ecotech
environmental monitoring solutions

EC9841

Oxides of Nitrogen Analyser

User Manual

Revision: E

www.ecotech.com

EC9841
Quick Start Guide.

Step 1 – Installation:

- Inspect analyzer for damage before turning on. ***Service Manual:- 1.1.***
- Select an appropriate location. ***Operation Manual:- 2.1.1.***
- Connect Gas lines. ***Operation Manual:- 2.1.2.2.***
- Connect Analog Output Cables. ***Operation Manual:- 2.1.2.1.***
- Connect RS232 Cables. ***Operation Manual:- 4.2.1.***
- Check the mains power selection switch (115 or 230 VAC). ***Operation Manual:- 2.2.***
- Connect AC Mains Power. ***Operation Manual:- 2.2.***

Step 2 – Start-up:

- Set Service Switches. ***Service Manual:- 1.1.2.***
- Turn On power. ***Operation Manual:- 2.2.***
- The Display should read "9841 NO_x Analyzer".
- Adjust the Display Contrast if required. ***Operation Manual:- 2.2.1.***
- Verify that the software is running by observing the Ecotech Globe rotating in the bottom left hand corner of the display.

Step 3. – Operation:

- Verify Instrument warm up and operation mode. ***Service Manual:- 2.2.***
- Set the correct time and date. ***Operation Manual:- 2.3.3.***
- If using RS232, configure the Interface menu. ***Operation Manual:- 2.5.11.***
- Check SYSTEM FAULTS menu. All PASS. ***Operation Manual:- 2.5.21.***
- Verify other menu settings. ***Service Manual:- 4.2.***

Step 4. – Calibration:

- Perform a quick (single point) calibration. ***Operation Manual:- 2.4.***
- Setup and Calibrate the Analog Outputs (if applicable). ***Operation Manual:- 2.6.3.***
- If necessary, perform a leak check. ***Service Manual:- 3.3.11.***
- If necessary, perform a pressure calibration. ***Service Manual:- 3.5.***
- If necessary, perform a converter efficiency check. ***Operation Manual:- 3.6.4.***
- If necessary, perform a Multipoint calibration. ***Operation Manual:- 3.6.***

Step 5. – Data Validation:

- Verify the results from your data acquisition system agree with the readings of the EC9841 NO_x analyzer.
- Verify that the analyzer responds to automatic calibration sequences.

The analyzer is now operating correctly.

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INDEX II

APPENDIX A II

DESCRIPTION II

APPENDIX B VIII

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Manual History

This manual is the combination of two previous versions which have now been merged into one document to cater for the continuing development of the EC9800 series analyzers. The original manuals were:

- ML9841A Operation Manual, PN: 98412026, Rev. T, September 1998.
- ML9841B Operation Manual, PN: 98417005, Rev. K, July 1999.

The scope of this new manual covers the following analyzers:

- EC9841A Nitrogen Oxides Analyzer, (A-Series), PN: 98413000-104.
- EC9841B Nitrogen Oxides, (B-Series), PN: 98417000-1.

Both of the instruments are manufactured by Ecotech P/L in Australia and support the new (SMD) Microprocessor Board (Part number 98000063-4). This manual is current for firmware version 1.11 and above.

Ecotech Manual ID: MAN 0012
Manual PN: 98417600.
Current Revision: E
Date Released: May 2007.
Description: EC9841 Nitrogen Oxides, Operation Manual, A & B Series.

Revision History

Rev	Date	Summary	Affected Pages
A	January 2004	New Release for new Microprocessor Board. A & B series Combined. Based on original manuals.	All
B	February 2004	Changes to menu options and structure.	All
C	June 2005	Changed to updated EC manual, formatting changes and updated safety information	All
C-1	November 2005	Changes due to new process PCB (second instrument gain added).	Various
		Calculation factors added	2-27, 2-28
D	March 2006	Changes to new process PCB (instrument gains) added	Various
E	May 2007	Updated specifications, language and links within pdf manual created.	

NOTE: The photograph on the binder of this manual is of the south coast of Australia during Bushfires in 2003. The photograph is courtesy of Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center. Photo Reference: ISS006-E-19897.

Notice

The information contained in this manual is subject to change without notice and does not represent a commitment on the part of the Ecotech Pty Ltd. Ecotech reserves the right to make changes in construction, design, specifications, and/or procedures that may not be reflected in this manual.

This manual is furnished on the express condition that the information herein will not be used for second source procurement, or purposes directly or indirectly detrimental to the interests of Ecotech.

MARK DECLARATION

Declaration of Conformity
Nitrogen Oxides Analyzer

Scope of Declaration

This declaration applies to Nitrogen Oxides Analyzers as manufactured by Ecotech P/L and which may be sold in the following configurations:

Part Number	Description
98413000-104 98417000-T	Nitrogen Oxides Analyzer A series with and without internal pump
98417000-1	Nitrogen Oxides Analyzer Trace
98415200-100	Nitrogen Oxides Analyzer, B series
98417000-2	Nitrogen Oxides Analyzer High Level Nitrogen Oxides Analyzer, with IZS

Ecotech certifies that this product operates in compliance with the following standards:

EN 61326-1 Electrical Equipment for measurement, control and laboratory use – EMC Requirements Edition 1.1 with amendment 1 plus amendment 2.

- Immunity Requirements EN61326-1

IEC-61000-4-11	Voltage Interrupts
IEC-61000-4-11	Voltage Dips
IEC-61000-4-3	Radiated RF electromagnetic field immunity test
IEC-61000-4-4	Electrical fast transient/burst immunity test
IEC-61000-4-5	Surge immunity test
IEC-61000-4-6	Immunity to conducted disturbances, induced by radio frequency fields

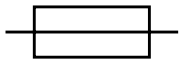
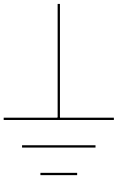
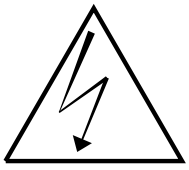
- Electromagnetic compatibility EN61326-1
  Annex A CISPR 22 and CISPR 16-2
  CISPR 16-1 and CISPR 16-2

EN 61010-1 Safety requirements for electrical equipment, control and laboratory use

- Section 19 of EN 60204-1
  Insulation Resistance Check
  Residual Voltage Check
  Earth Continuity

The equipment must be operated as per the directions given by Ecotech P/L in this manual.

Internationally Recognized Symbols Used on Ecotech Equipment

	IEC 60417, No. 5016	Electrical fuse
	IEC 60417, No. 5017	Earth (ground) terminal
	IEC 60417, No. 5021	Equipotentiality
	IEC 60417, No. 5032	Alternating current
	IEC 60417, No. 5041	Caution, hot surface
	ISO 7000-0434	Caution, refer to accompanying documents
	ISO 3864, No. B.3.6	Caution, risk of electric shock

Safety Requirements

- To reduce risk of personal injury caused by electrical shock, follow all safety notices and warnings in this documentation.
- This equipment should *always* be used with a protective earth installed.
- The EC9841 is compliant with the requirements of EN61010-1 A2:1995, *Safety Requirements for Equipment for Measurement, Control, and Laboratory Use*.
- If the equipment is used for purposes not specified by the manufacturer, the protection provided by this equipment may be impaired.
- Replacement of any part should only be carried out by qualified personnel, only using parts specified by the manufacturer. Always disconnect power source before removing or replacing any components.
- The Ozone Generator contains dangerous levels of voltage. Make sure the power is disconnected when opening the generator unit. If unfamiliar with the ozone generator refer to figure 8 in the service manual.
- This unit generates Ozone, for this reason, the exhaust pump must be connected through a charcoal scrubber to remove excess ozone.
- Surfaces marked with a “Caution, Hot Surface” (see internationally recognized symbols on page 4) sticker may get hot and deliver burns. Measure the temperature on the surface before making any contact with it.

Equipment Rating

- 100-120/220-240V~ ±10%
- 50/60 Hz
- 250 VA max
- FUSE: 5A for 115V operation

  3.15A for 240V operation
- All wiring must be in accordance with local norms and be carried out by experienced personnel.

Environmental Conditions

RELATIVE HUMIDITY	10% to 80%
Temperature	5 to 40 degrees C
Pollution degree	2
Installation category	II
Maximum altitude	2000m.

Instruments suitable for use in a sheltered environment only.

Never operate this equipment in the presence of flammable liquids or vapors, as this could cause a safety hazard.

Factory Service

We strive to provide efficient and expedient service when an instrument or component is returned for repair. Your assistance can help us to better provide the service you need.

To ensure that we process your factory repairs and returned goods efficiently and expeditiously, we need your help. Before you ship *any* equipment to our factory, please call our Service Response Center at **(+61) 1300 364 946**. This enables us to complete the necessary paperwork and process your equipment correctly when it reaches our facility.

When you call, please be prepared to provide the following information:

1. Your name and telephone number
2. Your company name with shipping address
3. The number of items being returned
4. The part number of each item
5. The model number or a description of each item
6. The serial number of each item, if applicable
7. A description of the problem you are experiencing if factory repair is needed, or the reason you are returning the equipment (e.g., sales return, warranty return, etc)
8. The original sales order number or invoice number related to the equipment
9. Whether repair work is under warranty or is to be billed and a purchase order number for any work to be billed.

When you call in, our Customer Service Representative will assign a Return Material Authorization (RMA) number to your shipment and initiate the necessary paperwork to process your equipment as soon as it reaches us. Please include this RMA number when you return equipment, preferably both inside and outside the shipping container. This will ensure that your equipment receives the most prompt attention possible. ***If the RMA number is not marked on the outside of the shipping container, the shipment will be rejected when it reaches our facility, and returned at your expense.***

Your assistance in this matter will enable us to serve you better. We appreciate your cooperation and support of our products and services.

Claims for Damaged Shipments and Shipping Discrepancies

Damaged Shipment

1. Inspect all instruments thoroughly on receipt. Check material in the container(s) against the enclosed packing list. If the contents are damaged and/or the instrument fails to operate properly, notify the carrier and Ecotech immediately.

2. The following documents are necessary to support claims:

    a. Original freight bill and bill of lading
    b. Original invoice or photocopy of original invoice
    c. Copy of packing list
    d. Photographs of damaged equipment and container

    You may want to keep a copy of these documents for your records also.

    Refer to the instrument name, model number, serial number, sales order number, and your purchase order number on all claims. Upon receipt of a claim, we will advise you of the disposition of your equipment for repair or replacement.

Shipping Discrepancies

Check all containers against the packing list immediately on receipt. If a shortage or other discrepancy is found, notify the carrier and Ecotech immediately. We will not be responsible for shortages against the packing list unless they are reported promptly.

Service and Spare Parts

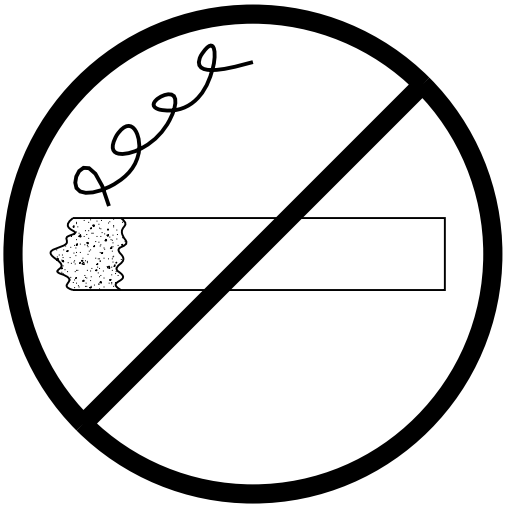
For world wide customer service & spare parts contact ECOTECH:

Address:	**Ecotech Pty Ltd** **1492 Ferntree Gully Road** **Knoxfield Victoria** **Australia. VIC 3180**
Phone:	**+61 1300 364 946**
Fax:	**+61 1300 668 763**
Email - Service:	**ecotech@ecotech.com.au**
Email - Spare Parts:	**parts@ecotech.com.au**
Web:	**www.ecotech.com.au**

Our Service Response Center handles product information, application assistance, factory repair, training, service, maintenance agreements, and technical assistance.

WARNING

Avoid smoking in the vicinity of the analyzer. Due to the complex chemical makeup of tobacco smoke, smoke drawn into the sample line may result in incorrect readings. Furthermore, tobacco smoke has been shown to contaminate converter and scrubber materials critical to the accuracy and stability of the analyzer.



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1.0 Description

The EC9841 nitrogen oxides analyzer uses gas-phase chemilluminescence detection to perform continuous analysis of nitric oxide (NO), total oxides of nitrogen (NO_X), and nitrogen dioxide (NO_2). The 9841 analyzer design represents an advance in nitrogen oxides analysis technology achieved by using adaptive microprocessor control of a single measurement channel.

The instrument consists of a pneumatic system, a NO_2-to-NO converter (molycon), a reaction cell, detector (PMT), and processing electronics. With an auto-zero routine that allows the analyzer to periodically check and correct for background illumination, the 9841 virtually eliminates zero drift.

In addition to temperature and pressure compensation, the analyzer can adjust the span ratio based on a known concentration of gas used to span the analyzer. This feature is not automatically implemented and must be selected by the operator.

Analog and digital outputs are available for data monitoring. The operator can select analog output as either current or voltage output. Current ranges are 0 to 20 mA, 2 to 20 mA, or 4 to 20 mA. Voltage outputs with the 50-pin I/O board include 0 to 10 V, 0 to 5 V, 0 to 1 V, and 0 to 0.1 V. (The 50-pin I/O board is optional in the EC9841 B series).

Data collection and recording is available for either a data acquisition system (such as a datalogger) or a strip chart recorder. With the DB50 connector supplied, voltage outputs of 0 to 1v are available well as digital input control and digital output status. The EC9841 also features internal data storage capabilities.

The instrument includes an over-range feature that, when enabled, automatically switches the analog output to a preselected higher range if the reading exceeds 90% of the nominal range. When the reading returns to 80% of the nominal range, the analyzer automatically returns to that range.

The U.S. EPA has designated the EC9841 nitrogen oxides analyzer as an *Equivalent Method*. Section 1.2 below includes the operational parameters necessary when using the analyzer in this mode.

1.1 Specifications

Note

All specifications are referenced to STP (standard temperature and pressure).

1.1.1 Range

- Display: Autoranging 0 to 20 ppm. Resolution = 1 ppt (selectable units and decimal places).
- Analog output: 0 to full scale from 0-0.050 ppm to 0-20 ppm with 0%, 5%, and 10% offset.
- Autoranging between 2 user-specified full scale values.
- U.S. EPA designated range: Any full scale range between 0 to 0.05 ppm and 0 to 1.0 ppm.

1.1.2 Noise (RMS)

- Measurement process: 0.25 ppb or 0.1% of concentration reading, whichever is greater; with Kalman filter active.
- Analog output: 0.25 ppb or 0.1% of analog output full scale, whichever is greater.

1.1.3 Lower Detectable Limit

- Measurement process: Less than 0.5 ppb or 0.2% of concentration reading, whichever is greater; with Kalman filter active.
- Analog output: 0.5 ppb or 0.2% of analog output full scale, whichever is greater.

1.1.4 Zero Drift

- Temperature dependent, 0.1 ppb per °C.
- Time dependent, at fixed temperature:

  24 hours: Less than 1 ppb

  30 days: Less than 1 ppb.

1.1.5 Span Drift

- Temperature dependent, 0.1% per °C.
- Time dependent, at fixed temperature.

  24 hours: 1% of reading

  30 days: 1% of reading.

1.1.6 Lag Time

Less than 25 seconds.

1.1.7 Rise/Fall Time, 95% of Final Value

Less than 60 seconds (with Kalman filter active).

1.1.8 Linearity Error

±1 of full scale (from best straight-line fit).

1.1.9 Precision

0.5 ppb or 1% of reading, whichever is greater.

1.1.10 Sample Flow Rate

640 mL/minute (total flow for two channels).

1.1.11 Sample Pressure Dependence

A 5% change in pressure produces less than 1% change in reading up to 2000m above sea level.

1.1.12 Temperature Range

- 5° to 40° C (41° to 104° F).
- U.S. EPA designated range: 15° to 35° C.
- Eignungsgeprüft range: 5° to 40° C.

1.1.13 Power

- 99 to 132 VAC; 198 to 264 VAC; 47 to 63 Hz.
- U.S. EPA designated range: 105 to 125 VAC, 60 Hz, or 200 to 240 VAC, 50 Hz.

1.1.14 Weight

- 26.4 kg (58 lb)

1.1.15 Analog Output

- Menu selectable current output of 0-20 mA, 2-20 mA, and 4-20 mA.
- Jumper selectable voltage output of 100 mV, 1 v, 5 V, and 10 V, with menu selectable zero offset of 0%, 5%, or 10%. The 9841B requires an optional 50 I/O board to give voltage output.

- Independent output for NO, NO_X, and NO_2.

1.1.16 Digital Output

- Multidrop RS232 port shared between analyzers for data, status, and control.
- Service RS232 port gives front panel access to a local or remote user.
- USB port connection on the rear panel provides data transfer and control.
- DB50 with discrete status, user control, and analog output.

1.2 U.S. EPA Reference Method

The EC9841 nitrogen oxides analyzer is designated under U.S. EPA regulations as reference method RFNA-1292-090. Use of the EC9841 under U.S. EPA designation as a reference method, as defined in 40 CFR Part 53, requires operation under the following conditions:

- Dual Gain: NO
- Range: Any full scale range from 0 to 0.05 ppm to 0 to 1.0 ppm
- Ambient temperature: 15° to 35° C
- Line voltage: 105 to 125 VAC, 60 Hz, or 200 to 240 VAC, 50 Hz.
- Flow rate: 0.64 slpm
- Ecotech external pump or equivalent (see section 2.1.2.3).

- Filter: A 5 micron PTFE filter must be installed in front of the sample inlet (Zero and Span gas must pass through this filter).
- If the units in the MEASUREMENT MENU are changed from volumetric to gravimetric (or gravimetric to volumetric), the analyzer must be re calibrated.
- The analyzer must be operated and maintained in accordance with this operation manual.
- The following menu selections must be used:

```
INTERFACE MENU
  ANALOG OUTPUT MENU
     RANGE: 0.05 PPM to 1.0 PPM
     OVER-RANGING: ENABLED or DISABLED

INSTRUMENT MENU
  MEASUREMENT MENU
     FILTER TYPE: KALMAN
     NO2 FILTER: DISABLED

CALIBRATION MENU
  CALIBRATION: MANUAL or TIMED
  SPAN COMP: DISABLED
```

```
TEST MENU
   PRES/TEMP/FLOW COMP: ON
   DIAGNOSTIC MODE: OPERATE
```

- The Service switch must be positioned to IN**.**

The EC9841B series is U.S. EPA equivalent with the following options (or equivalent):

- exhaust scrubber
- valve assembly for external zero span (EZS)
- rack mount assembly
- 50-pin connector PCA (Standard in A series)
- internal zero/span assembly (IZS)

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2.0 Installation and Operation

2.1 Mechanical Installation

Note

Before installation, the unit should be checked to ensure that the instrument arrived undamaged. The EC9841 *Service Manual* contains initial installation inspection instructions.

2.1.1 Selecting a Location

Select a location for the analyzer where temperature variation, dust, and moisture are minimal. The location should be well ventilated and should allow convenient access to the operator controls and front panel display. The analyzer can operate in a range of 5° to 40° C without risk of damage.

2.1.1.1 Rack Mount or Enclosed Location

The analyzer is supplied as a bench-top version with rubber feet or with the chassis slides to convert it to a rack-mount version. The optional rack-mount version is 24 inches (61 cm) deep and fits into a 19 inch (48.3 cm) RETMA instrumentation rack. The front panel will protrude slightly. Refer to the instructions provided with the rack-mount kit for assembly into a rack.

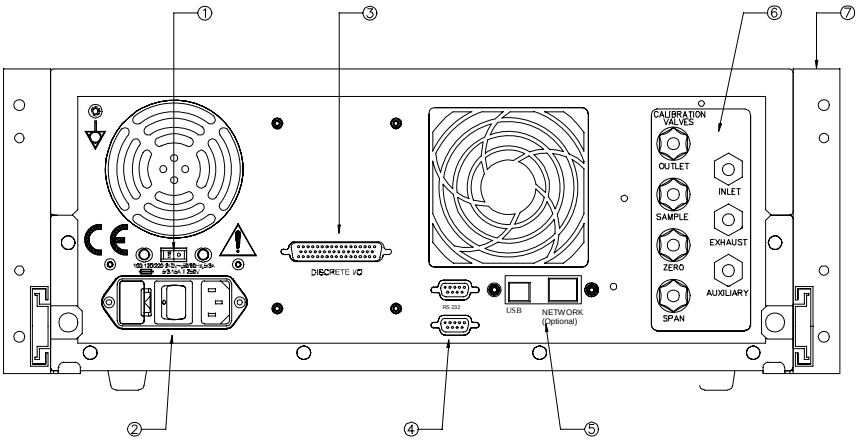
Caution

The rack-mount version requires a properly ventilated rack enclosure. The temperature inside enclosures that are not properly ventilated may rise as much as 15° C above the ambient air temperature. This may force the analyzer to operate outside of specifications. Optimum operation is obtained at an operating temperature of 20° to 30° C inside the rack enclosure. For ventilation calculations, use a heat dissipation rating of 150 watts or 512 Btu per hour.

After the analyzer has been mounted, make the pneumatic and electrical connections.

2.1.2 Connections

All pneumatic connections must be secure to ensure accurate operation of the analyzer. The following information describes connection techniques for pneumatic and electrical connections. Figure 2-1 shows the rear panel of the analyzer with associated connections. Notice the Network connection is optional



1. VOLTAGE SELECT SWITCH
2. POWER SWITCH/CONNECT R
3. 50 I/O & CONNECTOR
   (SEE FIG 2.5 & 2.6 FOR OPTIONAL BOARD).
4. TRISTATE RS232 CONNECTOR(S)
5. USB AND XPORT CONNECTORS
6. GAS CONNECTION PORTS
7. RACK MOUNT (OPTIONAL) (x2)

Figure 2-1. Analyzer Rear Panel

2.1.2.1 Recorder and DAS Connections

Caution

The EC9841 electrical ground is isolated from earth ground. To avoid possible ground loops, all electrical devices connected to the analyzer should have floating inputs (not connected to earth ground).

2.1.2.1.1 The 50-Pin I/O PCA

The 50-pin connector board plugs into the discrete I/O connector, and provides voltage and current outputs to drive a strip chart recorder (REC) and a data acquisition system (DAS). The outputs are illustrated in Figure 2-2.

The 50-pin I/O PCA is optional for the EC9841 B series analyzer.

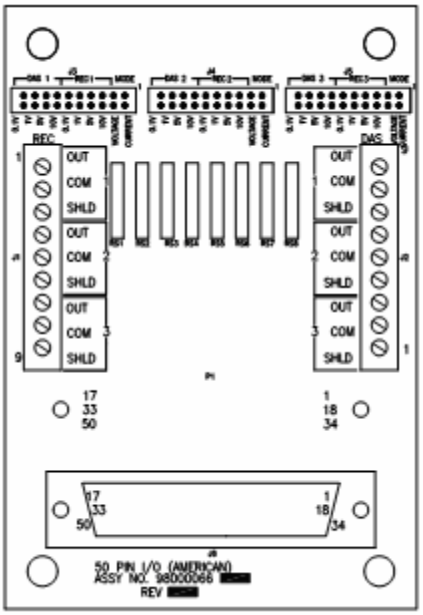


Figure 2-2. Optional 50-Pin Connector Board (Front)

The output is jumper-selectable as:

- Current (see the example in Figure 2-3). Range is set using the menu in a later step.
- Voltage, with selectable ranges of 0 to 0.1 v, 0 to 1 v, 0 to 5 v, and 0 to 10 v. See the example in Figure 2-3.

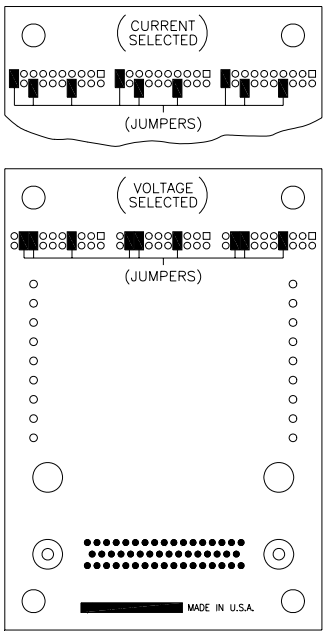


Figure 2-3. 50-Pin Connector Board with Sample Choices (Rear)

Select the output for your application using the following steps.

Remove the 50-pin connector board from the rear panel of the analyzer.

Place the jumpers on the pins that correspond to the desired printed selections on the front of the board. If current is selected, only the jumpers selecting current make contact with both rows of pins. The other jumpers are offset as shown in Figure 2-3.

If a current output is selected, the range must also be chosen from the menu when the instrument is operating. The compliance voltage for the current output is 12 v. A terminating resistor of 600 ohms or less should be used for measurement errors no greater than 1%.

If voltage output is selected, both the REC and DAS outputs are factory-set for 10 volts full scale. Other full scale outputs of 5 v, 1 v, and 0.1 v can be selected. Select the full scale output for REC and DAS. When using voltage output, the source resistance for both REC and DAS outputs is 1000 ohms. The recorder and DAS input resistance should be greater than 500K ohms for a measurement error no greater than 1%.

Connect the recorder or DAS wires to the appropriate terminal block. The wire positions are:

OUT = positive or signal
COM = ground or low
SHLD = shielded cable.

Caution

To prevent ground loop problems, connect the shield of the cable at the analyzer only, not at the recorder or DAS.

For additional information regarding output, see section 2.6 below.

2.1.2.1.2 Current Output Connections

When using the EC9841 without the 50-pin I/O PCA, the analyzer still provides current outputs to drive a strip chart recorder or DAS. These outputs are present on the discrete I/O connector at the following pins:

Function	Pin (50-Pin I/O Connector)
Current Out NO (+)	15
Current Out NO_X (+)	17
Current Output NO_2 (+)	2
DGND (Gnd)	1, 12, 14, or 16

If a current output is connected, the range must also be chosen from the menu when the instrument is operating. The compliance voltage for the current output is 12 v. A terminating resistor of 600 ohms or less should be used for measurement errors no greater than 1%.

2.1.2.1.3 Voltage Output Connections

The current output mentioned above can be converted to a voltage output by adding a terminating resistor across the output. This resistor must be 50 ohms per full scale voltage desired (50 ohms = 1 v full scale; 500 ohms = 10 v full scale, etc). Following is a list of typical output ranges and required terminating resistance:

Desired Output (Volts)	Terminating Resistance (Ohms)
10 Volts	500 Ohms
5 Volts	250 Ohms
1 Volt	50 Ohms*
0.1 Volt	5 Ohms

When using voltage output, the source resistance is 1000 ohms. The recorder or DAS input resistance should be greater than 500K ohms for a measurement error no greater than 1%.

2.1.2.2 Sample Gas Connections

Caution

Sample and zero air connections to the EC9841 should be maintained at ambient pressure, with any excess flow vented to the atmosphere.

The EC9841 requires at least 1.00 slpm (0.64 slpm sample plus 50% overflow) of particulate-filtered (<5 micron), dry (noncondensing) sample furnished at all times. A 5 micron inlet filter is necessary to meet USEPA requirements which is already installed in the A series analyzer.

Tubing used for sample gas and exhaust connections must be 1/4 inch OD and 1/8 to 3/16 inch ID. The recommended ID is 5/32 inch. A segment of clean Teflon® tubing should be purchased to connect the sample source to the sample inlet. Only use lines and fittings made of stainless steel, Teflon, Kynar®, or glass.

Instructions for tubing connections with Kynar fittings:

- Cut the tubing squarely and remove any burrs.
- Insert the tubing through the back of the nut until it reaches the tube stop in the fitting.
- Tighten the nut finger-tight plus 1-1/2 to 2 turns. A squeaking sound when tightening the nut is normal.
- All nuts should be re-tightened when the system reaches operating temperature.

2.1.2.3 Exhaust Connections

Connect the exhaust port of the analyzer to vacuum pump capable of 1 slpm at 20” Hg (67 kPa) vacuum (minimum capacity). The pump must be connected through a charcoal exhaust scrubber to remove excess ozone and prevent damage

to the pump. The exhaust of the pump should be connected to a manifold to vent the exhaust gas away from occupied areas.

Warning

After removal of power from the EC9841, the exhaust should be maintained for approximately 15 minutes to purge the exhaust of ozone and prevent possible combustion of the charcoal.

Optional exhaust pump and exhaust scrubber are available from Ecotech.

2.2 AC Power Connection

Verify that the power selection switch on the rear panel and the power cord and fuse are appropriate for your use. Move the switch right or left so the appropriate voltage rating is visible on the switch. Figure 2-1 above shows the voltage selection switch.

Warning

Power is supplied to the analyzer through a three-pin power plug. The ground must not be defeated and an adequate ground must be connected to the instrument, both for proper performance and for the safety of operating personnel. The warranty on the analyzer applies only if the analyzer is properly grounded. If it is not properly grounded and electric power is applied in violation of the national electric code, Ecotech assumes no responsibility for any injury or damage to personnel or property.

Warning

Be sure to check that the mains power selection switch is at the correct setting before turning the instrument on. Failure to do so may result in damage to the power supply.

Connect the power plug to the power receptacle and press the power switch to the ON position on the rear panel. Also make sure that the DC POWER switch on the front secondary panel is switched to ON.

2.2.1 Display Adjustments

Adjust the display contrast by simultaneously pressing two keys on the front panel (see Figure 2-4 below):

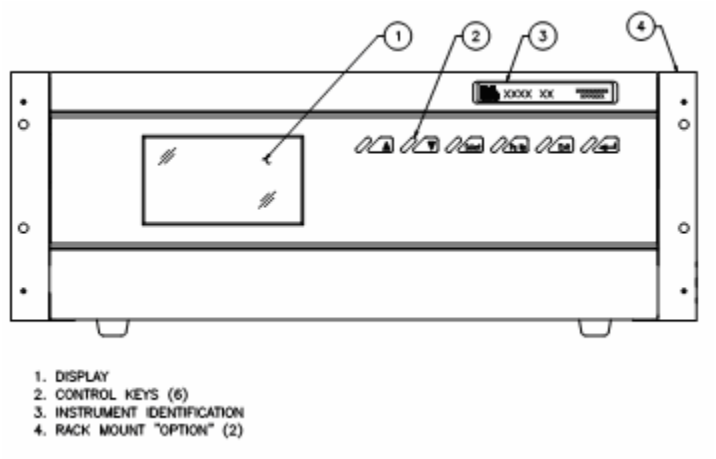


Figure 2-4. Analyzer Front Panel

- *Contrast*
  Up arrow (⮝) and <Select> for darker contrast, Down arrow (⮟) and <Select> for lighter contrast.
- *Backlight*
  The backlight brightness is fixed to maximum and cannot be adjusted.

Hold the key combinations until the desired contrast appears on the display.

Note

Pressing the Up or Down arrow key while not simultaneously pressing the <Select> key when the main screen is displayed causes the screen query, `START MANUAL CALIBRATION?` If this happens while adjusting the display, press the <Exit> key.

Note

The display is sensitive to the ambient air temperature and analyzer temperature. The appearance of the display will vary with changes in these conditions.

2.2.2 Warmup

When the instrument is initially powered up, several components in the instrument are required to reach operating temperature before the analyzer will begin operation. This process typically requires about 60 minutes from a cold condition. During the startup period, the message START-UP SEQUENCE ACTIVE will be displayed. This indicates progression toward normal operation.

Initial Screen Message	Instrument Activity
MOLYCON IS COLD	
MOLYCON IS WARM	
MOLYCON IS HOT	
BACKGROUND FILL	Cell filling with zero air.
BACKGROUND MEASURE	Zero reading from measurement cell. Final determination of system zero.
SAMPLE FILL	Cell filling with sample air.
SAMPLE MEASURE	Instrument operational (must be calibrated if this is the first power-up sequence).

The startup sequence is keyed to the molycon temperature. The molycon must reach 250° C before the ozone generator will begin operating. This will typically take about 45 minutes. The molycon reaches its operating temperature of 320° ±5° C approximately 60 minutes after applying power.

Note

The EC9841 will re-run the above start-up routine whenever power has been lost for more than two minutes. If power is lost for less than two minutes, the analyzer will return to its previous settings without the start-up routine.

2.3 Operation

This section describes the actions necessary to operate the instrument, first in general, then in specific terms. In section 2.5, the menu headers are shown as they appear on the display screen. The illustration is followed by explanatory information regarding the menu entries or choices. The entire menu tree is shown in Figure 2-6.

2.3.1 General Operation Information

All operator responses needed to operate the EC9841 are performed by pressing the 6 keys available on the front panel to the right of the display screen. The key functions are described below.

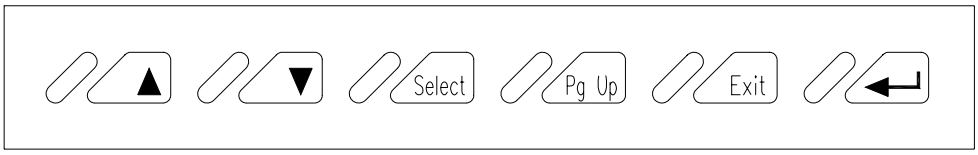


Figure 2-5. Analyzer Keyboard

The key functions are listed below:

- *Up arrow key* (▲)
  Moves the cursor to the previous menu item or, in an input field, moves the cursor to the next choice or increments the digit in a numerical field.
- *Down arrow key* (▼)
  Moves the cursor to the next menu item or, in an input field, moves the cursor to the next choice or decrements the digit in a numerical field.
- *<Select>*
  Selects the menu choice or selects the field for input.
- *<Pg Up>*
  Moves the cursor to the previous page or screen.
- *<Exit>*
  Leaves a field without making a change or returns the cursor to the main screen.
- *<Enter>* (↵)
  Confirms a menu item or a field selection to the microprocessor.

2.3.2 Using the Menu and Making Entries

The EC9841 analyzer is programmed with a series of menus that allow the operator to view parameters, such as those generated by the microprocessor, or to enter digital parameters, when appropriate, or to select from among the choices displayed.

The cursor is displayed as a movable highlighted area of text. (Letters appear as the opposite of the rest of the text on the screen.)

2.3.2.1 Screen Fields

Screen fields that allow input are of two types:

- *Choice fields*
  Contain a fixed series of choices in a wraparound scrolling format.
- *Digit fields*
  Fields of programmable digital parameters in either wraparound scrolling or non-wraparound scrolling format.

To select from among the choices in a choice field, first press the <Select> key to designate the field, then use the Up and Down arrow keys to highlight the desired selection. When the desired selection is displayed, press the <Enter> key to confirm the entry.

To set digits in a digit field, first press the <Select> key to designate the field and to highlight the different digits in the field. When the cursor indicates the digit you wish to change, press the Up or Down arrow key until the desired digit appears. Go to the next digit by pressing <Select>. When all digits of an entry are correct, press the <Enter> key to confirm the entry.

Caution

The <Select> key does not confirm an entry. You must press the <Enter> key.

2.3.2.2 Microprocessor-Generated Information

Some fields, such as those on the INSTRUMENT STATUS and SYSTEM TEMPERATURES screens, contain information generated by the microprocessor. The operator cannot affect the readings in these fields. (If you find that the cursor will not enter a field, the field contains microprocessor-generated information.)

2.3.2.3 Exiting Without Making a Change

If you decide not to make a change during this process, simply press the <Exit> key, and the values will return to the previous entries.

2.3.3 Setting the Date and Time

Before the instrument can be calibrated or collect data for regulatory use, the time and date must be set. Go to the INSTRUMENT MENU and select DATE and TIME. If these are not already set, use a 24-hour clock setting for time and set the date in

the day-month-year format. See section 2.5 for instructions on programming menu entries.

2.4 Analyzer Calibration

When the EC9841 analyzer is powered on *for the first time*, the analyzer must be calibrated to ensure accurate measurements. The analyzer does not require recalibration after further power interruptions or resets. However if the instrument is transported to a new location, or maintenance work is performed, the instrument may require re-calibration. To determine weather the instrument requires a calibration, a precision check can be performed as discussed in the following sections.

2.4.1 Precision Checks

A precision check is a Level 2 calibration as discussed in section 3.12. This means that the instrument is only checked against a know calibration source and is not adjusted. A precision check can be performed either manually or automatically.

2.4.2 Automatic

Most modern air quality monitoring systems have data acquisition systems which can automatically initiate and record the results of a daily precision check. The means by which the analyzer is externally controlled is via the 50 PIN IO connection, or via the RS232 multidrop connection. Refer to section 4.0 for more details on interfacing to these ports.

2.4.3 Manual

A manual precision check can be initiated as follows:

1. Connect a source of span gas to the analyzer through the Inlet port. (see *chapter 3.0* for instructions on preparing calibration gas).

2. From the CALIBRATION MENU set CALIBRATION to MANUAL and CAL. MODE to SPAN.

3. Allow the analyzer to sample the span gas until a stable reading is obtained, typically 15 minutes.

4. Verify this stable reading against the know calibration concentration.

5. Typically if it is within 5%, then a calibration is not required.

6. If a calibration is required, continue with the following procedure in section 3.0. If not, return the CAL. MODE to MEASURE.

2.4.4 Analyzer Calibration Instructions

Note

This procedure is a quick guide to single point span calibration of the EC9841 analyzer. For complete gas preparation and multipoint calibration instructions, refer to *Chapter 3, Calibration.*

Note

Changing instrument between single and dual gain modes is performed within the instrument menu see section 2.5.3.

Single Gain procedure

1. With a stable supply of calibration gas (NO) connected to the Inlet port of the analyzer, verify that in the CALIBRATION MENU, CALIBRATION is set to MANUAL and CAL. MODE to SPAN.

2. *From the primary screen,* start the calibration sequence by pressing either the Up or Down arrow key (⮝ or ⮟) until the display prompts START MANUAL CALIBRATION. Pressing the <Select> key will allow you to choose from: NO, SPAN or ZERO. Confirm that the display reads SPAN and press <Enter> (↵). A backlit cursor will be displayed on the NO_X concentration display.

3. Use the <Select> key to move the position of the backlit cursor, and the Up and Down arrow keys to increment and decrement the value of the backlit digit until the span calibration gas concentration value is displayed. When the desired concentration is displayed, press <Enter>.

4. Next move the cursor to the CONVERTER EFFICIENCY field. If the converter efficiency is known to be other than 100%, program this value and press <Enter>, otherwise press <Enter>.

5. Then move the backlit cursor to the INSTRUMENT GAIN field. The instrument gain is automatically calculated by the analyzer. Press <Enter> to confirm this value. Press <Exit> to return to the *primary screen.*

6. The concentration on the *primary screen* should now read the same as the concentration of the calibration gas.

Dual Gain procedure

1. With a stable supply of calibration gas (NO) connected to the Inlet port of the analyzer, verify that in the CALIBRATION MENU, CALIBRATION is set to MANUAL and CAL. MODE to SPAN.

2. Allow the analyzer to sample the gas until a stable reading is obtained, typically 15 minutes.

3. *From the primary screen,* start the calibration sequence by pressing either the Up or Down arrow key (⮝ or ⮟) until the display prompts START MANUAL CALIBRATION. Pressing the <Select> key will allow you to choose from: NO, SPAN or ZERO. Confirm that the display reads SPAN and press <Enter> (↵). A backlit cursor will be displayed on the NO concentration display.

4. Use the <Select> key to move the position of the backlit cursor, and the Up and Down arrow keys to increment and decrement the value of the backlit digit until the span calibration gas concentration value is displayed. When the desired concentration is displayed, press <Enter>.

5. *From the primary screen* as in step 2, start the calibration sequence by pressing either the Up or Down arrow (⮝ or ⮟) until the display prompts START MANUAL CALIBRATION. Pressing the <Select> key will allow you to choose from: NO, SPAN or ZERO. Confirm that the display reads SPAN and press <Enter> (↵). A backlit cursor will be displayed on the NO_x concentration display.

6. Now repeat steps 2-5 using the NO_x field in place of the NO field.

7. Next the efficiency of the converter must be determined. Follow steps 2-4 above replacing the NO standard with an appropriate converter gas i.e. NO_2.

8. Use the readings on the screen and the known concentrations delivered to the instrument to calculate the converter efficiency $NO_{2\ (measured)}$ / $NO_{2\ (expected)}$.

9. Next move the cursor to the CONVERTER EFFICIENCY field. If the converter efficiency is known to be other than 100%, program this value and press <Enter>, otherwise press <Enter>.Press <Exit> to return to the *primary screen.*

10. The concentration on the *primary screen* should now read the same as the concentration of the calibration gas.

Note

The auto-zero function of the EC9841 eliminates the need for a traditional zero calibration. In special applications where a zero calibration is required the following procedure can be used:

1. Connect a source of zero air to the analyzer through the Inlet port.

2. Allow the analyzer to sample the gas until a stable reading is obtained, typically 15 minutes.

3. *From the Primary Screen*, start the calibration sequence by pressing either the Up or Down arrow key (⮝ or ⮟) until the display prompts, `START MANUAL CALIBRATION? ZERO`. Confirm that the display reads `ZERO` and press <Enter> (↵). A backlit cursor will be displayed on the NO concentration display.

4. Use the <Select> key to move the position of the backlit cursor, and the Up and Down arrow keys to increment and decrement the value of the backlit digit until the NO zero value is displayed (e.g., `0.000 PPM`). When the desired concentration is displayed, press <Enter>.

This completes the span calibration of the EC9841 analyzer.

2.5 Menus and Screens

This section illustrates the various menus and screens for the EC9841 analyzer. A short description of each menu and screen is provided. The entire menu structure is shown below in Figure 2-6.

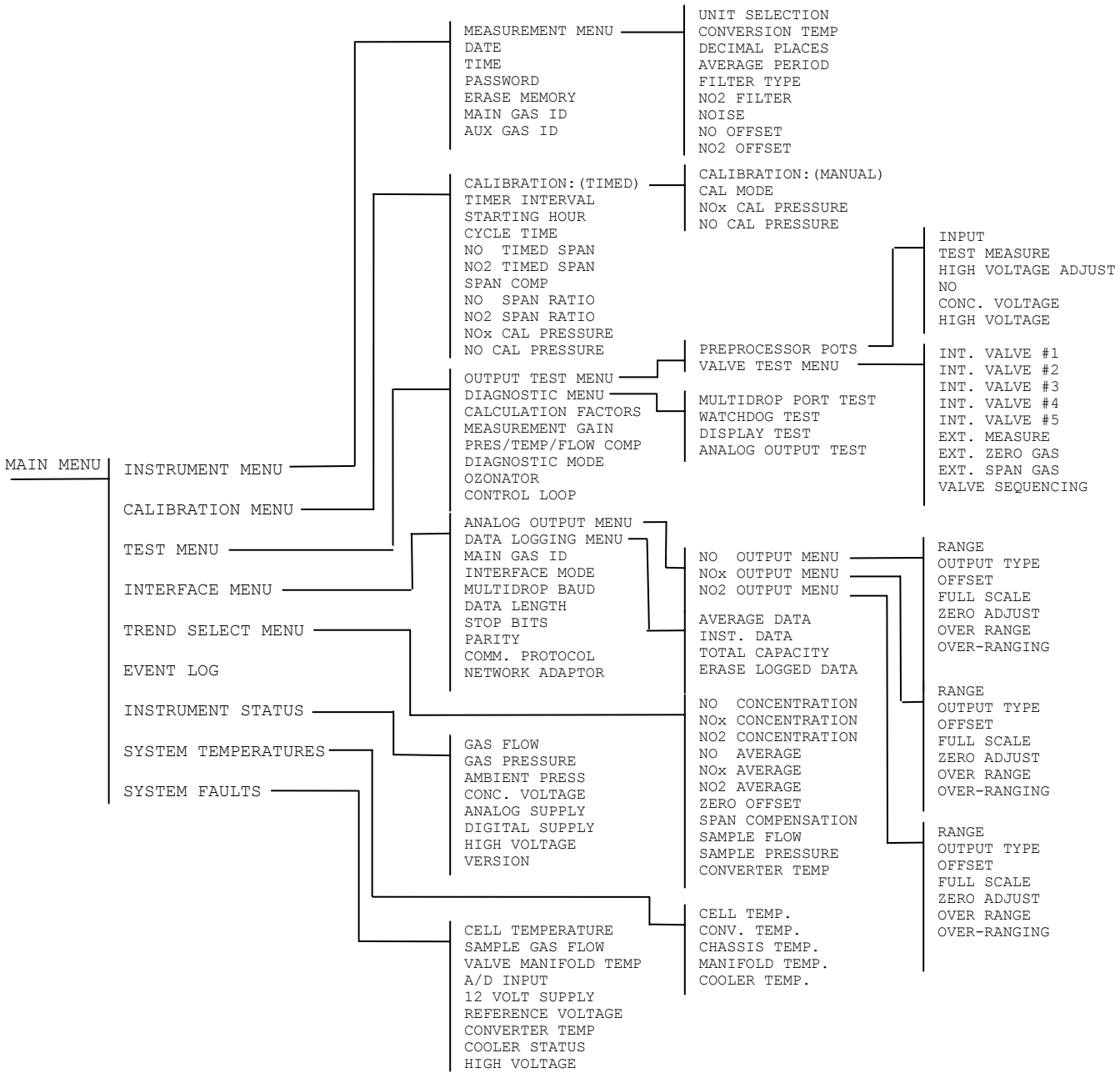


Figure 2-6. Menu Structure

Note

The values shown in the illustrations are examples only. Your display will be affected by the settings you choose.

2.5.1 Primary Screen

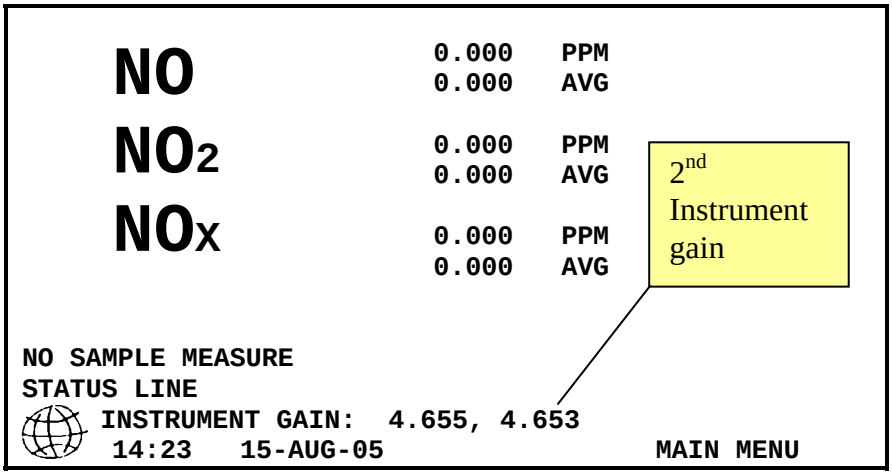


Figure 2-7. Primary Screen

When power is applied, the screen displays the Ecotech logo for a few seconds. It then identifies the analyzer and the notation MAIN MENU appears in the lower right corner. In the lower left hand corner there is the Ecotech Globe rotating, indicating that the program is running. After the warmup period, the operation mode is designated at the left of the screen and the current gas measurements for the analyzer are indicated, as shown in Figure 2-7.

Instrument faults will be reported on the status line which appears one line below the instrument state display. The following rules govern the information displayed on this line: If there are no failures, the status line is blank. If there is a single failure, that failure is displayed on the status line (i.e., ZERO FLOW, HEATER FAULT, etc). The status line will clear when the fault clears. If there are multiple failures, the failure at the top of the failure list will be displayed on the status line. When this failure clears, the next failure on the list will be displayed. The entire list of failures is displayed on the SYSTEM FAULTS screen.

The NO_x analyzer can be used with either one or two instrument gains. The single instrument gain is the only mode that is U.S.EPA approved. Instrument gains (displayed above the operational mode) indicates the relationship between the calibration concentration and a measured gas concentrations within the analyzer.

It is an essential parameter for the calibration of the analyzer and is an important requirement for system audits. The single gain option contains one instrument gain for the NOx channel. The Dual gain instrument contains two instrument gains, one for the NO channel (left) and another for the NO_x channel (right).

When the primary screen is displayed and the cursor highlights the words MAIN MENU, press <Select> or <Enter> to go to the MAIN MENU.

2.5.2 Main Menu

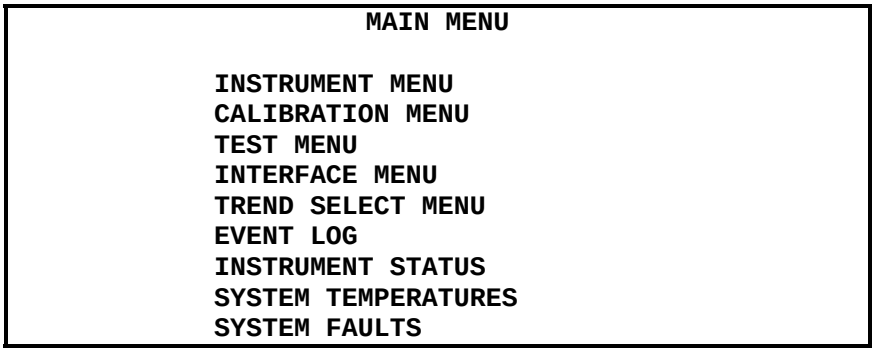


Figure 2-8. Main Menu

Each of the menus listed in Figure 2-8 above, except the final four, has one or more levels of menu items contained within the selection.

The EVENT LOG is a log created by the microprocessor to indicate deviations in the operating parameters. This screen can be used to determine the cause of system problems.

The INSTRUMENT STATUS and SYSTEM TEMPERATURES screens constantly update readings that apply to the operation of the instrument.

The SYSTEM FAULTS screen provides a pass or fail indication for various parameters that are continually monitored. These parameters must be within acceptable operating ranges in order to display PASS.

2.5.3 Instrument Menu

```
INSTRUMENT MENU

MEASUREMENT MENU
DATE:  15-AUG-03
TIME:  18:57
PASSWORD: UNLOCKED
DUAL GAIN: OFF
ERASE MEMORY: NO
MAIN GAS ID:  041
AUX GAS ID :  000
```

Figure 2-9. Instrument Menu

The items in the INSTRUMENT MENU address instrument settings needed to initiate operation.

DATE
The date format is day-month-year.

TIME
Set in 24-hour format. Setting the time resets the seconds (internally) to zero for synchronization with an external clock.

PASSWORD
See section 2.7, Password Protection.

DUAL GAIN
The instrument can be placed into two modes, dual instrument gain by selecting YES and single instrument gain by selecting NO. Only single gain mode is U.S.EPA approved.

ERASE MEMORY
Memory can be erased in two different ways, either RAM which does not wipe some settings or SETTINGS which will erase everything and reset all settings to default. If you do not wish to erase all setting select NO when, the following message is displayed:

```
!THIS WILL ERASE SYSTEM GAINS!
!!!ARE YOU SURE: NO
```

The word NO is highlighted in this warning. Scrolling to YES and pressing <Enter> will erase the memory in the analyzer.

Caution

If the analyzer memory is erased, all user-configured parameters will return to their default values. In addition, all instrument calibration will be lost, so the analyzer will have to be fully recalibrated. This feature is provided for service, and for preliminary configuration purposes. Please do not choose this selection during normal operation.

MAIN GAS ID

The ID address of the analyzer when Multidrop RS232 communications is used.

AUX GAS ID

The ID address of the analyzer when Multidrop RS232 communications is used.

2.5.4 Measurement Menu

```
          MEASUREMENT MENU

     UNIT SELECTION    : uG/M3
     CONVERSION TEMP   : 0 DEG C*
     DECIMAL PLACES    : 3
     AVERAGE PERIOD    : 1 MINUTE
     FILTER TYPE       : KALMAN
     NO2 FILTER        : ENABLED
     NOISE             : 0.204 PPB
     NO OFFSET         : 0.00 PPB
     NO2 OFFSET        : 0.00 PPB
```

Figure 2-10. Measurement Menu

The MEASUREMENT MENU consists of items needed for basic operation and data integrity.

UNIT SELECTION

PPM (parts per million), mG/M^3 (milligrams per cubic meter), nG/M^3 (nanograms per cubic meter), $\mu G/M^3$ (micrograms per cubic meter), PPT (parts per trillion) or PPB (parts per billion).

Note

If the gravimetric units are selected (mG/M^3, $\mu G/M^3$ or nG/M^3), then the conversion factors listed below will apply depending on the CONVERSION TEMP selected.

To convert 1 PPB "Gas" to ug/m^3 @ Multiply by:	0 °C	20 °C	25 °C
NO	1.339	1.248	1.228
NO_2	2.054	1.913	1.881

Note

If the units in the MEASUREMENT MENU are changed from volumetric to gravimetric (or gravimetric to volumetric), the analyzer must be re calibrated in order to meet U.S. EPA requirements.

CONVERSION TEMP

Sets the temperature that should be used in internal calculations to convert the concentration from volumetric units (ppm, ppb, ppt) into gravimetric units (mG/M^3, µG/M^3 or nG/M^3) in DEGREES CELCIUS (0, 20, 25). *This menu option is only displayed when the gravimetric units are selected.

DECIMAL PLACES

Set the number of decimal places in which the data is displayed on the screen. (0, 1, 2, 3, 4 or 5).

Note

The screen is able to display up to 7 characters of data including the decimal place for each reading.

AVERAGE PERIOD

Set time in hours (1, 4, 8, 12, or 24) or minutes (1, 3, 5, 10, 15, or 30). This establishes the period for average computations. This field is a wraparound field.

FILTER TYPE

Sets the time constant of the digital filter. Choices are NO FILTER, 300 SECONDS 90 SECONDS, 60 SECONDS, 30 SECONDS, 10 SECONDS, or KALMAN (adaptive).

Note

The Kalman filter is the factory default setting and must be used when using the instrument as a U.S. EPA equivalent method. The Kalman filter also gives the best overall performance for this instrument.

NO2 FILTER

A choice of ENABLED or DISABLED. When ENABLED is selected, a low pass digital filter is applied to the NO_2 measurement. This filter is used to remove any NO_2 artifact resulting from small pneumatic differences between the NO and NO_X gas channels.

NOISE

The standard deviation of the concentration. The manner in which this is done is as follows: (1) Take a concentration value once every two minutes; (2) Store 25 of these samples in a first-in last-out buffer; (3) Every two minutes, calculate the standard deviation of the current 25 samples. This is a microprocessor-generated field and cannot be set by the operator.

Note

The noise reading is only valid if zero air or a steady concentration of span gas has been supplied to the analyzer for at least one hour.

NO OFFSET

NO ZERO calibration correction factor. User can manually set the offset between ± 10.00 PPB.

NO2 OFFSET

NO2 ZERO calibration correction factor. User can manually set the offset between ± 10.00 PPB.

2.5.5 Calibration Menu

The CALIBRATION MENU contains entries used to calibrate the instrument. The choice of TIMED or MANUAL calibration displays a slightly different screen. TIMED calibration generates a zero/span check that occurs at a chosen interval without operator intervention. MANUAL calibration allows for operator-controlled calibration. Only one choice, TIMED or MANUAL, applies at any given time.

2.5.5.1 Timed Calibration

The following screen appears when CALIBRATION: TIMED is selected.

```
                CALIBRATION MENU

          CALIBRATION     :  TIMED
          TIMER INTERVAL  :  24 HOURS
          STARTING HOUR   :  0
          CYCLE TIME      :  15 MINS
          NO  TIMED SPAN  :  10.000 PPM
          NO2 TIMED SPAN  :  10.000 PPM
          SPAN COMP       :  ENABLED
          NO  SPAN RATIO  :  1.000
          NO2 SPAN RATIO  :  1.000
          NOx CAL PRESSURE:  750.0  TORR
          NO CAL PRESSURE :  750.0  TORR
```

Figure 2-11. Timed Calibration Menu

CALIBRATION
Designates TIMED or MANUAL calibration control.

TIMER INTERVAL
The number of hours between the zero/span checks.

STARTING HOUR
The hour when the first zero/span check will be performed.

CYCLE TIME
The period (1 to 59 minutes) of the zero & span steps during a timed calibration.

NO TIMED SPAN
Digital setting of the span concentration the operator expects the instrument to read.

NO2 TIMED SPAN
Digital setting of the span concentration the operator expects the instrument to read.

SPAN COMP
A choice of ENABLED or DISABLED. See *Chapter 3* for a description of automatic zero/span (AZS) checks.

NO SPAN RATIO
A microprocessor-generated field that is the value the span reading is multiplied to correct it to the calibration value. This value is only applied if SPAN COMP is ENABLED.

NO2 SPAN RATIO
A microprocessor generated field that is the value the span reading is multiplied to correct it to the calibration value. This value is only applied if SPAN COMP is ENABLED.

NOx CAL PRESSURE
This is the measured ambient pressure during the last NO_x calibration.

NO CAL PRESSURE
This is the measured ambient pressure during the last NO calibration.

2.5.5.2 Manual Calibration

The following screen appears when CALIBRATION: MANUAL is selected.

```
                CALIBRATION MENU

          CALIBRATION      :  MANUAL
          CAL. MODE        :  MEASURE


          NOx CAL PRESSURE :  750.0  TORR
          NO CAL PRESSURE  :  750.0  TORR
```

Figure 2-12. Manual Calibration Menu

CALIBRATION
Designates TIMED or MANUAL calibration control.

CAL. MODE
A choice of MEASURE (normal mode), CYCLE (zero/span sequence), SPAN (span valve), or ZERO (zero valve). The choice is based on the valve the operator wants to open. Selecting CYCLE starts an AZS cycle, which is discussed in *Chapter 3*.

NOx CAL PRESSURE
This is the measured ambient pressure during the last NO_x calibration.

NO CAL PRESSURE
This is the measured ambient pressure during the last NO calibration.

2.5.6 Test Menu

```
                    TEST MENU

      OUTPUT TEST MENU
      DIAGNOSTIC MENU
      CALCULATION FACTORS
      MEASUREMENT GAIN      :  32
      PRES/TEMP/FLOW COMP   :  ON
      DIAGNOSTIC MODE       :  OPERATE
      OZONATOR              :  ON
      CONTROL LOOP          :  ENABLED
      TEST MEASURE          : 0
      NO                    : 0.00000 PPM
```

Figure 2-13. Test Menu

The TEST MENU includes a series of submenus containing information and control settings for testing and verifying instrument functions. The operator may make changes to settings; however, when the instrument is returned to normal operation the instrument's automatic control function resumes. Changes made from this menu are for diagnostic and test purposes only.

MEASUREMENT GAIN
Entries are software-controlled settings of 1, 2, 4, 8, 16, 32, 64, and 128. This is the setting of the variable gain amplifier on the preprocessor.

PRES/TEMP/FLOW COMP
Choices are ON or OFF. OFF is used when running diagnostics to see pressure or temperature effects on readings. ON is used to compensate for automatic pressure and temperature compensation of sample.

DIAGNOSTIC MODE
Allows the operator to choose OPERATE, OPTIC, ELECT, or PREAMP. During measurement, set to OPERATE. During diagnostic testing, choose the desired system to be diagnosed.

OZONATOR
Choices are ON or OFF. ON is normally used. OFF is used to perform maintenance procedures.

CONTROL LOOP
Allows the operator to choose ENABLED or DISABLED. When ENABLED is selected, the microprocessor maintains control of the digital pots; when DISABLED is selected, the microprocessor does not control the digital pots and the user can manually adjust the digital pots. When CONTROL LOOP is ENABLED, the microprocessor will take control of the pots at the point at which the pots were

last set. *Control loops will be reset to* `ENABLED` *when the primary screen is displayed.*

TEST MEASURE
Software-controlled pot that is used by technicians when troubleshooting, or verifying correct instrument performance. This option only appears when the diagnostic mode is set to `OPTIC, ELECT or PREAMP.`

NO
Gas concentration reading during diagnostics. This option only appears when the diagnostic mode is set to `OPTIC, ELECT or PREAMP.`

2.5.7 Output Test Menu

```
                OUTPUT TEST MENU

            PREPROCESSOR POTS

            VALVE TEST MENU
```

Figure 2-14. Output Test Menu

The `OUTPUT TEST MENU` allows the user to select the menus to view controls for digital potentiometers and valves.

2.5.8 Preprocessor Pots Menu

```
                PREPROCESSOR POTS

      INPUT                :  40
      TEST MEASURE         :  0

      HIGH VOLTAGE ADJUST  :  53

      NO              0.400  PPM
      CONC. VOLTAGE   3.500  VOLTS
      HIGH VOLTAGE    650    VOLTS
```

Figure 2-15. Preprocessor Pots Menu

`PREPROCESSOR POTS` are electronically-controlled digital potentiometers used for adjustments to operations of the preprocessor board. Each pot is set with digits 0 to 99 in a non-wraparound scrolling field.

INPUT
Sets input gain on the preprocessor board.

TEST MEASURE
Software-controlled pot that is used by technicians when troubleshooting, or verifying correct instrument performance.

HIGH VOLTAGE ADJUST
Pot used to adjust high voltage to the PMT.

NO
PPM: Gas concentration reading.

CONC. VOLTAGE
Voltage from the preprocessor proportional to the chemilluminescent signal from the reaction cell. This voltage represents actual gas measurement.

HIGH VOLTAGE
Microprocessor-generated information. Use the value as reference when adjusting the high voltage adjust pot.

2.5.9 Valve Test Menu

```
          VALVE TEST MENU

     INT. VALVE #1    :  OPEN
     INT. VALVE #2    :  CLOSED
     INT. VALVE #3    :  CLOSED
     INT. VALVE #4    :  OPEN
     INT. VALVE #5    :  OPEN
     EXT. MEASURE     :  OPEN
     EXT. ZERO GAS    :  CLOSED
     EXT. SPAN GAS    :  CLOSED
     VALVE SEQUENCING :  ON
```

Figure 2-16. Valve Test Menu

The VALVE TEST MENU allows the valves to be set to either OPEN or CLOSED according to the operator's choice. To manually operate the valves**,** VALVE SEQUENCING needs to be turned off. The EC9841 *Service Manual* includes the names and pneumatic positions of the valves described here.

INT. VALVE #1
NO_X sample.

INT. VALVE #2
NO sample.

INT. VALVE #3
NO_X bypass.

INT. VALVE #4
NO bypass.

INT. VALVE #5
Background.

EXT. MEASURE
Externally supplied sample stream.

EXT. ZERO GAS
Externally supplied zero air.

EXT. SPAN GAS
Externally supplied span gas.

VALVE SEQUENCING
Set to ON or OFF. ON is used for automatic valve control. OFF is operator manual control of valves. Normal operation requires that VALVE SEQUENCING be set to ON. *VALVE SEQUENCING will automatically be reset to ON whenever the primary screen is displayed.*

2.5.10 Diagnostic Menu

```
                DIAGNOSTIC MENU

     MULTIDROP PORT TEST     : NO
     WATCHDOG TEST           : NO
     DISPLAY TEST            : NO
     ANALOG OUTPUT TEST      : NO
```

Figure 2-17. Diagnostic Menu

The DIAGNOSTIC MENU is information used to diagnose problems or suspected problems. The settings return to the previously set conditions when the operator leaves this menu.

MULTIDROP PORT TEST
Sends test of all printable characters to the Multidrop (rear) serial ports.

WATCHDOG TEST
Disables strobes to the watchdog timer. The system resets when this test is executed.

DISPLAY TEST

A series of 6 tests are available to check the working order of the display screen. Once the test is selected press the <Select> key to verify that the alternate pixels are visible. Press the <Pg Up> key to exit. The available tests are:

STRIPE 1

Causes the screen to show a series of very closely spaced vertical lines.

STRIPE 2

Shows a series of vertical lines in alternate positions to those is **STRIPE 1.**

CLEAR

Clears the screen of all pixels.

FILL

Fills the screen of pixels.

CHECK 1

Causes the screen to show a checkered pattern made up of single pixels.

CHECK 2

Displays a checkered pattern in alternate spaces to CHECK 1.

ANALOG OUTPUT TEST

Sends a 0.1 Hz sawtooth waveform to the selected analog output device to test its functionality. There are 6 analog outputs to choose from (`#1 to #6`). Analog outputs `#1 to #3` are available via the 50 PIN IO connector.

2.5.11 Calculation factors

```
            CALCULATION FACTORS
NO
  INSTRUMENT GAIN     : 1.0592
  P/T/F CORRECTION    : 1.0390
  BACKGROUND          : 0.0012
  ZERO OFFSET         : 0.0000 PPB
NOx
  INSTRUMENT GAIN     : 1.0427
  P/T/F CORRECTION    : 1.0398
  BACKGROUND          : 0.0016
NO2
  ZERO OFFSET         : 0.0000 PPB
  CONVERTER EFFICIENCY: 91.97
                                  EXIT
```

Figure 2-18. Calculation Factors Menu

The Calculation factors screen is a non editable screen which provides the values used to calculate different aspects of measurement and calibration.

2.5.12 Interface Menu

```
                INTERFACE MENU

          ANALOG OUTPUT MENU
          DATA LOGGING MENU
          MAIN GAS ID      :  041
          INTERFACE MODE   :  COMMAND
          MULTIDROP BAUD   :  2400
          DATA LENGTH      :  8 BITS
          STOP BITS        :  1 BIT
          PARITY           :  NONE
          COMM. PROTOCOL   :  ORIGINAL
```

Figure 2-19. Interface Menu

The INTERFACE MENU is used for adjustments related to the interfacing instruments.

The following are used only when one or more of the serial ports are to be used. See output connections information in *Chapter 4, Digital Communication.*

MAIN GAS ID
The ID address of the analyzer when Multidrop RS232 communications is used.

INTERFACE MODE
This establishes the RS232 communication mode. Choices are COMMAND or TERMINAL. TERMINAL uses the menu structure, and COMMAND uses the 9800 Serial Command Set.

MULTIDROP BAUD
The communication rate for RS232 (DB9) connector on rear panel. The available rates are 1200, 2400, 4800, 9600, 19200 and 38400.

DATA LENGTH
Sets the number of data bits used in serial transmissions. The available lengths are 7 and 8.

STOP BITS
Sets the number of stop bits used in serial transmissions. The available number of stop bits is 1 and 2.

PARITY
Sets the parity used in serial transmissions. The available choices are NONE, EVEN, and ODD.

COMM. PROTOCOL
Sets the communication protocol in serial transmissions. The available choices are ORIGINAL, BAVARIAN, and ENHANCED. See *Chapter 4*.

2.5.13 Analog Output Menu

```
ANALOG OUTPUT MENU

  NO  OUTPUT MENU
  NOx OUTPUT MENU
  NO2 OUTPUT MENU
```

Figure 2-20. Analog Output Menu

The ANALOG OUTPUT MENU contains settings that relate to the recording devices.

2.5.14 NO/NO_x/NO_2 Output Menus

The NO/NOx/NO2 OUTPUT MENUS contain the settings for each analog output channel. The three menus are functionally identical. The setting of *OUTPUT* and *OVER-RANGE* has no impact on the measurement range of the analyzer; it only affects the analog output scaling.

2.5.14.1 NO/NO_x/NO_2 Output Menu (Current)

```
NO OUTPUT MENU

RANGE          : 0.500 PPM
OUTPUT TYPE    : CURRENT
CURRENT RANGE  : 0-20 MA
FULL SCALE     : 0.00 %
ZERO ADJUST    : 0.00 %
OVER RANGE     : 20.00 PPM
OVER-RANGING   : DISABLED
```

Figure 2-21. Analog Output Menu (Current)

The above menu will be displayed whenever CURRENT OUTPUT is selected:

RANGE
Sets the upper range limit of concentration (in digits) that will be measured by the instrument. See section 2.6.3. This value cannot exceed the OVER RANGE value.

OUTPUT TYPE
Setting must match the choice on the 50-Pin I/O board (if installed), current or voltage.

CURRENT RANGE
Choices are 0-20 MA, 2-20 MA, and 4-20 MA.

FULL SCALE
X.XX%, a correction factor for full scale setting. Used when calibrating the analog outputs.

ZERO ADJUST
X.XX%, a correction factor for the zero setting. Used when calibrating the analog outputs.

OVER RANGE
Set to desired over range value. This value cannot be set below the RANGE value. See section 2.6.3. This is the alternate scale the recorder or DAS indicates when over-ranging is active and enabled. (When 90% of the set range is reached, this auto range is effective. When 80% of the original range is reached, it returns to the original range.)

OVER-RANGING
Set to ENABLED or DISABLED to turn the over-ranging feature on or off.

2.5.14.2 $NO/NO_x/NO_2$ Output Menu (Voltage)

```
            NO OUTPUT MENU

RANGE         :  0.500  PPM
OUTPUT TYPE   :  VOLTAGE
OFFSET        :  0    %
FULL SCALE    :  0.00 %
ZERO ADJUST   :  0.00 %
OVER RANGE:   :  20.00  PPM
OVER-RANGING  :  DISABLED
```

Figure 2-22. Analog Output Menu (Voltage)

The above menu will be displayed whenever VOLTAGE OUTPUT is selected:

RANGE
Sets the upper range limit of concentration (in digits) that will be measured by the instrument. See section 2.6.3. This value cannot exceed the OVER RANGE value.

OUTPUT TYPE
Setting must match the choice on the 50-Pin I/O board (if installed), current or voltage.

OFFSET
Used to offset recorded zero. Choices are 0%, 5%, or 10%.

FULL SCALE
X.XX%, a correction factor for full scale setting. Used when calibrating the analog outputs.

ZERO ADJUST
X.XX%, a correction factor for the zero setting. Used when calibrating the analog outputs.

OVER RANGE
Set to desired OVER RANGE value. This value cannot be set below the RANGE value. See section 2.6 below. This is the alternate scale the recorder or DAS indicates when over-ranging is active and enabled. (When 90% of the set range is reached, this auto range is effective. When 80% of the original range is reached, it returns to the original range.)

OVER-RANGING
Set to ENABLED or DISABLED to turn the over-ranging feature on or off.

2.5.15 Data Logging Menu

```
DATA LOGGING MENU

AVERAGE DATA  :  OFF
INST. DATA    :  OFF
TOTAL CAPACITY    :  0.0 DAYS
ERASE LOGGED DATA: NO
```

Figure 2-23. Data Logging Menu

The DATA LOGGING MENU contains settings that relate to the internal data recording facilities of the EC9841. This data can latter be retrieved using the Ecotech data downloading software mentioned in section 4.6.

AVERAGE DATA

If the average data is set to off, no average data is recorded. If it is set to on, then the average data displayed on the primary screen is recorded. The averaging period of this data is set in the MEASUREMENT MENU.

INST. DATA

The INST. DATA option allows you to select either off (where no data is recorded) or record instantaneous data with the following intervals: 1 HOUR, 30 MINUTES, 10 MINUTES, 5 MINUTES, 3 MINUTES OR 1 MINUTE.

TOTAL CAPACITY

When either of the above is set to on, the amount of free memory available for data logging will be displayed in days. This indicates how much data can be stored, before the earliest data will start to be overwritten.

Inst. Data (min)	*Total Capacity (days)*
1	26
3	79.6
5	132
10	265
30	796
60	1591

ERASE LOGGED DATA

When yes is selected and enter is pressed, all the logged data will be erased.

2.5.16 Network Adaptor Menu.

The Network Adaptor Menu allows the user to enter or change the I.P. address, Netmask and Gateway.

```
              NETWORK ADAPTER MENU

I.P. ADDRESS      0.    0.    0.    0.
NETMASK           0.    0.    0.    0.
GATEWAY           0.    0.    0.    0.
```

2.5.17 Trend Select Menu

TREND SELECT MENU is the graphic display of the parameters listed.

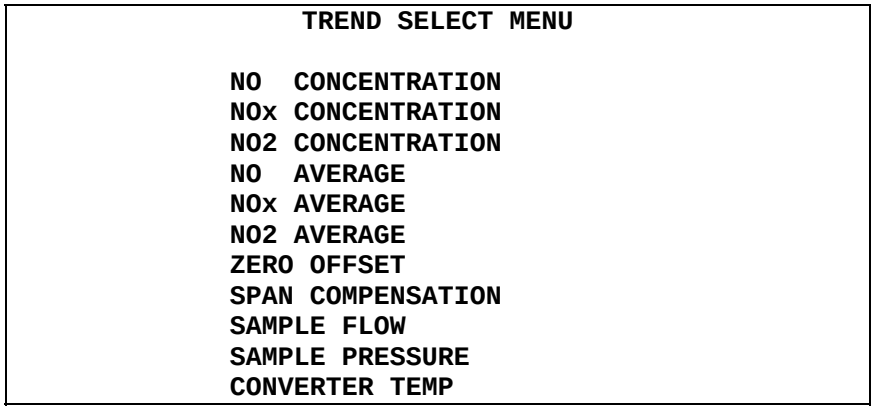


Figure 2-24 Trend Select Menu

Each graph is displayed as an x-y plot with the x-axis zero being the current time and the most distant number being the most historic data.

2.5.18 Event Log Screen

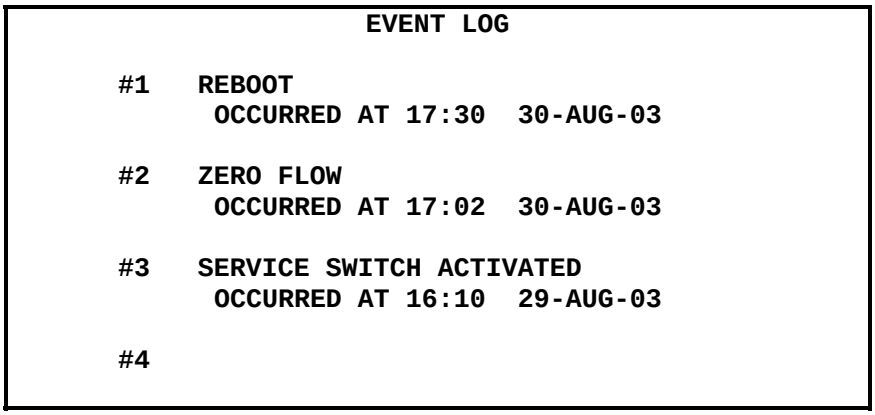


Figure 2-25. Event Log

The EVENT LOG displays notations of key events such as auto-zero and calibration or specific error conditions for up to 100 occurrences. This screen is a first in, last out type screen. The first entry is the latest occurrence. You can scroll through the events using the Up or Down arrow keys (▲ or ▼).

2.5.19 Instrument Status Screen

```
                INSTRUMENT STATUS

      GAS FLOW       :  0.64    SLPM
      GAS PRESSURE   :  168.2   TORR
      AMBIENT PRESS. :  625.5   TORR
      CONC. VOLTAGE  :  3.500   VOLTS
      ANALOG SUPPLY  :  11.9    VOLTS
      DIGITAL SUPPLY :  5.0     VOLTS

      HIGH VOLTAGE   :  650     VOLTS

VERSION 1.03.0002                        EXIT
```

Figure 2-26. Instrument Status Screen

INSTRUMENT STATUS is information continuously generated by the microprocessor for various parameters.

GAS FLOW
Calculated gas flow. Will indicate 0.00 if the flow transducer senses zero flow.

GAS PRESSURE
Current Gas pressure is the sample pressure inside the reaction cell and should be a little below current barometric pressure.

AMBIENT PRESSURE
Sample pressure as measure in the valve manifold upstream of the critical orifices.

CONC. VOLTAGE
Voltage from the preprocessor proportional to the chemilluminescent signal from the reaction cell. This voltage is represents the actual measurement of gas.

ANALOG SUPPLY
+12 volt (primary) power supply.

DIGITAL SUPPLY
+5 volt microprocessor power supply.

HIGH VOLTAGE
PMT power supply high voltage reading.

VERSION
Indicates the current firmware version installed in the Microprocessor.

Additional information on the INSTRUMENT STATUS screen is included in the *EC9841 Service Manual*.

2.5.20 System Temperatures Screen

```
SYSTEM TEMPERATURES

CELL TEMP.          :  50.0   DEG C
CONV. TEMP.         :  315.0  DEG C
CHASSIS TEMP.       :  35.0   DEG C
MANIFOLD TEMP.      :  55.0   DEG C
COOLER TEMP.        :  10.0   DEG C
```

Figure 2-27. System Temperatures Screen

The SYSTEM TEMPERATURES display is information continuously generated by the microprocessor.

CELL TEMP.
Temperature of the reaction cell.

CONV. TEMP.
Temperature of the molybdenum converter (molycon).

CHASSIS TEMP.
Temperature of air inside the chassis, measured on the microprocessor PCA.

MANIFOLD TEMP.
Temperature of the orifice heater in the valve manifold.

COOLER TEMP.
Temperature of the cooled PMT block.

Additional information on the SYSTEM TEMPERATURES screen is included in the *EC9841 Service Manual*.

2.5.21 System Faults Screen

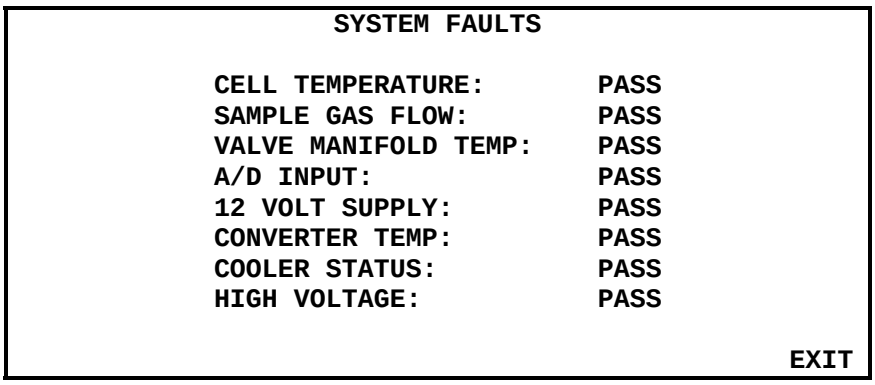


Figure 2-28. System Faults Screen

The SYSTEM FAULTS display provides a start, pass or fail indication for various parameters which are continually monitored. These parameters must be within acceptable operating ranges in order to display PASS. If the instrument is in startup mode, START will be displayed. Additional information on the SYSTEM FAULTS screen is included in the *EC9841 Service Manual*

2.6 Analog Output

Analog output connections are described in 2.1.2.1 above.

Before setting up the recorder and DAS analog outputs, decide what offset and over-ranging choices to make. A brief explanation of these terms follows, then the setup procedure is given. ***The setting of the analog output and over-range has no impact on the measurement range of the analyzer; it only affects the analog output scaling.***

2.6.1 Offset and Live Zero

At any selected output range, the operator may want to observe negative signal indications. Moving the zero indication up the scale to a specific point creates a live zero, thus allowing the recorder or DAS to show negative as well as positive indications.

The adjustment used to create a live zero is OFFSET. For example, a 10% offset moves the zero indication to the point where 10% would normally be indicated. The full reading available on the recorder paper or DAS would then be -10% to +90% of full scale. See Figure 2-29 below.

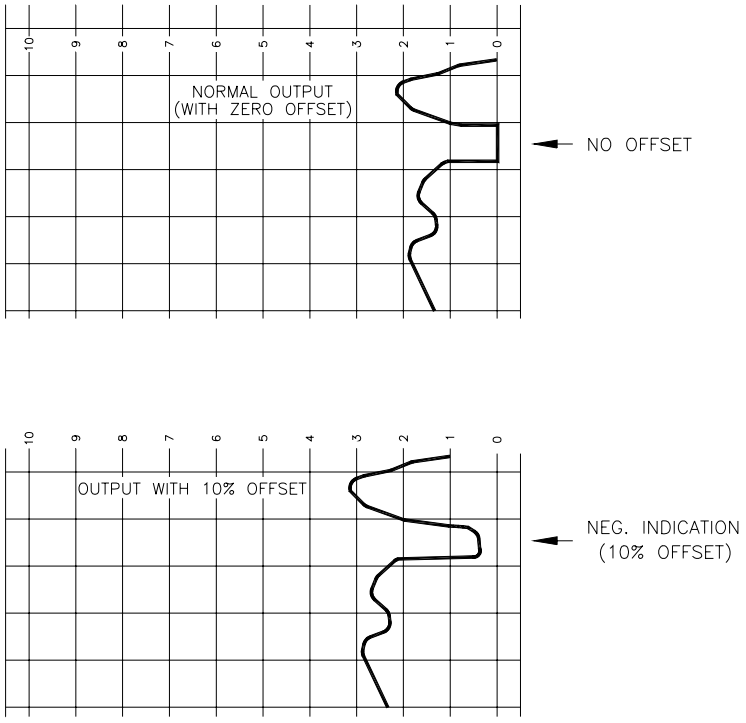


Figure 2-29. Strip Charts Illustrating Offset

Signal adjustments for zero and instrument gain to align the output with the user's recorder or other measurement device can be made in the ANALOG OUTPUT MENU in the fields FULL SCALE and ZERO ADJ. These adjustments may be necessary due to tolerance buildup, power supply variation, etc in either the analyzer or the measurement device.

2.6.2 Over Range Adjustment

Over-ranging is also enabled from the ANALOG OUTPUT MENU. The OVER RANGE setting is the auxiliary range the operator chooses to track the data should the data exceed full scale of the original range. *The setting of OVER-RANGE has no impact on the measurement range of the analyzer; it only affects the analog output scaling.*

With over-ranging enabled, as the concentration reaches 90% of the full scale value for the selected output range, the software generates a positive spike that takes the indicator from the 90% position to the 100% position. The output data is then scaled for the full scale chosen for over range. As the output drops back to 80% of the original full scale, the software generates a negative spike from the displayed value to zero. The output then reverts to the original range. See Figure 2-30 below for an example of over range on a typical strip chart recorder.

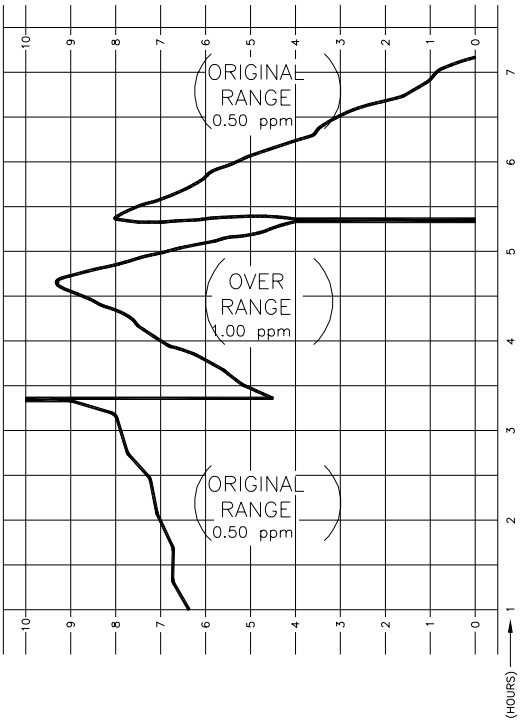


Figure 2-30. Over Range as Seen on a Strip Chart Recorder

The range value should generally be set first. However, because the range value must be less than the currently selected over range value, it may be necessary to increase the over range value to the desired setting first. The over range value is limited to be equal to or greater than the currently selected range value. For practicality, it is recommended that the over range be set to a value between 2 and 5 times the range value. For example, if the desired monitoring range is 0.2 ppm, the over range should be set between 0.4 ppm and 1.0 ppm.

Certain precautions must be taken when over-ranging is enabled to ensure that pollutant concentration measurements are reported correctly. When a data acquisition must interface with the analog output of the instrument, some means must be provided to indicate which range is in effect during all measurements. The user should monitor the 50-pin I/O connector pin 7, which is an open collector output indicating analog output #1 is in over-range.

2.6.3 Analog Output Calibration Procedure

This procedure is appropriate for connecting the EC9841 analyzer to a strip cart recorder, Data logger (DAS) or to a Digital voltmeter (DVM).

1. Enter the INTERFACE MENU and choose ANALOG OUTPUT MENU.

2. Select RANGE and enter the desired range by selecting the appropriate digits. Press <Enter> to confirm your choice.

3. Set the output type according to the termination selected for the discrete I/O connector. The choice will be either CURRENT or VOLTAGE.

   If current output is desired and the 50-pin board is installed, set the selection jumper to CURRENT *and de-select all voltage ranges*. If current output is desired and the 50-pin board is not installed, no hardware change is required.

   If voltage output is desired and the 50-pin board is installed, set the selection jumper to VOLTAGE. If voltage output is desired and the 50-pin board is not installed, an external termination resistor is required. This resistor must be 50 ohms per full scale voltage desired (50 ohms = 1 v full scale; 500 ohms = 10 v full scale, etc).

4. If voltage output type was selected, choose the desired OFFSET and press <Enter>. If current output type was selected, choose the desired output range and press <Enter>.

5. Select ZERO ADJUST and adjust the analog output to the selected offset position for zero concentration (i.e., if 10% OFFSET is selected, position the recorder pen or DAS at 10% of full scale). To make the adjustment, watch the recorder paper or DAS while you increment or decrement the zero adjustment correction factor that is displayed. Press <Enter> to confirm your setting.

6. Select FULL SCALE and adjust the analog output to 100% on the recorder paper or DAS. To make this adjustment, watch the recorder paper or DAS while you increment or decrement the full scale correction factor that is displayed. Press <Enter> to confirm your setting.

7. Select OVER RANGE and set to a range that is higher than the RANGE chosen at the top of the screen. When the digits reflect the desired over-range, press <Enter>.

8. Select OVER-RANGING and choose either ENABLED or DISABLED. Press <Enter>.

2.6.4 Calibration Requirements

To make your data acceptable to the regulatory authorities and to pass required periodic audits, you must calibrate the instrument before any data is collected for use in a monitoring program. The calibration procedure is included in *Chapter 3* of this manual.

Most regulatory requirements also include establishing a calibration verification program. If your organization does not have the staff to perform this task, Ecotech's Service personnel can provide assistance. See the front of this manual for contact details.

2.7 Password Protection

A password protection option was designed in order to solve the problem of altering the configuration of the machine by the user. This option prevents the user from configuring the EC9800 menus by creating an individual password. This feature allows the user to exclude changes to the front panel menus by locking them through a user-specified password.

2.7.1 Rules of Operation

- The password must be a four-digit number.
- After a memory erasure, the analyzer will default to UNLOCKED.
- The user must enter a four-digit number to lock the analyzer. The same four-digit number is used to unlock the analyzer as well.
- Once the analyzer is locked, the user may navigate through the menus, but cannot select a field for data entry.

- Each time the user wishes to lock the analyzer, the password must be entered. The password is only valid while the analyzer remains locked; previous passwords are not remembered.
- On the INSTRUMENT MENU there is a new entry labeled PASSWORD that displays the status of the menu as either UNLOCKED or LOCKED.

2.7.2 Sample Session

1. At INSTRUMENT MENU there is a field labeled PASSWORD. This should display the status UNLOCKED.
2. Select the field labeled PASSWORD. The status UNLOCKED will be replaced by 0000.
3. Using the select and arrow keys scroll to the desired numbers to represent the password.
4. When the desired password appears, press the <Enter> key. The password will disappear and the LOCKED message will take its place. The analyzer is now locked.
5. Scroll through the instrument menus. From this point forward, it is impossible to select any alterable fields.
6. Return to the INSTRUMENT MENU and select the PASSWORD field.
7. The LOCKED message will disappear and 0000 appears in its place.
8. Using the <Select> and arrow keys scroll the numbers of the password entered previously.
9. When the password is displayed, press the <Enter> key. The password will disappear and be replaced by the message UNLOCKED.
10. The analyzer is unlocked and the menu configuration can be altered

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3.0 Calibration

3.1 Overview

The calibration chapter consists of:

- a general discussion of analyzer calibration
- a description of the multipoint calibration procedure
- a description of automatic zero/span (AZS) setup
- a discussion of the AZS feature.

The *EC*9841 nitrogen oxides analyzer is a precision measuring device that must be calibrated against known sources of nitric oxide (NO) and nitrogen dioxide (NO_2) traceable to National Institute of Standards and Technology (NIST) standards. (Formerly, NIST was the National Bureau of Standards, or NBS.)

In general terms, the calibration process consists of the following steps.

1. Establish a reliable and stable calibrating source.
2. Provide a satisfactory interface between the calibration source and the analyzer.
3. Calibrate the analyzer against the calibrating source.

Multipoint calibration is used to establish the relationship between analyzer response and pollutant concentration over the analyzer's full scale range. Zero and span checks are frequently used to provide a two-point calibration or an indication of analyzer stability and function.

Regulations generally require that the analyzer be recalibrated anytime it is moved, serviced, or whenever the analyzer characteristics may have changed. This includes changing the instruments units from volumetric to gravimetric. Regulatory agencies establish the time intervals at which the analyzer must be calibrated to ensure satisfactory data for their purposes.

Important

Use of the EC9841 analyzer as a U.S. EPA designated reference method requires periodic multipoint calibration in accordance with the procedure described below. In addition, the instrument must be set to the parameters indicated in *Chapter 1, Introduction*.

3.1.1 Analyzer Calibration Instructions

Note

This procedure is a quick guide to single point span calibration of the EC9841 analyzer, intended for operators who are familiar with gas analyzers and preparation of calibration gas. For complete gas preparation and multipoint calibration instructions, refer to section 3.2 below.

Note

Changing instrument between single and dual gain modes is performed within the instrument menu see section 2.5.3.

Single gain procedure

1. Connect a source of span calibration gas to the analyzer through the Inlet port (see the remainder of this section for instructions on preparing calibration gas).

2. Allow the analyzer to sample the gas until a stable reading is obtained, typically 15 minutes.

3. From the primary screen, start the calibration sequence by pressing either the Up or Down arrow key (⮝ or ⮟) until the display prompts START MANUAL CALIBRATION. Pressing the <Select> key will allow you to choose from: NO, SPAN or ZERO. Confirm that the display reads SPAN and press <Enter> (↵). A backlit cursor will be displayed on the NO_X concentration display.

4. Use the <Select> key to move the position of the backlit cursor, and the Up and Down arrow keys to increment and decrement the value of the backlit digit until the span calibration gas concentration value is displayed. When the desired concentration is displayed, press <Enter>.

5. Next move the cursor to the CONVERTER EFFICIENCY field. If the converter efficiency is known to be other than 100%, program this value and press <Enter>; otherwise, press <Enter>.

6. Then move the backlit cursor to the INSTRUMENT GAIN field. The instrument gain is automatically calculated by the analyzer. Press <Enter> to confirm this value. Press <Exit> to return to the primary screen.

Dual gain procedure

1. Connect a source of span calibration gas to the analyzer through the Inlet port (see the remainder of this section for instructions on preparing calibration gas).

2. Allow the analyzer to sample the gas until a stable reading is obtained, typically 15 minutes.

3. From the primary screen, start the calibration sequence by pressing either the Up or Down arrow key (▲ or ▼) until the display prompts START MANUAL CALIBRATION. Pressing the <Select> key will allow you to choose from: NO, SPAN or ZERO. Confirm that the display reads SPAN and press <Enter> (↵). A backlit cursor will be displayed on the NO_X, move it to the NO concentration display.

4. Use the <Select> key to move the position of the backlit cursor, and the Up and Down arrow keys to increment and decrement the value of the backlit digit until the span calibration gas concentration value is displayed. When the desired concentration is displayed, press <Enter>.

5. Now repeat steps 2-4 using the NO_x field in place of the NO field.

> **Note:** When an instrument gain is altered and differs to the other gain by more than 10%, the other gain will be automatically altered to match that of the gain being changed. If the first (NO) instrument gain that is configured automatically changes when the second instrument gain (NOx) is set, the instrument is not operating properly and should be serviced (likely cause Molycon converter).

6. Next the efficiency of the converter must be determined. Follow steps 2-4 above replacing the NO standard with an appropriate converter gas i.e. NO_2 .

7. Use the readings on the screen and the known concentrations delivered to the instrument to calculate the converter efficiency $NO_{2\ (measured)}$ / $NO_{2\ (expected)}$.

8. Next move the cursor to the CONVERTER EFFICIENCY field. If the converter efficiency is known to be other than 100%, program this value and press <Enter>; otherwise, press <Enter>.Press <Exit> to return to the primary screen.

This completes the span calibration of the EC9841 analyzer.

Note

The auto-zero function of the EC9841 eliminates the need for a traditional zero calibration.

3.2 Multipoint Calibration and Zero/Span Check

Two alternative methods for dynamic multipoint calibration are specified in 40 CFR Part 50, Appendix F.

- Alternative A: Gas phase titration (GPT) of an NO standard with O_3 to generate known concentrations of NO_2.
- Alternative B: NO_2 permeation tube and a dynamic dilution system to produce known concentrations of NO_2.

Both methods provide reliable results when correct calibration procedures are followed. Experience has shown, however, that NO_2 permeation tubes may become unreliable if not handled properly. Furthermore, the conditions that contribute to the degradation of the tubes are not well understood at this time, so care should be exercised by those using Alternative B for calibrating NO_2 analyzers. Analyzers that require calibration of NO or NO_X channels must use an NO standard and a dynamic dilution system to generate known concentrations. Both alternatives require the use of an NO calibration gas to determine the efficiency of the analyzer's NO_2-to-NO converter.

Only Alternative A (GPT) is described in detail in this section and is recommended for calibrating the analyzer. A brief description of Alternative B is given, but use of an NO_2 permeation tube is recommended only for span checks.

Note

For more detail on either alternative, see Reference 2 (section 3.13).

Dynamic multipoint calibration of the analyzer requires an NO and an NO_2 source that provides at least six concentration levels in addition to zero air.

Zero and span checks must include zero air and at least one NO_2 span gas concentration. If a source other than the dynamic calibration source is used, the span gas concentration should be referenced to the dynamic multipoint calibration.

3.2.1 Interface Connections

All fittings, valves, pneumatic lines, and other components that make contact with the span gas must be made of Teflon, borosilicate glass, or stainless steel. Inaccurate calibrations may result when other materials are used.

The zero, span gas, and sample pressure at the analyzer sample inlet must not exceed that normally experienced due to variations in ambient pressure.

3.2.2 Zero Air Generation

The zero air required for the generation of calibration atmospheres and for zero checks of the analyzer must be free of NO, NO_2, O_3, and water which will cause a detectable response on the analyzer. Water can be removed by using a silica gel or calcium sulfate drying agent. It is useful to purchase drying agents with an indicator so you can know when they are depleted.

After drying, zero air can be obtained in two ways:

1. *Oxidation and scrubbing:* NO in the air source is oxidized to NO_2 by passing it through a chamber containing an ozone generating lamp. The products of the oxidation are then absorbed through activated charcoal. The air obtained by this process is filtered to remove charcoal particles before being used.

2. *Chemical oxidation:* NO in the air source is oxidized to NO_2 using a *purafil* (chromate agent on alumina support material). The same filtering process as shown in A is used. This alternative has the benefit of not requiring any electrical power to operate an ozone lamp.

3.3 Calibration and Zero/Span Check Schedule

The analyzer must be calibrated initially and periodically to determine the reliability and accuracy of all air quality data collected, and to alert you if the accuracy or reliability of the data is unacceptable. Factory zero/span data is supplied on the Final Test Sheet provided with each analyzer. Calibration is necessary before using the analyzer to perform sample measurements. The table below outlines a dynamic calibration and zero/span check schedule.

Phase	Examination	Frequency	Comments
I. Initial Examination	Zero/Span Check	Not applicable	The analyzer zero and span points must be checked soon after receiving shipment. A zero/span check must always precede calibration.
	Calibration	Not applicable	The analyzer must be calibrated immediately after the initial zero/span check.
II. Routine Examination	Zero/Span Check	Daily	Frequency can be altered based on a determination of reliability.
	Calibration	Weekly	Same as above.
III. Long Term Examination	Zero/Span Check	To be determined	Frequency determined after accumulation of data and analysis of Phase II.
	Calibration	To be determined	Same as above.

3.4 Calibration Standards

3.4.1 Standard Source of NO

Calibrating a nitrogen oxides analyzer requires a standard source of NO in the range of 50 to 100 ppm with no more than 1 ppm NO_2 impurity. The most reliable NO sources are those using NO cylinders traceable to NIST standards and diluted by calibrators.

3.4.2 Standard Source of NO_2

An NO_2 calibration standard can be obtained through the technique of GPT of an NO standard with O_3. The facility for performing GPT is provided in the Ecotech GasCal 1000 calibrator.

Reliable NO_2 calibration standards are also obtained using NO_2 permeation tubes. Contact Ecotech for details on the supply of a permeation calibrator which carries tubes traceable to a NIST primary standard.

With permeation tube calibrator devices, zero air is manufactured by ambient air scrubber elements integral to the calibrator or provided by some pressurized external source. The chemical composition of zero air must be the same for zero, span, and calibration operations.

Note

Regardless of the calibration procedure, standards must be traceable to NIST Standard Reference Materials (SRM). Procedures for certifying a working NO cylinder or NO_2 permeation tube are given in section 3.10 below.

3.4.3 Preparing the NO Regulator and Delivery System

Before connecting the nominal 50 to 100 ppm NO concentration standard to the calibration system, purge the regulator and delivery line to prevent back diffusion of O_2 and contaminants into the line. If O_2 is allowed to defuse into the tank, it will oxidize the NO to NO_2. The following procedure is used to prepare the NO regulator and delivery system.

1. Connect an all-stainless-steel, two-stage regulator with an output valve to the NO concentration standard. The regulator should have never been used, or used only on NO. Do not open the main cylinder valve. Make sure the second stage is off and the output valve is closed.

2. Open the main cylinder valve momentarily and close it quickly, just allowing the pressure to build up in the first stage of the regulator. Adjust the second stage to about 40 psi.

3. Use the output valve to vent almost all the gas in the regulator. Vent the gas through an activated charcoal column to the outside. Do not allow the pressure in the first stage of the regulator to drop to atmospheric. Stop at about 50 psi.

4. Open the main tank valve momentarily and repeat step 3.

5. Flush the regulator and delivery system by performing steps 2 and 3 with the delivery system line venting at a point as near the line restriction as possible. If the delivery line contains a gauge or tee, that leg must be flushed as well.

6. When the system has been flushed by five to ten repetitions of opening and closing the main valve, leave the main valve open and close the vent points in the delivery line so the system is leak-tight. Check the system for leaks.

7. ***Do not remove the regulator*** from the cylinder and do not do anything that would allow air to diffuse back into the regulator ***or this process must be repeated.***

3.5 Molycon Converter Efficiency

Converter efficiency is defined as the percentage of NO_2 converted to NO in the analyzer's molycon converter. The accuracy of NO_2 measurements with the EC9841 analyzer depends on the efficiency of the analyzer's NO_2-to-NO converter. The analyzer cannot be used as a U.S. EPA designated reference method unless the converter efficiency is 96% or greater.

The multipoint calibration procedure in this chapter contains a procedure for checking the molycon converter efficiency with an NO_2 concentration generated by GPT.

3.6 Multipoint Calibration Procedure, Alternative A: NO Concentration Standard and GPT

The procedure for calibrating the EC9841 nitrogen oxides analyzer is customized from the GPT procedure prescribed in 40 CFR Part 50, Appendix F. Before beginning a multipoint calibration of the instrument, read section 3.8 below.

Note

Calibration should only be performed when the instrument is stable and has been powered up for at least 2 hours.

3.6.1 Preparation

1. A qualified service technician must perform the periodic maintenance procedures in the *EC9841 Service Manual*. Check the SYSTEM FAULTS, INSTRUMENT STATUS, and SYSTEM TEMPERATURES screens to verify that the analyzer is in good working condition.

2. Prepare a GPT calibration system as shown in Figure 3-1 and discussed in section 3.8.

3. Ensure that the analyzer is properly connected to the output recording device, as described in the discussion of recorder and DAS connections found in *Chapter 2, Installation and Operation*. If necessary, go to the INTERFACE MENU, select the ANALOG OUTPUT MENU, and select the appropriate settings for the NO, NO_X, and NO_2 recording devices. Offsetting the analyzer's zero indication (OFFSET and ZERO ADJUST) to +5% of scale is recommended to facilitate observing negative zero drift on the NO_2 channel. Exit and return to the primary screen.

4. Go to the INSTRUMENT MENU, select the MEASUREMENT MENU, and disable the NO_2 filter.

5. Adjust the GPT calibration system O_3 generator and dilution air flow rates as specified in section 3.8.6. The total air flow must exceed the total demand of the analyzer(s) connected to the output manifold by 50% to ensure that no ambient air is pulled into the manifold vent during calibration.

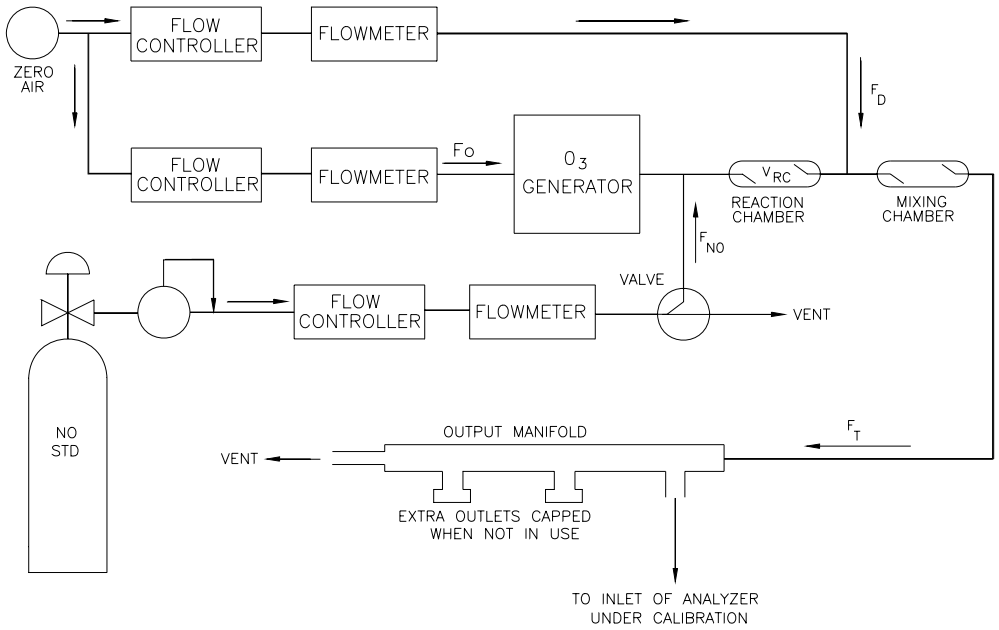

Figure 3-1. Typical GPT Calibration System Schematic

6. Go to the CALIBRATION MENU and select MANUAL calibration and MEASURE mode. Check to be sure that instrument parameters are set to the values specified in *Chapter 1*. Exit and return to the primary screen.

3.6.2 Zero Measurement

1. Allow the analyzer to sample zero air for 30 minutes, or until the NO, NO_X, and NO_2 readings drift by no more than 1% of their full scale ranges during a 10 minute period.

Note

The auto-zero function of the EC9841 eliminates the need for a traditional zero calibration.

2. Record the final, stable zero air responses as Z_{NO}, Z_{NOX}, and Z_{NO2}.

3.6.3 Span Adjustment

1. Adjust the NO flow from the standard NO cylinder to generate an NO concentration of approximately 80% of the full-scale NO range of the analyzer.

Note

It is imperative that all contaminants be removed from the NO pressure regulator and delivery systems before calibration. Failure to purge the system properly causes calibration errors. See section 3.4.3.

2. Calculate the exact NO and NO_X concentrations from the following equations:

$$[NO]_{OUT} = \frac{F_{NO} \times [NO]_{STD}}{F\,NO + F_O + F_D}$$

Equation 3.0-1

$$[NO_X]_{OUT} = \frac{F_{NO} \times ([NO]_{STD} + [NO_2]_{IMP})}{F_{NO} + F_O + F_D}$$

Equation 3.0-2

where:

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

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

$[NO]_{STD}$ = concentration of the undiluted NO standard, in ppm

$[NO_2]_{IMP}$ = concentration of NO_2 impurity in the standard NO cylinder, in ppm

F_{NO} = flow rate of the NO standard corrected to 25° C and 760 torr (101 kPa), in slpm

F_O = O_3 generator air flow rate corrected to 25° C and 760 torr (101 kPa), in slpm

F_D = dilution air flow rate corrected to 25° C and 760 torr (101 kPa), in slpm.

3. Allow the analyzer to sample the NO/NO_X concentration until stable NO and NO_X responses are obtained.

4. *From the primary screen*, press the Up or Down arrow key. When you are prompted START MANUAL CALIBRATION? respond SPAN by again pressing the Up or Down arrow key, then <Enter>. The cursor appears in the first digit of the NO_X concentration field. Use the <Select> and arrow keys to input the NO_X span point concentration calculated in step 2. Use the <Select> key to select the digit to be changed and the Up or Down keys to change the value. Press <Enter> to confirm the input value.

5. Now move the cursor to the CONVERTER EFFICIENCY field. If the converter efficiency is known, then program that value in and press <Enter>. If the efficiency is not known, program for a value of 100% and press <Enter>.

6. The INSTRUMENT GAIN values should be recorded for future reference. Press <Exit> to return to the *primary screen.*

7. The displayed NO value should now agree with the value calculated in Equation 3.0-1 of step 2; the NO_X span value should agree with the value calculated in Equation 3.0-2, step 2, and set in step 4. If the values do not agree with those calculated, check the standard. A common problem is that contaminating an NO standard with air leads to conversion of some NO to NO_2. Check the calibration system for leaks, for conditions that can cause the conversion of NO to NO_2, and for conditions that can consume NO or NO_2. Also, check the instrument for leaks; a leak in a channel may cause a low reading on that channel.

3.6.4 Preliminary Converter Efficiency Check

1. From the primary screen, press the Up or Down arrow key to prompt START MANUAL CALIBRATION? Confirm that the display reads SPAN and press <Enter>.

2. Move the backlit cursor to the CONVERTER EFFICIENCY field. Program this value for 100% and press <Enter>.

3. Press <Pg Up> or <Exit> to leave the calibration routine.

4. Adjust the NO flow rate to generate an NO concentration of approximately 90% of the full scale NO_2 range.

5. Allow the analyzer to sample this NO concentration until the analyzer readings have stabilized. Record the NO and NO_2 readings as $[NO]_{ORIG}$ and $[NO_2]_{ORIG}$.

6. Turn on the O_3 generator in the GPT system. Adjust the generator to produce sufficient O_3 to generate an NO_2 concentration equivalent to approximately 80% of the full scale NO_2 range. The NO_2 concentration must not exceed 90% of the original NO concentration generated in step 2.

7. When the analyzer readings have stabilized, record the NO and NO_2 readings as $[NO]_{FINAL}$ and $[NO_2]_{FINAL}$. Calculate the converter efficiency from the following equation:

$$EFF_{CONV} = \frac{D[NO_2]}{D[NO]} \times 100 = \frac{[NO_2]_{FINAL} - [NO_2]_{ORIG}}{[NO]_{ORIG} - [NO]_{FINAL}} \times 100$$

Equation 3.0-3

where:

$[NO]_{ORIG}$ = NO concentration before the addition of O_3, in ppm

$[NO]_{FINAL}$ = NO concentration after the addition of O_3, in ppm

$[NO_2]_{ORIG}$ = NO_2 concentration before the addition of O_3, in ppm

$[NO_2]_{FINAL}$= NO_2 concentration after the addition of O_3, in ppm.

8. If the converter efficiency is less than 96%, replace the converter.

9. From the primary screen, press the up or down arrow to prompt `START MANUAL CALIBRATION?` Confirm the display reads `SPAN` and press <Enter>.

10. Move the backlit cursor to the `CONVERTER EFFICIENCY` field. Program this value for the calculated converter efficiency (in %) and press <Enter>.

11. Press <Pg Up> or <Exit> to leave the calibration routine.

3.6.5 Preparation of the NO and NO_X Calibration Curves

1. Turn off the O_3 generator in the GPT calibration system.

2. Generate several additional NO/NO_X concentrations (at least five evenly spaced points) by decreasing the NO flow rate or increasing the dilution air flow rate (varying the dilution flow is recommended).

3. For each concentration generated, calculate the exact NO and NO_X concentrations using Equation 3.0-1 and Equation 3.0-2. Record the analyzer's NO and NO_X responses.

4. Plot the analyzer's NO and NO_X responses versus the corresponding calculated NO and NO_X concentrations and construct the NO and NO_X calibration curves. If desired, compute calibration relationships for both the NO and NO_X channels.

Note

For subsequent calibrations where linearity can be assumed, a two-point calibration (zero air point and NO/NO_X span point) may be used.

3.6.6 Preparation of the NO_2 Calibration Curve

1. Adjust the GPT calibration system O_3 generator air and dilution air flow rates as determined in step 5 of 3.6.1, Preparation.

2. Adjust the NO flow rate to generate an NO concentration of approximately 90% of the full scale NO_2 range. When the analyzer responses have stabilized, record the NO reading as $[NO]_{ORIG}$.

3. Turn on the O_3 generator in the GPT calibration system and adjust the generator to produce sufficient O_3 to generate an NO_2 concentration equivalent to approximately 80% of the full scale NO_2 range. The NO_2 concentration must not exceed 90% of the original NO concentration generated in step 2. When the analyzer responses have stabilized, record the NO reading as $[NO]_{FINAL}$.

4. Calculate the NO_2 concentration generated from the following equation:

$$[NO_2]_{OUT} = [NO]_{ORIG} - [NO]_{FINAL} + \frac{F_{NO} \times [NO_2]_{IMP}}{F_{NO} + F_O + F_D}$$

Equation 3.0-4

where:

$[NO_2]_{OUT}$ = diluted NO_2 concentration at the output manifold, in ppm

$[NO]_{ORIG}$ = NO concentration before the addition of O_3, in ppm

$[NO]_{FINAL}$ = NO concentration after the addition of O_3, in ppm

F_{NO} = NO flow rate in slpm

$[NO_2]_{IMP}$= concentration of NO_2 impurity in the standard NO cylinder, in ppm

F_O = O_3 generator air flow rate, in slpm

F_D = diluent air flow rate, in slpm.

5. Record the analyzer's NO_2 response.

6. Maintaining the same F_{NO}, F_O, and F_D, adjust the O_3 generator in the GPT calibration system to obtain several additional NO_2 concentrations (at least 5 evenly spaced points). Calculate each NO_2 concentration using Equation 3.0-4 and record the corresponding analyzer NO_2 responses.

7. Plot the analyzer's NO_2 responses versus the corresponding calculated NO_2 concentrations and construct the NO_2 calibration curve. If desired, compute a calibration relationship for the NO_2 channel.

3.6.7 Final Converter Efficiency Check

1. Calculate a least squares slope for the NO_2 calibration curve using $[NO_2]_{OUT}$ as the X variable and the corresponding NO_2 reading (in ppm) as the Y variable.

2. Calculate the final converter efficiency from the following equation:

$$EFF_{CONV}(\text{final}) = EFF_{CONV}(\text{equation 3}) \times \text{slope}$$

Equation 3.0-5

3. If the final converter efficiency is less than 96%, replace the converter and repeat the calibration process. If the converter efficiency is 96% or greater, the analyzer calibration is complete and the analyzer is ready for operation.

3.7 Multipoint Calibration Procedure, Alternative B: NO_2 Permeation Device

Although calibration of the analyzer with an NO_2 permeation tube is not recommended for reasons discussed earlier, a brief description of the calibration technique is given below.

1. In addition to an NO_2 permeation system, a source of NO and a GPT calibration system are required. The NO cylinder does not have to be NIST-traceable, but the NO concentration should be known to within 10%.

2. Prepare the analyzer for calibration (see section 3.6.1 for guidance).

3. Perform a pseudo-calibration of the analyzer using the NO source and GPT as described in section 3.6 above. Set the NO_X span assuming that the NO cylinder contains no NO_2 impurity. Check and set the converter efficiency as described in the GPT calibration procedure (section 3.6.7 above). The converter efficiency must be 96% or greater; if it isn't, replace the converter.

4. Set up an NO_2 permeation system as shown in Figure 3-2 and discussed in section 3.9 below.

5. Generate an NO_2 concentration of approximately 80% of the full scale NO_2 range. Calculate the exact NO_2 concentration from the following equation:

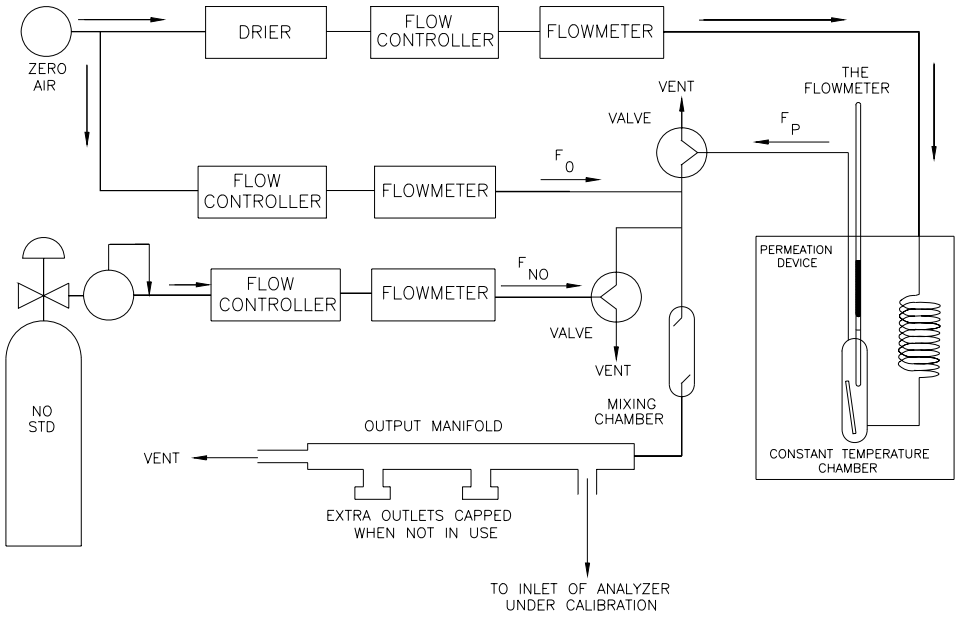

Figure 3-2. Calibration Apparatus with NO_2 Permeation Tube

$$[NO_2]_{OUT} = \frac{R \times K}{F_P + F_D}$$

Equation 3.0-6

where:

$[NO_2]_{OUT}$ = diluted NO_2 concentration at the output manifold, in ppm

R = NO_2 permeation rate, µg/min

K = 0.532 µl NO_2/µg NO_2 at 25° C and 760 torr (101 kPa)

F_P= air flow rate across permeation tube, corrected to 25° C and 760 torr (101 kPa), slpm

F_D = dilution air flow rate corrected to 25° C and 760 torr (101 kPa), slpm.

6. Set the span of the analyzer as described in the GPT calibration procedure by adjusting the NO_X span value (NO_X concentration field) to agree with the NO_2 concentration generated with the permeation tube. Record the NO_2 response and calculated NO_2 concentration.

7. Generate five additional NO_2 concentrations at equally spaced intervals. Record the analyzer NO_2 response and calculated NO_2 concentration for each calibration point.

8. Plot the analyzer NO_2 responses versus the corresponding NO_2 concentrations and construct the NO_2 calibration curve. If desired, compute the NO_2 calibration relationship.

3.8 Guidelines for Calibration Using GPT

3.8.1 Principle

This calibration technique is based on the rapid gas phase reaction between NO and O_3 to produce stoichiometric quantities of NO_2 in accordance with the equation:

$$NO + O_3 \rightarrow NO_2 + O_2$$

The quantitative nature of this reaction is such that when the NO concentration is known, the concentration of NO_2 can be determined. Ozone is added to excess NO in a dynamic calibration system and the NO channel of the analyzer is used as an indicator of changes in NO concentration.

With the addition of O_3, the decrease in NO concentration observed on the calibrated NO channel is equivalent to the concentration of NO_2 produced. The amount of NO_2 generated may be varied by adding variable amounts of O_3 from a stable, uncalibrated O_3 generator.

3.8.2 Preliminary GPT Design Considerations

In setting up the apparatus, some general considerations are important. First, determine the minimum total flow, F_T, required at the sample manifold. This flow is controlled by the number of analyzers and the sample flow rate demand of the individual analyzers to be connected to the manifold at the same time. Allow at least 0.5 slpm in excess of the required total flow.

The operational characteristics of the ozone source put limitations on the maximum flow, F_T, of the calibration system. The Ecotech GasCal 1000 calibrator can provide a reliable source of ozone. It consists of a cell adjacent to a low pressure mercury vapor lamp. Ozone-free air is passed through the tube and is irradiated with 185 nm light from the mercury lamp. The level of irradiation is controlled electronically. Ozone concentrations are varied by a switch. At a fixed temperature, pressure, air flow, and level of irradiation, ozone is produced at a constant rate. A change in air flow causes an inverse change in the ozone concentration when all other variables are held constant. This type of ozone source can generally supply up to 3 ppm of O_3 at an air flow in the range of 1 to 10 slpm, depending on the size of the generator.

To determine the operational characteristics of a particular ozone generator, adjust the ozone source to near-maximum irradiation, then measure the O_3 produced at different levels of air flow through the generator; eg, to 10 slpm. (A calibrated ozone monitor or other means of measuring O_3 concentrations is necessary.) A plot of the O_3 concentration versus the reciprocal air flow should be linear. The air flow that gives the desired maximum O_3 concentration, as determined by the maximum concentration of NO_2 needed for calibration, represents the maximum total flow for a calibration system using the generator.

Of course, lower air flows can be used to generate the required O_3 concentration by simply reducing the level of irradiation of the UV lamp. If the air flow characteristics of the ozone generator do not meet the minimum total flow requirements of the analyzer under calibration, then either the generator must be replaced or the number of analyzers to be calibrated simultaneously must be reduced.

3.8.3 Major Equipment Required

- Stable O_3 generator
- Strip chart recorder or DAS
- NO concentration standard (about 100 ppm NO in nitrogen).

3.8.4 System Setup

Figure 3-1 shows the suggested placement of the components of a typical GPT system. Such systems are also available commercially. All connections between components in the system should be made with glass, Teflon, or other nonreactive material. The discussion below is restricted to an apparatus capable of producing sample flows between 1 and 10 slpm at the manifold. This is the flow range over which GPT of excess NO with O_3 has been most widely used and investigated.

- *NO Flow Controller*. A device capable of maintaining constant NO flow within 2% of the required flow rate. Components in contact with the NO should be of a nonreactive material.
- *Air Flowmeters*. Calibrated flowmeters capable of measuring and monitoring air flow rates with an accuracy of 2% of the measured flow rate.
- *NO Flowmeter*. A calibrated flowmeter capable of measuring and monitoring NO flow rates with an accuracy of 2% of the measured flow rate. Use of a low volume certified bubblemeter and a stop watch is recommended.
- *Pressure Regulator for Standard NO Cylinder*. This regulator must have a nonreactive diaphragm and internal parts and a suitable delivery pressure.
- *Ozone Generator*. The generator must be capable of generating sufficient and stable levels of O_3 for reaction with NO to generate NO_2 concentrations in the range required. Ozone generators of the electric discharge type may produce NO and NO_2, and are not recommended. Also, ***the importance of using dry, clean zero air in the O_3 pneumatics cannot be overemphasized***. All connections between components in the calibration system downstream from the O_3 generator should be of glass, Teflon, or other nonreactive material.
- *Valve***.** A valve may be used as shown in Figure 3-1 to divert the NO flow when zero air is required at the manifold. The valve should be constructed of glass, Teflon, or other nonreactive material.
- *Reaction Chamber*. A chamber, constructed of glass, Teflon or other nonreactive material, for the quantitative reaction of O_3 with excess NO. The chamber should be of sufficient volume (V_{RC}) such that the residence time (t_R) meets the requirements specified in section 3.8.6. For practical reasons, t_R should be less than two minutes.
- *Mixing Chamber*. A chamber constructed of borosilicate glass, Teflon, or other nonreactive material, and designed to provide thorough mixing of the reaction products and diluent air. The residence time is not critical when the dynamic parameter specification given in section 3.8.6 below is met.
- *Output Manifold*. The output manifold should be constructed of borosilicate glass, Teflon, or other nonreactive material, and should be of sufficient diameter to ensure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to ensure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold.

3.8.5 Reagents

3.8.5.1 NO Concentration Standard

Pressurized cylinders of NO in N_2 at levels between 50 and 100 ppm are available commercially as working calibration standards. The buyer should specify that oxygen-free nitrogen be used as the diluent gas for the standard mixture to minimize the problem of NO_2 formation within the cylinder. In any case, the stan-

dard NO mixture must contain no more than 1.0 ppm NO_2 as impurity. Since the manufacturer's certification of the NO content in N_2 mixtures has sometimes been found to be unreliable, the calibration procedure requires that the NO content of such mixtures be assayed initially, and periodically thereafter, against an NIST-traceable NO or NO_2 standard. Traceability may be made to NO SRM 1683 or 1684 or to NO_2 SRM 1629. (The certification procedure is discussed in section 3.10 below.

It is suggested that the recertification of working NO standards be done quarterly, since the long term stability of NO mixtures has not been firmly established. Special apparatus and procedures apply when handling a reactive, toxic gas such as NO, even at concentrations of 50 to 100 ppm. It is imperative that the integrity of the NO standard be maintained when the gas is transferred from the pressurized cylinder to the reaction chamber. In addition, precautions must be taken to assure that the gas does not leak to the surroundings during the transfer. ***The need for cleanliness in the NO pressure regulator and associated gas delivery system cannot be overemphasized.*** Some of the problems of NO_2 impurity in the calibration system have been traced to the conversion of the standard NO to NO_2 by oxygen or other contaminants trapped in the standard cylinder. Refer to section 3.4.3 for the proper purging procedure of the pressure regulator.

3.8.5.2 Zero Air Source

Purified cylinder or compressed air is suitable for the zero air; however, if large volumes of zero air are required for the calibration, or especially if continuous operation is desired, purified compressed air is preferred. The zero air must be free of contaminants (such as NO, NO_2, O_3 or reactive hydrocarbons) that will cause a detectable response on the NO or NO_x channels of the analyzer, or that might react with either NO or NO_2 in the calibration system. To meet those specifications, the air can be purified by passing it through silica gel for drying, treating it with ozone to convert any NO to NO_2, and passing it through a mixture of activated charcoal (6-14 mesh) and molecular sieve (6-16 mesh, type 4A) to remove any NO_2, excess O_3, and hydrocarbons.

Silica gel maintains its drying efficiency until it has absorbed 20% of its weight, and can be regenerated indefinitely at 120° C. The addition of cobalt chloride to the surface of the gel provides an indicating ability. This type of gel, contained in a transparent drying column, is recommended. The mixture of activated charcoal and a molecular sieve also has a finite absorption capability. Since it is difficult to determine when the mixture's absorption capacity has been exceeded, it is recommended that the mixture be replaced at regular intervals, at least every three months, for an absorption volume of about 0.1 slpm.

3.8.6 Dynamic Parameter Specifications

3.8.6.1 Flow Rates

The O_3 generator air flow rate (F_O) and the NO flow rate (F_{NO}), positioned as shown in Figure 3-1, must be adjusted so that the following relationship holds:

$$P_R = [NO]_{RC} \times t_R \leq 2.75 \text{ ppm/minutes}$$

Equation 3.0-7

$$[NO]_{RC} = [NO]_{STD} \frac{F_{NO}}{[F_O + F_{NO}]}$$

Equation 3.0-8

$$t_R = \frac{V_{RC}}{F_O + F_{NO}} < 2 \text{ minutes}$$

Equation 3.0-9

where:

P_R = dynamic parameter specification, determined empirically, to ensure complete reaction of the available O_3, in ppm/min

$[NO]_{RC}$= NO concentration in the reaction chamber, in ppm

t_R = residence time of the reactant gases in the reaction chamber, in minutes

$[NO]_{STD}$= concentration of the undiluted NO standard, in ppm

F_{NO} = NO flow rate, in slpm

F_O = O_3 generator air flow rate, in slpm

V_{RC} = volume of the reaction chamber, in liters.

3.8.6.2 Flow Conditions

The flow conditions to be used in the GPT system are determined by the following procedure:

1. Determine F_T, the total flow required at the output manifold (F_T = analyzer demand plus 10% to 50% excess).

2. Establish $[NO]_{OUT}$ as the highest NO concentration (ppm) that will be required at the output manifold. $[NO]_{OUT}$ should be approximately equivalent to 90% of the URL of the NO_2 concentration range to be covered.

3. Determine F_{NO} as:

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

Equation 3.0-10

4. Select a convenient or available reaction chamber volume. Initially, a trial V_{RC} may be selected to be in the approximate range 0.2 to 0.5 liters.

5. Compute F_O as:

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

Equation 3.0-11

6. Compute t_R as:

$$t_R = \frac{V_{RC}}{F_O + F_{NO}}$$

Equation 3.0-12

7. Verify that t_R is less than two minutes. If not, select a reaction chamber with a smaller V_{RC}.

8. Compute the diluent air flow rate as:

$$F_D = F_T - F_O - F_{NO}$$

Equation 3.0-13

where F_D is the diluent air flow rate in slpm.

If F_O turns out to be impractical for the desired system, select a reaction chamber having a different V_{RC} and recompute F_O and F_D.

Note

A dynamic parameter lower than 2.75 ppm-minutes can be used if it can be determined empirically that quantitative reaction of O_3 with NO occurs. A procedure for making this determination, as well as a more detailed discussion of the above requirements and other related considerations, is given in EPA 600/4-75-003.

3.8.7 Determining NO_2 Impurity in the NO Cylinder

(Also see section 3.10 below).

1. Generate a known concentration of NO from the NO standard.
2. Set the span of the NO reading to agree with the NO level generated.
3. Note the NO_2 reading. The NO_2 impurity is given by $[NO_2]_{IMP}$ = NO_2 x (F_T/F_{NO}) provided that the molycon efficiency is 96% or better.

3.8.8 Helpful Formulas for Calibration by GPT

The NO concentration produced by the dilution system in section 3.6 above can be derived from:

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

Equation 3.0-14

where:

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

F_{NO}= NO flow rate, in slpm

$[NO]_{STD}$= concentration of the undiluted NO standard, in ppm

F_T = total flow, in slpm.

1. The exact NO_x concentration is calculated from:

$$[NO_X]_{OUT} = \frac{F_{NO} \times ([NO]_{STD} + [NO_2]_{IMP})}{F_T}$$

Equation 3.0-15

where:

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

$[NO_2]_{IMP}$= concentration of NO_2 impurity in the standard NO cylinder, in ppm.

3.9 Guidelines for Calibration Using NO_2 Permeation Devices

3.9.1 Principle

In a permeation device, an easily liquefiable gas, such as NO_2, is condensed inside an inert container, all or part of which is constructed from a polymeric material (often Teflon). Gas escapes from the container by dissolving in and permeating through the polymer walls at a temperature-dependent rate. The rate of gas effusion (in μg/min) at a constant temperature can be established by gravimetric determination of the weight loss of the permeation device over a known period of time.

In this calibration procedure, the NO and NO_x responses of the chemilluminescence analyzer are first calibrated with an NO standard. Next, accurately known concentrations of NO_2 are produced dynamically by diluting the effusion from an NO_2 permeation device with various flows of clean air to obtain a calibration for NO_2. Either the NO_2 permeation device or the NO source may be chosen as the reference standard for calibration; the remaining standard must be assayed against the reference standard for consistency.

3.9.2 Components of a Permeation Device Calibration System

Figure 3-2 shows a diagram of a typical permeation device calibration system. Such systems have been described in the literature and are commercially available. All connections between components in the system should be glass, Teflon, or other nonreactive material.

The system consists of four sections:

1. A controlled-temperature chamber that houses the NO_2 permeation device and is flushed continuously with purified, dry zero air, or nitrogen.

2. A regulated source of clean, dry zero air for diluting the NO_2 gas effluent from the permeation device. The source should be capable of providing air flows up to about 20 slpm.

3. An NO standard and delivery system.

4. A dilution-mixing, sampling, and exhaust section.

The suggestions for preparing, regulating, and measuring zero air flows discussed in connection with gas phase titration are applicable to this calibration system also. An NO standard with delivery system and a suitable dilution-mixing, sampling, and exhaust assembly were also discussed above. Therefore, the latter three sections of the permeation device calibration system do not require further discussion. A description of the constant temperature section follows.

3.9.3 Constant Temperature Chamber

Temperature control is the primary concern in using an NO_2 permeation device as a standard NO_2 source. For example, a change in temperature of about 0.5° C effects a change in the permeation rate of the device of about 4%. For that reason, it is important that the temperature of the device be maintained at a constant value within 0.1° C, and that it is closely monitored when the device is in use.

Generally, the NO_2 permeation device is housed in a temperature-controlled glass container with entrance and exit ports at opposite ends. A glass thermometer, accurate to 0.05° C, can be placed beside the device to monitor its temperature. A small fixed zero air or nitrogen flow (about 0.1 slpm) maintained at the same temperature as the permeation device flushes the NO_2 out of the device housing into a mixing chamber where the NO_2 is diluted with clean dry zero air. A valve (a three-way stopcock, for example) placed at the exit of the device housing may be used to divert the NO_2 stream to a vent when zero air is required at the manifold for making the necessary zero adjustments to the analyzer.

To maintain the temperature of the permeation device within 0.1° C of the desired value, the device and housing may be placed inside a constant temperature chamber (as in Figure 3-2) or outside the constant temperature chamber with the heat transfer medium circulated around the device housing (a West- or Liebig-type jacketed condenser, for example). The flushing zero air or nitrogen passes through a heat exchanger (e.g., a coil of copper tubing) in the constant temperature chamber before passing over the device to adjust its temperature to that of the device.

For a calibration system to be used in a laboratory or other permanent location, a circulating water bath makes an excellent constant temperature chamber. Many circulating water baths are capable of temperature control to ±0.1° C over a suitable temperature range (usually 15° to 35° C for most calibration work).

Commercial calibration systems often use circulating air in the constant temperature chamber; such a chamber has the advantage of being more portable than a water bath.

3.9.4 Flush Gas for the Permeation Device

In Figure 3-2, the zero air stream is split to allow a small air flow to pass continuously over the permeation device. Alternatively, the flush gas could be supplied from a cylinder of purified dry air or nitrogen. Whatever its source, the flushing stream must be dry enough that moisture does not condense on the surface of the device. Water condensate can react with the effusing NO_2 to form an acid mist, thus changing the NO_2 concentration. A transparent drying column containing a mixture of molecular sieve (e.g., 6-16 mesh, type 4A) and indicating calcium sulfate (e.g., Drierite) has been used effectively as a moisture scrubber on the flush gas line.

3.9.5 Standard NO_2 Permeation Devices

The diffusion properties of NO_2 make the construction of stable, accurate NO_2 permeation devices no easy feat. To assure their reliability, the devices must be handled carefully. Permeation devices are available from commercial sources and from NIST as a Standard Reference Material (SRM 1629). The NIST device has a certified permeation rate of approximately 1 μg/min at about 25° C. Permeation rates of commercial devices vary according to size and recommended operating temperature. Both NIST and commercial manufacturers provide explicit instructions on the use of their devices; for accurate measurements, follow those instructions.

Most permeation devices must equilibrate for at least 24 hours at the certified or operating temperature before the permeation rate stabilizes. If the device is subjected to extreme temperature variations when not in use, equilibration times may increase and the permeation rate may become erratic.

It was mentioned above that the flush gas over the permeation device must be extra dry. This is especially true of the NIST device, and of many others with a large surface area for NO_2 permeation. Some commercial devices that have very small permeating areas and which are designed to operate at elevated temperatures (40° to 60° C) may not be as susceptible to trace moisture in the flush gas.

Additional information regarding the use of permeation devices for calibration purposes is documented elsewhere.

If the NO_2 permeation device is to be used as the reference standard for calibration, the permeation rate of the device must be traceable to an NIST NO in N_2 standard (SRM 1683 or 1684) or NO_2 standard (SRM 1629). Otherwise, the

permeation device must be periodically assayed against the reference NO standard to assure consistency between the two working standards. Procedures for certifying the reference standard against NIST-traceable NO_2 or NO in N_2 standards and for comparing the NO_2 and NO working standards are discussed below.

3.9.6 Basic Design Considerations for a Calibration System

When designing a calibration system, first determine the operational criteria the system must meet. The calibration ranges the system must accommodate should be considered, along with the corresponding total air flow required. For maximum flexibility, design the system for use with the widest applicable range (normally 0 to 0.5 ppm NO_2 for ambient air measurement); it will serve more sensitive ranges when necessary. Since the NO_2 concentration is inversely proportional to the total flow at the manifold, the minimum required NO_2 concentration sets the upper limit of the dilution air flow. For example, using one NIST permeation device that generates about 1 μg NO_2/min, a total air flow of about 18 slpm is required to generate about 0.03 ppm NO_2. Lower concentrations would, of course, require higher dilution air flows.

Another consideration is the number of NO_2 analyzers that can be calibrated simultaneously with the calibration system. This is controlled not only by the sum of the respective analyzer sample flow rates, but also, and most importantly, by the minimum total flow of the calibration system at the manifold. Air flow is at a minimum when the NO_2 concentration is at a maximum. As specified in the calibration procedure, the maximum required NO_2 concentration is about 80% of the calibration range. Using one NIST permeation device and specifying an NO_2 analyzer range of 0 to 0.5 ppm NO_2, for example, and a total flow of about 1.3 slpm as excess flow, only about 1.0 slpm flow is available at the manifold for calibrating the NO_2 analyzers.

If the lower limit of the total flow of the NO_2 calibration gas is insufficient to meet the flow demand of the NO_2 analyzers, the problem could be solved by calibrating and using the analyzers on a more sensitive range whenever possible and appropriate. Alternatively, multiple permeation devices could be used in parallel to generate NO_2 concentrations at the upper end of the calibration range. Two NIST devices, for example, permits doubling the total flow at the manifold. By venting the effluent of all but one of the devices, NO_2 concentrations in the lower portion of the range could be easily provided.

3.10 Certification of Working Standards Against NIST-Traceable Standards

Calibration is normally done with a working standard so the standard traceable to an NIST standard is not used up. This section describes methods of determining

the concentration of the working standard by comparing it to the NIST-traceable standard.

The table below lists the NIST standards available. Either a cylinder or a permeation tube can be used as the reference.

Cylinder Gases			
NIST-SRM	**Type**	**Size Liters @ STP**	**Nominal Concentration**
1683b	Nitric Oxide in N_2	870	50 ppm
1684b	Nitric Oxide in N_2	870	100 ppm
1685b	Nitric Oxide in N_2	870	250 ppm

Permeation Tubes			
NIST-SRM	**Type**	**Permeation Rate µg/min @ 25°C**	**Concentration in ppm**
1629	Nitrogen Dioxide	1.0	0.532 @ 1 lpm 0.106 @ 5 lpm

Cylinders of working gas traceable to NIST SRMs (called U.S. EPA Protocol Calibration Gases) are also commercially available.

3.10.1 NO Working Standards Traced to NIST Standards

The NO content of the NO working standard must be periodically assayed against NIST-traceable NO or NO_2 standards. Any NO_2 impurity in the cylinder must also be assayed. Certification of the NO working standard should be made quarterly, or more frequently, as required. Procedures are outlined below for certification against either an NO or NO_2 NIST-traceable standard. The simplest and most straightforward procedure is to certify against an NO standard.

Note

If the assayed concentration of the NO_2 impurity in the NO cylinder, $[NO_2]_{IMP}$, is greater than the 1 ppm, make certain that the NO delivery system is not the source of contamination before discarding the NO standard. See section 3.4.3 for the procedure for treating the gas delivery system.

3.10.1.1 NO Working Standard Traced to NIST NO Standard

First, use the NIST-traceable NO standard and the GPT calibration procedure to calibrate the NO, NO_x and NO_2 responses of the analyzer. Also determine the

efficiency of the molycon. Refer to the calibration procedure described in section 3.6 for details.

Then generate several NO concentrations by diluting the NO working standard. Use the nominal NO cylinder concentration, $[NO]_{NOM}$, to calculate the diluted concentration. Plot the analyzer NO response (in ppm) versus the nominal diluted NO concentration and determine the slope, S_{NOM}. Calculate the NO concentration of the working standard $[NO]_{STD}$ from:

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

Equation 3.0-16

If the nominal NO concentration of the working standard is unknown, generate several NO concentrations to give on-scale NO responses. Measure and record F_{NO} and F_T for each NO concentration generated. Plot the analyzer NO response versus F_{NO}/F_T and determine the slope that gives $[NO]_{STD}$ directly.

The analyzer NO_2 responses to the generated NO concentrations reflect any NO_2 impurity in the NO working standard.

In the procedure above, it is also possible to assay the NO content of the working standard without first calibrating the NO and NO_2 responses of the analyzer. This is done by comparing relative NO responses of the working NO standard to the NIST-traceable NO standard. The NO_2 impurity can be determined from the analyzer NO_2 response, provided the molycon efficiency is known.

3.10.1.2 NO Working Standard Traced to NIST NO_2 Standard

Use the NO working standard and the GPT calibration procedure to calibrate the NO, NO_x and NO_2 responses of the analyzer. Refer to the calibration procedure for details. For this pseudo-calibration, use the nominal NO cylinder value and assume there is no NO_2 impurity in the cylinder.

From the GPT data, plot the analyzer's NO_2 responses versus the NO_2 concentration generated by GPT. Determine the slope of the NO_2 output curve, S_{NOM}, and the x-intercept of the curve. Generate several NO_2 concentrations by diluting the NIST-traceable standard. Plot the analyzer's NO_2 responses versus NO_2 concentrations. Determine the slope, S_{NIST}. Calculate the NO concentration of the working standard, $[NO]_{STD}$, from the following formula:

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

Equation 3.0-17

Calculate the NO_2 impurity from the following equation:

$$[NO_2]_{IMP} = \frac{(x - intercept)F_T}{F_{NO}} \times \frac{S_{NOM}}{S_{NIST}}$$

Equation 3.0-18

3.10.2 NO_2 Working Standards Traced to NIST Standards

If you have selected Alternative B for calibration, or if you want to verify your NO_2 working standard used for Level 2 zero/span checks, the following procedures apply.

3.10.2.1 NO_2 Working Standard Traced to NIST NO_2 Standard

The analyzer need not be calibrated for these measurements. Generate several NO_2 concentrations by diluting the NIST-traceable NO_2 standard. Plot the analyzer's NO_2 response versus NO_2 concentration and determine the slope, S_{NIST}. Generate several NO_2 concentrations by diluting the working NO_2 standard to give on-scale NO_2 responses. Measure the total flow at the manifold, F_T, in slpm for each NO_2 concentration generated.

Plot the analyzer's NO_2 response, in ppm, versus $1/F_T$ and determine the slope, S_{STD}. Calculate the permeation rate, R (μg/min), from:

$$R = \frac{S_{STD}}{K \times S_{NIST}}$$

Equation 3.0-19

where:

K = 0.532 μl NO_2/μg NO_2 at 25° C and 760 torr (760 torr = 101 kPa).

3.10.2.2 NO_2 Working Standard Traced to NIST NO Standard

Use the NIST-traceable NO standard and GPT calibration procedure to calibrate the NO, NO_x and NO_2 responses of the analyzer. Refer to the GPT calibration procedure for exact details. Generate several NO_2 concentrations by diluting the working NO_2 standard to give on-scale NO_2 responses.

Measure the total flow at the manifold, F_T (slpm), for each NO_2 concentration generated. Plot the analyzer's NO_2 response versus $1/F_T$ and determine the slope, S_{STD}. Calculate the permeation rate, R(μg/min) from:

$$R = \frac{S_{STD}}{K}$$

Equation 3.0-20

where:

K = 0.532 μl NO_2/μg NO_2 at 25° C and 760 torr (760 torr = 101 kPa).

3.10.2.3 Comparing NO_2 and NO Working Standards

To compare the working NO_2 standard to a certified NO working standard, follow the procedure outlined in section 3.10.1.2 above for certifying an NO_2 working standard against a NIST-traceable NO standard. The NO_x span adjustment must take into account any NO_2 impurity in the NO working standard. To make a comparison between a working NO standard and a certified NO_2 standard, follow the certification procedure outlined in section 3.10.1.2.

Note

For further information on calibration by GPT and NO_2 permeation devices, refer to Part 50, Chapter 1, Title 40 CFR, Appendix F (revised December 1, 1976) and Reference 13 of that appendix.

3.11 Calibration Requirements When Over-Ranging Is Employed

If you are utilizing the over-ranging feature of the analog outputs, use the following steps in conjunction with the procedure in section 3.6 or 3.7 to calibrate the instrument.

1. Choose the desired upper range limit for the normal monitoring range (RANGE).

2. Choose and set the desired upper range limit for the higher, over-range (OVER RANGE). A value between 2 and 5 times the RANGE value is recommended.

3. Disable over-ranging by setting OVER-RANGING to DISABLED.

4. Set the RANGE value equal to the OVER RANGE value.

5. Check the zero and set the span and converter efficiency as described in section 3.6 or 3.7.

6. Generate several concentration standards and determine the slope, intercept, and linearity of the higher OVER RANGE.

7. Reset RANGE to the normal monitoring range.

8. Generate several concentration standards and determine the slope, intercept, and linearity of the RANGE.

Note

Once the span and converter efficiency have been set on the higher range, no further adjustments should be made on the lower, normal monitoring range.

9. Re-enable over-ranging by setting OVER-RANGING to ENABLED.

3.12 Automatic Zero/Span Checks (AZS)

Over time, the calibration of nearly any sensitive instrument may change slightly (drift), causing error in the measured values. Accordingly, good quality assurance practice requires that the calibration of the EC9841 be checked periodically and, if necessary, that the instrument's span be adjusted to restore accurate calibration.

Section 12 of the Q.A. Handbook for Air Pollution Measurement Systems defines two types of calibration checks: a Level 1 Zero and Span calibration check is an authoritative assessment of the analyzer's calibration, using an NO or NO_2 span gas standard that is certified traceable to a SRM or CRM. The results of a Level 1 check can be used to adjust the analyzer's zero and span to restore accurate calibration. A Level 2 Zero and Span check is an informal calibration check, often with an uncertified standard, used to monitor the day-to-day relative readings of the analyzer. The results of a Level 2 check ***must not*** be used to adjust the analyzer's calibration, but may indicate the immediate need for a more authoritative Level 1 calibration check.

When used with a certified traceable NO or NO_2 span standard, the EC9841 automatic zero/span (AZS) feature may be used to automatically carry out a Level 1 calibration check on a periodic basis. Further, when the instrument's SPAN COMP is ENABLED, the EC9841 automatically and continually compensates subsequent concentration measurements for any minor calibration drift, as follows:

$$[NO]_{READ} = f_{AZS,NO} \times [NO]_{UNCOMP}$$

Equation 3.0-21

$$[NO_2]_{READ} = f_{AZS,NO_2} \times [NO_2]_{UNCOMP} \times$$

Equation 3.0-22

where:

$[NO]_{READ}$ and $[NO_2]_{READ}$ = the corrected instrument concentration readings based on the span compensation ratio obtained during the previous AZS cycle

$f_{AZS,NO}$ and $f_{AZS,NO2}$ = the NO and NO_2 span compensation ratios determined during the previous AZS cycle. The default value of both ratios is 1.000 until the first AZS cycle is carried out.

$[NO]_{UNCOMP}$ and $[NO_2]_{UNCOMP}$ = the instrument concentration readings without compensation.

During an AZS cycle, the EC9841 measures the concentration of the span gas provided to the span gas port. The measurement reading should equal the actual concentration of the span gas standard. If it does not, the instrument sets $[NO]_{READ}$ equal to $[NO]_{STD}$ and calculates a new f_{AZS} as follows:

$$f_{AZS,NO} = \frac{[NO]_{STD}}{[NO]_{UNCOMP}}$$

Equation 3.0-23

$$f_{AZS,NO_2} = \frac{[NO_2]_{STD}}{[NO_2]_{UNCOMP}}$$

Equation 3.0-24

where:

$[NO]_{STD}$ or $[NO_2]_{STD}$ = the certified concentration of the span gas standard at the span gas port.

The new value of f_{AZS} is then used to compensate subsequent measurement readings until the next AZS cycle.

Use of a Level 1 span check (with SPAN COMP: ENABLED) adjusts the instrument gains so the output of the instrument agrees with the concentration expected for the span gas. The previously determined multipoint calibration curve is used to verify that the analyzer output is linear.

Note

The zero value is a reference value only. Regardless of the state of the SPAN COMP option, the analyzer does not correct for shifts in the zero.

Note

A Level 1 span calibration requires external zero and span standards connected via the (optional) EZS valve assembly.

It is recommended that the NO or NO_2 source be checked against the instrument's previous calibration curve immediately after the generation of the calibration curve (see Section 12 of the Q.A. Handbook for Air Pollution Measurement Systems). It is also recommended that the concentration of this pollutant source be between 70% and 90% of the upper range limit of the analyzer and previous calibration curve. Subsequent use of this pollutant source, with AZS and compensation ENABLED, adjusts the span of the instrument to agree with the previous calibration line. Specific guidelines are contained Calibration Reference 1 for use of Level 1 span checks (Section 12) and certification of gas or permeation devices to SRM/CRM sources (Section 12).

Note

Use of SPAN COMP: ENABLED is not allowed under U.S. EPA designation at this time.

A Level 2 span check (with SPAN COMP: DISABLED) does not require certification of the span gas used during AZS, and the result of such a check may not be used to correct the data, but merely serves to indicate that the analyzer is functioning properly. If the AZS is used for Level 2 span checks, the SPAN COMP must be set to DISABLED. A Level 2 AZS cycle should be initiated immediately after multipoint calibration so that a valid reference point can be determined.

Unlike some of the other EC9800 series instruments, the EC9841 does not have the Internal option for AZS cycles. The external valve option must be installed to perform the AZS function. With that option installed, the outlet of the EZS valve module is connected with a short piece of tubing to the inlet of the analyzer (see Figure 2-5). The user must supply the span gas and the zero gas to the corresponding ports on the EZS valve module (Figure 2-5). The gases must be supplied to the analyzer at atmospheric pressure (for example, through a manifold as shown in Figure 3-1 or Figure 3-2).

It is possible to do automatic compensation with both NO and NO_2. However, there is only one span port available on the EZS valve manifold. This means that any mixing of NO and NO_2 must be done prior to the inlet of the analyzer. You may use premixed bottles of gas or the mixing may be accomplished in a glass or Teflon flask with sufficient volume and turbulence to assure uniform mixing. The analyzer measures the NO during one measurement cycle and NO_x during the next cycle. NO_2 is computed as the difference between NO_x and NO. The span compensation factors are applied at the end of the complete measurement cycle.

3.12.1 AZS Setup

1. Go to the CALIBRATION MENU.

2. At the prompt CALIBRATION, select TIMED.

3. At the prompt TIMER INTERVAL, set the number of hours between timed calibrations. Typical settings are 23 or 24 hours.

4. At the prompt STARTING HOUR, enter the hour of the day when AZS is to commence.

5. At the prompt CYCLE TIME, enter the number of minutes required for the span and zero steps to run.

6. At the prompt NO TIMED SPAN and NO2 TIMED SPAN, enter the value of the span gas to be used. Either or both values may be set depending on the concentrations in the span gas. Both channels will be calibrated each AZS cycle. If the ratio of the value entered to the value measured during each cycle is less than 0.75 or greater than 1.25, the compensation will not be calculated and will stay at the old value. A message will be placed in the EVENT LOG to indicate that the ratio was less than 0.75 or greater than 1.25.

7. At the prompt SPAN COMP, select ENABLED if you want the instrument span adjusted to agree with the span gas after each AZS cycle.

Caution

Setting an incorrect span gas value with SPAN COMP ENABLED causes all subsequent readings to be incorrect.

A built-in check verifies that the observed value is not different from the calibration value by more than 25%. If it is, no correction is made and an error message is sent to the EVENT LOG, setting the CALIBRATION ERROR flag.

7. The number displayed after NO SPAN RATIO and NO2 SPAN RATIO is the factor by which the instrument gain/gains are multiplied to cause the display and output to agree with the span gas. You cannot set this number. ***This value is set to 1.000 any time the span is set manually via the front panel***. (The assumption is that front panel adjustment is an instrument calibration, thus preventing compound adjustments.)

3.12.2 Description of the AZS Process

The instrument will initiate a full zero/span cycle starting at the prescribed hour. The valve to admit zero air will be opened and the sample valve closed. The instrument will allow the cell to fill with the zero gas for 12 minutes. The display and outputs are updated with the actual instrument reading during the entire zero cycle. The zero value is for user reference only, and is never used by the analyzer to compensate readings.

At the end of 12 minutes, the zero air valve is closed and the span gas valve is opened, admitting the span gas for 12 minutes. The display and outputs are updated with the actual instrument readings during the entire span cycle. The current value at the end of the span cycle is used to calculate the compensation value. If SPAN COMP is set to ENABLED, this is the value which is used to correct all subsequent readings to the calibration.

The zero air valve is switched on for 3 minutes to purge the cell of span gas.

At the end of 28 minutes seconds, monitoring resumes including putting data in the average, etc. (The data averages are ***not*** updated during zero/span check.)

3.13 Calibration References

1. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Part 1 EPA-454/R-98-004, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, 1998.

2. Technical Assistance Document For The Chemiluminescence Measurement of Nitrogen Dioxide", EPA-600/4-75-003, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory (MD-77), Research Triangle Park, NC 27711, December 1975

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4.0 Digital Communication

The EC9841 series of analyzers has three methods of digital communication, serial communication using RS232 signals, Universal Serial Bus (USB) or discrete control over the 50-pin I/O. Discrete control is limited to lines which either command a specific operation or indicate an operation is in progress. Serial communication allows access to the menu structure using a terminal and also includes a library of other specific operations. USB provides a simple way to monitor the current state of the analyzer, and download data that has been logged to the internal FLASH memory.

4.1 Discrete Control

Two control inputs are available through the 50-pin I/O connector. They are DOZERO and DOSPAN. These inputs will place the analyzer in either Zero mode or Span mode, respectively, the analyzer will remain in the selected mode while the input is active. When these inputs are made active the analyzer will actuate the valve drivers selected in the CALIBRATION MENU for CALIBRATION INTERNAL/ EXTERNAL. All other discrete connections are status outputs from the analyzer.

4.1.1 50-Pin I/O Functional Specification

The 50-pin connector on the back of the instrument will have functions assigned to pins per the following table (Note 1):

Signal Name	Number	Function
IOUT3	2	Analog current output #3 (*Note 2*).
DOZERO	5	External input to put the instrument into the zero mode.
DOSPAN	6	External input to put the instrument into the span mode.
OVERANGE1	7	Active output indicates that analog output #1 has gone into over-range.
OVERANGE2	8	Active output indicates that analog output #2 has gone into over-range.
OVERANGE3	9	Active output indicates that analog output #3 has gone into over-range.
ANAIN1	10	Unused analog input #1.
ANAIN2	11	Unused analog input #2.
IOUT1	15	Analog current output #1 (*Note 3*).
IOUT2	17	Analog current output #2 (*Note 4*).

Signal Name	Number	Function
SPANCYL	18	Active output indicates that the instrument is in the Span or Span Fill mode.
OUTSERV	19	Active output indicates that the Out of Service switch is in the out-of-service position.
ZEROON	20	Active output indicates that the instrument is in the Zero mode.
SPANON	21	Active output indicates that the instrument is in the Span mode.
ZEROCYL	22	Active output indicates that the instrument is in the Zero or Zero Fill mode.
IZSON	23	Active output indicates that Internal Zero/Span has been selected (*Note 5*).
STARTUP	24	Active output indicates that the startup sequence is active.
PPM/MET	25	Active output indicates that the instrument is in mg/M^3.
USERID1	26	USER ID byte bit 1. Used in conjunction with the PINID serial command.
USERID2	27	USER ID byte bit 2. Used in conjunction with the PINID command.
USERID3	28	USER ID byte bit 3. Used in conjunction with the PINID command.
USERID4	29	USER ID byte bit 4. Used in conjunction with the PINID command.
USERID5	30	USER ID byte bit 5. Used in conjunction with the PINID command.
USERID6	31	USER ID byte bit 6. Used in conjunction with the PINID command.
USERID7	32	USER ID byte bit 7. Used in conjunction with the PINID command.
USERID8	33	USER ID byte bit 8. Used in conjunction with the PINID command.
FLOWFAIL	35	Active output indicates that the sample flow is less than 0.1 slpm.
LAMPFAIL	36	Active output indicates that the lamp has failed (*Note 6*).

Signal Name	Number	Function
CHOPFAIL	37	Active output indicates that the chopper has failed (*Note 7*).
SPAN_OOR	38	Active output indicates that the span ratio is out of range (*Note 8*).
SPAREOC1	39	Spare open collector output #1
HEATERFAIL	40	Active output indicates that a system heater has failed (*Note 9*).
SPAREOC2	41	Spare open collector output #2
OPTEST	42	Active output indicates that the system has been put into the Optic Test mode.
ELECTST	43	Active output indicates that the system has been put into the Electric Test mode.
PS-FAIL	44	Active output indicates that the 12-volt supply voltage has gone out of range (*Note 10*).
HV-FAIL	45	Active output indicates that the PMT high voltage supply has failed (*Note 11*).
SYSFAIL	46	The sum of all failures in the instrument (*Note 12*).
POWER_ON	47	Active output indicates that power to the analyzer is on.
SPDRVR1	48	Spare Driver #1
AGND	1,14,16	Ground reference for analog outputs.
DGND	12	
PGND	13,34	Ground reference for digital inputs or outputs.
CGND	49	Chassis ground.
+12V	50	+12V (50 mA maximum).
	3,4	Unused.

4.1.1.1 Notes

1. All outputs are open collector active LOW.
2. Analog output #3 is NO_2.
3. Analog output #1 is NO.
4. Analog output #2 is NO_X.
5. Not valid.
6. Not used.
7. Not valid.
8. Span ratio out of range is defined as calibration gain changing below 75% or above 125% gain change.
9. An error is flagged if the iso-flow block temperature is below 35° C or above 60° C ***or*** if the reaction cell temperature is below 35° C or above 60° C ***or*** if the converter temperature is below 220° C or above 340° C.
10. An error is flagged if the 12-volt supply voltage is below 11.1 volts or greater than 14.3 volts.
11. An error is flagged if the high voltage reading differs by more than 25% of the expected value as determined from the high voltage pot setting.
12. This signal is the logical OR of `FLOWFAIL`, `LAMPFAIL`, `CHOPFAIL`, `CVFAIL`, `COOLERFAIL`, `HEATERFAIL`, `REFFAIL`, `PS-FAIL`, and `HV-FAIL`.

4.1.2 50-Pin I/O Inputs

The `DOZERO` and `DOSPAN` controls (pins 5 and 6) are TTL compatible inputs with internal 4.7K ohm pull-up resistors. These inputs are active low and can be driven to ground by dry contact relays, open collectors or TTL compatible ICs. The logic levels for control inputs are standard TTL levels. They are:

low < 0.8 V 2 V < **high** < 5 V

4.1.3 50-Pin I/O Outputs

The status outputs are active low ULN2003 open collector Darlingtons. The status outputs can be used to drive relays or, with the use of external pull-up resistors, as a voltage indication of on/off conditions. The internal +12 V (pin 50) or an external power supply may used as the relay or indicator power source.

Current through the outputs should be kept as low as possible, ideally around 1 mA. If an external supply is used it should be less than 50 VDC, and the current sunk by each output should be <50 mA. ***If the internal +12 V supply is used the total current drawn must be kept to less than 50 mA or damage to the analyzer will result.***

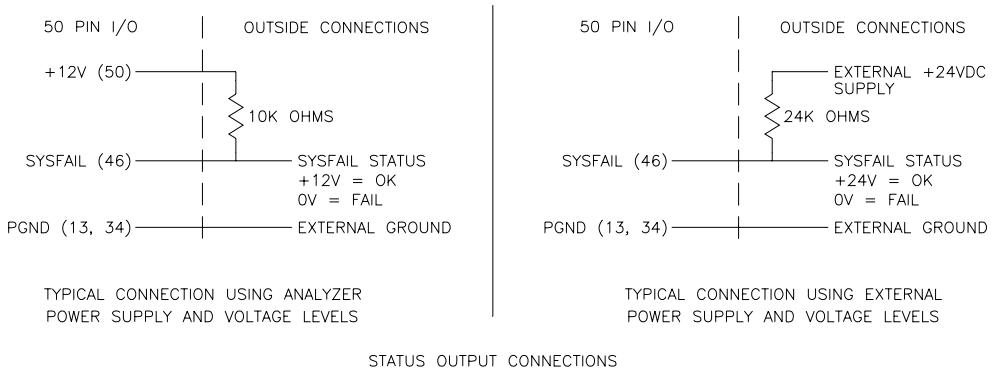


Figure 4-1. Status Output Connections

4.2 Serial Control

Two modes of operation are available using the serial interface. These modes are Terminal and Command. In Command mode, a library of commands becomes available. These are listed at the end of this chapter. In Terminal mode the instrument communication is through the analyzer menu structure.

4.2.1 Serial Connections

The EC9841 has two tristate RS232 ports on the rear of the analyzer. The tristate RS232 causes all instruments not addressed to turn off their transmission capability until the next activation command is received.

Communication among devices is defined in terms of Data Terminal Equipment (DTE) and Data Communication Equipment (DCE) per the EIA standard, RS232.

4.2.2 Cable Connections

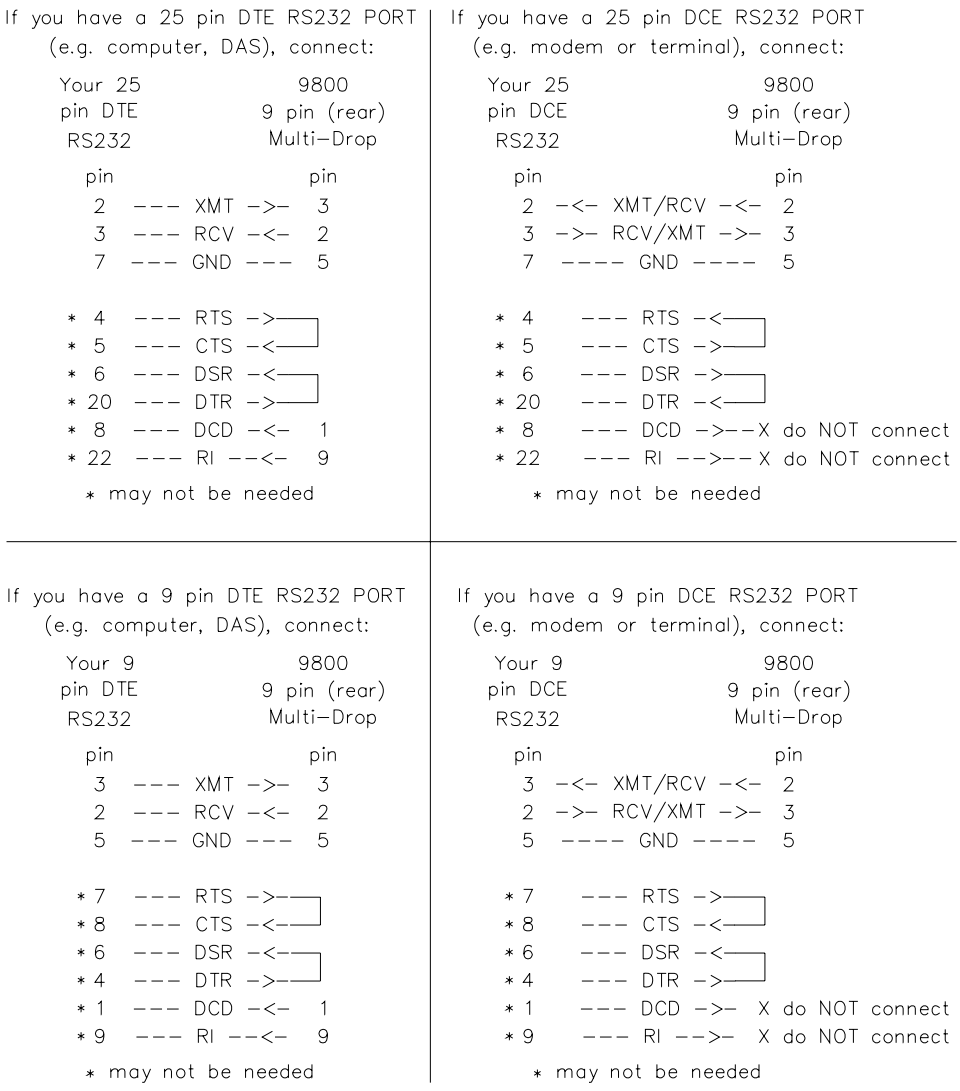


Figure 4-2. Serial Interface Connection Diagrams

4.3 Serial Terminal Control

If the EC9841 is operated in the Terminal mode, a terminal connected to one of the RS232 ports will produce the same results as pressing the six front panel keys with the exception that the same characters sent to the LCD instrument display will also be sent to the terminal. The terminal keys will map into the front panel keys as follows:

Key	Key Label	Function
Enter	ENTER	enter
7	HOME	exit
9	PG UP	page up
8	UP ARROW	up
2	DOWN ARROW	down
6	RT. ARROW	select

The ***Terminal mode must not be used*** if the multidrop port is *daisy-chained* to other instruments.

The mode may be changed using the INTERFACE MENU through the INTERFACE MODE menu selection. When in Terminal mode, this choice may be made manually, or through the serial port. The mode may be changed from Command to Terminal through the serial port using the REMOTE command. For information on required communication parameters refer to the REMOTE command in section 4.4.5.2.

4.4 Serial Command Control

When in the Command mode, two command sets are available. These are the 9800 command set and the Bavarian Network command set. The 9800 command set is recommended for general use. The Bavarian Network command set was set to support a specialized network in Bavaria. Additionally, three communication protocols are provided to allow the user to specify the different handshaking based on their requirements.

4.4.1 9800 Command Set Format

All 9800 commands follow the command format as specified in this section. The specific 9800 commands and their functions are described in section 4.4.5.

9800 Command Format: <CCCCCCCCC>,<III>,<D>,<NN>,<PPPPPPPPPPPP><T>

Where:

<CCCCCCCCC>	= command in ASCII, 1 to 9 characters
<III>	= three-digit instrument ID in ASCII format
<D>	= single digit data type in ASCII (optional)
<NN>	= number of parameters in ASCII, 1 to 9 (optional)
<PPPPPPPPPPPP>	= parameter in ASCII, 1 to 15 characters (optional)

<T> = termination <CR> or <LF>

For commands that do not have parameters the format is the subset :

<CCCCCCCCC>,<III><T>

For commands with multiple parameters, the parameters are separated by the comma delimiter and the termination character follows the last parameter :

<CCCCCCCCC>,<III>,<D>,<NN>,<PPPPPPPPPPPP>,<PPPPPPPPPPPP><T>

4.4.1.1 Examples

An 9800 command with no parameters would be the concentration request, DCONC, used here with an instrument I.D. of 001.

DCONC,001<CR>

If no device I.D. is programmed, the I.D. ??? can be used to address any analyzer connected to the RS232 line. An example of this is shown here.

DCONC,???<CR>

Caution

Using this I.D. will result in a response from *all* analyzers connected to the serial line.

An example of an 9800 command with a parameter would be the trend dump command, DTREND, used here with an instrument I.D. of 134.

DTREND,134,1,1,GASAVG<CR>

4.4.2 Bavarian Network Command Set Format

All Bavarian Network commands follow the command format as specified in this section. The specific Bavarian commands and their function are described in section 4.4.5.1.

Bavarian Network Command Format: <STX><TEXT><ETX><BCC1><BCC2>

Where:

<STX> = ASCII Start Of Transmission = 02 hex

<TEXT> = ASCII text maximum length of 120 characters

<ETX> = ASCII end of transmission = 03 hex

<BCC1> = ASCII representation of block check value MSB

<BCC2> = ASCII representation of block check value LSB

The block check algorithm begins with 00 Hex and exclusive-OR each ASCII character from <STX> to <ETX> inclusive. This block check value is then converted to ASCII format and sent after the <ETX> character.

4.4.2.1 Examples

The following is an example of a valid Bavarian data request for an instrument that has an I.D. of 97:

```
<STX>DA097<EXT>3A
```

The block check calculation is best shown by the following table:

Character	Hex Value	Binary	Block Check
<STX>	02	0000 0010	0000 0010
D	44	0100 0100	0100 0110
A	41	0100 0001	0000 0111
0	30	0011 0000	0011 0111
9	39	0011 1001	0000 1110
7	37	0011 0111	0011 1001
<ETX>	03	0000 0011	0011 1010

The binary value 0011 1010 corresponds to the hex value 3A. This value in ASCII forms the last two characters of the data request message. Please note that the I.D. of 97 is sent as the sequence 097. All I.D. strings must have 3 digits and the user should always pad with ASCII zero characters.

This is an example of a valid command to put the unit in the manual span mode if the instrument has an I.D. of 843:

```
<STX>ST843 K<ETX>52
```

The block check operation is best shown with the following table:

Character	Hex Value	Binary	Block Check
<STX>	02	0000 0010	0000 0010
S	53	0101 0011	0101 0001
T	54	0101 0100	0000 0101
8	38	0011 1000	0011 1101
4	34	0011 0100	0000 1001
3	33	0011 0011	0011 1010
	20	0010 0000	0001 1010
K	4B	0100 1011	0101 0001
<ETX>	03	0000 0011	0101 0010

The binary block check value is 0101 0010 which is the hex value 52 as shown at the end of the command string.

4.4.3 Protocol Definition and Selection

There are three protocol selections available for the EC9841 via the INTERFACE MENU. These are provided so the user may select the appropriate protocol for their desired application. The first protocol designated *original* should be used when upgrading software in analyzers that are already in serial networks. The original protocol is provided for back-compatibility as it completely duplicates the protocol already in the field. The second protocol provided is Bavarian. The Bavarian protocol should be used with the Bavarian Network Command Set for any Bavarian network applications. Note specifying the Bavarian protocol still allows the user to access the 9800 command set. The third protocol provided is the *enhanced* protocol. The enhanced protocol provides a more robust handshaking environment as specified in section 4.4.3.9.

4.4.3.1 Original Protocol

This protocol is provided for back compatibility with pervious versions (before Version 2.05) of 9800B software. There are a number of idiosyncrasies in the original protocol that are preserved to allow existing applications to use upgraded software without modifying their interface.

4.4.3.2 Command Acknowledgment

- For 9800 style commands that provide a data response, the data response itself is the acknowledgment.
- For 9800 style commands that do not provide a data response, the acknowledgment is the returned ASCII string O.K.
- For Bavarian Network commands, no acknowledgment is returned.

4.4.3.3 Negative Command Acknowledgment

- For 9800 commands, if a valid Instrument I.D. is received with an invalid command string the message `INVALID COMMAND` is sent.
- For Bavarian Network commands, no negative command acknowledgment is sent.

4.4.3.4 Original Protocol Idiosyncrasies

- Block check characters are not checked on Bavarian commands.
- The `<STX>` character is ignored.
- The `<ETX>` character is a valid termination for Bavarian commands even in the absence of a `<STX>` character.
- The `DA` command will function without a serial I.D.
- The string `DA<CR>` is a valid command.
- The zero padding on the response to the `DA` command contains six ASCII zeros instead of the standard ten ASCII zeros.
- The data type must be sent on 9800 style commands but it is not checked against the actual parameters.
- The number of data parameters must be sent on 9800 style commands but it is not checked against the actual parameters.

4.4.3.5 Bavarian Protocol

This protocol is intended to correct the idiosyncrasies in the original protocol, as noted in section 4.4.3.1, as they apply to the Bavarian network. This protocol selection strictly applies the Bavarian network protocol to all commands.

4.4.3.6 Command Acknowledgment

- For 9800 style commands that provide a data response, the response itself is the acknowledgment.
- For 9800 style commands that do not provide a data response, no acknowledgment is returned.
- For Bavarian Network commands no acknowledgment is returned.

4.4.3.7 Negative Acknowledgment

For 9800 commands and for Bavarian Network commands, no negative command acknowledgment is sent.

4.4.3.8 Bavarian Protocol Idiosyncrasies

- The string DA<CR> is a valid command.
- The DA command will function without an I.D.
- The data type must be sent on 9800 style commands but it is not checked against the actual parameters.
- The number of data parameters must be sent on 9800 style commands but it is not checked against the actual parameters.

4.4.3.9 Enhanced Protocol

This protocol is provided to allow easier and more robust interfacing between the EC9841 and a computer. Every command with a valid I.D. will respond with either <ACK> or <NAK>. Bavarian commands also respond with either <ACK> or <NAK>, although this is outside the normal Bavarian Network protocol.

Note

This protocol selection ***should not*** be used in Bavarian network applications.

4.4.3.10 Command Acknowledgment

- For all valid 9800 and Bavarian commands, an ASCII <ACK> character is returned.
- For commands that request data, the data will be sent after the <ACK> character.

4.4.3.11 Negative Command Acknowledgment

- Any detected error will respond with the ASCII <NAK> character followed by an error message.
- Due to the constraints of the multidrop environment the unit I.D. must be received intact for a <NAK> response to be sent.
- An invalid command will cause the response <NAK>UNKNOWN COMMAND<CR><LF>.
- An invalid command format will cause the response <NAK> BAD COMMAND FORMAT<CR><LF>.
- A bad block check on a Bavarian command will cause the response <NAK>BAD BLOCK CHECK<CR><LF>.
- If a Bavarian command is sent without a set of matching <STX> and <ETX> characters it will cause the response <NAK>BAD STX ETX PAIR<CR><LF>.

4.4.3.12 Enhanced Protocol Idiosyncrasies

- The string DA<CR> is a valid command.
- The DA command will function without an I.D.
- The data type must be sent on 9800 style commands but it is not checked against the actual parameters.
- The number of data parameters must be sent on 9800 style commands, but it is not checked against the actual parameters.

4.4.4 Establishing Communications

The first step in establishing communications with the EC9841 is to connect a computer or terminal to one of the instrument's RS232 serial ports as specified in section 4.2.1. The default serial configuration for either serial port is 2400,8,N,1 (2400 baud, 8 bits, no parity, and one stop bit). If you need to change the serial configuration from the default, use the INTERFACE MENU.

Once the instrument has been connected, place the instrument in Command mode by entering the INTERFACE MENU via the front panel and selecting COMMAND as the INTERFACE MODE. Then, using a communication package such as HYPER TERMINAL establishes communications with the instrument.

To test the communication connection type DCOMM,??? and press the Enter key. The complete alphanumeric set recognized by the EC9841 should be displayed on the computer followed by END OF MULTI-DROP PORT TEST.

4.4.4.1 Multidrop Communications

The term multidrop is a idiomatic contraction of the term *multiple drops*. It is a term used to denote a parallel connection of multiple RS232 transceivers. In this scheme, all receivers share the same receive line that comes from a single master. Likewise, these multiple transceivers share the same transmit line which goes back to a single master. This strategy is a method of attaching multiple slave units (instruments) to a single master (computer), see Figure 4-3 below.

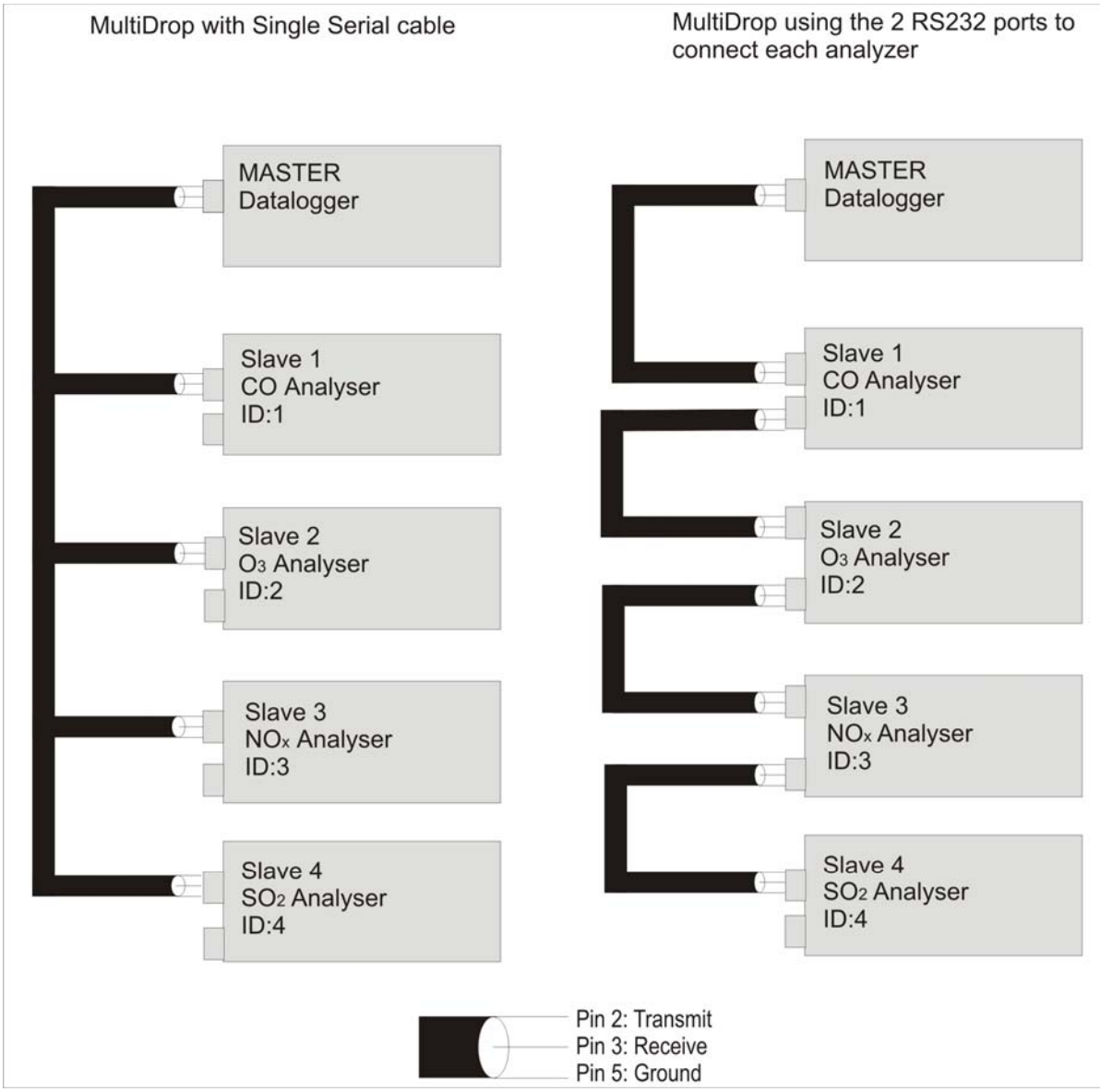


Figure 4-3 Diagram showing two possible Multidrop configurations; using a single cable with multiple RS232 connections (left) or using multiple serial cable to attach each analyzer to the next in line and then onto the Datalogger (right).

In the multidrop strategy, each unit is given an identification number (I.D.) which is sent with each command from the master. When a unit recognizes its unique I.D., it processes the command and responds appropriately. The integrity of this method relies on a strict enforcement of the following rules:

- Each unit in the multidrop must have a unique I.D. that is programmed into the unit before attaching to the network.

- After a command is sent by the master, the master must then wait for a response. Only after a reasonable time-out period should the master send another command.
- The multidrop master must include a time-out mechanism in the event that the I.D. sent with the command is garbled. Clearly a <NAK> on a bad I.D. is not possible for the units in this scheme.
- The master must correlate the unit response with I.D. sent in the command to know which unit in the multidrop is responding.
- Any command that would cause two units on the multidrop to respond at the same time must be avoided. If more than one unit attempts to respond on the common transmit line, a "data collision" will occur destroying both messages.

4.4.4.2 Programming Instrument Identifiers

Note

The Instrument ID. or Main Gas ID. can be set manually in the Instrument Menu or the Interface Menu. Refer to section 2.5.3 for further details. This is this preferred method.

Alternatively, the command PI is the only command used to set the Instrument I.D. for a given analyzer. The instrument can then be used standalone or as one of several multidrop (daisy-chain) analyzers. The format of this command is:

```
PIXXX YYY<CR>
```

Where:

XXX is the unit I.D.

YYY is the secondary unit I.D.

- The parameter XXX is the unit I.D. and must be three characters.
- Unit I.D.'s such as 1 should be programmed as 001.
- For the 9841 the YYY parameter is the second unit I.D. and may be used for any command query. This is in support of existing Bavarian networks.
- Only one analyzer at a time may be programmed with an I.D. Do not issue this command with multiple units on a multidrop.

4.4.4.3 Examples

- The string PI001<CR> will program a unit to the I.D. of 001.

- The string `PI001 123` will program a unit to the I.D. of 001 with a serial number of 123.
- The string `PI003 004` will program a EC9841 for a main I.D. of 003 and a secondary I.D. of 004.

4.4.5 Serial Command Sets

This section describes the Bavarian Network and 9800 command sets available on the EC9841 using the instrument Command mode.

4.4.5.1 Bavarian Protocol Command Set

Command
`{DA}`

Function
Bavarian network command that returns the current instantaneous concentration.

Format
`<STX>{DA}{<DEVICE I.D.>}<ETX><BCC1><BCC2>`

Device response
`<STX>{MD}{02}<SP><kkk><SP><+nnnn+ee><SP><ss><SP><ff><SP>{00000000}`
`<SP><mmm><SP><+pppp+ee><SP><ss><SP><ff><SP>{00000000}<SP><ETC>`
`<BCC1><BCC2` where:

`+nnnn+ee =` NO concentration
`ss =` status byte for both channels with the following bit map (positive logic):

`D0 =` instrument off
`D1 =` out of service
`D2 =` instrument is in zero mode
`D3 =` instrument is in span mode
`D4 =` unused
`D5 =` unused
`D6 =` units (1 = ppm, 0 = mg/m3)
`D7 =` unused.

`ff =` failure byte for both channels with the following bit map (positive logic):

`D0 =` flow sensor failure
`D1 =` instrument failure
`D2 =` unused
`D3 =` unused
`D4 =` lamp failure
`D5 =` temperature sensor failure

D6 = unused
D7 = unused.

kkk = NO channel ID
mmm = NO instrument ID
+pppp+ee = instantaneous NOx gas concentration in ppb or mg/m3
BCC1 = first byte of the block check calculation
BCC2 = second byte of the block check calculation.

The block check calculation is performed by clearing the block check number. An iterative EXCLUSIVE OR is performed on this number with every character in the message from the <STX> to the <ETX> (inclusive). The resulting value is converted in a two-digit pseudo hex number and sent out as BCC1 and BCC2.

Command
{PI}

Function
Bavarian network command that sets the device ID and serial number of the analyzer.

Format
<STX>{PI}{<DEVICE I.D.>}<SP?{<INSTRUMENT SERIAL NUMBER>}<ETX>
<BCC1><BCC2>

Note
The auxiliary device I.D. for NO_x is determined by the INSTRUMENT SERIAL NUMBER.

Command
{ST}

Function
Bavarian network command that sets the instrument mode to zero, span, or measure.

Format
<STX>{ST}{<DEVICE I.D.>}<SP>{COMMAND}<ETC><BCC1><BCC2> where:

COMMAND = M for measure, N for zero, K for span.

4.4.5.2 9800 Command Set

Note

The {TERMINATOR} can be either a <CR> or <LF>.
The {<DEVICE I.D.>} = Three Digit Instrument I.D. in ASCII Format.

Command
ABORT

Function
Commands the addressed device to abort the current mode and return to the measure mode.

Format
ABORT,{<DEVICE I.D.>}{TERMINATOR}

Device response
<ACK> if the unit under test is able to perform the command, <NAK> if not.

Command
DAVGC

Function
Sends the current average concentration data to the serial port.

Format
DAVGC,{<DEVICE I.D.>}{TERMINATOR}

Device response
{NO}<SPACE>{NO2}<SPACE>{NOX}<SPACE>{STATUS WORD}<CR><LF>

All numbers are in floating point format. See the DCONC command for an explanation of the STATUS WORD.

Command
DAZSC

Function
Commands the addressed device to perform a zero/span cycle. The system returns to the measure mode when the cycle has completed.

Format
DAZSC,{<DEVICE I.D.<}{TERMINATOR}

Device response
<ACK> if the unit under test is able to perform the command, <NAK> if not.

Command
DCOMM

Function
Performs a character dump to the serial output when called.

Format
DCOMM,{<DEVICE I.D.>}{TERMINATOR}

Device response
<ACK> if the unit under test performs a successful loopback, <NAK> if not.

Command
DCONC

Function
Sends the current instantaneous concentration data to the serial port.

Format
DCONC,{<DEVICE I.D.>}{TERMINATOR}

Device response
{NO}<SPACE>{NOX}<SPACE>{NO2}<SPACE>{STATUS WORD}<CR><LF>

All numbers are in floating point format. The STATUS WORD indicates the instrument status in hex using the following format:

Bit 15 (MSB) = SYSFAIL
Bit 14 = FLOWFAIL
Bit 13 = LAMPFAIL
Bit 12 = CHOPFAIL
Bit 11 = CVFAIL
Bit 10 = COOLERFAIL
Bit 9 = HEATERFAIL
Bit 8 = REFFAIL
Bit 7 = PS-FAIL
Bit 6 = HV-FAIL
Bit 5 = OUT OF SERVICE
Bit 4 = instrument is in zero mode
Bit 3 = instrument is in span mode
Bit 2 = unused

Bit 1 = SET→PPM selected, CLEAR→MG/M3
Bit 0 (LSB) = reserved.

Command
DEVENT

Function
Dumps the Event Log message buffer to the serial port.

Format
DEVENT, {<DEVICE I.D.>}{TERMINATOR}

Device response
#XX {Message #XX <CR><LF> OCCURRED AT HH:MM DD-MON-YY{<CR><LF>

The last 100 messages are reported. XX is the index into the event log message buffer; 99 = oldest point (reported first), 0 = newest point (reported last).

The message field is null if no message exists.

Command
DGAIN

Function
Dumps gain data.

Format
DGAIN,{<DEVICE I.D.>}{TERMINATOR}

Device response
{INSTRUMENT GAIN},{ZERO OFFSET}<CR><LF>

Command
DINSTR

Function
Dumps INSTRUMENT STATUS MENU.

Format
DINSTR,{<DEVICE I.D.>}{TERMINATOR}

Device response
{STAT1},{STAT2},{STAT3},{STAT4},{STAT5},{STAT6},{STAT7},{STAT8},
{STAT9},{STAT10},{STAT11},{STAT12}<CR><LF> where:

STAT1 = gas flow
STAT2 = gas pressure
STAT3 = reference voltage
STAT4 = concentration voltage
STAT5 = analog supply
STAT6 = digital supply
STAT7 = ground offset
STAT8 = ozone generator flow
STAT9 = high voltage
STAT10 = lamp current, mA
STAT11 = ambient pressure
STAT12 = Startup flag (1 = in startup mode).

Startup flag and ground offset are integers; all other numbers are in floating point format. The status field is null if it does not apply to the analyzer type.

Command
DSPAN

Function
Commands the unit under test to enter the span mode and stay there.

Format
DSPAN,{<DEVICE I.D.>}{TERMINATOR}

Device response
<ACK> if the unit under test is able to perform the command, <NAK> if not.

Command
DTEMPS

Function
Dumps SYSTEM TEMPERATURES MENU.

Format
DTEMPS,{<DEVICE I.D.>}{TERMINATOR}

Device response
{TEMP1},{TEMP2},{TEMP3},{TEMP4},{TEMP5},{TEMP6},{TEMP7},{TEMP8},
{TEMP9},{TEMP10}<CR><LF> where:

TEMP1 = cell temperature
TEMP2 = converter temperature
TEMP3 = chassis temperature
TEMP4 = flow temperature
TEMP5 = cooler temperature
TEMP6 = mirror temperature
TEMP7 = lamp temperature
TEMP8 = ozone generator lamp temperature
TEMP9 = IZS temperature
TEMP10 = manifold temperature.

All temperatures are in floating point format. The temperature field is null if it does not apply to the analyzer type.

Command
DTREND

Function
Dumps the requested trend buffer to the serial port.

Format
DTREND,{<DEVICE I.D.>},1,1,<PARAMETER>{TERMINATOR} where PARAMETER=

GASCONC for the last 100 instantaneous NO readings
NOXCONC for the last 100 instantaneous NOx readings
NO2CONC for the last 100 instantaneous NO2 readings
GASAVG for the last 100 averaged NO readings
NOXAVG for the last 100 averaged NOx readings
NO2AVG for the last 100 averaged NO2 readings
PRESSURE for the last 100 cell pressure readings
FLOW for the last 100 flow readings
REF for the last 100 reference readings
SPANCMP for the last 100 span compensation readings from AZS cycles
ZERO for the last 100 zero readings from AZS cycles
CNVTR for the last 100 converter temperature readings.

Device response
{INDEX}<SPACE>{PARAMETER}<CR><LF> where:

INDEX is the index into the trend buffer. 0 = oldest point, 99 = newest point.

Formatted as an integer.
PARAMETER is the requested data in floating point format.

Command
DZERO

Function
Commands the unit under test to enter the zero mode and stay there.

Format
DZERO,{<DEVICE I.D.>}{TERMINATOR}

Device response
<ACK> if the unit under test is able to perform the command, <NAK> if not.

Command
PINID

Function
Programs the 50-pin device ID.

Format
PINID,{<DEVICE I.D.>},1,1,BBBBBBBB{TERMINATOR} where:

BBBBBBBB is the desired bit pattern in binary format to be programmed into the device ID. The most significant bit is on the left, least significant bit on the right (for example, 10100101 would correspond to a device ID of A5 hex or 165 decimal).

Device response
<ACK>

Command
REMOTE

Function
Puts the instrument in the VT-100 compatible terminal mode. All of the menus (with the exception of the trend displays) become available to a remote controller through the serial port. The remote PC (an ANSI terminal may also be used) should be configured as follows:

Windows: Terminal mode (Hyper Terminal accessory), terminal emulation = VT-100, communications settings = 9600 (or whatever the current instrument host baud rate is), 8 bits, 1 stop, no parity.

An ANSI terminal should be configured as follows:

WYSE WY-60 or WY-75: VT-100 emulation, full duplex.

WYSE WY-50: Not recommended (no ANSI mode).

Recommended baud rate is at least 4800 baud. The following (remote terminal) keys are now active (using numeric keypad with NUM LOCK enabled on remote terminal):

Key	Key Label	Function
Enter	Enter	Enter
7	Home	Exit
9	Pg Up	Page up
8	Up arrow	Up
2	Down arrow	Down
6	Right arrow	Select

Format
REMOTE,{<DEVICE I.D.>}{TERMINATOR}

Device response
<ACK>, then clearscreen, then menu display.

Command
RESET

Function
Reboots the instrument (software reset).

Format
RESET,{<DEVICE I.D.>}{TERMINATOR}

Device response
<ACK>

Command
GETDATA

Function
Used to collect logged data from an analyzer.

Format
This command takes two different formats depending on the transmission state. TO begin with, the following format must be used:

GETDATA,{<DEVICE I.D.>},2,1,<START TIME>,<END TIME>,<DATA TYPE>{TERMINATOR}
Where START TIME is the date/time of the first piece of data to collect, and END TIME is the date/time of the final data to collect. Both must be in the following format:
YY/MM/DD{SPACE}HH:NN
If END TIME is omitted, then all data since START TIME is returned. Year must be 03 or greater.

Where DATA TYPE=
I to only receive instantaneous logged data
A to only receive Averaged logged data
{EMPTY} to receive both instantaneous and averaged logged data.

After the request has been issued, data will be returned in the same packet format as is documented for USB data requests. After each packet, the following command should be issued to request the next packet of data:

GETDATA,{<DEVICE I.D.>},2,1,<REQUEST>{TERMINATOR}
Where REQUEST=
0 to retransmit previous packet logged data
1 to transmit next block of packet data

Device response
Refer to command 2 in the USB protocol specification. The complete USB packet format is used for the response to this serial command.

4.5 USB Communication

The USB port is located on the rear of the analyzer. This cannot be multidropped with other analyzers, but multiple analyzers can be connected to a single USB port on a computer by using a USB hub. This connection is ideal for collecting data from a standalone analyzer or using a laptop that may not have a serial port, see Figure 4-4 below.

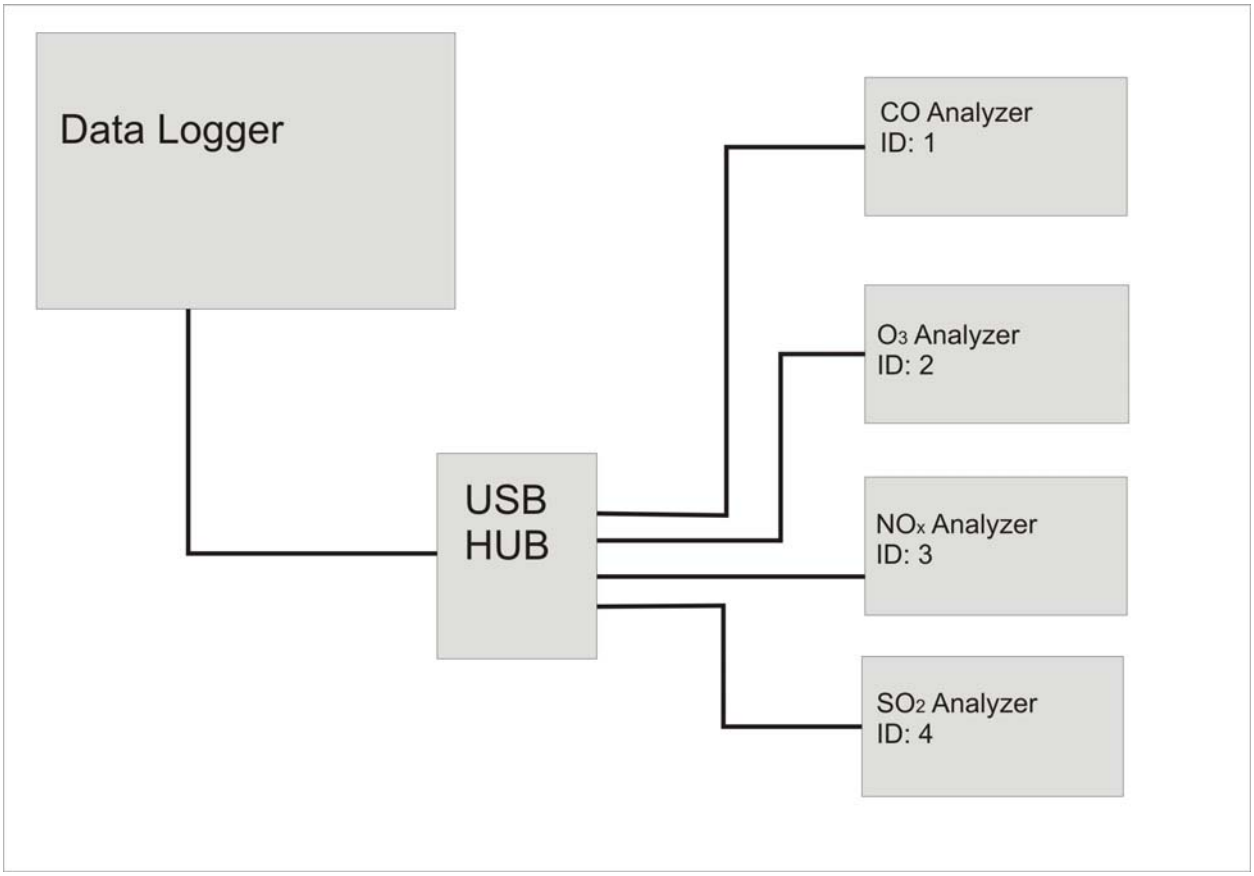


Figure 4-4. Configuration for analyzers using USB to communicate with Datalogger via a USB Hub.

4.5.1 Installing the driver on a PC

The following are instructions to install the EC9841 analyzer to a computer through the USB connection. It will provide efficient communication between the analyzer and computer with the use of the EC9800 Communicator software described in section 4.6.

NOTE

Screen shots and instructions below apply to Windows XP, but will be similar for any other Windows operating system.

1. Turn on computer and log in.

2. Connect the analyzer by USB cable to the USB port on the rear of the computer.

3. After 10-20 seconds the dialog box shown in should appear. If no dialog box appears, open the Control Panel and double-click Add New Hardware.

Figure 4-5. Screenshot of menu which appears when USB is connected

4. Insert the CD containing the Ecotech 9800 Analyzer Driver into the CD drive. The computer should recognise the CD and continue with the installation after a few seconds. If it does not, click the Next button after loading the CD.

NOTE

A dialog box similar to that in Figure 4-6 may appear. If it does, click the Continue Anyway button.

Figure 4-6. Dialog Box, which may appear during installation

5. The installation should now proceed. When complete click the Finish button.

The driver installation is now complete.

4.6 EC9800 Communicator Software

The *EC9800 Communicator* software is supplied on CD with the EC9841 series analyzer and allows the user to communicate with the analyzer by direct serial connection, modem or USB. The two functions of the program are to:

- Download recorded data (Data Acquire mode)
- Remotely access the analyzer's control panel (Remote Terminal mode)

To set the EC*9800 Communicator*'s output, connection and analyzer properties use the settings dialog box. Refer to section 4.6.3.

4.6.1 Data Acquire Mode

Data Acquire mode enables the user to download recorded data from the analyzer to a text file

4.6.1.1 Using Data Acquire Mode

1. Ensure that all Settings are correct. Refer to section 4.6.3.
2. Under the Mode menu, tick the **Data Acquire** option
3. On the **Comm** menu, select **Start**.
4. In the dialog box that appears, enter the start date/time for the data in dd/mm/yy hh:mm format.
   For example, enter 30/11/2003 14:20 for 2:20PM on 30 November 2003.
5. In the dialog box that next appears, enter the end date/time in the same format.

The *EC9800 Communicator* will now retrieve the data. To stop downloading before all data has been retrieved, select **Stop** on the **Comm** menu.

Note

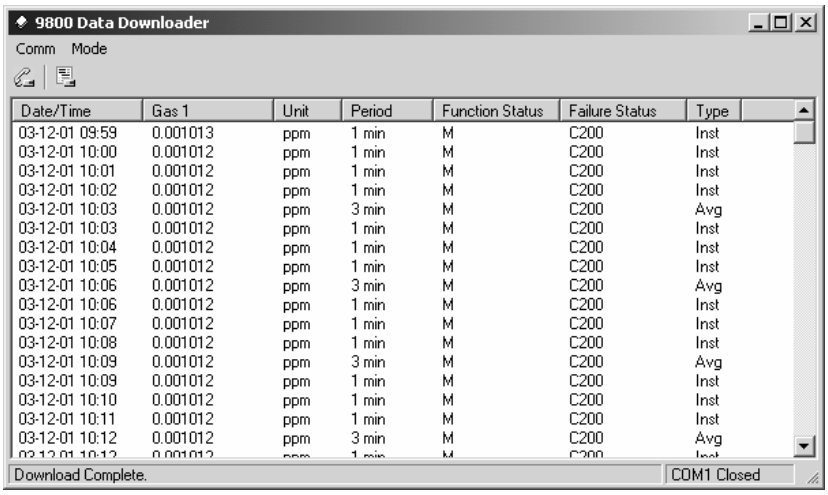
The analyzer must be in **Command** mode before the Data Acquire mode can be used. If the program was last used in Remote Terminal mode, the analyzer may still be in **Remote** mode. See section 4.6.2.2 for further details.

Note

Data Acquire mode only retrieves data already logged by the analyzer. To remotely instruct the analyzer to log data, use the **Remote Terminal mode**.

4.6.1.2 Viewing the Acquired Data

If the communication was successful, a table of data similar to the below will be displayed:



Date/Time	Gas 1	Unit	Period	Function Status	Failure Status	Type
03-12-01 09:59	0.001013	ppm	1 min	M	C200	Inst
03-12-01 10:00	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:01	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:02	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:03	0.001012	ppm	3 min	M	C200	Avg
03-12-01 10:03	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:04	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:05	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:06	0.001012	ppm	3 min	M	C200	Avg
03-12-01 10:06	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:07	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:08	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:09	0.001012	ppm	3 min	M	C200	Avg
03-12-01 10:09	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:10	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:11	0.001012	ppm	1 min	M	C200	Inst
03-12-01 10:12	0.001012	ppm	3 min	M	C200	Avg

Figure 4-7. Acquired Data completion screenshot

The same data is displayed in the output text file, as set on the Output tab of the **Settings** dialog box, with the fields delimited by commas. A description of each field follows below.

Field	On-screen	In text file
Date/Time	The date/time, in the format selected in the Output tab of the Settings dialog box, when the data in that row were recorded.	As for on-screen
(Data)	Up to three channels of analyzer data, with column headings as set by the analyzer.	As for on-screen

Unit	The unit for the analyzer data.	Codes representing the data units
Period	The repetition period. For averaged data, the repetition period is also the averaging period.	As for on-screen, with the period in minutes
Function status	The function status of the analyzer at the time of measurement.	As for on-screen
Failure status	The failure status of the analyzer at the time of measurement.	As for on-screen
Type	*Inst* = instantaneous data. *Avg* = averaged data.	I = instantaneous data. A = averaged data.

4.6.2 Remote Terminal Mode

Remote Terminal mode can be used to access the analyzer's control panel remotely.

4.6.2.1 Starting a Remote Terminal mode session

1. Ensure that all Settings are correct. Refer to section 4.6.3.

2. Under the **Mode** menu, choose the **Remote Terminal** option.

3. On the **Comm** menu, select **Start**.

4. The screen should replicate the analyzer's display similar to Figure 4-8. The user now has access to the analyzer control panel, with the buttons at the bottom of the screen replicating the buttons on the front panel of the analyzer. If a blank screen appears, terminate the connection as per step 2 below and reconnect.

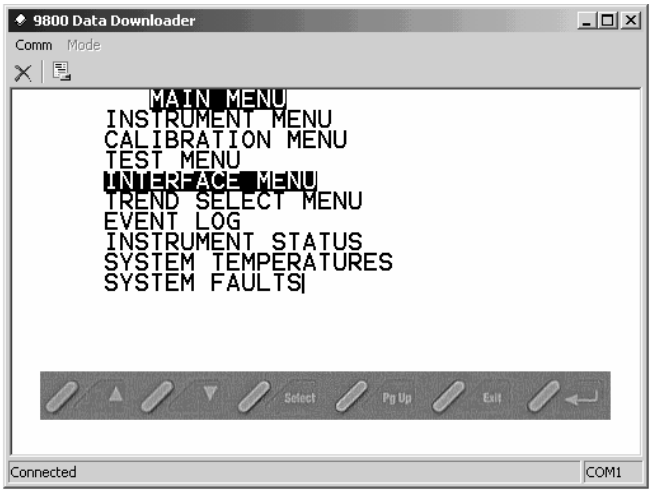


Figure 4-8. Remote Terminal

4.6.2.2 Ending a Remote Terminal mode session

Controlling the analyzer by remote terminal automatically sets the analyzer to **Remote** mode.

Note

It is advisable that the user always returns the analyzer to **Command** mode at the end of the remote terminal session, so that other users may download data.

To end the remote terminal session:

1. Set the **Interface Mode** option on the **Interface Menu** to **Command**. For detailed instructions on how to do this see section 4.6.2.3.

2. Terminate the connection by selecting the **Stop** option on the **Comm** menu.

4.6.2.3 Setting the analyzer to Command mode during a Remote Terminal session

1. Click exit repeatedly to display the analyzer's start-up window. **Main Menu** should be highlighted.

2. Click enter to enter the Main Menu.

3. Click up or down until **Interface Menu** is highlighted.

4. Click enter to enter the Interface Menu.

5. Click up or down until **Interface Mode** is highlighted.

6. Click select

7. Click up or down to change the interface mode to **Command**.

4.6.3 Settings

Open the Settings dialog box by either clicking the  button, choosing the **Comm/Settings** menu option or by pressing F2. Click on one of the icons on the left of the dialog box to access that tab.

4.6.3.1 Output

This function sets the options for the text file the program downloads data to.

Output file

Enter the path and filename of the text file that the *EC9800 Communicator* will write acquired data to. Clear the text box if a text file is not required.

If the file exists?
Choose Append to have the data added to the end of an existing file, choose overwrite to have an existing file overwritten, or choose Prompt to have the user prompted before writing to an existing file.

Date format
Choose the date/time format, or the user can select their own, in which to record the date and time of the analyzer data.

4.6.3.2 Connection

This function sets the options for the communication connection between the computer and the analyzer.

Connection type
Choose the type of connection to communicate with the analyzer. The choice changes the other options available in this tab.

4.6.3.2.1 Direct Serial Connection

Port
Choose the COM port on the computer where the serial cable is connected. Connect the other end of the serial cable to the analyzer.

Baud rate
Choose the baud rate that has been set on the analyzer.

4.6.3.2.2 Modem Connection

Connect using
Choose from the list of modems detected from the computer

Phone
Enter the phone number to which the analyzer is connected.

4.6.3.2.3 USB Connection

Analyzer

Select the analyzer to communicate with from a detected list

4.6.3.3 Analyzer Tab

This function sets the analyzer information for the analyzer being communicated with.

Analyzer ID
If the user has multidropped multiple analyzers onto the one communication line, enter the ID of the analyzer to communicate with.

Average Data
Tick this box to download the averaged data that has been generated by the analyzer.

Instantaneous Data
Tick this box to download the instantaneous data that has been generated by the analyzer.

4.6.4 Keyboard shortcuts

The following are keyboard shortcuts that can be used in general operation of the program.

- F2 - Display the Settings dialog box
- F5 - Start communicating with analyzer
- F6 - Stop communicating with analyzer

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APPENDIX A

USB PROTOCOL PARAMETER LIST

Note: parameters are for all EC9800 analyzers and may not be applicable to an individual analyzer.

#	Description	Notes
0	Internal Valve 1	0=Closed, 1=Open
1	Internal Valve 2	0=Closed, 1=Open
2	Internal Valve 3	0=Closed, 1=Open
3	External Measure Valve	0=Closed, 1=Open
4	External Zero Valve	0=Closed, 1=Open
5	External Span Valve	0=Closed, 1=Open
6	Aux Valve 1	0=Closed, 1=Open
7	Aux Valve 2	0=Closed, 1=Open
8	Aux Valve 3	0=Closed, 1=Open
9	Valve Sequencing	0=Off, 1=On
10	LCD Contrast POT	0=Lightest, 99=Darkest
11	PRE POT 1	Measure coarse pot for all analysers except 9841A which is chassis fan speed.
12	PRE POT 2	Measure Fine: 981X, 9820, 9830, 9841, 9842 Bench Fan Speed: 9841A Reference_zero : 9850
13	PRE POT 3	Input for all except 9850 which is measure gain.
14	PRE POT 4	981X, 984X: Test Measure 9820, 9830: test_reference 9850: reference gain
15	PRE POT 5	981X: Lamp Adjust 9820,9830,9850:test measure 984X: high voltage adjust
16	PRE POT 6	9850: high voltage adjust
17	PRE POT 7	9850: lamp adjust
18	VREG POT 1	Flow control zero
19	VREG POT 2	
20	VREG POT 3	
21	VREG POT 4	
22	VREG POT 5	Fan speed control
23	VREG POT 6	Pump speed fine
24	VREG POT 7	Pump speed coarse
25	Analogue input 0	
26	Analogue input 1	
27	Analogue input 2	

28	Analogue input 3	
29	Analogue input 4	
30	Analogue input 5	
31	Analogue input 6	
32	Analogue input 7	
33	Analogue input 8	
34	Analogue input 9	
35	Analogue input 10	
36	Analogue input 11	
37	Analogue input 12	
38	Analogue input 13	
39	Analogue input 14	
40	Analogue input 15	
41	50 PIN IO bits 0-7	BIT 7: Span Out of Range BIT 6: Span On BIT 5: Copper Fail BIT 4: Zero On BIT 3: Lamp Fail BIT 2: Out Of Service BIT 1: Flow Fail BIT 0: Span Cycle
42	50 PIN IO bits 8-15	BIT 7: Pump On BIT 6: Range 1 BIT 5: Startup BIT 4: Heater Fail BIT 3: Range 0 BIT 2: IZS On BIT 1: Spare 1 BIT 0: ZeroCycle
43	50 PIN IO bits 16-23	BIT 7: Power On BIT 6: Sys Fail BIT 5: High Voltage Fail BIT 4: Power Supply Fail BIT 3: Electric Test BIT 2: Optical Test BIT 1: Range 2 BIT 0: PPm / Metric
44	50 PIN IO bits 24-31	Really User ID
45	50 PIN IO bits 32-39	BIT 7: P4 BIT 6: P3 BIT 5: P2 BIT 4: P1 BIT 3: Spare Driver 1 BIT 2: BIT 1:

		BIT 0: Reference Fail
46	50 PIN IO bits 40-47	BIT 7: BIT 6: BIT 5: BIT 4: BIT 3: BIT 2: BIT 1: P6 BIT 0: P5
47	50 PIN IO bits 48-55	BIT 7: Status 2 LED BIT 6: Status 1 LED BIT 5: Sys Fail LED BIT 4: HeartBeat LED BIT 3: BIT 2: BIT 1: BIT 0:
48	50 PIN IO bits 56-63	BIT 7: BIT 6: BIT 5: BIT 4: BIT 3: BIT 2: BIT 1: BIT 0: Status 3 LED
49	PGA Gain	0-7
50	**Primary Gas Concentration**	
51	**Secondary Gas Concentration**	
52	**Calculated Gas Concentration**	
53	**Primary Gas Average**	
54	**Secondary Gas Average**	
55	**Calculated Gas Average**	
56	Instrument Gain	
57	Main Gas ID	
58	Aux Gas ID	
59	Decimal Places	
60	**Noise**	
61	Gas 1 Offset	
62	Gas 3 Offset	
63	Flow Temperature	
64	Lamp Current	
65	Digital Supply	
66	Concentration Voltage	
67	High Voltage	
68	Ozonator	0=Off, 1=On

69	Control Loop	
70	Diagnostic Mode	
71	**Gas Flow**	
72	Gas Pressure	
73	**Ambient Pressure**	
74	Analog Supply	
75	**Cell Temperature**	
76	Converter Temperature	
77	**Chassis Temperature**	
78	Manifold Temperature	
79	Cooler Temperature	
80	Mirror Temperature	
81	Lamp Temperature	
82	O3 Lamp Temperature	
83	Instrument Status	
84	Reference Voltage	
85	Calibration State	0 = MEASURE 1 = CYCLE 2 = ZERO 3 = SPAN
86	Primary Raw Concentration	(before 984X background and gain)
87	Secondary Raw Concentration	(before 984X background and gain)
88	984X Background Concentration	(before gain)
89	Calibration Pressure	
90	Converter Efficiency	
91	Multidrop Baud Rate	
92	Analog Range Gas 1	
93	Analog Range Gas 2	
94	Analog Range Gas 3	
95	Output Type Gas 1	0=Voltage 1=Current
96	Output Type Gas 2	0=Voltage 1=Current
97	Output Type Gas 3	0=Voltage 1=Current
98	Voltage Offset /Current Range Gas1	0=0% or 0-20mA 1=5% or 2-20mA 2=10% or 4-20mA
99	Voltage Offset /Current Range Gas2	0=0% or 0-20mA 1=5% or 2-20mA 2=10% or 4-20mA
100	Voltage Offset /Current Range Gas3	0=0% or 0-20mA 1=5% or 2-20mA 2=10% or 4-20mA
101	Full Scale Gas 1	

102	Full Scale Gas 2	
103	Full Scale Gas 3	
104	Zero Adjust Gas 1	
105	Zero Adjust Gas 2	
106	Zero Adjust Gas 3	
107	Negative 10V Supply	
108	50 Pin IO ANIN1	20mV resolution analog input (0-5V)
109	50 Pin IO ANIN2	20mV resolution analog input (0-5V)
110	Instrument State	
111	CO Linearisation Factor A	
112	CO Linearisation Factor B	
113	CO Linearisation Factor C	
114	CO Linearisation Factor D	
115	CO Linearisation Factor E	
116	Instrument Units	0= PPM 1=PPB 2=PPT 3=mG/M^3 4=µG/M^3 5=nG/M^3
117	Background Measure Time	In seconds
118	Sample Fill Time	In seconds
119	Sample Measure Time	In seconds
120	Aux Measure Time	In seconds
121	Aux Sample Fill Time	In seconds
122	Background Fill Time	In seconds
123	Zero Fill Time	In seconds
124	Zero Measure Time	In seconds
125	Span Fill Time	In seconds
126	Span Measure Time	In seconds
127	Span Purge Time	In seconds
128	Background Pause Time	In seconds
129	Background Interleave Factor	In seconds
130	Calibration Pressure 2	
131	AUX Instrument Gain	
132	Background voltage	
133	AUX Background Voltage	
134	O3 Generator Output	PPM
135	O3 Generator On/Off	
136	Calibration Point 1	PPM
137	Calibration Point 2	PPM
138	Calibration Point 3	PPM
139	Calibration Point 4	PPM
140	Calibration Point 5	PPM

141	Desired Pump Flow	SLPM
142	Actual Pump Flow	SLPM
143	Set Lamp Current	%
144	Lamp Current	mA
145	Cycle Time	Minutes
146	Analog GND Offset	Volts

Appendix B

Failure Status descriptions

The failure status codes provided by the 9800 downloader are described below. Each of the 4 units of the code represent a column below, the description within the box of the corresponding unit explains the failure status of various components, if any, and more detailed descriptions are outlines below the table.

Unit	1st Digit	2nd Digit	3rd Digit	4th Digit
0	NO FAILURE	NO FAILURE	NO FAILURE	GRAV
1	CHOPFAIL	REFFAIL	ZEROON	GRAV
2	LAMPFAIL	HEATERFAIL	OUT OF SERVICE	VOL
3	CHOPFAIL LAMPFAIL	REFFAIL HEATERFAIL	ZEROON OUT OF SERVICE	VOL
4	FLOWFAIL	COOLERFAIL	HV-FAIL	GRAV
5	CHOPFAIL FLOWFAIL	REFFAIL COOLERFAIL	ZEROON HV-FAIL	GRAV
6	LAMPFAIL FLOWFAIL	HEATERFAIL, COOLERFAIL	OUT OF SERVICE HV-FAIL	VOL
7	CHOPFAIL LAMPFAIL FLOWFAIL	REFFAIL HEATERFAIL COOLERFAIL	ZEROON OUT OF SERVICE HV-FAIL	VOL
8	SYSFAIL	CVFAIL	PS-FAIL	GRAV SPANON
9	CHOPFAIL SYSFAIL	REFFAIL CVFAIL	ZEROON PS-FAIL	GRAV SPANON
A	LAMPFAIL SYSFAIL	HEATERFAIL, CVFAIL	OUT OF SERVICE PS-FAIL	VOL SPANON
B	CHOPFAIL LAMPFAIL SYSFAIL	REFFAIL HEATERFAIL CVFAIL	ZEROON OUT OF SERVICE PS-FAIL	VOL SPANON
C	FLOWFAIL SYSFAIL	COOLERFAIL, CVFAIL	HV-FAIL PS-FAIL	GRAV SPANON
D	CHOPFAIL FLOWFAIL SYSFAIL	REFFAIL COOLERFAIL, CVFAIL	ZEROON HV-FAIL PS-FAIL	GRAV SPANON
E	LAMPFAIL FLOWFAIL SYSFAIL	HEATERFAIL, COOLERFAIL, CVFAIL	OUT OF SERVICE HV-FAIL PS-FAIL	VOL SPANON
F	CHOPFAIL LAMPFAIL FLOWFAIL SYSFAIL	REFFAIL HEATERFAIL COOLERFAIL, CVFAIL	ZEROON OUT OF SERVICE HV-FAIL PS-FAIL	VOL SPANON

CHOPFAIL	Indicates that the chopper has failed.
LAMPFAIL	Indicates that the lamp has failed.
FLOWFAIL	Indicates that the sample flow is less than 0.1 slpm.
SYSFAIL	Indicates one or more components have failed.
HEATERFAIL	Indicates that a system heater has failed.
COOLERFAIL	Indicates that a cooler has failed.
CVFAIL	Indicates that a converter has failed.
ZEROON	Indicates that the instrument is in the Zero mode.

OUT OF SERVICE	'Out of service' switch has been activated on analyzer
HV-FAIL	Indicates that the PMT high voltage supply has failed.
PS-FAIL	Indicates that the 12-volt supply voltage has gone out of range.
GRAV	Measuring in gravimetric units i.e. MG/M3
VOL	Measuring in volumetric units i.e. PPM

Example:
If a failure status is received as C022 then the failures of the instrument as determined by this code are:

C= FLOWFAIL — Indicates that the sample flow is less than 0.1 slpm.
SYSFAIL — Indicates one or more components have failed.

0 = No Failure

2 = OUT OF SERVICE — 'Out of service' switch has been activated on analyzer

2 = VOL — Measuring in volumetric units i.e. PPM

Unit	1st Digit	2nd Digit	3rd Digit	4th Digit
0	NO FAILURE	NO FAILURE	NO FAILURE	GRAV
1	CHOPFAIL	REFFAIL	ZEROON	GRAV
2	LAMPFAIL	HEATERFAIL	OUT OF SERVICE	VOL
3	CHOPFAIL LAMPFAIL	REFFAIL HEATERFAIL	ZEROON OUT OF SERVICE	VOL
4	FLOWFAIL	COOLERFAIL	HV-FAIL	GRAV
5	CHOPFAIL FLOWFAIL	REFFAIL COOLERFAIL	ZEROON HV-FAIL	GRAV
6	LAMPFAIL FLOWFAIL	HEATERFAIL, COOLERFAIL	OUT OF SERVICE HV-FAIL	VOL
7	CHOPFAIL LAMPFAIL FLOWFAIL	REFFAIL HEATERFAIL COOLERFAIL	ZEROON OUT OF SERVICE HV-FAIL	VOL
8	SYSFAIL	CVFAIL	PS-FAIL	GRAV SPANON
9	CHOPFAIL SYSFAIL	REFFAIL CVFAIL	ZEROON PS-FAIL	GRAV SPANON
A	LAMPFAIL SYSFAIL	HEATERFAIL, CVFAIL	OUT OF SERVICE PS-FAIL	VOL SPANON
B	CHOPFAIL LAMPFAIL SYSFAIL	REFFAIL HEATERFAIL CVFAIL	ZEROON OUT OF SERVICE PS-FAIL	VOL SPANON
C	FLOWFAIL SYSFAIL	COOLERFAIL, CVFAIL	HV-FAIL PS-FAIL	GRAV SPANON
D	CHOPFAIL FLOWFAIL SYSFAIL	REFFAIL COOLERFAIL, CVFAIL	ZEROON HV-FAIL PS-FAIL	GRAV SPANON
E	LAMPFAIL FLOWFAIL SYSFAIL	HEATERFAIL, COOLERFAIL, CVFAIL	OUT OF SERVICE HV-FAIL PS-FAIL	VOL SPANON
F	CHOPFAIL LAMPFAIL FLOWFAIL SYSFAIL	REFFAIL HEATERFAIL COOLERFAIL, CVFAIL	ZEROON OUT OF SERVICE HV-FAIL PS-FAIL	VOL SPANON

CHOPFAIL	Indicates that the chopper has failed.
LAMPFAIL	Indicates that the lamp has failed.
FLOWFAIL	Indicates that the sample flow is less than 0.1 slpm.
SYSFAIL	Indicates one or more components have failed.
HEATERFAIL	Indicates that a system heater has failed.
COOLERFAIL	Indicates that a cooler has failed.
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GRAV	Measuring in gravimetric units i.e. MG/M3
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Example:
If a failure status is received as C022 then the failures of the instrument as determined by this code are:

C=	FLOWFAIL	Indicates that the sample flow is less than 0.1 slpm.
	SYSFAIL	Indicates one or more components have failed.
0 =	No Failure	
2 =	OUT OF SERVICE	'Out of service' switch has been activated on analyzer
2 =	VOL	Measuring in volumetric units i.e. PPM