

**Model 42i**  
**NO<sub>y</sub>**

**Instruction Manual**

Chemiluminescence NO-DIF-NO<sub>y</sub> Analyzer

Part Number 102975-00

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CE

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# WEEE Compliance

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



Thermo Fisher Scientific has contracted with one or more recycling/disposal companies in each EU Member State, and this product should be disposed of or recycled through them. Further information on Thermo Fisher Scientific's compliance with these Directives, the recyclers in your country, and information on Thermo Fisher Scientific products which may assist the detection of substances subject to the RoHS Directive are available at: [www.thermo.com/WEEERoHS](http://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 “[Preventative 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
- Appendix E “[Standards for Trace Level Analyzers](#)” provides information about generating zero air.





## 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  |
|---|--|
|  <b>DANGER</b>           | A hazard is present that will result in death or serious personal injury if the warning is ignored. ▲        |
|  <b>WARNING</b>          | A hazard is present or an unsafe practice can result in serious personal injury if the warning is ignored. ▲ |
|  <b>CAUTION</b>          | The hazard or unsafe practice could result in minor to moderate personal injury if the warning is ignored. ▲ |
|  <b>Equipment Damage</b> | 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   |
|--|---|
| <br><b>WARNING</b>          | <p>If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. ▲</p> <p>The service procedures in this manual are restricted to qualified service personnel only. ▲</p> <p>The Model 42i-NO<sub>y</sub> is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated. ▲</p>  |
| <br><b>CAUTION</b>          | <p>Ozone is present in the exhaust, therefore, the exhaust should be plumbed to a suitable vent. ▲</p> <p>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. ▲</p>  |
| <br><b>Equipment Damage</b> | <p>Do not attempt to lift the analyzer by the cover or other external fittings. ▲</p> <p>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. ▲</p> <p>This adjustment should only be performed by an instrument service technician. ▲</p> <p>Handle all printed circuit boards by the edges only. ▲</p> <p>Do not remove the panel or frame from the LCD module. ▲</p> <p>The LCD module polarizing plate is very fragile, handle it carefully. ▲</p> <p>Do not wipe the LCD module polarizing plate with a dry cloth, it may easily scratch the plate. ▲</p> <p>Do not use Ketonics solvent or aromatic solvent to clean the LCD module, use a soft cloth moistened with a naphtha cleaning solvent. ▲</p> <p>Do not place the LCD module near organic solvents or corrosive gases. ▲</p> <p>Do not shake or jolt the LCD module. ▲</p> |

## FCC Compliance

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

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

## WEEE Symbol

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

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



## Where to Get Help

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

1-866-282-0430 Toll Free

1-508-520-0430 International



# Contents

|                  |  |            |
|------------------|--|------------|
| <b>Chapter 1</b> | <b>Introduction.....</b>                                       | <b>1-1</b> |
|                  | Principle of Operation .....                                   | 1-2        |
|                  | Specifications .....   | 1-4        |
| <b>Chapter 2</b> | <b>Installation .....</b>                                      | <b>2-1</b> |
|                  | Lifting .....  | 2-1        |
|                  | Unpacking and Inspection .....                                 | 2-1        |
|                  | Setup Procedure .....  | 2-2        |
|                  | Connecting External Devices .....                              | 2-8        |
|                  | Terminal Board PCB Assemblies.....                             | 2-8        |
|                  | I/O Terminal Board.....  | 2-8        |
|                  | D/O Terminal Board .....                                       | 2-10       |
|                  | 25-Pin Terminal Board .....                                    | 2-11       |
|                  | Startup .....  | 2-12       |
| <b>Chapter 3</b> | <b>Operation .....</b>   | <b>3-1</b> |
|                  | Display.....   | 3-1        |
|                  | Pushbuttons .....  | 3-2        |
|                  | Soft Keys.....   | 3-3        |
|                  | Software Overview .....  | 3-4        |
|                  | Power-Up Screen .....  | 3-6        |
|                  | Run Screen.....  | 3-6        |
|                  | Main Menu.....   | 3-7        |
|                  | Range Menu .....   | 3-8        |
|                  | Single Range Mode .....  | 3-8        |
|                  | Dual Range Mode.....   | 3-9        |
|                  | Auto Range Mode.....   | 3-11       |
|                  | Gas Units.....   | 3-13       |
|                  | NO, DIF, and NO <sub>y</sub> Ranges.....                       | 3-13       |
|                  | Set Custom Ranges .....  | 3-14       |
|                  | Custom Ranges .....  | 3-15       |
|                  | Averaging Time.....  | 3-15       |
|                  | Calibration Factors Menu .....                                 | 3-16       |
|                  | NO, NO <sub>y</sub> , and Prereactor Backgrounds .....         | 3-17       |
|                  | NO, DIF, and NO <sub>y</sub> Coefficients.....                 | 3-18       |
|                  | Reset User Calibration Default.....                            | 3-19       |
|                  | Calibration Menu .....   | 3-19       |
|                  | Calibrate NO, NO <sub>y</sub> and Prereactor Backgrounds ..... | 3-20       |
|                  | Calibrate NO, DIF or NO <sub>y</sub> Coefficients .....        | 3-21       |

|  |      |
|--|------|
| Zero/Span Check .....                  | 3-21 |
| Next Time .....                        | 3-22 |
| Period Hours.....                      | 3-22 |
| Zero/Span/Purge Duration Minutes ..... | 3-23 |
| Zero/Span Averaging Time .....         | 3-23 |
| Zero/Span Ratio.....                   | 3-24 |
| Instrument Controls Menu .....         | 3-24 |
| Ozonator.....                          | 3-24 |
| PMT Supply .....                       | 3-25 |
| Auto/Manual Mode .....                 | 3-25 |
| Datalogging Settings .....             | 3-26 |
| Select SREC/LREC.....                  | 3-26 |
| View Logged Data.....                  | 3-27 |
| Number of Records.....                 | 3-27 |
| Date and Time.....                     | 3-28 |
| Erase Log .....                        | 3-28 |
| Select Content.....                    | 3-29 |
| Concentrations.....                    | 3-29 |
| Other Measurements.....                | 3-30 |
| Analog Inputs.....                     | 3-31 |
| Commit Content .....                   | 3-31 |
| Reset to Default Content .....         | 3-31 |
| Configure Datalogging.....             | 3-32 |
| Logging Period Min .....               | 3-32 |
| Memory Allocation Percent.....         | 3-33 |
| Data Treatment .....                   | 3-33 |
| Communication Settings.....            | 3-33 |
| Baud Rate .....                        | 3-34 |
| Instrument ID.....                     | 3-34 |
| Communication Protocol.....            | 3-35 |
| Streaming Data Configuration .....     | 3-35 |
| Streaming Data Interval .....          | 3-36 |
| Concentrations.....                    | 3-36 |
| Other Measurements.....                | 3-37 |
| Analog Inputs.....                     | 3-37 |
| RS-232/RS-485 Selection.....           | 3-38 |
| TCP/IP Settings.....                   | 3-38 |
| Use DHCP .....                         | 3-39 |
| IP Address.....                        | 3-39 |
| Netmask.....                           | 3-39 |
| Default Gateway .....                  | 3-40 |
| Host Name .....                        | 3-40 |
| I/O Configuration.....                 | 3-41 |
| Output Relay Settings .....            | 3-41 |
| Logic State .....                      | 3-41 |
| Instrument State .....                 | 3-42 |

|  |      |
|--|------|
| Alarms.....                                  | 3-42 |
| Non-Alarm .....                              | 3-43 |
| Digital Input Settings.....                  | 3-43 |
| Logic State .....                            | 3-44 |
| Instrument Action.....                       | 3-44 |
| Analog Output Configuration.....             | 3-45 |
| Select Output Range .....                    | 3-45 |
| Minimum and Maximum Value .....              | 3-46 |
| Choose Signal to Output .....                | 3-47 |
| Analog Input Configuration.....              | 3-48 |
| Descriptor .....                             | 3-49 |
| Units.....                                   | 3-49 |
| Decimal Places .....                         | 3-50 |
| Number of Table Points.....                  | 3-50 |
| Table Point .....                            | 3-50 |
| Volts .....                                  | 3-51 |
| User Value .....                             | 3-51 |
| Temperature Compensation.....                | 3-52 |
| Pressure Compensation .....                  | 3-52 |
| Screen Contrast.....                         | 3-53 |
| Service Mode .....                           | 3-53 |
| Date/Time .....                              | 3-54 |
| Diagnostics Menu .....                       | 3-54 |
| Program Versions.....                        | 3-55 |
| Voltages .....                               | 3-55 |
| Motherboard Voltages.....                    | 3-56 |
| Interface Board Voltages .....               | 3-56 |
| I/O Board Voltages .....                     | 3-56 |
| External Converter Board Voltages.....       | 3-57 |
| Temperatures .....                           | 3-57 |
| Pressure.....                                | 3-58 |
| Flow.....                                    | 3-58 |
| Prereactor Zero .....                        | 3-58 |
| Analog Input Readings.....                   | 3-59 |
| Analog Input Voltages.....                   | 3-59 |
| Digital Inputs.....                          | 3-59 |
| Relay States .....                           | 3-60 |
| Test Analog Outputs.....                     | 3-60 |
| Set Analog Outputs.....                      | 3-60 |
| Instrument Configuration .....               | 3-61 |
| Contact Information .....                    | 3-61 |
| Alarms Menu .....                            | 3-62 |
| Internal Temperature .....                   | 3-63 |
| Min and Max Internal Temperature Limits..... | 3-63 |
| Chamber Temperature.....                     | 3-64 |
| Min and Max Chamber Temperature Limits ..... | 3-64 |

|   |      |
|---|------|
| Cooler Temperature.....   | 3-64 |
| Min and Max Cooler Temperature Limits .....                         | 3-65 |
| External Converter Temperature.....                                 | 3-65 |
| Min and Max External Converter Temperature Limits .....             | 3-66 |
| Pressure.....   | 3-66 |
| Min and Max Pressure Limits .....                                   | 3-67 |
| Flow.....   | 3-67 |
| Min and Max Flow Limits .....                                       | 3-67 |
| Ozonator Flow.....  | 3-68 |
| Zero and Span Check.....  | 3-68 |
| Max Zero and Span Offset .....                                      | 3-69 |
| Zero and Span Auto Calibration .....                                | 3-69 |
| NO, DIF, and NO <sub>y</sub> Concentration.....                     | 3-69 |
| Min and Max NO, DIF, and NO <sub>y</sub> Concentration Limits ..... | 3-70 |
| Min Trigger .....   | 3-70 |
| Prereactor Concentration.....                                       | 3-71 |
| Min and Max Prereactor Concentration Limits.....                    | 3-71 |
| Min Trigger .....   | 3-72 |
| Service Menu .....  | 3-72 |
| PMT Voltage Adjustment .....  | 3-73 |
| Range Mode Select.....  | 3-73 |
| External Converter Set Temperature .....                            | 3-74 |
| Pressure Calibration .....  | 3-74 |
| Calibrate Pressure Zero .....                                       | 3-75 |
| Calibrate Pressure Span .....                                       | 3-75 |
| Restore Default Calibration.....                                    | 3-76 |
| Flow Calibration .....  | 3-76 |
| Calibrate Flow Zero .....   | 3-77 |
| Calibrate Flow Span.....  | 3-77 |
| Restore Default Flow Calibration.....                               | 3-78 |
| Input Board Calibration.....  | 3-78 |
| Manual Input Calibration .....                                      | 3-78 |
| Automatic Input Calibration.....                                    | 3-79 |
| Input Frequency Display.....  | 3-80 |
| Temperature Calibration.....  | 3-80 |
| Analog Output Calibration .....                                     | 3-81 |
| Analog Output Calibrate Zero .....                                  | 3-82 |
| Analog Output Calibrate Full-Scale .....                            | 3-82 |
| Analog Input Calibration .....                                      | 3-82 |
| Analog Input Calibrate Zero .....                                   | 3-83 |
| Analog Input Calibrate Full-Scale .....                             | 3-83 |
| Ozonator Safety .....   | 3-84 |
| Dilution Ratio.....   | 3-84 |
| Display Pixel Test .....  | 3-85 |
| Restore User Defaults.....  | 3-85 |
| Password Menu.....  | 3-85 |

|                  |  |            |
|------------------|--|------------|
|                  | Set Password .....   | 3-86       |
|                  | Lock Instrument .....  | 3-86       |
|                  | Change Password .....  | 3-86       |
|                  | Remove Password.....   | 3-87       |
|                  | Unlock Instrument.....   | 3-87       |
| <b>Chapter 4</b> | <b>Calibration.....</b>  | <b>4-1</b> |
|                  | Calibration Equipment .....  | 4-1        |
|                  | Zero Gas Generator.....  | 4-2        |
|                  | Compression .....  | 4-2        |
|                  | Drying .....   | 4-2        |
|                  | Oxidation.....   | 4-2        |
|                  | Scrubbing.....   | 4-2        |
|                  | Gas Phase Titrator.....  | 4-3        |
|                  | Flow Controllers .....   | 4-3        |
|                  | Pressure Regulator.....  | 4-3        |
|                  | Ozone Generator .....  | 4-4        |
|                  | Diverter Valve.....  | 4-4        |
|                  | Reaction Chamber .....   | 4-4        |
|                  | Mixing Chamber.....  | 4-4        |
|                  | Output Manifold .....  | 4-4        |
|                  | Reagents.....  | 4-4        |
|                  | NO Concentration Standard.....   | 4-4        |
|                  | Assaying a Working NO Standard Against a NIST-traceable NO<br>Standard.....        | 4-5        |
|                  | Zero Air .....   | 4-6        |
|                  | Dynamic Parameter Specifications for Gas Titrator.....                             | 4-6        |
|                  | Determining GPT System Flow Conditions .....                                       | 4-6        |
|                  | Pre-Calibration .....  | 4-8        |
|                  | Calibration.....   | 4-9        |
|                  | Connect GPT Apparatus to the Analyzer .....  | 4-9        |
|                  | Adjust Instrument Gain .....   | 4-10       |
|                  | Set Backgrounds to Zero .....  | 4-10       |
|                  | Calibrate the NO Channel to the NO Calibration Gas .....                           | 4-12       |
|                  | Calibrate the NO <sub>y</sub> Channel to the NO <sub>y</sub> Calibration Gas ..... | 4-12       |
|                  | Preparing NO, NO <sub>y</sub> , and DIF Calibration Curves .....                   | 4-13       |
|                  | Alternative Calibration Procedure Using NO <sub>2</sub> Permeation Tube....        | 4-16       |
|                  | Calibration in Dual Range and Auto Range Mode.....                                 | 4-16       |
|                  | Set Background Readings to Zero .....  | 4-16       |
|                  | Calibrate Low NO .....   | 4-17       |
|                  | Calibrate Low NO <sub>y</sub> .....  | 4-18       |
|                  | Calibrate Low DIF.....   | 4-18       |
|                  | Calibrate High NO.....   | 4-19       |
|                  | Calibrate High NO <sub>y</sub> .....   | 4-19       |
|                  | Calibrate High DIF.....  | 4-20       |
|                  | Zero and Span Check.....   | 4-21       |

|                  |  |            |
|------------------|--|------------|
| <b>Chapter 5</b> | <b>Preventative Maintenance .....</b>                                | <b>5-1</b> |
|                  | Safety Precautions .....   | 5-1        |
|                  | Replacement Parts .....  | 5-2        |
|                  | Cleaning the Outside Case .....                                      | 5-2        |
|                  | Ozonator Air Feed Drying Column Replacement .....                    | 5-2        |
|                  | Sample Filters Inspection and Replacement .....                      | 5-2        |
|                  | Capillaries Inspection and Replacement .....                         | 5-3        |
|                  | Bypass Pump Capillaries Inspection and Replacement .....             | 5-4        |
|                  | Thermoelectric Cooler Fins Inspection and Cleaning .....             | 5-6        |
|                  | Fan Filters Inspection and Cleaning .....                            | 5-6        |
|                  | Leak Test .....  | 5-7        |
|                  | Pump Rebuilding .....  | 5-7        |
|                  | Bypass Pump Rebuilding .....   | 5-10       |
| <br>             |  |            |
| <b>Chapter 6</b> | <b>Troubleshooting.....</b>  | <b>6-1</b> |
|                  | Safety Precautions .....   | 6-1        |
|                  | Troubleshooting Guides.....  | 6-1        |
|                  | Board-Level Connection Diagrams .....                                | 6-5        |
|                  | Connector Pin Descriptions .....                                     | 6-7        |
|                  | Service Locations.....   | 6-21       |
| <br>             |  |            |
| <b>Chapter 7</b> | <b>Servicing .....</b>   | <b>7-1</b> |
|                  | Safety Precautions .....   | 7-2        |
|                  | Firmware Updates .....   | 7-4        |
|                  | Accessing the Service Mode.....                                      | 7-4        |
|                  | Replacement Parts List .....   | 7-4        |
|                  | Cable List.....  | 7-6        |
|                  | External Device Connection Components .....                          | 7-7        |
|                  | Removing the Measurement Bench and Lowering the Partition Panel..... | 7-10       |
|                  | Pump Replacement .....   | 7-11       |
|                  | Vacuum Pump Diaphragm and Valve Replacement.....                     | 7-12       |
|                  | Diaphragm Replacement.....   | 7-13       |
|                  | Valve Replacement.....   | 7-14       |
|                  | Bypass Pump Replacement.....   | 7-16       |
|                  | Fan Replacement.....   | 7-17       |
|                  | PMT Cooler and Reaction Chamber Assembly Replacement.....            | 7-18       |
|                  | Photomultiplier Tube Replacement .....                               | 7-20       |
|                  | PMT High Voltage Power Supply Replacement.....                       | 7-21       |
|                  | PMT Voltage Adjustment .....   | 7-23       |
|                  | Reaction Chamber Cleaning or Removal .....                           | 7-23       |
|                  | External Converter Replacement .....                                 | 7-25       |
|                  | Solenoid Valve Replacement .....                                     | 7-27       |
|                  | Ozonator Assembly Replacement .....                                  | 7-28       |

Ozonator Transformer Replacement ..... 7-30  
 Input Board Replacement ..... 7-30  
 Input Board Calibration..... 7-32  
 DC Power Supply Replacement ..... 7-32  
 Analog Output Testing ..... 7-33  
 Analog Output Calibration ..... 7-36  
 Analog Input Calibration ..... 7-37  
     Calibrating the Input Channels to Zero Volts ..... 7-37  
     Calibrating the Input Channels to Full-Scale ..... 7-37  
 Pressure Transducer Assembly Replacement..... 7-38  
 Pressure Transducer Calibration..... 7-39  
 Temperature Control Board Replacement..... 7-41  
 Ambient Temperature Calibration ..... 7-42  
 Fuse Replacement ..... 7-43  
 I/O Expansion Board (Optional) Replacement ..... 7-43  
 Digital Output Board Replacement..... 7-45  
 Motherboard Replacement..... 7-46  
 Measurement Interface Board Replacement ..... 7-47  
 External Converter Interface Board Replacement ..... 7-48  
 Flow Transducer Replacement ..... 7-49  
 Flow Transducer Calibration..... 7-50  
 Front Panel Board Replacement..... 7-51  
 LCD Module Replacement ..... 7-52  
 Service Locations..... 7-53

**Chapter 8**      **System Description ..... 8-1**  
 Hardware ..... 8-1  
 External Converter ..... 8-3  
     Mode Solenoids ..... 8-3  
 Reaction Chamber ..... 8-3  
     Prereactor Solenoid ..... 8-4  
     Optical Filter..... 8-4  
     Pressure Transducer ..... 8-4  
     Sample Flow Sensor ..... 8-4  
 Ozonator..... 8-4  
     Ozonator Flow Switch ..... 8-4  
 Prereactor..... 8-4  
 Photomultiplier Tube ..... 8-4  
 Photomultiplier Tube Cooler ..... 8-5  
 External Pump ..... 8-5  
     Sample Capillary ..... 8-5  
     Dry Air Capillary ..... 8-5  
 Bypass Pump Assembly ..... 8-5  
     Capillaries ..... 8-5  
 Teflon Particulate Filter ..... 8-5  
 Software ..... 8-5

|   |      |
|---|------|
| Instrument Control.....                             | 8-5  |
| Monitoring Signals.....                             | 8-6  |
| Measurement Calculations .....                      | 8-6  |
| Output Communication .....                          | 8-7  |
| Electronics .....                                   | 8-7  |
| Motherboard.....                                    | 8-7  |
| External Connectors.....                            | 8-8  |
| Internal Connectors .....                           | 8-8  |
| Measurement Interface Board .....                   | 8-8  |
| Measurement Interface Board Connectors.....         | 8-8  |
| External Converter Interface Board .....            | 8-9  |
| External Converter Interface Board Connectors ..... | 8-9  |
| Flow Sensor Assembly .....                          | 8-9  |
| Pressure Sensor Assembly .....                      | 8-9  |
| Temperature Control Board.....                      | 8-9  |
| PMT Power Supply Assembly .....                     | 8-10 |
| Input Board Assembly.....                           | 8-10 |
| Digital Output Board.....                           | 8-10 |
| I/O Expansion Board (Optional) .....                | 8-10 |
| Front Panel Connector Board .....                   | 8-10 |
| I/O Components.....                                 | 8-11 |
| Analog Voltage Outputs.....                         | 8-11 |
| Analog Current Outputs (Optional) .....             | 8-11 |
| Analog Voltage Inputs (Optional) .....              | 8-12 |
| Digital Relay Outputs .....                         | 8-12 |
| Digital Inputs.....                                 | 8-12 |
| Serial Ports .....                                  | 8-13 |
| RS-232 Connection .....                             | 8-13 |
| RS-485 Connection .....                             | 8-14 |
| Ethernet Connection.....                            | 8-14 |
| External Accessory Connector .....                  | 8-14 |

|                  |   |            |
|------------------|---|------------|
| <b>Chapter 9</b> | <b>Optional Equipment.....</b>            | <b>9-1</b> |
|                  | Internal Zero/Span and Sample Valves..... | 9-1        |
|                  | Ozonator Permeation Dryer.....            | 9-1        |
|                  | Ozone Particulate Filter .....            | 9-1        |
|                  | I/O Expansion Board Assembly.....         | 9-2        |
|                  | Terminal Block and Cable Kits .....       | 9-2        |
|                  | Cables .....                              | 9-2        |
|                  | Mounting Options.....                     | 9-4        |

|                   |                      |            |
|-------------------|----------------------|------------|
| <b>Appendix A</b> | <b>Warranty.....</b> | <b>A-1</b> |
|-------------------|----------------------|------------|

|                   |  |            |
|-------------------|--|------------|
| <b>Appendix B</b> | <b>C-Link Protocol Commands.....</b>   | <b>B-1</b> |
|                   | Instrument Identification Number ..... | B-1        |



|   |      |
|---|------|
| Commands .....                              | B-2  |
| Commands List.....                          | B-2  |
| Measurements .....                          | B-9  |
| Alarms.....                                 | B-13 |
| Diagnostics .....                           | B-17 |
| Datalogging.....                            | B-17 |
| Calibration .....                           | B-26 |
| Keys/Display .....                          | B-29 |
| Measurement Configuration .....             | B-31 |
| Hardware Configuration .....                | B-34 |
| Communications Configuration .....          | B-38 |
| I/O Configuration.....                      | B-42 |
| Record Layout Definition .....              | B-46 |
| Format Specifier for ASCII Responses.....   | B-47 |
| Format Specifier for Binary Responses ..... | B-47 |
| Format Specifier for EREC Layout.....       | B-48 |
| Text .....                                  | B-48 |
| Value String.....                           | B-48 |
| Value Source .....                          | B-48 |
| Alarm Information .....                     | B-49 |
| Translation Table.....                      | B-49 |
| Selection Table.....                        | B-49 |
| Button Designator.....                      | B-49 |
| Examples.....                               | B-50 |

|                   |  |            |
|-------------------|--|------------|
| <b>Appendix C</b> | <b>MODBUS Protocol .....</b>                                   | <b>C-1</b> |
|                   | Serial Communication Parameters .....                          | C-1        |
|                   | TCP Communication Parameters .....                             | C-2        |
|                   | Application Data Unit Definition .....                         | C-2        |
|                   | Slave Address.....   | C-2        |
|                   | MBAP Header .....  | C-2        |
|                   | Function Code.....   | C-3        |
|                   | Data.....  | C-3        |
|                   | Error Check .....  | C-3        |
|                   | Function Codes.....  | C-3        |
|                   | (0x01/0x02) Read Coils / Read Inputs .....                     | C-3        |
|                   | (0x03/0x04) Read Holding Registers / Read Input Registers..... | C-5        |
|                   | (0x05) Force (Write) Single Coil.....                          | C-7        |
|                   | MODBUS Parameters Supported .....                              | C-8        |

|                   |   |            |
|-------------------|---|------------|
| <b>Appendix D</b> | <b>Geysitech (Bayern-Hessen) Protocol .....</b> | <b>D-1</b> |
|                   | Serial Communication Parameters .....           | D-1        |
|                   | TCP Communication Parameters .....              | D-2        |
|                   | Instrument Address .....                        | D-2        |
|                   | Abbreviations Used .....                        | D-2        |

## Contents

|   |     |
|---|-----|
| Basic Command Structure .....                         | D-2 |
| Block Checksum <BCC> .....                            | D-3 |
| Geysitech Commands .....                              | D-3 |
| Instrument Control Command (ST) .....                 | D-3 |
| Data Sampling/Data Query Command (DA).....            | D-4 |
| Measurements reported in response to DA command ..... | D-6 |
| Single Range Mode .....                               | D-6 |
| Dual/Auto Range Mode.....                             | D-6 |
| Operating and Error Status .....                      | D-7 |

|                   |  |            |
|-------------------|--|------------|
| <b>Appendix E</b> | <b>Standards for Trace Level Analyzers .....</b> | <b>E-1</b> |
|-------------------|--|------------|

# Figures

|   |      |
|---|------|
| <b>Figure 1–1.</b> Model 42i NO <sub>y</sub> External Molybdenum Converter .....            | 1-3  |
| <b>Figure 1–2.</b> Model 42i NO <sub>y</sub> Flow Schematic .....                           | 1-3  |
| <b>Figure 2–1.</b> Remove the Packing Material .....  | 2-2  |
| <b>Figure 2–2.</b> Model 42i NO <sub>y</sub> Rear Panel .....                               | 2-3  |
| <b>Figure 2–3.</b> Bypass Pump Assembly Rear Panel .....                                    | 2-4  |
| <b>Figure 2–4.</b> Atmospheric Dump Bypass Plumbing .....                                   | 2-4  |
| <b>Figure 2–5.</b> Twin-Head Vacuum Pump Installation.....                                  | 2-5  |
| <b>Figure 2–6.</b> Model 42i NO <sub>y</sub> Typical Installation Diagram .....             | 2-7  |
| <b>Figure 2–7.</b> I/O Terminal Board Views .....   | 2-9  |
| <b>Figure 2–8.</b> D/O Terminal Board Views.....  | 2-10 |
| <b>Figure 2–9.</b> 25-Pin Terminal Board Views.....   | 2-11 |
| <b>Figure 3–1.</b> Front Panel Display.....   | 3-2  |
| <b>Figure 3–2.</b> Front Panel Pushbuttons.....   | 3-2  |
| <b>Figure 3–3.</b> Flowchart of Menu-Driven Software .....                                  | 3-5  |
| <b>Figure 3–4.</b> Pin-Out of Rear Panel Connector in Single Range Mode .....               | 3-9  |
| <b>Figure 3–5.</b> Pin-Out of Rear Panel Connector in Dual Range Mode .....                 | 3-10 |
| <b>Figure 3–6.</b> Analog Output in Auto Range Mode.....                                    | 3-11 |
| <b>Figure 3–7.</b> Pin-Out of Rear Connector in Auto Range Mode.....                        | 3-12 |
| <b>Figure 4–1.</b> GPT System.....  | 4-3  |
| <b>Figure 5–1.</b> Inspecting and Replacing the Capillaries .....                           | 5-3  |
| <b>Figure 5–2.</b> Inspecting and Replacing the Bypass Pump Capillaries.....                | 5-5  |
| <b>Figure 5–3.</b> Inspecting and Cleaning the Fan Filters.....                             | 5-7  |
| <b>Figure 5–4.</b> Rebuilding the Pump.....   | 5-9  |
| <b>Figure 5–5.</b> Rebuilding the Bypass Pump .....   | 5-11 |
| <b>Figure 6–1.</b> Board-Level Connection Diagram - Common Electronics.....                 | 6-5  |
| <b>Figure 6–2.</b> Board-Level Connection Diagram - Measurement System .....                | 6-6  |
| <b>Figure 6–3.</b> Board-Level Connection Diagram - External Converter .....                | 6-7  |
| <b>Figure 7–1.</b> Properly Grounded Antistatic Wrist Strap .....                           | 7-4  |
| <b>Figure 7–2.</b> Component Layout for Analyzer .....                                      | 7-8  |
| <b>Figure 7–3.</b> Component Layout for External Converter .....                            | 7-9  |
| <b>Figure 7–4.</b> Component Layout for Bypass Pump.....                                    | 7-9  |
| <b>Figure 7–5.</b> Removing the Measurement Bench and Lowering the Partition<br>Panel ..... | 7-10 |
| <b>Figure 7–6.</b> Replacing the Pump.....  | 7-12 |
| <b>Figure 7–7.</b> Vacuum Pump – Head Plate and Motor View .....                            | 7-15 |

## Figures

|   |      |
|---|------|
| <b>Figure 7–8.</b> Replacing the Bypass Pump.....                           | 7-17 |
| <b>Figure 7–9.</b> Replacing the Fan .....                                  | 7-18 |
| <b>Figure 7–10.</b> PMT Cooler and Reaction Chamber .....                   | 7-19 |
| <b>Figure 7–11.</b> Replacing the PMT.....                                  | 7-21 |
| <b>Figure 7–12.</b> Replacing the PMT HVPS.....                             | 7-22 |
| <b>Figure 7–13.</b> Cleaning or Removing the Reaction Chamber.....          | 7-25 |
| <b>Figure 7–14.</b> External Molybdenum Converter Assembly.....             | 7-26 |
| <b>Figure 7–15.</b> Replacing the Solenoid Valve.....                       | 7-28 |
| <b>Figure 7–16.</b> Replacing the Ozonator Assembly.....                    | 7-29 |
| <b>Figure 7–17.</b> Replacing the Input Board .....                         | 7-31 |
| <b>Figure 7–18.</b> Replacing the DC Power Supply.....                      | 7-33 |
| <b>Figure 7–19.</b> Rear Panel Analog Input and Output Pins .....           | 7-34 |
| <b>Figure 7–20.</b> Replacing the Pressure Transducer .....                 | 7-39 |
| <b>Figure 7–21.</b> Replacing the I/O Expansion Board (Optional).....       | 7-44 |
| <b>Figure 7–22.</b> Rear Panel Board Connectors .....                       | 7-45 |
| <b>Figure 7–23.</b> Replacing the Measurement Interface Board .....         | 7-48 |
| <b>Figure 7–24.</b> Replacing the Flow Transducer .....                     | 7-49 |
| <b>Figure 7–25.</b> Replacing the Front Panel Board and the LCD Module..... | 7-52 |
| <b>Figure 8–1.</b> Analyzer Hardware Components.....                        | 8-2  |
| <b>Figure 8–2.</b> External Converter Hardware Components.....              | 8-2  |
| <b>Figure 8–3.</b> Bypass Pump Hardware Components .....                    | 8-3  |
| <b>Figure 9–1.</b> Rack Mount Option Assembly .....                         | 9-4  |
| <b>Figure 9–2.</b> Bench Mounting.....                                      | 9-5  |
| <b>Figure 9–3.</b> EIA Rack Mounting .....                                  | 9-6  |
| <b>Figure 9–4.</b> Retrofit Rack Mounting.....                              | 9-7  |
| <b>Figure B–1.</b> Flags .....  | B-13 |

# Tables

|   |      |
|---|------|
| <b>Table 1–1.</b> Model 42i NO <sub>y</sub> Specifications .....                  | 1-4  |
| <b>Table 2–1.</b> NO <sub>y</sub> Converter Interface Board DC/Data Wiring.....   | 2-6  |
| <b>Table 2–2.</b> NO <sub>y</sub> Converter Interface Board AC Wiring .....       | 2-6  |
| <b>Table 2–3.</b> I/O Terminal Board Pin Descriptions .....                       | 2-9  |
| <b>Table 2–4.</b> D/O Terminal Board Pin Descriptions.....                        | 2-10 |
| <b>Table 2–5.</b> 25-Pin Terminal Board Pin Descriptions.....                     | 2-11 |
| <b>Table 3–1.</b> Front Panel Pushbuttons .....                                   | 3-3  |
| <b>Table 3–2.</b> Default Analog Outputs in Single Range Mode.....                | 3-9  |
| <b>Table 3–3.</b> Default Analog Outputs in Dual Range Mode .....                 | 3-10 |
| <b>Table 3–4.</b> Default Analog Outputs in Auto Range Mode .....                 | 3-12 |
| <b>Table 3–5.</b> Available Operating Ranges .....                                | 3-14 |
| <b>Table 3–6.</b> Analog Output Zero to Full-Scale Table .....                    | 3-46 |
| <b>Table 3–7.</b> Signal Type Group Choices.....                                  | 3-48 |
| <b>Table 4–1.</b> Scrubbing Materials .....                                       | 4-3  |
| <b>Table 6–1.</b> Troubleshooting - General Guide .....                           | 6-2  |
| <b>Table 6–2.</b> Troubleshooting - Alarm Messages .....                          | 6-3  |
| <b>Table 6–3.</b> Motherboard Connector Pin Descriptions.....                     | 6-7  |
| <b>Table 6–4.</b> Measurement Interface Board Connector Pin Descriptions .....    | 6-12 |
| <b>Table 6–5.</b> Front Panel Board Connector Pin Diagram .....                   | 6-15 |
| <b>Table 6–6.</b> I/O Expansion Board (Optional) Connector Pin Descriptions ..... | 6-16 |
| <b>Table 6–7.</b> Digital Output Board Connector Pin Descriptions.....            | 6-18 |
| <b>Table 6–8.</b> Input Board Connector Pin Descriptions .....                    | 6-19 |
| <b>Table 6–9.</b> Temperature Control Board Connector Pin Descriptions .....      | 6-20 |
| <b>Table 6–10.</b> External Converter Board Connector Pin Descriptions.....       | 6-20 |
| <b>Table 7–1.</b> Model 42i NO <sub>y</sub> Replacement Parts.....                | 7-4  |
| <b>Table 7–2.</b> Model 42i NO <sub>y</sub> Cables .....                          | 7-6  |
| <b>Table 7–3.</b> External Device Connection Components .....                     | 7-7  |
| <b>Table 7–4.</b> Analog Output Channels and Rear Panel Pin Connections.....      | 7-35 |
| <b>Table 7–5.</b> Analog Input Channels and Rear Panel Pin Connections.....       | 7-35 |
| <b>Table 8–1.</b> RS-232 DB Connector Pin Configurations .....                    | 8-13 |
| <b>Table 8–2.</b> RS-485 DB Connector Pin Configuration .....                     | 8-14 |
| <b>Table 9–1.</b> Cable Options.....  | 9-3  |
| <b>Table 9–2.</b> Color Codes for 25-Pin and 37-Pin Cables .....                  | 9-3  |
| <b>Table 9–3.</b> Mounting Options .....  | 9-4  |
| <b>Table B–1.</b> C-Link Protocol Commands .....                                  | B-2  |

## Tables

|  |      |
|--|------|
| <b>Table B–2.</b> Averaging Times.....                                 | B-10 |
| <b>Table B–3.</b> Alarm Trigger Values.....                            | B-17 |
| <b>Table B–4.</b> Record Output Formats.....                           | B-22 |
| <b>Table B–5.</b> Stream Time Values .....                             | B-26 |
| <b>Table B–6.</b> Standard Ranges .....                                | B-31 |
| <b>Table B–7.</b> Contrast Levels .....                                | B-35 |
| <b>Table B–8.</b> Reply Termination Formats .....                      | B-40 |
| <b>Table B–9.</b> Analog Current Output Range Values.....              | B-42 |
| <b>Table B–10.</b> Analog Voltage Output Range Values .....            | B-43 |
| <b>Table B–11.</b> Default Output Assignment.....                      | B-44 |
| <b>Table C–1.</b> Read Coils for Model 42i NO <sub>y</sub> .....       | C-8  |
| <b>Table C–2.</b> Read Registers for Model 42i NO <sub>y</sub> .....   | C-9  |
| <b>Table C–3.</b> Write Coils for Model 42i NO <sub>y</sub> .....      | C-11 |
| <b>Table D–1.</b> Operating Status for Model 42i NO <sub>y</sub> ..... | D-7  |
| <b>Table D–2.</b> Error Status for Model 42i NO <sub>y</sub> .....     | D-7  |

# Chapter 1

## Introduction

The Model 42i NO<sub>y</sub> Chemiluminescence Analyzer combines proven detection technology, easy to use menu-driven software, and advanced diagnostics to offer unsurpassed flexibility and reliability. The Model 42i NO<sub>y</sub> 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
- Detection limits of 50 ppt or better
- Fast response time
- Linearity through all ranges
- Standard prereactor for continuous zero correction
- Independent NO-DIF-NO<sub>y</sub> ranges
- Replaceable NO<sub>y</sub> converter cartridge
- 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 1-4

Thermo Fisher Scientific is pleased to supply this chemiluminescence NO<sub>y</sub> 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 42i NO<sub>y</sub> operates on the principle that nitric oxide (NO) and ozone (O<sub>3</sub>) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO<sub>2</sub> molecules decay to lower energy states. Specifically:



NO<sub>y</sub> compounds (other than NO) must first be transformed into NO before they can be measured using the chemiluminescent reaction. They are converted to NO by a molybdenum converter heated to about 325 °C.

NO<sub>y</sub> is the sum of all reactive oxides of nitrogen (NO, NO<sub>2</sub>, NO<sub>3</sub>, N<sub>2</sub>O<sub>5</sub>, HNO<sub>2</sub>, HNO<sub>3</sub>, PAN, organic nitrates and aerosol nitrates). To minimize the loss of NO<sub>y</sub> prior to measurement, an external converter (molybdenum) module ([Figure 1–1](#)) that limits sample transport time and surface contact area is used. From the external converter, a flow arrangement using an external bypass pump to rapidly draw sample from the converter module for both NO and NO<sub>y</sub> channels is used.

After exiting the converter module, the analyzer draws a slip stream for each channel to feed the internal mode valve (NO or NO<sub>y</sub>) within the analyzer module ([Figure 1–2](#)). When the solenoid is normally open (NO mode), sample that has bypassed the converter is sent to the reaction chamber. When the solenoid mode is normally closed (NO<sub>y</sub> mode), sample that has passed through the converter is sent to the reaction chamber for analysis.

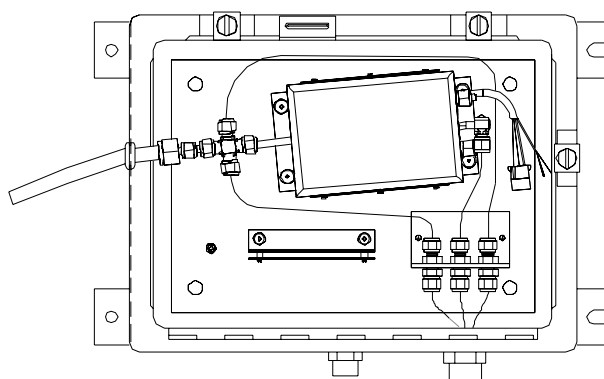
A third mode routes the sample to a prereactor to create a dynamic zero reading for the analyzer. The prereactor is sized so that greater than 99% of a 200 ppb NO sample will react prior to entering the reaction chamber but is small enough to allow interferents (olefins) to pass onto the chamber.

The combination of the three modes generates three signals: NO, NO<sub>y</sub>, and the difference between the two (DIF).

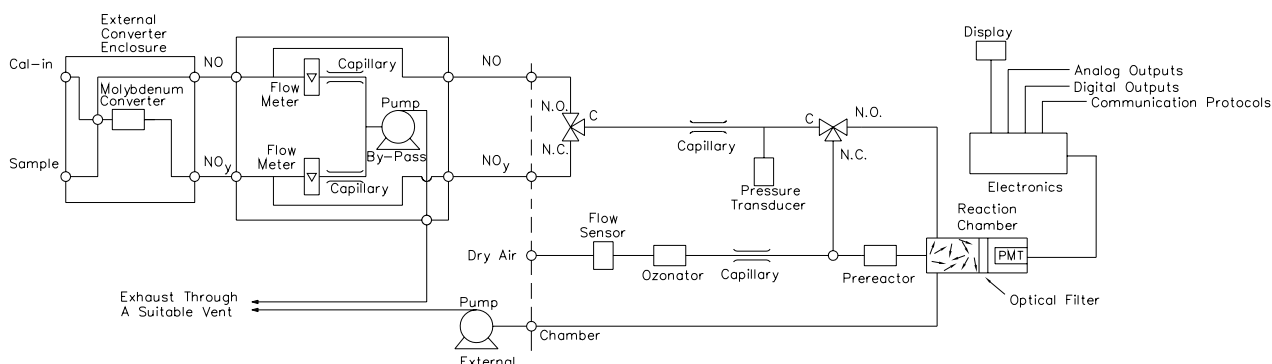


Dry air enters the Model 42i NO<sub>y</sub> through the *dry air* bulkhead, passes through a flow switch, and then through a silent discharge ozonator. The ozonator generates the ozone needed for the chemiluminescent reaction. At the reaction chamber, the ozone reacts with the NO in the sample to produce excited NO<sub>2</sub> molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the luminescence generated during this reaction. From the reaction chamber, the sample travels to the exhaust fitting, then to the pump.

The NO and NO<sub>y</sub> concentrations calculated in the NO and NO<sub>y</sub> modes are stored in memory. The difference between the concentrations is used to calculate the DIF concentration. The Model 42i NO<sub>y</sub> outputs NO, DIF, and NO<sub>y</sub> concentrations to the front panel display, the analog outputs, and also makes the data available over the serial or Ethernet connection.



**Figure 1-1.** Model 42i NO<sub>y</sub> External Molybdenum Converter



**Figure 1-2.** Model 42i NO<sub>y</sub> Flow Schematic

## Specifications

Table 1–1 lists the specifications for the Model 42i NO<sub>y</sub>.

**Table 1–1.** Model 42i NO<sub>y</sub> Specifications

|                                   |   |
|-----------------------------------|---|
| Preset ranges                     | 0-5, 10, 20, 50, 100, 200 ppb<br>0-10, 20, 50, 100, 200, 500 µg/m <sup>3</sup>  |
| Custom ranges                     | 0-50 to 200 ppb<br>0-10 to 500 µg/m <sup>3</sup>  |
| Zero roise                        | 25 ppt RMS (120 second averaging time)  |
| Lower detectable limit            | 50 ppt (120 second averaging time)  |
| Zero drift (24 hour)              | Negligible  |
| Span drift                        | ±1% full-scale  |
| Response time (in automatic mode) | 60 seconds (10 second averaging time)<br>90 seconds (60 second averaging time)<br>300 seconds (300 second averaging time)                                     |
| Linearity                         | ±1% full-scale  |
| Sample flow rate                  | 1 LPM   |
| Operating temperature             | 15–35 °C (may be safely operated over the 5–40 °C)*   |
| Power requirements                | 100 VAC @ 50/60 Hz<br>115 VAC @ 50/60 Hz<br>220–240 VAC @ 50/60 Hz<br>300 watts   |
| Physical dimensions               | 16.75" (W) X 8.62" (H) X 23" (D)  |
| Weight                            | Approximately 60 lbs. (including external pump)   |
| 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 10Mbps Ethernet connection, static or dynamic TCP/IP addressing  |

\*In non-condensing environments. Performance specifications based on operation in 15–35 °C range.

## Chapter 2

# Installation

Installing the Model 42i NO<sub>y</sub> includes the following recommendations and procedures:

- “Lifting” on page 2-1
- “Unpacking and Inspection” on page 2-1
- “Setup Procedure” on page 2-2
- “Connecting External Devices” on page 2-8
- “Startup” on page 2-12

### 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.



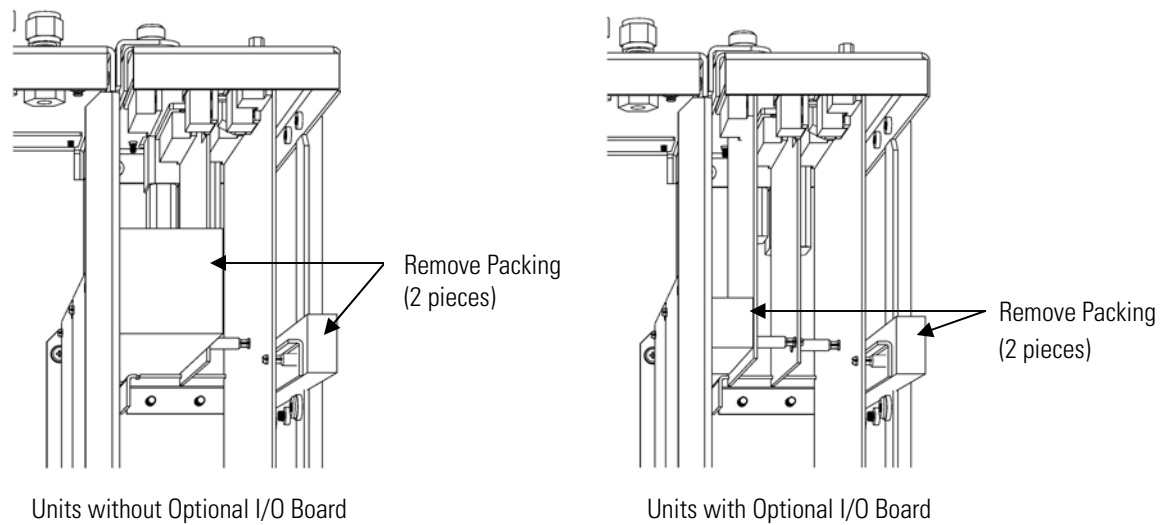
**Equipment Damage** Do not attempt to lift the instrument by the cover or other external fittings. ▲

### Unpacking and Inspection

The Model 42i NO<sub>y</sub> is shipped complete in multiple containers. If there is obvious damage to the shipping containers 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 its 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. Check for possible damage during shipment.
5. Check that all connectors and circuit boards are firmly attached.
6. Re-install the cover.
7. Remove any protective plastic material from the case exterior.
8. Remove the external converter module and conduit from their shipping containers.
9. Remove the external pump from its shipping container and place next to the instrument.

## Setup Procedure

Use the following procedure to setup the instrument:

1. Refer to [Figure 2–6](#) for the following connections. Ensure that the sample line is not contaminated by dirty, wet, or incompatible materials. All tubing should be constructed of FEP Teflon®, 316 stainless steel, borosilicate glass, or similar tubing with an OD of 1/4-inch and a minimum ID of 1/8-inch.

2. Cut conduit to proper length.
3. Run the NO and NO<sub>y</sub> sample tubing and the CAL tubing along with the 5-conductor data cable in the 3/4-inch conduit.
4. Inside the external converter assembly, run the tubing through the bulkhead fittings and connect the NO and CAL tubing to the cross connector on the input to the converter and connect the NO<sub>y</sub> tubing to the output of the converter.
5. At the back of the bypass pump assembly, connect the NO and NO<sub>y</sub> tubing to the appropriately labeled bulkheads (Figure 2–3).
6. Connect tubing and sample filters between the bypass pump assembly and the rear of the analyzer (Figure 2–2).

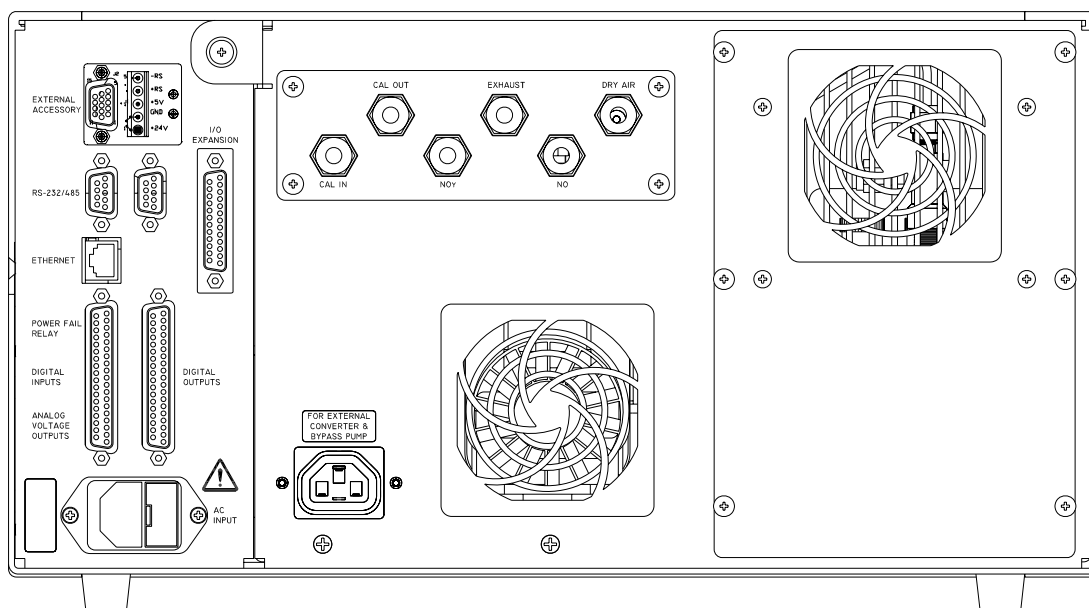
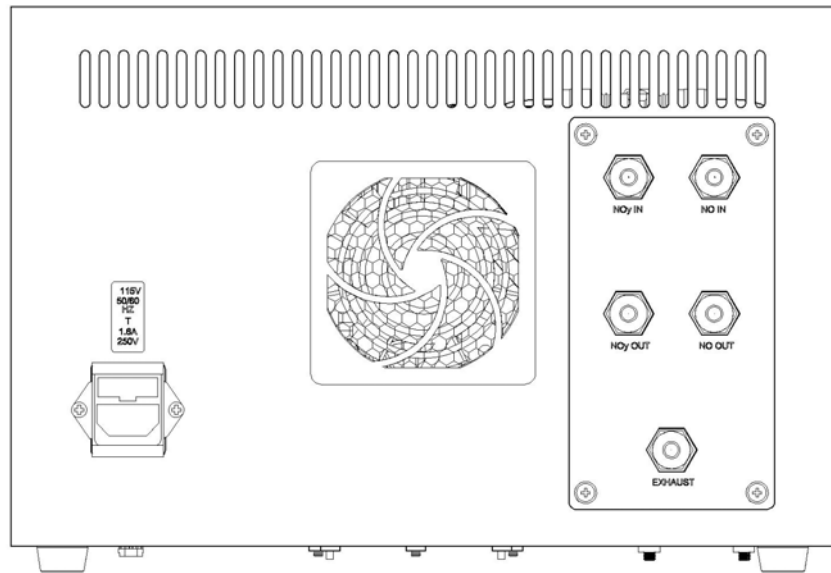


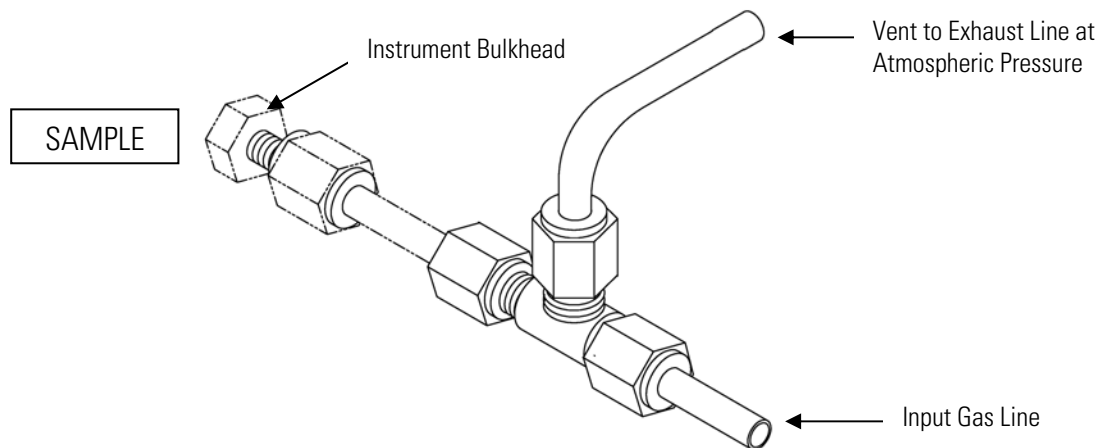
Figure 2–2. Model 42i NO<sub>y</sub> Rear Panel



**Figure 2–3.** Bypass Pump Assembly Rear Panel

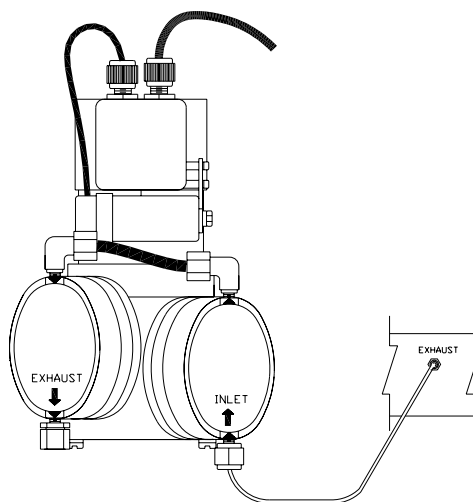
7. Connect the CAL tubing from the external converter module to the calibration gas source (such as a Model 146*i* calibrator).

**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

8. Connect the DC/Data cable to the 5 position terminal board on the rear of the analyzer and the 5 position terminal block on the NO<sub>y</sub> Interface Board inside the external converter assembly (Table 2-1).
9. Attach the AC Y adapter cable to the rear panel of the instrument.
10. Run the AC cable in the 1/2-inch conduit and connect the connector end to the Y adapter and the other end to the 3 position terminal block on the NO<sub>y</sub> Interface Board and the grounding stud in the external converter assembly (Table 2-2).
11. Attach the AC cable between the bypass pump assembly and the other side of the AC Y adapter on the rear of the analyzer.
12. Connect the air dryer to the DRY AIR bulkhead.
13. Connect the pump vacuum port (inlet) to the EXHAUST bulkhead (Figure 2-5).



**Figure 2-5.** Twin-Head Vacuum Pump Installation

14. Connect the pump exhaust to a suitable vent.



**CAUTION** Ozone is present in the exhaust, therefore, the exhaust should be plumbed to a suitable vent. ▲



**Equipment Damage** DO NOT connect the pump exhaust port to the EXHAUST bulkhead. This can cause permanent damage to both the cooler and the photomultiplier tube. ▲

15. 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 2-8

“External Device Connection Components” on page 7-7

“Terminal Block and Cable Kits” on page 9-2

“Instrument Controls Menu” on page 3-24

For detailed information about troubleshooting a connection, refer to “Analog Output Testing” on page 7-33.

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



**WARNING** The Model 42i NO<sub>y</sub> is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated. ▲

**Table 2–1.** NO<sub>y</sub> Converter Interface Board DC/Data Wiring

| Pin | Label  | Wire Color |
|-----|--------|------------|
| 1   | +24V   | Red        |
| 2   | GND    | Green      |
| 3   | +5V    | Black      |
| 4   | +RS485 | Blue       |
| 5   | -RS485 | Brown      |

**Table 2–2.** NO<sub>y</sub> Converter Interface Board AC Wiring

| Pin | Wire Color |
|-----|------------|
| 1   | Black      |
| 2   | White      |
| 3   | Green      |



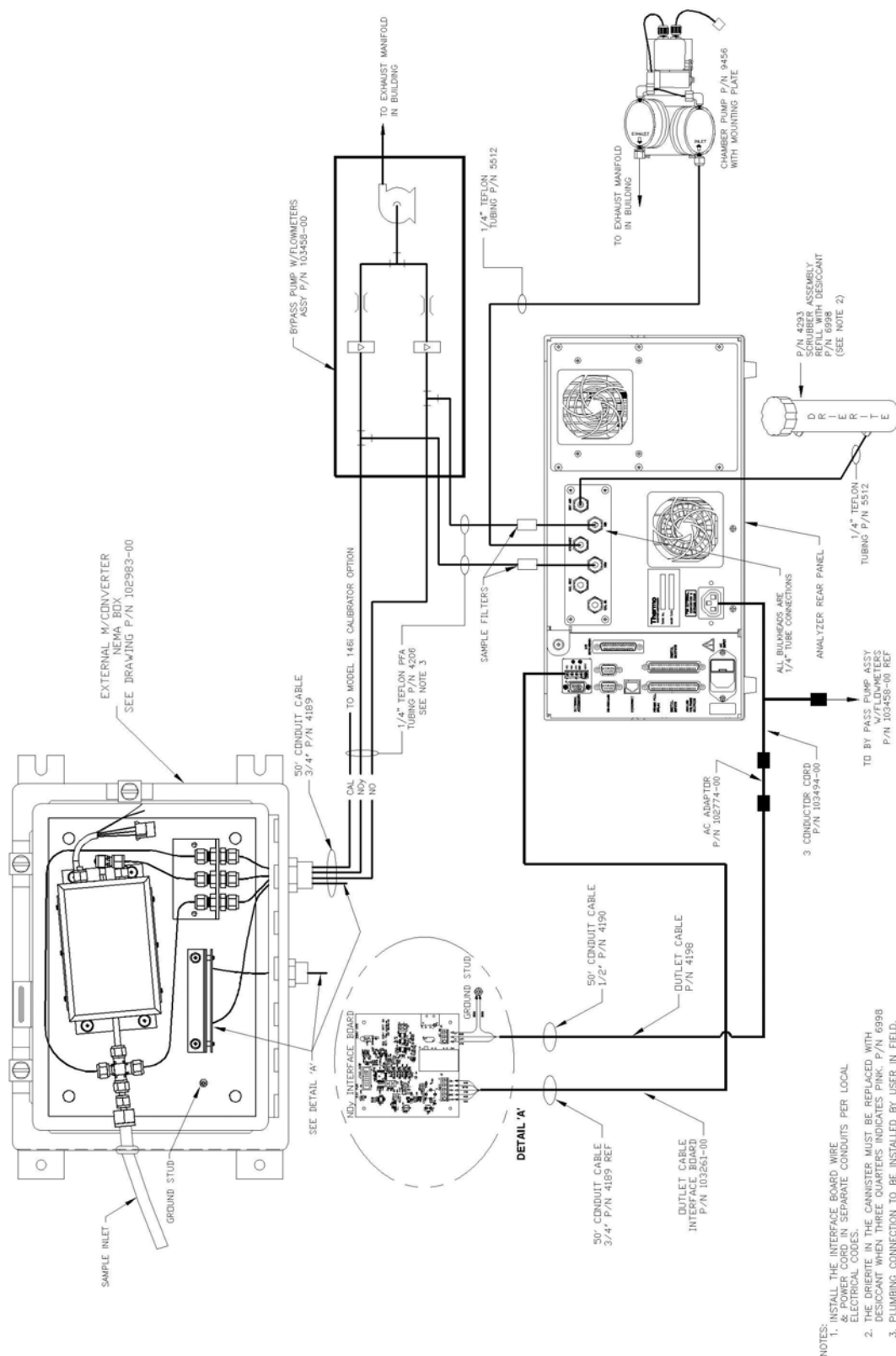


Figure 2-6. Model 42i NO<sub>y</sub> Typical Installation Diagram

## Connecting External Devices

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

These connection options include:

- Individual terminal board PCB assemblies
- Terminal block and cable kits (optional)
- Individual cables (optional)

For detailed information on the optional connection components, refer to the “[Optional Equipment](#)” chapter. For associated part numbers, refer to “[External Device Connection Components](#)” on page 7-7.

## Terminal Board PCB Assemblies

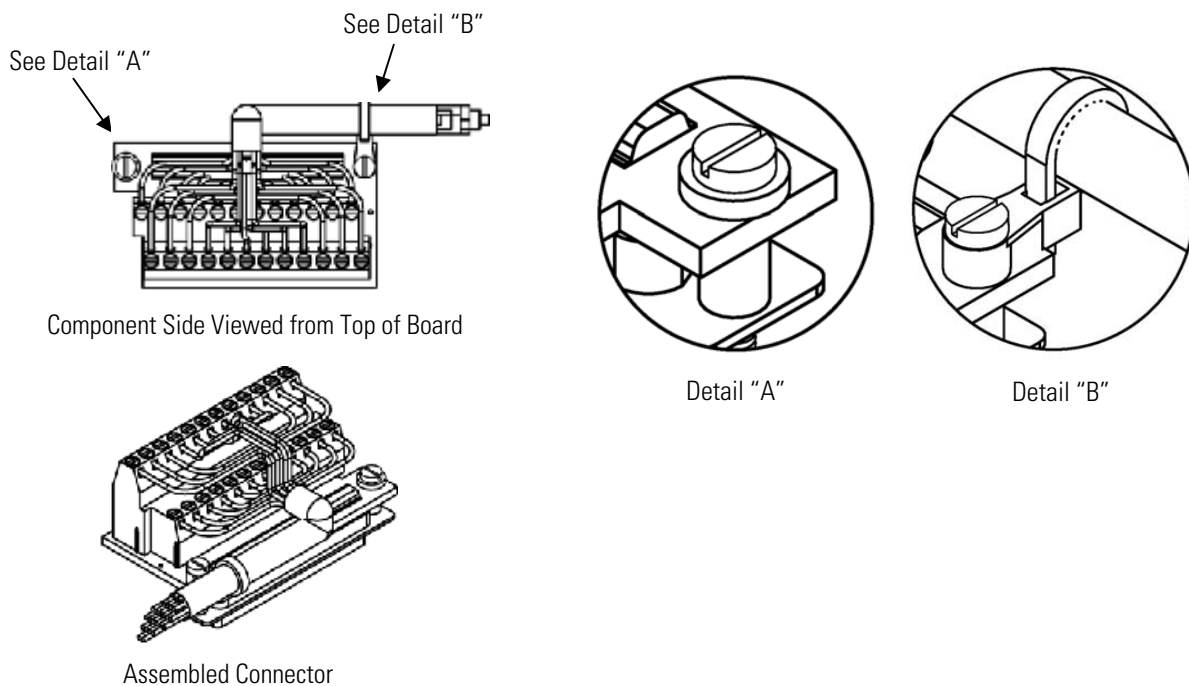
The following terminal board PCB assemblies are available for *iSeries* instruments:

- 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 2–7](#) shows the recommended method for attaching the cable to the terminal board using the included tie-down and spacer. [Table 2–3](#) identifies the connector pins and associated signals.

**Note** All of the Input/Output (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. ▲



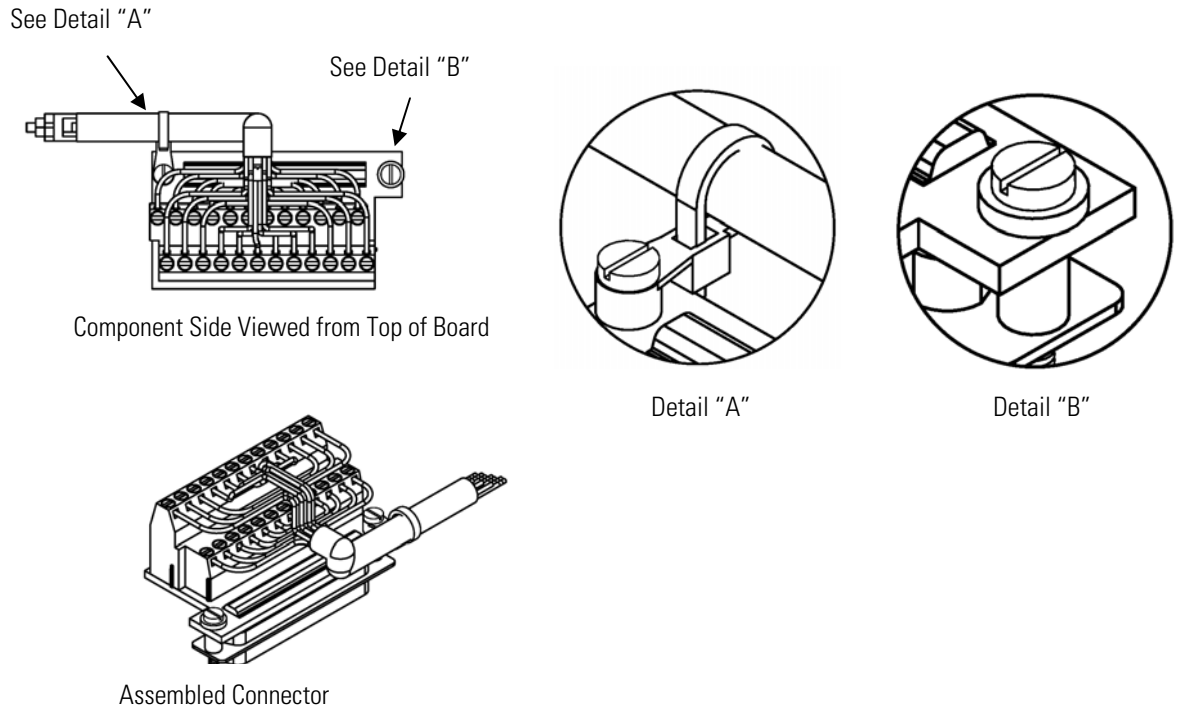
**Figure 2-7.** I/O Terminal Board Views

**Table 2-3.** 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 2–8 shows the recommended method for attaching the cable to the digital output (D/O) terminal board using the included tie-down and spacer. Table 2–4 identifies the connector pins and associated signals.

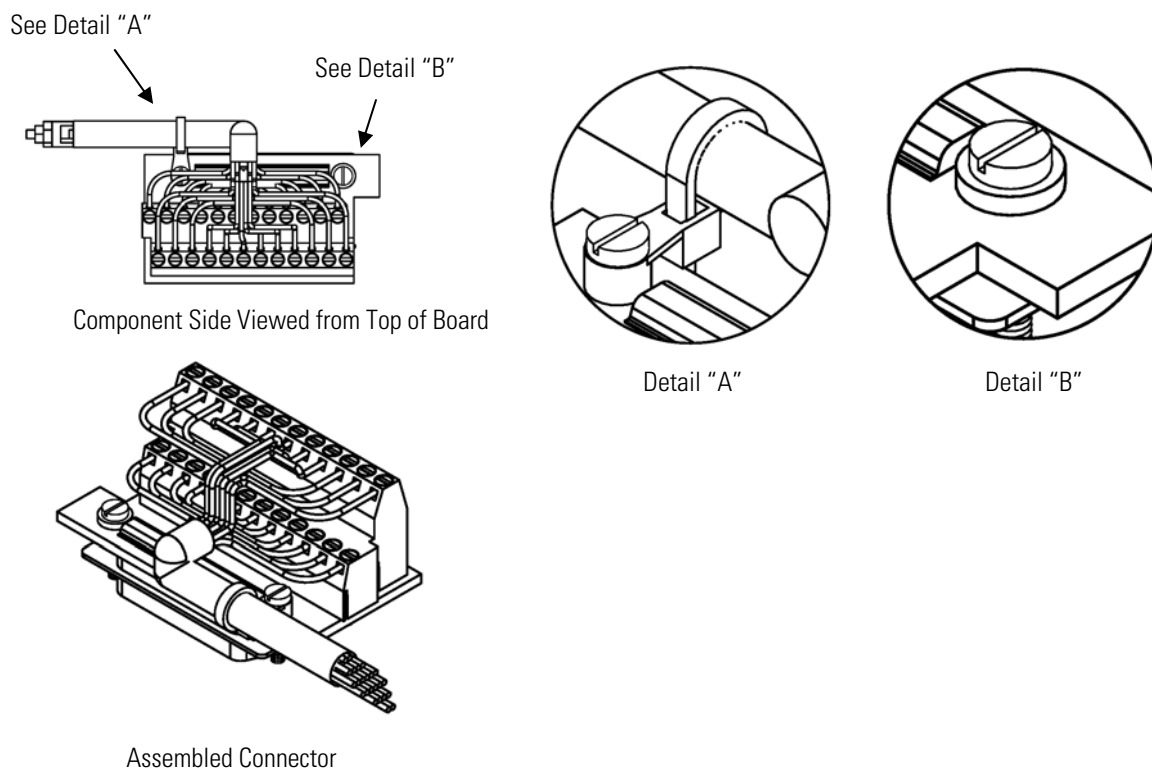


**Figure 2–8.** D/O Terminal Board Views

**Table 2–4.** 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  | (not used)         |
| 10  | Relay5_ContactB    | 22  | +24V               |
| 11  | Relay6_ContactA    | 23  | (not used)         |
| 12  | Relay6_ContactB    | 24  | +24V               |

**25-Pin Terminal Board** The 25-pin terminal board is included with the optional I/O Expansion Board.



**Figure 2-9.** 25-Pin Terminal Board Views

**Table 2-5.** 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

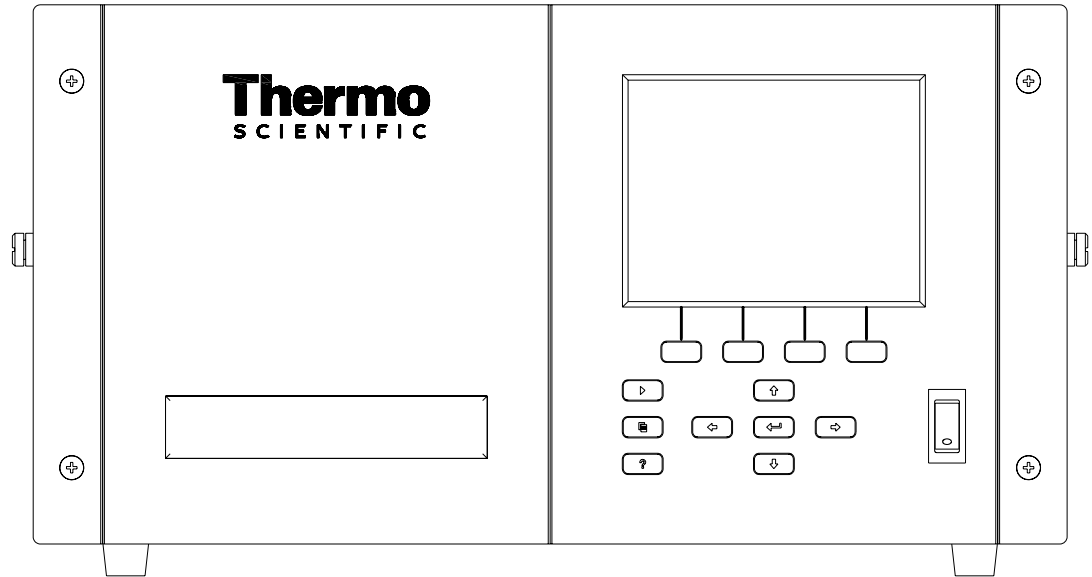
## Operation

This chapter describes the front panel display, front panel pushbuttons, and menu-driven software. For details, see the following topics:

- “Display” on page 3-1
- “Pushbuttons” on page 3-2
- “Software Overview” on page 3-4
- “Range Menu” on page 3-8
- “Averaging Time” on page 3-15
- “Calibration Factors Menu” on page 3-16
- “Calibration Menu” on page 3-19
- “Instrument Controls Menu” on page 3-24
- “Diagnostics Menu” on page 3-54
- “Alarms Menu” on page 3-62
- “Service Menu” on page 3-72
- “Password Menu” on page 3-85

### 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.



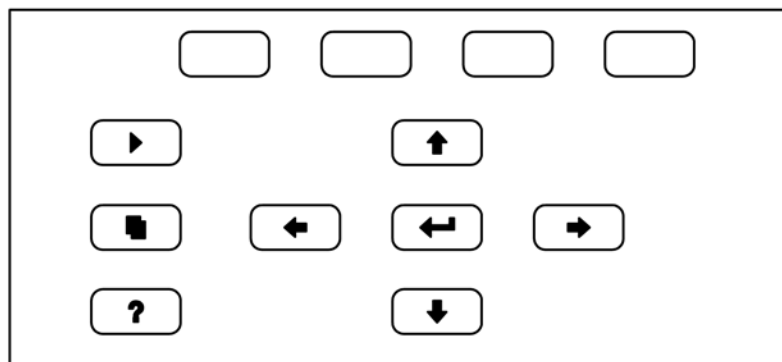
**Figure 3–1.** Front Panel Display



**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 NO, DIF, and NO <sub>y</sub> concentrations.  |
|  = 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<br>  = 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 42i NO<sub>y</sub> 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 NO, DIF, and NO<sub>y</sub> concentrations, 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.

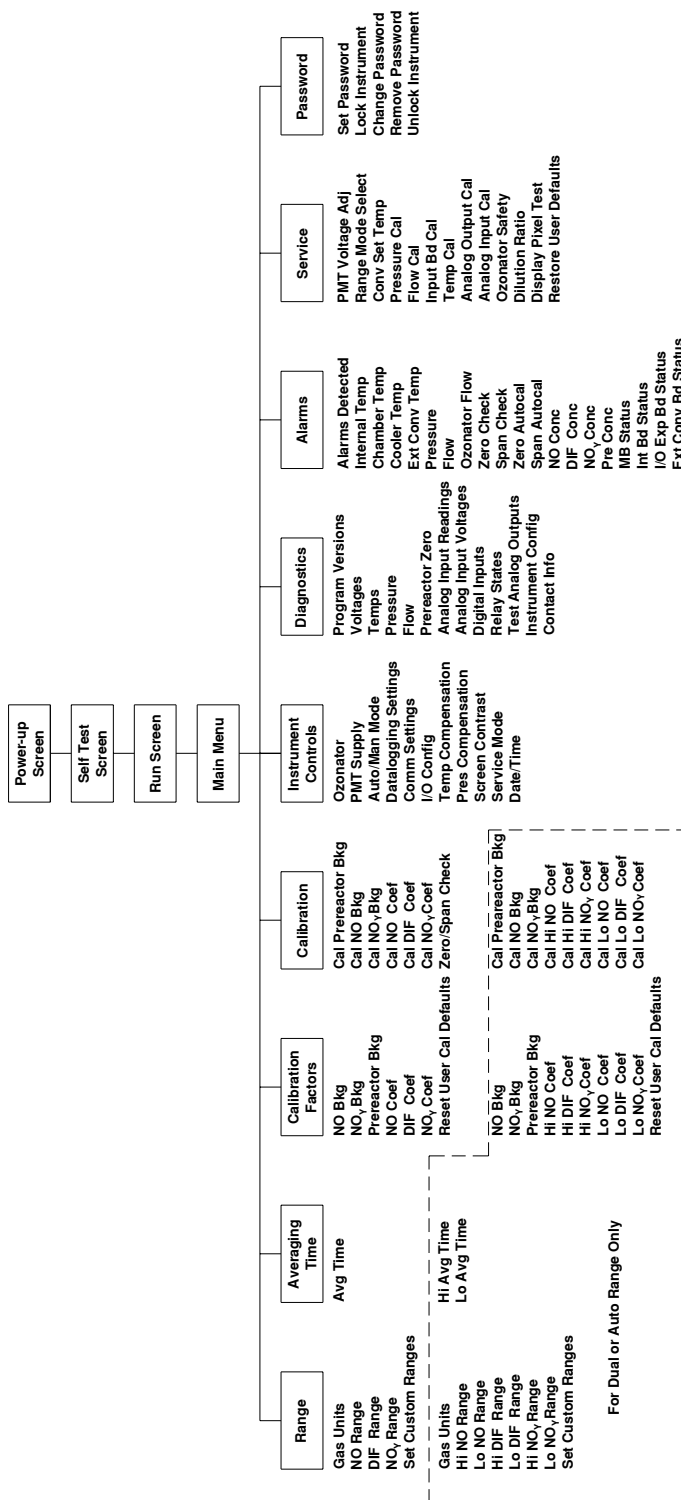


Figure 3–3. Flowchart of Menu-Driven Software



## Power-Up Screen

The Power-Up screen is displayed on power up of the Model 42i NO<sub>y</sub>. The Self-Test is displayed while the internal components are warming up and diagnostic checks are performed.



## Run Screen






The Run screen displays the NO, DIF, and NO<sub>y</sub> concentrations. The status bar displays optional zero/span solenoid valves, if installed, time, and alarm status. The word "SAMPLE" on the bottom left of the display indicates the analyzer has the span/zero valve option and is in "SAMPLE" mode. Other modes appear in the same area of the display as "ZERO" or "SPAN". For more information about the optional solenoid valves, see Chapter 9, "[Optional Equipment](#)".

When operating in dual or auto range mode two sets of coefficients are used to calculate the NO-DIF-NO<sub>y</sub> "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   |       |             |
|-----------------|-------|-------------|
| NO              | 62.7  | PPB         |
| DIF             | 25.5  | PPB         |
| NO <sub>y</sub> | 88.2  | PPB         |
| 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       |       |             |
|---------------------|-------|-------------|
| NO                  | 62.7  | PPB         |
| DIF                 | 25.5  | PPB         |
| NO <sub>y</sub>     | 88.2  | PPB         |
| 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, NO-DIF-NO<sub>y</sub> 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          PPB
NO RANGE            50
DIF RANGE           50
NOy RANGE           50
SET CUSTOM RANGES

RANGE  AVG  DIAGS  ALARM
```

```
RANGE:
>GAS UNITS          PPB
HI NO RANGE        100
LO NO RANGE         50
HI DIF RANGE       100
LO DIF RANGE        50
HI NOy RANGE       100
LO NOy RANGE        50↓

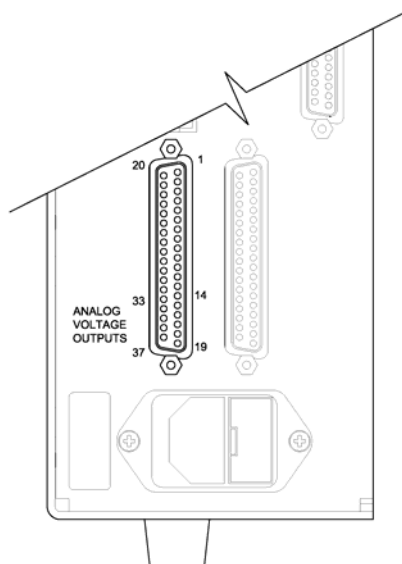
RANGE  AVG  DIAGS  ALARM
```

SET CUSTOM RANGES

## Single Range Mode

In the single range mode, the NO, DIF, and NO<sub>y</sub> channels each have one range, one averaging time, and one span coefficient.

By default, the three 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 [3-73](#).



**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                  | NO Analog Output              |
| 2       | 33                 | 3                  | DIF Analog Output             |
| 3       | 15                 | 5                  | NO <sub>y</sub> Analog Output |
| 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 may not apply. ▲

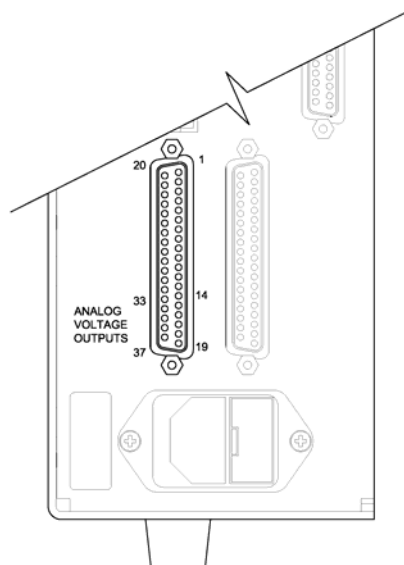
## Dual Range Mode

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 NO analog output can be set to output concentrations from 0 to 50 ppb and the high NO analog output set to output concentrations from 0 to 100 ppb.

In addition to each channel having two ranges, each channel has two span coefficients. 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 NO range is set to 0–50 ppb and the high NO range is set to 0–200 ppb.

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 3-73.



**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                  | NO High Range              |
| 2       | 33                 | 3                  | NO Low Range               |
| 3       | 15                 | 5                  | DIF High Range             |
| 4       | 34                 | 7                  | DIF Low Range              |
| 5       | 17                 | 9                  | NO <sub>y</sub> High Range |
| 6       | 36                 | 11                 | NO <sub>y</sub> Low Range  |
| 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 may not apply. ▲



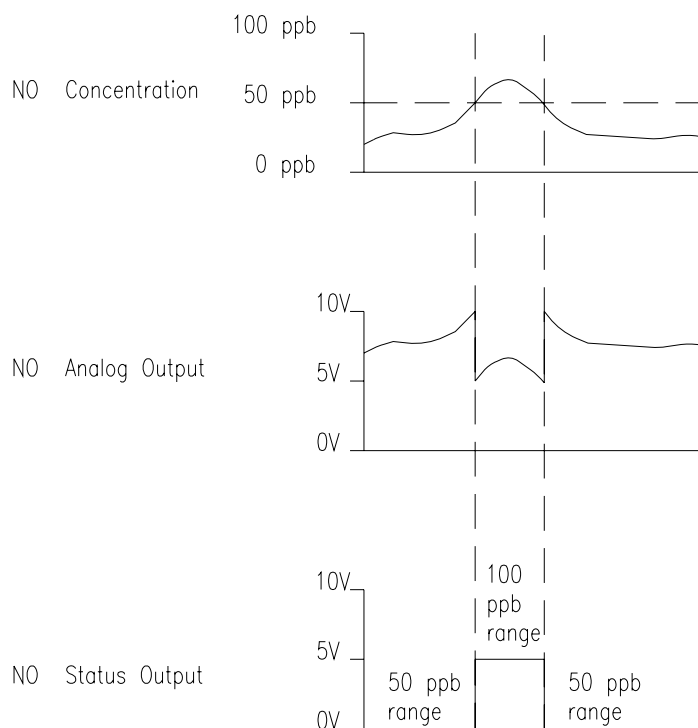
## Auto Range Mode

The auto range mode switches the NO, DIF, and NO<sub>y</sub> analog outputs between high and low ranges, depending on the NO<sub>y</sub> concentration level. The high and low ranges are defined in the Range menu.

For example, suppose the low range is set to 50 ppb and the high range is set to 100 ppb (Figure 3–6). Sample concentrations below 50 ppb are presented to the low ranges analog outputs and sample concentrations above 50 ppb are presented to the high ranges analog outputs. 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.

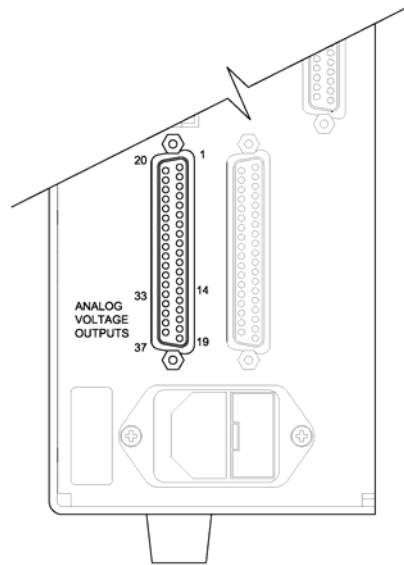
When the high ranges are active, the NO concentration must drop to 85% of the low NO range for the low ranges to become active.

In addition to each channel having two ranges, each channel has two span coefficients. 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 NO range is set to 0–50 ppb and the high NO range is set to 0–200 ppb.



**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 3-73.



**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                  | NO Analog Output   |
| 2       | 33                 | 3                  | DIF Analog Output  |
| 3       | 15                 | 5                  | NO <sub>y</sub> Analog Output                                      |
| 4       | 34                 | 7                  | Range Status:<br>half-scale = high range<br>zero scale = low range |
| 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 may not apply. ▲

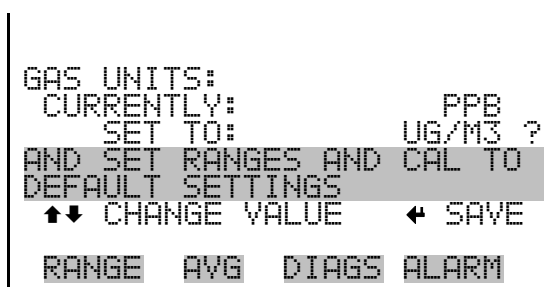
## Gas Units

The Gas Units screen defines how the NO, DIF, and NO<sub>y</sub> concentration readings are expressed. Gas units of parts per billion (ppb) and micrograms per cubic meter (µg/m<sup>3</sup>) are available. The µg/m<sup>3</sup> gas concentration mode is calculated using a standard pressure of 760 mmHg and a standard temperature of 20 °C.

When switching from ppb to µg/m<sup>3</sup>, the analog ranges all default to the highest range in that mode. For example, when switching from µg/m<sup>3</sup> to ppb, all the ranges default to 200 ppb. 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 ppb to µg/m<sup>3</sup> 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. ▲



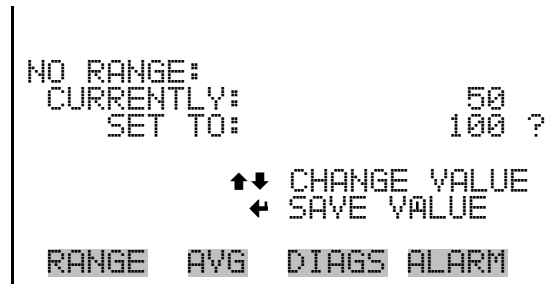
## NO, DIF, and NO<sub>y</sub> Ranges

The NO, DIF, and NO<sub>y</sub> Ranges screen defines the concentration range of the analog outputs. For example, a DIF range of 0–50 ppb defaults the DIF analog output to concentrations between 0 and 50 ppb.

The display shows the current NO, DIF, or NO<sub>y</sub> 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 NO 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 operating ranges.

- In the Main Menu, choose Range > **NO, DIF, or NOy Range**.



**Table 3–5.** Available Operating Ranges

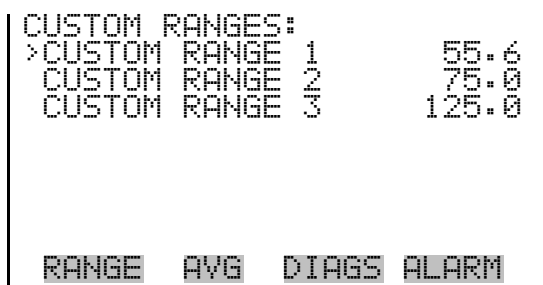
| ppb | µgm <sup>3</sup> |
|-----|------------------|
| 5   | 10               |
| 10  | 20               |
| 20  | 50               |
| 50  | 100              |
| 100 | 200              |
| 200 | 500              |
| C1  | C1               |
| C2  | C2               |
| C3  | C3               |

C1, C2, and C3 are custom ranges. For more information about custom ranges, see “[Set Custom Ranges](#)” below.

## Set Custom Ranges

The Set Custom Ranges menu lists three custom ranges: C1, C2, and C3. Custom ranges are user-defined ranges. In the ppb mode, any value between 5 and 200 ppb can be specified as a range. In the µg/m<sup>3</sup> mode, any value between 10 and 500 µg/m<sup>3</sup> can be specified as a range.

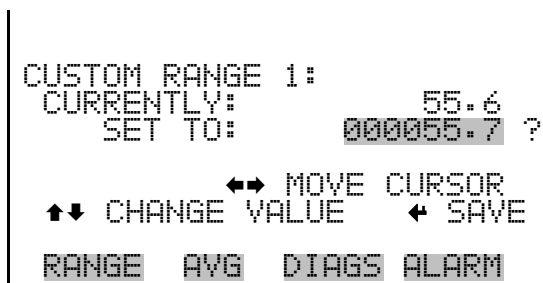
- In the Main Menu, choose Range > **Set Custom Ranges**.



**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 NO, DIF, or NO<sub>y</sub> Ranges screen. For more information about selecting ranges, see “NO, DIF, and NO<sub>y</sub> Ranges” above.

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



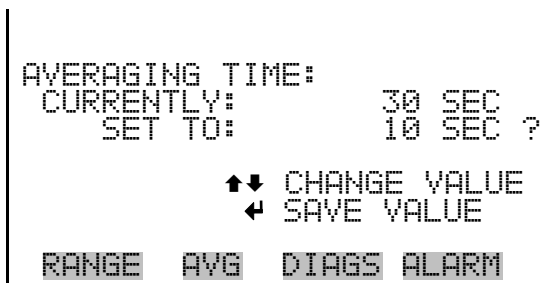
## Averaging Time

The Averaging Time defines a time period (10 to 300 seconds) over which NO, DIF, and NO<sub>y</sub> measurements are taken. The average concentration of the NO, DIF, and NO<sub>y</sub> readings are calculated for that time period. The front panel display and analog outputs are updated every 10 seconds for averaging times between 10 and 300 seconds. An averaging time of 10 seconds, for example, means that the average concentration of the last 10 seconds will be output at each update. An averaging time of 300 seconds means that the moving average concentration of the last 300 seconds will be output at each update. Therefore, the lower the averaging time the faster the front panel display and analog outputs respond to concentration changes. Longer averaging times are typically used to smooth output data.

The Averaging Time screen for the single range mode is shown below. In the dual and auto range modes, an Averaging Time Menu is displayed before the averaging time screens. This additional 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: 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds. Additional averaging times are available in NO and NO<sub>y</sub> mode, see “Auto/Manual Mode” later in this chapter.

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



## Calibration Factors Menu

Calibration factors are used to correct the NO, DIF, and NO<sub>y</sub> 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 “HI” and “LO” 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 “NO, NO<sub>y</sub>, and Prereactor Backgrounds” and “NO, DIF, and NO<sub>y</sub> Coefficients” below for more information.

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

```

CALIBRATION FACTORS:
>NO BKG          0.0
NOy BKG         0.0
PREREACTION BKG 0.0
NO COEF          1.000
DIF COEF         1.000
NOy COEF        1.000
RESET USER CAL DEFAULTS

RANGE  AVG  DIAGS  ALARM

```

```

CALIBRATION FACTORS:
>NO BKG          0.0
NOy BKG         0.0
PREREACTION BKG 0.0
HI NO COEF       1.000
HI DIF COEF      1.000
HI NOy COEF     1.000
LO NO COEF       1.000↓
RANGE  AVG  DIAGS  ALARM

```

```

LO DIF COEF      1.000
LO NOy COEF     1.000
RESET USER CAL DEFAULTS

```







## NO, NO<sub>y</sub>, and Prereactor Backgrounds

The NO, NO<sub>y</sub> and Prereactor background corrections are determined during zero calibration. The NO background is the amount of signal read by the analyzer in the NO channel while sampling zero air. The NO<sub>y</sub> background is the amount of signal read by the analyzer in the NO<sub>y</sub> channel while sampling zero air. The Prereactor background is the amount of signal read by the analyzer when the sample is routed through the prereactor. The background signal is the combination of electrical offsets, PMT dark currents, and trace substances undergoing chemiluminescence. Before the analyzer sets the NO, NO<sub>y</sub> and Prereactor readings to zero, it stores these values as the NO, NO<sub>y</sub>, and Prereactor background corrections, respectively. The DIF background correction is determined from the NO and NO<sub>y</sub> background corrections and is not displayed. The background corrections are typically below 1.5 ppb.

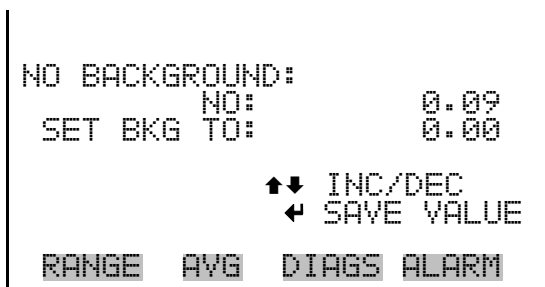
The NO, NO<sub>y</sub> and Prereactor Background screens are used to perform a manual zero calibration of the instrument. Before performing a zero calibration, allow the analyzer to sample zero air until stable readings are obtained. The NO channel should be calibrated first. The NO, NO<sub>y</sub>, and Prereactor Background screens operate the same way. Therefore, the following description of the NO background applies to the NO<sub>y</sub> and Prereactor background screens as well. The first line of the display shows the current NO reading. The second line of the display shows the NO background correction that is stored in memory. The NO background correction is a value, expressed in the current gas units, that is subtracted from the NO reading to produce the NO reading that is displayed.

In the example below, the analyzer is displayed 0.09 ppb of NO while sampling zero air. A background correction is 0.0 ppb means that 0 ppb is being subtracted from the NO concentration being displayed. Therefore, the background correction must be increased to 0.09 ppb in order for the

NO reading to be at 0 ppb, i.e., a NO reading of 0.09 ppb minus a NO background reading of 0.09 ppb gives the corrected NO reading of 0 ppb.

To set the NO reading in the example below to zero, use  to increment the NO background correction to 0.09 ppb. As the NO background correction is increased, the NO concentration is decreased. Note that at this point, pressing  and  however, has no effect on the analog outputs or the stored NO background correction of 0.0 ppb. A question mark following both the NO reading and the NO background correction indicates that these are proposed changes as opposed to implemented changes. To escape this screen without saving any changes, press  to return to the Calibration Factors menu or  to return to the Run screen. Press  to actually set the NO reading to 0 ppb and store the new background correction of 0.09 ppb. Then the question mark prompt beside the NO reading disappears.

- In the Main Menu, choose Calibration Factors > **NO, NO<sub>y</sub>, or Prereactor Bkg.**





## NO, DIF, and NO<sub>y</sub> Coefficients

The NO, DIF, and NO<sub>y</sub> span coefficient are usually calculated by the instrument processor during calibration. The span coefficients are used to correct the NO, DIF, and NO<sub>y</sub> readings. The NO and NO<sub>y</sub> span coefficients normally has a value near 1.000. The DIF span coefficient normally has a value between 0.95 and 1.050.

The NO, DIF, and NO<sub>y</sub> Coefficient screens allow the NO, DIF, and NO<sub>y</sub> span coefficients to be manually changed while sampling span gas of known concentration. The NO, DIF, and NO<sub>y</sub> Coefficient screens operate the same way. Therefore, the following description of the NO coefficient screen applies to the DIF, and NO<sub>y</sub> coefficient screens as well.

The display shows the current NO concentration reading. The next line of the display shows the NO span coefficient that is stored in memory and is being used to correct the NO concentration. Notice that as the span coefficient value is changed, the current NO concentration reading on the above line also changes. However, no real changes are made to the value

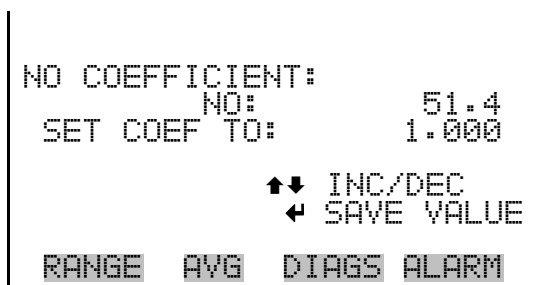


stored in memory until  is pressed. Only proposed changes, as indicated by a question mark prompt, are displayed until  is pressed.

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). ▲

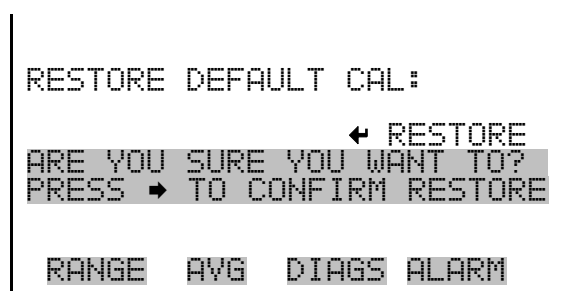
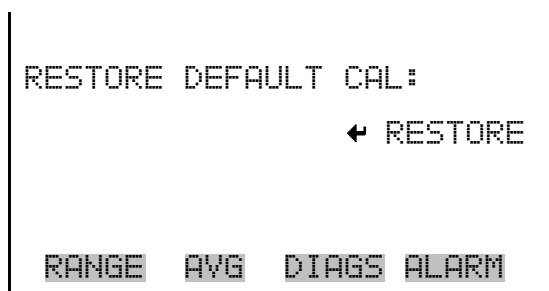
- In the Main Menu, choose Calibration Factors > NO, DIF, or NO<sub>y</sub> Coef.



## 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 the analyzer, including zero backgrounds, the NO, DIF, and NO<sub>y</sub> coefficients, and the calibration pressure. The screens below show the calibration menu in single mode and

dual/auto range modes. The zero/span check is visible only if the zero/span option is installed in single range mode.

The calibration procedure is the same in dual, auto, or single range, however, there are two sets of gas coefficients in dual or auto range (i.e. low and high coefficients). This enables each range to be calibrated separately. When calibrating the instrument in dual or auto range, be sure to use a low span gas to calibrate the low range and a high span gas to calibrate the high range.

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

```
CALIBRATION:
>CAL PREREACTOR ZERO
CAL NO BACKGROUND
CAL NOy BACKGROUND
CAL NO COEFFICIENT
CAL DIF COEFFICIENT
CAL NOy COEFFICIENT
ZERO/SPAN CHECK
RANGE  AVG  DIAGS  ALARM

CALIBRATION:
>CAL PREREACTOR ZERO
CAL NO BACKGROUND
CAL NOy BACKGROUND
CAL HI NO COEFFICIENT
CAL HI DIF COEFFICIENT
CAL HI NOy COEFFICIENT
CAL LO NO COEFFICIENT
RANGE  AVG  DIAGS  ALARM

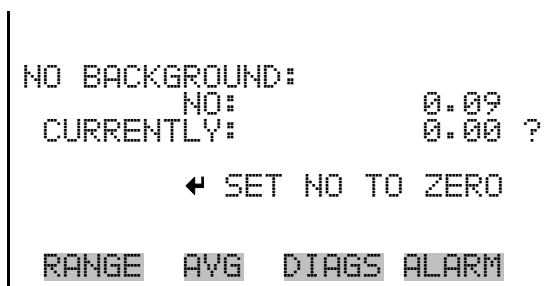
CAL LO DIF COEFFICIENT
CAL LO NOy COEFFICIENT
```

## Calibrate NO, NO<sub>y</sub>, and Prereactor Backgrounds

The Calibrate NO Background screen is used to adjust the background, or perform a “zero calibration”. Be sure the analyzer samples zero air until the readings stabilize. The NO, NO<sub>y</sub>, and Prereactor Background screens operate the same way. Therefore, the following description of the NO background applies to the NO<sub>y</sub> and Prereactor background screens as well. The first line of the display shows the current NO reading.

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 Prereactor Zero**, **Cal NO Background**, or **Cal NO<sub>y</sub> Background**.



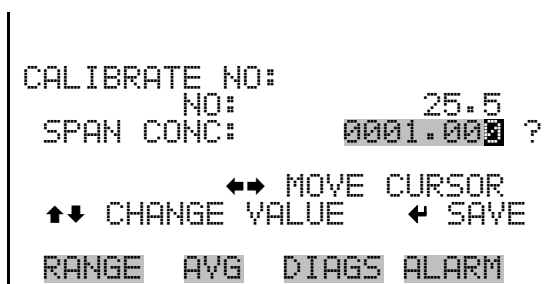
## Calibrate NO, DIF or NO<sub>y</sub> Coefficients

The Calibrate NO Coefficient screen is used to adjust the NO span concentration while sampling span gas of known concentration. All calibration screens operate the same way. Therefore, the following description of the NO calibration screen applies to the DIF and NO<sub>y</sub> calibration screens as well.

The display shows the current NO concentration reading and the current NO range. The next line of the display is where the NO calibration gas concentration is entered.

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

- In the Main Menu, choose Calibration > **Cal NO, DIF or NO<sub>y</sub> Coefficient**.



## Zero/Span Check

The Zero/Span Check menu is available with the zero/span valve option when in NO or NO<sub>y</sub> measurement modes. It is used to program the instrument to perform fully automated zero and span check 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      OFF
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.

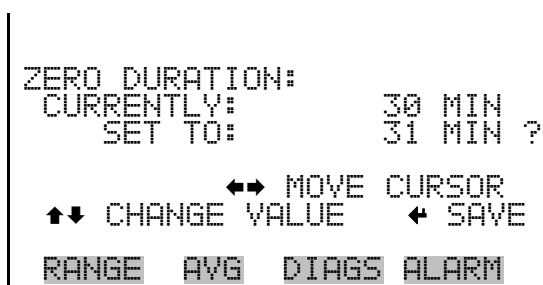
- In the Main Menu, choose Calibration > Zero/Span Check > **Period Hours**.

```
ZERO/SPAN PERIOD:
CURRENTLY: 024 HRS
SET TO:    02 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 screen to 0 (off). The same applies to perform just a span or purge check.

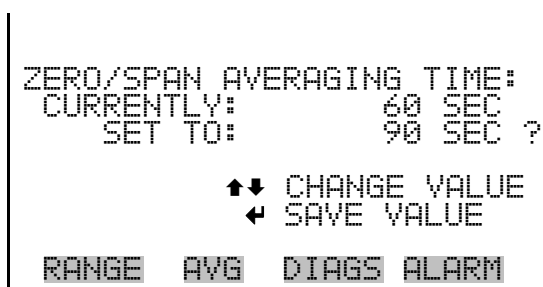
- In the Main Menu, choose Calibration > Zero/Span Check > **Zero, Span or Purge Duration Min.**



### Zero/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. 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 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:
>OZONATOR
  PMT SUPPLY
  AUTO/MANUAL MODE
  DATALOGGING SETTINGS
  COMMUNICATION SETTINGS
  I/O CONFIGURATION
  TEMPERATURE COMPENSATION↓

RANGE  AVG  DIAGS  ALARM

PRESSURE COMPENSATION
SCREEN CONTRAST
SERVICE MODE
DATE/TIME
```

## Ozonator

The Ozonator screen is used to turn the internal ozonator on or off. The display shows the status of the control line that turns the ozonator on or off. The next line of the display shows the user-specified ozonator setting. Under most conditions, the control line status and ozonator set status are the same. However, as a safety precaution, the microprocessor can override the user-specified ozonator setting. This occurs only if the ozonator flow

doesn't indicate any flow or if the DIF converter temperature is below the minimum alarm limit. In this case, an alarm is activated and the ozonator is turned off. This is done to prevent the ozonator from overheating, which will result in permanent damage to the ozonator, or if the converter temperature drops below the minimum limit, which reduces the effectiveness of the ozone destruct.

It is possible, however, to override the ozonator shut-off due to converter temperature being out of range, by setting the ozonator safety "OFF" in the "Service Mode".

**Note** The ozonator must be "ON" to obtain NO, DIF, and NO<sub>y</sub> readings. As an additional safety precaution, a lit LED mounted on the measurement interface board indicates that the ozonator is on. ▲

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



## PMT Supply

The PMT Supply screen is used to turn the PMT power supply on or off. This is useful in a troubleshooting situation.

- In the Main Menu, choose Instrument Controls > **PMT Supply**.



## Auto/Manual Mode

The Auto/Manual Mode screen allows selection of the automatic mode (NO/NO<sub>y</sub>), NO mode (manual NO), NO<sub>y</sub> mode (manual NO<sub>y</sub>) or prereactor mode (manual prereact). The auto cycle mode switches the

## Operation

### Instrument Controls Menu

mode solenoid valve automatically on a 10 second cycle so that NO, DIF, and NO<sub>y</sub> concentrations are determined. The manual NO mode puts the mode solenoid valve into the open position so that the sample gas bypasses the external converter and alternates between NO and prereactor measurements. Therefore, only the NO concentration is determined. The manual NO<sub>y</sub> mode puts the mode solenoid valve into the closed position so that the sample gas passes through the external converter and alternates between NO<sub>y</sub> and prereactor measurements. Therefore, only the NO<sub>y</sub> concentration is determined.

- In the Main Menu, choose Instrument Controls > **Auto/Manual Mode**.

```
MODE:
CURRENTLY:      MANUAL NO
SET TO:         NO/NOy ?

      ↑↓ CHANGE VALUE
      ← SAVE VALUE

RANGE  AVG  DIAGS  ALARM
```

## 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

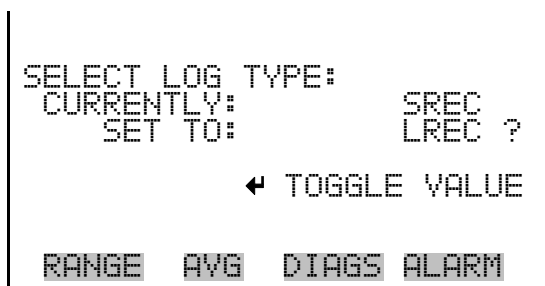
RANGE  AVG  DIAGS  ALARM
```

### 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**.

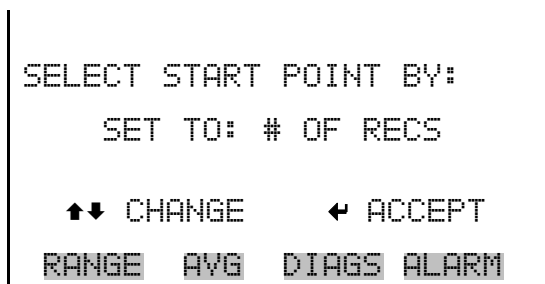




### View Logged Data

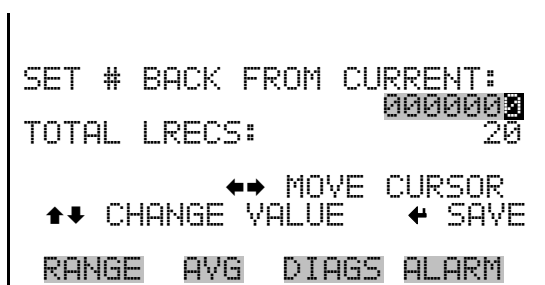
The View Logged Data screen is used to select the start point to view the logged data by number of records or date and time.

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



### Number of Records

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



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

## Operation

### Instrument Controls Menu

```
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
  ↑↓  FGUP/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
  ↑↓  FGUP/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**.



### 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**.




### 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.

## Operation


### Instrument Controls Menu

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 (NO<sub>y</sub>) is visible only in auto range mode.

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


```
CONCENTRATIONS:
>NONE
NO
DIF
NOy
LO NO
LO DIF
LO NOy
RANGE  AVG  DIAGS  ALARM
↓
HI NO
HI DIF
HI NOy
RANGE
PREREACTOR
LO PREREACTOR
HI PREREACTOR
```

## Other Measurements

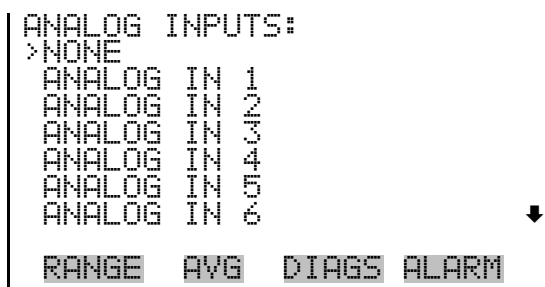
The Other Measurements screen allows the user to select the output signal that is tied to the selected field item. The selected item is shown by “<--” after it. Items displayed are determined by the options installed. Note that at this point, pressing  indicates that these are proposed changes as opposed 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
INT TEMP
CHAMBER TEMP
COOLER TEMP
EXT CNV TEMP
CHAMBER PRES
FLOW
RANGE  AVG  DIAGS  ALARM
↓
PMT VOLTS
OZONATOR FLOW
```

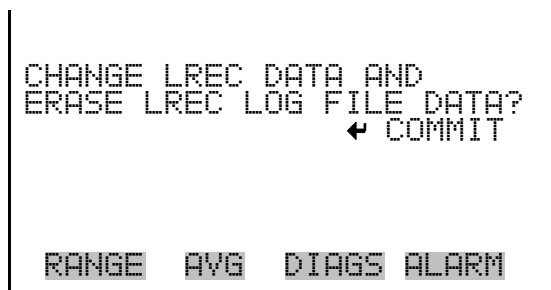
**Analog Inputs** The Analog Inputs screen allows the user to select the output signal (none or analog inputs 1-8) that is tied to the selected field item. The selected item is shown by “<--” after it. Note that at this point, pressing  indicates that these are proposed changes as opposed to implemented 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**.

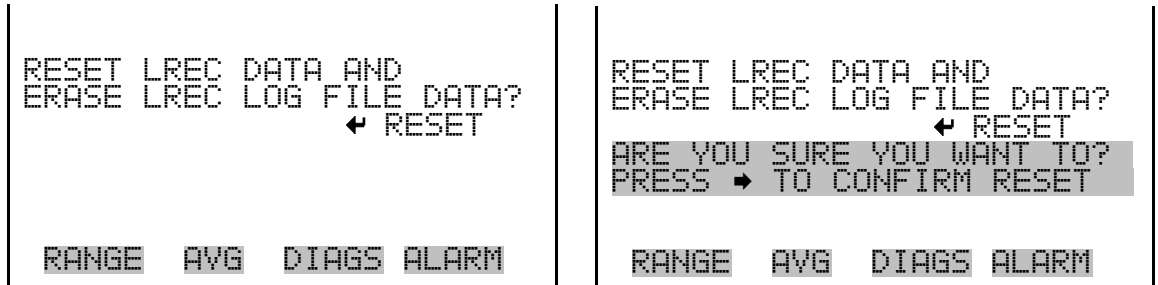


**Reset to Default Content** The Reset to Default Content screen is used to reset all of the datalogging field items to default values. For more information about selecting the analog output signal group choices, see “Select Content” above.

## Operation

### Instrument Controls Menu

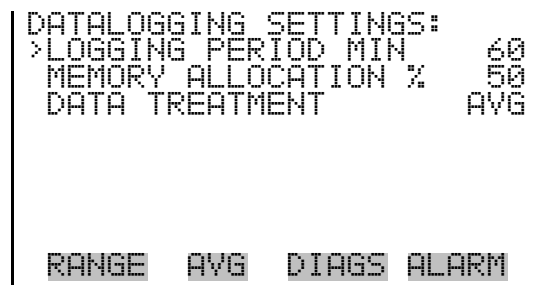
- In the Main Menu, choose Instrument Controls > Datalogging Settings > **Reset to Default Content**.



### Configure Datalogging

The Configure Datalogging menu deals with datalogging configuration for the currently selected record type.

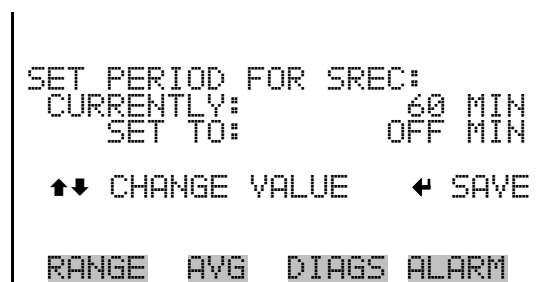
- In the Main Menu, choose Instrument Controls > Datalogging Settings > **Configure Datalogging**.



### 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).

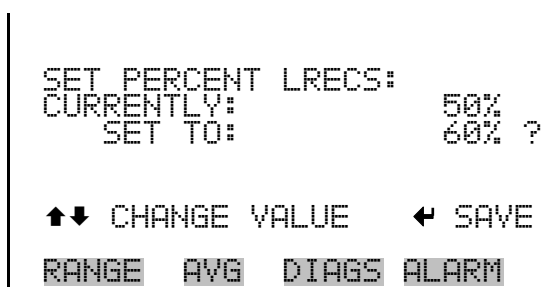
- In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > **Logging Period Min**.



## 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.

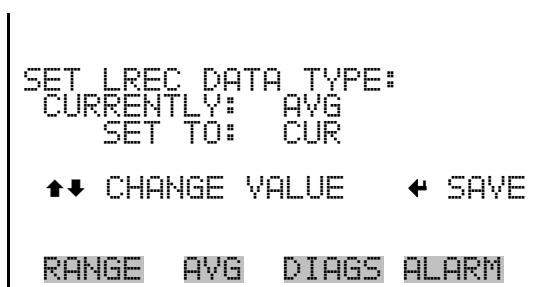
- In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > **Memory Allocation %**.



## Data Treatment

The Data Treatment screen is used to select the data type for the selected record type: 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**.

## Operation

### Instrument Controls Menu

```
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

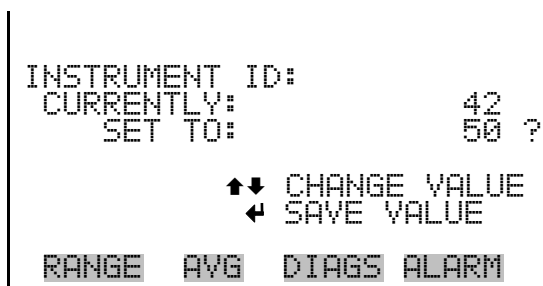
RANGE  AVG  DIAGS  ALARM
```

#### 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 42i NO<sub>y</sub> has a default Instrument ID of 42. 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**.

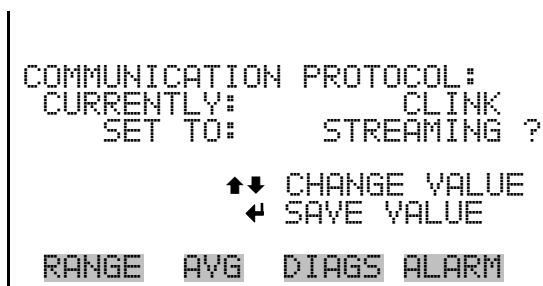




### Communication Protocol

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**.



### 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, Prepend Timestamp, and Add Flags are toggle items that change between yes or no when selected. ▲

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

## Operation

### Instrument Controls Menu

```
STREAMING DATA CONFIG
>INTERVAL          10 SEC
ADD LABELS        NO
PREPEND TIMESTAMP YES
ADD FLAGS         YES
ITEM 1            DIF
ITEM 2            INIT
ITEM 3            PRES ↓
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
```

### 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 (NO<sub>y</sub>) is visible only in auto range mode.

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

```

CONCENTRATIONS:
>NONE
NO
DIF
NOj
RANGE
PREREACTOR

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. Items displayed are determined by the options installed.

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

```

OTHER MEASUREMENTS:
>NONE
INT TEMP
CHAMBER TEMP
COOLER TEMP
EXT CNV TEMP
CHAMBER PRES
FLOW

RANGE  AVG  DIAGS  ALARM

PMT VOLTS
OZONATOR FLOW
    
```

### 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

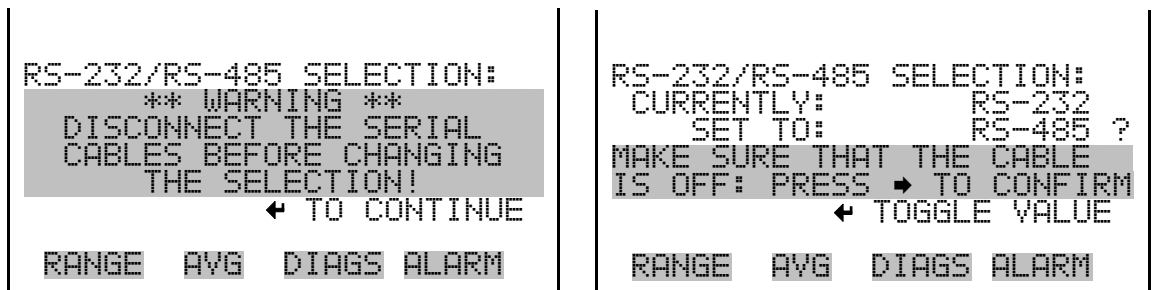
RANGE  AVG  DIAGS  ALARM
    
```

**RS-232/RS-485 Selection**

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

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

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



**TCP/IP Settings**

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

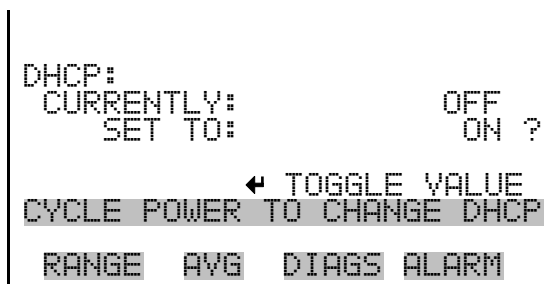
**Note** The instrument power must be cycled after any of these parameters have been changed for the change to take effect. ▲

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



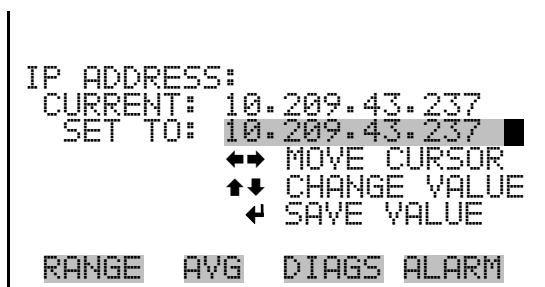
**Use DHCP** The Use DHCP screen is used to specify whether to use DHCP or not. When DHCP is enabled, the network dynamically provides an IP address for the instrument.

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



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

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



**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](#)” above.

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

## Operation

### Instrument Controls Menu

```
NETMASK:
CURRENT: 255.255.254.0
SET TO: 255.255.254.0
      ←→ 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](#)” above. 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: 10.209.42.1
SET TO: 10.209.42.1
      ←→ 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.

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

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

```

I/O CONFIGURATION:
>OUTPUT RELAY SETTINGS
DIGITAL INPUT SETTINGS
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          GEN ALARM
2   NOP          NONE
3   NOP          UNITS
4   NOP          CONC ALARM
5   NOP          NONE
6   NOP          NONE
7   NOP          NO MODE  ↓

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.

## Operation

### Instrument Controls Menu

```
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 or non-alarm to choose from.

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

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

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. The I/O board status alarm is only present if the I/O expansion board is installed. The zero and span check/calibration alarms are only present if the zero/span valve option is installed and the instrument is operating in manual mode.

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



```

ALARM STATUS ITEMS:
>NONE
GEN ALARM
NO CONC MAX
NO CONC MIN
DIF CONC MAX
DIF CONC MIN
NOy CONC MAX
RANGE  AVG  DIAGS  ALARM

NOy CONC MIN
INT TEMP
CHAMB TEMP
COOLER TEMP
EXT CV TEMP
PRESSURE
FLOW
OZONE FLOW
MB STATUS
MIB STATUS
I/O BD STATUS
CONC ALARM
EXT CONV STAT
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 (NO)
SERVICE
UNITS
ZERO MODE
SPAN MODE
NO MODE
RANGE  AVG  DIAGS  ALARM

NOy MODE
PRE MODE
SAMPLE MODE
PURGE 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          NO MODE
 2  NOP          NO MODE
 3  NOP          SET BACKGROUND
 4  NOP          CAL TO LO SPAN
 5  NOP          AOUTS TO ZERO
 6  NOP          AOUTS TO FS
 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
NO MODE
NO MODE
PRE MODE
SET BACKGROUND
                                <---
                                ↓

RANGE  AVG  DIAGS  ALARM

CAL TO LO SPAN
AOUTS TO ZERO
AOUTS TO FS
CAL TO HI SPAN
  
```

### Analog Output Configuration

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

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

```

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

RANGE  AVG  DIAGS  ALARM
  
```

```

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

RANGE  AVG  DIAGS  ALARM
  
```

### Select Output Range

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

## Operation

### Instrument Controls Menu

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

```
SELECT OUTPUT RANGE:
SELECTED OUTPUT:    V ALL
CURRENTLY:          0-10V
SET TO:             0-5V ?

↑↓ CHANGE VALUE    ← SAVE

RANGE  AVG  DIAGS  ALARM
```

### Minimum and Maximum Value

The Minimum Value screen is used to edit the zero (0) to full-scale (100) value in percentages for the selected analog output channel. See [Table 3–6](#) 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:    V ALL
CURRENTLY:          N/A %
SET TO:             0000.0 % ?

↑↓ CHANGE VALUE    ← SAVE

RANGE  AVG  DIAGS  ALARM
```

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

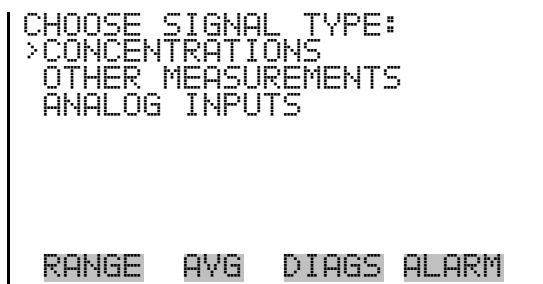
| Output             | Zero % Value | Full-Scale 100% Value |
|--------------------|--------------|-----------------------|
| NO                 | Zero (0)     | Range Setting         |
| DIF                | Zero (0)     | Range Setting         |
| NO <sub>y</sub>    | Zero (0)     | Range Setting         |
| LO NO              | Zero (0)     | Range Setting         |
| LO DIF             | Zero (0)     | Range Setting         |
| LO NO <sub>y</sub> | Zero (0)     | Range Setting         |

| Output                  | Zero % Value  | Full-Scale 100% Value    |
|-------------------------|---|--------------------------|
| HI NO                   | Zero (0)  | Range Setting            |
| HI DIF                  | Zero (0)  | Range Setting            |
| HI NO <sub>y</sub>      | Zero (0)  | Range Setting            |
| Prereactor              | Zero (0)  | Range Setting            |
| LO Prereactor           | Zero (0)  | Range Setting            |
| HI Prereactor           | Zero (0)  | Range Setting            |
| Range                   | Recommend not to change the setting for this output |                          |
| Internal Temp           | User-set alarm min value                            | User-set alarm max value |
| Chamber Temp            | User-set alarm min value                            | User-set alarm max value |
| Cooler Temp             | User-set alarm min value                            | User-set alarm max value |
| External Converter Temp | User-set alarm min value                            | User-set alarm max value |
| Chamber Pressure        | User-set alarm min value                            | User-set alarm max value |
| Flow                    | User-set alarm min value                            | User-set alarm max value |
| PMT Volts               | 700 volts   | 1100 volts               |
| Ozonator Flow           | User-set alarm min value                            | User-set alarm max value |
| Everything Else         | 0 Units   | 10 Units                 |

## Choose Signal to Output

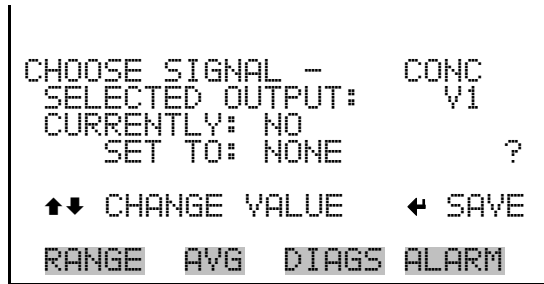
The Choose Signal to Output screen displays a submenu list of the analog output signal group choices. Group choices are Concentrations, Other Measurements, and Analog Inputs (if the I/O expansion board option is installed). This allows the user to select the output signal to the selected output channel. In dual or auto range mode, “HI” or “LO” is displayed to indicate high or low concentrations. Range (NO<sub>y</sub>) 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**.



## Operation

### Instrument Controls Menu



**Table 3–7.** Signal Type Group Choices

| Concentrations                           | Other Measurements      | Analog Inputs  |
|--|-------------------------|----------------|
| None                                     | None                    | None           |
| NO (single/auto range mode)              | Internal Temp           | Analog Input 1 |
| DIF (single/auto range mode)             | Chamber Temp            | Analog Input 2 |
| NO <sub>y</sub> (single/auto range mode) | Cooler Temp             | Analog Input 3 |
| LO NO (dual mode)                        | External Converter Temp | Analog Input 4 |
| LO DIF (dual mode)                       | Chamber Pressure        | Analog Input 5 |
| LO NO <sub>y</sub> (dual mode)           | Flow                    | Analog Input 6 |
| HI NO (dual mode)                        | PMT Volts               | Analog Input 7 |
| HI DIF (dual mode)                       | Ozonator Flow           | Analog Input 8 |
| HI NO <sub>y</sub> (dual mode)           |                         |                |
| Range (auto range mode)                  |                         |                |
| Prereactor (single/auto range mode)      |                         |                |
| LO Prereactor (dual mode)                |                         |                |
| HI Prereactor (dual mode)                |                         |                |

### Analog Input Configuration

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

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

```

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

```

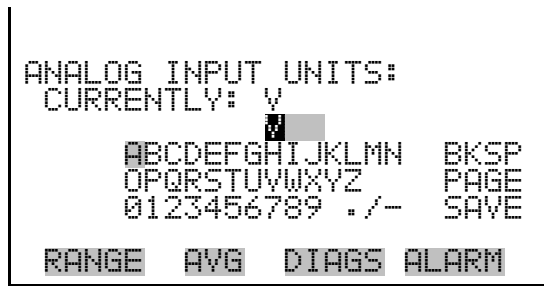
ANALOG INPUT DESCRIPTOR:
CURRENTLY: IN1
          IN1
          ABCDEFGHIJKLMNOP BKSP
          OPQRSTUVWXYZ    PAGE
          0123456789 . / -  SAVE
RANGE  AVG  DIAGS  ALARM
  
```

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

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

## Operation

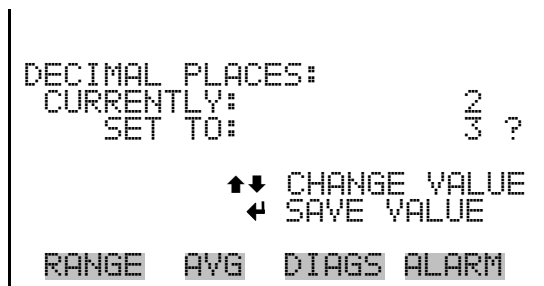
### Instrument Controls Menu



### 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.

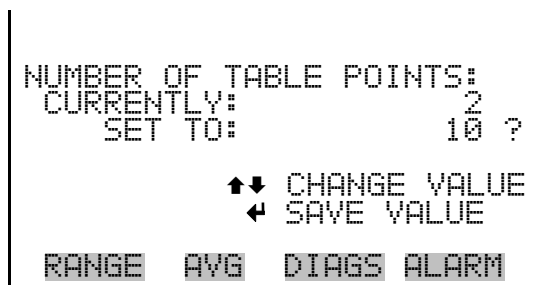
- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > **Decimal Places**.



### 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**.

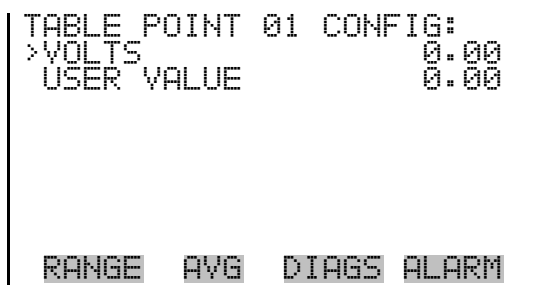


### Table Point

The Table Point submenu allows the user to set up an individual table point.

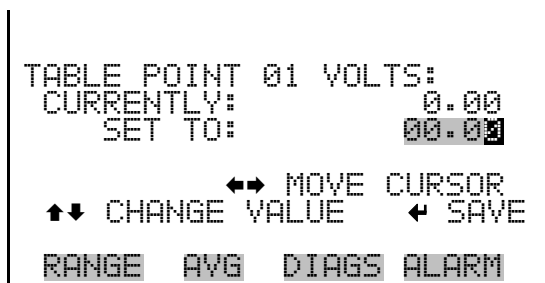


- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > **Point 1-10.**



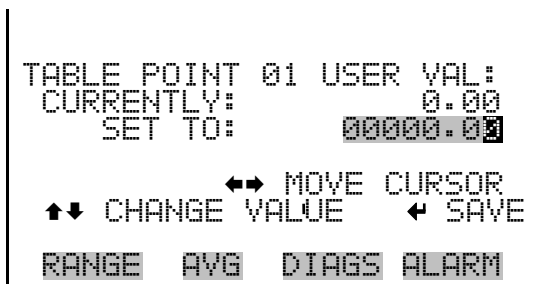
**Volts** The Volts screen allows the user to set the input voltage for the selected table point in the conversion table, from 0.00 to 10.50. The default table is a two-point table with point 1: 0.00 V = 000.0 U and point 2: 10.00 V = 10.0 U.

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



**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.**

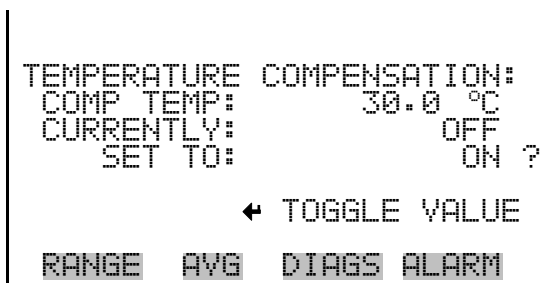


## Temperature Compensation

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 Interface board). When temperature compensation is off, the display shows the factory standard temperature of 30 °C.

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



## Pressure Compensation

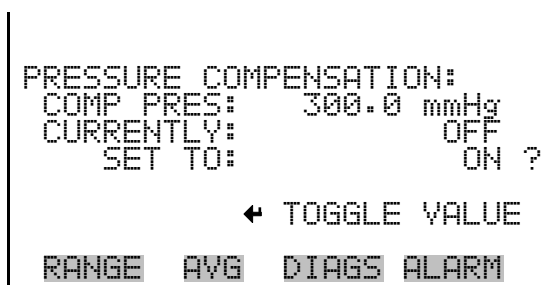
Pressure compensation provides compensation for any changes to the instrument's output signal due to reaction chamber pressure variations. The effects of reaction chamber pressure changes on the analyzer's subsystems and output have been empirically determined. This empirical data is used to compensate 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 in prereactor mode. When pressure compensation is off, the first line of the display shows the factory standard pressure of 300 mmHg.

**Note** Turning the pressure compensation ON and OFF can produce significant artificial jumps in the apparent sample concentration. If the

pressure compensation feature is to be used, the instrument must be calibrated with the pressure compensation feature ON. For more information about calibration, see Chapter 4, “Calibration”. ▲

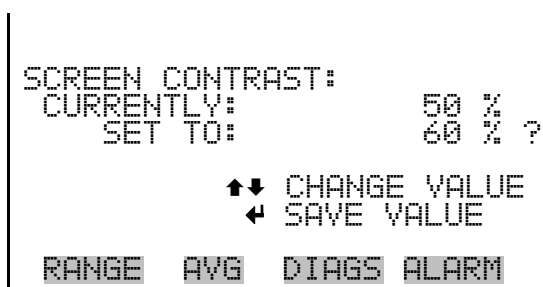
- In the Main Menu, choose Instrument Controls > **Pressure Compensation**.



## Screen Contrast

The Screen Contrast screen is used to change the contrast of the display. Intensities between 0 and 100% in increments of 10 are available. Changing the screen contrast may be necessary if the instrument is operated at extreme temperatures.

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

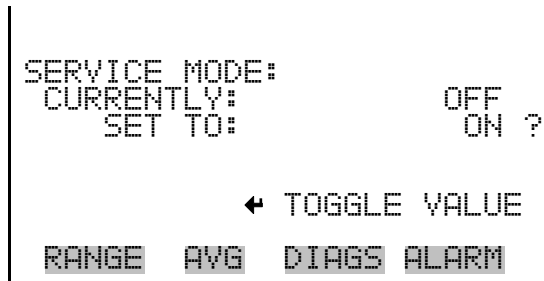


## Service Mode

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 42i NO<sub>y</sub>. For more information about the service mode, see “Service Menu” later in this chapter.

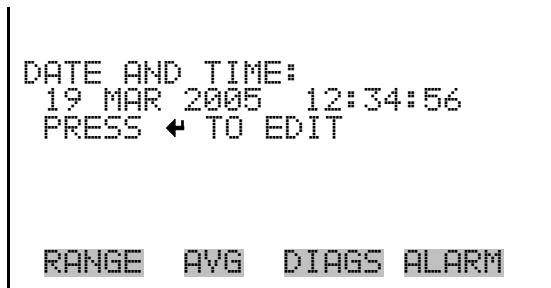
**Note** The service mode should be turned off when finished, as it prevents remote operation. ▲

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



**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**.



## Diagnostics Menu

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

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

```

DIAGNOSTICS:
>PROGRAM VERSION
VOLTAGES
TEMPERATURES
PRESSURE
FLOW
PREREACTOR ZERO
ANALOG INPUT READINGS
↓
RANGE  AVG  DIAGS  ALARM

ANALOG INPUT VOLTAGES
DIGITAL INPUTS
RELAY STATES
TEST ANALOG OUTPUTS
INSTRUMENT CONFIGURATION
CONTACT INFORMATION
  
```

## Program Versions

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

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

```

PROGRAM VERSIONS:
PRODUCT:  MODEL 42iNOy
VERSION:   01.03.21.154
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  
EXT CONVERTER 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:  
PMT 785.5 V  
3.3 SUPPLY 3.3 V  
5.0 SUPPLY 5.0 V  
15.0 SUPPLY 15.0 V  
P15.0 SUPPLY 15.0 V  
24.0 SUPPLY 24.0 V  
-15.0 SUPPLY -15.0 V  
  
RANGE  AVG  DIAGS  ALARM
```

### I/O Board Voltages

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

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

```

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

RANGE  AVG  DIAGS  ALARM
  
```

### External Converter Board Voltages

The External Converter Board screen (read only) is used to display the current voltage readings on the external converter board.

- In the Main Menu, choose Diagnostics > Voltages > **Ext Converter Board Voltages**.

```

EXT CONV BOARD VOLTAGES:
15.0 SUPPLY          15.0 V
24.0 SUPPLY          24.0 V
-15.0 SUPPLY         -15.0 V

RANGE  AVG  DIAGS  ALARM
  
```

### Temperatures

The Temperatures screen (read only) displays the internal temperature, reaction chamber temperature, cooler temperature, and converter temperatures. 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              28.6 °C
CHAMBER              49.2 °C
COOLER              -10.0 °C
EXT CONVERTER        320.7 °C
EXT CONV SET         325.0 °C

RANGE  AVG  DIAGS  ALARM
  
```

## Pressure

The Pressure screen (read only) displays the reaction chamber pressure. The pressure is measured by a pressure transducer at the reaction chamber. This value is updated once per second, so it will shift as the measurement mode changes between NO, NO<sub>y</sub>, and prereactor mode.

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

```

PRESSURE:          282.5 mmHg

RANGE  AVG  DIAGS  ALARM

```

## Flow

The Flow screen (read only) displays the sample and ozonator flow rate. The flows are measured by internal flow sensors. For more information, see [“Introduction”](#).

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

```

FLOW:              1.300 LPM
OZONATOR FLOW      OK

RANGE  AVG  DIAGS  ALARM

```

## Prereactor Zero

The Prereactor Zero screen (read only) displays the current prereactor background (zero) reading. In dual or auto range modes, low range and high range are displayed. The example below shows the prereactor zero screen in single range mode.

- In the Main Menu, choose Diagnostics > **Prereactor Zero**.



```

PREREACTION:          0.68

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  PFB
CO2          250   PPM
FL1          20.42 LPM
WND          9.86  V
FL2          1.865 LPM
IO7          0.0   V↓
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 and set the relay state open or closed.

```
RELAY STATE:
>OUTPUT 1        0
OUTPUT 2        0
OUTPUT 3        0
OUTPUT 4        1
OUTPUT 5        0
OUTPUT 6        0
OUTPUT 7        1
                ↓
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 purchased options). ▲

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

```

INSTRUMENT CONFIGURATION:
> I/O EXPANSION BOARD  YES
ZERO/SPAN VALVES      YES
PERM DRYER             YES
NH3 SCRUBBER           NO
CONVERTER              MOLY
DILUTION               YES
AUTO CALIBRATION      YES

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 .

Items displayed are determined by the options installed. The zero/span check and auto calibration screens are visible only if the zero/span check or auto calibration options are enabled. The motherboard status, interface board status, I/O Expansion board status (if installed), and external converter board status 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
  CHAMBER TEMP           OK
  COOLER TEMP           OK
  EXT CONVERTER TEMP     OK
  PRESSURE               OK
  FLOW                   OK ↓

RANGE  AVG  DIAGS  ALARM

OZONATOR FLOW           OK
ZERO CHECK              OK
SPAN CHECK              OK
ZERO AUTOCAL            OK
SPAN AUTOCAL           OK
NO CONCENTRATION       OK
DIF CONCENTRATION      OK
NOx CONCENTRATION     OK
PRE CONCENTRATION      OK
MOTHERBOARD STATUS     OK
INTERFACE STATUS       OK
I/O EXP STATUS          OK
EXT CONV BD STATUS     OK
  
```

## Internal Temperature

The Internal Temperature screen displays the current internal temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 8 to 47 °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.**

```

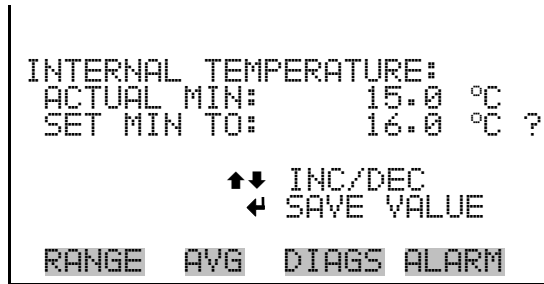
INTERNAL TEMPERATURE:
ACTUAL          28.6 °C
>MIN           15.0 °C
MAX            45.0 °C

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.

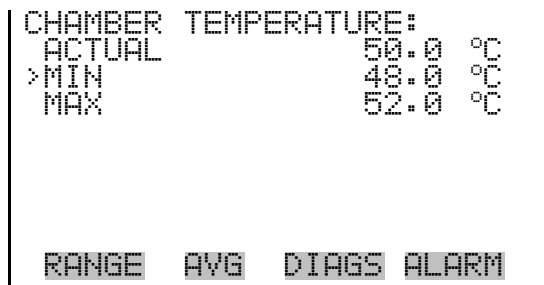
- In the Main Menu, choose Alarms > Internal Temp > **Min** or **Max**.



## Chamber Temperature

The Chamber Temperature screen displays the current chamber temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 45 to 55 °C. If the chamber 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.

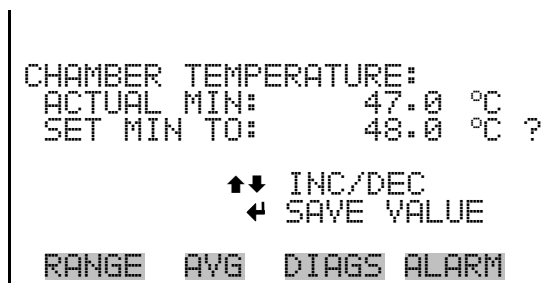
- In the Main Menu, choose Alarms > **Chamber Temp**.



## Min and Max Chamber Temperature Limits

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

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



## Cooler Temperature

The Cooler Temperature screen displays the current cooler temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits

range from -40 to 10 °C. If the cooler 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 > **Cooler Temp.**

```

COOLER TEMPERATURE:
  ACTUAL             -9.8 °C
>MIN                 -20.0 °C
  MAX                -1.0 °C

RANGE  AVG  DIAGS  ALARM
  
```

### Min and Max Cooler Temperature Limits

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

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

```

COOLER TEMPERATURE:
  ACTUAL MIN         -20.0 °C
  SET MIN TO:       -10.0 °C ?

      ↑↓ INC/DEC
      ← SAVE VALUE

RANGE  AVG  DIAGS  ALARM
  
```

### External Converter Temperature

The External Converter Temperature screen displays the current external converter temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 300 to 700 °C. The actual alarm setpoints should be set for the installed converter. If the external converter 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 > **Ext Converter Temp.**

```
EXT CONVERTER TEMP:
ACTUAL          320.7 °C
>MIN           300.0 °C
MAX            350.0 °C

RANGE  AVG  DIAGS  ALARM
```

### Min and Max External Converter Temperature Limits

The Minimum External Converter Temperature alarm limit screen is used to change the minimum external converter temperature alarm limit. The minimum and maximum external converter temperature screens function the same way.

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

```
EXT CONVERTER TEMP:
ACTUAL MIN      300.0 °C
SET MIN TO:    310.0 °C ?

  ↑↓ INC/DEC
  ← SAVE VALUE

RANGE  AVG  DIAGS  ALARM
```

### Pressure

The Pressure screen displays the current reaction chamber pressure reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 200 to 450 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          232.5 mmHg
>MIN           200.0 mmHg
MAX            450.0 mmHg

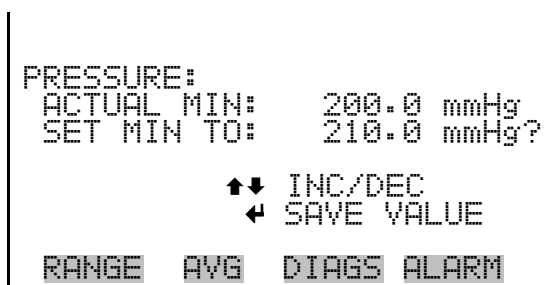
RANGE  AVG  DIAGS  ALARM
```



### Min and Max Pressure Limits

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

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



### Flow

The Flow screen displays the current sample flow reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 0 to 2 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 > **Flow**.



### Min and Max Flow Limits

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

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

```
FLOW:
ACTUAL MIN:    0.750 LPM
SET MIN TO:    0.760 LPM ?

      ↑↓ INC/DEC
      ← SAVE VALUE

RANGE  AVG  DIAGS  ALARM
```

## Ozonator Flow

The Ozonator Flow screen (read only) is used to display the ozonator flow readings. If the ozonator flow reading is 0.050 LPM (50 cc) or below, an alarm is activated, and an alarm condition screen appears as “LOW”. If the ozonator flow is above 0.050, the no alarm condition screen is displayed, indicating that the flow is acceptable. Inadequate ozonator flow will cause the ozonator to overheat, resulting in permanent damage to the ozonator.

- In the Main Menu, choose Alarms > **Ozonator Flow**.

```
OZONATOR FLOW:
ACTUAL        > 0.050 LPM

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. The zero and span check screens are visible only if the zero/span check option is enabled and function the same way.

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

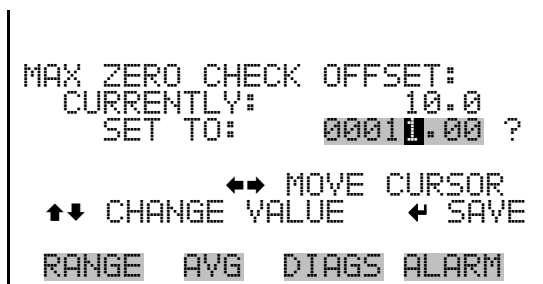
```
ZERO CHECK:
ALARM:      OK
RESPONSE:   0.0
>MAX OFFSET 10.0

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**.



## 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**.



## NO, DIF, and NO<sub>y</sub> Concentration

The NO Concentration screen displays the current NO concentration and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 0 to 500 ppb or  $\mu\text{g}/\text{m}^3$ . 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 NO 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. The DIF and NO<sub>y</sub> concentration screens function the same way.

- In the Main Menu, choose Alarms > **NO, DIF, or NO<sub>y</sub> Concentration**.

```
NO CONCENTRATION:
ACTUAL              62.7
>MIN                0.0
MAX                200.0
MIN TRIGGER        CEILING

RANGE  AVG  DIAGS  ALARM
```

### Min and Max NO, DIF, and NO<sub>y</sub> Concentration Limits

The Minimum NO Concentration alarm limit screen is used to change the minimum NO concentration alarm limits. The minimum and maximum NO, DIF, and NO<sub>y</sub> concentration alarm limit screens function the same way.

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

```
NO CONCENTRATION:
ACTUAL MIN:          0.0
SET MIN TO:         00000.00 ?

      ←→ MOVE CURSOR
↑↓ CHANGE VALUE    ← SAVE

RANGE  AVG  DIAGS  ALARM
```

### Min Trigger

The Minimum Trigger screen allows the user to view and set the NO, DIF, and NO<sub>y</sub> 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 > **Min Trigger**.

```

MIN TRIG<CEILING/FLOOR>:
ACTUAL TRIGGER:  CEILING
SET TRIGGER TO:   FLOOR ?

← TOGGLE AND SAVE VALUE

RANGE  AVG  DIAGS  ALARM

```

## Prereactor Concentration

The Prereactor Concentration screen displays the current prereactor concentration and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 0 to 5 ppb or  $\mu\text{g}/\text{m}^3$ . 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 prereactor 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 > **Pre Concentration**.

```

PREREACTOR CONCENTRATION:
ACTUAL                0.09
>MIN                 0.00
MAX                  2.00
MIN TRIGGER          CEILING

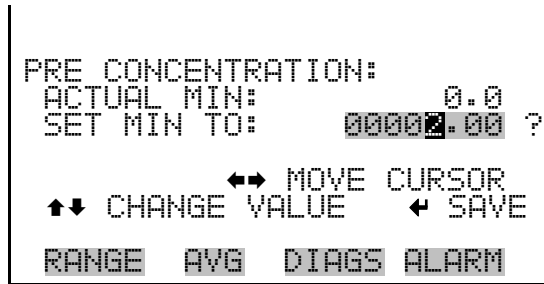
RANGE  AVG  DIAGS  ALARM

```

## Min and Max Prereactor Concentration Limits

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

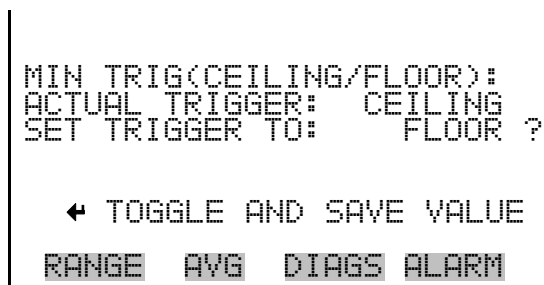
- In the Main Menu, choose Alarms > Pre Concentration > **Min** or **Max**.



### Min Trigger

The Minimum Trigger screen allows the user to view and set the prereactor 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 > Pre Concentration > **Min Trigger**.



## 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, “HI” or “LO” multi-point calibration is displayed to indicate the calibration of the high or low concentrations.

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

```

SERVICE:
>PMT VOLTAGE ADJUSTMENT
RANGE MODE SELECT
EXT CONVERTER SET TEMP
PRESSURE CALIBRATION
FLOW CALIBRATION
INPUT BOARD CALIBRATION
TEMPERATURE CALIBRATION ↓

RANGE  AVG  DIAGS  ALARM

ANALOG OUT CALIBRATION
ANALOG INPUT CALIBRATION
OZONATOR SAFETY
DILUTION RATIO
DISPLAY PIXEL TEST
RESTORE USER DEFAULTS
  
```

## PMT Voltage Adjustment

The PMT Voltage Adjustment screen is used to manually adjust the PMT supply voltage. The PMT voltage adjustment screen is visible only when the instrument is in service mode. For more information on the service mode, see “Service Mode” earlier in this chapter.

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

- In the Main Menu, choose Service > **PMT Voltage Adjustment**.

```

SET PMT VOLTAGE:
  SET PMT:      -750.0 V
  COUNTS:      2254 ?

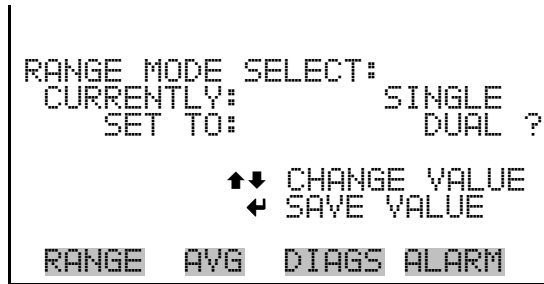
  ↑↓ CHANGE VALUE
  ← SAVE VALUE

RANGE  AVG  DIAGS  ALARM
  
```

## 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**.

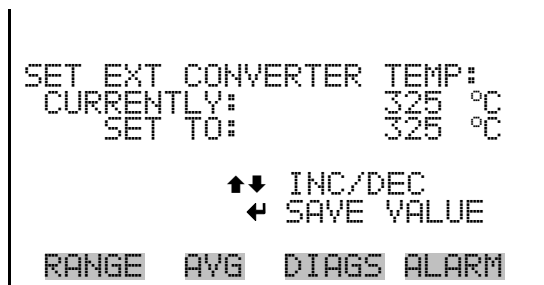


## External Converter Set Temperature

The External Converter Set Temperature screen is used to change the converter set temperature. The external converter set temperature reading is updated every second. The external converter set temperature screen 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 > **Ext Converter Set Temperature**.



## Pressure Calibration

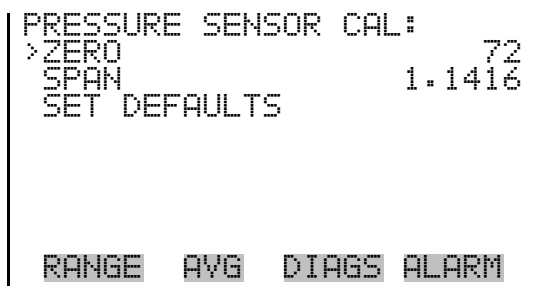
The Pressure Calibration submenu is used to calibrate the pressure sensor to zero, span, or restore factory default values. The pressure calibration is visible only when the instrument is in service mode. For more information on the service mode, see “[Service Mode](#)” earlier in this chapter.

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**.



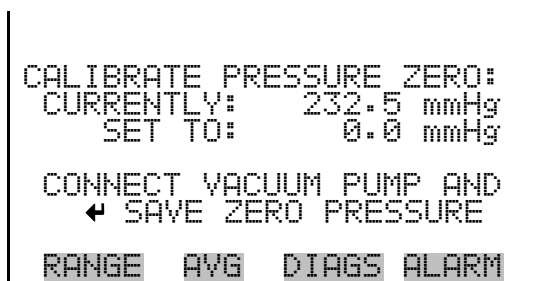


### Calibrate Pressure Zero

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**.

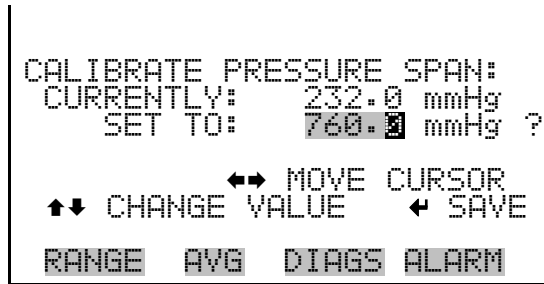


### Calibrate Pressure Span

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. ▲

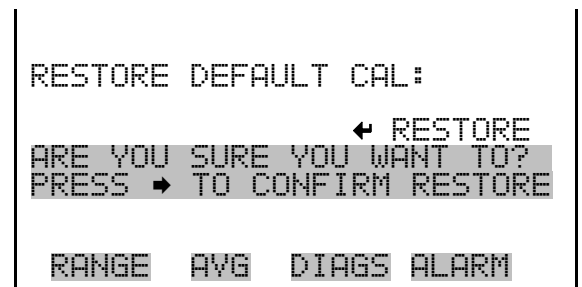
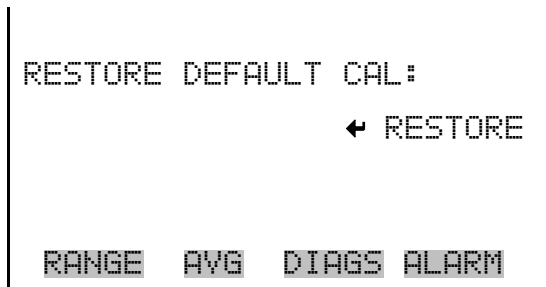
- In the Main Menu, choose Service > Pressure Calibration > **Span**.



### Restore Default Pressure Calibration

The Restore Default 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           200
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:    0.004 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 calibration 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:    1.000 LPM
SET TO:      0.800 LPM ?

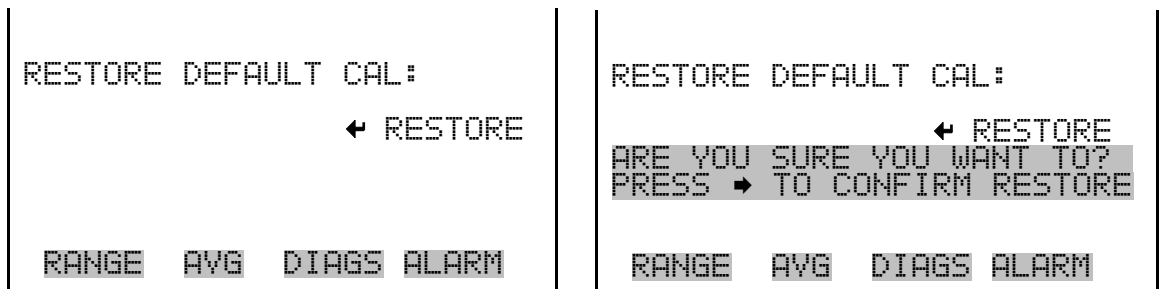
      ↔ MOVE CURSOR
↑↓ CHANGE VALUE ← SAVE

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**.

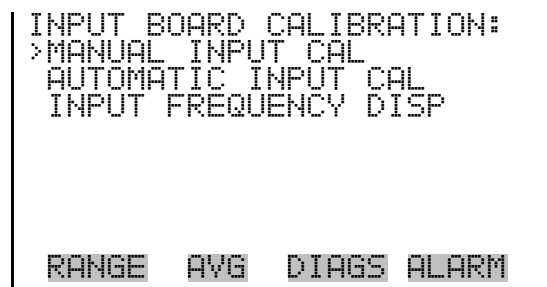


### Input Board Calibration

The Input Board Calibration menu is used to initiate a calibration of the input A/D stages. The input board calibration menu 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 > **Input Board Calibration**.

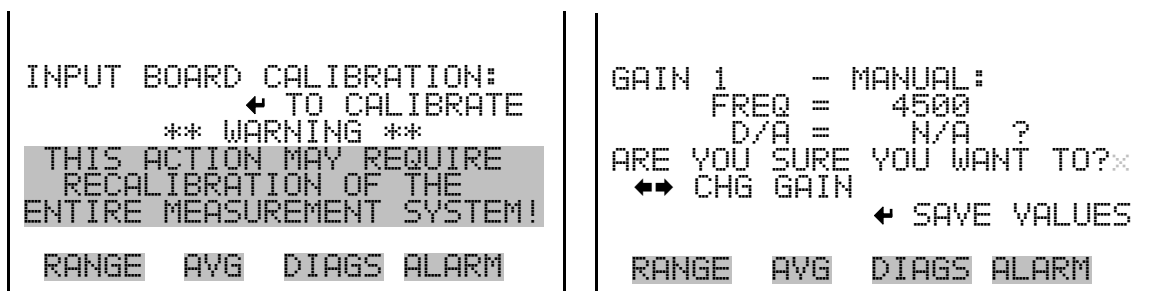


### Manual Input Calibration

The Manual Input Calibration screen is used to do a manual calibration of the input board A/D stages per the following procedure:

**Note** The measurement system and the PMT are both shut off inside this screen. ▲


1. In the Main Menu, choose Service > Input Board Calibration > **Manual Input Calibration.**
2. Press  to leave warning screen.
3. Make a note of the frequency at gain of 1.
4. Use  and  to change the gain between 10 and 100.
5. Use  and  to increment or decrement the D/A counts so the frequency at gain 100 is equal to the frequency at gain 1.
6. Press  to save new input board calibration.



### Automatic Input Calibration

The Automatic Input Calibration screen is used to do an automatic calibration of the input board A/D stages. A message will be displayed after the optimum setting has been determined.

**Note** The measurement system and the PMT are both shut off inside this screen. ▲

- In the Main Menu, choose Service > Input Board Calibration > **Automatic Input Calibration.**
- Press  to leave warning screen and begin automatic calibration.

```

INPUT BOARD CALIBRATION:
      ← TO CALIBRATE
      ** WARNING **
THIS ACTION MAY REQUIRE
RECALIBRATION OF THE
ENTIRE MEASUREMENT SYSTEM!
RANGE  AVG  DIAGS  ALARM
  
```

```

INPUT BOARD CALIBRATION:
      ** IN PROGRESS **
D/A    =    2047
TARGET =     0
FREQ   =     0      0
ZERO   =     0 CNT = 1
RANGE  AVG  DIAGS  ALARM
  
```

### Input Frequency Display

The Input Frequency Display screen is used to manually adjust the input board gain. This may be used as a troubleshooting tool for the input board. The gain setting and test mode are reset upon exiting this screen.

- In the Main Menu, choose Service > Input Board Calibration > **Input Frequency Display**.
- Press  to leave warning screen.
- Use  and  to toggle the test signal and bypass the PMT.
- Use  and  to change the gain between 1, 10 and 100.

```

INPUT BOARD CALIBRATION:
      ← TO CALIBRATE
      ** WARNING **
CONCENTRATION CALCULATION
IS HALTED INSIDE
THIS SCREEN!
RANGE  AVG  DIAGS  ALARM
  
```

```

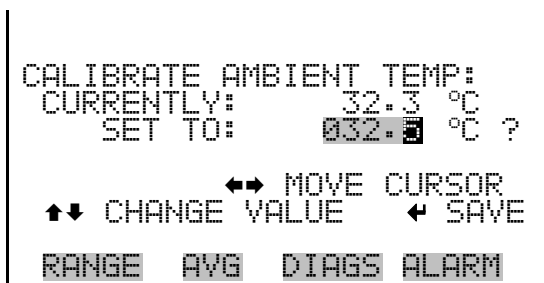
INPUT GAIN TEST:
GAIN = 1
TEST = OFF
FREQ = 5000
↔ CHG GAIN ↑↑ TEST MODE
RANGE  AVG  DIAGS  ALARM
  
```

### 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**.

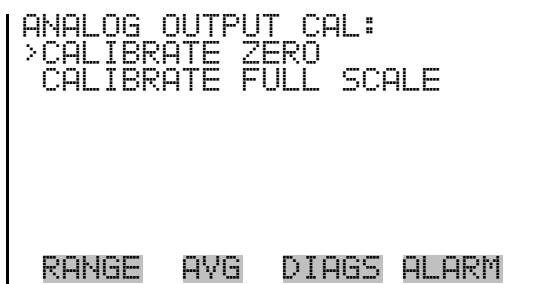
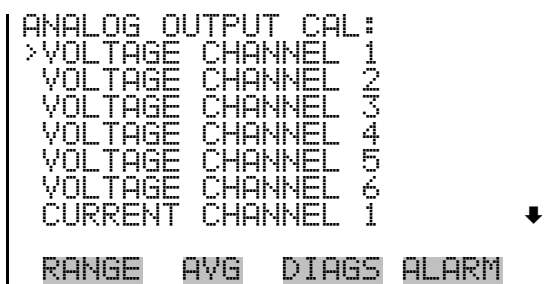


## Analog Output Calibration

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. ▲

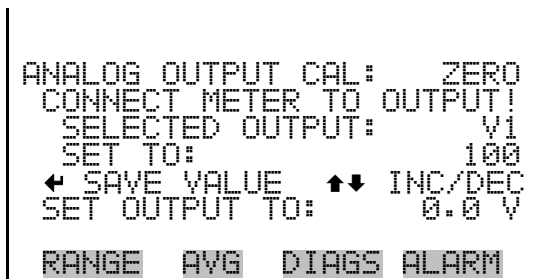
- In the Main Menu, choose Service > **Analog Out Calibration**.



### Analog Output 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.

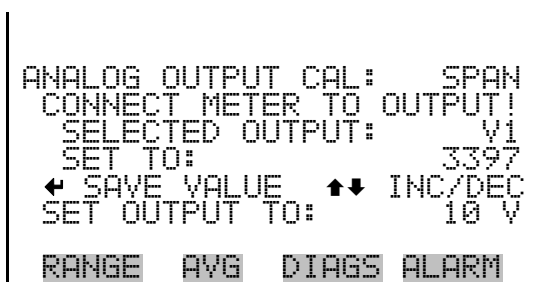
- In the Main Menu, choose Service > Analog Out Calibration > Select Channel > **Calibrate Zero**.



### Analog Output 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 Input Calibration

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

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



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

```

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

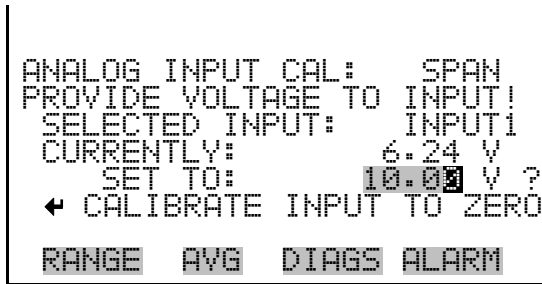
```

ANALOG INPUT CAL:  ZERO
DISCONNECT SELECTED INPUT!
SELECTED INPUT:    INPUT1
CURRENTLY:         6.24 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.

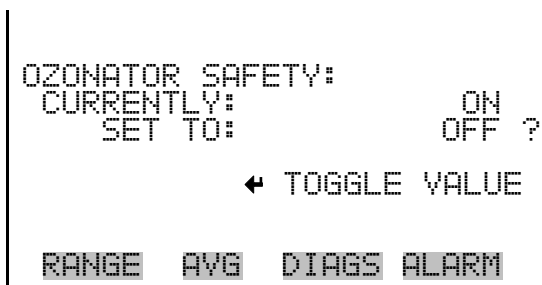
- In the Main Menu, choose Service > Analog Input Calibration > Select Channel > **Calibrate Full Scale**. (Hook up a voltage source of 10 V to the analog input channel.)



## Ozonator Safety

The Ozonator Safety screen is used to turn the ozonator safety feature on or off. If the ozonator safety is turned off, the ozonator will always be on, even if the converter is not up to temperature. The ozonator safety screen is visible only when the instrument is in service mode. For more information on the service mode, see “[Service Mode](#)” earlier in the chapter.

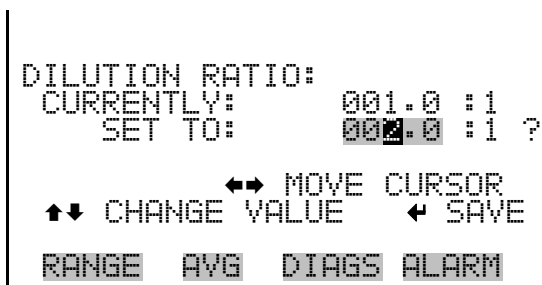
- In the Main Menu, choose Service > **Ozonator Safety**.



## 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.

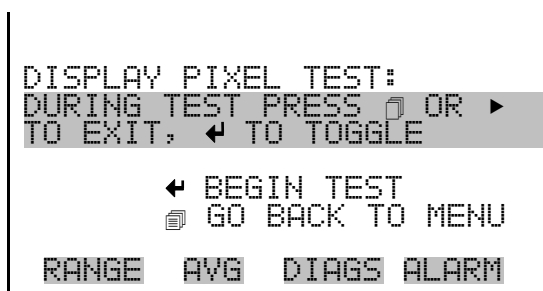
- In the Main Menu, choose Service > **Dilution Ratio**.



## 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.

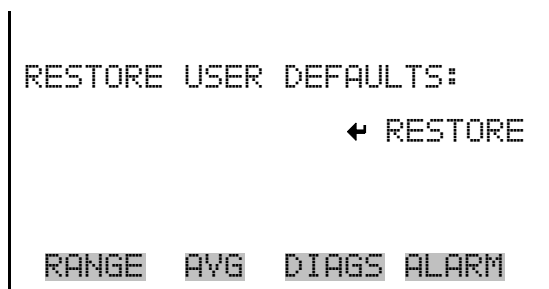
- In the Main Menu, choose Service > **Display Pixel Test**.



## 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 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 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 is shown if the instrument is unlocked.

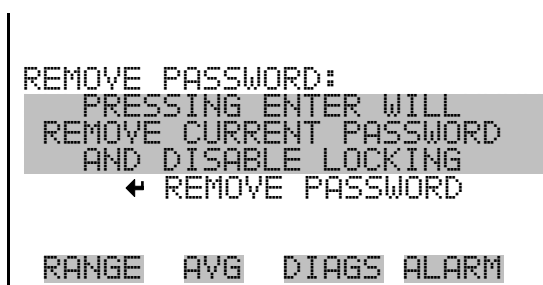
- In the Main Menu, choose Password > **Change Password**



## Remove Password

The Remove Password screen is used to erase the current password and disable password protection. The remove password is shown if the instrument is unlocked and the password set.

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



## 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**





## Chapter 4

# Calibration

This chapter describes procedures for performing a multipoint calibration of the Model 42i NO<sub>y</sub>. The information described here is considered to be adequate to perform the calibration. However, if greater detail is desired, the user is referred to the Code of Federal Regulations, Title 40, Part 50, Appendix F.

The calibration technique is based on the rapid gas phase reaction between NO and O<sub>3</sub> which produces stoichiometric quantities of NO<sub>2</sub> in accordance with the reaction:



The quantitative nature of this reaction is such that when the NO concentration is known, the concentration of NO<sub>2</sub> can be determined. Ozone is added to excess NO in a dynamic calibration system, and the NO channel of the chemiluminescence NO-DIF-NO<sub>y</sub> analyzer is used as an indicator of changes in NO concentration.

When O<sub>3</sub> is added, the decrease in NO concentration observed on the calibrated NO channel is equivalent to the concentration of NO<sub>2</sub> produced. Adding variable amounts of O<sub>3</sub> from a stable O<sub>3</sub> generator can change the amount of NO<sub>2</sub> generated. The following sections discuss the required apparatus and procedures for calibrating the instrument:

- [“Calibration Equipment”](#) on page 4-1
- [“Pre-Calibration”](#) on page 4-8
- [“Calibration”](#) on page 4-9
- [“Calibration in Dual Range and Auto Range Mode”](#) on page 4-16
- [“Zero and Span Check”](#) on page 4-21

## Calibration Equipment

The following equipment may be used to calibrate the analyzer:

- Zero gas generator
- Gas phase titrator

**Note** In this chapter  $\text{NO}_2$  is used as a surrogate compound for all  $\text{NO}_y$  species that are required to be converted to NO ( $\text{NO}_2$ ,  $\text{NO}_3$ ,  $\text{N}_2\text{O}_5$ ,  $\text{HNO}_2$ ,  $\text{HNO}_3$ , PAN, organic nitrates and aerosol nitrates). ▲

## Zero Gas Generator

A zero air source, such as a Thermo Scientific *Model 111 Zero Air Supply* or *Model 1160 Zero Air Supply*, free of contaminants such as NO,  $\text{NO}_2$ , and  $\text{O}_3$  is required for dilution, calibration, and gas phase titration.

### Compression

The zero air source should be at an elevated pressure to allow accurate and reproducible flow control and to aid in subsequent operations such as drying, oxidation, and scrubbing. An air compressor that gives an output of 10 psig is usually sufficient for most applications.

### 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.

### Oxidation

NO is usually oxidized to  $\text{NO}_2$  in order to ease its scrubbing. Oxidation can be accomplished by either ozonation or chemical contact. During ozonation, the air is passed through an ozone generator. The  $\text{O}_3$  that is produced reacts with the NO to form  $\text{NO}_2$ . Care must be taken to allow sufficient residence time for the ozonation reaction to go to completion.

Chemical oxidation is accomplished by passing the air stream through a reacting bed. Such agents as  $\text{CrO}_3$  on an alumina support or Purafil® are very efficient at oxidizing NO to  $\text{NO}_2$ . The chemical contact approach has the advantage of needing no electrical power input for its application.

### Scrubbing

Fixed bed reactors are commonly used in the last step of zero air generation to remove the remaining contaminants by either further reaction or absorption. [Table 4-1](#) lists materials that can be effective in removing contaminants.



**Table 4–1.** Scrubbing Materials

| To Remove                          | Use                                      |
|------------------------------------|--|
| NO <sub>2</sub>                    | Soda-Lime (6-12 mesh), Purafil           |
| Hydrocarbons                       | Molecular Sieve (4A), Activated Charcoal |
| O <sub>3</sub> and SO <sub>2</sub> | Activated Charcoal                       |

## Gas Phase Titrator

A gas phase titrator (GPT), such as is included in the Thermo Scientific Model 146 Series Multigas Calibration System is used to generate NO<sub>2</sub> concentrations from NO concentrations. NO<sub>2</sub> is one of the the major components of NO<sub>y</sub>. Figure 4-1 shows the suggested placement of the component parts of a gas phase titration apparatus.



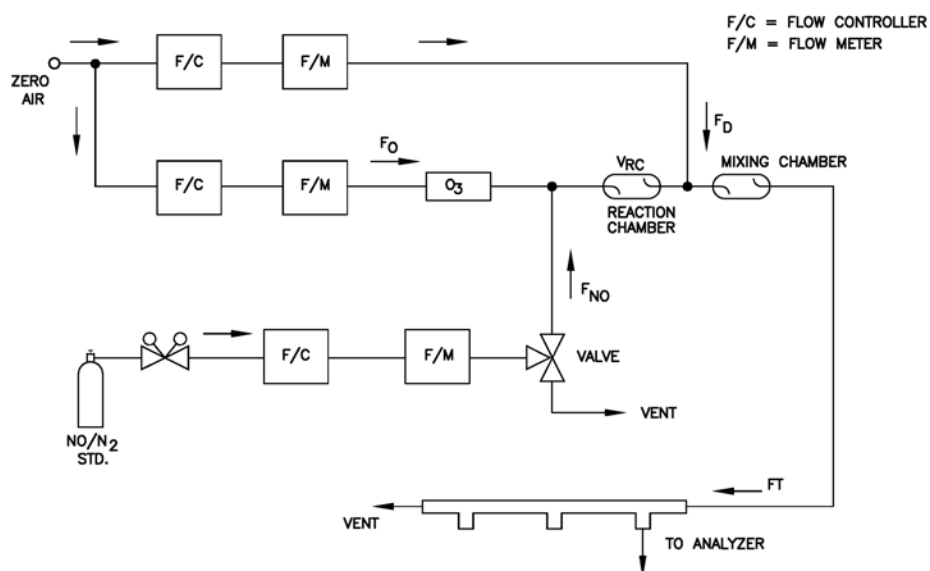
**Equipment Damage** All connections between components in the system should be made with glass, Teflon®, or other non-reactive material. ▲

### Flow Controllers

The airflow controllers should be devices capable of maintaining constant airflows within ±2% of the required flow rate. The NO flow controller should be capable of maintaining constant NO flows within ±2% of the required flow rate.

### Pressure Regulator

The pressure regulator for the standard NO cylinder must have a non-reactive diaphragm and internal parts, and a suitable delivery pressure.



**Figure 4–1.** GPT System

**Ozone Generator** The ozone generator must be capable of generating sufficient and stable levels of ozone for reaction with NO to generate NO<sub>2</sub> concentrations in the range required.

**Note** Ozone generators of the electric discharge type may produce NO and NO<sub>2</sub> and are not recommended. ▲

**Diverter Valve** A valve can be used to divert the NO flow when zero air is required at the manifold.

**Reaction Chamber** The reaction chamber used for the reaction of ozone with excess NO should have sufficient volume so that the residence time meets the requirements specified in this chapter.

**Mixing Chamber** The mixing chamber is used to provide thorough mixing of the reaction products and diluent air.

**Output Manifold** The output manifold should be of sufficient diameter to insure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to insure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold.

**Reagents** The following information describes the NO concentration standard and the method for calculating the NO concentration standard and the NO<sub>2</sub> impurity.

**NO Concentration Standard** A cylinder containing 10 to 50 ppm NO in N<sub>2</sub> with less than 1 ppm NO<sub>2</sub> is usually used as the concentration standard. The cylinder must be traceable to a National Institute of Standards and Technology (NIST) NO in N<sub>2</sub> Standard Reference Material or NO<sub>2</sub> Standard Reference Material.

Procedures for certifying the NO cylinder (working standard) against an NIST traceable NO or NO<sub>2</sub> standard and for determining the amount of NO<sub>2</sub> impurity are given in EPA Publication No. EPA-600/4-75-003, "Technical Assistance Document for the Chemiluminescence Measurement of Nitrogen Dioxide."

In addition, the procedure for the certification of a NO working standard against an NIST traceable NO standard and determination of the amount of NO<sub>2</sub> impurity in the working standard is reproduced here. The cylinder should be re-certified on a regular basis as determined by the local quality control program.

Use the NIST traceable NO standard and the GPT calibration procedure to calibrate the NO, NO<sub>y</sub>, and NO<sub>2</sub> responses of the instrument. Also determine the converter efficiency of the analyzer. Refer to the calibration procedure in this manual and in the Code of Federal Regulations, Title 40, Part 50, Appendix F for exact details. Ignore the recommended zero offset adjustments.

**Assaying a Working NO Standard Against a NIST-traceable NO Standard**

Use the following procedure to calculate the NO concentration standard and NO<sub>2</sub> impurity.

1. Generate several NO concentrations by dilution of the NO working standard.
2. Use the nominal NO concentration, [NO]<sub>NOM</sub>, to calculate the diluted concentrations.
3. Plot the analyzer NO response (in ppm) versus the nominal diluted NO concentration and determine the slope, S<sub>NOM</sub>.
4. Calculate the [NO] concentration of the working standard, [NO]<sub>STD</sub>, from:

$$[\text{NO}]_{\text{STD}} = [\text{NO}]_{\text{NOM}} \times S_{\text{NOM}}$$

5. If the nominal NO concentration of the working standard is unknown, generate several NO concentrations to give on-scale NO responses.
6. Measure and record F<sub>NO</sub> and F<sub>T</sub> for each NO concentration generated.
7. Plot the analyzer NO response versus F<sub>NO</sub>/F<sub>T</sub> and determine the slope which gives [NO]<sub>STD</sub> directly. The analyzer NO<sub>y</sub> responses to the generated NO concentrations reflect any NO<sub>2</sub> impurity in the NO working standard.

8. Plot the difference between the analyzer  $\text{NO}_y$  and NO responses versus  $F_{\text{NO}}/F_{\text{T}}$ . The slope of this plot is  $[\text{NO}_2]_{\text{IMP}}$ .

**Zero Air** A source of zero air free of contaminants should be used as described earlier in this chapter. Contaminants can cause a detectable response on the instrument and may also react with the NO,  $\text{O}_3$ , or  $\text{NO}_2$  during the gas phase titration.

## Dynamic Parameter Specifications for Gas Titrator

Use the following definitions for the remainder of this chapter.

|                              |   |
|------------------------------|---|
| $P_{\text{R}}$ =             | Dynamic parameter specification to ensure complete reaction of the available $\text{O}_3$ , ppm-min |
| $[\text{NO}]_{\text{RC}}$ =  | NO concentration in the reaction chamber, ppm   |
| $t_{\text{R}}$ =             | residence time of the reactant gases in the reaction chamber, min                                   |
| $[\text{NO}]_{\text{STD}}$ = | Concentration of the undiluted NO standard, ppm   |
| $F_{\text{NO}}$ =            | NO flow rate, sccm  |
| $F_{\text{O}}$ =             | $\text{O}_3$ generator air flow rate, sccm  |
| $V_{\text{RC}}$ =            | Volume of the reaction chamber, cc  |
| $F_{\text{T}}$ =             | Analyzer demand plus 10 to 50% excess   |

The  $\text{O}_3$  generator (ozonator) airflow rate and the NO flow rate must be adjusted such that the following relationships hold:

$$P_{\text{R}} = [\text{NO}]_{\text{RC}} \times t_{\text{R}} \geq 2.75 \text{ ppm} \cdot \text{min}$$

$$[\text{NO}]_{\text{RC}} = [\text{NO}]_{\text{STD}} \frac{F_{\text{NO}}}{(F_{\text{O}} + F_{\text{NO}})}$$

$$t_{\text{R}} = \frac{V_{\text{RC}}}{F_{\text{O}} + F_{\text{NO}}} < 2 \text{ min}$$

## Determining GPT System Flow Conditions

Use the following procedure to determine the flow conditions to be used in the GPT system.

1. Determine  $F_{\text{T}}$ , the total flow required at the output manifold, which should be equal to the analyzer demand plus 10 to 50 percent excess.

2. Establish  $[\text{NO}]_{\text{OUT}}$  as the highest NO concentration that will be required at the output manifold.  $[\text{NO}]_{\text{OUT}}$  should be about equal to 90% of the upper range limit (URL) of the  $\text{NO}_2$  concentration range to be covered.

3. Determine  $F_{\text{NO}}$  as:

$$F_{\text{NO}} = \frac{[\text{NO}]_{\text{OUT}} \times F_{\text{T}}}{[\text{NO}]_{\text{STD}}}$$

4. Select a convenient or available reaction chamber volume. Initially a trial volume may be selected in the range of 200 to 500 cc.

5. Compute  $F_{\text{O}}$  as:

$$F_{\text{O}} = \sqrt{\frac{[\text{NO}]_{\text{STD}} \times F_{\text{NO}} \times V_{\text{RC}}}{2.75}} - F_{\text{NO}}$$

6. Compute  $t_{\text{R}}$  as:

$$t_{\text{R}} = \frac{V_{\text{RC}}}{F_{\text{O}} + F_{\text{NO}}}$$

7. Verify that  $t_{\text{R}} < 2$  minutes. If not, select a reaction chamber with a smaller  $V_{\text{RC}}$ .

8. Compute the diluent air flow rate as:

$$F_{\text{D}} = F_{\text{T}} - F_{\text{O}} - F_{\text{NO}}$$







9. If  $F_{\text{O}}$  turns out to be impractical for the desired system, select a reaction chamber having a different  $V_{\text{RC}}$  and recompute  $F_{\text{D}}$  and  $F_{\text{O}}$ .

## Pre-Calibration





Perform the following pre-calibration procedure before calibrating the Model 42i NO<sub>y</sub>. For detailed information about the menu parameters and the icons used in these procedures, see the “[Operation](#)” chapter.

**Note** 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. ▲

1. Allow the instrument to warm up and stabilize.
2. Be sure the ozonator is ON. If the ozonator is not ON:
  - a. Press  to display the Main Menu, then choose Instrument Controls > **Ozonator**.
  - b. Press  to toggle the ozonator ON.
  - c. Press  to return to the Run screen.
3. Be sure the instrument is in the auto mode, that is, NO, DIF, and NO<sub>y</sub> measurements are being displayed on the front panel display. If the instrument is not in auto mode:
  - a. Press  to display the Main Menu, then choose Instrument Controls > **Auto/Manual Mode**.
  - b. Select NO/NO<sub>y</sub>, and press .
  - c. Press  to return to the Run screen.
4. Select NO, DIF, and NO<sub>y</sub> ranges, and push the AVG soft key to display the Averaging Time screen. It is recommended that a higher averaging time be used for best results. For more information about the ranges or averaging time, see the “[Operation](#)” chapter.

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

5. Set the calibration pressure to the current reactor pressure.
  - a. Press , choose > Calibration Factors > **Cal Pressure**.
  - b. Use   to increment/decrement the value to match the current reactor pressure, and press  to save the new calibration pressure value.
6. Verify that any filters used during normal monitoring are also used during calibration.
7. If required, connect the analog/digital outputs to a strip chart recorder(s) or PC(s).

## Calibration

The following procedure calibrates the analyzer using the gas phase titrator and zero gas generator described previously in this manual. It is suggested that a calibration curve have at least seven points between the zero and full scale NO concentrations. Although the seven-point curve is optional, two of whatever number of points is chosen should be located at the zero and 90% levels and the remaining points equally spaced between these values.

**Note** When the instrument is equipped with internal zero/span and sample valves, the ZERO and SPAN ports should give identical responses to the SAMPLE port when test gases are introduced. The user should calibrate the instrument using the SAMPLE port to introduce the zero and span gas sources. ▲

After calibration, the zero and span sources should be plumbed to the appropriate ports on the rear panel of the instrument, and then reintroduced to the instrument. The instrument should give identical responses to the test gases whether they are introduced via the SAMPLE port or the ZERO or SPAN ports. If not, the plumbing and/or valves should be serviced.

## Connect GPT Apparatus to the Analyzer

Use the following procedure to connect the GPT apparatus to the analyzer.

1. Assemble a dynamic calibration system such as the one shown in [Figure 4-1](#).

2. Ensure that all flow meters are calibrated under the conditions of use against a reliable standard, such as a soap-bubble meter or wet-test meter. All volumetric flow rates should be corrected to 25 °C and 760 mmHg.
3. Precautions should be taken to remove O<sub>2</sub> and other contaminants from the NO pressure regulator and delivery system prior to the start of calibration to avoid any conversion of NO to NO<sub>2</sub>. Failure to do so can cause significant errors in calibration. This problem can be minimized by:
  - a. Carefully evacuating the regulator after the regulator has been connected to the cylinder and before opening the cylinder valve.
  - b. Thoroughly flushing the regulator and delivery system with NO after opening the cylinder valve.
  - c. Not removing the regulator from the cylinder between calibrations unless absolutely necessary.
4. Connect the analyzer sample bulkhead input to the output of the GPT system.

## Adjust Instrument Gain

Use the following procedure to adjust the instrument gain. This includes:

- Setting the Prereactor, NO and NO<sub>y</sub> backgrounds to zero
- Calibrating the NO channel to the NO calibration gas
- Calibrating the NO<sub>y</sub> channel to the NO<sub>y</sub> calibration gas

### Set Backgrounds to Zero



The Prereactor, NO and NO<sub>y</sub> background corrections are determined during zero calibration. The background signal is the combination of electrical offsets, PMT dark current, and trace substances undergoing chemiluminescence. For more detailed information, see “NO, NO<sub>y</sub>, and Prereactor Backgrounds” in the “Operation” chapter.

Use the following procedure to set the prereactor background. Both the NO and NO<sub>y</sub> background screens operate the same way, and the following procedure also applies to the NO and NO<sub>y</sub> background screen.

**Note** The Prereactor channel should be calibrated first and then calibrate the NO channel, then the NO<sub>y</sub> channel. ▲



For detailed information about the menu parameters and the icons used in these procedures, see the “[Operation](#)” chapter.

1. Determine the GPT flow conditions required to meet the dynamic parameter specifications as indicated in “[Dynamic Parameter Specifications for Gas Titrator](#)” earlier in this chapter.
2. Adjust the GPT diluent air and O<sub>3</sub> generator air flows to obtain the flows determined in “[Dynamic Parameter Specifications for Gas Phase Titrator](#)” earlier in this chapter. The total GPT airflow must exceed the total demand of the analyzer. The Model 42i NO<sub>y</sub> requires approximately 1 liter/min of sample flow, and a total GPT airflow of at least 2.5 liters/min is recommended.
  - a. Allow the analyzer to sample zero air until the NO, NO<sub>y</sub>, and DIF responses stabilize.
  - b. After the responses have stabilized, from the Main Menu, choose Calibration > **Cal Prereactor Zero**.
  - c. Press  to set the zero concentration reading to zero.
  - d. Press  to return to the Calibration menu and repeat this procedure to set the NO and NO<sub>y</sub> background to zero.
  - e. Record the stable zero air responses as Z<sub>NO</sub>, Z<sub>NO<sub>y</sub></sub>, and Z<sub>DIF</sub> (recorder response, percent scale).
3. Adjust the NO flow from the standard NO cylinder to generate a NO concentration of about 80% of the upper range limit (URL) of the NO range. The exact NO concentration is calculated from:

$$[\text{NO}]_{\text{OUT}} = \frac{F_{\text{NO}} \times \text{NO}_{\text{STD}}}{F_{\text{NO}} + F_{\text{O}} + F_{\text{D}}}$$

Where:

[NO]<sub>OUT</sub> = Diluted NO concentration at the output manifold, ppm

NO<sub>STD</sub> = No feed concentration

F<sub>NO</sub> = No flow

F<sub>O</sub> = Ozone flow





F<sub>D</sub> = Dilution flow


### Calibrate the NO Channel to the NO Calibration Gas

Use the following procedure to calibrate the NO channel to the NO calibration gas.

1. Allow the analyzer to sample the NO calibration gas until the NO, DIF, and NO<sub>y</sub> readings have stabilized.
2. When the responses stabilize, from the Main Menu, choose Calibration > **Cal NO Coefficient**.

The NO line of the Calibrate NO screen displays the current NO concentration. The SPAN CONC line of the display is where you enter the NO calibration gas concentration.

Use   to move the cursor left and right and use   to increment and decrement the numeric character at the cursor.

3. Press  to calculate and save the new NO coefficient based on the entered span concentration.

The NO recorder response will equal:

$$\text{Recorder Response (\% scale)} = \frac{[\text{NO}]_{\text{OUT}}}{\text{URL}} \times 100 + Z_{\text{NO}}$$


Where:

URL = Nominal upper range limit of the NO channel, ppm





4. Record the [NO]<sub>OUT</sub> concentration and the analyzer NO response as indicated by the recorder response.



### Calibrate the NO<sub>y</sub> Channel to the NO<sub>y</sub> Calibration Gas

Use the following procedure to calibrate the NO<sub>y</sub> channel to the NO<sub>y</sub> calibration gas.

1. Press  to return to the Calibration menu, and choose **Cal NO<sub>y</sub> Coefficient**.
2. Verify that the NO<sub>y</sub> calibration gas concentration is the same as the NO calibration gas concentration plus any known NO<sub>2</sub> impurity (the assumption is that any NO<sub>y</sub> impurity is primarily NO<sub>2</sub>).

The NO<sub>y</sub> line of the Calibrate NO<sub>y</sub> screen displays the current NO<sub>y</sub> concentration. The SPAN CONC line of the display is where you enter the NO<sub>y</sub> calibration gas concentration.

Use   to move the cursor left and right and use   to increment and decrement the numeric character at the cursor.

3. Press  to calculate and save the new NO<sub>y</sub> coefficient based on the entered span concentration.
4. Press  to return to the Run screen. The exact NO<sub>y</sub> concentration is calculated from:

$$[\text{NO}_y]_{\text{OUT}} = \frac{F_{\text{NO}} \times ([\text{NO}]_{\text{STD}} + [\text{NO}_2]_{\text{IMP}})}{F_{\text{NO}} + F_{\text{O}} + F_{\text{D}}}$$

Where:

[NO<sub>y</sub>]<sub>OUT</sub> = diluted NO<sub>y</sub> concentration at the output manifold, ppm

[NO<sub>2</sub>]<sub>IMP</sub> = concentration of NO<sub>2</sub> impurity in the standard NO cylinder, ppm

The NO<sub>y</sub> recorder response will equal:

$$\text{Recorder Response (\% scale)} = \frac{[\text{NO}_y]_{\text{OUT}}}{\text{URL}} \times 100 + Z_{\text{NO}_x}$$

Where:

URL = Nominal upper range limit of the NO<sub>y</sub> channel, ppm





5. Record the NO<sub>y</sub> concentration and the analyzer's NO<sub>y</sub> response.

### Preparing NO, NO<sub>y</sub>, and DIF Calibration Curves

Use the following procedures to prepare the NO, NO<sub>y</sub>, and DIF calibration curves.

1. Generate several additional NO and NO<sub>y</sub> concentrations by decreasing F<sub>NO</sub> or increasing F<sub>D</sub>.
2. For each concentration generated, calculate the exact NO and NO<sub>y</sub> concentrations using the above equations for [NO]<sub>OUT</sub> and [NO<sub>y</sub>]<sub>OUT</sub>.
3. Record the NO and NO<sub>y</sub> responses.

4. Plot the analyzer responses versus the respective calculated NO and NO<sub>y</sub> concentrations and draw or calculate the respective calibration curves. For subsequent calibrations where linearity can be assumed, these curves may be checked with a three-point calibration consisting of a zero point, NO and NO<sub>y</sub> concentrations of approximately 80% of the URL, and an intermediate concentration.
5. Sample this NO concentration until the NO and NO<sub>y</sub> responses have stabilized, then measure and record the NO concentration as [NO]<sub>ORIG</sub>.
6. Adjust the GPT system to generate a NO concentration near 90% of the URL of the instrument range selected.
7. Adjust the O<sub>3</sub> generator in the GPT system to generate sufficient O<sub>3</sub> to produce a decrease in the NO concentration equivalent to about 80% of the URL of the DIF range. The decrease must not exceed 90% of the NO concentration determined in Steps 5 and 6 above.
8. When the analyzer responses stabilize, record the resultant NO concentrations as [NO]<sub>REM</sub>.
9. From the Main Menu choose Calibration > **Cal DIF Coefficient**.  
The DIF line of the Calibrate DIF screen displays the current DIF concentration. The SPAN CONC line of the display is where you enter the DIF calibration gas concentration. Note that NO<sub>2</sub> is being used as the DIF component.
10. Set the NO<sub>2</sub> calibration gas concentration to reflect the sum of the following: the NO<sub>2</sub> concentration generated by GPT, ([NO]<sub>ORIG</sub> - [NO]<sub>REM</sub>), and any NO<sub>2</sub> impurity.

Use   to move the cursor left and right and use   to increment and decrement the numeric character at the cursor.


$$[\text{NO}_2]_{\text{OUT}} = ([\text{NO}]_{\text{ORIG}} - [\text{NO}]_{\text{REM}}) + \frac{F_{\text{NO}} \times [\text{NO}_2]_{\text{IMP}}}{F_{\text{NO}} + F_{\text{O}} + F_{\text{D}}}$$

Where:

$[\text{NO}_2]_{\text{OUT}}$  = diluted  $\text{NO}_2$  concentration at the output manifold, ppm

$[\text{NO}]_{\text{ORIG}}$  = original NO concentration, prior to addition of  $\text{O}_3$ , ppm

$[\text{NO}]_{\text{REM}}$  = NO concentration remaining after addition of  $\text{O}_3$ , ppm

11. Press  to calculate and save the new DIF coefficient based on the entered span concentration.

The analyzer does a one point DIF span coefficient calculation, corrects the DIF reading for converter inefficiency, and then adds the corrected DIF to the NO signal to give a corrected  $\text{NO}_y$  signal.

If the analyzer calculates a DIF span coefficient of less than 0.96, either the entered DIF concentration is incorrect, the converter is not being heated to the proper temperature, the instrument needs servicing (leak or imbalance), or the converter needs replacement or servicing. The DIF analog output will reflect the  $\text{NO}_2$  concentration generated by GPT, any  $\text{NO}_2$  impurity, and the  $\text{NO}_2$  zero offset.

The recorder response will be as follows:

$$\text{Recorder Response (\% scale)} = \frac{[\text{NO}_2]_{\text{OUT}}}{\text{URL}} \times 100 + Z_{\text{NO}_2}$$

Where:

URL = Nominal upper range limit of the DIF channel, ppm

12. Record the DIF concentration and the analyzer's DIF response.
13. Maintaining the same  $F_{\text{NO}}$ ,  $F_{\text{O}}$ , and  $F_{\text{D}}$ , adjust the ozone generator to obtain several other concentrations of  $\text{NO}_2$  over the DIF range (at least five evenly spaced points across the remaining scale are suggested).
14. Record the stable responses and plot the analyzer's DIF responses versus the corresponding calculated (using the above equation for  $[\text{NO}_2]_{\text{OUT}}$ ) concentrations and draw or calculate the DIF calibration curve.

**Note** It is important that the curve be linear within  $\pm 1\%$  FS over the DIF range. If the curve is nonlinear, the analyzer is not operating correctly, (possible leak, or converter failure, etc.), and should be serviced. Assuming the curve is linear, subsequent data should be reduced using this DIF calibration curve response. ▲

## Calibration

### Calibration in Dual Range and Auto Range Mode

Using the Calibration Factors menu can change the calibration factors. This is often useful in a troubleshooting situation. However, after the above calibration procedure is completed, all subsequent data reduction depends on the calibration parameters, remaining the same as during the initial calibration. ▲

Therefore, never change any calibration factor without first recording the value so that after any troubleshooting procedure is completed, the initial value can be re-entered thereby not altering the multipoint calibration. ▲

### Alternative Calibration Procedure Using NO<sub>2</sub> Permeation Tube

Although it is recommended that a GPT system be used to calibrate the analyzer, the procedure described in the Code of Federal Regulations, Title 40, Part 50, Appendix F using a NO<sub>2</sub> permeation tube may be used as an alternative procedure for calibrating the instrument.

### Calibration in Dual Range and Auto Range Mode

The dual/auto range calibration feature is used to calibrate the analyzer at two different span levels (as opposed to a single span level in the standard mode) generating a “tailored multi-point” calibration curve stored in the analyzer's memory. This feature may be used:

- When widely different gas levels are being monitored, such as a factor of 10 or greater apart
- If precision and span levels are being introduced using separate tanks
- If more than one multi-component cylinder is being used to calibrate the instrument

Properly designed chemiluminescence analyzers are inherently linear over a wide dynamic range; and under normal USEPA compliance situations this feature is not required. Dual calibration may be used for span levels less than a factor of 10 apart, however if this is done to correct for a significant non-linearity, it may mask the problems causing the effect, such as, bad calibration cylinder, leaks in sampling lines, or low ozonator output.



Use the following procedures to calibrate the analyzer in dual or auto range mode.

### Set Background Readings to Zero

Use the following procedure to set the prereactor background reading to zero. Both the NO background and NO<sub>y</sub> background screens operate the same way, and the following procedure also applies to the NO and NO<sub>y</sub> background screen.

**Note** The Prereactor channel should be calibrated first and then calibrate the NO channel, then the NO<sub>y</sub> channel. ▲

For detailed information about the menu parameters and the icons used in these procedures, see the “[Operation](#)” chapter.

1. Follow the “[Pre-Calibration](#)” procedure described previously in this chapter.
2. Introduce zero air to the SAMPLE bulkhead and allow the analyzer to sample zero air until the NO, NO<sub>y</sub>, and DIF responses stabilize.
3. When the responses stabilize, from the Main Menu choose Calibration > **Cal Prereactor Zero**.
4. The Prereactor Background screen displays the current prereactor background and zero concentration.
5. Press  to set the zero background to zero.
6. Press  to return to the Run screen.
7. Repeat Steps 3 through 6, selecting **Cal NO Background** or **Cal NO<sub>y</sub> Background** to set the NO and NO<sub>y</sub> backgrounds to zero.

## Calibrate Low NO





Use the following procedure to calibrate NO channel to the NO calibration gas.


1. Disconnect the source of zero air from the SAMPLE bulkhead. In its place, connect a source of NO calibration gas of about 80% of the low NO full-scale range.
2. Allow the analyzer to sample the low NO calibration gas until the NO, DIF, and NO<sub>y</sub> readings stabilize.
3. When the responses are stable, from the Main Menu choose Calibration > **Cal Lo NO Coefficient**.
4. The Lo NO field displays the current NO concentration.

## Calibration

Calibration in Dual Range and Auto Range Mode


The Lo NO Span Conc field is where you enter the low NO calibration gas concentration.

Use   to move the cursor left and right and use   to increment and decrement the numeric character at the cursor.





5. Press  to calculate and save the new low NO coefficient based on the entered span concentration.



## Calibrate Low NO<sub>y</sub>

Use the following procedure to calibrate the NO<sub>y</sub> channel to the NO<sub>y</sub> calibration gas.

1. Press  to return to the Calibration menu and choose **Cal Lo NO<sub>y</sub> Coefficient**.
2. Verify that the low NO<sub>y</sub> calibration gas concentration is the same as the low NO calibration gas concentration plus any known NO<sub>2</sub> impurity (the assumption is that any NO<sub>y</sub> impurity is primarily NO<sub>2</sub>).

The Lo NO<sub>y</sub> field displays the current NO<sub>y</sub> concentration. The Lo NO<sub>y</sub> Span Conc field is where you enter the low NO<sub>y</sub> calibration gas concentration.

Use   to move the cursor left and right and use   to increment and decrement the numeric character at the cursor.

3. Press  to calculate and save the new low NO<sub>y</sub> coefficient based on the entered span concentration.
4. Press  to return to the Run screen.

## Calibrate Low DIF





Use the following procedure to calibrate the DIF channel to the DIF calibration gas.


1. Adjust the O<sub>3</sub> generator in the GPT system to generate sufficient O<sub>3</sub> to produce a decrease in the low NO concentration equivalent to about 80% of the URL of the low DIF range. The decrease must not exceed 90% of the low NO concentration determined in the “[Calibrate Low NO<sub>y</sub>](#)” procedure.
2. From the Main Menu choose Calibration > **Cal Lo DIF Coefficient**.



The Lo DIF field displays the current DIF concentration. The Lo DIF Span Conc field is where you enter the Lo DIF calibration gas concentration. Note that NO<sub>2</sub> is being used as the DIF component.

3. Set the low NO<sub>2</sub> calibration gas concentration to reflect the sum of the NO<sub>2</sub> concentration generated by GPT and any NO<sub>2</sub> impurity (the assumption is that any NO<sub>y</sub> impurity is primarily NO<sub>2</sub>).

Use   to move the cursor left and right and use   to increment and decrement the numeric character at the cursor.





4. Press  to calculate and save the new low DIF coefficient based on the entered span concentration.


## Calibrate High NO

Use the following procedure to calibrate the NO channel to the NO calibration gas.

1. Connect a source of high NO calibration gas of about 80% of the high NO full-scale range. Allow the analyzer to sample the high NO calibration gas until the NO, NO<sub>y</sub>, and DIF readings have stabilized.
2. After the responses have stabilized, from the Main Menu, choose Calibration > **Cal Hi NO Coefficient**.

The Hi NO field displays the current NO concentration. The Hi NO Span Conc field is where you enter the high NO calibration gas concentration.

Use   to move the cursor left and right and use   to increment and decrement the numeric character at the cursor.

3. Press  to calculate and save the new high NO coefficient based on the entered span concentration.

## Calibrate High NO<sub>y</sub>





Use the following procedure to calibrate the NO<sub>y</sub> channel to the NO<sub>y</sub> calibration gas.



1. Press  to return to the Calibration menu, and choose **Cal Hi NO<sub>y</sub> Coefficient**.

## Calibration

Calibration in Dual Range and Auto Range Mode

2. Verify that the high NO<sub>y</sub> calibration gas concentration is the same as the high NO calibration gas concentration plus any known NO<sub>2</sub> impurity (the assumption is that any NO<sub>y</sub> impurity is primarily NO<sub>2</sub>).

Use   to move the cursor left and right and use   to increment and decrement the numeric character at the cursor.

3. Press  to calculate and save the new high NO<sub>y</sub> coefficient based on the entered span concentration.
4. Press  to return to the Run screen.

## Calibrate High DIF





Use the following procedure to calibrate the DIF channel to the DIF calibration gas.


1. Adjust the O<sub>3</sub> generator in the GPT system to generate sufficient O<sub>3</sub> to produce a decrease in the high NO concentration equivalent to about 80% of the URL of the high DIF range. The decrease must not exceed 90% of the high NO concentration determined in the “[Calibrate High NO<sub>y</sub>](#)” procedure.

2. From the Main Menu, choose Calibration > **Cal Hi DIF Coefficient**.

The Hi DIF field displays the current DIF concentration. The Hi NO<sub>2</sub> Span Conc field is where you enter the high NO<sub>2</sub> calibration gas concentration. Note that NO<sub>2</sub> is being used as the DIF component.

3. Set the high NO<sub>2</sub> calibration gas concentration to reflect the sum of the NO<sub>2</sub> concentration generated by GPT and any NO<sub>2</sub> impurity.

Use   to move the cursor left and right and use   to increment and decrement the numeric character at the cursor.

4. Press  to calculate and save the new high DIF coefficient based on the entered span concentration.

You can change the calibration factors by using the Calibration Factors menu. This is often useful in a troubleshooting situation. However, after the above calibration procedure is completed, all subsequent data reduction depends on the calibration parameters remaining the same as during the initial calibration.

Therefore never change any calibration factor without first recording the value so that after any troubleshooting procedure is completed, the initial value can be re-entered thereby not altering the multipoint calibration.

## Zero and Span Check

The analyzer requires initial and periodic calibration according to the procedures outlined in this manual. Initially, the frequency of the calibration procedure should be determined by the stability of the zero and span checks, which may be run daily. You should generate a new calibration curve when zero and span checks indicate a shift in instrument gain of more than 10 percent from that determined during the most recent multipoint calibration. You can adjust the frequency of calibration and even zero and span checks appropriately as you gain confidence with the instrument.

You should have a quality control plan where the frequency and the number of points required for calibration can be modified on the basis of calibration and zero and span check data collected over a period of time. Note however, that the EPA requires a minimum of one multipoint calibration per calendar quarter. Such a quality control program is essential to ascertain the accuracy and reliability of the air quality data collected and to alert the user if the accuracy or reliability of the data should become unacceptable. A compilation of this kind might include items such as dates of calibration, atmospheric conditions, calibration factors, and other pertinent data.

Use the following procedure to perform a zero and span check.

1. Connect the zero gas to the SAMPLE bulkhead in a standard instrument or to the ZERO bulkhead in a Model 42i NO<sub>y</sub> equipped with the zero/span and sample solenoid valve option.
2. Allow the instrument to sample zero gas until a stable reading is obtained on the NO, DIF, and NO<sub>y</sub> channels then record the zero readings. Unless the zero has changed by more than  $\pm 0.010$  ppm, it is recommended that the zero not be adjusted. If an adjustment larger than this is indicated due to a change in zero reading, a new multipoint calibration curve should be generated.
3. Attach a supply of known concentration of NO and NO<sub>2</sub> (usually generated via an NIST traceable NO working standard and a GPT system) to the SAMPLE bulkhead (or SPAN bulkhead for instruments equipped with the zero/span and sample solenoid valve option) on the rear panel.

## Calibration

### Zero and Span Check

4. Allow the instrument to sample the calibration gas until a stable reading is obtained on the NO, DIF, and NO<sub>y</sub> channels. If the calibration has changed by more than  $\pm 10\%$ , a new multipoint calibration curve should be generated.
5. When the calibration check has been completed, record the NO, DIF, and NO<sub>y</sub> values.
6. Reconnect the analyzer sample line to the SAMPLE bulkhead.

# Chapter 5

## Preventative 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 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
- “Ozonator Air Feed Drying Column Replacement” on page 5-2
- “Sample Filters Inspection and Replacement” on page 5-2
- “Capillaries Inspection and Replacement” on page 5-3
- “Bypass Pump Capillaries Inspection and Replacement” on page 5-4
- “Thermoelectric Cooler Fins Inspection and Cleaning” on page 5-6
- “Fan Filters Inspection and Cleaning” on page 5-6
- “Leak Test” on page 5-7
- “Pump Rebuilding” on page 5-7
- “Bypass Pump Rebuilding” on page 5-10

### 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 grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the “[Servicing](#)” chapter. ▲

## Replacement Parts

See the “[Servicing](#)” chapter for a list of replacement parts.

## 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. ▲

## Ozonator Air Feed Drying Column Replacement

Use the following procedure to replace the ozonator air feed drying column.

1. Remove the drying column from the connector DRY AIR bulkhead on the rear panel of the instrument.
2. Replace spent absorbent material (indicating Drierite or silica gel) with new or regenerated material.
3. Reinstall the drying column to the DRY AIR bulkhead.
4. Perform a Zero/Span check (see the “[Calibration](#)” chapter).

## Sample Filters Inspection and Replacement

Teflon particulate filters should be inspected regularly and, if necessary, replaced. A filter that does not interact with NO or NO<sub>2</sub> in air should be employed. A suitable filter should have a 5 (or 2) micron pore size. The filter should be replaced on a regular maintenance schedule to prevent the absorption of sample gas by trapped material on the filter. Initially, the filter should be inspected more frequently until an appropriate maintenance schedule is determined. Perform a zero/span check after filter replacement (see the “[Calibration](#)” chapter).

## Capillaries Inspection and Replacement

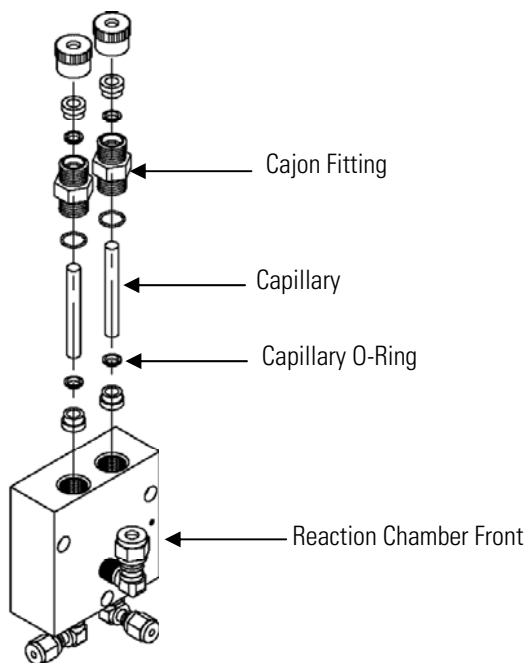


The capillaries normally only require inspection when instrument performance indicates that there may be a flow problem.

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the “[Servicing](#)” chapter. ▲

Use the following procedure to inspect and replace the capillaries.

1. Turn the instrument OFF and unplug the power cord.
2. Remove the instrument cover.
3. Locate the capillary holders. See [Figure 5–1](#) and [Figure 7–2](#).



**Figure 5–1.** Inspecting and Replacing the Capillaries

4. Remove the Cajon® fitting(s) from the reaction chamber body using a 5/8-inch wrench being careful not to lose the ferrule or O-ring.

## Preventative Maintenance

### Bypass Pump Capillaries Inspection and Replacement

5. Remove the glass capillaries, ferrule, and O-ring. Inspect O-ring for cuts or abrasion, and replace as necessary.
6. Check capillary for particulate deposits. Clean or replace as necessary.
7. Replace capillary in reaction chamber body, making sure the O-ring is around the capillary before inserting it into the body.
8. Replace Cajon fitting. Note that the Cajon fitting should be tightened slightly more than hand tight.
9. Reconnect tubing to top of fittings, being careful to insert ferrule and O-ring properly, and tighten knurled nut finger tight.
10. Re-install the cover.
11. Connect the power cord and turn the instrument ON.

## Bypass Pump Capillaries Inspection and Replacement



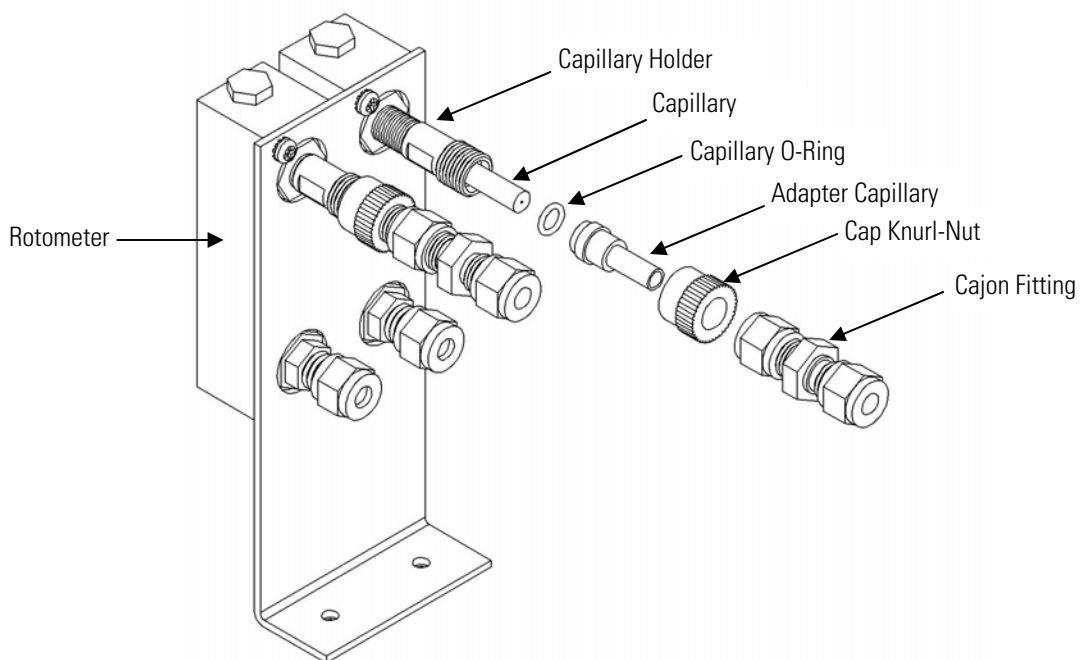
The capillaries normally only require inspection when instrument performance indicates that there may be a flow problem.

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the “[Servicing](#)” chapter. ▲

Use the following procedure to inspect and replace the capillaries.

1. Turn the instrument OFF and unplug the power cord.
2. Remove the bypass pump housing cover.
3. Locate the capillary holders. See [Figure 5–1](#) and [Figure 7–2](#).





**Figure 5–2.** Inspecting and Replacing the Bypass Pump Capillaries

4. Remove the Cajon® fitting(s) from the rotometer, being careful not to lose the ferrule or O-ring.
5. Remove the glass capillaries, ferrule, and O-ring. Inspect O-ring for cuts or abrasion, and replace as necessary.
6. Check capillary for particulate deposits. Clean or replace as necessary.
7. Replace capillary in capillary holder body, making sure the O-ring is around the capillary before inserting it into the body.
8. Replace Cajon fitting. Note that the Cajon fitting should be tightened slightly more than hand tight.
9. Re-install the cover.
10. Connect the power cord and turn the instrument ON.

## Thermoelectric Cooler Fins Inspection and Cleaning



Use the following procedure to inspect and clean the thermoelectric cooler fins.

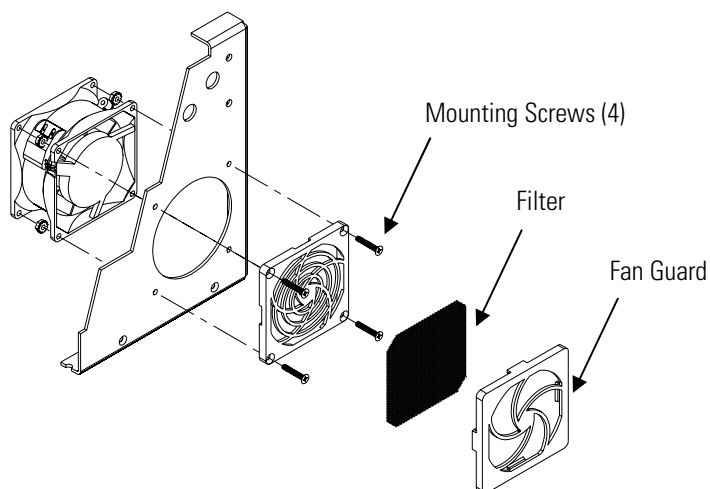
**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the “[Servicing](#)” chapter. ▲

1. Turn the instrument off and unplug the power cord.
2. Remove the instrument cover.
3. Locate the PMT cooler ([Figure 7–2](#) and [Figure 7–10](#)).
4. Blow off the cooler fins using clean pressurized air. It may be more convenient to vacuum the cooler fins. In either case, make sure that any particulate accumulation between the fins has been removed.
5. If necessary, use a small brush to remove residual particulate accumulation.
6. Replace the cover.
7. Connect the power cord and turn the instrument ON.

## Fan Filters Inspection and Cleaning

Use the following procedure to inspect and clean the fan filters.

1. Remove the two fan guards from the fans and remove the filters.
2. Flush the filters with warm water and let dry (a clean, oil-free purge will help the drying process) or blow the filters clean with compressed air.
3. Re-install the filters and fan guards.



**Figure 5–3.** Inspecting and Cleaning the Fan Filters

## Leak Test

Use the following procedure to perform a leak test.

1. Cap three of the four ports on the rear of panel of the bypass pump with a leak-tight cap, excluding the exhaust port.
2. Connect a suitable vacuum gauge to the fourth port, excluding the exhaust port.
3. Turn pump on and the pressure reading on the vacuum gauge should drop below 160 mmHg.

If the pump diaphragm is in good condition and the capillaries are not blocked, it should take less than one minute from the time the inlet is plugged to the time the reading below 160 mmHg is obtained.

## Pump Rebuilding

Use the following procedure to rebuild the pump (Figure 5–4). To replace the pump, see “[Pump Replacement](#)” in the “[Servicing](#)” chapter.

Equipment Required:

Pump Repair Kit (two repair kits required per pump)

Allen Wrench, 3 mm and 4 mm

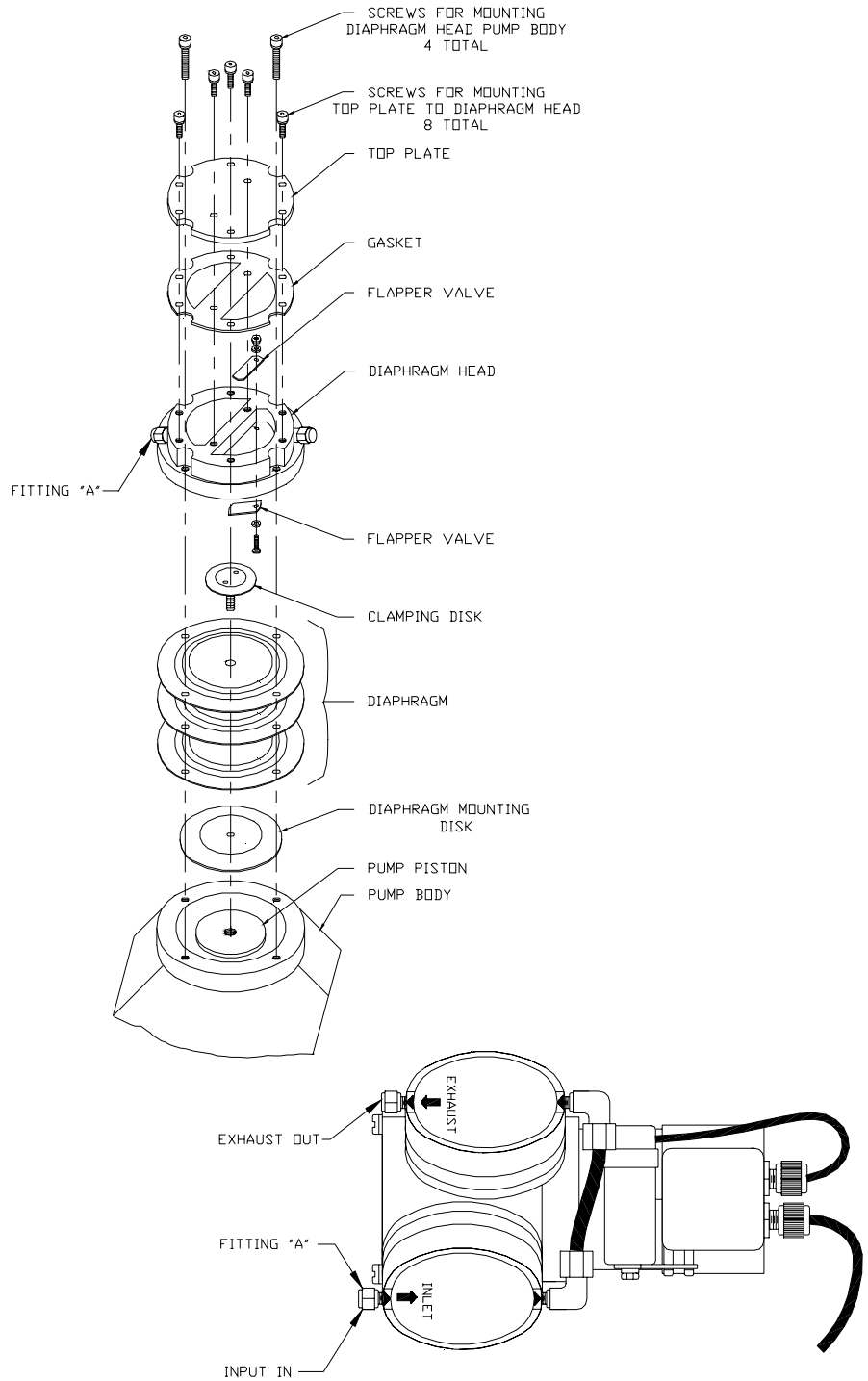
Wrench, 9/16-inch

## Needlenose Pliers



**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see the “[Servicing](#)” chapter. ▲

1. Turn instrument off, unplug the power cord, and disconnect the pump plumbing from the instrument.
2. Note the orientation of the pump head top plate for later reassembly. Using a 3 mm Allen wrench, remove the eight socket head screws and washers securing the pump head top plate.
3. Discard the old Teflon gasket.
4. Note the orientation of the diaphragm head for later reassembly. Remove the diaphragm head. Using a 4 mm Allen wrench, remove the four socket head screws securing the diaphragm head to the pump body.
5. Insert the tips of blunt needlenose pliers in the dimples of the clamping disk, then loosen and remove the clamping disk.
6. Remove and discard the old Teflon gasket.
7. Insert the clamping disk into the new Teflon diaphragm (three pieces) and screw the clamping disk into the pump. Do not over tighten.



**Figure 5–4.** Rebuilding the Pump

8. Remove the screw and nut securing the flapper valves and remove and discard old flapper valves.

9. Install the new flapper: check that the screw head and not the washer is on the smooth side of the pump, and check that the flappers are completely flat and straight.
10. Align the diaphragm head correctly as noted in Step 2, and secure with the four socket head screws.
11. Place the new Teflon gasket over the pump head so that the eight screws holes are aligned.
12. Replace the top plate and secure with the eight screws and washers being sure that the Teflon gasket stays in place.
13. Reconnect the plumbing to the instrument and plug in the pump power cord.
14. Check that the reaction chamber pressure reads between 200 and 450 mmHg.

## **Bypass Pump Rebuilding**

Use the following procedure to rebuild the bypass pump (Figure 5-5). To replace the bypass pump, see “Bypass Pump Replacement” in the “Servicing” chapter.

Equipment Required:

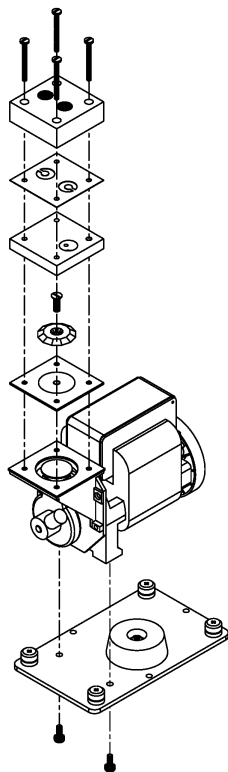
Flatblade screwdriver

Pump Repair Kit (flapper valve and diaphragm)



**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. 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 5–5.** Rebuilding the Bypass Pump

4. Remove the screw securing the diaphragm to piston and remove diaphragm.
5. Assemble the pump by following the previous steps in reverse, making 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” procedure described in this chapter.





# Chapter 6

## Troubleshooting

This instrument has been designed to achieve a high level of reliability. In the event of problems or failure, the troubleshooting guidelines, board-level connection diagrams, connector pin descriptions, and testing procedures presented in this chapter should be helpful in isolating and identifying problems.

For additional fault location information refer to the “[Preventative 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 Fisher Scientific can also be consulted in the event of problems. See “[Service Locations](#)” on page 6-21 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](#)” on page 6-1
- “[Troubleshooting Guides](#)” on page 6-1
- “[Board-Level Connection Diagrams](#)” on page 6-5
- “[Connector Pin Descriptions](#)” on page 6-7
- “[Service Locations](#)” on page 6-21

### 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 general troubleshooting information and indicates the checks that you should perform if you experience an instrument problem.

Table 6–2 lists all the alarm messages you may see on the graphics display and provides recommendations about how to resolve the alarm condition. See “Alarms Menu” in the “Operation” chapter for detailed information.

**Table 6–1.** Troubleshooting - General Guide

| <b>Malfunction</b>                    | <b>Possible Cause</b>                                  | <b>Action</b>  |
|---------------------------------------|--|--|
| Does not start up                     | No power   | Check that the instrument is plugged into the proper source (115 or 220 VAC, 50 or 60Hz).<br><br>Check instrument fuses. |
|                                       | Power Supply   | Check voltages using a digital voltmeter.  |
| 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                               | Unplug power cord. Clean or replace capillary.   |
|                                       | No ozone reaching the reaction chamber                 | Check the Instrument Control menu to see if the ozonator is ON. If it is ON, check dry air supply.                       |
| No output signal                      | Disconnected or defective input or high voltage supply | Unplug power cord. Check that cables are connected properly. Check cable resistance.                                     |
|                                       | Analyzer not calibrated                                | Recalibrate.   |
|                                       | Defective $\pm 15$ volt                                | Check supply voltages (Diagnostics menu).  |
| Calibration Drift                     | Dryer or ozonator depleted                             | Replace.   |
|                                       | Line voltage fluctuations                              | Check to see if line voltage is within specifications.   |
|                                       | Defective pump   | Rebuild pump.  |
|                                       | Unstable NO or NO <sub>2</sub> source                  | Replace.   |
|                                       | Clogged capillaries                                    | Unplug power cord. Clean or replace capillary.   |
|                                       | Clogged sample air filter                              | Replace filter element.  |
| Excessive Noise                       | Defective or low sensitivity PMT                       | Unplug power cord. Remove PMT. Install known good PMT. Plug in power cord. Check performance.                            |
|                                       | Defective input board                                  | Replace board.   |
|                                       | Defective cooler                                       | Check temperature (less than $-7^{\circ}\text{C}$ at $T_{\text{amb}} = 25^{\circ}\text{C}$ ).                            |

| <b>Malfunction</b>           | <b>Possible Cause</b>                     | <b>Action</b>  |
|------------------------------|---|--|
| Non-linear response          | Incorrect calibration source              | Verify accuracy of multipoint calibration source gas.                                  |
|                              | Leak in sample probe line                 | Check for variable dilution.   |
| Excessive response time      | Partially blocked sample capillary        | Unplug power cord. Clean or replace capillary.   |
|                              | Hang up/blockage in sample filter         | Change element.  |
| Improper converter operation | Questionable calibration gas              | Verify accuracy.   |
|                              | Converter temperature too high or too low | Temperature should be approximately 325 °C for Molybdenum, 625 °C for stainless steel. |
|                              | Low line voltage                          | Check to see if line voltage is within specifications.                                 |
|                              | Molybdenum consumed                       | Replace Molybdenum converter cartridge.  |

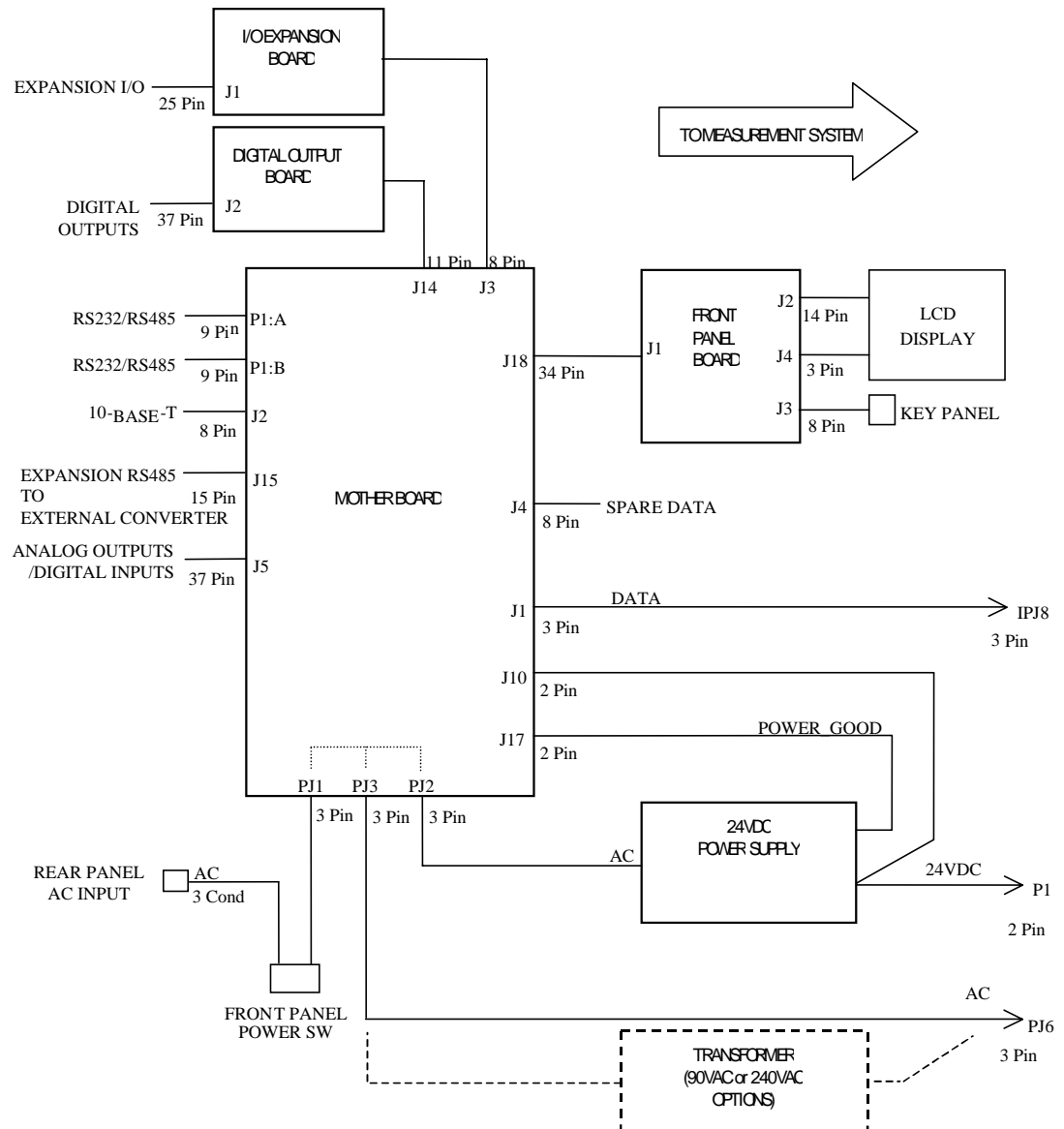
**Table 6–2.** Troubleshooting - Alarm Messages

| <b>Alarm Message</b>  | <b>Possible Cause</b>                        | <b>Action</b>  |
|-----------------------|--|--|
| Alarm - Internal Temp | Check fan operation                          | Replace fan if not operating properly.   |
|                       | Check fan filter                             | Clean or replace foam filter, refer to "Preventive Maintenance" chapter in this manual.  |
| Alarm - Chamber Temp  | Chamber temperature below set point of 50 °C | Check 10K ohm thermistor, replace if bad.<br><br>Check temperature control board to insure the LEDs are coming on. If not, temperature control board could be defective. |
| Alarm - Cooler Temp   | Check fan operation                          | Replace defective fan.   |
|                       | Check fan filter                             | Clean or replace foam filter.  |
|                       | Cooler reads 80 °C                           | Replace cooler.  |
|                       | Cooler does not hold set point of -7 °C      | Replace cooler – thermoelectric module inside cooler failed.   |
|                       | Cooler reads -99.9 °C                        | Replace cooler – thermocouple bad.   |

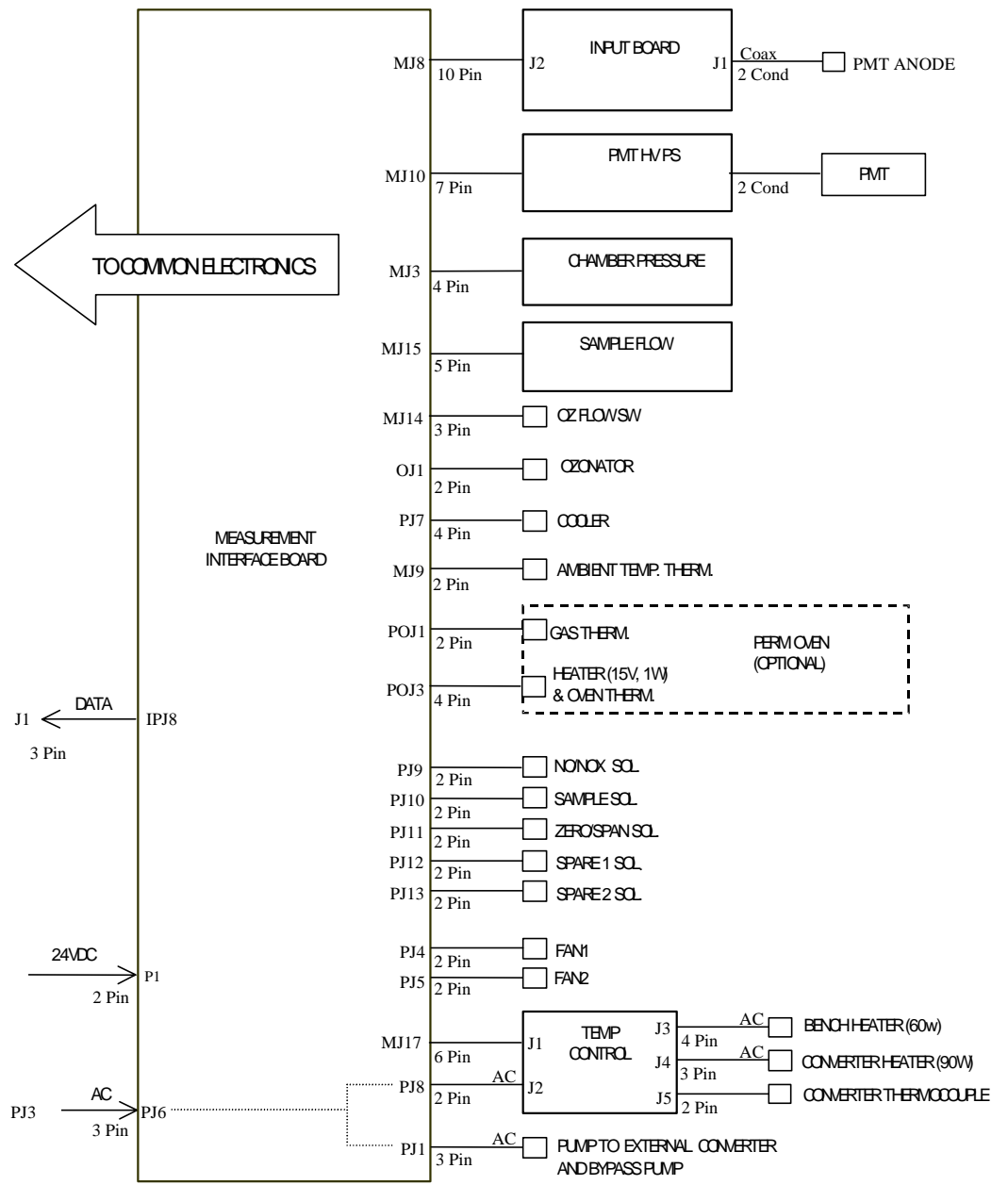
| <b>Alarm Message</b>                                | <b>Possible Cause</b>                  | <b>Action</b>  |
|---|--|--|
| Alarm – External Conv. Temp                         | Converter temperature low              | Molybdenum converter should be hot to the touch, if not the heater may have failed. Check that converter temp. set point is approximately 325 °C. Check that voltage to the heater is 115 VAC.   |
| Alarm - Pressure                                    | High pressure indication               | Check the pump for a tear in the diaphragm, replace with pump repair kit if necessary. Refer to “Preventive Maintenance” chapter 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 (0.020 inch ID) for blockage. Replace as necessary.<br><br>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 – Ozonator Flow                               | Ozone flow low                         | Check ozone capillary (0.010 inch ID) for blockage. Replace as necessary.  |
| Alarm - Zero Check<br>Alarm - Span Check            | Instrument out of calibration          | Recalibrate instrument.  |
| Alarm - Zero Autocal<br>Alarm - Span Autocal        |  | Check gas supply. Perform manual calibration.  |
| Alarm – NO, DIF, NO <sub>y</sub> , Prereactor Conc. | Concentration has exceeded range limit | Check to insure range corresponds with expected value. If not select proper range.   |
| Alarm - Motherboard Status                          | Internal cables not connected properly | Check that all internal cables are connected properly.   |
| Alarm - Interface Status                            | Board is defective                     | Recycle AC power to instrument. If still alarming, change board.   |
| Alarm - I/O Exp Status                              |  |  |
| Alarm - Ext Converter Status                        |  |  |

## Board-Level Connection Diagrams

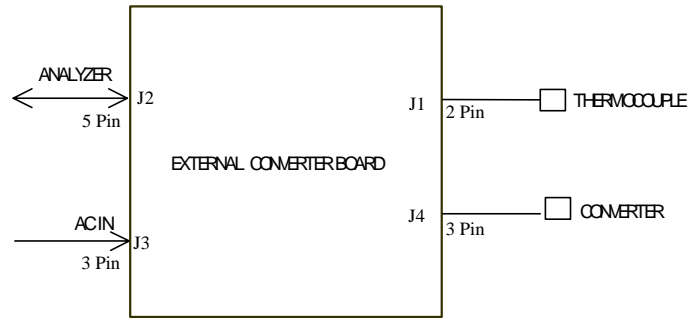
Figure 6–1 through Figure 6–3 are board-level connection diagrams for the common electronics, measurement system, and external converter. These illustrations can be used along with the connector pin descriptions in Table 6–3 through Table 6–10 to troubleshoot board-level faults.



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



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



**Figure 6–3.** Board-Level Connection Diagram - External Converter

## Connector Pin Descriptions

The connector pin descriptions in [Table 6–3](#) through [Table 6–10](#) can be used along with the board-level connection diagrams to troubleshoot board-level faults.

[“Motherboard Connector Pin Descriptions”](#) on page 6-7

[“Measurement Interface Board Connector Pin Descriptions”](#) on page 6-12

[“Front Panel Board Connector Pin Diagram”](#) on page 6-15

[“I/O Expansion Board \(Optional\) Connector Pin Descriptions”](#) on page 6-16

[“Digital Output Board Connector Pin Descriptions”](#) on page 6-18

[“Input Board Connector Pin Descriptions”](#) on page 6-19

[“Temperature Control Board Connector Pin Descriptions”](#) on page 6-20

[“External Converter Board Connector Pin Descriptions”](#) on page 6-20

**Table 6–3.** Motherboard Connector Pin Descriptions

| Connector Label | Reference Designator | Pin | Signal Description        |
|-----------------|----------------------|-----|---------------------------|
| INTF DATA       | J1                   | 1   | Ground                    |
|                 |                      | 2   | +RS485 to Interface Board |
|                 |                      | 3   | -RS485 to Interface Board |
| 10-BASE-T       | J2                   | 1   | Ethernet Output (+)       |
|                 |                      | 2   | Ethernet Output (-)       |
|                 |                      | 3   | Ethernet Input (+)        |
|                 |                      | 4   | NC                        |

## Troubleshooting

### Connector Pin Descriptions

| Connector Label | Reference Designator | Pin | Signal Description            |
|-----------------|----------------------|-----|-------------------------------|
|                 |                      | 5   | NC                            |
|                 |                      | 6   | Ethernet Input (-)            |
|                 |                      | 7   | NC                            |
|                 |                      | 8   | NC                            |
| EXPANSION BD    | J3                   | 1   | +5V                           |
|                 |                      | 2   | +24V                          |
|                 |                      | 3   | +24V                          |
|                 |                      | 4   | Ground                        |
|                 |                      | 5   | Ground                        |
|                 |                      | 6   | Ground                        |
|                 |                      | 7   | +RS485 to Expansion Board     |
|                 |                      | 8   | -RS485 to Expansion Board     |
| SPARE DATA      | J4                   | 1   | +5V                           |
|                 |                      | 2   | +24V                          |
|                 |                      | 3   | +24V                          |
|                 |                      | 4   | Ground                        |
|                 |                      | 5   | Ground                        |
|                 |                      | 6   | Ground                        |
|                 |                      | 7   | +RS485 to Spare Board         |
|                 |                      | 8   | -RS485 to Spare Board         |
| I/O             | J5                   | 1   | Power Fail Relay N.C. Contact |
|                 |                      | 2   | Ground                        |
|                 |                      | 3   | TTL Input 1                   |
|                 |                      | 4   | TTL Input 2                   |
|                 |                      | 5   | Ground                        |
|                 |                      | 6   | TTL Input 5                   |
|                 |                      | 7   | TTL Input 7                   |
|                 |                      | 8   | TTL Input 8                   |
|                 |                      | 9   | TTL Input 10                  |
|                 |                      | 10  | Ground                        |
|                 |                      | 11  | TTL Input 13                  |
|                 |                      | 12  | TTL Input 15                  |
|                 |                      | 13  | Ground                        |
|                 |                      | 14  | Analog Voltage 1              |



| Connector Label | Reference Designator | Pin | Signal Description            |
|-----------------|----------------------|-----|-------------------------------|
|                 |                      | 15  | Analog Voltage 3              |
|                 |                      | 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                     |

## Troubleshooting

### Connector Pin Descriptions

| Connector Label   | Reference Designator | Pin | Signal Description   |
|-------------------|----------------------|-----|----------------------|
|                   |                      | 8   | SPI Input            |
|                   |                      | 9   | SPI Output           |
|                   |                      | 10  | SPI Board Select     |
|                   |                      | 11  | SPI Clock            |
| EXT. RS485        | J15                  | 1   | -RS485 to Rear Panel |
|                   |                      | 2   | -RS485 to Rear Panel |
|                   |                      | 3   | +5V                  |
|                   |                      | 4   | +5V                  |
|                   |                      | 5   | +5V                  |
|                   |                      | 6   | Ground               |
|                   |                      | 7   | Ground               |
|                   |                      | 8   | Ground               |
|                   |                      | 9   | NC                   |
|                   |                      | 10  | NC                   |
|                   |                      | 11  | +24                  |
|                   |                      | 12  | +24                  |
|                   |                      | 13  | +24                  |
|                   |                      | 14  | +24                  |
|                   |                      | 15  | +24                  |
| 24 MONITOR        | J17                  | 1   | 24V Power Monitor    |
|                   |                      | 2   | Ground               |
| FRONT PANEL<br>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     |

| Connector Label | Reference Designator | Pin | Signal Description             |
|-----------------|----------------------|-----|--------------------------------|
|                 |                      | 13  | LD2 – LCD Signal               |
|                 |                      | 14  | LD7 – LCD Signal               |
|                 |                      | 15  | LD3 – LCD Signal               |
|                 |                      | 16  | LCD Bias Voltage               |
|                 |                      | 17  | +5V                            |
|                 |                      | 18  | Ground                         |
|                 |                      | 19  | Ground                         |
|                 |                      | 20  | LCD_ONOFF – LCD Signal         |
|                 |                      | 21  | Keypad Row 2 Input             |
|                 |                      | 22  | Keypad Row 1 Input             |
|                 |                      | 23  | Keypad Row 4 Input             |
|                 |                      | 24  | Keypad Row 3 Input             |
|                 |                      | 25  | Keypad Col 2 Select            |
|                 |                      | 26  | Keypad Col 1 Select            |
|                 |                      | 27  | Keypad Col 4 Select            |
|                 |                      | 28  | Keypad Col 3 Select            |
|                 |                      | 29  | Ground                         |
|                 |                      | 30  | Ground                         |
|                 |                      | 31  | Ground                         |
|                 |                      | 32  | Ground                         |
|                 |                      | 33  | +24V                           |
|                 |                      | 34  | +24V                           |
| <hr/>           |                      |     |                                |
| 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                             |
| <hr/>           |                      |     |                                |
| RS232/RS485:B   | P1:B                 | 1   | NC                             |
|                 |                      | 2   | Serial Port 2 RX (-RS485 IN)   |
|                 |                      | 3   | Serial Port 2 TX (-RS485 OUT)  |

## Troubleshooting

### Connector Pin Descriptions

| Connector Label | Reference Designator | Pin | Signal Description             |
|-----------------|----------------------|-----|--------------------------------|
|                 |                      | 4   | NC                             |
|                 |                      | 5   | Ground                         |
|                 |                      | 6   | NC                             |
|                 |                      | 7   | Serial Port 2 RTS (+RS485 OUT) |
|                 |                      | 8   | Serial Port 2 CTS (+RS485 IN)  |
|                 |                      | 9   | NC                             |
| AC IN           | PJ2                  | 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 6–4.** Measurement Interface Board Connector Pin Descriptions

| Connector Label | Reference Designator | Pin | Signal Description            |
|-----------------|----------------------|-----|-------------------------------|
| DATA            | IPJ8                 | 1   | Ground                        |
|                 |                      | 2   | +RS485 from Motherboard       |
|                 |                      | 3   | -RS485 from Motherboard       |
| PRES            | MJ3                  | 1   | Pressure Sensor Input         |
|                 |                      | 2   | Ground                        |
|                 |                      | 3   | +15V                          |
|                 |                      | 4   | -15V                          |
| INPUT BD        | MJ8                  | 1   | +15V                          |
|                 |                      | 2   | Ground                        |
|                 |                      | 3   | -15V                          |
|                 |                      | 4   | +5V                           |
|                 |                      | 5   | Ground                        |
|                 |                      | 6   | Measurement Frequency Output  |
|                 |                      | 7   | Amplifier Zero Adjust Voltage |

| Connector Label | Reference Designator | Pin | Signal Description              |
|-----------------|----------------------|-----|---------------------------------|
|                 |                      | 8   | SPI Output                      |
|                 |                      | 9   | SPI Clock                       |
|                 |                      | 10  | SPI Board Select                |
| AMB TEMP        | MJ9                  | 1   | Ambient Temperature Thermistor  |
|                 |                      | 2   | Ground                          |
| HVPS            | MJ10                 | 1   | HV Power Supply Voltage Adjust  |
|                 |                      | 2   | Ground                          |
|                 |                      | 3   | HV Power Supply On/Off          |
|                 |                      | 4   | Ground                          |
|                 |                      | 5   | HV Power Supply Voltage Monitor |
|                 |                      | 6   | Ground                          |
|                 |                      | 7   | Ground                          |
| FLOW SW         | MJ14                 | 1   | NC                              |
|                 |                      | 2   | Ground                          |
|                 |                      | 3   | Ozonator Flow OK Switch         |
| FLOW            | MJ15                 | 1   | Flow Sensor Input               |
|                 |                      | 2   | Ground                          |
|                 |                      | 3   | +15V                            |
|                 |                      | 4   | -15V                            |
|                 |                      | 5   | Ground                          |
| TEMP CTRL       | MJ17                 | 1   | Bench Temperature Input         |
|                 |                      | 2   | Ground                          |
|                 |                      | 3   | -15V                            |
|                 |                      | 4   | Converter Heater On/Off         |
|                 |                      | 5   | Converter Temperature Input     |
|                 |                      | 6   | +15V_PWR                        |
| OZONATOR        | OJ1                  | 1   | Ozonator Output A               |
|                 |                      | 2   | Ozonator Output B               |
| 24V IN          | P1                   | 1   | +24V                            |
|                 |                      | 2   | Ground                          |
| AC PUMP         | PJ1                  | 1   | AC-HOT                          |
|                 |                      | 2   | AC-NEUT                         |
|                 |                      | 3   | AC-Ground                       |
| FAN 1           | PJ4                  | 1   | +24V                            |

## Troubleshooting

### Connector Pin Descriptions

| Connector Label | Reference Designator | Pin | Signal Description         |
|-----------------|----------------------|-----|----------------------------|
|                 |                      | 2   | Ground                     |
| FAN 2           | PJ5                  | 1   | +24V                       |
|                 |                      | 2   | Ground                     |
| AC IN           | PJ6                  | 1   | AC-HOT                     |
|                 |                      | 2   | AC-NEUT                    |
|                 |                      | 3   | AC-Ground                  |
| COOLER          | PJ7                  | 1   | Cooler Thermistor          |
|                 |                      | 2   | Ground                     |
|                 |                      | 3   | +15V_PWR                   |
|                 |                      | 4   | Cooler On/Off Control      |
| AC TEMP         | PJ8                  | 1   | AC-HOT                     |
|                 |                      | 2   | AC-NEUT                    |
|                 |                      | 3   | AC-Ground                  |
| NO/NOX SOL.     | PJ9                  | 1   | +24V                       |
|                 |                      | 2   | NO/NOX Solenoid Control    |
| SAMPLE SOL.     | PJ10                 | 1   | +24V                       |
|                 |                      | 2   | Sample Solenoid Control    |
| Z/S SOL.        | PJ11                 | 1   | +24V                       |
|                 |                      | 2   | Zero/Span Solenoid Control |
| SPARE1 SOL.     | PJ12                 | 1   | +24V                       |
|                 |                      | 2   | Spare 1 Solenoid Control   |
| SPARE2 SOL.     | PJ13                 | 1   | +24V                       |
|                 |                      | 2   | Spare 2 Solenoid Control   |
| PERM OVEN THERM | POJ1                 | 1   | Perm Oven Gas Thermistor   |
|                 |                      | 2   | Ground                     |
| PERM OVEN       | POJ3                 | 1   | Perm Oven Heater On/Off    |
|                 |                      | 2   | +15V_PWR                   |
|                 |                      | 3   | Perm Oven Thermistor       |
|                 |                      | 4   | Ground                     |

**Table 6–5.** Front Panel Board Connector Pin Diagram

| <b>Connector Label</b> | <b>Reference Designator</b> | <b>Pin</b> | <b>Signal Description</b> |
|------------------------|-----------------------------|------------|---------------------------|
| MOTHER BOARD           | 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          |
|                        |                             | 9          | LD0 – LCD Signal          |
|                        |                             | 10         | LD5 – LCD Signal          |
|                        |                             | 11         | LD1 – LCD Signal          |
|                        |                             | 12         | LD6 – LCD Signal          |
|                        |                             | 13         | LD2 – LCD Signal          |
|                        |                             | 14         | LD7 – LCD Signal          |
|                        |                             | 15         | LD3 – LCD Signal          |
|                        |                             | 16         | LCD Bias Voltage          |
|                        |                             | 17         | +5V                       |
|                        |                             | 18         | Ground                    |
|                        |                             | 19         | Ground                    |
|                        |                             | 20         | LCD_ONOFF – LCD Signal    |
|                        |                             | 21         | Keypad Row 2 Input        |
|                        |                             | 22         | Keypad Row 1 Input        |
|                        |                             | 23         | Keypad Row 4 Input        |
|                        |                             | 24         | Keypad Row 3 Input        |
|                        |                             | 25         | Keypad Col 2 Select       |
|                        |                             | 26         | Keypad Col 1 Select       |
|                        |                             | 27         | Keypad Col 4 Select       |
|                        |                             | 28         | Keypad Col 3 Select       |
|                        |                             | 29         | Ground                    |
|                        |                             | 30         | Ground                    |
|                        |                             | 31         | Ground                    |
|                        |                             | 32         | Ground                    |
|                        |                             | 33         | +24V                      |

## Troubleshooting

### Connector Pin Descriptions

| Connector Label | Reference Designator | Pin | Signal Description        |
|-----------------|----------------------|-----|---------------------------|
|                 |                      | 34  | +24V                      |
| LCD DATA        | J2                   | 1   | LD0_5V – LCD Signal       |
|                 |                      | 2   | LD1_5V – LCD Signal       |
|                 |                      | 3   | LD2_5V – LCD Signal       |
|                 |                      | 4   | LD3_ONOFF_5V – LCD Signal |
|                 |                      | 5   | LCD_ONOFF_5V – LCD Signal |
|                 |                      | 6   | LFLM_5V – LCD Signal      |
|                 |                      | 7   | NC                        |
|                 |                      | 8   | LLP_5V – LCD Signal       |
|                 |                      | 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   | +5V Supply                |
|                 |                      | 2   | NC                        |
|                 |                      | 3   | Ground                    |

**Table 6–6.** 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 |



| Connector Label | Reference Designator | Pin | Signal Description     |
|-----------------|----------------------|-----|------------------------|
|                 |                      | 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                     |
|                 |                      | 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       |
| <hr/>           |                      |     |                        |
| MOTHER BD       | J2                   | 1   | +5V                    |
|                 |                      | 2   | +24V                   |
|                 |                      | 3   | +24V                   |
|                 |                      | 4   | Ground                 |
|                 |                      | 5   | Ground                 |
|                 |                      | 6   | Ground                 |
|                 |                      | 7   | +RS485 to Motherboard  |
|                 |                      | 8   | -RS485 to Motherboard  |
| <hr/>           |                      |     |                        |

**Troubleshooting**

## Connector Pin Descriptions

**Table 6–7.** Digital Output Board Connector Pin Descriptions

| <b>Connector Label</b> | <b>Reference Designator</b> | <b>Pin</b> | <b>Signal Description</b> |
|------------------------|-----------------------------|------------|---------------------------|
| MOTHER BD              | J1                          | 1          | +5V                       |
|                        |                             | 2          | +24V                      |
|                        |                             | 3          | +24V                      |
|                        |                             | 4          | Ground                    |
|                        |                             | 5          | Ground                    |
|                        |                             | 6          | Ground                    |
|                        |                             | 7          | SPI Reset                 |
|                        |                             | 8          | SPI Input                 |
|                        |                             | 9          | SPI Output                |
|                        |                             | 10         | SPI Board Select          |
|                        |                             | 11         | SPI Clock                 |
| DIGITAL OUTPUTS        | J2                          | 1          | Relay 1 Contact a         |
|                        |                             | 2          | Relay 2 Contact a         |
|                        |                             | 3          | Relay 3 Contact a         |
|                        |                             | 4          | Relay 4 Contact a         |
|                        |                             | 5          | Relay 5 Contact a         |
|                        |                             | 6          | Relay 6 Contact a         |
|                        |                             | 7          | Relay 7 Contact a         |
|                        |                             | 8          | Relay 8 Contact a         |
|                        |                             | 9          | Relay 9 Contact a         |
|                        |                             | 10         | Relay 10 Contact a        |
|                        |                             | 11         | NC                        |
|                        |                             | 12         | Solenoid Drive Output 1   |
|                        |                             | 13         | Solenoid Drive Output 2   |
|                        |                             | 14         | Solenoid Drive Output 3   |
|                        |                             | 15         | Solenoid Drive Output 4   |
|                        |                             | 16         | Solenoid Drive Output 5   |
|                        |                             | 17         | Solenoid Drive Output 6   |
|                        |                             | 18         | Solenoid Drive Output 7   |
|                        |                             | 19         | Solenoid Drive Output 8   |
|                        |                             | 20         | Relay 1 Contact b         |
|                        |                             | 21         | Relay 2 Contact b         |

| Connector Label | Reference Designator | Pin | Signal Description |
|-----------------|----------------------|-----|--------------------|
|                 |                      | 22  | Relay 3 Contact b  |
|                 |                      | 23  | Relay 4 Contact b  |
|                 |                      | 24  | Relay 5 Contact b  |
|                 |                      | 25  | Relay 6 Contact b  |
|                 |                      | 26  | Relay 7 Contact b  |
|                 |                      | 27  | Relay 8 Contact b  |
|                 |                      | 28  | Relay 9 Contact b  |
|                 |                      | 29  | Relay 10 Contact b |
|                 |                      | 30  | +24V               |
|                 |                      | 31  | +24V               |
|                 |                      | 32  | +24V               |
|                 |                      | 33  | +24V               |
|                 |                      | 34  | +24V               |
|                 |                      | 35  | +24V               |
|                 |                      | 36  | +24V               |
|                 |                      | 37  | +24V               |

**Table 6–8.** Input Board Connector Pin Descriptions

| Connector Label | Reference Designator | Pin | Signal Description            |
|-----------------|----------------------|-----|-------------------------------|
| PMT IN          | J1                   | 1   | PMT Input                     |
|                 |                      | 2   | Ground                        |
| INTF BD         | J2                   | 1   | +15V                          |
|                 |                      | 2   | Ground                        |
|                 |                      | 3   | -15V                          |
|                 |                      | 4   | +5V                           |
|                 |                      | 5   | Ground                        |
|                 |                      | 6   | Measurement Frequency Output  |
|                 |                      | 7   | Amplifier Zero Adjust Voltage |
|                 |                      | 8   | SPI Input                     |
|                 |                      | 9   | SPI Clock                     |
|                 |                      | 10  | SPI Board Select              |

**Table 6–9.** Temperature Control Board Connector Pin Descriptions

| Connector Label | Reference Designator | Pin | Signal Description            |
|-----------------|----------------------|-----|-------------------------------|
| INTERFACE       | J1                   | 1   | Bench Temperature Input       |
|                 |                      | 2   | Ground                        |
|                 |                      | 3   | -15V                          |
|                 |                      | 4   | Converter Heater On/Off       |
|                 |                      | 5   | Converter Temperature Input   |
|                 |                      | 6   | +15V_PWR                      |
| AC INPUT        | J2                   | 1   | AC-HOT                        |
|                 |                      | 2   | AC-NEUT                       |
| BENCH           | J3                   | 1   | Bench Heater AC Output        |
|                 |                      | 2   | Bench Heater AC Return        |
|                 |                      | 3   | Ground                        |
|                 |                      | 4   | Bench Thermistor              |
| CONVERTER       | J4                   | 1   | Ground                        |
|                 |                      | 2   | Converter Heater AC Output    |
|                 |                      | 3   | Converter Heater AC Return    |
| CONV TC         | J5                   | 1   | Converter Thermocouple TC     |
|                 |                      | 2   | Converter Thermocouple TC+    |
| SS TEMP         | J6                   | 1   | SS Temperature Range Jumper A |
|                 |                      | 2   | SS Temperature Range Jumper B |

**Table 6–10.** External Converter Board Connector Pin Descriptions

| Connector Label | Reference Designator | Pin | Signal Description         |
|-----------------|----------------------|-----|----------------------------|
| CONV TC         | J1                   | 1   | Converter Thermocouple TC  |
|                 |                      | 6   | Converter Thermocouple TC+ |
| ANALYZER COMM   | J2                   | 1   | +24V                       |
|                 |                      | 2   |                            |
|                 |                      | 3   |                            |
|                 |                      | 4   |                            |
|                 |                      | 5   | AC-NEUT                    |
| AC IN           | J3                   | 1   | AC-HOT                     |
|                 |                      | 2   | AC-NEUT                    |

| Connector Label | Reference Designator | Pin | Signal Description         |
|-----------------|----------------------|-----|----------------------------|
|                 |                      | 3   | AC-Ground                  |
| CONVERTER       | J4                   | 1   | Ground                     |
|                 |                      | 2   | Converter Heater AC Output |
|                 |                      | 2   | Converter Heater AC Return |

## Service Locations

For additional assistance, service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at [www.thermo.com/aqi](http://www.thermo.com/aqi).

1-866-282-0430 Toll Free

1-508-520-0430 International



# Chapter 7

## Servicing

This chapter explains how to replace the Model 42i NO<sub>y</sub> subassemblies. It assumes that a subassembly has been identified as defective and needs to be replaced.

For fault location information refer to the “[Preventative Maintenance](#)” chapter and the “[Troubleshooting](#)” chapter in this manual.

The service mode in the “[Operation](#)” chapter also includes parameters and functions that are useful when making adjustments or diagnosing problems.

For additional service assistance, see “[Service Locations](#)” at the end of this chapter.

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

- “[Safety Precautions](#)” on page 7-2
- “[Firmware Updates](#)” on page 7-4
- “[Accessing the Service Mode](#)” on page 7-4
- “[Replacement Parts List](#)” on page 7-4
- “[Cable List](#)” on page 7-6
- “[External Device Connection Components](#)” on page 7-7
- “[Removing the Measurement Bench and Lowering the Partition Panel](#)” on page 7-10
- “[Pump Replacement](#)” on page 7-11
- “[Vacuum Pump Diaphragm and Valve Replacement](#)” on page 7-12
- “[Bypass Pump Replacement](#)” on page 7-16
- “[Fan Replacement](#)” on page 7-17
- “[PMT Cooler and Reaction Chamber Assembly Replacement](#)” on page 7-18
- “[Photomultiplier Tube Replacement](#)” on page 7-20
- “[PMT High Voltage Power Supply Replacement](#)” on page 7-21

- “PMT Voltage Adjustment” on page 7-23
- “Reaction Chamber Cleaning or Removal” on page 7-23
- “External Converter Replacement” on page 7-25
- “Solenoid Valve Replacement” on page 7-27
- “Ozonator Assembly Replacement” on page 7-28
- “Ozonator Transformer Replacement” on page 7-30
- “Input Board Replacement” on page 7-30
- “Input Board Calibration” on page 7-32
- “DC Power Supply Replacement” on page 7-32
- “Analog Output Testing” on page 7-33
- “Analog Output Calibration” on page 7-36
- “Analog Input Calibration” on page 7-37
- “Pressure Transducer Assembly Replacement” on page 7-38
- “Pressure Transducer Calibration” on page 7-39
- “Temperature Control Board Replacement” on page 7-41
- “Ambient Temperature Calibration” on page 7-42
- “Fuse Replacement” on page 7-43
- “I/O Expansion Board (Optional) Replacement” on page 7-43
- “Digital Output Board Replacement” on page 7-45
- “Motherboard Replacement” on page 7-46
- “Measurement Interface Board Replacement” on page 7-47
- “External Converter Interface Board Replacement” on page 7-48
- “Flow Transducer Replacement” on page 7-49
- “Flow Transducer Calibration” on page 7-50
- “Front Panel Board Replacement” on page 7-51
- “LCD Module Replacement” on page 7-52
- “Service Locations” on page 7-53

## **Safety Precautions**

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





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

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



**CAUTION** Carefully observe the instructions in each procedure. Avoid contact with converter heated components. ▲

Allow converter to cool to room temperature before handling converter components. ▲



**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component (Figure 7-1). If an antistatic wrist strap is not available, be sure to touch a grounded metal object before touching any internal components. When the instrument is unplugged, the chassis is not at earth ground. ▲

Handle all printed circuit boards by the edges. ▲

Do not point the photomultiplier tube at a light source. This can permanently damage the tube. ▲

Do not remove the LCD panel or frame from the LCD module. ▲

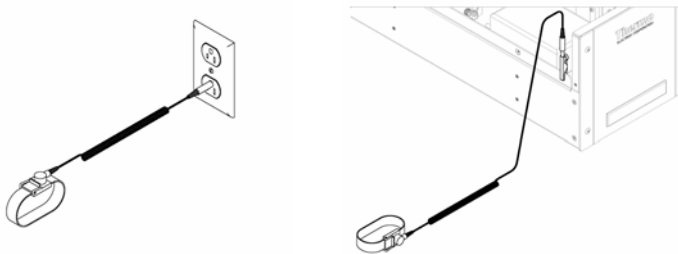
The LCD polarizing plate is very fragile, handle it carefully. ▲

Do not wipe the LCD 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 Menu 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 42i NO<sub>y</sub> major subassemblies. Refer to Figure 7-2 through Figure 7-4 to identify the component location.

**Table 7-1.** Model 42i NO<sub>y</sub> Replacement Parts

| Part Number | Description                  |
|-------------|------------------------------|
| 100480-00   | Front Panel Pushbutton Board |
| 101491-05   | Processor Board              |
| 100533-00   | Motherboard                  |
| 100539-00   | Digital Output Board         |

| <b>Part Number</b> | <b>Description</b>                                    |
|--------------------|---|
| 100542-00          | I/O Expansion Board (Optional)                        |
| 102340-00          | Front Panel Connector Board                           |
| 102496-00          | Front Panel Display                                   |
| 101399-00          | Transformer, 220-240VAC (Optional)                    |
| 101863-00          | Transformer, 100VAC (Optional)                        |
| 100536-00          | Measurement Interface Board                           |
| 102999-00          | External Converter Interface Board                    |
| 100856-00          | Temperature Control Board (Molybdenum Converter)      |
| 101167-00          | Input Board Assembly                                  |
| 9973               | Ozonator Assembly                                     |
| 101419-00          | Ozonator Transformer                                  |
| 101023-00          | Pressure Transducer                                   |
| 101021-00          | Flow Transducer (Sample)                              |
| 101620-00          | Flow Switch (Ozone)                                   |
| 9367               | Photomultiplier Tube (PMT)                            |
| 101024-00          | PMT High Voltage Power Supply                         |
| 101324-00          | PMT Base Socket Assembly                              |
| 101390-00          | Solenoid Valve  |
| 101020-00          | Cooler Assembly                                       |
| 101008-03          | Reaction Chamber Assembly                             |
| 101009-00          | External Converter Assembly (Molybdenum 110VAC)       |
| 9269               | Molybdenum Converter Cartridge                        |
| 9456               | Pump 120VAC, 60Hz                                     |
| 8079               | Pump 110VAC, 50Hz                                     |
| 101426-00          | Bypass Pump 110VAC w/Plate                            |
| 8606               | Pump Repair Kit (for 101426-00)                       |
| 9457               | Pump 220VAC, 50Hz                                     |
| 8500               | Pump 220VAC, 60Hz                                     |
| 8080               | Pump 100VAC, 50-60Hz                                  |
| 9464               | Pump Repair Kit                                       |
| 101055-00          | AC Receptacle Assembly                                |
| 101681-00          | Power Supply Assembly, 24VDC, w/Base Plate and Screws |
| 100907-00          | Fan, 24VDC  |
| 8630               | Fan Filter  |

| Part Number | Description  |
|-------------|--|
| 101905-00   | Fuse, 250VAC, 4.0 Amp, SlowBlow (for 100VAC and 110VAC models) |
| 101904-00   | Fuse, 250VAC, 2.0 Amp, SlowBlow (for 220-240VAC models)        |
| 101688-00   | Ambient Temperature Connector with Thermistor                  |
| 4119        | Capillary 0.008-inch ID  |
| 4126        | Capillary 0.020-inch ID  |
| 4110        | Capillary 0.022-inch ID  |
| 6556        | Optical Filter Kit (Red Filter, Quartz Window, Rubber Washer)  |
| 6998        | DriRite  |

## Cable List

Table 7–2 describes the Model 42i NO<sub>y</sub> cables. See the “[Troubleshooting](#)” chapter for associated connection diagrams and board connector pin descriptions.

**Table 7–2.** Model 42i NO<sub>y</sub> Cables

| Part Number | Description                                     |
|-------------|---|
| 101036-00   | DC Power Supply 24V Output                      |
| 101037-00   | 115VAC Supply to Interface Board                |
| 101048-00   | RS-485/Data                                     |
| 101038-00   | AC 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                                 |
| 101346-00   | Temperature Control                             |
| 101355-00   | Signal Output Ribbon                            |
| 101050-00   | Heater Power                                    |
| 101055-00   | Main AC Receptacle Assembly                     |
| 102057-00   | AC to External Pump                             |
| 103494-00   | 3 Conductor Cable                               |
| 102774-00   | AC Adaptor                                      |
| 4198        | Outlet Cable External Converter                 |
| 103261-00   | Outlet Cable Interface Board External Converter |

## External Device Connection Components

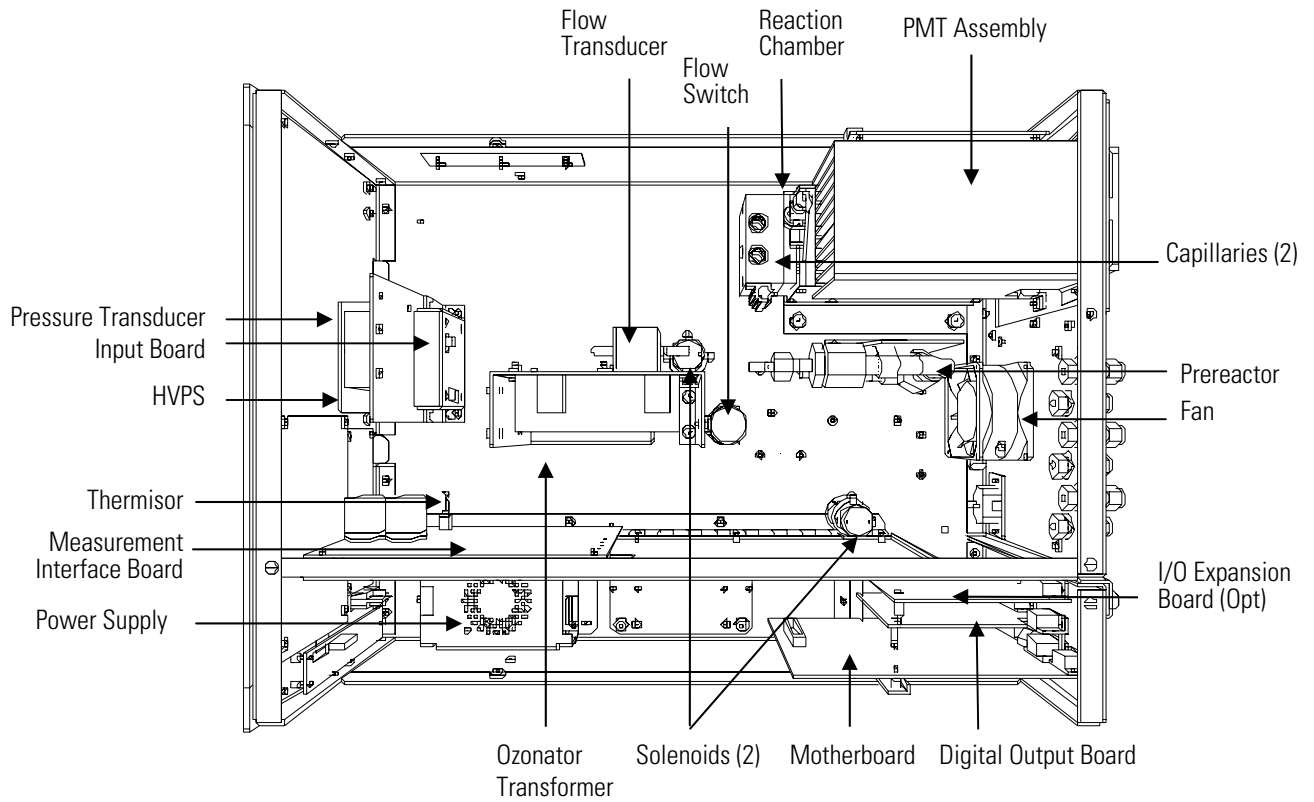
Table 7–3 lists the standard and optional cables and components used for connecting external devices such as PCs and data loggers to an *iSeries* instrument.

**Table 7–3.** External Device Connection Components

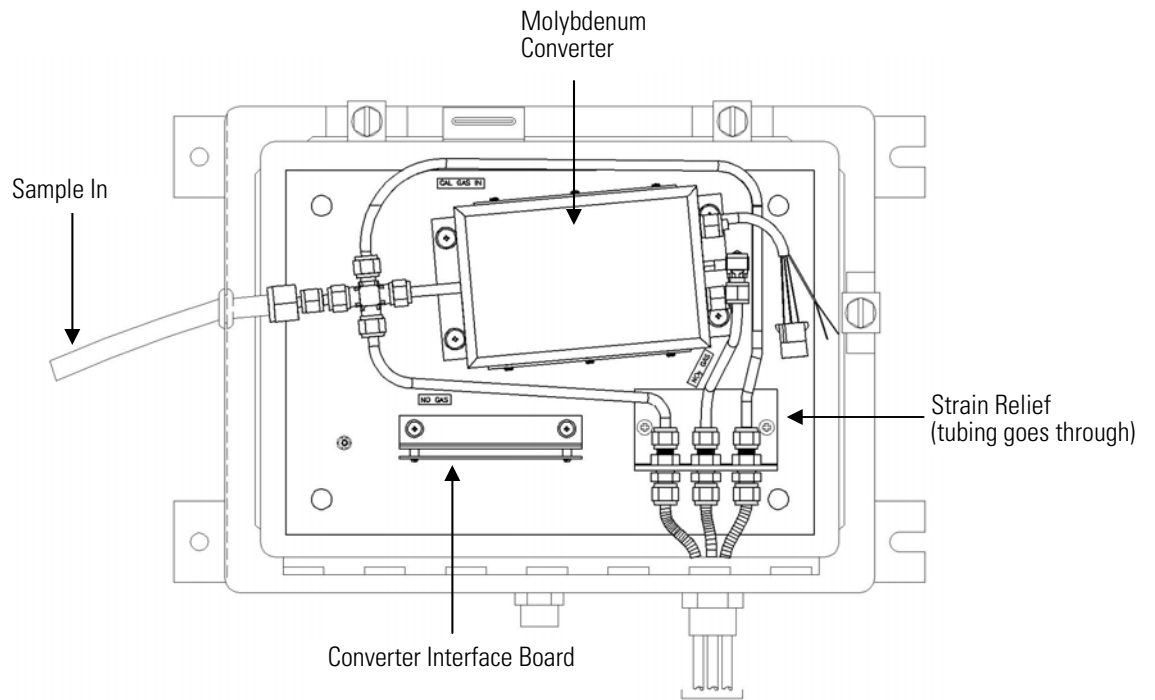
| Part Number | Description  |
|-------------|--|
| 102562-00   | Terminal Block and Cable Kit (DB25) (optional)   |
| 102556-00   | Terminal Block and Cable Kit (DB37) (optional)   |
| 102645-00   | Cable, DB37M to Open End Cable, Six Feet (optional)  |
| 102646-00   | Cable, DB37F to Open End, Six Feet (optional)  |
| 102659-00   | Cable, DB25M to Open End, Six Feet (optional)  |
| 6219        | Cable, RS-232 (optional)   |
| 103005-00   | Terminal Board PCB Assembly, DB15M (standard with all NO <sub>y</sub> instruments)                           |
| 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 Expansion Board in all instruments. |

## Servicing

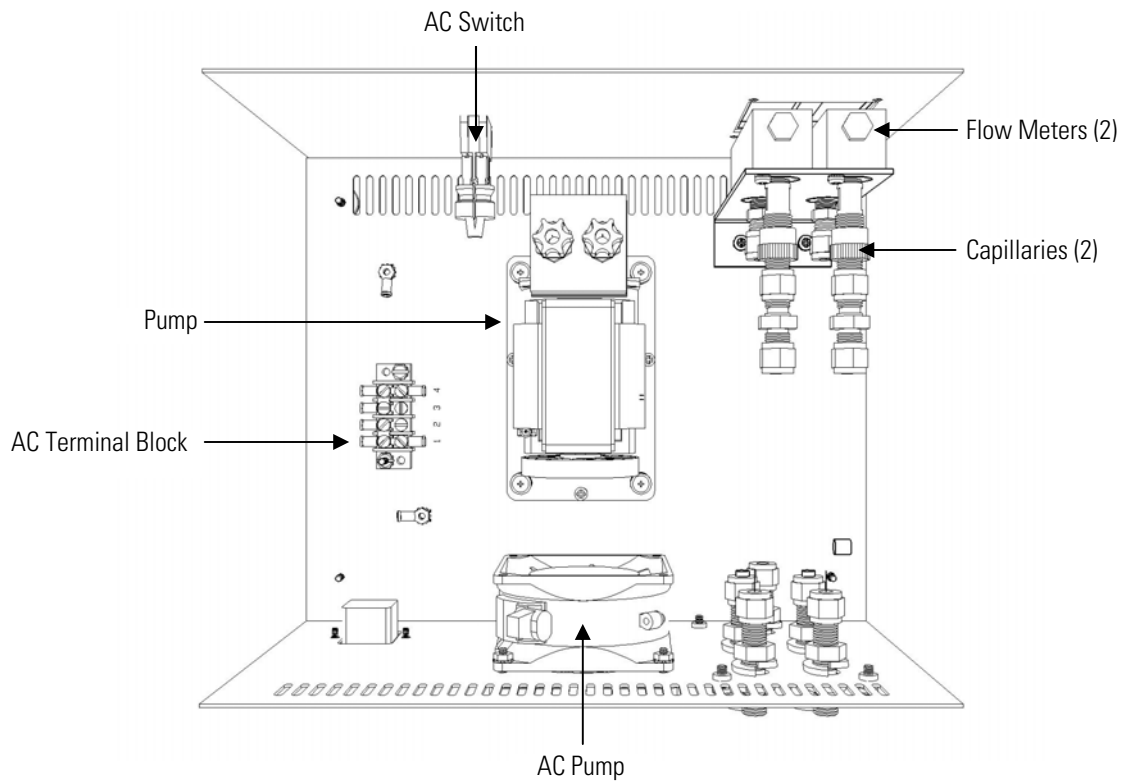
### External Device Connection Components



**Figure 7-2.** Component Layout for Analyzer



**Figure 7-3.** Component Layout for External Converter



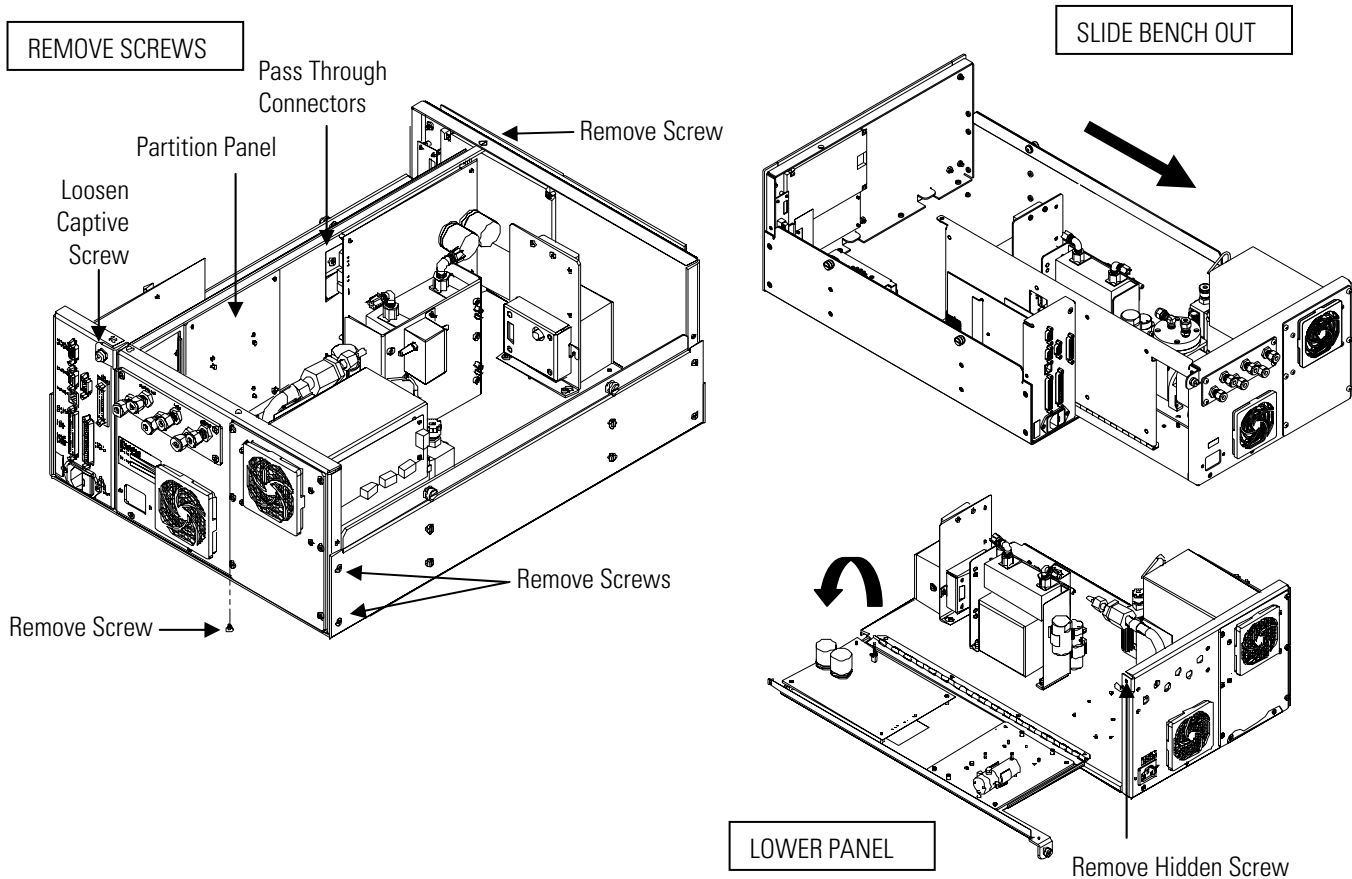
**Figure 7-4.** Component Layout for Bypass Pump

## Servicing

Removing the Measurement Bench and Lowering the Partition Panel

# Removing the Measurement Bench and Lowering the Partition Panel

The measurement bench can be removed and the partition panel can be lowered to improve access to connectors and components. Refer to the following steps when a procedure requires lowering the partition panel (see [Figure 7-5](#)).



**Figure 7-5.** Removing the Measurement Bench and Lowering the Partition Panel

Equipment Required:

Philips screwdriver



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



1. Turn instrument OFF and unplug the power cord.
2. 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 previous steps in reverse.

## **Pump Replacement**

Use the following procedure to replace the pump (see [Figure 7–6](#)). To rebuild the pump, see “[Pump Rebuilding](#)” in the “Preventive Maintenance” chapter.

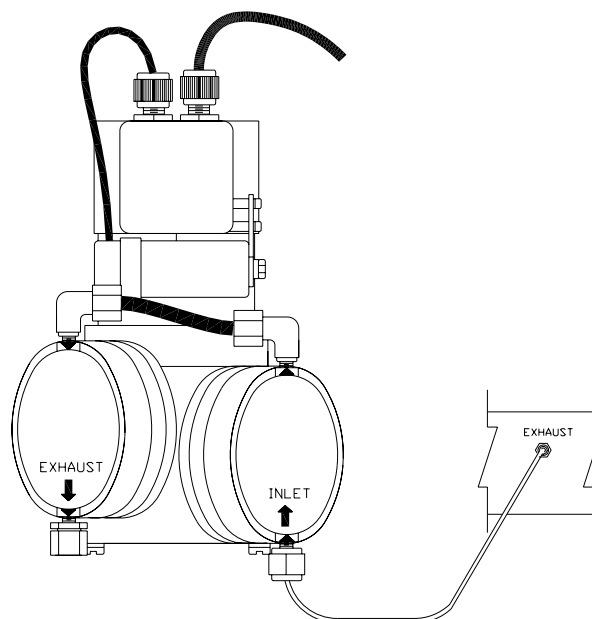
Equipment Required:

110V pump or 220V pump

1. Disconnect the pump power line from the AC power outlet.

## Servicing

### Vacuum Pump Diaphragm and Valve Replacement



**Figure 7-6.** Replacing the Pump

2. Remove both inlet and exhaust lines from the pump.
3. Install the new pump by following the previous steps in reverse.

## Vacuum Pump Diaphragm and Valve Replacement

Use the following procedures to replace the diaphragm and valve for the vacuum pumps (Figure 7-7).

Equipment Required:

- Allen wrench, 4 mm
- Nut driver, 7/32-inch or 5.5 mm
- Allen wrench, 3 mm
- Spanner wrench, 3.8 mm diameter by 4.5 mm long inserts
- Small flat-blade screwdriver
- Large flat-blade screwdriver
- Cleaning agent (alcohol)
- Fine-grade steel wool
- “LOC-TITE” blue breakable thread adhesive



**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. ▲

## Diaphragm Replacement

Use the following procedure to replace the diaphragm (Figure 7-7).

1. Undo the four socket head cap screws and washers (“C”) for each head and lift off the heads with tubing from the pump body. Keep the heads connected if at all possible: disconnecting and then reconnecting the PTFE tube can cause leaks.
2. Check for smooth opening and closing of the reed valves (“Q”): a number of sets of diaphragms can be replaced before there is a need to replace the valves. Follow the instructions for “valve replacement” if changing of the valves is required.
3. Use the spanner wrench to loosen and remove the one-piece clamping disc/screw (“E”). Remove the old diaphragms from both heads (“G”).
4. Remove the four pan head screws with M5 washers (“J”) and remove the housing cover (“K”) from the front of the pump body. If necessary, carefully use a small flat-bladed screwdriver to pry-off the housing cover.
5. Install the two PTFE (white color) diaphragms together with one TFM (translucent) diaphragm as shown in Figure E-1. Install with the ridges of the diaphragm convolutions as shown in the diaphragm stack cross-section inset.
6. Temporarily insert two of the head screws through the diaphragms and screw into the pump body to keep the position of the diaphragms as the clamping disc is tightened. Any stress applied re-aligning the diaphragm in the process of assembling the head will significantly reduce diaphragm life
7. Check the threads of the clamping disc to insure that they are clean and free of debris. Apply a small amount of the breakable thread adhesive to the clamping disc threads and install.

## Servicing

### Vacuum Pump Diaphragm and Valve Replacement

8. Rotate the counterweight until the connecting rod is in mid-stroke and then tighten the clamping disc. Do not over tighten the clamping disc.

**Note** Over tightening of the clamping disc will significantly reduce diaphragm life. Tighten enough to avoid contact with the head. If a significant amount of torque is required to tighten, first re-check to see if the threads are clear, then check that the connection rod support disc (“H”) is properly seated on the connection rod. Over-torque of the clamping disc must never be a way to avoid contact with the head. ▲

9. Remove the two temporary aligning screws and re-install the heads on to the pump body. The correct head bolt torque range is 20-30 inch-pounds.
10. Turn the counterweight (“M”) through at least one full revolution to check for smooth operation.
11. Re-install the housing cover and check the pump for correct performance.

## Valve Replacement

Use the following procedure to replace the valve.

1. With the head off the pump, unscrew the socket head cap screws with M4 lock washers (“S”) to remove the head lid (“T”) and gasket (“V”).
2. Loosen the single pan head screw, washers and nut (“P”) and remove the two stainless steel reed valves (“Q”). If necessary, hold the nut in place with a nut-driver.
3. Lightly clean the valve seat area of debris or deposits with fine-grade steel wool. This area must be clean and smooth, without pits or scratches. Do not scratch the head plate. Finish the cleaning with alcohol and then air-dry the parts.
4. Lay the two replacement reed valves on a flat surface to the direction of any slight bend.
5. Lay the replacement reed valves in place, center bowed out (see valve installation), and tighten the pan head screw, both washers, and the nut. Be certain that the reed valves lay straight and smooth with

clearance from the recessed edge to prevent sticking. If a reed valve curves away from the valve hole, remove the screw, flip the valve over and reinstall.

- Match the holes of the PTFE head gasket (“V”) with the head seal surface, install the head lid, and tighten the two center bolts with M4 lock washers first and then cross alternate tightening of the perimeter bolts. Re-tighten the two center bolts after the other bolts are tight.

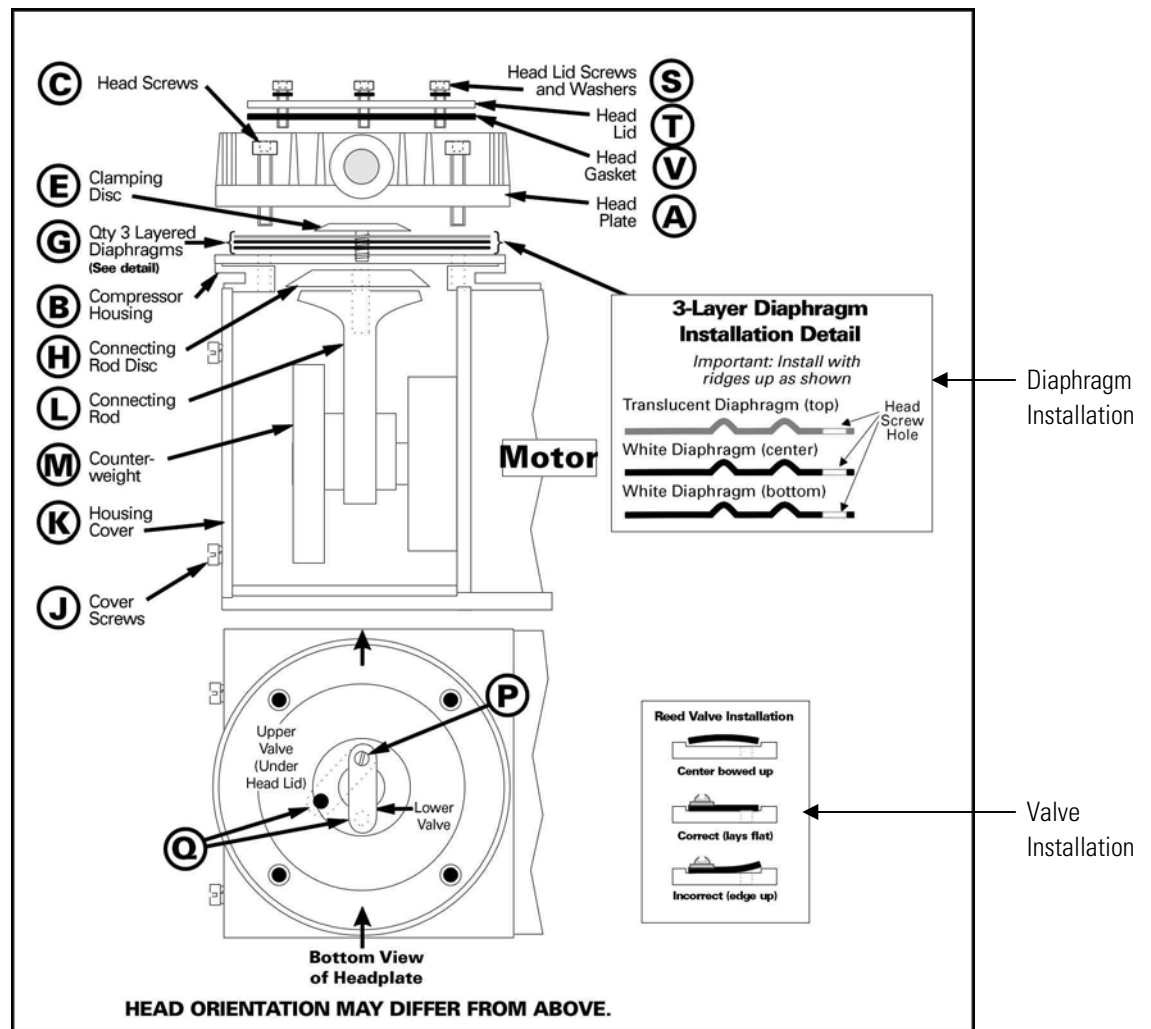


Figure 7-7. Vacuum Pump – Head Plate and Motor View

## **Bypass Pump Replacement**

Use the following procedure to replace the bypass pump (Figure 7–8).

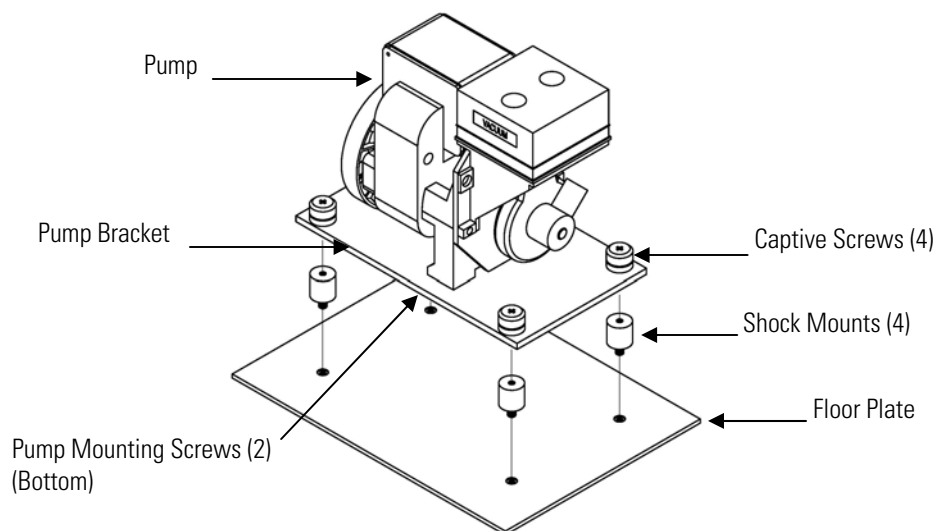
Equipment Required:

- Pump
- Nut driver
- Philips screwdriver



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

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Disconnect 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 the shock mounts.
5. Invert the pump assembly, remove the two pump mounting screws located on the bottom side of the pump bracket, and remove the bracket from the pump.
6. Install the new pump by following the previous steps in reverse.
7. Perform a leak test as described in the “Preventive Maintenance” chapter.



**Figure 7–8.** Replacing the Bypass Pump

## Fan Replacement

Use the following procedure to replace the fan ([Figure 7–9](#)).

Equipment Required:

- Fan
- Philips screwdriver

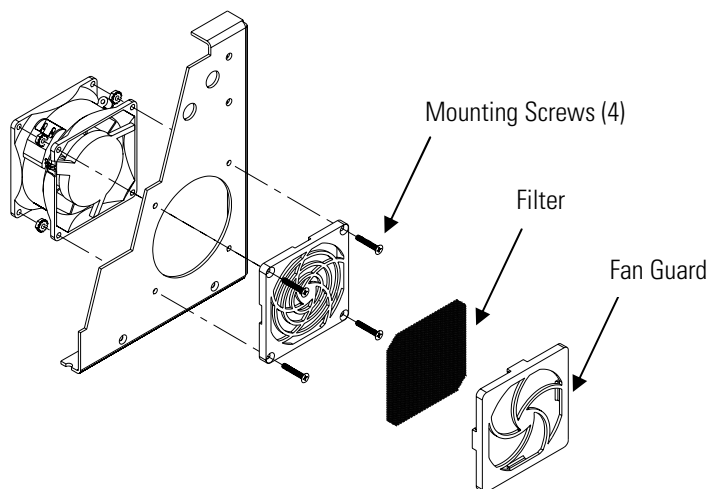


**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

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

## Servicing

### PMT Cooler and Reaction Chamber Assembly Replacement



**Figure 7–9.** Replacing the Fan

## PMT Cooler and Reaction Chamber Assembly Replacement

Use the following procedure to replace the PMT cooler and reaction chamber assembly (see [Figure 7–10](#)).

### Equipment Required:

- PMT cooler
- Wrench, 7/16-inch
- Wrench, 9/16-inch
- Nut driver, 1/4-inch
- Philips screwdriver
- Wire cutters

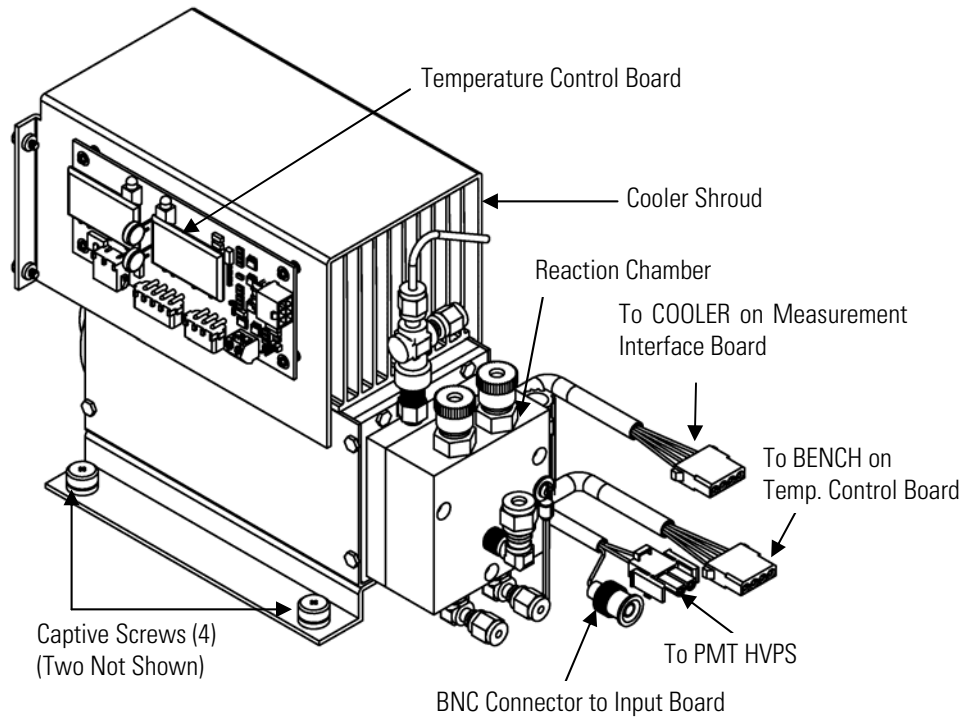


**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

1. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter to lower the partition panel, then proceed to the next step below.



2. Disconnect the reaction chamber connector from the temperature control board.
3. Snap off the temperature control board from the board mounts.
4. Remove the four screws securing the cooler shroud to the rear panel and remove the shroud.



**Figure 7–10.** PMT Cooler and Reaction Chamber

5. Disconnect plumbing connections from the reaction chamber.
6. Disconnect the cables from the PMT high voltage power supply, the input board, and the measurement interface board. Remove all tie-wraps securing the cables.
7. Loosen four captive screws holding cooler to floor plate and remove the cooler assembly with the reaction chamber.

**Note** If only the cooler is being replaced, remove the PMT and reaction chamber from the old cooler and install them on the new cooler. ▲

8. Install new cooler by following previous steps in reverse.

**Note** Fasten knurled fittings on reaction chamber finger tight. ▲

Make sure that the heat shrink covered tubing between the reaction chamber and the converter is light tight at the connections. ▲

9. Re-install the measurement bench. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter.

## Photomultiplier Tube Replacement

Use the following procedure to replace the PMT tube.

Equipment Required:

Photomultiplier tube and PMT base

Nut driver, 5/16-inch

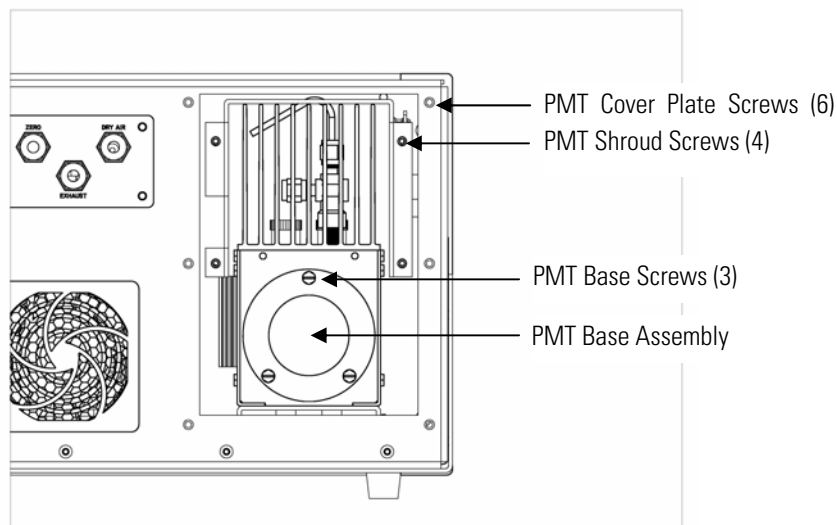
Flat blade screwdriver

Philips screwdriver, small



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

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Disconnect the high voltage cable from the PMT power supply and unplug the BNC cable from the Input Board.
3. Remove six external screws holding PMT cover plate and the four screws holding the PMT shroud to the panel and remove the PMT cover plate ([Figure 7-11](#)). If the cooler fan is attached, unplug the fan power cord if necessary.



**Figure 7–11.** Replacing the PMT

4. Remove the three retaining screws holding PMT base assembly to the cooler using a 5/16-inch nut driver.



**Equipment Damage** Do not point the photomultiplier tube at a light source. This can permanently damage the tube. ▲

5. Pull the PMT and PMT base from cooler assembly by twisting it slightly back and forth.
6. To install PMT, follow previous steps in reverse making sure to backfill the cooler with dry air or nitrogen prior to replacing the PMT.
7. Perform a photomultiplier tube calibration. See “[PMT Voltage Adjustment](#)” in the “[Operation](#)” chapter.

## PMT High Voltage Power Supply Replacement

Use the following procedure to replace the PMT high voltage power supply ([Figure 7–12](#)).

Equipment Required:

- PMT high voltage power supply
- Nut driver, 1/4-inch
- Philips screwdriver

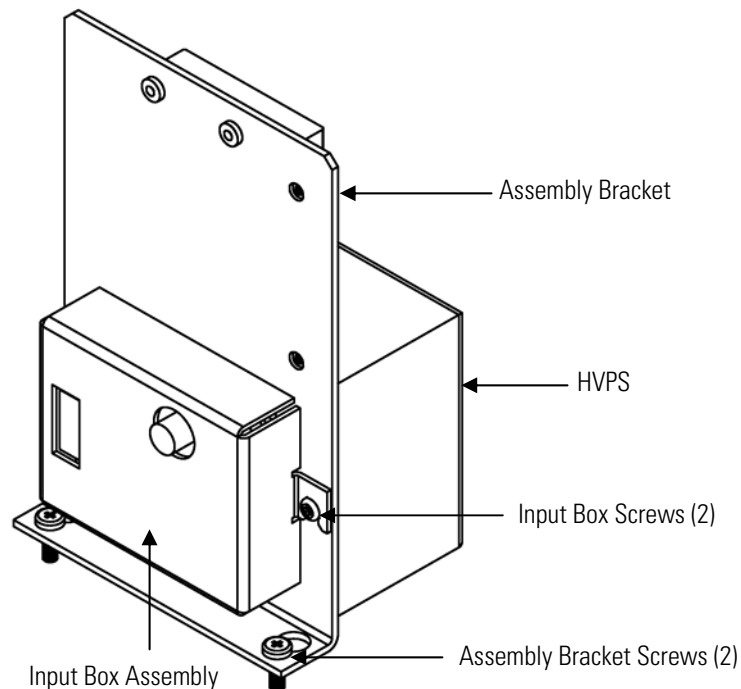
## Servicing

### PMT High Voltage Power Supply Replacement



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

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Disconnect the two PMT high voltage supply cables.
3. Loosen the two retaining screws securing the assembly bracket to the floor plate and slide the assembly towards the rear slightly and lift it off the base screws.
4. Loosen two screws on the input box assembly and lift the input box assembly off the power supply.
5. Remove the four screws securing the power supply to the bracket and remove the power supply.



**Figure 7-12.** Replacing the PMT HVPS





6. To install the power supply, follow the previous steps in reverse.
7. Recalibrate the instrument. Refer to the calibration procedures in the “[Calibration](#)” chapter.

## PMT Voltage Adjustment





Use the following procedure to adjust the PMT voltage.

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

1. Select the NO, DIF, and NO<sub>y</sub> ranges. Refer to “Range Menu” in the “[Operation](#)” chapter.
2. Set the PREREACTION BKG, NO BKG, and NO<sub>y</sub> BKG calibration factors to 0.0. Refer to “[Calibration Factors Menu](#)” in the “[Operation](#)” chapter.
3. Set the NO COEF, NO<sub>y</sub> COEF, and DIF COEF to 1.000.
4. Set the Averaging Time to 10 seconds. Refer to “[Averaging Time](#)” in the “[Operation](#)” chapter.
5. Connect the calibration gas and allow the instrument to sample calibration gas until the reading stabilizes.
6. From the Main Menu, press  to scroll to Service > press  >  to scroll to **PMT Voltage Adjustment** > and press .

The Set PMT Voltage screen appears.

**Note** If Service Mode is not displayed, refer to “[Accessing the Service Mode](#)” on page 7-4, then return to the beginning of this step. ▲

7. At the Set PMT Voltage screen, use   to increment/decrement the counts until the instrument displays the calibration gas concentration value.

## Reaction Chamber Cleaning or Removal

Use the following procedure to clean or remove the reaction chamber (see [Figure 7-13](#)).

## Servicing

### Reaction Chamber Cleaning or Removal

#### Equipment Required:

Allen Wrench, 9/64-inch

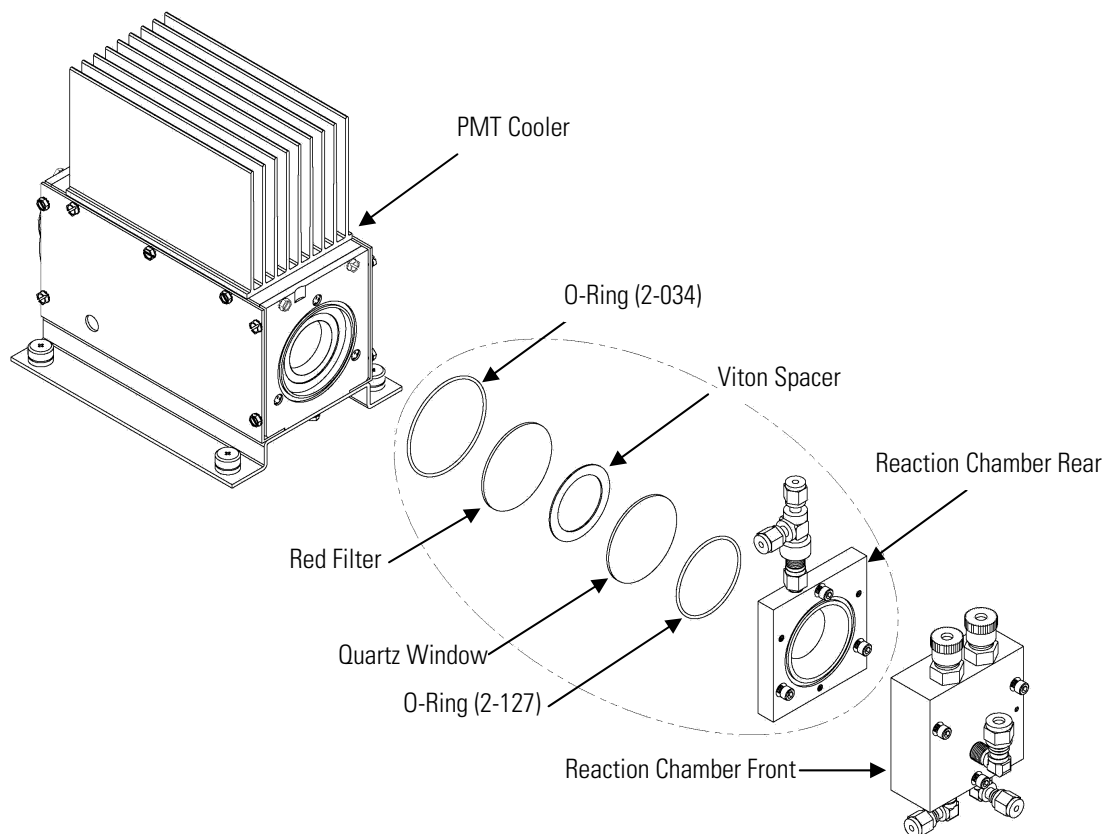
Wrench, 7/16-inch

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. Remove PMT cooler as described in “[PMT Cooler and Reaction Chamber Assembly Replacement](#)” in this chapter.
2. Disconnect all plumbing connections from the reaction chamber.
3. Remove the three socket head screws fastening front of reaction chamber to rear ([Figure 7-13](#)). This exposes the inner surfaces of both sections of the reaction chamber and the quartz window. To clean these surfaces use cotton swabs and methanol.
4. To continue removing rear of reaction chamber remove the three socket head screws holding it to cooler, being careful to keep quartz window and red filter in cooler body.
5. To reinstall reaction chamber, follow previous steps in reverse, making sure to backfill the cooler with dry air or nitrogen prior to installing reaction chamber.
6. Re-install the measurement bench. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter.



**Figure 7–13.** Cleaning or Removing the Reaction Chamber

## External Converter Replacement

Use the following procedure to replace the converter ([Figure 7–14](#)).

Equipment Required:

- External Converter
- Wrench, 7/16-inch
- Wrench, 9/16-inch
- Wrench, 1/2-inch
- Wrench, 5/8-inch
- Screwdriver
- Nut driver, 1/4-inch
- Nut driver, 5/16-inch

## Servicing

### External Converter Replacement

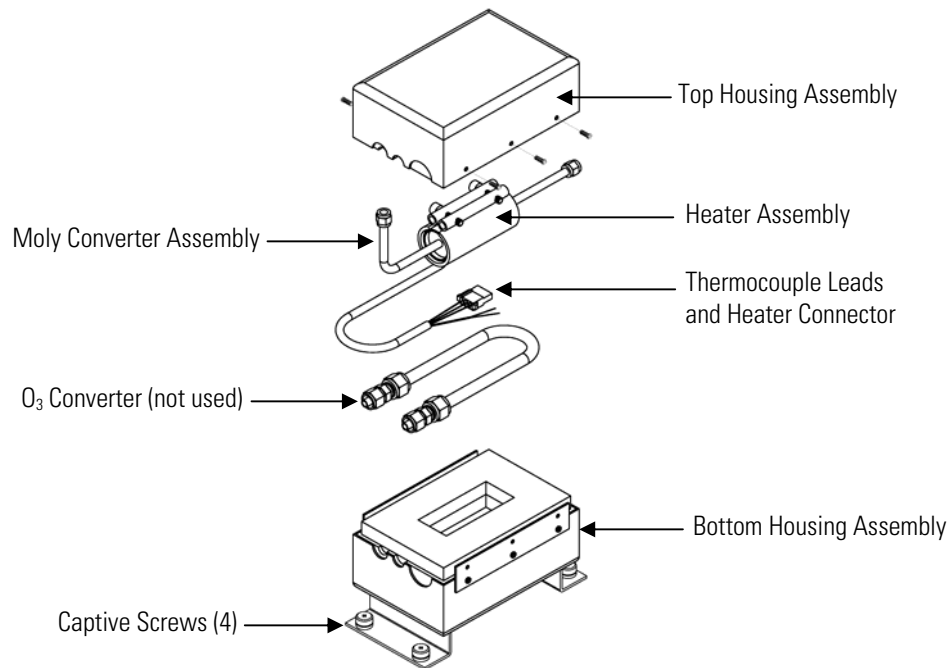


**CAUTION** Avoid contact with converter heated components. Allow converter to cool to room temperature before handling converter components. ▲



**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. Allow converter to cool to room temperature to prevent contact with heated components.
3. Disconnect plumbing at converter inlet and outlet.
4. Disconnect thermocouple leads and heater connector from temperature control board.
5. Loosen the four captive screws holding converter housing to floor plate.



**Figure 7-14.** External Molybdenum Converter Assembly



6. Remove the six screws holding the top housing assembly to the bottom half.
7. Remove the converter cartridge/heater assembly from the bottom housing assembly.
8. Loosen the heater clamp, pry heater apart no wider than necessary and remove the converter cartridge noting the proper orientation of heater wires and thermocouple probe.
9. To replace converter, follow previous steps in reverse. **Note** Be sure to wrap the O<sub>3</sub> converter tube snugly around the heater.

## Solenoid Valve Replacement

Use the following procedure to replace a solenoid valve (Figure 7–15).

Equipment Required:

Solenoid valve

Wrench, 5/16-inch

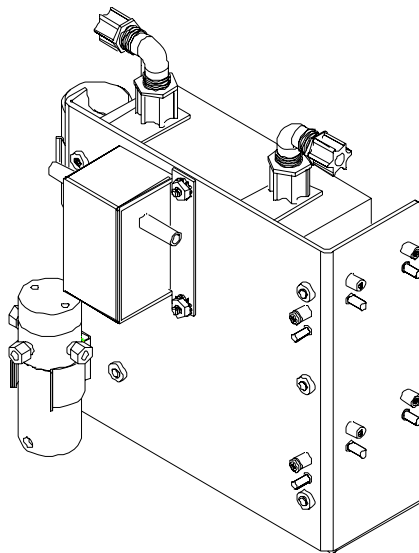
Philips screwdriver



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

1. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter to lower the partition panel, then proceed to the next step below.
2. Disconnect solenoid from the Measurement Interface board. Note electrical connections to facilitate re-connection.
3. Remove plumbing from solenoid. Note plumbing connections to facilitate re-connection.
4. Pull solenoid valve from mounting clip.
5. To replace solenoid, follow previous steps in reverse.

6. Re-install the measurement bench. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter.



**Figure 7–15.** Replacing the Solenoid Valve

## Ozonator Assembly Replacement

Use the following procedure to replace the ozonator assembly ([Figure 7–16](#)).

Equipment Required:

Ozonator assembly

Wrench, 5/8-inch

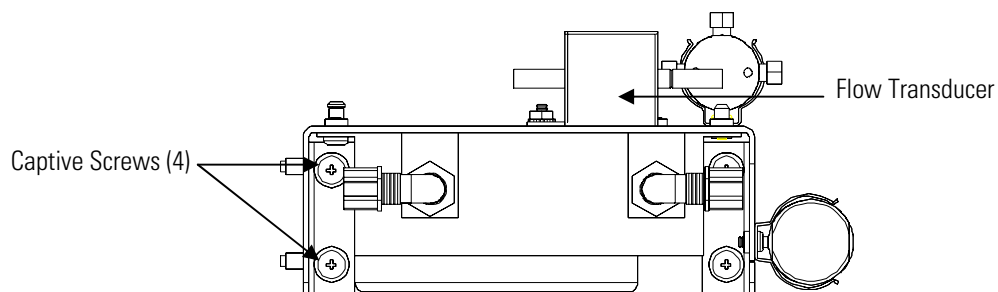
Philips screwdriver



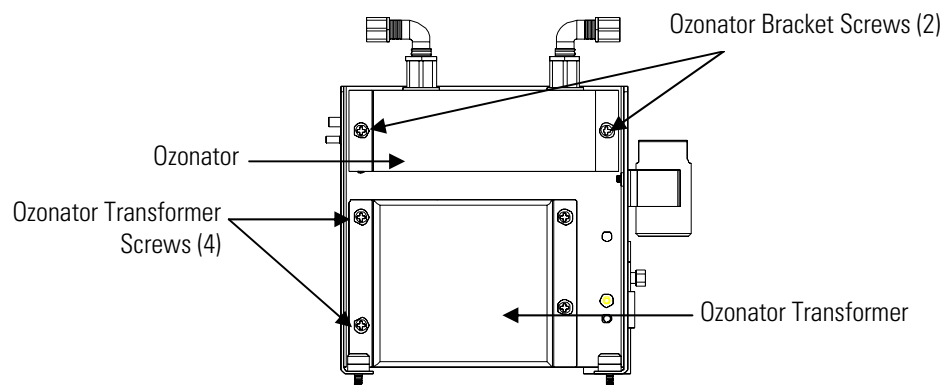
**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

1. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter to lower the partition panel, then proceed to the next step below.
2. Carefully disconnect the plumbing at the glass inlet and outlet of the ozonator.

3. Disconnect the stainless steel tubing from the flow transducer.
4. Loosen the four captive screws securing the ozonator bracket to the floor plate.



Ozonator – Top View



Ozonator – Side View

**Figure 7–16.** Replacing the Ozonator Assembly

5. Remove the two screws securing the ozonator to the ozonator bracket.
6. Unplug the ozonator from the ozonator transformer by lifting the ozonator straight up.
7. To install the ozonator, follow the previous steps in reverse.

8. Re-install the measurement bench. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter.

## Ozonator Transformer Replacement

Use the following procedure to replace the ozonator transformer (Figure 7–16).

Equipment Required:

Ozonator transformer

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 ozonator assembly as described in “[Ozonator Assembly Replacement](#).”
3. Disconnect the plug connecting the ozonator transformer to the measurement interface board (OZONATOR connector).
4. Remove the four screws holding the ozonator transformer to the ozonator bracket and remove the ozonator transformer.
5. To install the ozonator transformer, follow the previous steps in reverse.
6. Re-install the measurement bench. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter.

## Input Board Replacement

Use the following procedure to replace the input board (Figure 7–17).

Equipment Required:

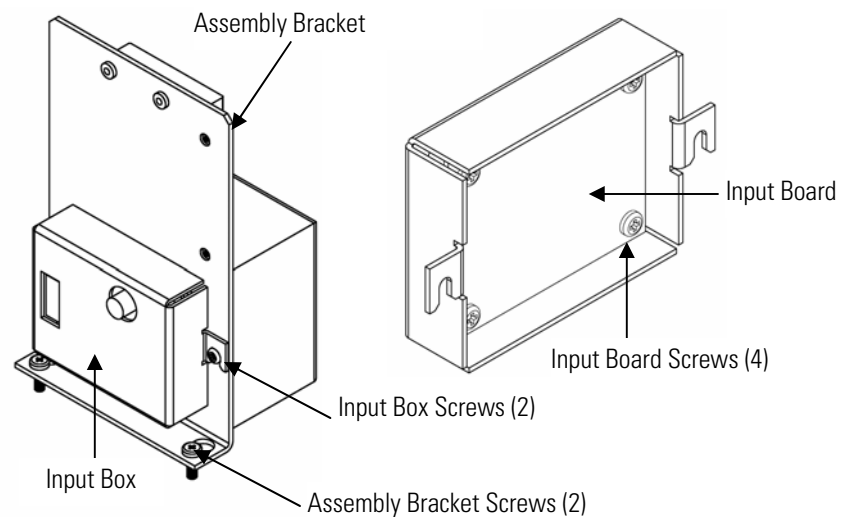
Input board

Philips screwdriver



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

1. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter to lower the partition panel, then proceed to the next step below.
2. Disconnect the coaxial cable with BNC connector and the ribbon cable.
3. Loosen the two screws holding the assembly bracket to the floor plate, move the assembly towards the rear, and lift the assembly off the screws.
4. Loosen the two screws holding the input box to the assembly bracket and lift the input box off the screws.



**Figure 7–17.** Replacing the Input Board

5. Remove the four screws holding the input board to the input box and remove the input board.
6. Install the input board by following the previous steps in reverse.
7. Re-install the measurement bench. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” in this chapter.
8. Perform an input board calibration. See the “[Input Board Calibration](#)” procedure that follows.

## Input Board Calibration



After replacing the input board, use the following procedure to calibrate the input board.

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

1. From the Main Menu, press to scroll to Service > press > to scroll to **Input Board Calibration** > and press .

The Input Board Calibration screen appears.

**Note** If Service Mode is not displayed, refer to “[Accessing the Service Mode](#)” on page 7-4 , then return to the beginning of this step. ▲

2. At the Input Board Calibration screen, press to select Manual Input Cal, and press to calibrate.

The screen displays the frequency at GAIN 1.

3. Make a note of the FREQ value displayed at GAIN 1, then press or to change the GAIN to 100.

4. At the GAIN 100 screen, use to increment the D/A counts until the FREQ value matches or is slightly above (within 50 counts) the value noted in the previous step.

5. Press to store the value.

The screen flashes **Calculating - Please Wait!** and **Done - Values Saved!** messages.

## DC Power Supply Replacement

Use the following procedure to replace the DC power supply ([Figure 7-18](#)).

Equipment Required:

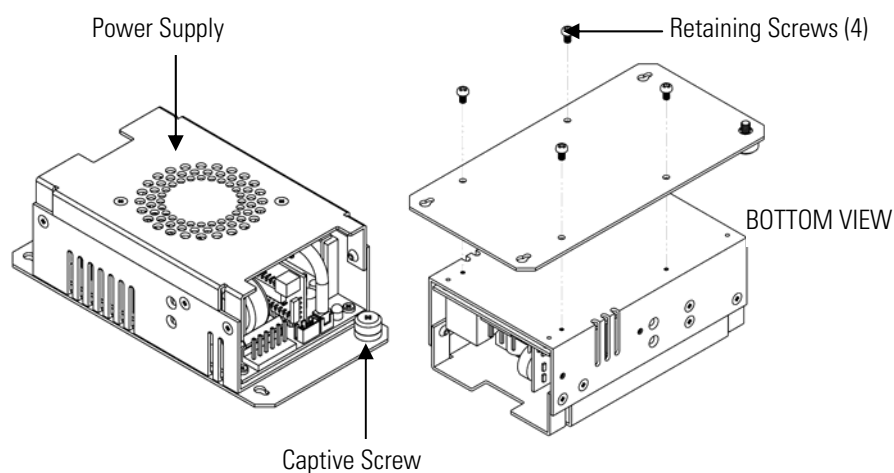
DC power supply

Philips screwdriver



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

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Disconnect all the power supply electrical connections. Note connector locations to facilitate re-connection.
3. Loosen the captive screw securing the power supply to the chassis plate and lift out the power supply.



**Figure 7–18.** Replacing the DC Power Supply

4. Turn the power supply upside down and remove the four retaining screws securing the power supply to the power supply plate and remove the power supply.
5. To install the DC power supply, follow the previous steps in reverse.

## Analog Output Testing

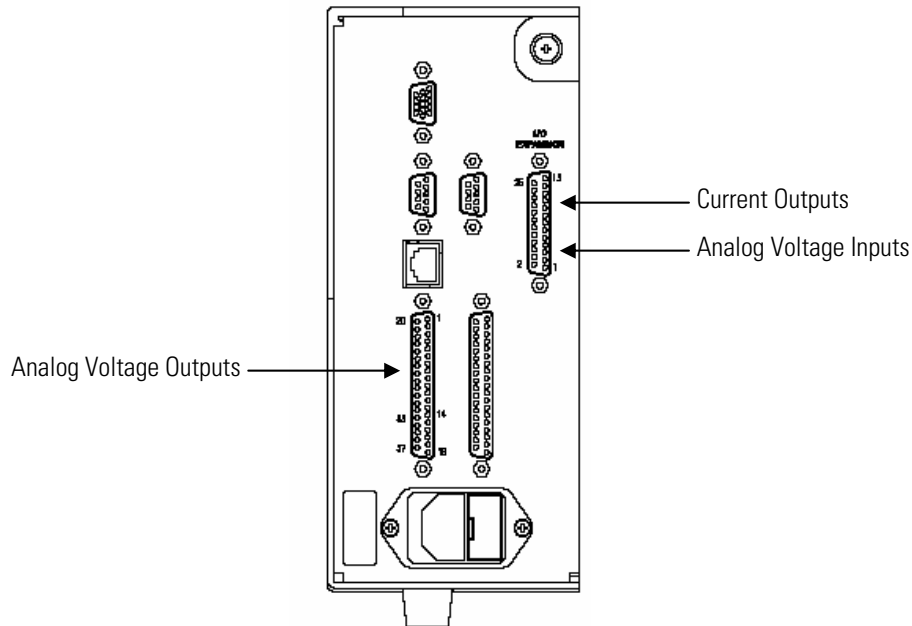
The analog outputs should be tested if the concentration value on the front panel display disagrees with the analog outputs. To check the analog outputs, you connect a meter to an analog output channel (voltage or current) and compare the meter reading with the output value set on the Test Analog Outputs screen.

Equipment Required:

Multimeter

Use the following procedure to test the analog outputs.



1. Connect a meter to the channel to be tested. [Figure 7–19](#) shows the analog output pins and [Table 7–4](#) identifies the associated channels.



**Figure 7–19.** Rear Panel Analog Input and Output Pins

2. From the Main Menu, press  to scroll to Diagnostics, > press  >  to scroll to Test Analog Outputs, and press .
- The Test Analog Outputs screen appears.
3. Press  to scroll to the desired channel corresponding to the rear panel terminal pins where the meter is connected, and press .
- The Set Analog Outputs screen appears.
4. Press  to set the output to zero.
- The Output Set To line displays Zero.
5. Check that the meter is displaying the 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 a 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.

**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 | 13, 16, 18, 20, 22, 24 |

**Table 7-5.** Analog Input Channels and Rear Panel Pin Connections





| Input Channel | Pin          |
|---------------|--------------|
| 1             | 1            |
| 2             | 2            |
| 3             | 3            |
| 4             | 5            |
| 5             | 6            |
| 6             | 7            |
| 7             | 9            |
| 8             | 10           |
| Ground        | 4, 8, 11, 14 |

## 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 7–19](#) 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 Output Calibration > and press .










The Analog Output Cal screen appears.

**Note** If Service Mode is not displayed, refer to “[Accessing the Service Mode](#)” on page [7-4](#) , then return to the beginning of this step. ▲

3. At the Analog Output Cal screen, press  to scroll to the desired voltage channel or current channel corresponding to the rear panel terminal pin 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 0.0V (or 0.0 or 4.0 mA for a current channel), then press  to save the value.
6. Press  to return to the previous screen.
7. Press   to select Calibrate Full-Scale.
8. Use   until the meter reads the value shown in the Set Output To line, then press  to save the value.

## Analog Input Calibration

Use the following procedures to calibrate the analog inputs after replacing the optional I/O expansion board. These procedures include selecting analog input channels, calibrating them to zero volts, and then calibrating them to full-scale using a known voltage source.



### Calibrating the Input Channels to Zero Volts

Use the following procedure to calibrate the input channels to zero volts.

1. From the Main Menu, press  to scroll to Service, press  >  to scroll to Analog Input Calibration, and press .


The Analog Input Cal screen displays.

**Note** If Service Mode is not displayed, refer to “[Accessing the Service Mode](#)” on page 7-4, then return to the beginning of this step. ▲



2. At the Analog Input Cal screen, press  to scroll to a channel, and press .

3. With the cursor at Calibrate Zero, press .

The screen displays the input voltage for the selected channel.

4. Make sure that nothing is connected to the channel input pins and press  to calibrate the input voltage on the selected channel to zero volts.

The screen displays 0.00 V as the voltage setting.

5. Press  >  to return to the Analog Input Cal screen and repeat Steps 2 through 4 to calibrate other input channels to zero as necessary.

6. Continue with the “[Calibrating the Input Channels to Full-Scale](#)” procedure that follows.

### Calibrating the Input Channels to Full-Scale





Use the following procedure to calibrate the input channels to full scale by applying a known voltage to the channels.

Equipment Required:












## Servicing

### Pressure Transducer Assembly Replacement

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 7-19](#) shows the analog output pins and [Table 7-5](#) identifies the associated channels.
2. From the Main Menu, press  to scroll to Service, press  >  to scroll to Analog Input Calibration, and press .

The Analog Input Cal screen displays input channels 1-8.

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.

## Pressure Transducer Assembly Replacement

Use the following procedure to replace the pressure transducer assembly ([Figure 7-20](#)).

Equipment Required:

Pressure transducer assembly

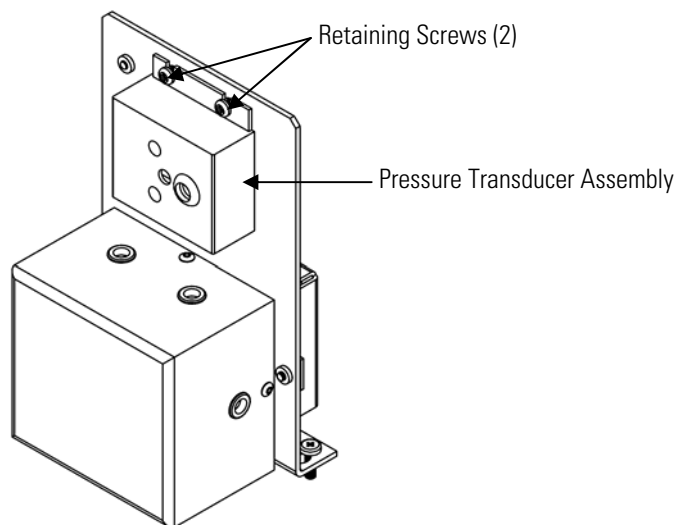
Philips screwdriver



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

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Disconnect plumbing from the pressure transducer assembly. Note the plumbing connections to facilitate reconnection.

3. Disconnect the pressure transducer cable.



**Figure 7–20.** Replacing the Pressure Transducer

4. Remove the two pressure transducer assembly retaining screws and remove the pressure transducer assembly.
5. To install the pressure transducer assembly, follow 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.

Equipment Required:

Vacuum pump



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

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







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

**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 mm Hg per foot of altitude. ▲









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

1. Remove the cover.
2. Disconnect the tubing from the pressure transducer and connect a vacuum pump known to produce a vacuum less than 1 mm Hg.
3. From the Main Menu, press  to scroll to Service > press  >  to scroll to Pressure Calibration > and press .

The Pressure Sensor Cal menu appears.

**Note** If Service Mode is not displayed, refer to “[Accessing the Service Mode](#)” on page 7-4 , then return to the beginning of this step. ▲

4. At the Pressure Sensor Cal menu, press  to select **Zero**.  
The Calibrate Pressure Zero screen appears.
5. Wait at least 10 seconds for the zero reading to stabilize, then press  to save the zero pressure value.
6. Disconnect the pump from the pressure transducer.

7. Press  to return to the Pressure Sensor Cal menu.
8. At the Pressure Sensor Cal menu, 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.

## Temperature Control Board Replacement

Use the following procedure to replace the temperature control board (Figure 7-10).

Equipment Required:

- Temperature control board
- Small flat-blade screwdriver



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

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Disconnect all connectors from the temperature control board. Use a small flat-blade screwdriver to loosen the two screws securing the CONV TC cable. Note that the red wire is towards the rear and the yellow wire is towards the front.
3. Snap off the board from the board mounts.
4. To install the temperature control board, follow previous steps in reverse.

# Ambient Temperature Calibration

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

Equipment Required:

Calibrated thermometer or 10K  $\pm$ 1% Resistor



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

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



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

1. Remove the instrument cover.
2. Tape the thermistor (plugged into the measurement interface board) to a calibrated thermometer (Figure 7-2).

**Note** Since the thermistors are interchangeable to an accuracy of  $\pm$ 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  $\pm$ 5% change in resistance, thus this alternative procedure can be quite accurate as a check; however, it clearly is not NIST traceable. ▲

3. From the Main Menu, press  to scroll to Service > press  >  to scroll to **Temperature Calibration** > and press .

The Calibrate Ambient Temperature screen appears.



**Note** If Service Mode is not displayed, refer to “[Accessing the Service Mode](#)” on page 7-4 , 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.

## Fuse Replacement

Use the following procedure to replace the fuse.

Equipment Required:

Replacement fuses:

250VAC, 4 Amp, SlowBlow (for 100VAC and 110VAC models)

250VAC, 2 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.

## I/O Expansion Board (Optional) Replacement

Use the following procedure to replace the optional I/O expansion board ([Figure 7-21](#)).

Equipment Required:

I/O expansion board

Nut driver, 3/16-inch



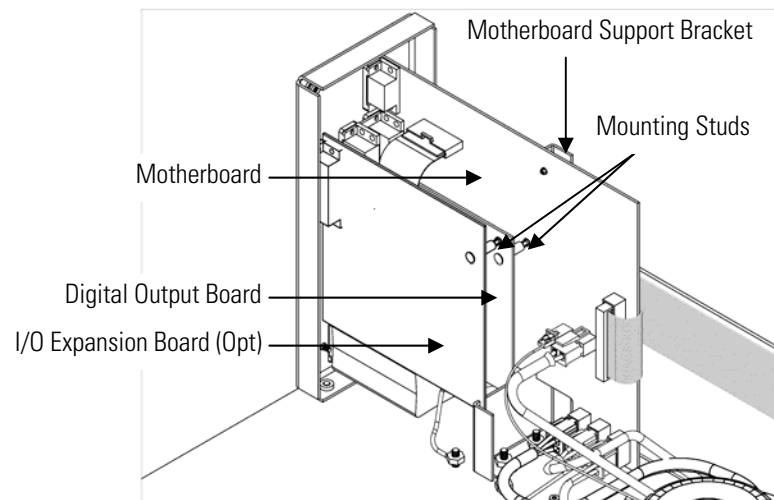
**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

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

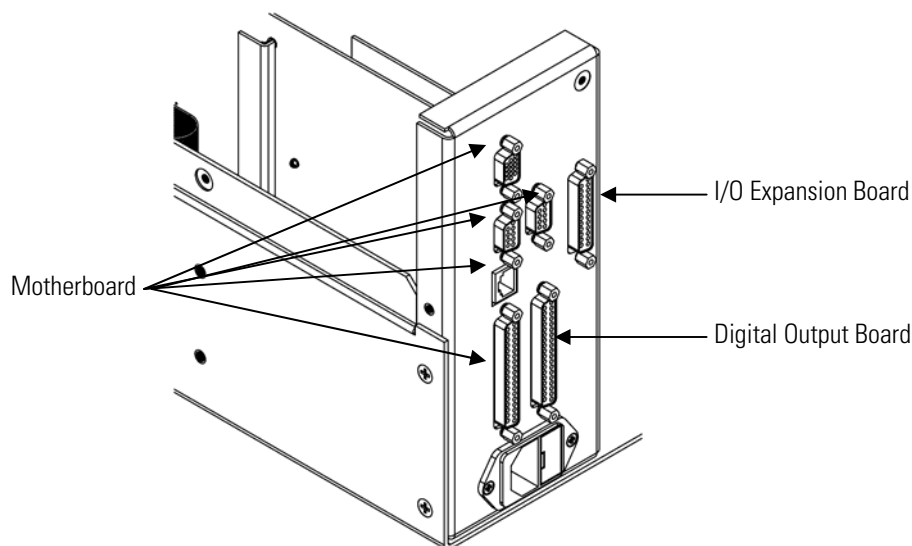
## Servicing

### I/O Expansion Board (Optional) Replacement

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 7-22).
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.
6. Calibrate the analog current outputs and analog voltage inputs as defined earlier in this chapter.



**Figure 7-21.** Replacing the I/O Expansion Board (Optional)



**Figure 7–22.** Rear Panel Board Connectors

## Digital Output Board Replacement

Use the following procedure to replace the digital output board ([Figure 7–21](#)).

Equipment Required:

- Digital output board
- Nut driver, 3/16-inch



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

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Remove the I/O expansion board (optional), if used. See the “[I/O Expansion Board \(Optional\) Replacement](#)” procedure in this chapter.
3. Disconnect the digital output board ribbon cable from the motherboard.
4. Using the nut driver, remove the two standoffs securing the board to the rear panel ([Figure 7–22](#)).

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 7–23).

Equipment Required:

Motherboard

Philips screwdriver

Nut driver, 3/16-inch



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

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Remove the I/O expansion board (optional), if used. See the “[I/O Expansion Board \(Optional\) Replacement](#)” procedure in this chapter.
3. Remove the digital output board. See the “[Digital Output Board Replacement](#)” procedure in this chapter.
4. Unplug all connectors from the motherboard. Note connector locations to facilitate reconnection.
5. Using the nut driver, remove the six standoffs securing the board to the rear panel.
6. Pop off the motherboard from motherboard support bracket, and remove the motherboard.
7. To install the motherboard, follow previous steps in reverse.
8. Calibrate the analog voltage outputs as defined earlier in this chapter (all ranges).

## Measurement Interface Board Replacement

Use the following procedure to replace the measurement interface board (Figure 7–23).

Equipment Required:

Measurement interface board

Philips screwdriver

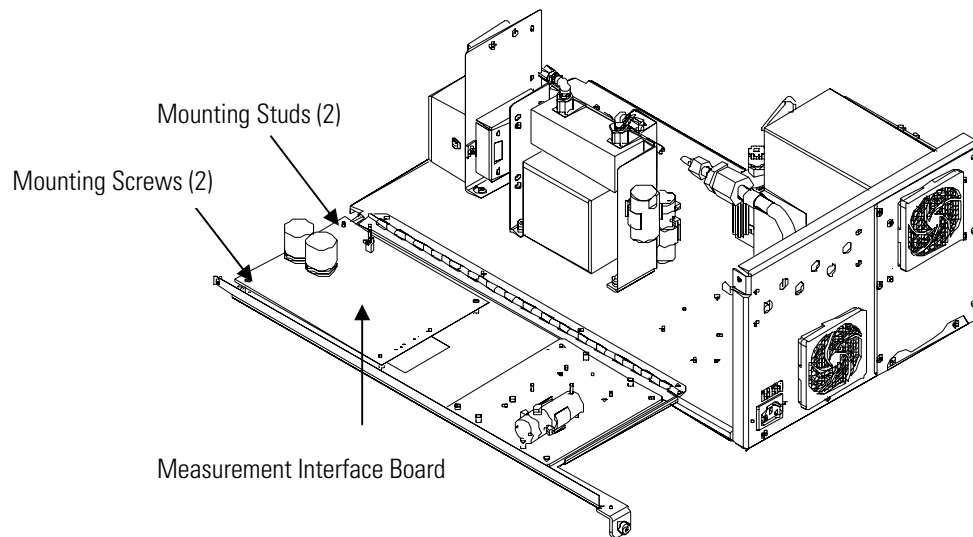


**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

1. Lower the partition panel, then proceed to the next step below. Refer to “[Removing the Measurement Bench and Lowering the Partition Panel](#)” on page 7-10 in this chapter.
2. Unplug all connectors. 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 four mounting studs and remove the board (Figure 7–23).
4. To install the measurement interface board, follow previous steps in reverse.
5. Re-install the measurement bench.
6. Calibrate the PMT voltage, pressure transducer, flow transducer, input board, and ambient temperature sensor as defined earlier in this chapter.

## Servicing

### External Converter Interface Board Replacement



**Figure 7–23.** Replacing the Measurement Interface Board

## External Converter Interface Board Replacement

Use the following procedure to replace the external converter interface board.

### Equipment Required:

External converter interface board





Philips screwdriver

Nut driver, 7/16-inch, wrench, or 1/4-inch flat head 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. ▲

7. Loosen the four screws on the outside of the external converter box, until all of the clamps can be rotated out of the way and open the external converter box door.
8. Locate the external converter interface board, and unplug all connectors. Note the locations of the connectors to facilitate reconnection.
9. Remove the two screws at the top of the external converter interface board. Pop off the external converter interface board from the four mounting studs and remove the board.

10. To install the external converter interface board, follow the previous steps in reverse.
11. Power up the Model 42i NO<sub>y</sub>, and check that the converter in the external converter box is heating properly. From the Main Menu, press  to scroll to **Diagnostics** > press  >  to scroll to **Temperature** > and press . External converter temperature should reach 350 °C within one half hour.

## Flow Transducer Replacement

Use the following procedure to replace the flow transducer (Figure 7–24).

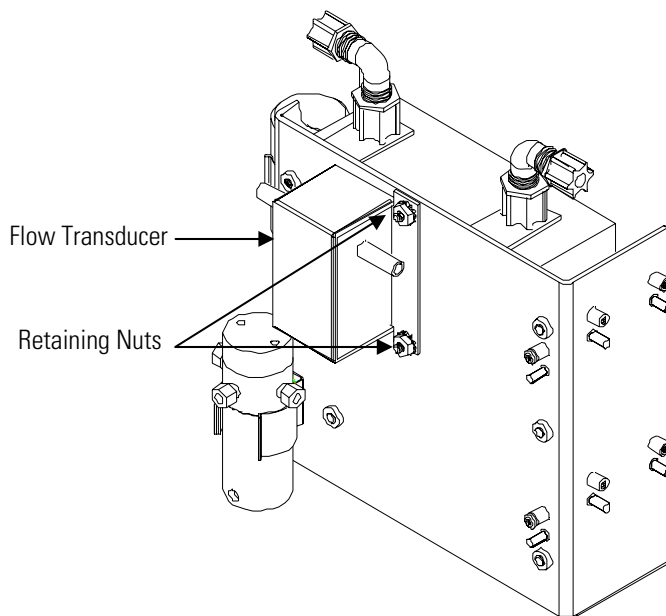
Equipment Required:

Flow transducer



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

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Disconnect the plumbing connections from the flow transducer. Note the plumbing connections to facilitate reconnection.



**Figure 7–24.** Replacing the Flow Transducer

3. Disconnect the flow transducer cable from the measurement interface board.
4. Loosen the two retaining nuts securing the flow transducer to the ozonator bracket and remove the flow transducer.
5. To install the flow transducer, follow 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 grounded antistatic wrist strap must be worn while handling any internal component. ▲

1. Remove the 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 7-4 , then return to the beginning of this step. ▲



4. At the Flow Sensor Cal menu, press  to select **Zero**.  
The Calibrate Flow Zero screen appears.
5. Wait at least 10 seconds for the zero reading to stabilize, 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 menu.
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.

## Front Panel Board Replacement

Use the following procedure to replace the front panel board (Figure 7-25).

Equipment Required:

Front panel board



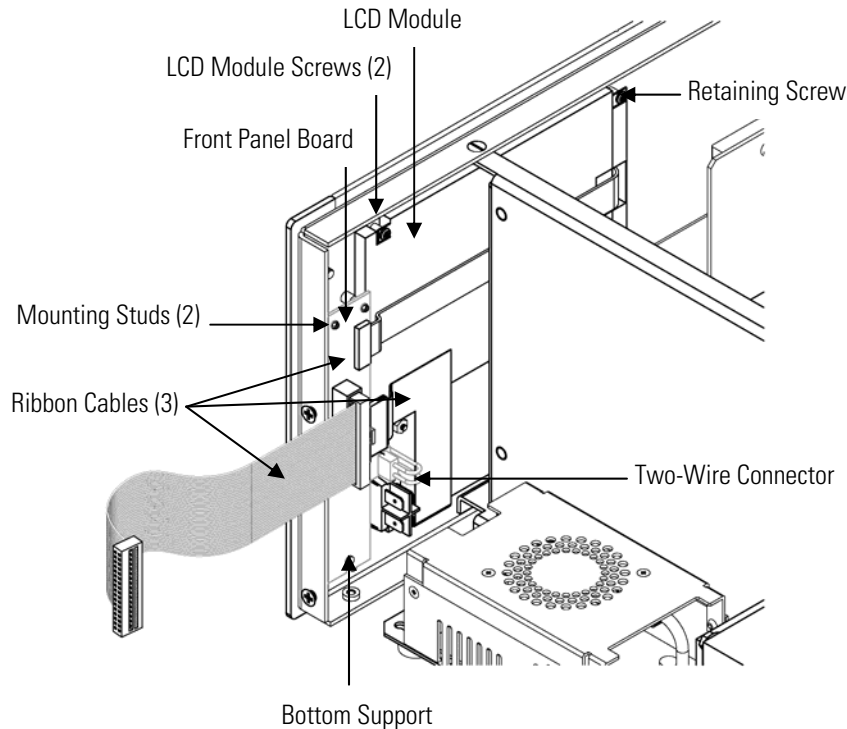
**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Remove the three ribbon cables and the two-wire connector from the front panel board.

## Servicing

### LCD Module Replacement

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 7–25.** Replacing the Front Panel Board and the LCD Module

## LCD Module Replacement

Use the following procedure to replace the LCD module (Figure 7–25).

Equipment Required:

LCD module

Philips screwdriver



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



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

Do not remove the LCD panel or frame from the module. ▲

The LCD polarizing plate is very fragile, handle it carefully. ▲

Do not wipe the LCD 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. ▲

1. Turn instrument OFF, unplug the power cord, and remove the cover.
2. Disconnect the ribbon cable and the two-wire connector from the front panel board.
3. Remove the four screws at the corners of the LCD module.
4. Slide the LCD module out towards the right of the instrument.
5. Replace the LCD module by following previous steps in reverse.

## **Service Locations**

For additional assistance, service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at [www.thermo.com/aqi](http://www.thermo.com/aqi).

1-866-282-0430 Toll Free

1-508-520-0430 International



# Chapter 8

## System Description

This chapter describes the function and location of the system components, provides an overview of the software structure, and includes a description of the system electronics and input/output connections and functions as follows:

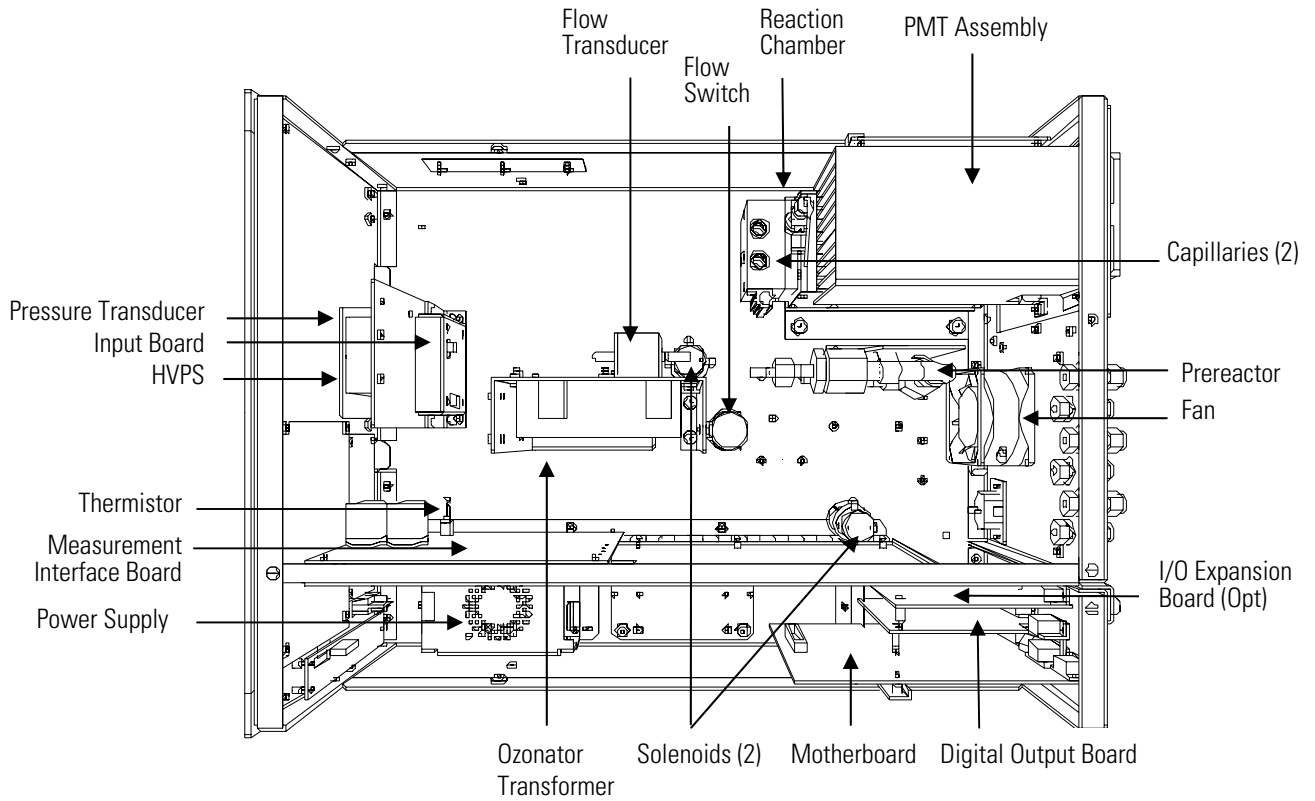
- “Hardware” on page 8-1
- “Software” on page 8-5
- “Electronics” on page 8-7
- “I/O Components” on page 8-11

### Hardware

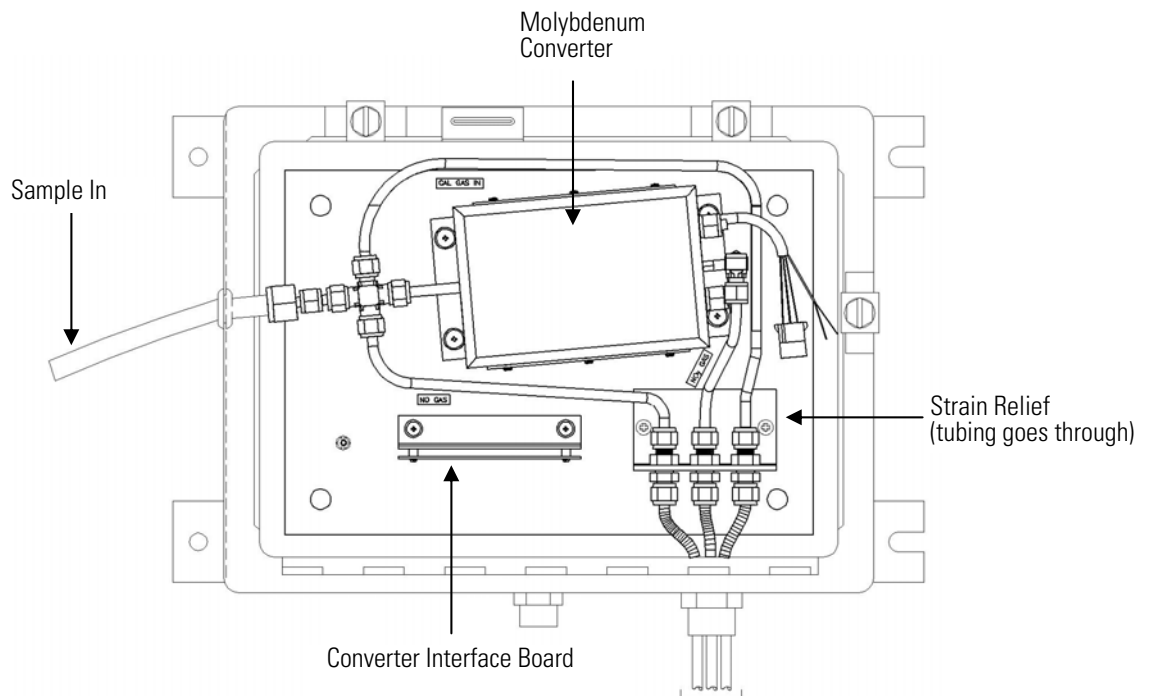
Model 42i NO<sub>y</sub> hardware components (Figure 8–1) include:

- External converter
- Reaction chamber
- Ozonator
- Prereactor
- Photomultiplier tube
- Photomultiplier tube cooler
- External Pump
- Bypass Pump Assembly
- Teflon particulate filter

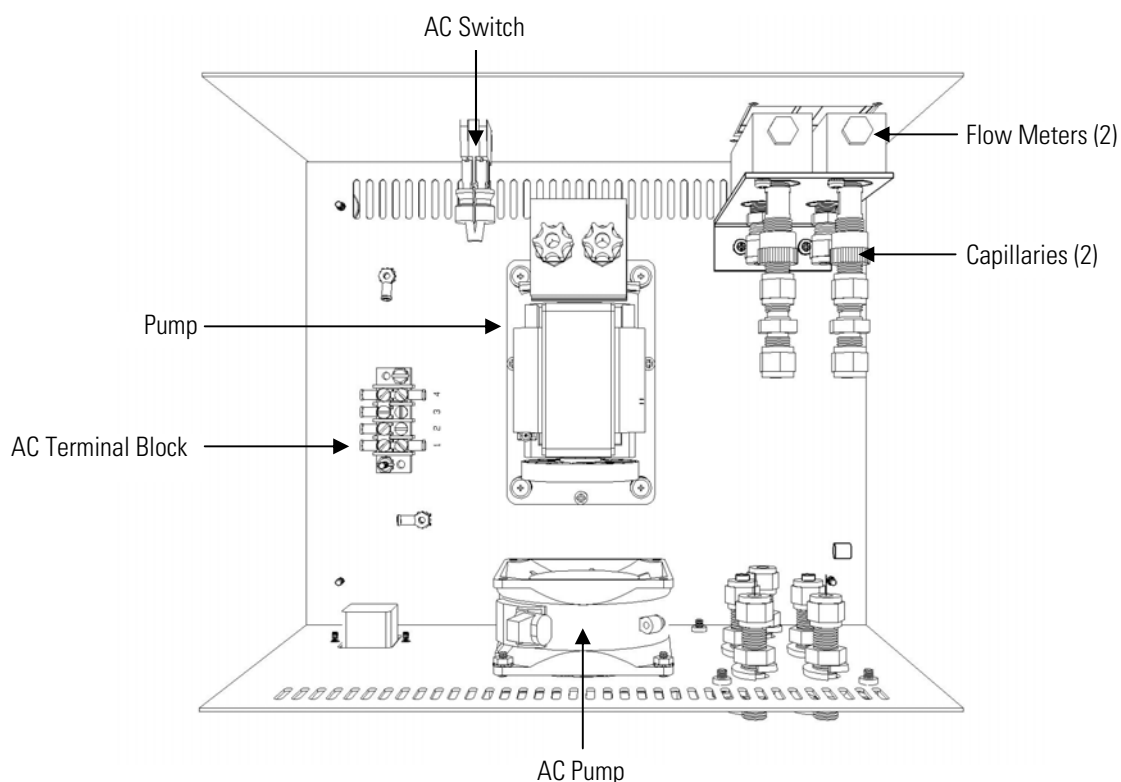
**System Description**  
Hardware



**Figure 8-1.** Analyzer Hardware Components



**Figure 8-2.** External Converter Hardware Components



**Figure 8–3.** Bypass Pump Hardware Components

## External Converter

The external converter heats molybdenum to approximately 325 °C in order to convert and detect NO<sub>y</sub> species other than NO. The external converter consists of an insulated housing, heater, replaceable cartridge, and a type K thermocouple sensor. Inside the external converter assembly housing is a converter interface board that is used to control and monitor the converter temperature.

## Mode Solenoids

The mode solenoid valves switch analyzer operation between the NO mode, NO<sub>y</sub> mode, and Prereactor mode. One valve selects raw sample (NO mode) or sample through the external conv (NO<sub>y</sub> mode). The other valve selects the prereactor.

## Reaction Chamber

The reaction chamber is where the sample reacts with ozone and produces excited NO<sub>2</sub> that gives off a photon of energy when it decays.

The reaction chamber is heated and controlled to approximately 50 °C in order to ensure the greatest instrument stability. The sample and ozone

flow capillaries and a thermistor sensor are also housed in/on the reaction chamber assembly.

**Prereactor Solenoid**

The prereactor solenoid valve directs the sample either to the reaction chamber or the prereactor.

**Optical Filter**

The optical filter housed in the reaction chamber limits the spectral region viewed by the detector and eliminates possible interferences due to other chemiluminescent reactions.

**Pressure Transducer**

The pressure transducer measures the reaction chamber pressure.

**Sample Flow Sensor**

The sample flow sensor located at the reaction chamber inlet measures the sample flow into the reaction chamber.

**Ozonator**

The ozonator generates the necessary ozone concentration required for the chemiluminescent reaction. The ozone reacts with the NO in the ambient air sample to produce the electronically excited NO<sub>2</sub> molecules.

**Ozonator Flow Switch**

The ozonator flow switch located at the ozonator inlet completes an electrical safety circuit when air flows through the sensor to the ozonator. If airflow stops, the flow sensor breaks the electrical circuit to the ozonator and shuts it off to prevent the ozonator from overheating.

**Prereactor**

The prereactor is plumbed before the reaction chamber so that the sample reacts with ozone prior to the reaction chamber giving a dynamic zero reading for the analyzer. The prereactor is sized so that greater than 99% of a 200 ppb NO sample will react prior to entering the reaction chamber, yet is small enough to allow other potential interferences to pass through to the reaction chamber.

**Photomultiplier Tube**

The photomultiplier tube (PMT) provides the infrared sensitivity required to detect the NO<sub>2</sub> luminescence resulting from the reaction of the ozone with the ambient air sample.

Optical energy from the reaction is converted to an electrical signal by the PMT and sent to the input board that transmits it to the processor.



## **Photomultiplier Tube Cooler**

The thermoelectric PMT cooler reduces the PMT temperature to approximately  $-7^{\circ}\text{C}$  to minimize dark current and increase instrument sensitivity. The cooler helps to increase zero and span stability over a wide ambient temperature range. The cooler housing also shields the PMT from external electrical and optical interferences.

## **External Pump**

The external vacuum pump draws the reacted gases out of the reaction chamber.

## **Sample Capillary**

The sample capillary along with the pump is used to control flow in the sample line.

## **Dry Air Capillary**

The dry air capillary along with the pump is used to control flow in the dry air line through the ozonator.

## **Bypass Pump Assembly**

The external bypass pump assembly draws the sample from the external converter through the sample line.

## **Capillaries**

The capillaries along with the pump are used to control flow in the sample line.

## **Teflon Particulate Filter**

A 5-10 micron pore size, two-inch diameter Teflon® element is available for the Model 42i NO<sub>y</sub>. 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.

## **Software**

The processor software tasks are organized into four areas:

- Instrument Control
- Monitoring Signals
- Measurement Calculations
- Output Communication

## **Instrument Control**

Low-level embedded processors are used to control the various functions on the boards, such as analog and digital I/O and heater control. These

processors are controlled over a serial interface with a single high-level processor that also controls the front-panel user interface. The low-level processors all run a common piece of firmware that is bundled with the high-level firmware and loaded on power-up if a different version is detected.

Each board has a specific address that is used to identify to the firmware what functions are supported on that board. This address is also used for the communications between the low-level processors and the high-level processor.

Every tenth of a second the frequency counters, analog I/O, and digital I/O are read and written to by the low-level processor. The counters are accumulated over the past second and the analog inputs are averaged over that second. The high-level processor polls the low-level processors once per second to exchange the measurement and control data.

## **Monitoring Signals**

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 representing the NO/NO<sub>y</sub> are accumulated and reported for the user-specified averaging time. 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).

In auto mode, every ten seconds the NO/NO<sub>y</sub> and Prereactor solenoids are switched and the processor waits three seconds for the reaction chamber to flush and stabilize. After those three seconds, it accumulates the signal counts for seven seconds before again switching the solenoid. In manual NO or manual NO<sub>y</sub> modes, every ten seconds the Prereactor solenoid is switched and the same process is applied.

## **Measurement Calculations**

The calculation of the NO and NO<sub>y</sub> concentrations is lengthy and uses the high-level processor to provide the most accurate readings. The calculation begins by subtracting the appropriate electronic offset from the seven-second count accumulation. Following this correction, the raw accumulated counts are scaled according to the gain setting of the input board.

Next, the uncorrected NO, NO<sub>y</sub> and Prereactor values are determined according to a unique averaging algorithm which minimizes errors resulting from rapidly changing gas concentrations. This algorithm results in NO, NO<sub>y</sub> and Prereactor values which are stored in RAM in a circular buffer that holds all the ten second data from the previous five minutes. This data is averaged over the selected time interval, which can be any multiple of ten between 10 and 300.

The background values for NO, NO<sub>y</sub> and Prereactor, which are corrected for temperature, are subtracted from their respective averages. The Prereactor value is subtracted from the NO and NO<sub>y</sub> values to provide dynamically compensated NO and NO<sub>y</sub> readings. The NO reading is corrected by the stored span factor. The NO<sub>y</sub> reading is partially corrected by the span factor, and balance factor. The corrected NO value is subtracted from the partially corrected NO<sub>y</sub> value to yield an uncorrected DIF value. The DIF value is then corrected for converter efficiency to give a corrected DIF reading. Finally, the corrected DIF reading is added to the corrected NO reading to yield a fully corrected NO<sub>y</sub> value.

## **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 NO, DIF, and NO<sub>y</sub> concentrations simultaneously. The display is updated every 10 seconds.

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.

All heaters and the bypass pump operate on 110VAC. An optional transformer is required if operating on the 210-250VAC or 90-110VAC ranges. The sample pump operates directly from line voltages and is selected appropriately.

An on/off switch controls all power to the instrument and external converter, 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 (for external converter assembly)
- 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
- Fans and solenoid outputs
- Cooler control
- 120VAC outputs for the pump and temperature control board
- Ozonator
- Flow and pressure sensors

- Ambient temperature sensor
- Temperature control board
- PMT high voltage supply
- Measurement input board

## External Converter Interface Board

The external converter interface board serves as a central connection area for all measurement electronics in the external converter. It contains power supplies and interface circuitry for the converter heater. It sends status data to the motherboard and receives control signals from the motherboard.

## External Converter Interface Board Connectors

Connectors located on the external converter interface board include:

- 120VAC power supply input
- DC/Data
- Converter thermocouple
- Converter heater

## 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.

## Temperature Control Board

The temperature control board regulates and sets the temperature of the reaction chamber and external converter.

The reaction chamber temperature is measured with a thermistor. The voltage across the thermistor is fed to the main processor for use in calculating and displaying the reaction chamber temperature. The voltage across the thermistor is also compared to a set-point voltage and used to control that the reaction chamber heaters to maintain a constant temperature of 50 °C. Protective circuitry prevents over heating in the event of broken wires to the thermistor.

## **PMT Power Supply Assembly**

The PMT power supply produces high voltage to operate the photo multiplier tube used in the measurement system. The output voltage is adjustable from approximately 600 to 1200 volts under software control.

## **Input Board Assembly**

The input board accepts the current signal from the PMT and converts it to a voltage, which is scaled by a factor of approximately 1, 10, or 100 depending on the full-scale range of the NO channel. The scaled voltage signal is converted to a frequency and sent to the microprocessor.

The input board includes a test signal that can be activated under software control. The test signal is injected at the first stage of the input board in parallel with the PMT input. This allows the input board and the connection to the processor system to be tested and calibrated without using the PMT.

## **Digital Output Board**

The digital output board connects to the motherboard and provides solenoid driver outputs and relay contact outputs to a connector located on the rear panel of the instrument. Ten relay contacts normally open (with power off) are provided which are electrically isolated from each other. Eight solenoid driver outputs (open collector) are provided along with a corresponding +24VDC supply pin on the connector.

## **I/O Expansion Board (Optional)**

The I/O expansion board connects to the motherboard and adds the capability to input external analog voltage inputs and to output analog currents via a connector located on the rear panel of the instrument. It contains local power supplies, a DC/DC isolator supply, a sub-processor and analog circuits. Eight analog voltage inputs are provided with an input voltage range of 0V to 10VDC. Six current outputs are provided with a normal operating range of 0 to 20 mA.

## **Front Panel Connector Board**

The front panel connector board interfaces between the motherboard and the front panel mounted function key panel and Graphics display. It serves as central location to tie the three connectors required for the function key panel, the graphics display control lines, and the graphics display backlight to a single ribbon cable extending back to the motherboard. This board also includes signal buffers for the graphics display control signals and a high voltage power supply for the graphics display backlight.

## I/O Components

External I/O is driven from a generic bus that is capable of controlling the following devices:

- Analog output (voltage and current)
- Analog input (voltage)
- Digital output (TTL levels)
- Digital input (TTL levels)

**Note** The instrument has spare solenoid valve drivers and I/O support for future expansion. ▲

### Analog Voltage Outputs

The instrument provides six analog voltage outputs. Each may be software configured for any one of the following ranges, while maintaining a minimum resolution of 12 bits:

- 0-100mV
- 0-1V
- 0-5V
- 0-10V

The user can calibrate each analog output zero and span point through firmware. At least 5% of full-scale over and under range are also supported.

The analog outputs may be assigned to any measurement or diagnostic channel with a user-defined range in the units of the selected parameter. The voltage outputs are independent of the current outputs.

### Analog Current Outputs (Optional)

The optional I/O Expansion board includes six isolated current outputs. These are software configured for any one of the following ranges, while maintaining a minimum resolution of 11 bits:

- 0-20 mA
- 4-20 mA

The user can calibrate each analog output zero and span point through firmware. At least 5% of full-scale over and under range are also supported.

The analog outputs may be assigned to any measurement or diagnostic channel with a user-defined range in the units of the selected parameter. The current outputs are independent of the voltage outputs. The current

outputs are isolated from the instrument power and ground, but they share a common return line (Isolated GND).

## **Analog Voltage Inputs (Optional)**

The optional I/O expansion board includes eight analog voltage inputs. These inputs are used to gather measurement data from third-party devices such as meteorological equipment. The user may assign a label, unit, and a voltage to user-defined unit conversion table (up to 16 points). All voltage inputs have a resolution of 12 bits over the range of 0 to 10 volts.

## **Digital Relay Outputs**

The instrument includes one power fail relay on motherboard and ten digital output relays on the digital output board. These are reed relays rated for at least 500 mA @ 200VDC.

The power fail relay is Form C (both normally opened and normally closed contacts). All other relays are Form A (normally opened contacts) and are used to provide alarm status and mode information from the analyzer, as well as remote control to other devices, such as for controlling valves during calibration. The user may select what information is sent out each relay and whether the active state is opened or closed.

## **Digital Inputs**

Sixteen digital inputs are available which may be programmed to signal instrument modes and special conditions including:

- NO Measure Mode
- NO<sub>y</sub> Measure Mode
- PRE Measure Mode
- Zero Gas Mode
- Span Gas Mode
- Set Background
- Cal to Low Span
- Cal to High Span
- Analog Outputs to Full-Scale
- Analog Outputs to Zero

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 115,200 baud. 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, datalogger, 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 10Mbps 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 used in the Model 42i NO<sub>y</sub> analyzer to communicate with the external converter assembly. RS-485 signals are used to communicate with the external converter interface board to monitor the converter temperature.

## Chapter 9

# Optional Equipment

The Model 42i NO<sub>y</sub> is available with the following options:

- “Internal Zero/Span and Sample Valves” on page 9-1
- “Ozonator Permeation Dryer” on page 9-1
- “Ozone Particulate Filter” on page 9-1
- “I/O Expansion Board Assembly” on page 9-2
- “Terminal Block and Cable Kits” on page 9-2
- “Cables” on page 9-2
- “Mounting Options” on page 9-4

### Internal Zero/Span and Sample Valves

With the zero/span assembly option, a source of span gas is connected to the SPAN port and a source of zero air is connected to the ZERO port. Zero and span gas should be supplied at atmospheric pressure. It may be necessary to use an atmospheric dump bypass plumbing arrangement to accomplish this.

For more information, refer to the “[Installation](#)” chapter and the “[Operation](#)” chapter.

### Ozonator Permeation Dryer

The permeation dryer minimizes routing maintenance procedures by providing a continuous stream of dry air to the ozonator (using the selective water permeation characteristics of the dryer). With the permeation dryer option, it is not necessary to constantly replenish the ozonator air-drying column as in the standard instrument.

Refer to the “[Operation](#)” chapter for more information.

### Ozone Particulate Filter

The ozone particulate filter minimizes the potential for contamination of the ozonator by trapping any particulate matter before passing through the ozonator.

## 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.

## Terminal Block and Cable Kits

The optional terminal block and cable kits provide a convenient way to connect devices to the instrument. These kits break out the signals on the rear panel connector to individual numbered terminals.

Two types of terminal block and cable kits are available. One kit is for the DB37 connectors and can be used for either the analog output connector or the relay output connector. The other kit is for the DB25 connector and can be used for the optional I/O expansion board. For associated part numbers, refer to “[External Device Connection Components](#)” on page 7-7.

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 7-7.

**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

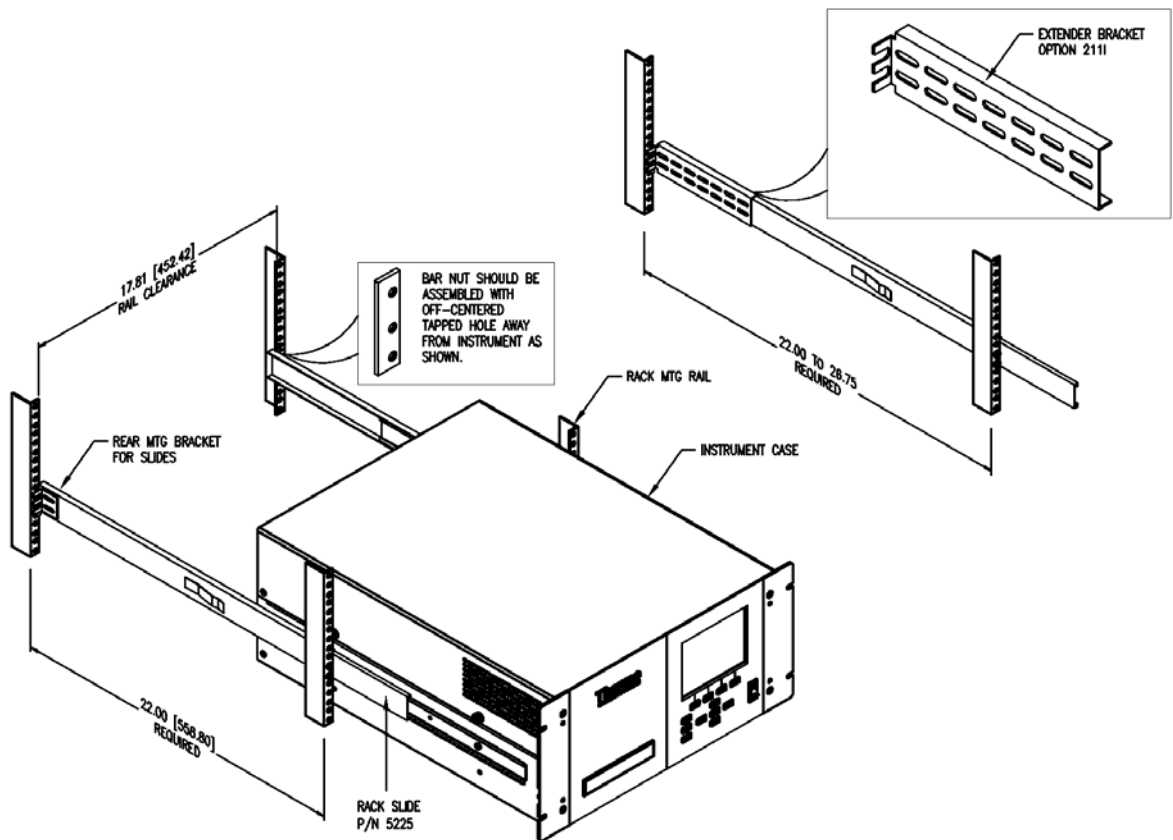
| Pin | Color        | Pin   | Color             |
|-----|--------------|---|-------------------|
| 1   | BLACK        | 20  | RED/BLACK         |
| 2   | BROWN        | 21  | ORANGE/BLACK      |
| 3   | RED          | 22  | YELLOW/BLACK      |
| 4   | ORANGE       | 23  | GREEN/BLACK       |
| 5   | 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

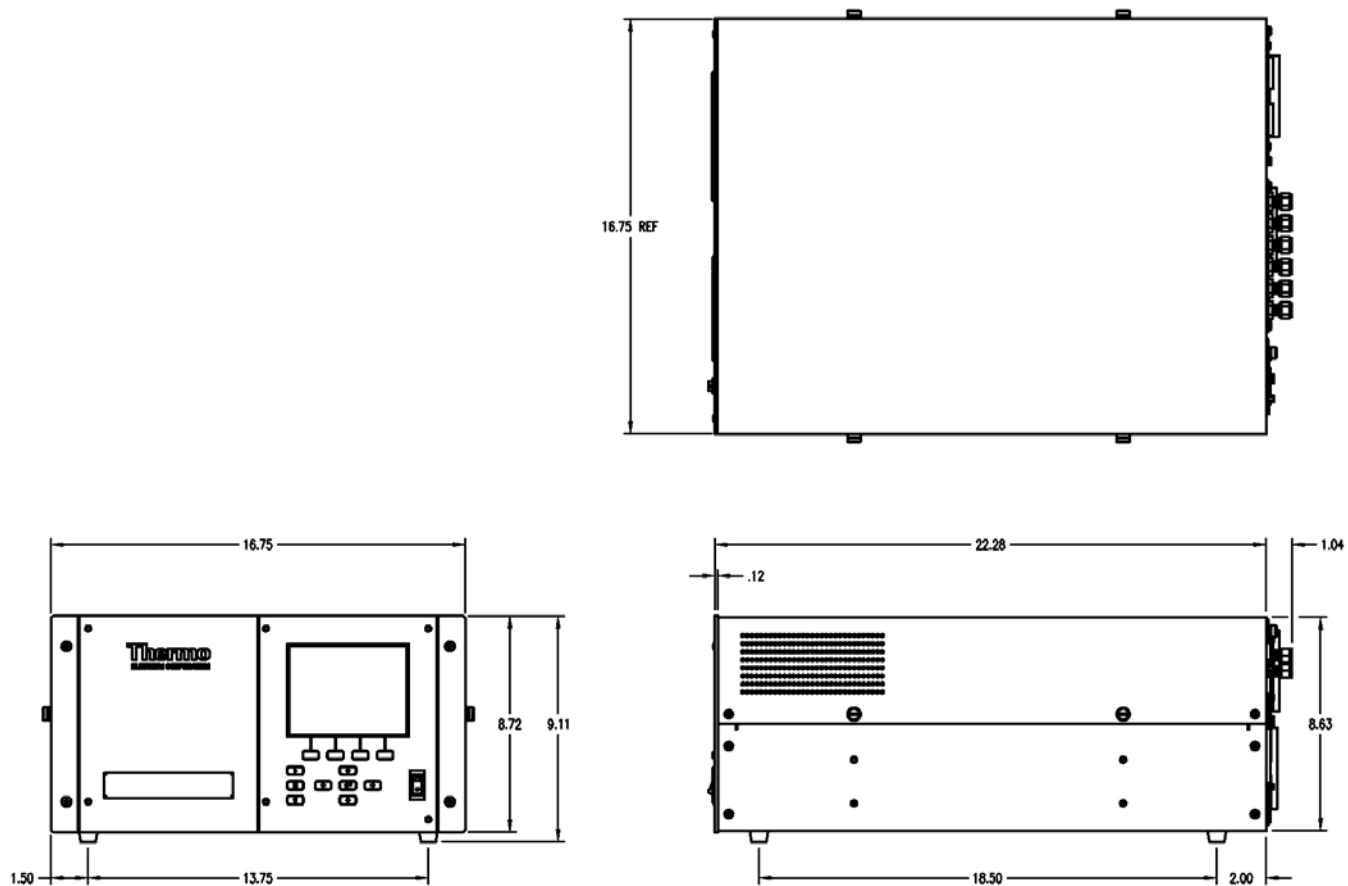
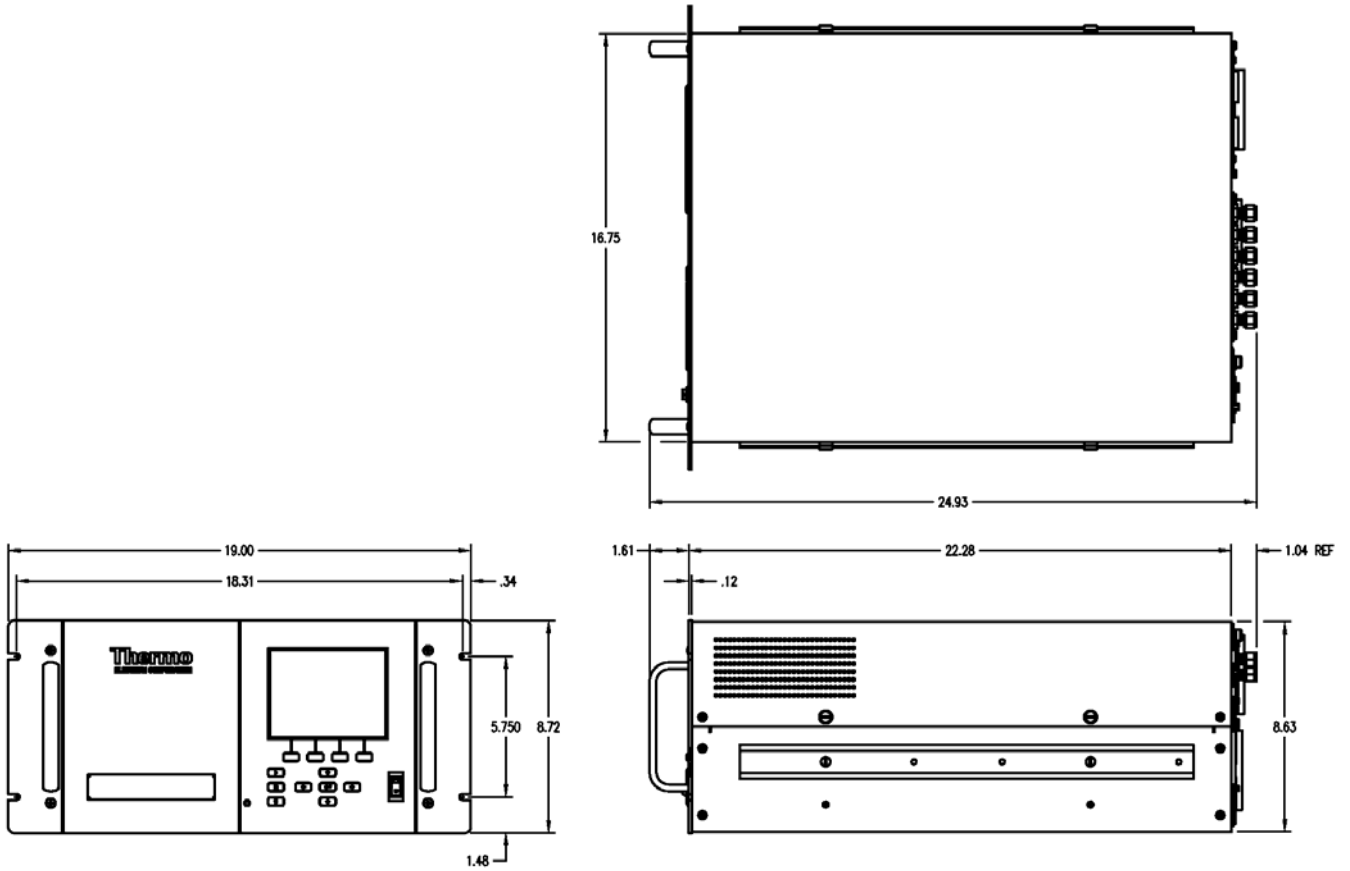


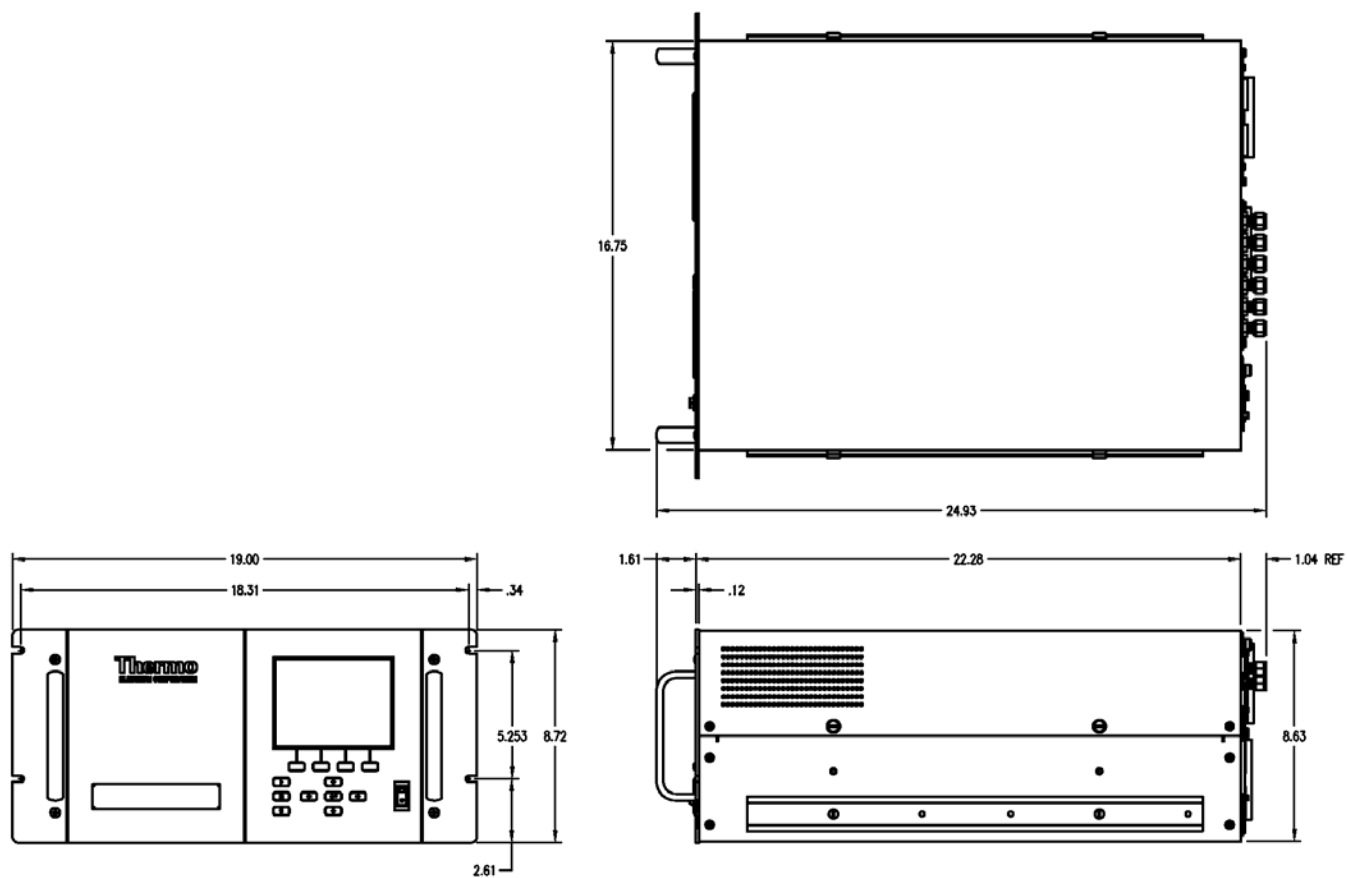
Figure 9-2. Bench Mounting

**Optional Equipment**  
Mounting Options



**Figure 9-3.** EIA Rack Mounting





**Figure 9-4.** Retrofit Rack Mounting



# Appendix A

## Warranty

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

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

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

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

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

# Appendix B

## C-Link Protocol Commands

This appendix provides a description of the C-Link protocol commands that can be used to remotely control a Model 42i NO<sub>y</sub> 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” on page B-1
- “Commands” on page B-2
- “Measurements” on page B-9
- “Alarms” on page B-13
- “Diagnostics” on page B-17
- “Datalogging” on page B-17
- “Calibration” on page B-26
- “Keys/Display” on page B-29
- “Measurement Configuration” on page B-31
- “Hardware Configuration” on page B-34
- “Communications Configuration” on page B-38
- “I/O Configuration” on page B-42
- “Record Layout Definition” on page B-46

### 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 ASCII 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 170 decimal, which directs the command to the Model 42i NO<sub>y</sub>, and is terminated by a carriage return “CR” (ASCII character code 13 decimal).

|             |   |   |   |   |      |
|-------------|---|---|---|---|------|
| <ASCII 170> | 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 ppb” instead of the correct command “set gas unit ppb.”

```
Send:          set unit ppb
Receive:       set unit ppb bad cmd
```

The “save” and “set save params” commands stores parameters in FLASH. It is important that each time instrument parameters are changed, that this command be sent. If changes are not saved, they will be lost in the event of a power failure.

## Commands List

Table B–1 lists the 42i NO<sub>y</sub> C-Link protocol commands. The interface will respond to the command strings outlined below.

**Table B–1.** C-Link Protocol Commands

| Command  | Description   | Page |
|----------|---|------|
| addr dns | Reports/sets domain name server address for Ethernet port | B-38 |
| addr gw  | Reports/sets default gateway address for Ethernet port    | B-38 |
| addr ip  | Reports/sets IP address for Ethernet port                 | B-38 |
| addr nm  | Reports/sets netmask address for Ethernet port            | B-39 |

| <b>Command</b>               | <b>Description</b>   | <b>Page</b> |
|------------------------------|--|-------------|
| alarm chamber temp max       | Reports/sets chamber temperature alarm maximum value                   | B-13        |
| alarm chamber temp min       | Reports/sets chamber temperature alarm minimum value                   | B-13        |
| alarm conc dif max           | Reports/sets current DIF concentration alarm maximum value             | B-14        |
| alarm conc dif min           | Reports/sets current DIF concentration alarm minimum value             | B-14        |
| alarm conc no max            | Reports/sets current NO concentration alarm maximum value              | B-14        |
| alarm conc no min            | Reports/sets current NO concentration alarm minimum value              | B-14        |
| alarm conc noy max           | Reports/sets current NO <sub>y</sub> concentration alarm maximum value | B-14        |
| alarm conc noy min           | Reports/sets current NO <sub>y</sub> concentration alarm minimum value | B-14        |
| alarm conc pre max           | Reports/sets current prereactor concentration alarm maximum value      | B-14        |
| alarm conc pre min           | Reports/sets current prereactor concentration alarm minimum value      | B-14        |
| alarm cooler temp max        | Reports/sets PMT cooler temperature alarm maximum value                | B-14        |
| alarm cooler temp min        | Reports/sets PMT cooler temperature alarm minimum value                | B-14        |
| alarm ext converter temp max | Reports/sets external converter temperature alarm maximum value        | B-15        |
| alarm ext converter temp min | Reports/sets external converter temperature alarm minimum value        | B-15        |
| alarm internal temp max      | Reports/sets internal temperature alarm maximum value                  | B-15        |
| alarm internal temp min      | Reports/sets internal temperature alarm minimum value                  | B-15        |
| alarm pressure max           | Reports/sets pressure alarm maximum value                              | B-15        |
| alarm pressure min           | Reports/sets pressure alarm minimum value                              | B-15        |
| alarm sample flow max        | Reports/sets sample flow alarm maximum value                           | B-16        |
| alarm sample flow min        | Reports/sets sample flow alarm minimum value                           | B-16        |
| alarm trig conc dif          | Reports/sets current DIF concentration alarm warning value             | B-16        |
| alarm trig conc no           | Reports/sets current NO concentration alarm warning value              | B-16        |
| alarm trig conc noy          | Reports/sets current NO <sub>y</sub> concentration alarm warning value | B-16        |
| alarm trig conc pre          | Reports/sets current prereactor concentration alarm warning value      | B-16        |

**C-Link Protocol Commands**

## Commands

| <b>Command</b>    | <b>Description</b>  | <b>Page</b> |
|-------------------|---|-------------|
| analog iout range | Reports analog current output range per channel                   | B-42        |
| analog vin        | Retrieves analog voltage input data per channel                   | B-42        |
| analog vout range | Reports analog voltage output range per channel                   | B-42        |
| avg time          | Reports/sets averaging time                                       | B-9         |
| baud              | Reports/sets current baud rate                                    | B-39        |
| bkg no            | Reports/sets current NO background                                | B-28        |
| bkg pre           | Reports/sets current prereactor background                        | B-28        |
| cal dif coef      | Sets/auto-calibrates DIF coefficient                              | B-26        |
| cal high dif coef | Sets/auto-calibrates high range DIF coefficient                   | B-26        |
| cal high no coef  | Sets/auto-calibrates high range NO coefficient                    | B-26        |
| cal high noy coef | Sets/auto-calibrates high range NO <sub>y</sub> coefficient       | B-26        |
| cal low dif coef  | Sets/auto-calibrates low range DIF coefficient                    | B-26        |
| cal low no coef   | Sets/auto-calibrates low range NO coefficient                     | B-26        |
| cal low noy coef  | Sets/auto-calibrates low range NO <sub>y</sub> coefficient        | B-26        |
| cal no bkg        | Sets/auto-calibrates NO background                                | B-26        |
| cal no coef       | Sets/auto-calibrates NO coefficient                               | B-26        |
| cal noy bkg       | Sets/auto-calibrates NO <sub>y</sub> background                   | B-26        |
| cal noy coef      | Sets/auto-calibrates NO <sub>y</sub> coefficient                  | B-26        |
| cal pre bkg       | Sets/auto-calibrates prereactor background                        | B-26        |
| clr lrecs         | Clears away only long records that have been saved                | B-18        |
| clr records       | Clears away all logging records that have been saved              | B-17        |
| clr srecs         | Clears away only short records that have been saved               | B-18        |
| contrast          | Reports/sets current screen contrast                              | B-34        |
| conv set temp     | Reports/sets temperature setpoint for DIF converter               | B-35        |
| conv temp         | Reports current DIF converter temperature                         | B-11        |
| cooler temp       | Reports temperature of PMT cooler (same as PMT temperature)       | B-11        |
| copy lrec to sp   | Sets/copies current lrec selection into the scratch pad           | B-24        |
| copy sp to lrec   | Sets/copies current selections in scratch pad into lrec list      | B-24        |
| copy sp to srec   | Sets/copies current selections in scratch pad into srec list      | B-24        |
| copy sp to stream | Sets/copies current selections in scratch pad into stream list    | B-24        |
| copy srec to sp   | Sets/copies current srec selection into the scratch pad           | B-24        |
| copy stream to sp | Sets/copies current streaming data selection into the scratch pad | B-24        |



| <b>Command</b>      | <b>Description</b>   | <b>Page</b> |
|---------------------|--|-------------|
| custom              | Reports/sets defined custom range concentration  | B-32        |
| data treatment lrec | Reports/sets data treatment for concentration values in long records   | B-18        |
| data treatment srec | Reports/sets data treatment for concentration values in short records  | B-18        |
| date                | Reports/sets current date  | B-35        |
| default params      | Sets parameters to default values  | B-36        |
| dhcp                | Reports/sets state of use of DHCP  | B-39        |
| diag volt iob       | Reports diagnostic voltage level for I/O expansion board   | B-17        |
| diag volt mb        | Reports diagnostic voltage level for motherboard   | B-17        |
| diag volt mib       | Reports diagnostic voltage level for measurement interface board   | B-17        |
| dif                 | Reports current DIF concentration  | B-10        |
| dif coef            | Reports/sets current DIF coefficient   | B-27        |
| dif gas             | Reports/sets DIF span gas concentration  | B-27        |
| dig in              | Reports status of the digital inputs   | B-43        |
| din                 | Reports/sets digital input channel and active state  | B-43        |
| do (down)           | Simulates pressing down pushbutton   | B-29        |
| dout                | Reports/sets digital output channel and active state   | B-44        |
| dtoa                | Reports outputs of the digital to analog converters per channel  | B-44        |
| en (enter)          | Simulates pressing enter pushbutton  | B-29        |
| er                  | Returns a brief description of the main operating conditions in the format specified in the commands         | B-20        |
| erec                | Returns a brief description of the main operating conditions in the format specified in the command          | B-20        |
| erec format         | Reports/sets erec format (ASCII or binary)   | B-22        |
| erec layout         | Reports current layout of erec data  | B-23        |
| flags               | Reports 8 hexadecimal digits (or flags) that represent the status of the ozonator, PMT, gas mode, and alarms | B-12        |
| flow                | Reports current measured sample flow in LPM  | B-11        |
| format              | Reports/sets current reply termination format  | B-40        |
| gas mode            | Reports current mode of sample, zero, or span  | B-32        |
| gas unit            | Reports/sets current gas units   | B-33        |
| he (help)           | Simulates pressing help pushbutton   | B-29        |
| high avg time       | Reports/sets high range averaging time   | B-9         |

**C-Link Protocol Commands**

## Commands

| <b>Command</b> | <b>Description</b>  | <b>Page</b> |
|----------------|---|-------------|
| high dif       | Reports DIF concentration calculated with high range coefficients             | B-10        |
| high dif coef  | Reports/sets high range DIF coefficients                                      | B-27        |
| high dif gas   | Reports/sets high range DIF span gas concentration                            | B-27        |
| high no        | Reports NO concentration calculated with high range coefficients              | B-10        |
| high no coef   | Reports/sets high range NO coefficients                                       | B-27        |
| high no gas    | Reports/sets high range NO span gas concentration                             | B-27        |
| high noy       | Reports NO <sub>y</sub> concentration calculated with high range coefficients | B-10        |
| high noy coef  | Reports/sets high range NO <sub>y</sub> coefficients                          | B-27        |
| high noy gas   | Reports/sets high range NO <sub>y</sub> span gas concentration                | B-27        |
| high pre       | Reports prereactor concentration calculated with high range coefficients      | B-10        |
| high range dif | Reports/selects current DIF high range  | B-31        |
| high range no  | Reports/selects current NO high range   | B-31        |
| high range noy | Reports/selects current NO <sub>y</sub> high range                            | B-31        |
| host name      | Reports/sets host name string   | B-40        |
| instr name     | Reports instrument name   | B-40        |
| instrument id  | Reports/sets instrument id  | B-41        |
| internal temp  | Reports current internal instrument temperature                               | B-11        |
| isc (iscreen)  | Retrieves framebuffer data used for the display                               | B-29        |
| layout ack     | Disables stale layout/layout changed indicator ('**')                         | B-41        |
| le (left)      | Simulates pressing left pushbutton  | B-29        |
| list din       | Lists current selection for digital input                                     | B-18        |
| list dout      | Lists current selection for digital output                                    | B-18        |
| list lrec      | Lists current selection lrec logging data                                     | B-19        |
| list sp        | Lists current selection in the scratchpad list                                | B-19        |
| list srec      | Lists current selection srec logging data                                     | B-19        |
| list stream    | Lists current selection streaming data output                                 | B-19        |
| list var aout  | Reports list of analog output, index numbers, and variables                   | B-45        |
| list var din   | Reports list of digital input, index numbers, and variables                   | B-45        |
| list var dout  | Reports list of digital output, index numbers, and variables                  | B-45        |
| list var log   | Reports the allowable variable to be set for logging data                     | B-19        |
| low avg time   | Reports/sets low averaging time   | B-9         |

| <b>Command</b> | <b>Description</b>   | <b>Page</b> |
|----------------|--|-------------|
| low dif        | Reports DIF concentration calculated with low range coefficients             | B-10        |
| low dif coef   | Reports/sets low range DIF coefficient                                       | B-27        |
| low dif gas    | Reports/sets low range DIF span gas concentration                            | B-27        |
| low no         | Reports NO concentration calculated with low range coefficients              | B-10        |
| low no coef    | Reports/sets low range NO coefficient  | B-27        |
| low no gas     | Reports/sets low range NO span gas concentration                             | B-27        |
| low noy        | Reports NO <sub>y</sub> concentration calculated with low range coefficients | B-10        |
| low noy coef   | Reports/sets low range NO <sub>y</sub> coefficient                           | B-27        |
| low noy gas    | Reports/sets low range NO <sub>y</sub> span gas concentration                | B-28        |
| low pre        | Reports prereactor concentration calculated with low range coefficients      | B-10        |
| low range dif  | Reports/sets current DIF low range   | B-31        |
| low range no   | Reports/sets current NO low range  | B-31        |
| low range noy  | Reports/sets current NO <sub>y</sub> low range                               | B-31        |
| lr             | Outputs long records in the format specified in the command                  | B-20        |
| lrec           | Outputs long records   | B-21        |
| lrec format    | Reports/sets output format for long records (ASCII or binary)                | B-22        |
| lrec layout    | Reports current layout of lrec data  | B-23        |
| lrec mem size  | Reports maximum number of long records that can be stored                    | B-23        |
| lrec per       | Reports/sets long record logging period                                      | B-23        |
| malloc lrec    | Reports/sets memory allocation for long records                              | B-24        |
| malloc srec    | Reports/sets memory allocation for short records                             | B-24        |
| me (menu)      | Simulates pressing menu pushbutton   | B-29        |
| meas mode      | Reports/sets which measurement mode is active                                | B-34        |
| mode           | Reports operating mode in local, service, or remote                          | B-41        |
| no             | Reports current NO concentration   | B-10        |
| no bkg         | Reports/sets current NO background   | B-28        |
| no coef        | Reports/sets current NO coefficient  | B-27        |
| no gas         | Reports/sets NO span gas concentration                                       | B-27        |
| no of lrec     | Reports/sets number of long records stored in memory                         | B-23        |
| no of srec     | Reports/sets number of short records stored in memory                        | B-23        |
| noy            | Reports current NO <sub>y</sub> concentration                                | B-10        |

**C-Link Protocol Commands**

## Commands

| <b>Command</b>  | <b>Description</b>  | <b>Page</b> |
|-----------------|---|-------------|
| noy bkg         | Reports/sets current NO <sub>y</sub> background                               | B-28        |
| noy coef        | Reports/sets current NO <sub>y</sub> coefficient                              | B-27        |
| noy gas         | Reports/sets NO <sub>y</sub> span gas concentration                           | B-27        |
| ozonator        | Reports/sets ozonator on or off   | B-36        |
| ozonator flow   | Reports current ozonator flow   | B-36        |
| ozonator safety | Reports/sets ozonator safety on or off  | B-36        |
| ozonator status | Reports status of ozonator and safety   | B-37        |
| pmt status      | Reports/sets PMT status on or off   | B-37        |
| pmt temp        | Reports temperature of the PMT cooler (same as cooler temperature)            | B-11        |
| pmt voltage     | Reports current PMT voltage   | B-11        |
| pre             | Reports current prereactor concentration                                      | B-10        |
| pres            | Reports current reaction chamber pressure                                     | B-12        |
| pres comp       | Reports/sets pressure compensation on or off                                  | B-34        |
| program no      | Reports analyzer program number   | B-41        |
| push            | Simulates pressing a key on the front panel                                   | B-29        |
| range dif       | Reports/sets current DIF range  | B-31        |
| range mode      | Reports/sets current range mode   | B-32        |
| range no        | Reports/sets current NO range   | B-31        |
| range noy       | Reports/sets current NO <sub>y</sub> range                                    | B-31        |
| react temp      | Reports current reaction chamber temperature                                  | B-12        |
| relay stat      | Reports/sets relay logic status to for the designated relay(s)                | B-45        |
| ri (right)      | Simulates pressing right pushbutton   | B-29        |
| ru (run)        | Simulates pressing run pushbutton   | B-29        |
| sample          | Sets zero/span valves to sample mode  | B-33        |
| sample flow     | Reports current measured sample flow in LPM                                   | B-11        |
| sample gas      | Sets zero/span valves to sample gas mode                                      | B-33        |
| save            | Stores parameters in FLASH  | B-37        |
| save params     | Stores parameters in FLASH  | B-37        |
| sc (screen)     | C-series legacy command that reports a generic response (Use iscreen instead) | B-30        |
| sp field        | Reports/sets item number and name in scratch pad list                         | B-25        |
| span            | Sets zero/span valves to span mode  | B-33        |
| span gas        | Sets zero/span valves to span gas mode  | B-33        |

| Command       | Description  | Page |
|---------------|--|------|
| sr            | Reports last short record stored                               | B-20 |
| srec          | Reports maximum number of short records                        | B-21 |
| srec format   | Reports/sets output format for short records (ASCII or binary) | B-22 |
| srec layout   | Reports current layout of short record data                    | B-23 |
| srec mem size | Reports maximum number of short records                        | B-23 |
| srec per      | Reports/sets short record logging period                       | B-23 |
| stream per    | Reports/sets current set time interval for streaming data      | B-25 |
| stream time   | Reports/sets a time stamp to streaming data or not             | B-26 |
| temp comp     | Reports/sets temperature compensation on or off                | B-34 |
| time          | Reports/sets current time (24-hour time)                       | B-37 |
| up            | Simulates pressing up pushbutton                               | B-29 |
| zero          | Sets zero/span valves to zero mode                             | B-33 |
| zero gas      | Sets zero/span valves to zero gas mode                         | B-33 |

## 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 12:300 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 9
Receive:   set low avg time 9 ok
```

**Table B–2.** Averaging Times

| <i>Selection</i> | <b>Time, NO Measure Mode,<br/>NO<sub>y</sub> Measure Mode</b> | <b>Time, NO/NO<sub>y</sub> Measure<br/>Mode</b> |
|------------------|---|---|
| 0                | 1* seconds  |   |
| 1                | 1*  |   |
| 2                | 2*  |   |
| 3                | 5*  |   |
| 4                | 10  | 10 seconds                                      |
| 5                | 20  | 20  |
| 6                | 30  | 30  |
| 7                | 60  | 60  |
| 8                | 90  | 90  |
| 9                | 120   | 120   |
| 10               | 180   | 180   |
| 11               | 240   | 240   |
| 12               | 300   | 300   |

\*Manual mode only

---

**no**  
**dif**  
**noy**  
**pre**  
**high no**  
**high dif**  
**high noy**  
**high pre**  
**low no**  
**low dif**  
**low noy**  
**low pre**

These commands report the measured NO, DIF, NO<sub>y</sub> and prereactor concentrations when operating in single range, or high and low NO, DIF, NO<sub>y</sub>, and prereactor when operating in dual or auto range mode. The example below shows that the NO concentration is 67.2 ppb.

```
Send:          no
Receive:       no 6720E-2 ppb
```

---

### conv temp

This command reports the current DIF converter temperature. The example below reports that the current converter temperature is 320.7 °C.

```
Send:      conv temp
Receive:   conv temp 320.7 deg C
```

---

### cooler temp

This command reports the current PMT cooler temperature. The example below reports that the current PMT cooler temperature is -2.8 °C.

```
Send:      pmt temp
Receive:   pmt temp -2.8 deg C
```

---

### flow

#### sample flow

These commands report the current measured flow. The example below reports that the flow measurement is 0.700 liters/minute.

```
Send:      flow
Receive:   flow 0.7 1/m
```

---

### 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 027.2 deg C, actual 027.2
```

---

### pmt temp

This command reports the PMT cooler temperature. The example below reports that the PMT cooler temperature is -2.8 °C.

```
Send:      pmt temp
Receive:   pmt temp -2.8 deg C
```

---

### pmt voltage

This command reports the PMT voltage. The example below reports that the current PMT voltage is -750 volts.

```
Send:      pmt voltage
Receive:   pmt voltage -750
```

---

**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 300 mmHg is used as default pressure even though the actual pressure is 306.3 mmHg. The example below shows that the actual reaction chamber pressure is 306.3 mmHg.

Send: pres  
Receive: pres 300.0 mm Hg, actual 306.6

---

**react temp**

This command reports the current reaction chamber temperature. The example below reports that the current reaction temperature is 49.0 °C.

Send: react temp  
Receive: react temp 49.0 deg C

---

**flags**

This reports 8 hexadecimal digits (or flags) that represent the status of the ozonator, PMT, 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 ozonator and PMT are both on, and that the instrument is in the span gas mode.

Send: flags  
Receive: flags 80028000



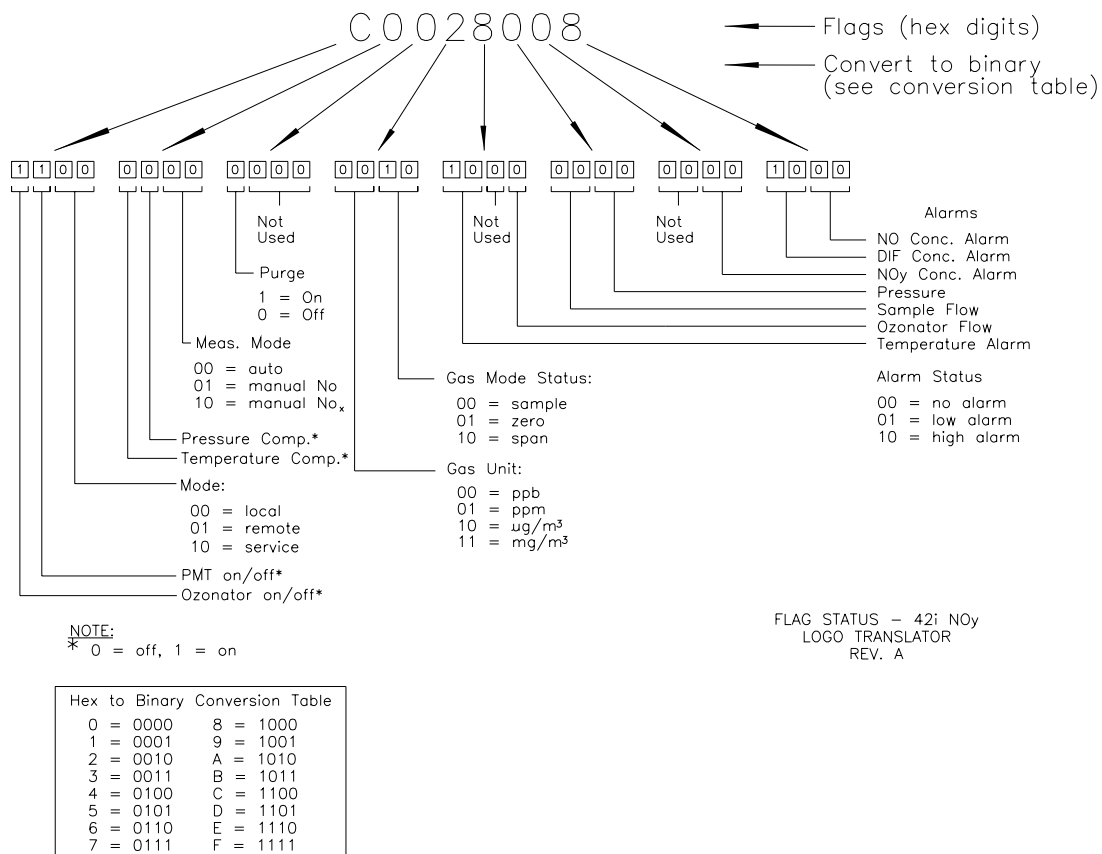


Figure B-1. Flags

## Alarms

**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 47.0 °C.

Send: alarm chamber temp min  
Receive: alarm chamber temp min 47.0 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 50.0 °C.

Send: set alarm chamber temp max 50.0  
Receive: set alarm chamber temp max 50.0 ok

---

**alarm conc no min**  
**alarm conc dif min**  
**alarm conc noy min**  
**alarm conc pre min**  
**alarm conc no max**  
**alarm conc dif max**  
**alarm conc noy max**  
**alarm conc pre max**

These commands report the NO, DIF, NO<sub>y</sub>, and prereactor concentration alarm minimum and maximum values current setting. The example below reports that the NO concentration minimum is 62.7 ppb.

Send:           alarm conc no min  
Receive:       alarm conc no min 62.7 ppb

**set alarm conc no min *value***  
**set alarm conc dif min *value***  
**set alarm conc noy min *value***  
**set alarm conc pre min *value***  
**set alarm conc no max *value***  
**set alarm conc dif max *value***  
**set alarm conc noy max *value***  
**set alarm conc pre max *value***

These commands set the NO, DIF, NO<sub>y</sub>, and prereactor 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 NO concentration alarm maximum value to 115.

Send:           set alarm conc no max 115  
Receive:       set alarm conc no max 115 ok

---

**alarm cooler temp min**  
**alarm cooler temp max**

These commands report the cooler temperature alarm minimum and maximum value current settings. The example below reports that the cooler temperature alarm minimum value is -10.0 °C.

Send:           alarm cooler temp min  
Receive:       alarm cooler temp min -10.0 deg C

**set alarm cooler temp min *value***  
**set alarm cooler temp max *value***

These commands set the cooler temperature alarm minimum and maximum values to *value*, where *value* is a floating-point number representing cooler temperature alarm limits in degrees C. The example below sets the cooler temperature alarm maximum value to -2.0 °C.

```
Send:      set alarm cooler temp max -2.0
Receive:   set alarm cooler temp max -2.0 ok
```

**alarm ext converter temp min****alarm ext converter temp max**

These commands report the external converter temperature alarm minimum and maximum value current settings. The example below reports that the external converter temperature alarm minimum value is 300.0 °C.

```
Send:      alarm ext converter temp min
Receive:   alarm ext converter temp min 300.0 deg C
```

**set alarm ext converter temp min *value*****set alarm ext converter temp max *value***

These commands set the external converter temperature alarm minimum and maximum values to *value*, where *value* is a floating-point number representing the external converter temperature alarm limits in degrees C. The example below sets the external converter temperature alarm maximum value to 340.0 °C.

```
Send:      set alarm ext converter temp max 340
Receive:   set alarm ext converter temp max 340 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:      alarm internal temp min
Receive:   alarm internal temp min 15.0 deg C
```

**set alarm internal temp min *value*****set alarm internal temp max *value***

These commands set the internal temperature 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 alarm internal temp max 45
Receive:   set alarm internal temp max 45 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:      alarm pressure min
Receive:   alarm pressure 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 0.300 LPM.

```
Send:      alarm sample flow min
Receive:   alarm sample flow min 0.3 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 2 LPM.

```
Send:      set alarm sample flow max 2
Receive:   set alarm sample flow max 2 ok
```

---

**alarm trig conc no**

**alarm trig conc dif**

**alarm trig conc noy**

**alarm trig conc pre**

This command reports the NO, DIF, NO<sub>y</sub>, and prereactor concentration alarm trigger action for minimum alarm, current setting, to either floor or ceiling. The example below shows the NO concentration minimum alarm trigger to ceiling, according to [Table B-3](#).

```
Send:      alarm trig conc no
Receive:   alarm trig conc no 1
```

**set alarm trig conc no *value***

**set alarm trig conc dif *value***

**set alarm trig conc noy *value***

**set alarm trig conc pre *value***

These commands set the NO, DIF, NO<sub>y</sub>, and prereactor concentration alarm minimum *value*, where *value* is set to either floor or ceiling, according to Table B-3. The example below sets the NO concentration minimum alarm trigger to ceiling.

Send: set alarm trig conc no 1  
Receive: set alarm trig conc no 1 ok

**Table B-3.** Alarm Trigger Values

| Value | Alarm Trigger |
|-------|---------------|
| 00    | Floor         |
| 01    | Ceiling       |

## Diagnostics

---

### diag volt mb

This command reports the diagnostic voltage measurements on the motherboard. The sequence of voltages is: Positive 24, positive 15, positive 5, positive 3.3, and negative 3.3. Each voltage value is separated by a space.

Send: diag volt mb  
Receive: diag volt mb 24.1 14.9 4.9 3.2 -3.2

---

### diag volt mib

This command reports the diagnostic voltage measurements on the measurement interface board. The sequence of voltages is: Positive 24, positive 15, negative 15, positive 5, positive 3.3, and positive 15. 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 14.9

---

### 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 35 CONC ALARM open  
                  3 4 UNITS open  
                  4 11 GEN ALARM closed  
                  7 7 NO MODE open  
                  8 8 NOy 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 1 no
           2 2 dif
           3 3 noy
           4 18 intt
           5 25 pres
           6 26 smp1f
```

---

**list var log**

This command reports the allowable variable to be set for logging data.

```
Send:      list var log
Receive:   list var log
           index variable
           0 none
           1 no
           2 dif
           3 noy
           6 lono
           7 lodif
           8 lonoy
           11 hino
           12 hidif
           13 hinoy
           18 intt
           19 rctt
           20 pmtt
           22 cvext
           25 pres
           26 smp1f
           27 pmtv
           28 ain1
           29 ain2
           30 ain3
           31 ain4
           32 ain5
           33 ain6
           34 ain7
           35 ain8
```

36 ozonf  
 37 pre  
 38 lopre  
 39 hipre

**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 errec/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
              12:31 02-22-03 flags 54089100 no -8413E-1 noy -8485E-1
              lono -6471E-1 lonoy -6527E-1 pres 130.9 pmtt 53.2 intt
              80.0 rctt 80.0 convt 61 smp1f 0.500 ozonf 0.000 pmtv -
              115
```

**errec**

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 “errec format” commands. For details on how to decode the flag fields within these records, see the “flags” command.

```
Send:          errec
Receive:       errec
              10:11 04-06-05 flags DD008000 no 0.000 noy 0.000 dif
              0.000 1 lono 147.500 lonoy 0.000 lodif 0.000 1 pmtv
              805.491 tempal 1 pres 172.278 pcal 150.000 smp1f 0.000
              ozonf 0.050 hiavgtime 10 loavgtime 10 nobkg 0.000
              noybkf 0.000 nocoef 1.000 noycoef 1.000 difcoef 1.000
              lonocoef 1.000 lonoycoef 1.000 lodifcoef 1.000 norange
              100000.000 noyrange 100000.000 difrange 100000.000
              lonorange 100000.000 lonoyrange 100000.000 lodifrange
              100000.000
```



```

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 and dynamic data. 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 dual range, the long records and short records contain the high and low NO and NO<sub>y</sub> concentrations. In single range the low NO and low NO<sub>y</sub> values are set to 0 and the high NO and high NO<sub>y</sub> are used. In NO or NO<sub>y</sub> only mode, the pertinent high value used, other concentrations are set to 0. Concentrations are stored in either ppb or µg/m<sup>3</sup>.

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
           11:03 02-22-03  flags 54089100 no 8416E-1 noy 8458E-1
           lono 6474E-1 lonoy 6506E-1 pres 131.4 pmtt 53.1 intt
           80.0 rctt 80.0 convt 61 simplf 0.500 ozonf 0.000 pmtv -
           116
           11:04 02-22-03  flags 54089100 no 8421E-1 noy 8457E-1
           lono 6477E-1 lonoy 6505E-1 pres 131.5 pmtt 53.1 intt
           80.0 rctt 80.0 convt 61 simplf 0.500 ozonf 0.000 pmtv -
           116
           11:05 02-22-03  flags 54089100 no 8440E-1 noy 8456E-1
           lono 6492E-1 lonoy 6505E-1 pres 131.5 pmtt 53.2 intt
           80.0 rctt 80.0 convt 61 simplf 0.500 ozonf 0.000 pmtv -
           116
           11:06 02-22-03  flags 54089100 no 8432E-1 noy 8483E-1
           lono 6486E-1 lonoy 6525E-1 pres 133.0 pmtt 53.0 intt
           80.0 rctt 80.0 convt 61 simplf 0.500 ozonf 0.000 pmtv -
           116
           11:07 02-22-03  flags 54089100 no 8442E-1 noy 8383E-1
           lono 6494E-1 lonoy 6449E-1 pres 131.5 pmtt 53.1 intt
  
```

```
80.0 rctt 80.0 convt 61 smplf 0.500 ozonf 0.000 pmtv -  
116
```

where:

pmtv = PMT Voltage  
pmtt = PMT Temperature  
intt = Internal Temperature  
rctt = Reaction Chamber Temperature  
convt = External Converter Temperature  
smplf = Sample Flow  
ozonf = Ozonator Flow  
pres = Pressure

---

**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 %f %f %f %f %f %f %f %f
               %f
               t D L ffffffffffffff
               flags noy hino hino pres pmtt intt rctt convt simplf
               ozonf pmtv
```

---

**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 7 blocks were reserved for long records and the maximum number of long records that can be stored in memory is 1426.

```
Send:          lrec mem size
Receive:       lrec mem size 1426 recs, 7 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 lrec 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 no bkg**  
**set cal noy bkg**  
**set cal pre bkg**

These commands will auto-calibrate the NO, NO<sub>y</sub>, and prereactor backgrounds. If the instrument is set to manual NO<sub>y</sub> mode, the response to “set cal no bkg” will be “can’t, wrong settings”. The example below shows a successful auto-calibration of the NO background.

Send: set cal no bkg  
Receive: set cal no bkg ok

---

**set cal no coef**  
**set cal dif coef**  
**set cal noy coef**  
**set cal high no coef**  
**set cal high dif coef**  
**set cal high noy coef**  
**set cal low no coef**  
**set cal low dif coef**  
**set cal low noy coef**

These commands will auto-calibrate NO, DIF, and NO<sub>y</sub> coefficients based on NO, DIF, and NO<sub>y</sub> 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 NO coefficient.

Send:            set cal low no coef  
Receive:         set cal low no coef ok

---

**no coef**  
**dif coef**  
**noy coef**  
**high no coef**  
**high dif coef**  
**high noy coef**  
**low no coef**  
**low dif coef**  
**low noy coef**

These commands report NO, DIF, and NO<sub>y</sub> 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 NO coefficient is 1.000.

Send:            no coef  
Receive:         no coef 1.000

**set no coef *value***  
**set dif coef *value***  
**set noy coef *value***  
**set high no coef *value***  
**set high dif coef *value***  
**set high noy coef *value***  
**set low no coef *value***  
**set low dif coef *value***  
**set low noy coef *value***

These commands set the NO, DIF, and NO<sub>y</sub> coefficients to user-defined values to *value*, where *value* is a floating-point representation of the coefficient. The example below sets the NO coefficient to 1.005.

Send:            set no coef 1.005  
Receive:         set no coef 1.005 ok

---

**no gas**  
**dif gas**  
**noy gas**  
**high no gas**  
**high dif gas**  
**high noy gas**  
**low no gas**  
**low dif gas**

**low noy gas**

These commands report NO, DIF, and NO<sub>y</sub> span gas concentrations used to auto-calibrate low NO, DIF, and NO<sub>y</sub> coefficients. 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 reports that the NO low span gas concentration is 240.0 ppb.

Send: low no gas  
Receive: low no gas 2400E-1 ppb

*set no gas value*  
*set dif gas value*  
*set noy gas value*  
*set high no gas value*  
*set high dif gas value*  
*set high noy gas value*  
*set low no gas value*  
*set low dif gas value*  
*set low noy coef value*

These commands set the NO, DIF, and NO<sub>y</sub> span gas concentrations used by the auto-calibration routine to *value*, where *value* is a floating-point representation of the gas concentration in current selected units. The gas units are the same as those chosen by the user. The example below sets the NO span gas concentration to 123.4 ppb.

Send: set no gas 123.4  
Receive: set no gas 123.4 ok

---

**no bkg**  
**noy bkg**  
**bkg no**  
**bkg pre**

These commands report the current NO, NO<sub>y</sub>, and prereactor backgrounds. The example below reports that the NO background is 5.5 ppb.

Send: no bkg  
Receive: no bkg 5.5 ppb

*set no bkg value*  
*set noy bkg value*  
*set bkg no value*  
*set bkg pre value*

These commands are used to set NO, NO<sub>y</sub>, and prereactor 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 NO background to 5.5 ppb.

Send:            set no bkg 5.5  
Receive:         set no bkg 5.5 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 *iSeries* 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 no  
range dif  
range noy  
high range no  
high range dif  
high range noy  
low range no  
low range dif  
low range noy

These commands report NO, DIF, and NO<sub>y</sub> 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 NO full-scale range is set to 50 ppb, according to [Table B-6](#).

Send: range no  
Receive: range no 3: 5000E-2 ppb

*set range Selection*  
*set high range Selection*  
*set low range Selection*

These commands select the NO, DIF, and NO<sub>y</sub> full-scale ranges, according to [Table B-6](#). The example below sets the NO full-scale range to 200 ppb.

Send: set range 5  
Receive: set range 5 ok

**Table B-6.** Standard Ranges

| Selection | ppb | µg/m <sup>3</sup> |
|-----------|-----|-------------------|
| 0         | 5   | 10                |
| 1         | 10  | 20                |
| 2         | 20  | 50                |
| 3         | 50  | 100               |
| 4         | 100 | 200               |
| 5         | 200 | 500               |
| 6         | C1  | C1                |
| 7         | C2  | C2                |
| 8         | 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 5.50 ppb.

Send: custom 1  
Receive: custom 1 550E-2 ppb

**set custom range range value**

**set custom 1 value**

**set custom 2 value**

**set custom 3 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 ppb or  $\mu\text{g}/\text{m}^3$ . The example below sets the custom 1 range to 55.5 ppb.

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**  
**set sample gas**

These commands set 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**  
**set zero gas**

These commands set 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**  
**set span gas**

These commands set 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 (ppb or  $\mu\text{g}/\text{m}^3$ ). The example reports that the gas unit is set to ppb.

Send: gas unit  
Receive: gas unit ppb

**set gas unit**  
*unit* = | ppb |  $\mu\text{g}/\text{m}^3$  |

This command sets the gas units to ppb or  $\mu\text{g}/\text{m}^3$ . The example below sets the gas units to  $\mu\text{g}/\text{m}^3$ .

Send: set gas unit ug/m3  
Receive: set gas unit ug/m3 ok

---

### meas mode

This command reports which measurement mode (NO/NO<sub>y</sub>, NO, NO<sub>y</sub>, or prereactor) is active. The example below reports that the measurement mode is set to NO.

Send: meas mode  
Receive: meas mode no

### set meas mode *mode*

*mode* = | no/noy | no | noy | pre |

This command sets the instrument to NO/NO<sub>y</sub> (auto) mode, manual NO mode, manual NO<sub>y</sub> mode, or manual prereactor mode. The example below sets the instrument to the manual NO mode.

Send: set meas mode no  
Receive: set meas mode no 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%           |

---

**conv set temp**

This command reports the temperature that the external converter is set to. The example below reports that the converter temperature is set to 325 °C.

Send: conv set temp  
Receive: conv set temp 325 deg C

**set conv set temp *value***

This command sets the temperature that the external converter is set to, where *value* is an integer representing degrees C. The example below sets the converter temperature to 325 °C.

Send: set conv set temp  
Receive: set conv set temp 325 deg C ok

---

**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

---

**ozonator**

This command reports the ozonator is on or off. The example below reports that the ozonator is on.

Send: ozonator  
Receive: ozonator on

**set ozonator *onoff***

These commands set the ozonator *on* or *off*. The example below sets the ozonator off.

Send: set ozonator off  
Receive: set ozonator off ok

---

**ozonator flow**

This command reports the current ozonator flow. The example below reports that the current ozonator flow is 0.050 LPM.

Send: ozonator flow  
Receive: ozonator flow 0.050 l/m

---

**ozonator safety**

This command reports the status of the ozonator safety on or off. The example below reports that the ozonator safety is on.

Send: ozonator safety  
Receive: ozonator safety on



### **set ozonator safety *onoff***

These commands set the ozonator safety *on* or *off*. The example below sets the ozonator safety *off*.

Send:           set ozonator safety off  
Receive:       set ozonator safety off ok

---

### **ozonator status**

This command reports the status of the ozonator and safety. The example below reports that the ozonator is *off*.

Send:           ozonator status  
Receive:       ozonator status off

---

### **pmt**

#### **pmt status**

These commands report the status of the PMT *on* or *off*. The example below reports that the PMT is *on*.

Send:           pmt status  
Receive:       pmt status on

#### **set pmt *onoff***

These commands set the PMT *on* or *off*. The example below turns the PMT *off*.

Send:           set pmt off  
Receive:       set pmt off 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

## Communications Configuration

**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
```

---

**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 192.168.1.15
```

**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 192.168.1.15
Receive:   set addr ip 192.168.1.15 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

| <b>Format</b> | <b>Reply Termination</b> |
|---------------|--------------------------|
| 00            | <CR>                     |
| 01            | <NL> sum xxxx <CR>       |

where `xxxx` = 4 hexadecimal digits that represent the sum of all the characters (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  
NO-DIF-NOy Analyzer  
NO-DIF-NOy Analyzer

---

### **instrument id**

This command reports the instrument id.

Send: instrument id  
Receive: instrument id 42

### **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 50  
Receive: set instrument id 50 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 42iY 01.03.21.154

---

### **set layout ack**

This command disables the stale layout/layout change indicator (\*) that is attached to each response if the layout has changed.

## I/O Configuration

Send: set layout ack  
Receive: set layout ack ok

---

### **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 9 corresponding to action of “analog outputs to zero” with the active state being high.

Send:            din 5  
Receive:         din 5 9 AOUTS TO ZERO 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 1 3 high  
Receive:         set din 1 3 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 4
Receive:       dout 4 11 GEN ALARM 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 4 11 open
Receive:       set dout 4 11 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** If the instrument is in a mode which does not provide a particular output, and that output is selected, the value will be 0.0. ▲

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 | NO              | High NO              | High/Low NO              |
| 2      | Voltage Output | DIF             | High DIF             | High/Low DIF             |
| 3      | Voltage Output | NO <sub>y</sub> | High NO <sub>y</sub> | High/Low NO <sub>y</sub> |
| 4      | Voltage Output | Not Used        | Low NO               | Range (NO <sub>y</sub> ) |
| 5      | Voltage Output | Not Used        | Low DIF              | Not Used                 |
| 6      | Voltage Output | Not Used        | Low NO <sub>y</sub>  | Not Used                 |
| 7      | Current Output | NO              | High NO              | High/Low NO              |
| 8      | Current Output | DIF             | High DIF             | High/Low DIF             |
| 9      | Current Output | NO <sub>y</sub> | High NO <sub>y</sub> | High/Low NO <sub>y</sub> |
| 10     | Current Output | Not Used        | Low NO               | Range (NO <sub>y</sub> ) |



| D to A | Function       | Single Range | Dual Range          | Auto Range |
|--------|----------------|--------------|---------------------|------------|
| 11     | Current Output | Not Used     | Low DIF             | Not Used   |
| 12     | Current Output | Not Used     | Low NO <sub>y</sub> | 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 no
           2 dif
           3 noy
           18 intt
           19 rctt
           20 pmtt
           21 convt
           25 pres
           26 smp1f
           27 pmtv
           28 ain1
           29 ain2
           30 ain3
           31 ain4
           32 ain5
           33 ain6
           34 ain7
           35 ain8
```

---

### 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. ▲

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 EREC 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 *iSeries* 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 42*i* NO<sub>y</sub> 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 *iSeries* to support MODBUS RTU 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

iSeries 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 slave 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 42i NO<sub>y</sub>.

### **(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,<br>03=Illegal Data, 04=Slave Device Failure |

Here is an example of a request and response to read outputs 2–15:

**Request**

| <i>Field Name</i>      | <i>(Hex)</i> |
|------------------------|--------------|
| Function               | 0x01         |
| Starting Address Hi    | 0x00         |
| Starting Address Lo    | 0x02         |
| Quantity of Outputs Hi | 0x00         |
| Quantity of Outputs Lo | 0x0D         |

**Response**

| <i>Field Name</i>   | <i>(Hex)</i> |
|---------------------|--------------|
| 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 0–15. 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,<br>03=Illegal Data, 04=Slave Device Failure |

Here is an example of a request and response to read registers 10–13:

**Request**

| <i>Field Name</i>   | <i>(Hex)</i> |
|---------------------|--------------|
| Function            | 0x03         |
| Starting Address Hi | 0x00         |
| Starting Address Lo | 0x09         |
| No. of Registers Hi | 0x00         |
| No. of Registers Lo | 0x04         |

**Response**

| <i>Field Name</i>      | <i>(Hex)</i> |
|------------------------|--------------|
| 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**

| <i>Field Name</i> | <i>(Hex)</i> |
|-------------------|--------------|
| Function          | 05           |
| Output Address Hi | 00           |
| Output Address Lo | 05           |
| Output Value Hi   | FF           |
| Output Value Lo   | 00           |

**Response**

| <i>Field Name</i> | <i>(Hex)</i> |
|-------------------|--------------|
| 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 42i NO<sub>y</sub>.

**Table C-1.** Read Coils for Model 42i NO<sub>y</sub>

| <b>Coil Number</b> | <b>Status</b>        |
|--------------------|----------------------|
| 1                  | AUTORANGE (NO)       |
| 2                  | LOCAL/REMOTE         |
| 3                  | SERVICE              |
| 4                  | UNITS                |
| 5                  | ZERO MODE            |
| 6                  | SPAN MODE            |
| 7                  | NO MODE              |
| 8                  | NO <sub>y</sub> MODE |
| 9                  | NOT USED             |
| 10                 | PRE MODE             |
| 11                 | GEN ALARM            |
| 12                 | NO CONC MAX ALARM    |



| <b>Coil Number</b> | <b>Status</b>                  |
|--------------------|--------------------------------|
| 13                 | NO CONC MIN ALARM              |
| 14                 | DIF CONC MAX ALARM             |
| 15                 | DIF CONC MIN ALARM             |
| 16                 | NO <sub>y</sub> CONC MAX ALARM |
| 17                 | NO <sub>y</sub> CONC MIN ALARM |
| 18                 | NOT USED                       |
| 19                 | NOT USED                       |
| 20                 | NOT USED                       |
| 21                 | NOT USED                       |
| 22                 | INT TEMP ALARM                 |
| 23                 | CHAMB TEMP ALARM               |
| 24                 | COOLER TEMP ALARM              |
| 25                 | NOT USED                       |
| 26                 | EXT CONVERTER TEMP ALARM       |
| 27                 | NOT USED                       |
| 28                 | PRESSURE ALARM                 |
| 29                 | FLOW ALARM                     |
| 30                 | OZONE FLOW ALARM               |
| 31                 | MOTHERBOARD STATUS ALARM       |
| 32                 | INTERFACE BD STATUS ALARM      |
| 33                 | I/O EXP BD STATUS ALARM        |
| 34                 | AUTORANGE                      |
| 35                 | CONC ALARM                     |
| 36                 | SAMPLE MODE                    |
| 37                 | PURGE MODE                     |
| 38                 | EXT CONVERTER STATUS ALARM     |
| 39                 | ZERO CHECK/CAL ALARM           |
| 40                 | SPAN CHECK/CAL ALARM           |

**Table C-2.** Read Registers for Model 42i NO<sub>y</sub>

| <b>Register Number</b> | <b>Variable</b> |
|------------------------|-----------------|
| 40001&40002            | NO              |
| 40003&40004            | DIF             |

**MODBUS Protocol**

## MODBUS Parameters Supported

| <b>Register Number</b> | <b>Variable</b>          |
|------------------------|--------------------------|
| 40005&40006            | NO <sub>y</sub>          |
| 40007&40008            | NOT USED                 |
| 40009&40010            | NOT USED                 |
| 40011&40012            | LOW NO                   |
| 40013&40014            | LOW DIF                  |
| 40015&40016            | LOW NO <sub>y</sub>      |
| 40017&40018            | NOT USED                 |
| 40019&40020            | NOT USED                 |
| 40021&40022            | HIGH NO                  |
| 40023&40024            | HIGH DIF                 |
| 40025&40026            | HIGH NO <sub>y</sub>     |
| 40027&40028            | NOT USED                 |
| 40029&40030            | NOT USED                 |
| 40031&40032            | RANGE (NO <sub>y</sub> ) |
| 40033&40034            | NOT USED                 |
| 40035&40036            | INTERNAL TEMPERATURE     |
| 40037&40038            | CHAMBER TEMPERATURE      |
| 40039&40040            | COOLER TEMPERATURE       |
| 40041&40042            | NOT USED                 |
| 40043&40044            | EXT CONVERTER TEMP       |
| 40045&40046            | NOT USED                 |
| 40047&40048            | NOT USED                 |
| 40049&40050            | CHAMBER PRESSURE         |
| 40051&40052            | SAMPLE FLOW              |
| 40053&40054            | PMT VOLTS                |
| 40055&40056            | ANALOG IN 1              |
| 40057&40058            | ANALOG IN 2              |
| 40059&40060            | ANALOG IN 3              |
| 40061&40062            | ANALOG IN 4              |
| 40063&40064            | ANALOG IN 5              |
| 40065&40066            | ANALOG IN 6              |
| 40067&40068            | ANALOG IN 7              |
| 40069&40070            | ANALOG IN 8              |
| 40071&40072            | OZONATOR FLOW            |

| Register Number | Variable                              |
|-----------------|---------------------------------------|
| 40073&40074     | PREREACTOR                            |
| 40075&40076     | LOW PREREACTOR                        |
| 40077&40078     | HIGH PREREACTOR                       |
| 40079&40080     | NO CORRECTION CONC*                   |
| 40081&40082     | DIF CORRECTION CONC*                  |
| 40083&40084     | NO <sub>y</sub> CORRECTION CONC*      |
| 40085&40086     | NOT USED                              |
| 40087&40088     | NOT USED                              |
| 40089&40090     | LOW NO CORRECTION CONC*               |
| 40091&40092     | LOW DIF CORRECTION CONC*              |
| 40093&40094     | LOW NO <sub>y</sub> CORRECTION CONC*  |
| 40095&40096     | NOT USED                              |
| 40097&40098     | NOT USED                              |
| 40099&40100     | HIGH NO CORRECTION CONC*              |
| 40101&40102     | HIGH DIF CORRECTION CONC*             |
| 40103&40104     | HIGH NO <sub>y</sub> CORRECTION CONC* |
| 40105&40106     | NOT USED                              |
| 40107&40108     | NOT USED                              |
| 401109&401110   | CAPPILLARY TEMP                       |

\*If O<sub>2</sub> Correction Option is installed.

**Table C-3.** Write Coils for Model 42i NO<sub>y</sub>

| Coil Number | Action Triggered     |
|-------------|----------------------|
| 101         | ZERO MODE            |
| 102         | SPAN MODE            |
| 103         | NO MODE              |
| 104         | NO <sub>y</sub> MODE |
| 105         | NOT USED             |
| 106         | PRE MODE             |
| 107         | SET BACKGROUND       |
| 108         | CAL TO LOW SPAN      |
| 109         | AOUTS TO ZERO        |
| 110         | AOUTS TO FS          |
| 111         | CAL TO HIGH SPAN     |



## 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 *iSeries* 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 42*i* NO<sub>y</sub> 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 *iSeries* 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

iSeries 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.

## Geositech Commands

The following commands are supported by the Geositech protocol:

- Instrument Control Command (ST)
- Data Sampling/Data Query Command (DA)

## Instrument Control Command (ST)

There are three control commands supported by the Geositech 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 “[Measurements reported in response to DA command](#)” 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>.



## Operating and Error Status

See [Table D-1](#) for operating status and [Table D-2](#) for error status for the Model 42i NO<sub>y</sub>.

**Table D-1.** Operating Status for Model 42i NO<sub>y</sub>

|                                  | D7       | D6       | D5       | D4       |  | D3       | D2       | D1       | D0       |
|----------------------------------|----------|----------|----------|----------|--|----------|----------|----------|----------|
| <b>→ Bit</b>                     | <b>8</b> | <b>7</b> | <b>6</b> | <b>5</b> |  | <b>4</b> | <b>3</b> | <b>2</b> | <b>1</b> |
| → Hex-value                      | 80       | 40       | 20       | 10       |  | 08       | 04       | 02       | 01       |
|                                  | MSB      |          |          |          |  | LSB      |          |          |          |
| <b>Operating status:</b>         |          |          |          |          |  |          |          |          |          |
| 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 42i NO<sub>y</sub>

|                       | D7       | D6       | D5       | D4       |  | D3       | D2       | D1       | D0       |
|-----------------------|----------|----------|----------|----------|--|----------|----------|----------|----------|
| <b>→ Bit</b>          | <b>8</b> | <b>7</b> | <b>6</b> | <b>5</b> |  | <b>4</b> | <b>3</b> | <b>2</b> | <b>1</b> |
| → Hex-value           | 80       | 40       | 20       | 10       |  | 08       | 04       | 02       | 01       |
|                       | MSB      |          |          |          |  | LSB      |          |          |          |
| <b>Error status:</b>  |          |          |          |          |  |          |          |          |          |
| Not Used              | 0        | 0        | 0        | 0        |  | 0        | 0        | 0        | 1        |
| Not Used              | 0        | 0        | 0        | 0        |  | 0        | 0        | 1        | 0        |
| Not Used              | 0        | 0        | 0        | 0        |  | 0        | 1        | 0        | 0        |
| Any Temperature 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        |
| Ozonator Flow Alarm   | 0        | 1        | 0        | 0        |  | 0        | 0        | 0        | 0        |
| Not used              | 1        | 0        | 0        | 0        |  | 0        | 0        | 0        | 0        |



# Appendix E

## Standards for Trace Level Analyzers

The development of ultra-sensitive analytical analyzers for the measurement of trace quantities of pollutants such as NO, NO<sub>2</sub>, or SO<sub>2</sub> has raised a number of questions concerning proper calibration procedures and equipment. Analyzers that in theory have detection limits below 1 ppb, may not in practice be useful due to inadequate and/or inaccurate calibration practices.

Thermo Fisher Scientific has in its development of Trace Level instrumentation used the same basic principles for calibration as for standard analyzers. However, enhanced emphasis on the zero air supply used for dilution of standard gases and for establishing a zero background signal is made.

Chemiluminescence NO/NO<sub>x</sub> and fluorescence SO<sub>2</sub> analyzers (when properly designed) have been shown in numerous research studies and compliance monitoring situations to be inherently linear over a wide dynamic range. Calibration is normally done using first a zero gas then a span gas generated by dilution of a calibration gas cylinder. Dilution is done by dynamic mixing of accurately known flows of span gas and zero gas. For Trace Level analyzers, mass flow controllers that are NIST traceable are required. Nitric oxide and sulfur dioxide calibration standards between 1 and 10 ppm are readily available in specially treated cylinders, and have been shown to have excellent stability and accuracy. NIST traceable mass flow controllers with full scale ranges from 20 sccm to 20,000 sccm are also readily available. It is therefore relatively straightforward to generate span gas concentration from below 1 ppb to 10 ppb assuming a suitable zero gas source is used. For example:

$$[\text{NO}]_{\text{GENERATED}} = [\text{NO}]_{\text{SPAN}} \times \frac{\text{NO Flow}}{\text{Total Flow}}$$

Assuming a calibration cylinder of 1 ppm, NO flow of 10 sccm, and a total flow of 10,000 sccm, allows generation of span concentration of 1 ppb. Using the specifications of the mass flow controllers and calibration cylinder, this concentration should be accurate to within ±5%. Multi-point concentrations from 0.5 ppb to 10 ppb may be similarly generated, establishing the linearity of the particular analyzer being calibrated.

Thermo Fisher Scientific believes it is not necessary to generate concentrations below these levels since the fundamental linearity of the instrumentation has been demonstrated.

If however, the zero air used for dilution and for establishing baseline conditions has impurity levels greater than several tenths of a ppb, the accuracy of the analyzer being calibrated may be severely jeopardized. A 0.5 ppb impurity level is equivalent to a 10% relative error for a 5 ppb concentration.

Ultra-zero ambient monitoring gases are available from gas suppliers, however, the typical analyses for NO<sub>x</sub> and SO<sub>2</sub> impurities only guarantee levels below 5 ppb. In practice, Thermo Fisher Scientific's personnel as well as other users of Trace Level equipment have found these gases to be at least an order of magnitude better than what is guaranteed, and therefore are adequate for most purposes. Non-reactive and diffusion resistant regulators are required, and as the cylinder pressure falls below 500 psig, the integrity of the zero gas becomes more in question.

Rather than relying on cylinder sources for zero air, Thermo Fisher Scientific routinely uses zero air generated by "brute force", that is, by compression, chemical scrubbing and reaction. Ambient air that has been compressed and pressurized to give an output of about 25 psig is dried by passing the air through a heatless air dryer (for example) and then sent through a series of chemical reactors and/or scrubbers. Normally, these include indicating silica gel, Purafil, activated charcoal, and a fine (5 micron) particulate filter. When first used, this "brute force" approach actually can generate enhanced impurity levels for NO<sub>x</sub> and SO<sub>2</sub>, as these gases desorb from the chemical reactors. However, after 24 to 48 hours of continuous operation, impurity levels will generally fall and stabilize below detection limits for the Trace Level analyzers. It is critical when using this type of zero air source to always maintain flow through the system. If flow is interrupted, even for a short period, a reconditioning time of up to 24 hours may be required.

The Model 42*i* Trace Level analyzer has zero air diagnostic capability built within the instrument. The monitor has three channels, a NO, NO<sub>x</sub>, and prereactor channel. The prereactor channel mixes the sample with a high concentration of ozone prior to the detection chamber. This effectively creates a dynamic zero by removing any NO from the gas stream. If the zero air source being used is truly a good zero air, the background signals in the NO, NO<sub>x</sub>, and prereactor modes are virtually identical (within 0.1 to 0.2 ppb due to pneumatic differences). If the background in the no and/or NO<sub>x</sub> channels are enhanced relative to the prereactor channel, the zero air source being used is inadequate. When calibrating the zero in the Model 42*i* Trace Level, the background levels are calculated and available in the Calibration Factors menu. Normal background levels are in the 0.5 to 1.5

ppb range, primarily due to the dark current of the photomultiplier tube, note due to impurities in the zero gas source.

In conclusion, tests by the United States Environmental Agency, Tennessee Valley Authority, Battelle National Labs, and THERMO FISHER SCIENTIFIC's Engineering Department have demonstrated that Trace Level analyzers are readily calibrated at the low concentration levels require for sub-ambient monitoring. Although extra care is required, primarily in zero air generation, users familiar with normal compliance requirements should be able with minimal additional effort to obtain valid concentration data.

