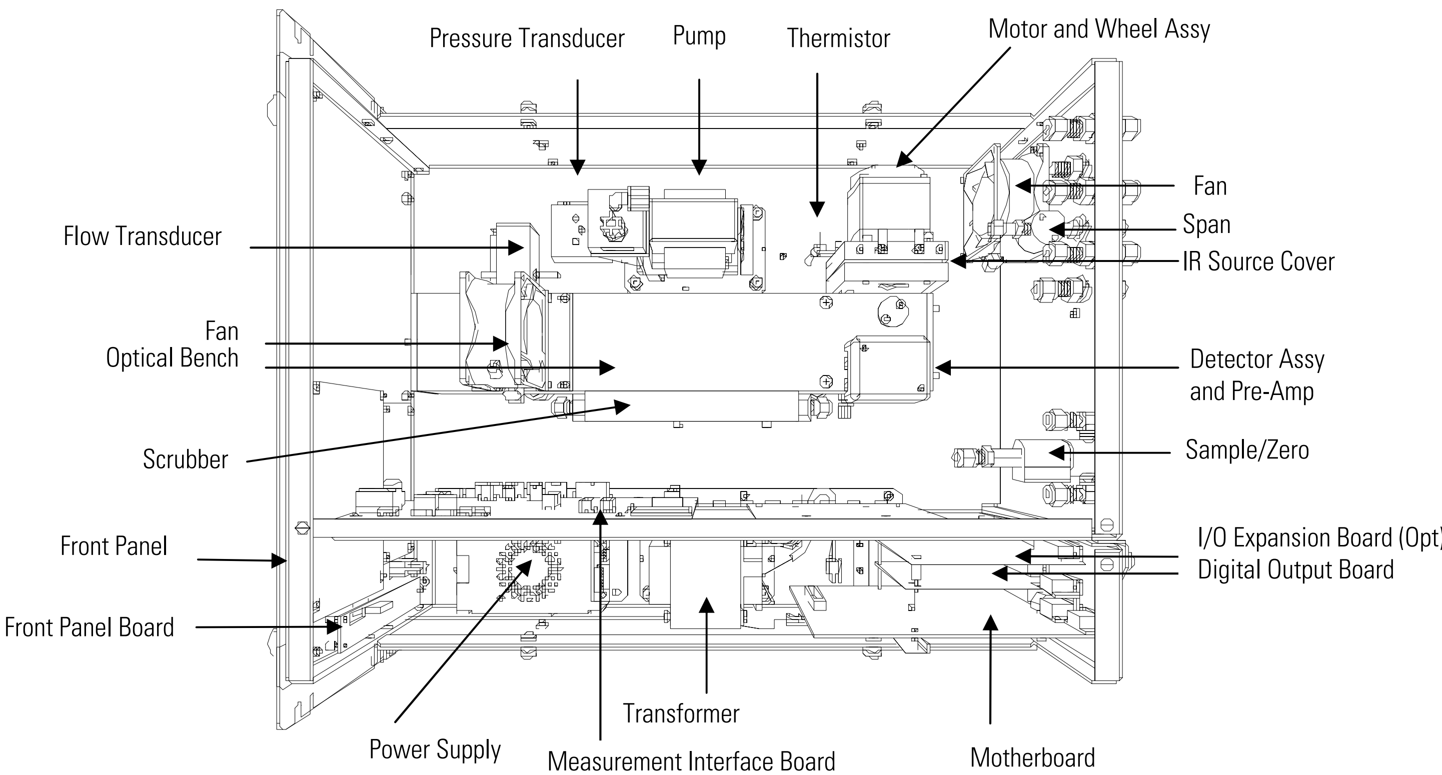


Figure 7–2. Component Layout

Removing the Measurement Bench and Lowering the Partition Panel

The partition panel of the measurement bench 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).

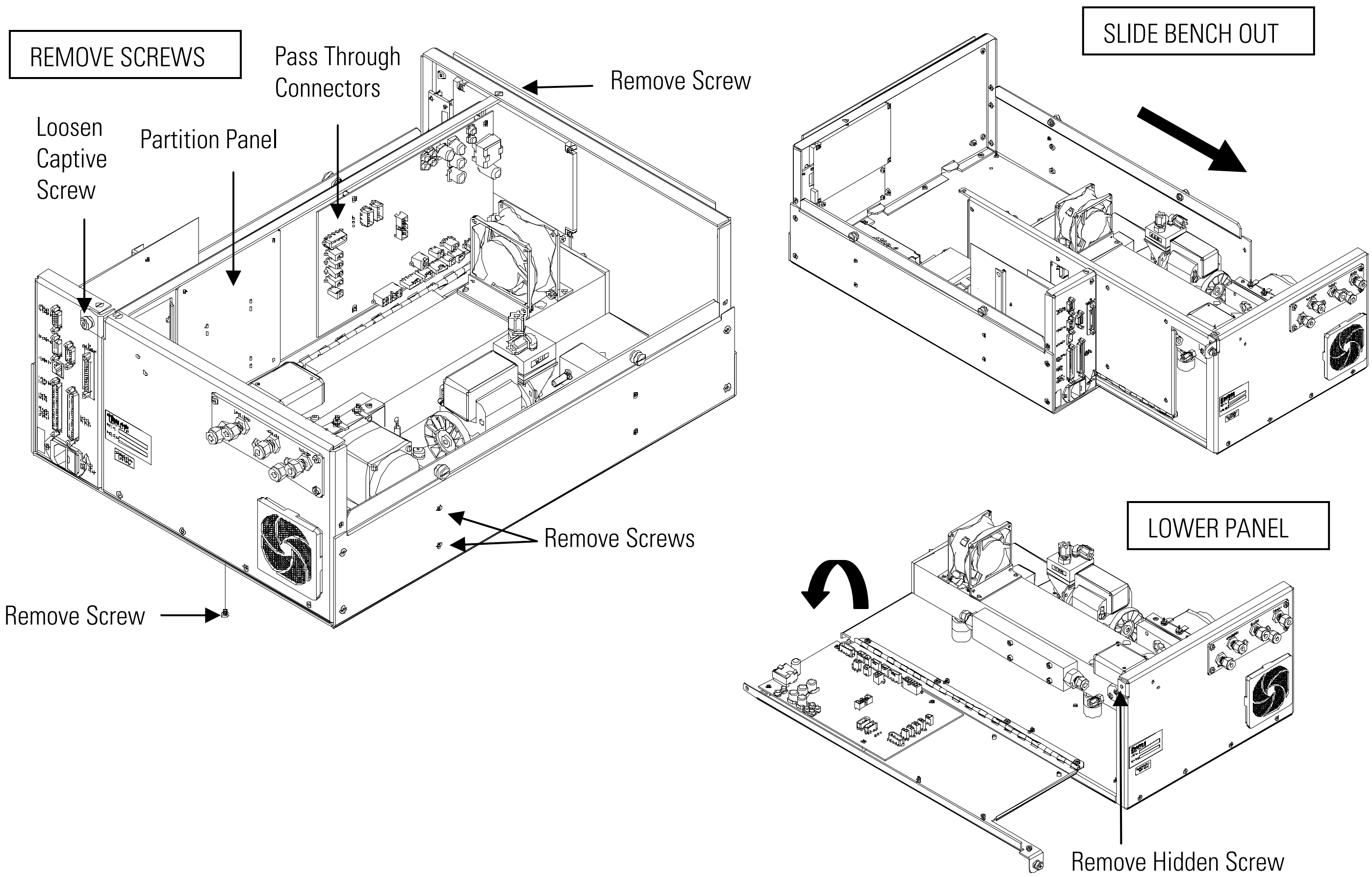


Figure 7–3. Removing the Measurement Bench and Lowering the Partition Panel

Equipment Required:

Philips screwdriver

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground antistatic wrist strap must be worn while handling any internal component. ▲

1. Turn instrument OFF and unplug the power cord.

2. If the instrument is mounted in a rack, remove it from the rack.

3. Remove the cover.

4. Disconnect the plumbing connections at the rear of the measurement bench.

5. Disconnect the three connectors that pass through the center of the partition panel.

6. Remove two screws from the left side of the case (viewed from front).

7. Remove one screw from the bottom front 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.

Rear Panel Fan Replacement

Use the following procedure to replace the rear panel fan (Figure 7–4).

Equipment Required:

Fan

Philips screwdriver

Adjustable wrench

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 fan guard from the fan and remove the filter.

3. Pull the power connectors off the fan.

4. Remove the four fan mounting screws and remove the fan.

5. Install a new fan following the previous steps in reverse.

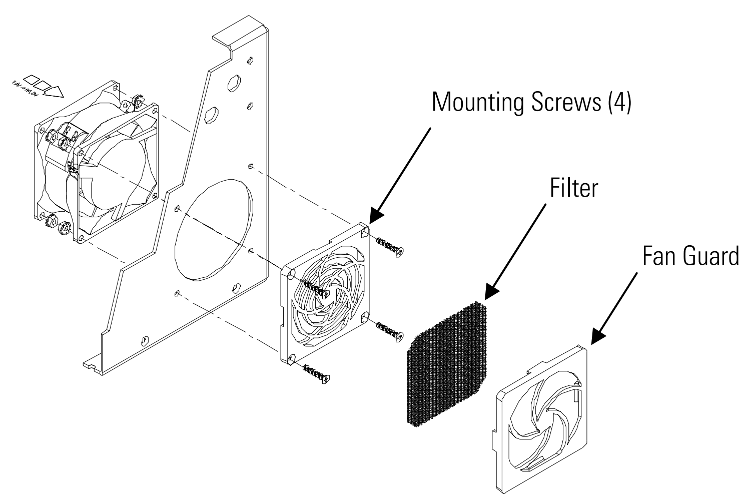


Figure 7–4. Replacing the Rear Panel Fan

Bench Fan Replacement

Use the following procedure to replace the bench fan (Figure 7-5).

Equipment Required:

Fan

Philips screwdriver

Adjustable wrench

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground antistatic wrist strap must be worn while handling any internal component. ▲

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Pull the power connectors off the fan.

3. Remove the four bench mounting screws and remove the fan from the optical bench.

4. Remove the four fan mounting screws holding the fan brackets to fan.

5. Install a new fan following the previous steps in reverse.

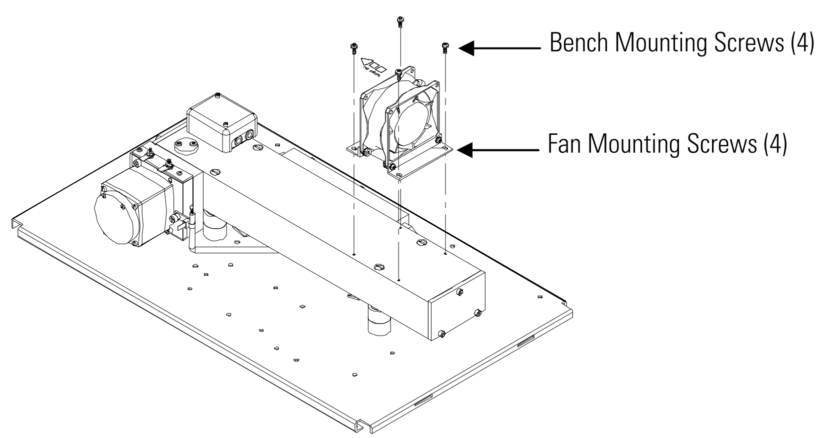


Figure 7–5. Replacing the Bench Fan

IR Source Replacement

Use the following procedure to replace the IR source (Figure 7–6).

Equipment Required:

IR Source

Flatblade screwdriver

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground antistatic wrist strap must be worn while handling any internal component. ▲

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Wait for the IR source assembly to cool down.

3. Remove the two cover screws holding the IR source cover to the motor plate and remove the IR source cover (Figure 7–6).

4. Loosen both clamp screws from the IR source mounting posts and remove IR source.

5. Install a new IR source by following the previous steps in reverse. Ensure that the IR source element is evenly spaced between the mounting posts.

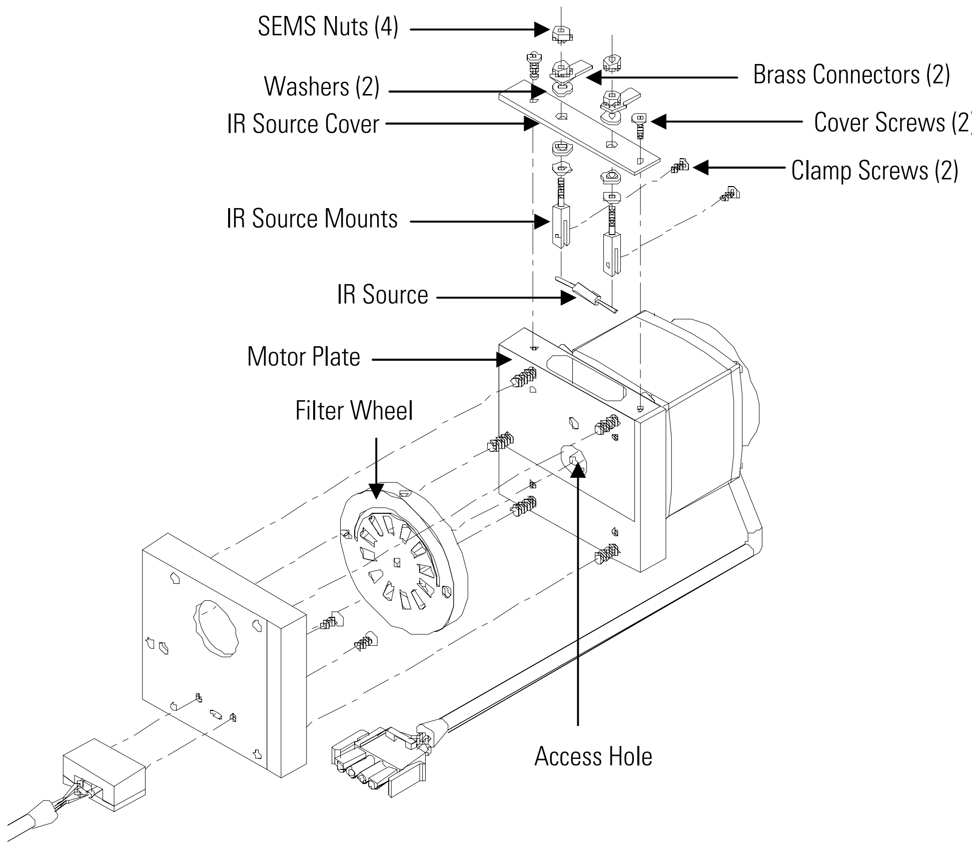


Figure 7–6. Replacing the IR Source

Filter Wheel Replacement

Use the following procedure to replace the filter wheel.

Equipment Required:

Filter wheel

Allen wrenches, 5/32-inch and 5/64-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 chopper motor and wheel assembly by removing the three motor plate Allen screws holding the motor plate to the optical bench (Figure 7–7). Disconnect purge tube from wheel housing.

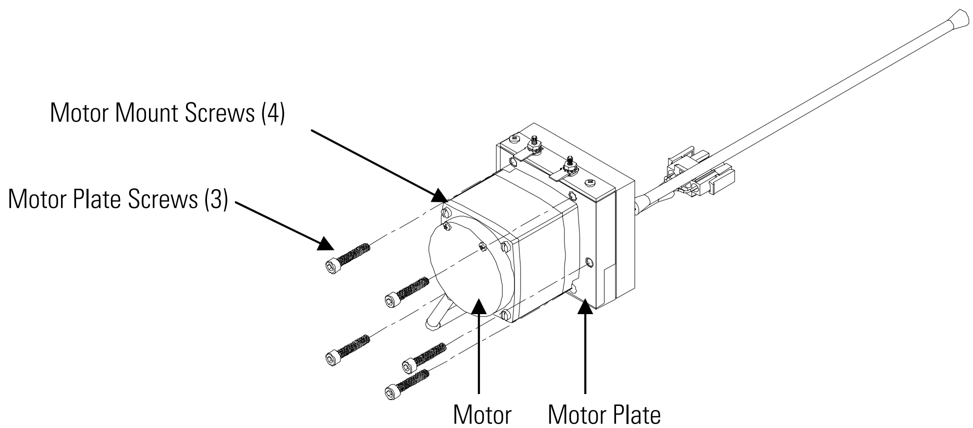


Figure 7–7. Removing the Motor

3. Remove the cross recessed screw on the bottom or the motor plate.

4. Insert the 5/64-inch Allen wrench through the access hole in the bottom of the motor plate, loosen the set screw holding the filter wheel to the motor shaft, and **carefully** pry the filter wheel off the motor shaft (Figure 7–6).

5. Install new filter wheel by following the previous steps in reverse. Make sure that the set screw seats on the flat of the motor shaft.

6. After the filter wheel is installed, spin the wheel and observe that it runs true on the motor shaft.

7. Let the instrument sample zero air for about 90 minutes.

8. From the Main Menu, press [↓] to scroll to Service > press [↵] > [↓] to scroll to **Initial S/R Ratio** > and press [↵].

   The Initial S/R Ratio screen appears.

Note If Service Mode is not displayed, refer to "Accessing the Service Mode" on page 7-3, then return to the beginning of this step. ▲

9. At the Initial S/R Ratio screen, press ↵ to select set the initial S/R ratio to the value of the current ratio and press to store the value. The initial S/R ratio should be between 1.14 and 1.18.

10. Calibrate the instrument. Refer to the "Calibration" chapter in this manual.

Chopper Motor Replacement

Use the following procedure to replace the chopper motor (Figure 7–7).

Equipment Required:

Chopper motor

Allen wrenches, 5/32-inch and 5/64-inch

Flatblade screwdriver

Phillips screwdriver

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground antistatic wrist strap must be worn while handling any internal component. ▲

1. Disconnect the chopper motor power cable from the MOT DRV connector on the measurement interface board.

2. Follow the directions for "Filter Wheel Replacement" procedure, up to and including Step 4.

3. Remove the chopper motor from the motor plate by removing the two screws that hold it to the motor plate.

4. Install the new chopper motor by following the previous steps in reverse.

5. Install the filter wheel on the motor shaft, make sure that the set screw seats on the flat of the motor shaft, and tighten the set screw.

6. Calibrate the instrument. Refer to the "Calibration" chapter in this manual.

Optical Bench Replacement

Use the following procedure to replace the optical bench (Figure 7–8).

Equipment Required:

Optical bench

Philips screwdriver

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 chopper motor cable from the MOT DRV connector on the measurement interface board, and disconnect the detector cable from the PREAMP cable connector on the measurement interface board.

3. Disconnect the plumbing connections from the optical bench.

4. Remove the four screws holding the optical bench to the shock mounts and carefully remove the optical bench.

5. Replace the optical bench by following the previous steps in reverse.

6. Calibrate the instrument. Refer to the "Calibration" chapter in this manual.

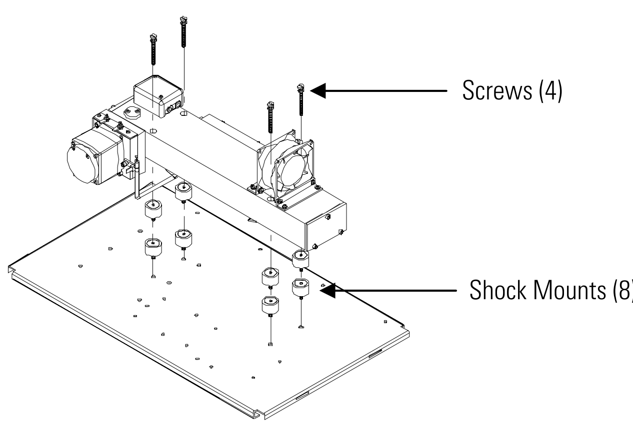


Figure 7–8. Replacing the Optical Bench

Optical Switch Replacement

Use the following procedure to replace the optical switch (Figure 7–9).

Equipment Required:

Optical switch

Flatblade screwdriver, 1/4-inch and 3/16-inch

Philips screwdriver

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 optical bench following the "Optical Bench Replacement" procedure in this chapter.

3. Turn the optical bench over, remove the two screws securing the optical switch assembly to the case, and remove the optical switch.

4. Install the new optical switch by following the previous steps in reverse.

5. Calibrate the instrument. Refer to the "Calibration" chapter in this manual.

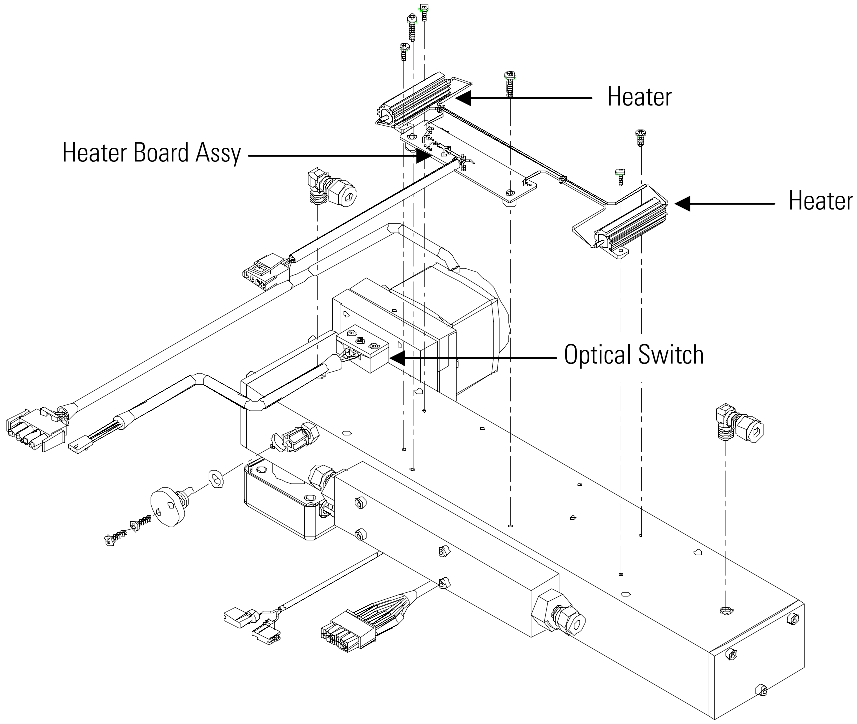


Figure 7–9. Replacing the Optical Switch (Inverted View)

Bench Heater Assembly Replacement

Use the following procedure to replace the bench heater assembly (Figure 7–9).

Equipment Required:

Bench heater

Heat conductive compound

Flatblade screwdriver, 1/4-inch

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 optical bench following the "Optical Bench Replacement" procedure in this chapter.

3. Remove the two screws holding each heater to the bottom of the optical bench, and remove both heaters and the heater board assembly.

4. Apply heat conductive compound to the bottom of the heaters and install the new heaters and heater board assembly.

5. Calibrate the instrument. Refer to the "Calibration" chapter in this manual.

Detector/Preamplifier Assembly Replacement

Use the following procedure to replace the detector/preamplifier assembly (Figure 7–10).

Equipment Required:

detector/preamplifier assembly

Allen wrenches, 3/32-inch and 7/64-inch

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 cable from the PREAMP connector on the measurement interface board and disconnect the two wires from the top of the chopper motor plate.

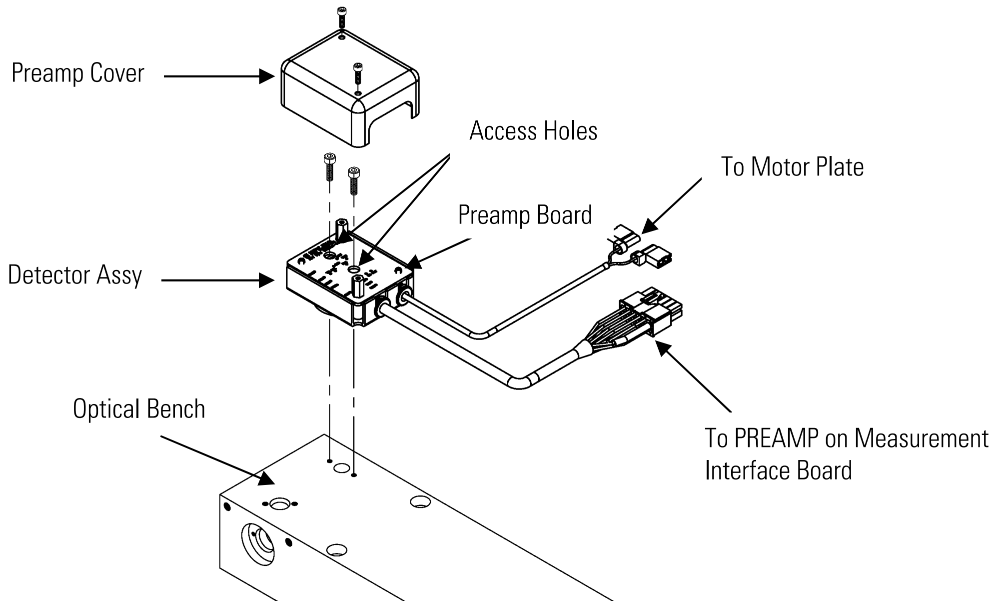


Figure 7–10. Replacing the Detector/Preamplifier Assembly

3. Remove the two screws holding the preamplifier cover to the preamplifier assembly and remove the cover.

4. Insert an Allen wrench through the access holes in the preamplifier printed circuit board, and remove the screws holding the detector assembly to the optical bench. Carefully remove the detector assembly from the optical bench.

5. Install the new detector assembly by following the previous steps in reverse.

6. Calibrate the preamp board, and then return to Step 7 to set S/R. Refer to the "Preamp Board Calibration" procedure that follows.

7. Set S/R as follows:

   a. From the Main Menu, press [↓] to scroll to Service > press [↵] > [↓] to Initial S/R Ratio > and press [↵].

   The Initial S/R Ratio screen appears.

   b. At the Initial S/R Ratio screen, press [↵] to select set the initial S/R ratio to the value of the current ratio and press to store the value. The initial S/R ratio should be between 1.14 and 1.18.

Note If Service Mode is not displayed, refer to "Accessing the Service Mode" on page 7-3, then return to the beginning of this step. ▲

8. Calibrate the instrument. Refer to the "Calibration" chapter in this manual.

Preamp Board Calibration

Calibrate the preamp board after replacing the preamp board.

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

1. Let the instrument sample zero air for about 90 minutes.

2. From the Main Menu, press [⬇] to scroll to Service > press [↵] > [⬇] to scroll to Preamp Board Calibration > and press [↵].

   The Preamp Board Cal screen appears.

Note If Service Mode is not displayed, refer to "Accessing the Service Mode" on page 7-3, then return to the beginning of this step. ▲

3. At the Preamp Board Cal screen, use [⬆] [⬇] until either the Sample or Reference value reads more than 150,000 then press [↵] to save the value.

Pump Replacement

Use the following procedure to rebuild the pump (Figure 7–11).

Equipment Required:

Pump

Nut driver

Philips screwdriver, #2

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 pump power cable from the AC PUMP connector on the measurement interface board.

3. Remove both lines from the pump.

4. Loosen the four captive screws holding the pump bracket to the shock mounts and remove the pump assembly and from the shock mounts.

5. Install the new pump by following the previous steps in reverse.

6. Perform a leak test as described in the "Preventive Maintenance" chapter.

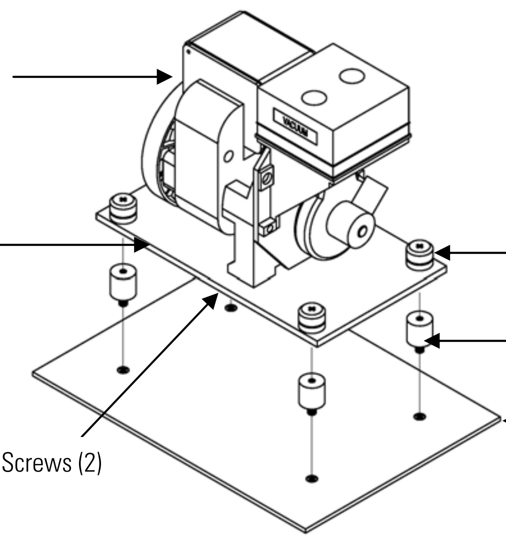


Figure 7–11. Replacing the Pump

Pressure Transducer Replacement

Use the following procedure to replace the pressure transducer (Figure 7–12).

Equipment Required:

Pressure transducer

Philips screwdriver, #2

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 (Figure 7–2). Note the plumbing connections to facilitate reconnection.

3. Disconnect the pressure transducer from the PRES connector on the measurement interface board.

4. Loosen the two pressure transducer assembly retaining screws and remove the pressure transducer assembly (Figure 7–12).

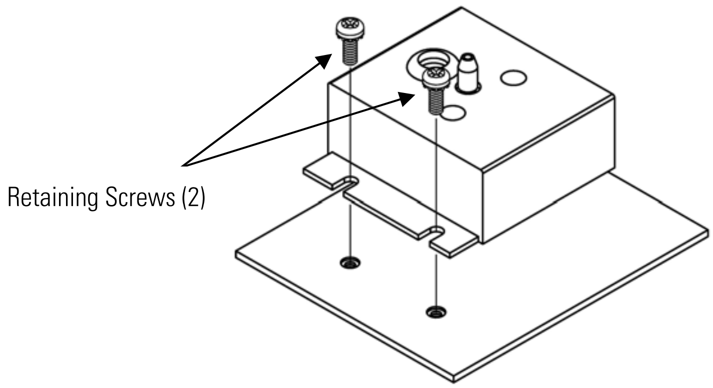


Figure 7–12. Replacing the Pressure Transducer

5. To install the pressure transducer assembly, follow the previous steps in reverse.

6. Calibrate the pressure transducer. Refer to the "Pressure Transducer Calibration" procedure that follows.

Pressure Transducer Calibration

Use the following procedure to calibrate the pressure transducer.

Note 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 mmHg per foot of altitude. ▲

Do not attempt to calibrate the pressure transducer unless the pressure is known accurately. ▲

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 ground antistatic wrist strap must be worn while handling any internal component. ▲

1. Remove the instrument cover.

2. Disconnect the tubing from the pressure transducer and connect a vacuum pump known to produce a vacuum less than 1 mmHg.

3. From the Main Menu, press ⬇ to scroll to Service > press ↵ > ⬇ to scroll to **Pressure Calibration** > and press ↵.

   The Pressure Sensor Cal menu appears

Note If Service Mode is not displayed, refer to "Accessing the Service Mode" on page 7-3, 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, and 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 instrument tubing to the pressure transducer.

11. Install the cover.

Flow Transducer Replacement

Use the following procedure to replace the flow transducer (Figure 7–13).

Equipment Required:

Flow transducer

Philips screwdriver, #2

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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 flow transducer cable from the FLOW connector on the measurement interface board (Figure 7–2).

3. Disconnect the plumbing connections from the flow transducer. Note the plumbing connections to facilitate reconnection.

4. Loosen the two retaining screws holding the flow transducer to the floor plate and remove the flow transducer (Figure 7–13).

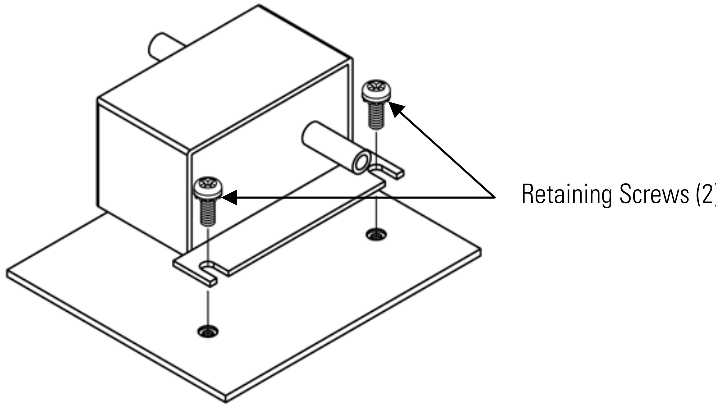


Figure 7–13. Replacing the Flow Transducer

5. Install the new flow transducer following the previous steps in reverse.

6. Calibrate the flow transducer. Refer to the "Flow Transducer Calibration" procedure that follows.

Flow Transducer Calibration

Use the following procedure to calibrate the flow transducer.

Equipment Required:

Calibrated flow sensor

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 ground antistatic wrist strap must be worn while handling any internal component. ▲

1. Remove the instrument cover.

2. Disconnect the pump cable from AC PUMP connector on the measurement interface board.

3. From the Main Menu, press [↓] to scroll to Service > press [↵] > [↓] to scroll to **Flow Calibration** > and press [↵].

   The Flow Sensor Cal menu appears.

Note If Service Mode is not displayed, refer to "Accessing the Service Mode" on page 7-3, then return to the beginning of this step. ▲

4. At the Flow Sensor Cal screen, press [↵] to select **Zero**.

   The Calibrate Flow Zero screen appears.

5. Wait at least 10 seconds for the zero reading to stabilize, and then press [↵] to save the zero flow value.

6. Reconnect the pump cable to the AC PUMP connector on the measurement interface board.

7. Connect a calibrated flow sensor at the SAMPLE bulkhead on the rear panel.

8. Press to return to the Flow Sensor Cal screen.

9. At the Flow Sensor Cal menu, press ↓ ↵ to select **Span**.

   The Calibrate Flow Span screen appears.

10. Wait at least 10 seconds for the reading to stabilize, use ← → and ↑ ↓ to enter the flow sensor reading, and press ↵ to save the value.

11. Install the cover.

Zero/Span and Sample Solenoid Valve Replacement

Use the following procedure to replace the solenoid.

Equipment Required:

Solenoid

Philips screwdriver, #2

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. ▲

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unplug the solenoid electrical connector from the measurement interface board.

3. Remove the Teflon® lines from the solenoid.

4. Remove both screws holding the solenoid to the rear panel, and remove the solenoid.

5. Install the solenoid by following the previous steps in reverse.

6. Perform a leak test as described in the "Preventive Maintenance" chapter.

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 7–14 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 menu displays.

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 displays.

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.

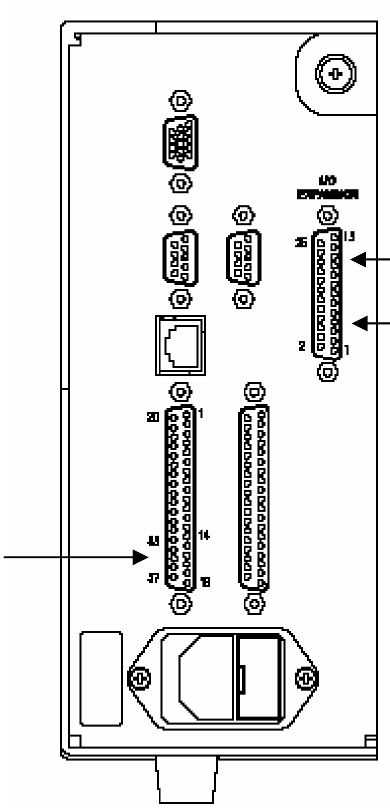


Figure 7–14. Rear Panel Analog Input and Output Pins

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
Ground	16, 18, 19, 35, 37	Current Output Return	16, 18, 20, 22, 24

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 7–14 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 menu is displayed.

Note If Service Mode is not displayed, refer to "Accessing the Service Mode" on page 7-3, 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 menu.

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.

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

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 menu displays.

Note If Service Mode is not displayed, refer to "Accessing the Service Mode" on page 7-3, then return to the beginning of this step. ▲

2. At the Analog Input Cal menu, 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 7–14 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 menu displays input channels 1-8.

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.

Ambient Temperature Calibration

Use the following procedure to calibrate the ambient internal temperature for the instrument.

Equipment Required:

Calibrated thermometer or 10K ohm ±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 ground 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 menu appears.

Note If Service Mode is not displayed, refer to "Accessing the Service Mode" on page 7-3, then return to the beginning of this step. ▲

4. Wait at least 10 seconds for the ambient reading to stabilize, use [←] [→] and [↑] [↓] to enter the known temperature, and press [↵] to save the temperature value.

5. Install the cover.

I/O Expansion Board (Optional) Replacement

Use the following procedure to replace the optional I/O expansion board (Figure 7–15).

Note After replacing the optional I/O expansion board, calibrate the current outputs and the analog voltage inputs. See "Analog Output Calibration" on page 7-29 and "Analog Input Calibration" on page 7-30 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 ground 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 7–16).

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.

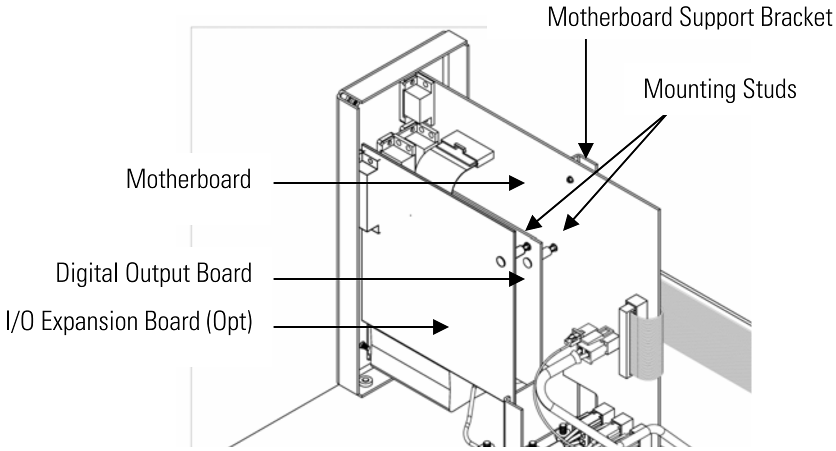


Figure 7–15. Replacing the I/O Expansion Board (Optional)

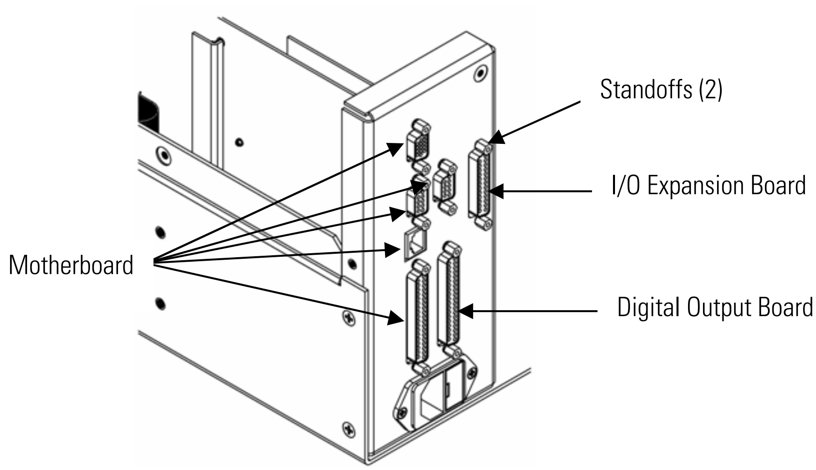


Figure 7–16. Rear Panel Board Connectors

Digital Output Board Replacement

Use the following procedure to replace the digital output board (Figure 7–15).

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 ground 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 "I/O Expansion Board (Optional) Replacement" on page 7-33.

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 7–16).

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 7–15).

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 ground 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 "I/O Expansion Board (Optional) Replacement" on page 7-33.

3. Remove the digital output board. See "Digital Output Board Replacement" on page 7-34.

4. Unplug all connectors from the motherboard. Note connector locations to facilitate reconnection.

5. Using the nut driver, remove the eight 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 7–17).

Equipment Required:

Measurement interface board

Philips screwdriver, #2

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground antistatic wrist strap must be worn while handling any internal component. ▲

1. Remove the measurement bench and lower the partition panel to gain access to the measurement interface board connectors and standoffs. Refer to "Removing the Measurement Bench and Lowering the Partition Panel" on page 7-7.

2. Unplug all connectors from the measurement interface board (Figure 7–17). Note the locations of the connectors to facilitate reconnection.

3. Unscrew the two screws at the top of the measurement interface board. Pop off the measurement interface board from the two mounting studs at the bottom of the board and remove the board.

4. To install the measurement interface board, follow the previous steps in reverse.

5. Re-install the measurement bench. Refer to "Removing the Measurement Bench and Lowering the Partition Panel" on page 7-7 in this chapter.

6. Calibrate the preamp board, pressure transducer, flow transducer, and ambient temperature sensor as defined earlier in this chapter.

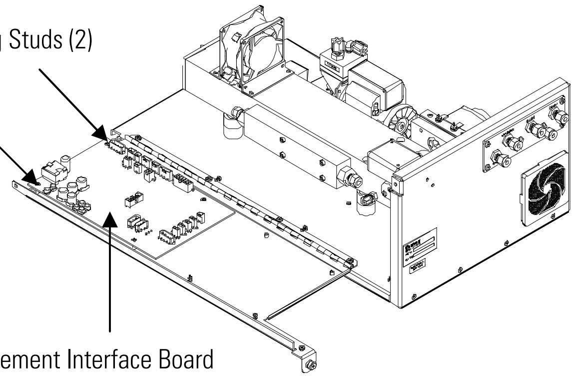


Figure 7–17. Replacing the Measurement Interface Board

Front Panel Board Replacement

Use the following procedure to replace the front panel board (Figure 7–18).

Equipment Required:

Front panel board

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly ground 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.

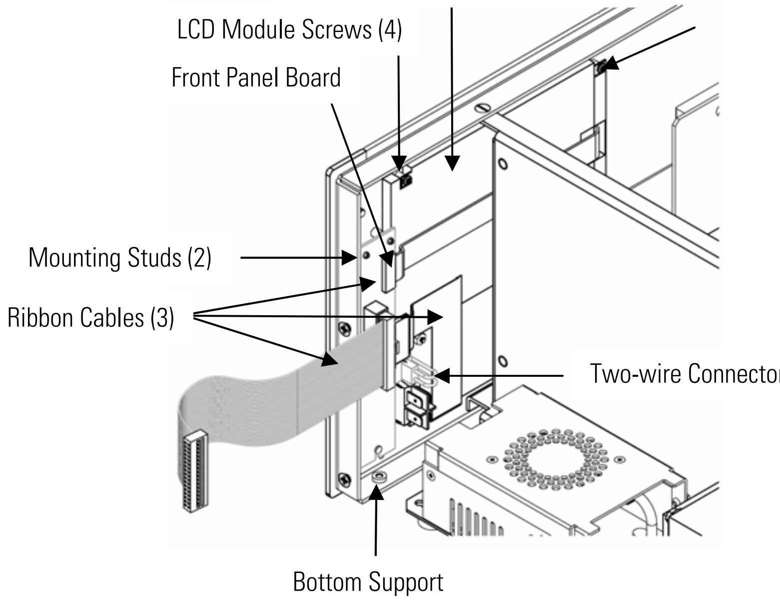


Figure 7–18. Replacing the Front Panel Board and the LCD Module

LCD Module Replacement

Use the following procedure to replace the LCD module (Figure 7–18).

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 ground 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 four screws at the corners of the LCD module (viewed front).

3. Disconnect the ribbon cable and the two-wire connector from the front panel board.

4. Slide the LCD module out towards the right and rear of the instrument.

5. Replace the LCD module by following previous steps in reverse.

Service Locations

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

866-282-0430 Toll Free

508-520-0430 International

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 as follows:

- "Hardware" on page 8-1
- "Software" on page 8-3
- "Electronics" on page 8-4
- "I/O Components" on page 8-8

Hardware

Model 48*i* Trace Level-Enhanced hardware components (Figure 8–1) include:

- Optical bench
- Band-pass filter
- Bench heater board
- Chopper motor
- Optical pickup
- Gas filter wheel
- Infrared source
- Pre-amplifier assembly with IR detector
- Sample flow sensor
- Pressure transducer
- Capillary
- Pump
- Purge flow switch (optional)

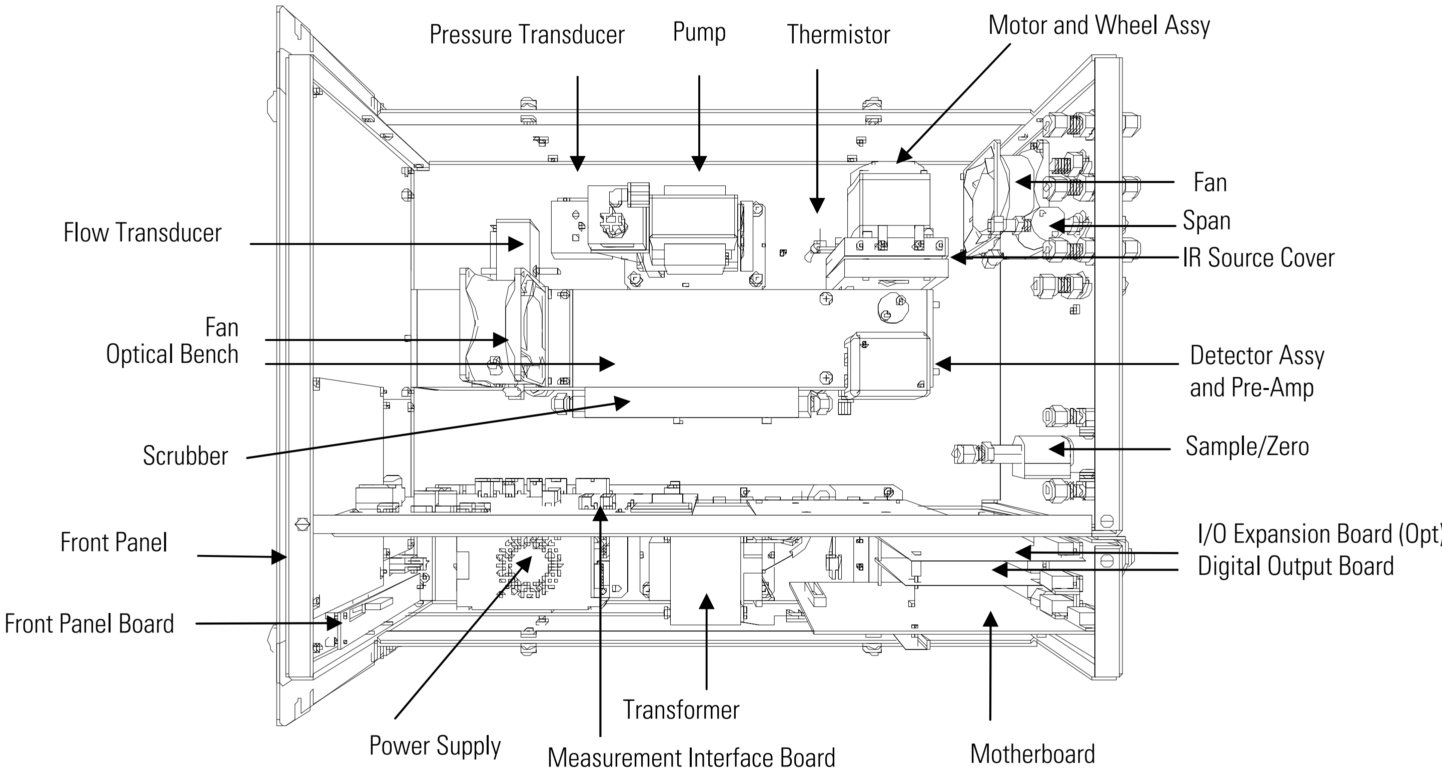


Figure 8–1. Hardware Components

Optical Bench

The optical bench is an airtight chamber that contains the sample gas. The bench includes mirrors that cause the infrared light from the infrared source to pass through the sample gas multiple times before reaching the infrared detector.

Band-pass Filter

The band-pass filter limits the light entering the optical bench to a narrow band of the infrared portion of the spectrum.

Bench Heater Board

The bench heater board applies power to the bench heater resistors and transmits the bench temperature monitored by a thermistor. This assembly is used for maintaining the optical bench at a constant temperature.

Chopper Motor

The chopper motor spins the gas filter wheel and chopper disk at a uniform speed.

Optical Pickup

The optical pickup detects the position of the gas filter wheel, provides synchronizing signals for the signal demodulation, and provides a method for checking the chopper motor speed.

Gas Filter Wheel

The gas filter wheel contains samples of CO and N_2 gas that filter the radiation from the infrared source. A chopper disk that rotates along with the wheel periodically interrupts the radiation to create a modulated signal.

Infrared Source

The infrared source is a special wire-wound resistor operated at high temperature to create infrared radiation.

Pre-amplifier Assembly with IR Detector

The pre-amplifier assembly is mounted on the optical bench along with an infrared detector that detects the energy of the infrared light passing through the optical bench. It amplifies the pulsating signal from the infrared detector.

Sample Flow Sensor

The sample flow sensor, located at the optical bench outlet, measures the flow of sample through the optical bench.

Pressure Transducer

The pressure transducer measures the pressure of the sample gas.

Capillary

The capillary and the pump control the sample gas flow.

Pump

The pump draws the sample gas through the optical filter bench.

Purge Flow Switch (optional)

The purge flow switch monitors the flow of purge gas when the filter wheel purge gas option is installed.

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. 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

Signals are gathered from the low-level processors once per second, and then processed by the high-level processor to produce the final measurement values. The one-second accumulated counts are accumulated and reported for the user-specified averaging time. If this averaging time is greater than ten seconds, the measurement is reported every 10 seconds. The one-second average of the other analog inputs are reported directly (no additional signal conditioning is performed by the high-level processor).

Output Communication

The front panel display, serial and Ethernet data ports, and analog outputs are the means of communicating the results of the above calculations. The front panel display presents the concentrations simultaneously. The display is updated every 1-10 seconds, depending on the averaging time.

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 output and thermistor input from the bench heater board
- Flow and pressure sensor inputs
- Chopper motor output
- Optical pickup input
- Pre-amp board
- Ambient temperature thermistor
- Purge flow switch input

Flow Sensor Assembly

The flow sensor assembly consists of a board containing an instrumentation amplifier and a flow transducer with input and output gas fittings. The flow transducer output is produced by measuring the pressure difference across a precision orifice. This unit is used for measuring the flow of sample gas in the measurement system.

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.

Bench Heater Board

The bench heater board provides connections for the optical bench heater resistors and optical bench temperature thermistor.

The optical bench temperature is measured with a thermistor. The voltage across the thermistor is applied to the main processor and used to display and control the temperature of the optical bench. The main processor compares the voltage to a set point and controls the 120VAC power to the bench heater resistors to maintain a constant bench temperature.

Pre-amp Board Assembly

The pre-amp board assembly amplifies the signal from an infrared sensor that receives light passing through the sample gas. The preamplifier gain is adjusted by the main processor to bring the signal amplitude within a normal operating range. The output of the pre-amp board is fed to the measurement interface board. Wires from the pre-amp board apply power to the infrared source resistor. The pre-amp board assembly is mounted on top of the optical bench.

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 to10VDC. 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 analyzer 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
- MODBUS Slave
- Geysitech (Bayern-Hessen)
- Streaming Data

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 48*i* Trace Level-Enhanced analyzer.

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 48*i* Trace Level-Enhanced is available with the following options:

- "Teflon Particulate Filter" on page 9-1
- "I/O Expansion Board Assembly" on page 9-1
- "Terminal Block and Cable Kits" on page 9-1
- "Cables" on page 9-2
- "Mounting Options" on page 9-4

Teflon Particulate Filter

A 5-10 micron pore size, two-inch diameter Teflon® element is available for the Model 48*i* Trace Level-Enhanced. This filter should be installed just prior to the SAMPLE bulkhead. When using a filter, all calibrations and span checks must be performed through the filter.

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 to "Terminal Board PCB Assemblies" on page 2-5 for information on attaching the cable to the connector board. For associated part numbers, refer to "External Device Connection Components" on page 7-5.

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 "External Device Connection Components" on page 7-5.

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" on page 7-5.

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	PIND/RED
19	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 configuration described in Table 9–3 and shown in Figure 9–1 through Figure 9–4.

Table 9–3. Mounting Options

Mounting Type	Description
Bench	Positioned on bench, includes mounting feet, and front panel side-trim handles.
EIA rack	Mounted in an EIA-style rack, includes mounting slides, and front panel EIA-rack mounting handles.
Retrofit rack	Mounted in a Thermo non-EIA rack, includes mounting slides, and retrofit front panel rack-mounting handles.

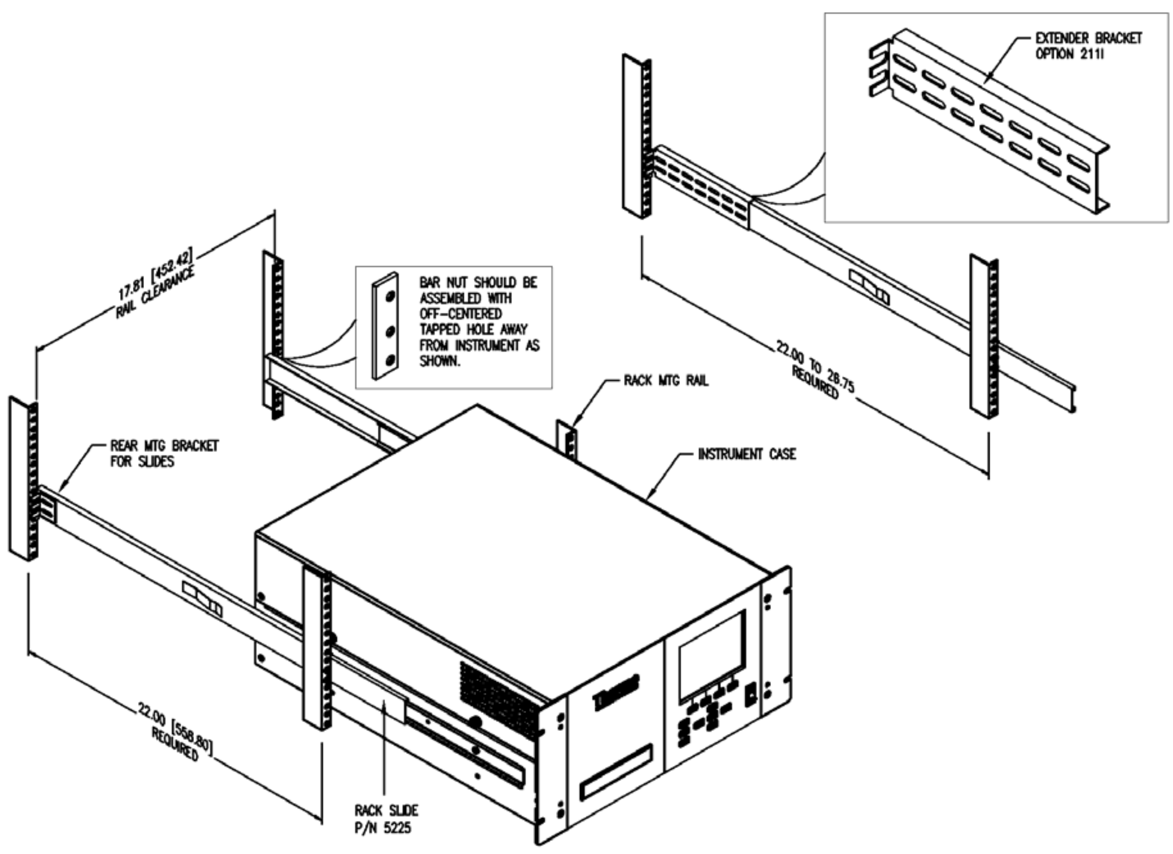


Figure 9–1. Rack Mount Option Assembly

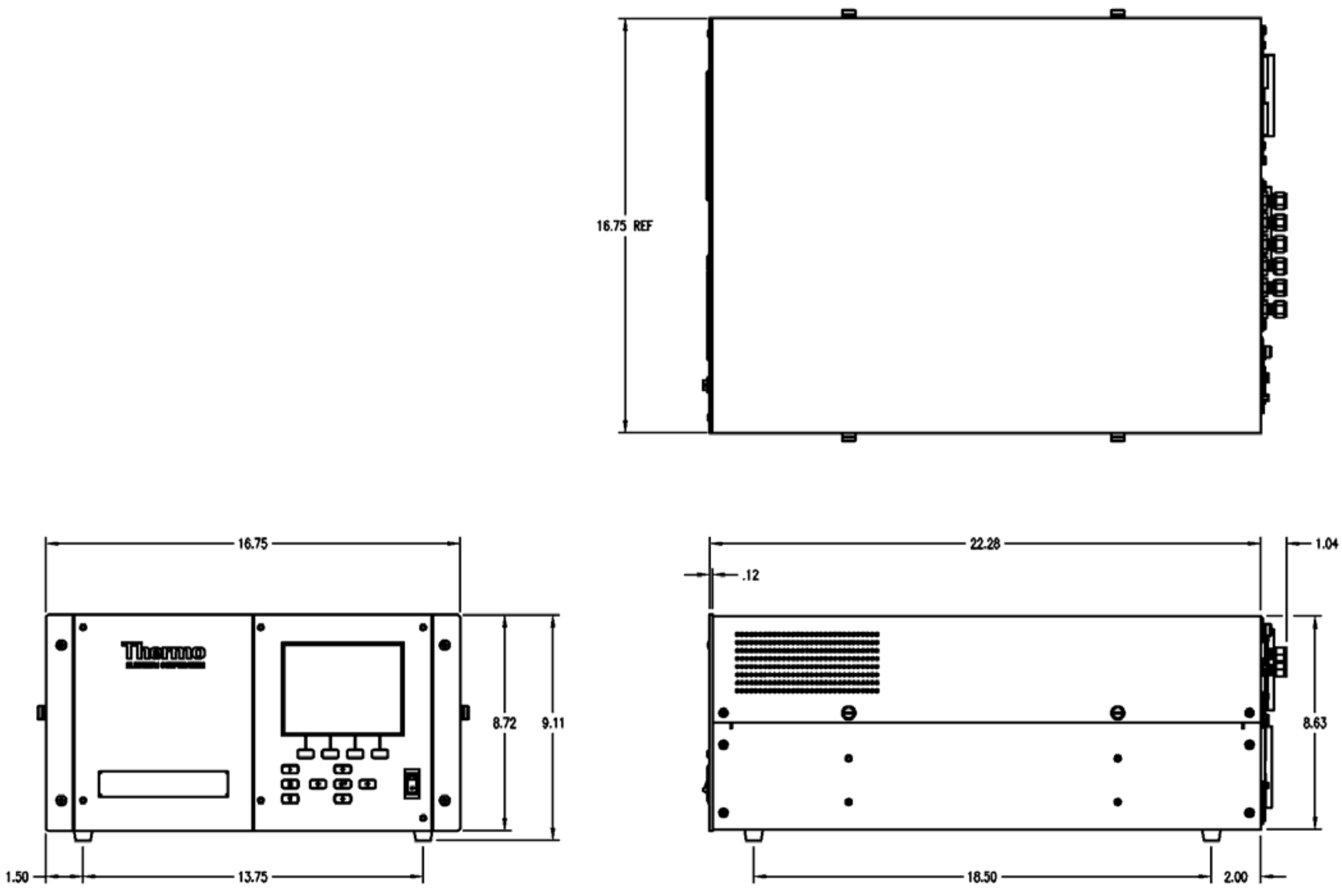


Figure 9–2. Bench Mounting

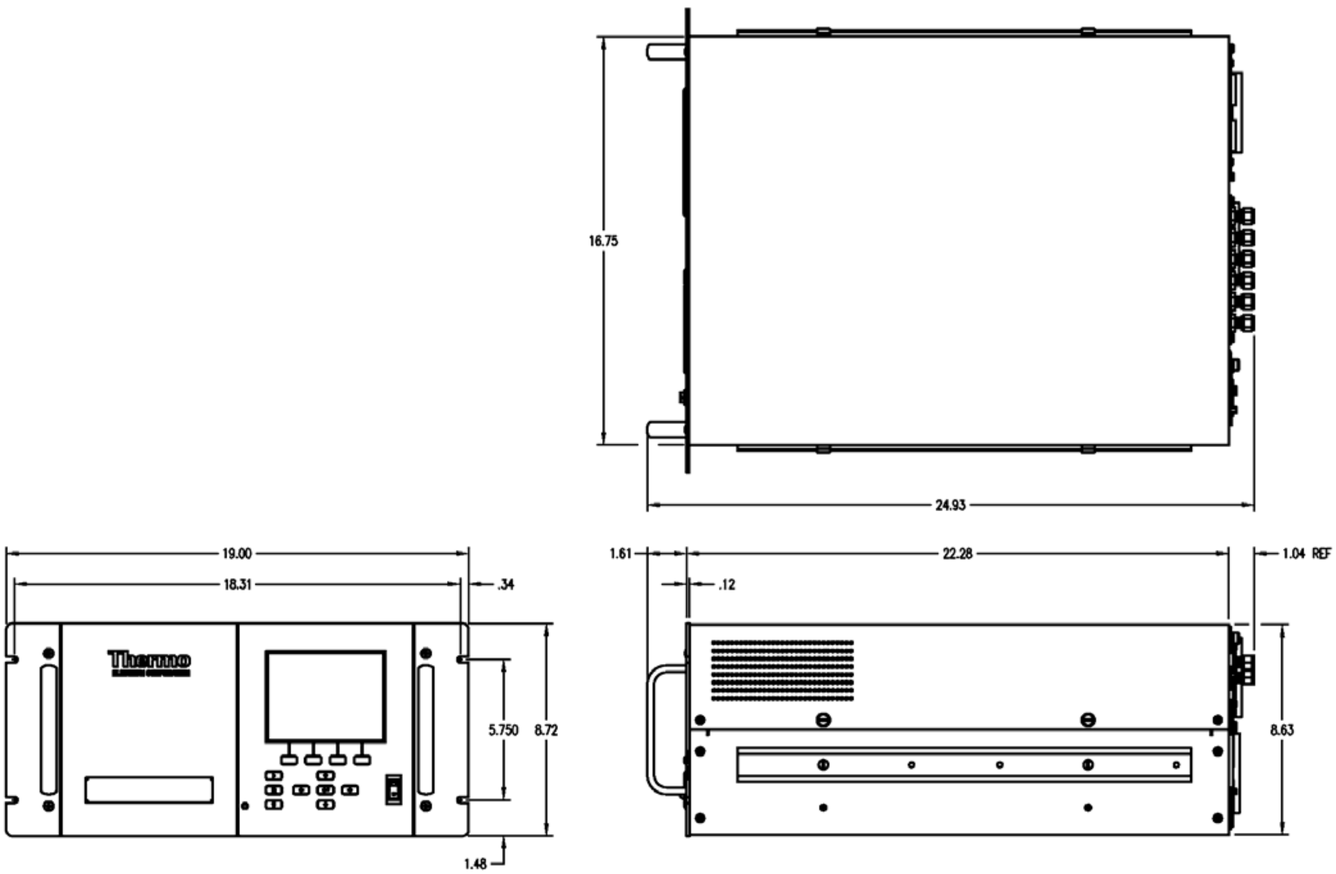


Figure 9–3. EIA Rack Mounting

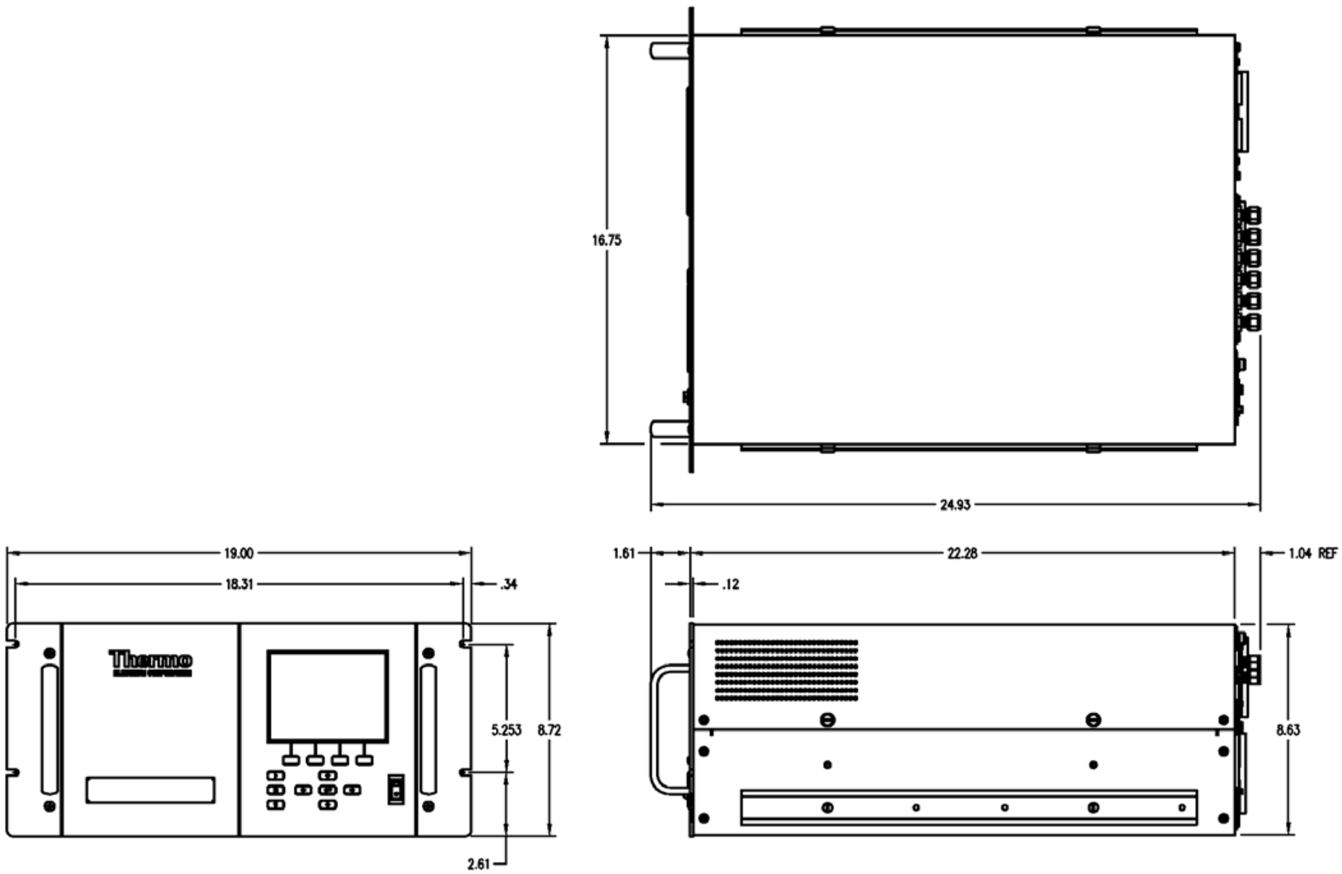


Figure 9–4. Retrofit Rack Mounting

Appendix A
Warranty

Seller warrants that the Products will operate substantially in conformance with Seller's published specifications, when subjected to normal, proper and intended usage by properly trained personnel, for 12 months from date of shipment (the "Warranty Period"). Seller agrees during the Warranty Period, provided it is promptly notified in writing upon the discovery of any defect and further provided that all costs of returning the defective Products to Seller are pre-paid by Buyer, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in substantial conformance with said specifications. 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 provisions of Section 5 above. Lamps, fuses, bulbs and other expendable items are expressly excluded from the warranty under this Section 8. Seller's sole liability with respect to equipment, materials, parts or software furnished to Seller by third party suppliers shall be limited to the assignment by Seller to Buyer of any such third party supplier's warranty, to the extent the same is assignable. 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 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 Section 8, Buyer shall pay Seller therefore 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

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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 48*i* Trace Level-Enhanced 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.

Streaming data is sent out the serial port or the Ethernet port on a user-defined periodic basis. Streaming data over Ethernet is only generated when a connection is made on TCP port 9881.

For details, see the following topics:

Instrument Identification Number

Each command sent to the analyzer over the serial port 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 analyzer 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 176 decimal, which directs the command to the Model 48*i* Trace Level-Enhanced, and is terminated by a carriage return "CR" (ASCII character code 13 decimal).

<ASCII 176>	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.

Entering Units in PPB

When interfacing to an instrument via C-link commands, always enter the concentration values in ppb or μg/m^3 units. For example, to set a background value to 20 ppm, enter 20000 (ppb) as the value for the set background command.

Commands List

Table B–1 lists the 48*i* Trace Level-Enhanced 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 dns address	B-33
addr gw	Reports/sets default gateway address	B-33
addr ip	Reports/sets IP address	B-33
addr nm	Reports/sets netmask address	B-34
agc int	Reports current AGC intensity	B-15
alarm agc intensity max	Reports/sets AGC intensity alarm maximum value	B-11
alarm agc intensity min	Reports/sets AGC intensity alarm minimum value	B-11
alarm bias voltage max	Reports/sets bias voltage alarm maximum value	B-12
alarm bias voltage min	Reports/sets bias voltage alarm minimum value	B-12
alarm chamber temp max	Reports/sets chamber temperature alarm maximum value	B-12
alarm chamber temp min	Reports/sets chamber temperature alarm minimum value	B-12
alarm conc max	Reports/sets current CO concentration alarm maximum value	B-12
alarm conc min	Reports/sets current CO concentration alarm minimum value	B-12
alarm internal temp max	Reports/sets internal temperature alarm maximum value	B-13
alarm internal temp min	Reports/sets internal temperature alarm minimum value	B-13
alarm motor speed max	Reports/sets motor speed alarm maximum value	B-13
alarm motor speed min	Reports/sets motor speed alarm minimum value	B-13
alarm pressure max	Reports/sets pressure alarm maximum value	B-14
alarm pressure min	Reports/sets pressure alarm minimum value	B-14
alarm sample flow max	Reports/sets sample flow alarm maximum value	B-14
alarm sample flow min	Reports/sets sample flow alarm minimum value	B-14
alarm trig conc	Reports/sets current CO concentration alarm warning value	B-14
analog iout range	Reports analog current output range per channel	B-37
analog vin	Retrieves analog voltage input data per channel	B-37
analog vout range	Reports analog voltage output range per channel	B-37

Command	Description	Page
avg time	Reports/sets averaging time	B-8
baud	Reports/sets current baud rate	B-34
bias voltage	Reports current IR bias supply voltage	B-15
cal co bkg	Sets/auto-calibrates CO background	B-23
cal co coef	Sets/auto-calibrates CO coefficient	B-23
cal high co coef	Sets/auto-calibrates high range CO coefficient	B-23
cal low co coef	Sets/auto-calibrates low range CO coefficient	B-23
chamber temp	Reports optical chamber temperature	B-9
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
co	Reports current CO concentration	B-9
co bkg	Reports/sets current CO background	B-25
co coef	Reports/sets current CO coefficient	B-24
coef 0	Reports coefficients of the curve developed from hi multi-point calibration	B-24
coef 1	Reports coefficients of the curve developed from hi multi-point calibration	B-24
coef 2	Reports coefficients of the curve developed from hi multi-point calibration	B-24
contrast	Reports/sets current screen contrast	B-31
copy lrec to sp	Sets/copies current lrec selection into the scratch pad	B-22
copy sp to lrec	Sets/copies current selections in scratch pad into lrec list	B-21
copy sp to srec	Sets/copies current selections in scratch pad into srec list	B-21
copy sp to stream	Sets/copies current selections in scratch pad into stream list	B-21
copy srec to sp	Sets/copies current srec selection into the scratch pad	B-22
copy stream to sp	Sets/copies current streaming data selection into the scratch pad	B-22
custom	Reports/sets defined custom range concentration	B-29
data treatment lrec	Reports/sets data treatment for concentration values in long records	B-16
data treatment srec	Reports/sets data treatment for concentration values in short records	B-16
date	Reports/sets current date	B-32
default params	Sets parameters to default values	B-32
dhcp	Reports/sets state of use of DHCP	B-34

Command	Description	Page
diag volt iob	Reports diagnostic voltage level for I/O expansion board	B-16
diag volt mb	Reports diagnostic voltage level for motherboard	B-15
diag volt mib	Reports diagnostic voltage level for measurement interface board	B-15
dig in	Reports status of the digital inputs	B-38
din	Reports/sets digital input channel and active state	B-38
do (down)	Simulates pressing down pushbutton	B-26
dout	Reports/sets digital output channel and active state	B-38
dtoa	Reports outputs of the digital to analog converters per channel	B-39
en (enter)	Simulates pressing enter pushbutton	B-26
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-20
flags	Reports 8 hexadecimal digits (or flags) that represent the status of the AGC circuit, pressure and temperature compensation status, gas units, gas mode, and alarms	B-11
flow	Reports current measured sample flow in LPM	B-9
format	Reports/sets current reply termination format	B-35
gas mode	Reports current mode of sample, zero, or span	B-29
gas unit	Reports/sets current gas units	B-30
he (help)	Simulates pressing help pushbutton	B-26
high avg time	Reports/sets high range averaging time	B-8
high co	Reports CO concentration calculated with high range coefficients	B-9
high co coef	Reports/sets high range CO coefficients	B-24
high coef 0	Reports coefficients of the curve developed from hi multi-point calibration	B-24
high coef 1	Reports coefficients of the curve developed from hi multi-point calibration	B-24
high coef 2	Reports coefficients of the curve developed from hi multi-point calibration	B-24
high range	Reports/selects current CO high range	B-28

Command	Description	Page
high ratio	Reports sample/reference ratio calculated using the high averaging time	B-10
high sp conc	Reports/sets high span concentration	B-25
host name	Reports/sets host name string	B-35
init ratio	Reports initial sample/reference ratio	B-25
instr name	Reports instrument name	B-35
instrument id	Reports/sets instrument id	B-36
internal temp	Reports current internal instrument temperature	B-9
isc (iscreen)	Retrieves framebuffer data used for the display	B-26
layout ack	Disables stale layout/layout changed indicator ('*')	B-36
le (left)	Simulates pressing left pushbutton	B-26
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-40
list var din	Reports list of digital input, index numbers, and variables	B-40
list var dout	Reports list of digital output, index numbers, and variables	B-40
low avg time	Reports/sets low averaging time	B-8
low co	Reports CO concentration calculated with low range coefficients	B-9
low co coef	Reports/sets low range CO coefficient	B-24
low coef 0	Reports coefficients of the curve developed from lo multi-point calibration	B-24
low coef 1	Reports coefficients of the curve developed from lo multi-point calibration	B-24
low coef 2	Reports coefficients of the curve developed from lo multi-point calibration	B-24
low range	Reports/sets current CO low range	B-28
low ratio	Reports sample/reference ratio calculated using the low averaging time	B-10
low sp conc	Reports/sets low span concentration	B-25
lr	Outputs long records in the format specified in the command	B-17
lrec	Outputs long records	B-18

Command	Description	Page
lrec format	Reports/sets output format for long records (ASCII or binary)	B-19
lrec layout	Reports current layout of lrec data	B-20
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
me (menu)	Simulates pressing menu pushbutton	B-26
mode	Reports operating mode in local, service, or remote	B-36
motor	Reports motor speed	B-10
no of lrec	Reports/sets number of long records stored in memory	B-21
no of srec	Reports/sets number of short records stored in memory	B-21
pres	Reports current reaction chamber pressure	B-10
pres comp	Reports/sets pressure compensation on or off	B-30
program no	Reports analyzer program number	B-36
push	Simulates pressing a key on the front panel	B-26
range	Reports/sets current CO range	B-28
range mode	Reports/sets current range mode	B-29
ratio	Reports sample/reference ratio	B-10
relay stat	Reports/sets relay logic status to for the designated relay(s)	B-40
ri (right)	Simulates pressing right pushbutton	B-26
ru (run)	Simulates pressing run pushbutton	B-26
sample	Sets zero/span valves to sample mode	B-29
save	Stores parameters in FLASH	B-32
save params	Stores parameters in FLASH	B-32
sc (screen)	C-series legacy command that reports a generic response (Use iscreen instead)	B-27
sp conc	Reports/sets span concentration	B-25
sp field	Reports/sets item number and name in scratch pad list	B-22
span	Sets zero/span valves to span mode	B-30
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-20
srec mem size	Reports maximum number of short records	B-20

Command	Description	Page
srec per	Reports/sets short record logging period	B-20
stream per	Reports/sets current set time interval for streaming data	B-22
stream time	Reports/sets a time stamp to streaming data or not	B-23
temp comp	Reports/sets temperature compensation on or off	B-31
time	Reports/sets current time (24-hour time)	B-32
up	Simulates pressing up pushbutton	B-26
zero	Sets zero/span valves to zero mode	B-30

Measurements

avg time
high avg time
low avg time
These commands report the averaging time in seconds when operating in single range, or averaging time used with the high and low ranges when operating in dual or auto range mode. The example below shows that the averaging time is 300 seconds, according to Table B–2.

```
Send:         avg time
Receive:      avg time 11:300 sec
```

set avg time *selection*
set high avg time *selection*
set low avg time *selection*
These commands set the averaging time, high and low averaging times, according to Table B–2. The example below sets the low range averaging time to 120 seconds.

```
Send:         set low avg time 8
Receive:      set low avg time 8 ok
```

Table B–2. Averaging Times

Selection	Averaging Time (seconds)
0	1 seconds
1	2
2	5
3	10
4	20
5	30
6	60
7	90

Selection	Averaging Time (seconds)
8	120
9	180
10	240
11	300

co
high co
low co

These commands report the measured CO concentration when operating in single range, or high and low CO when operating in dual or auto range mode. The example below shows that the CO concentration is 40 ppm.

```
Send:        co
Receive:     co 0040E+0 ppm
```

flow

This command reports the current sample flow. The example below reports that the current sample flow is 1.108 liters/minute.

```
Send:        flow
Receive:     flow 1.108 1/m
```

chamber temp

This command reports the current optical chamber temperature. The example below reports that the current optical chamber temperature is 45.2 °C.

```
Send:        chamber temp
Receive:     chamber temp 45.2 deg C
```

internal temp

This command reports the current internal instrument 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 30 °C is used as the default temperature even though the actual internal temperature is 27.2 °C. The example below shows that temperature compensation is on and that the internal temperature is 27.2 °C.

```
Send:        internal temp
Receive:     internal temp 27.2 deg C, actual 27.2
```

motor
This command reports the current motor speed. The example below reports that the current motor speed is 100%.

```
Send:        motor
Receive:     motor 100%
```

pres
This command reports the current reaction chamber pressure. The first pressure reading is the pressure reading being used in instrument calculations. The second pressure is the actual pressure reading being measured. If pressure compensation is on, then both pressure readings are the same. If pressure compensation is off, a pressure of 760 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.

```
Send:        pres
Receive:     pres 753.4 mmHg
```

ratio
high ratio
low ratio
The "ratio" command reports the sample/reference ratio in single mode. The "high ratio" commands reports the sample/reference ratio using high averaging time and the "low ratio" command using low averaging time, when operating in dual or auto mode. The example below shows that the current ratio is 1.16110.

```
Send:        ratio
Receive:     ratio 1.161100
```

flags
This reports 8 hexadecimal digits (or flags) that represent the status of the AGC circuit, pressure and temperature compensation status, gas units, gas 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 the AGC circuit is on, that the instrument is in the span gas mode, and that the CO high concentration alarm is activated.

```
Send:        flags
Receive:     flags 80028000
```

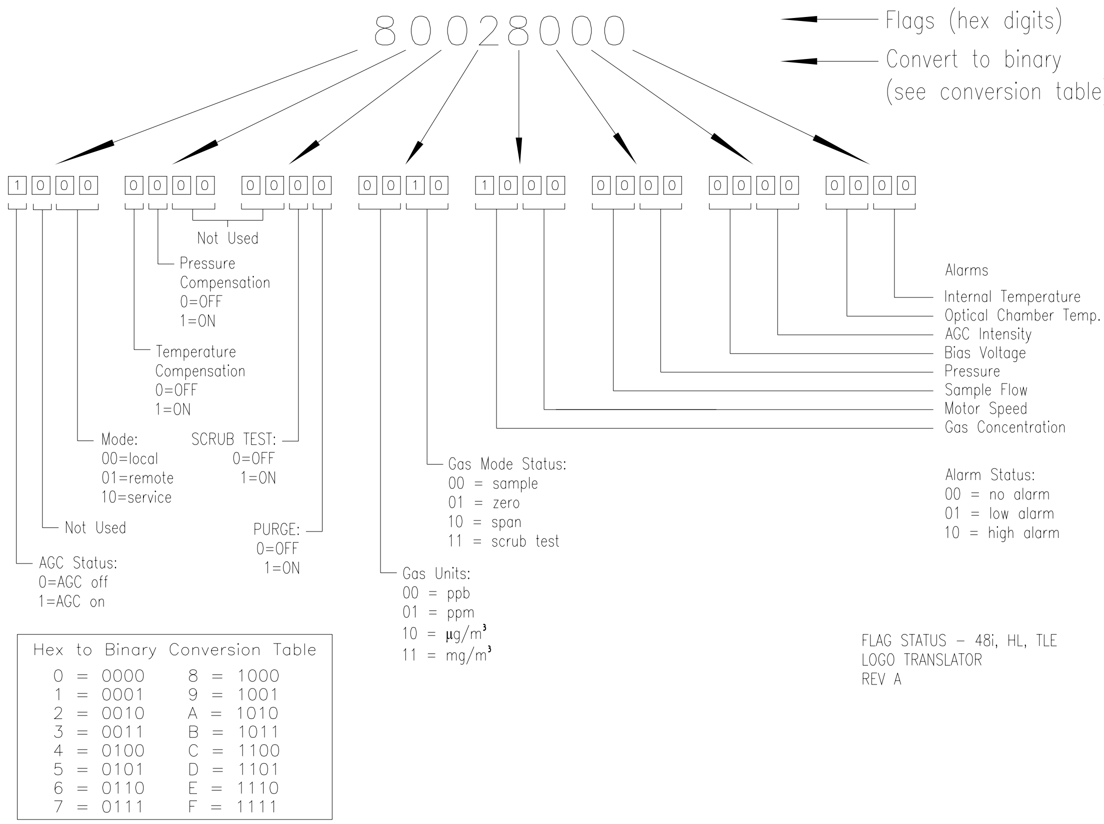

Figure B–1. Flags

Alarms

alarm agc intensity min
alarm agc intensity max
These commands report the agc intensity alarm minimum and maximum value current settings. The example below reports that the agc intensity alarm minimum value is 20.

```
Send:        alarm agc intensity min
Receive:     alarm agc intensity min 20
```

set alarm agc intensity min *value*
set alarm agc intensity max *value*
These commands set the agc intensity alarm minimum and maximum values to *value*, where *value* is a floating-point number representing agc intensity alarm limits. The example below sets the agc intensity alarm maximum value to 20.

```
Send:        set alarm agc intensity max 20
Receive:     set alarm agc intensity max 20 ok
```

alarm bias voltage min
alarm bias voltage max
These commands report the bias voltage alarm minimum and maximum value current settings. The example below reports that the bias voltage alarm minimum value is 20.

```
Send:         alarm bias voltage min
Receive:      alarm bias voltage min 20
```

set alarm bias voltage min *value*
set alarm bias voltage max *value*
These commands set the bias voltage alarm minimum and maximum values to *value*, where *value* is a floating-point number representing bias voltage alarm limits. The example below sets the bias voltage alarm maximum value to 20.

```
Send:         set alarm bias voltage max 20
Receive:      set alarm bias voltage max 20 ok
```

alarm chamber temp min
alarm chamber temp max
These commands report the chamber temperature alarm minimum and maximum value current settings. The example below reports that the chamber temperature alarm minimum value is 35.0 °C.

```
Send:         alarm chamber temp min
Receive:      alarm chamber temp min 35.0 deg C
```

set alarm chamber temp min *value*
set alarm chamber temp max *value*
These commands set the chamber temperature alarm minimum and maximum values to *value*, where *value* is a floating-point number representing chamber temperature alarm limits in degrees C. The example below sets the chamber temperature alarm maximum value to 55.0 °C.

```
Send:         set alarm chamber temp max 55.0
Receive:      set alarm chamber temp max 55.0 ok
```

alarm conc min
alarm conc max
These commands report the CO concentration alarm minimum and maximum values current setting. The example below reports that the CO concentration minimum is 5.2 ppm.

```
Send:         alarm conc min
Receive:      alarm conc min 5.2 ppm
```

set alarm conc min *value*
set alarm conc max *value*
These commands set the CO concentration alarm minimum and maximum values to *value*, where *value* is a floating-point representation of the concentration alarm limits. Values must be in the units that are currently set for use. The example below sets the CO concentration alarm maximum value to 215.

```
Send:        set alarm conc max 215
Receive:     set alarm conc max 215 ok
```

---

alarm internal temp min
alarm internal temp max
These commands report the internal temperature alarm minimum and maximum value current settings. The example below reports that the internal temperature alarm minimum value is 15.0 °C.

```
Send:        internal temp alarm min
Receive:     internal temp alarm min 15.0 deg C
```

set internal temp alarm min *value*
set internal temp alarm max *value*
These commands set the internal temperature alarm minimum and maximum values to *value*, where *value* is a floating-point number representing internal temperature alarm limits in degrees C. The example below sets the internal temperature alarm maximum value to 45.0 °C.

```
Send:        set internal temp alarm max 45
Receive:     set internal temp alarm max 45 ok
```

---

alarm motor speed min
alarm motor speed max
These commands report the motor speed alarm minimum and maximum value current settings. The example below reports that the motor speed alarm minimum value is 20 minutes.

```
Send:        alarm motor speed min
Receive:     alarm motor speed min 20
```

set alarm motor speed min *value*
set alarm motor speed max *value*
These commands set the motor speed alarm minimum and maximum values to *value*, where *value* is a floating-point number representing motor speed alarm limits in minutes. The example below sets the motor speed alarm maximum value to 20 minutes.

```
Send:        set alarm motor speed max 20
Receive:     set alarm motor speed max 20 ok
```

alarm pressure min
alarm pressure max
These commands report the pressure alarm minimum and maximum value current settings. The example below reports that the pressure alarm minimum value is 205 mmHg.

```
Send:         pressure alarm min
Receive:      pressure alarm min 205 mmHg
```

set alarm pressure min *value*
set alarm pressure max *value*
These commands set the 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 215 mmHg.

```
Send:         set alarm pressure max 215
Receive:      set alarm pressure max 215 ok
```

alarm sample flow min
alarm sample flow max
These commands report the sample flow alarm minimum and maximum value current settings. The example below reports that the sample flow alarm minimum value is 2 LPM.

```
Send:         alarm sample flow min
Receive:      alarm sample flow min 2 l/min
```

set alarm sample flow min *value*
set alarm sample flow max *value*
These commands set the sample flow alarm minimum and maximum values to *value*, where *value* is a floating-point number representing sample flow alarm limits in liters per minute. The example below sets the sample flow alarm maximum value to 1 LPM.

```
Send:         set alarm sample flow max 1
Receive:      set alarm sample flow max 1 ok
```

alarm trig conc
This command reports the CO concentration alarm trigger action for minimum alarm, current setting, to either floor or ceiling. The example below shows the CO concentration minimum alarm trigger to ceiling, according to Table B–3.

```
Send:         alarm trig conc
Receive:      alarm trig conc 1
```

set alarm trig conc *value*
These commands set the CO concentration alarm minimum *value*, where *value* is set to either floor or ceiling, according to Table B–3. The example below sets the CO concentration minimum alarm trigger to ceiling.

```
Send:         set alarm trig conc 1
Receive:      set alarm trig conc 1 ok
```

Table B–3. Alarm Trigger Values

Value	Alarm Trigger
00	Floor
01	Ceiling

Diagnostics

agc int
This command reports the current intensity of the reference channel AGC circuit. The example below reports that the current AGC intensity is 200,000 Hz.

```
Send:         agc int
Receive:      agc int 250000 Hz
```

bias voltage
This command reports the current IR bias supply voltage. The example below reports that the bias voltage is -102.3 volts

```
Send:         bias voltage
Receive:      bias voltage -102.3 V
```

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, positive 18 IR, positive 18 MOT, and VBIAS. 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 17.9 17.9
```

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
```

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
```

data treatment lrec
data treatment srec
These commands report the current selection of data treatment for concentrations in the long records (lrecs) or short records (srecs). The example below reports the data treatment for concentrations in lrec is minimum.

```
Send:        data treatment lrec
Receive:     data treatment lrec min
```

set data treatment lrec *string*
set data treatment srec *string*
string = | cur | avg | min | max |

These commands set the data treatment to current, average, minimum, or maximum for the concentration values recorded in the long records (lrecs) or short records (srecs). The example below sets the data treatment for concentrations in lrec to minimum.

```
Send:        set data treatment lrec min
Receive:     set data treatment lrec min 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 22 I/O BD COMM closed
               2 2 LOCAL/REMOTE open
               3 4 UNITS open
               4 19 BIAS VOLTAGE closed
               7 7 SAMPLE MODE open
               8 8 GEN MODE open
```

---

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 10 auxt
               2 13 pres
               3 14 smplfl
               4 15 intensity
```

---

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:         lr01
Receive:      lr01
              10:15 05-12-03 flags 9c040000 co 7349E+0 loco 5994E+0
              intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0
              biasv -115.5 intensity 1999940
```

---

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
              09:48 04-06-05 flags 9C040510 co 0.000  4 loco -0.002
              4 s/r 0.000 los/r 0.902 biasv -112.668 agci 96.500 intt
              34.023 cht 47.995 smpfl 0.000 pres 0.000 avgt1 10 avgt2
              10 cobkg -0.000 cocoef 1.000 lococoef 1.000 corange
              10000000.000 locorange 10000000.000 motor 100.000
```

---

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
             10:15 05-12-03 flags 9c040000 co 7349E+0 loco 5994E+0
             intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0
             biasv -115.5 intensity 1999940
             10:15 05-12-03 flags 9c040000 co 7349E+0 loco 5994E+0
             intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0
             biasv -115.5 intensity 1999940
             10:15 05-12-03 flags 9c040000 co 7349E+0 loco 5994E+0
             intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0
             biasv -115.5 intensity 1999940
             10:15 05-12-03 flags 9c040000 co 7349E+0 loco 5994E+0
             intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0
             biasv -115.5 intensity 1999940
             10:15 05-12-03 flags 9c040000 co 7349E+0 loco 5994E+0
             intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0
             biasv -115.5 intensity 1999940
```

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
             s/r pres intensity motor
```

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 co bkg
This command will auto-calibrate the CO background. The example below shows a successful auto-calibration of the CO background.

```
Send:        set cal co bkg
Receive:     set cal co bkg ok
```

set cal co coef
set cal high co coef
set cal low co coef
These commands will auto-calibrate CO coefficients based on CO span gas concentrations. The high and low commands are only available in dual and auto range mode. If the mode is incorrect, the instrument responds with "can't, wrong settings". The example below shows a successful auto-calibration of the low CO coefficient.

```
Send:        set cal low co coef
Receive:     set cal low co coef ok
```

co coef
high co coef
low co coef
These commands report CO coefficients in single range mode, or the high and low range coefficients in dual or auto range mode. If the mode is incorrect, the instrument responds with "can't, wrong settings". The example below reports that the CO coefficient is 1.200.

```
Send:        co coef
Receive:     co coef 1.200
```

set co coef *value*
set high co coef *value*
set low co coef *value*
These commands set the CO coefficients to user-defined values to value, where *value* is a floating-point representation of the coefficient. The example below sets the CO coefficient to 1.200.

```
Send:        set co coef 1.200
Receive:     set co coef 1.200 ok
```

coef 0
coef 1
coef 2
high coef 0
high coef 1
high coef 2
low coef 0
low coef 1
low coef 2
The "coef 0", coef 1", and coef 2" commands report the coefficients of the curve developed from the Hi Multi-Point Calibration in single range mode. The "high coef 0", high coef 1", and high coef 2" commands report the coefficients of the curve developed from the Hi Multi-Point Calibration in dual or auto range mode. The "low coef 0", low coef 1", and low coef 2" commands report the coefficients of the curve developed from the Lo Multi-Point Calibration in dual and auto range mode. The example below reports the coefficient 0 having a value of 1.005.

```
Send:        coef 0
Receive:     coef 0 1.005 ok
```

co bkg
This command reports the current CO backgrounds. The example below reports that the CO background is 1.4 ppm.

```
Send:         co bkg
Receive:      co bkg 1.4 ppm
```

set co bkg *value*
This command is used to set CO backgrounds to user-defined values to *value*, where *value* is a floating-point representation of the background in current selected units. The example below sets the CO background to 1.4 ppm.

```
Send:         set co bkg 1.400
Receive:      set co bkg 1.400 ok
```

init ratio
This command reports the initial sample/reference ratio. The example below reports that the initial ratio was 1.16210.

```
Send:         initial ratio
Receive:      initial ratio 1.16210
```

sp conc
high sp conc
low sp conc
These commands report span concentration in single range mode, or the high and low span concentrations in dual or auto range mode. If the mode is incorrect, the instrument responds with "can't, wrong settings". The example below reports the span gas concentration in single range mode.

```
Send:         sp conc
Receive:      sp conc 1000
```

set sp conc *value*
set high sp conc *value*
set low sp conc *value*
These commands set the span concentrations to user-defined values to *value*, where *value* is a floating-point representation of the span concentration in current selected units. The example below sets the span concentration to 1000 ppb in the single range mode.

```
Send:         set sp conc 1000
Receive:      set sp conc 1000 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

range
high range
low range
These commands report CO range in single range mode, or the high and low ranges in dual or auto range mode. If the mode is incorrect, the instrument responds with "can't, wrong settings". The example below reports that the CO full-scale range is set to 50 ppm, according to Table B–6.

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

set range *Selection*
set high range *Selection*
set low range *Selection*
These commands select the CO full-scale ranges, according to Table B–6. The example below sets the CO full-scale range to 50 ppm.

```
Send:        set range 5
Receive:     set range 5 ok
```

Table B–6. Standard Ranges

Selection	ppm	mg/m^3
0	1	1
1	2	2
2	5	5
3	10	10
4	20	20
5	50	50
6	100	100
7	200	200
8	500	500
9	1,000	1,000
10	C1	C1
11	C2	C2
12	C3	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 55.0 ppm.

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

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 or mg/m^3. The example below sets the custom 1 range to 55.5 ppm.

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

range mode
This command reports the current range mode.

```
Send:        range mode
Receive:     range mode single
```

set range mode *mode*

This command sets the current range mode to single, dual, or auto. The example below sets the range mode to single.

```
Send:        set range mode single
Receive:     set range mode single ok
```

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

```
Send:        gas mode
Receive:     gas mode sample
```

set sample
This command sets the zero/span valves to the sample mode. The example below sets the instrument to sample mode, that is, the instrument is reading the sample gas.

```
Send:         set sample
Receive:      set sample ok
```

set zero
This command sets the zero/span valves to the zero mode. The example below sets the instrument to zero mode that is, the instrument is reading the sample gas.

```
Send:         set zero
Receive:      set zero ok
```

set span
This command sets the zero/span valves to the span mode. The example below sets the instrument to span mode that is, the instrument is sampling span gas.

```
Send:         set span
Receive:      set span ok
```

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

```
Send:         gas unit
Receive:      gas unit ppm
```

set gas *unit*
unit = | ppm | mg/m^3 |

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

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

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

```
Send:         pres comp
Receive:      pres comp on
```

set pres comp *onoff*
These commands turn the pressure compensation *on* or *off*. The example below turns pressure compensation off.

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

temp comp
This command reports whether temperature compensation is on or off. The example below shows the temperature compensation is off.

```
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.

```
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–7.

```
Send:         contrast
Receive:      contrast 5:50%
```

set contrast *level*
This command sets the screen's *level* of contrast, according to Table B–7. The example below sets the contrast level to 50%.

```
Send:         set contrast 5
Receive:      set contrast 5 ok
```

Table B–7. Contrast Levels

Level	Contrast Level
0	0%
1	10%
2	20%
3	30%
4	40%
5	50%
6	60%
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–8.

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

set format *format*

This command sets the reply termination *format*, where *format* is set according to Table B–8. The example below sets the reply termination format to checksum.

```
Send:        set format 01
Receive:     set format 01 ok
```

Table B–8. 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
              CO Analyzer
              CO Analyzer
```

instrument id

This command reports the instrument id.

```
Send:         instrument id
Receive:      instrument id 12
```

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 12
Receive:      set instrument id 12 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 48iTLE 01.02.12.095
```

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–9. 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–9. 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–9. 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–10.

```
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–10. 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–10. 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–11. 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–11. Default Output Assignment

D to A	Function	Single Range	Dual Range	Auto Range
1	Voltage Output	CO	Low CO	CO
2	Voltage Output	CO	High CO	Range Status
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
7	Current Output	CO	Low CO	CO
8	Current Output	CO	High CO	Range Status
9	Current Output	Not Used	Not Used	Not Used
10	Current Output	Not Used	Not Used	Not Used
11	Current Output	Not Used	Not Used	Not Used
12	Current Output	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 co
              5 sr
              8 intt
              9 cht
              10 auxt
              13 pres
              14 smplfl
              15 intensity
              16 speed
              28 biasv
```

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 parameters listed below.

For details of the Model 48*i* Trace Level-Enhanced 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 Parameters 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 48*i* Trace Level-Enhanced.

(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 Parameters Supported

The following Table C–1 through Table C–3 lists the MODBUS parameters supported for the Model 48*i* Trace Level-Enhanced.

Table C–1. Read Coils for 48*i* Trace Level-Enhanced

Coil Number	Status
1	AUTO RANGE
2	LOCAL/REMOTE
3	SERVICE
4	UNITS
5	ZERO MODE
6	SPAN MODE
7	SAMPLE MODE
8	GEN ALARM
9	CONC MAX ALARM
10	CONC MIN ALARM
11	INTERNAL TEMP ALARM
12	BENCH TEMP ALARM

Coil Number	Status
13	PRESSURE ALARM
14	SAMPLE FLOW ALARM
15	INTENSITY ALARM
16	MOTOR SPEED ALARM
17	BIAS VOLTAGE
18	MOTHERBOARD STATUS ALARM
19	MEASUREMENT INTERFACE BD STATUS ALARM
20	I/O EXP BD STATUS ALARM
21	CONC ALARM
22	PURGE MODE
23	SCRUB TEST MODE
24	ZERO CHECK/CAL
25	SPAN CHECK/CAL

Table C–2. Read Registers for 48*i* Trace Level-Enhanced

Register Number	Variable
40001&40002	CO
40003&40004	LO CO
40005&40006	HI CO
40007&40008	RANGE STATUS
40009&40010	S/R
40011&40012	LO S/R
40013&40014	HI S/R
40015&40016	INT TEMP
40017&40018	BENCH TEMP
40019&40020	NOT USED
40021&40022	NOT USED
40023&40024	NOT USED
40025&40026	BENCH PRESSURE
40027&40028	SAMPLE FLOW
40029&40030	INTENSITY
40031&40032	MOTOR SPEED
40033&40034	ANALOG IN 1

Register Number	Variable
40035&40036	ANALOG IN 2
40037&40038	ANALOG IN 3
40039&40040	ANALOG IN 4
40041&40042	ANALOG IN 5
40043&40044	ANALOG IN 6
40045&40046	ANALOG IN 7
40047&40048	ANALOG IN 8
40049&40050	NOT USED
40051&40052	NOT USED
40053&40054	NOT USED
40055&40056	BIAS SUPPLY
40057&40058	NOT USED
40059&40060	NOT USED
40061&40062	NOT USED
40063&40064	SCRUBBER EFFICIENCY

Table C–3. Write Coils for 48*i* Trace Level-Enhanced

Coil Number	Action
101	ZERO MODE
102	SPAN MODE
103	SET BACKGROUND
104	CAL TO LOW SPAN
105	AOUTS TO ZERO
106	AOUTS TO FS
107	CAL TO HIGH SPAN
108	SCRUBBER TEST

Appendix D
Geysitech (Bayern-Hessen) Protocol

This appendix provides a description of the Geysitech (Bayern-Hessen or BH) Protocol Interface and is supported both over RS-232/485 as well as TCP/IP over Ethernet.

The Geysitech Commands that are implemented are explained in detail in this document. The Geysitech protocol support for the *i*Series enables the user to perform the functions of reading the various concentrations and to trigger the instrument to be in sample/zero/span mode if valid for that instrument. This is achieved by using the supported Geysitech commands listed below.

For details of the Model 48*i* Trace Level-Enhanced Geysitech Protocol specification, see the following topics:

"Serial Communication Parameters" on page D-1

"TCP Communication Parameters" on page D-2

"Instrument Address" on page D-2

"Abbreviations Used" on page D-2

"Basic Command Structure" on page D-2

"Block Checksum" on page D-3

"Geysitech Commands" on page D-3

Serial Communication Parameters

The following are the communication parameters that are used to configure the serial port of the *i*Series to support Geysitech protocol.

Number of Data bits	: 8
Number of Stop bits	: 1
Parity	: None
Data rate	: from 1200-115200 Baud (9600 is default)

TCP Communication Parameters

*i*Series Instruments support the Geysitech/TCP protocol over TCP/IP. The register definition is the same as for the serial interface.

TCP connection port for Geysitech: 9882

Instrument Address

The Geysitech instrument address has a value between 0 and 127 and is represented by 3 digit ASCII number with leading zeros or leading spaces if required (e.g. Instrument address of 1 is represented as 001 or <SP><SP>1)

The instrument Address is the same as the Instrument ID used for C-Link and MODBUS commands. This can be set via the front panel.

The Instrument Address is represented by <address> in the examples throughout this document.

Note Device IDs 128 through 247 are not supported because of limitations imposed by the C-Link protocol. ▲

Abbreviations Used

The following is a list of abbreviations used in this document:

<CR> is abbreviation for Carriage Return (ASCII code 0x0D)

<STX> is abbreviation for Start of Text (ASCII code 0x02)

<ETX> is abbreviation for End of Text (ASCII code 0x03)

<SP> is abbreviation for space (ASCII code 0x20)

Basic Command Structure

The following is the basic structure of a Geysitech command:

<STX>Command text<ETX><BCC>

OR

<STX>Command text<CR>

Each Command is framed by control characters, <STX> at the start and terminated with either <ETX> or <CR>.

If a command is terminated with <ETX> then additional two characters <BCC> is attached after <ETX>, this is the block checksum.

Block Checksum <BCC>

The block checksum is calculated beginning with a seed value of 00000000, binary (0x00), and bitwise exclusive ORing with each of the characters of the command string (or response) including the framing characters <STX> and <ETX>. The checksum works as an error check. The command terminator determines the presence or absence of <BCC>.

If a command is terminated by <ETX> then the next two characters are the checksum, if the command is terminated with <CR> no checksum is attached

The block checksum is represented by two characters, which represent a 2 digit hex number (1byte). (e.g. 1 byte 0xAB hex checksum will be represented by the two characters 'A' & 'B')

The checksum is referred to as <BCC> throughout this document.

Geysitech Commands

The following commands are supported by the Geysitech protocol:

- Instrument Control Command (ST)
- Data Sampling/Data Query Command (DA)

Instrument Control Command (ST)

There are three control commands supported by the Geysitech protocol.

This <control command> is a single letter, which triggers an action in the instrument. These commands are active only when service mode is inactive and the zero/span option is present.

Command 'N' switches the instrument gas mode to Zero mode.

Command 'K' switches the instrument gas mode to Span mode.

Command 'M' switches the instrument gas mode to Sample mode.

The following are the different acceptable formats of the ST command:

<STX>ST<address><control command><ETX><BCC>

OR

<STX>ST<address><control command><CR>

OR

<STX>ST<address><SP><control command><CR>

OR

<STX>ST<address><SP><control command><ETX><BCC>

The <address> is optional, which means it can be left out completely. The <address> if present must match the Instrument Address. Additional space can be present after the <address>.

If the received command does not satisfy the above formats or if the <address> does not match the Instrument Address the command is ignored.

This is a sample command to switch the instrument to zero mode, instrument id 5:

```
<STX>ST005<SP>N<CR>
```

Data Sampling/Data Query Command (DA)

This command DA initiates a data transfer from the instrument. The instrument responds with measurement data, which depends on the range mode and is listed in "Measurement reported in response to DA commands" below.

The command structure for a data query command is as follows:

<STX>DA<address><ETX><BCC>

The <address> is optional, which means it can be left out completely. The <address> if present must match the Instrument Address. Additional space can be present after the <address>.

If the <address> is left out then no space is allowed in the query string.

A command with no address is also a valid command.

The following are the different acceptable formats of the DA command with Instrument Address 5:

<STX>DA<CR>

<STX>DA005<CR>

<STX>DA<SP><SP>5<ETX><BCC>

<STX>DA<ETX><BCC>

The data query string is valid and will be answered with data transmission only if the command starts with <STX> which is followed by the characters DA, and the <address> (if present) matches the Instrument Address, and the command is terminated with either <CR> with no checksum or <ETX> followed by the correct checksum <BCC>.

Sample Data Reply String in response to Data Query Command (DA):

In response to a valid data query command (DA) the instrument responds in the following format:

<STX>MD02<SP><address><SP><measured value1><SP><status><SP><SFKT><SP><address+1><SP><measured value2><SP ><status><SP><SFKT><ETX><BCC>

The response uses the same command terminators as used by the received command i.e. if the received command was terminated with a <CR> the response is terminated with <CR> and if the command was terminated with a <ETX><BCC> the response is terminated with<ETX> and the computed checksum <BCC>.

The 02 after the MD indicates, that two measurements are present in the reply string, (a 03 for three measurements and so on, this will also determine the length of the reply string).

<address> is the Instrument Address. Each subsequent measurement attached to the response will have the <address + X> where X keeps incrementing by 1 for each measurement included.

<measured value> is the concentration value in currently selected gas units represented as exponential representation with 4 characters mantissa and 2 characters exponent, each with sign.

Mantissa: sign and 4 digits. The decimal point is assumed to be after the first digit and is not transmitted.

Exponent: sign and 2 digits.

Example:

-5384000.0 is represented as -5384+06

+0.04567 is represented as +4567-02

<status>: is formed by < operating status > and < error status > and separated by a space i.e.

<operating status><SP><error status>

Each of the two (<operating status> and <error status>) are formed by two characters each representing a 2 digit hex number which is one byte (8 Bits) operation status and one byte (8 Bits) error status.

These two bytes contain the information about the main operating conditions of the instrument at that instant. For details on how to interpret the status bytes refer to Table D–1 and Table D–2 below.

<SFKT>: is the space provided for future use for special function, it currently contains a string of ten 0's i.e. <0000000000>.

Example:

Geysitech Protocol with transmission of three concentrations (Instrument ID is 1, Operation Status is 03, Error Status is 04):

Data Query String: `<STX>DA<CR>`

Reply String:

```
<STX>MD03<SP>001<SP>+2578+01<SP>03 <SP>04<SP>0000000000 <SP>002 <SP>
                   ↑             ↑                                                   ↑
              Address    First Concentration(E-format)=25.78              Address+1

+5681+00<SP>03<SP>04<SP>0000000000<SP>003<SP>+1175+01<SP>03<SP>04<SP
   ↑                                                  ↑            ↑
Second Concentration = 5.681                   Address+2    Third Concentration=11.75

0000000000<SP><CR>
```

The attached concentrations are in the selected gas units. The measurements that are attached to the response if not valid in a particular mode then a value of 0.0 will be reported.

Measurements reported in response to DA command

The following measurements reported in response to DA command are for the Model 48*i* Trace Level-Enhanced.

Single Range Mode

The 1 measurement reported in single range mode for the Model 48*i* Trace Level-Enhanced includes:

- CO

Dual/Auto Range Mode

The 2 measurements reported in dual or auto range modes for the Model 48*i* Trace Level-Enhanced include:

- low CO
- high CO

Operating and Error Status

See Table D–1 for operating status and Table D–2 for error status for the Model 48*i* Trace Level-Enhanced.

Table D–1. Operating Status for Model 48*i* Trace Level-Enhanced

	D7	D6	D5	D4		D3	D2	D1	D0
→ Bit	**8**	**7**	**6**	**5**		**4**	**3**	**2**	**1**
→ Hex-value	80	40	20	10		08	04	02	01
	MSB					LSB			
Operating status:									
Service Mode (On)	0	0	0	0		0	0	0	1
Maintenance (Local)	0	0	0	0		0	0	1	0
Zero gas (On)	0	0	0	0		0	1	0	0
Span gas (On)	0	0	0	0		1	0	0	0
Gas Unit Indication (ppm OR ppb)	0	0	0	1		0	0	0	0
Ozonator (Off)	0	0	1	0		0	0	0	0
PMT (Off)	0	1	0	0		0	0	0	0
Not used	1	0	0	0		0	0	0	0

Table D–2. Error Status for Model 48*i* Trace Level-Enhanced

	D7	D6	D5	D4		D3	D2	D1	D0
→ Bit	**8**	**7**	**6**	**5**		**4**	**3**	**2**	**1**
→ Hex-value	80	40	20	10		08	04	02	01
	MSB					LSB			
Error status:									
Internal Temperature Alarm	0	0	0	0		0	0	0	1
Optical Chamber Temperature Alarm	0	0	0	0		0	0	1	0
AGC Intensity Alarm	0	0	0	0		0	1	0	0
Bias Voltage Alarm	0	0	0	0		1	0	0	0
Pressure Alarm	0	0	0	1		0	0	0	0
Sample Flow Alarm	0	0	1	0		0	0	0	0
Motor Speed Alarm	0	1	0	0		0	0	0	0
Not used	1	0	0	0		0	0	0	0