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TELEDYNE
INSTRUMENTS
Advanced Pollution Instrumentation
A Teledyne Technologies Company

INSTRUCTION MANUAL

Chemiluminescent
$NO/NO_2/NO_X$ ANALYZER
Model 200A



© Teledyne Advanced Pollution Instrumentation
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HIGHLIGHTS

The purpose of this Highlights Page is to list the changes that were incorporated into this Manual per DCN 5247.

Chapter / Page Number	Description
Title Page	• Changed Revision number and date. • Added DCN number to footer.
Text – All Pages	• Changed Revision number and date. • Added DCN to all footers of Text, P/N 02246G. • Added "PRINTED DOCUMENTS ARE UNCONTROLLED" to all footers of Instruction Manual, P/N 02246G.
TOC / x	• Updated List of Figures in TOC.
3 / 3-3, 3-4	• Updated Warranty Section.
8 / 8-15	• Added note to replace the 5 dessicant bags if black PMT cover for the Sensor Assembly is removed.
10 / 10-1 thru 10-7	• Updated Spare Parts List, Tables 10-1 thru 10-6.
10 / 10-7, 10-8	• Added Tables 10-7 and 10-8 for new Expendables Kits.

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TELEDYNE
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Advanced Pollution Instrumentation
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INSTRUCTION MANUAL

MODEL 200A
NITROGEN OXIDE ANALYZER

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10 December 2008

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SAFETY MESSAGES

Your safety and the safety of others is very important. We have provided many important safety messages in this manual. Please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Each safety message is associated with a safety alert symbol. These symbols are found in the manual and inside the instrument. The definition of these symbols is described below:



GENERAL WARNING/CAUTION: Refer to the instructions for details on the specific danger.



CAUTION: Hot Surface Warning



CAUTION: Electrical Shock Hazard



Technician Symbol: All operations marked with this symbol are to be performed by qualified maintenance personnel only.



Electrical Ground: This symbol inside the instrument marks the central safety grounding point for the instrument.

CAUTION

The analyzer should only be used for the purpose and in the manner described in this manual.

If you use the analyzer in a manner other than that for which it was intended, unpredictable behavior could ensue with possible hazardous consequences.



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1 HOW TO USE THIS MANUAL

The Model 200A has been designed to provide serviceability, reliability and ease of operation. The M200A's microprocessor continually checks operating parameters such as temperatue, flow, and critical voltages. The instruments modular design uses captive screws to facilitate repair and ease of access. If you encounter any difficulty refer to Section 9 General Troubleshooting Hints.

We recognize that the need for information in this manual changes as time passes. When the instrument first arrives, it is necessary to get it up and running quickly and verify its correct operation. As time passes, more detailed information is often required on special configurations, calibration alternatives and other operational details. Finally there is the need for periodic maintenance and to quickly troubleshoot problems to assure maximum reliability and data integrity.

To address these needs, we have created three indexes to the information inside. They are:

Table of Contents:

Outlines the contents of the manual in the order the information is presented. This is a good overview of the topics covered in the manual. There is also a list of Tables and a list of Figures.

Index to M200A Front Panel Menus:

The Menu Index (Table 5-5-1 and Table 5-5-2, Table 5-5-3 and Table 5-5-4) briefly describes the front panel menus and refers you to other sections of the manual that have a detailed explanation of each menu selection.

Troubleshooting Section 9:

The Troubleshooting Section, outlined in the Table of Contents, allows you to diagnose and repair the instrument based on variables in the TEST menu, the results of DIAGNOSTIC tests, and performance faults such as excessive noise or drift. The troubleshooting section also explains the operation, adjustment, diagnosis and testing of each instrument subsystem.

If you are unpacking the instrument for the first time, please refer to Getting Started in Section 2.

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2 GETTING STARTED

2.1 Unpacking

1. Verify that there is no apparent shipping damage. If damage has occurred please advise shipper first, then Teledyne API.

CAUTION

To avoid personal injury, always use two persons to lift and carry the Model 200A.



2. Before operation, it is necessary to remove the shipping hold-down screws. Remove the instrument cover, then refer to Table 2-2-1 for screw location.
3. Also check for internal shipping damage, and generally inspect the interior of the instrument to make sure all circuit boards and other components are in good shape and all boards are seated properly.
4. Please check the voltage and frequency label on the rear panel of the instrument for compatability with the local power before plugging in the M200A.

2.2 Electrical and Pneumatic Connections

1. Refer to Table 2-2-2 to locate the rear panel electrical and pneumatic connections.
2. Attach the pump to the Exhaust Out port on the rear panel as shown in Table 2-2-3.
3. If you are connecting to a calibrator, attach a vented sample inlet line to the sample inlet port. The pressure of the sample gas at the inlet port should be at ambient pressure. The exhaust from the pump should be vented to atmospheric pressure. See Table 2-2-3 for inlet and exhaust line venting recommendations during calibration.
4. If desired, attach the analog output connections to a strip chart recorder and/or datalogger. Refer to Table 9-9-12 for the jumper settings for the desired analog output voltage range. Factory default setting is 0-5 VDC.
5. Connect the power cord to the correct voltage line, then turn to Section 2.3 Initial Operation.

WARNING

Analyzer Exhaust – O_3 Scrubber – Pump Pack Danger – Analyzer exhaust contains ozone.

Ozone scrubber must always be present between analyzer exhaust and pump.

Vent pump exhaust to well ventilated area at atmosphere pressure FIRE or EXPLOSION HAZARD.

Do not use charcoal treated with halogen compounds – use only Teledyne API P/N 00596 charcoal.

Wait at least 5 minutes after turning off pump before removing ozone scrubber WARNING.



WARNING

Lethal voltages present inside case.

Do not operate with cover off during normal operation.

Before operation check for correct input voltage and frequency.

Do not operate without proper chassis grounding.

Do not defeat the ground wire on power plug.

Turn off analyzer power before disconnecting electrical subassemblies.



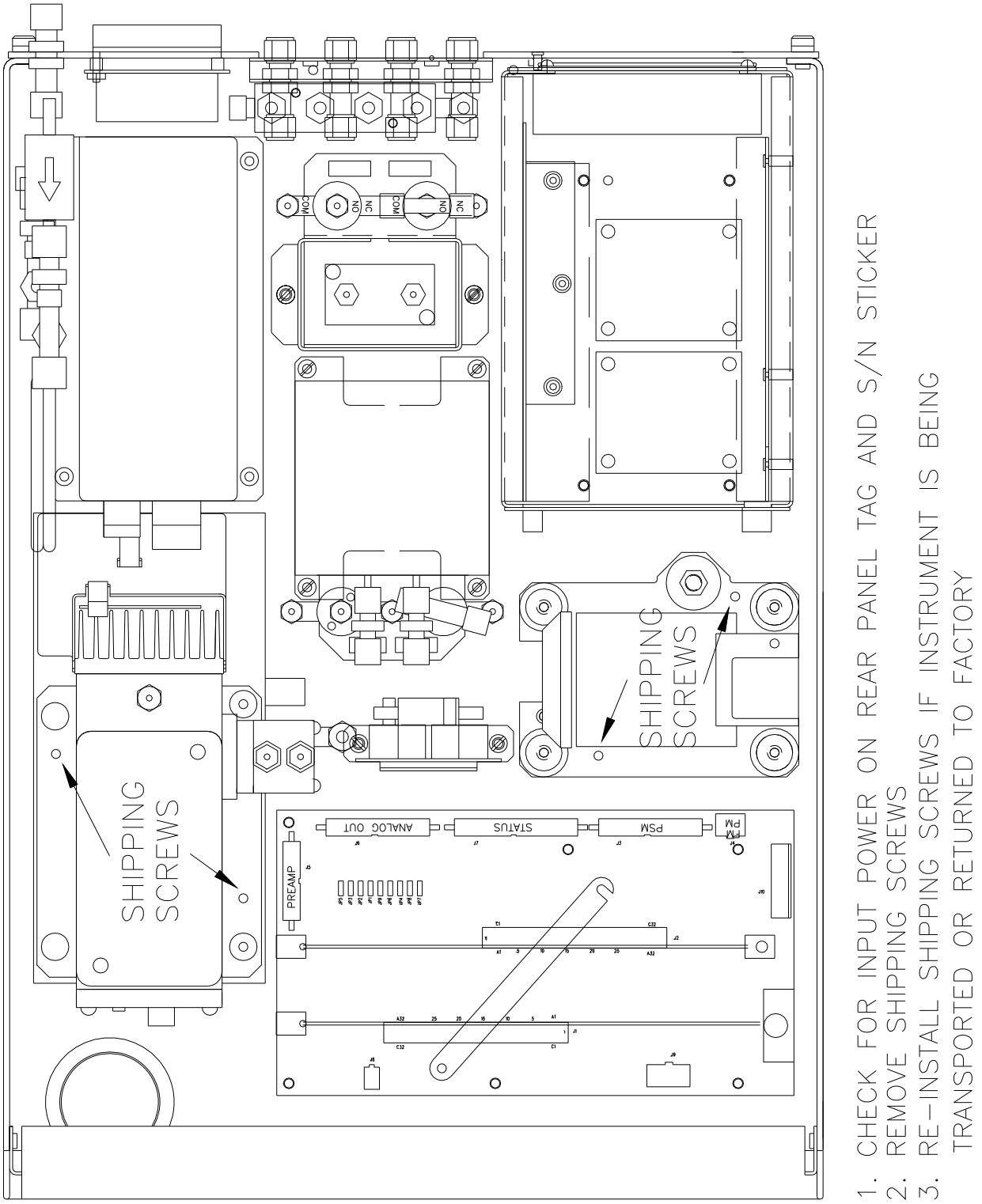
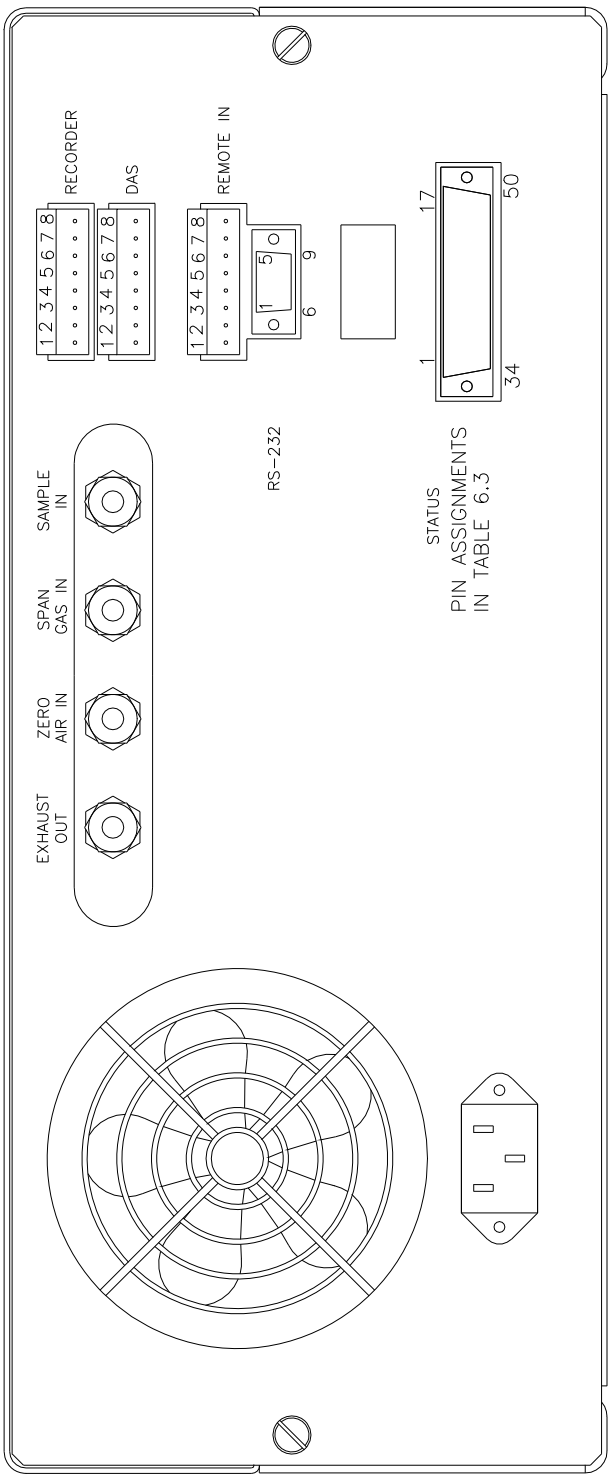


Table 2-2-1: Removal of Shipping Screws & Check for Correct Power



RECORDER AND DAS
PIN ASSIGNMENTS

PIN NO.	ASSIGNMENT
1	+ NO2 CONC
2	– NO2 CONC
3	+ NOx CONC
4	– NOx CONC
5	+ NO CONC
6	– NO CONC
7	+ TCHN
8	– TCHN

REMOTE IN
PIN ASSIGNMENTS

PIN NO.	ASSIGNMENT
1	+ REM ZERO CAL
2	– REM ZERO CAL
3	+ REM SPAN CAL
4	– REM SPAN CAL
5	
6	
7	
8	

RS–232 PORT
PIN ASSIGNMENTS

PIN NO.	ASSIGNMENT
1	
2	TX(RX) DATA
3	RS(TX) DATA
4	
5	SIG GROUND
6	DSR
7	
8	CTS
9	

Table 2-2-2: Rear Panel

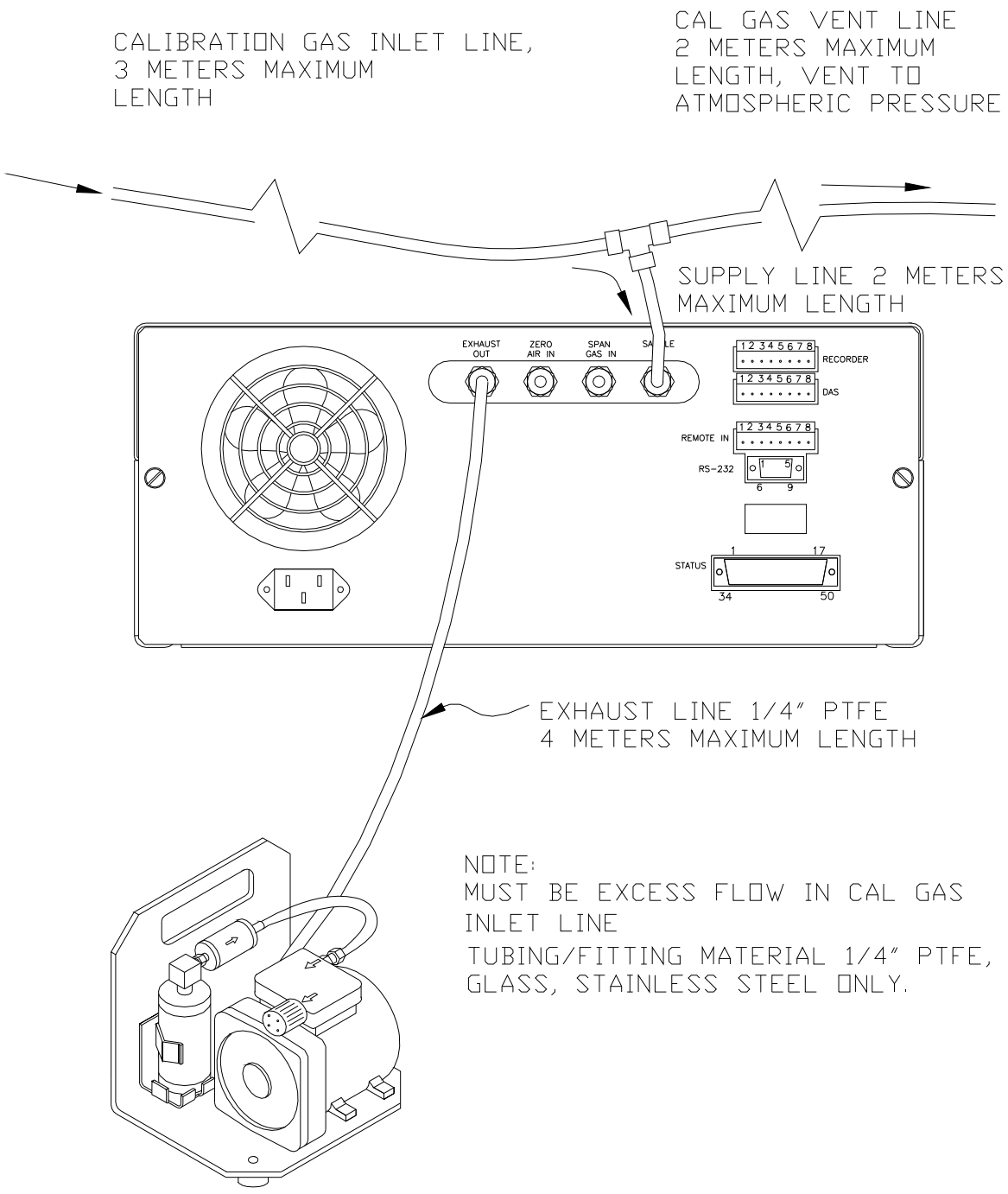


Table 2-2-3: Inlet and Exhaust Venting

2.3 Initial Operation

1. Turn on the instrument power.
2. The display should immediately light, displaying the instrument type (M200A) and the computer's memory configuration. If you are unfamiliar with the M200A, we recommend that you read the overview Section 4 before proceeding. A diagram of the software menu trees is in Table 5-5-1 and Table 5-5-2.
3. The M200A requires about 30 minutes for all internal components to come up to temperature. During this time the ozone generator power is OFF until the membrane dryer has time to purge itself, therefore there will be no response from the instrument, even if span gas is coming in the sample port. During this time temperatures and other conditions are out of specification. Because many warning conditions could be displayed warning conditions are suppressed for 30 minutes after power up. After 30 minutes, warning messages will be displayed until the respective warning conditions are within specifications. Use the CLR key on the front panel to clear warning messages.
4. While waiting for instrument temperatures to come up, you can check for correct operation by using some of the M200A's diagnostic and test features.
5. Examine the TEST functions by comparing the values listed in Table 2-2-6 to those in the display. Remember that as the instrument warms up the values may not have reached their final values yet. If you would like to know more about the meaning and utility of each TEST function, refer to Table 9-9-1. Also, now is a good time to verify that the instrument was shipped with the options you ordered. Table 2-2-6 includes a list of options. Section 6 covers setting up the options.
6. Electric Test and Optic Test both generate simulated signals in the M200A.
   A. Electric Test tests the electronics of the PMT signal path. To operate Electric Test from the front panel press SETUP-MORE-DIAG, then scroll to ELECTRICAL TEST and press ENTR to turn on the electric test. When ELEC test is operating, scroll the TEST function to PMT and compare instrument response to the values indicated in Table 2-2-6 . To turn off this test press EXIT. For more information on the circuitry being tested refer to the Troubleshooting Section 9.1.3.2.
   B. Optic Test is an "end to end" test of the analyzer HVPS/PMT/ electronics/computer. It simulates a signal by turning on a LED in the Sensor Module. To operate Optic Test from the front panel press SETUP-MORE-DIAG, then scroll to OPTIC test and press ENTR to turn on the optic test. Scroll the TEST function PMT and compare instrument response to the values indicated in Table 2-2-6. To turn off this test press EXIT. To return to the SAMPLE mode press EXIT until SAMPLE is displayed in the upper left display. For more information about OT operation, see Section 9.1.3.3.

7. When the instrument is warmed up, re-check the TEST functions against Table 2-2-6. All of the readings should compare closely with those in the Table. If they do not, see Section 9.1.1. The next task is to calibrate the analyzer. There are several ways to do a calibration, they are summarized in Table 7-7-1. For a preliminary checkout we recommend calibration with zero air and span gas coming in through the sample port. The procedure is:

Step 1 - Enter the expected NO_x and NO span gas concentrations:

Step Number	Action	Comment
1.	Press CAL-CONC-NOx	This key sequence causes the M200A to prompt for the expected NOx concentration. Enter the NOx span concentration value by pressing the key under each digit until the expected value is set.
2.	Press ENTR	ENTR stores the expected NOx span value. This value will be used in the internal formulas to compute subsequent NOx concentration values.
3.	Press CAL-CONC-NO	In the same CAL-CONC sub menu press the NO button and enter the expected NO span value, then ENTR. As before this value will be used in the internal formulas to compute the subsequent NO concentration values.
4.	Press EXIT-EXIT	Returns instrument to SAMPLE mode.
5.	Press SETUP-RNGE-MODE-SING-ENTR	If necessary you may want to change ranges. Normally the instrument is shipped in single range mode set at 500 ppb. We recommend doing the initial checkout on the 500 ppb range.
6.	Press SETUP-RNGE-SET	After SETUP-RNGE-SET, enter 500 and press ENTR. The instrument will now be in the 500 ppb range.
7.	Press EXIT	Returns instrument to SAMPLE mode.

Step 2 - Calibrate the instrument:

Zero/Span Calibration Procedure

Step Number	Action	Comment
1.	Input Zero gas	Allow Zero gas to enter the sample port on the rear of the instrument.
2.	Press CAL	The M200A enters the calibrate mode from sample mode.
3.	Wait 10 min	Wait for reading to stabilize at the zero value. If you wait less than 10 minutes the final zero value may drift.
4.	Press ZERO	The ZERO button will be displayed.
5.	Press ENTR	Pressing ENTR actually changes the calculation equations and zeroes the instrument.
6.	Input Span Gas	Switch gas streams to span gas.
7.	Wait 10 min	Wait for reading to stabilize at the span value. If you wait less than 10 minutes the final span value may drift.
8.	Press SPAN	The SPAN button should be displayed. If it is not, check the Troubleshooting Section 9.2.8 for instructions on how to proceed. In certain circumstances at low span gas concentrations (<100ppb), both the ZERO and SPAN buttons will appear.
9.	Press ENTR	Pressing ENTR actually changes the calculation equations so that the concentration displayed is the same as the expected span concentration you entered above, thus spanning the instrument.
10.	Press EXIT	Pressing EXIT returns the instrument to SAMPLE mode.

Step 3 - Review the quality of the calibration:

Calibration Quality Check Procedure

Step Number	Action	Comment
1.	Scroll the TEST function menu until the NO_x SLOPE is displayed.	The SLOPE value for NOx should be 1.0 ± 0.3. If the value is not in this range, check Section 7.10 or 9. If the SLOPE value is in the acceptable range, the instrument will perform optimally.
2.	Scroll the TEST function menu until the NO SLOPE is displayed.	The SLOPE value for NO should be 1.0 ± 0.3. If the value is not in this range, check Section 7.10 or 9. If the SLOPE is in the acceptable range, the instrument will perform optimally. NOTE: The NO and NOx slopes should be equal within ± 0.1.
3.	Scroll the TEST function menu until the NOx OFFSET is displayed.	The M200A will display the OFFSET parameter for the NOx equation. This number should be near zero. A value of 0.0 ± 150 mV indicates calibration in the optimal range. If the OFFSET value is outside this range, check Section 7.4 or 9 for procedures to correct the OFFSET value to near zero.
4.	Scroll the TEST function menu until the NO OFFSET is displayed.	The instrument will now display the NO OFFSET value. It should also have a value near zero (0.0 ± 150 mV).

Step 4 - The M200A is now ready to measure sample gas.

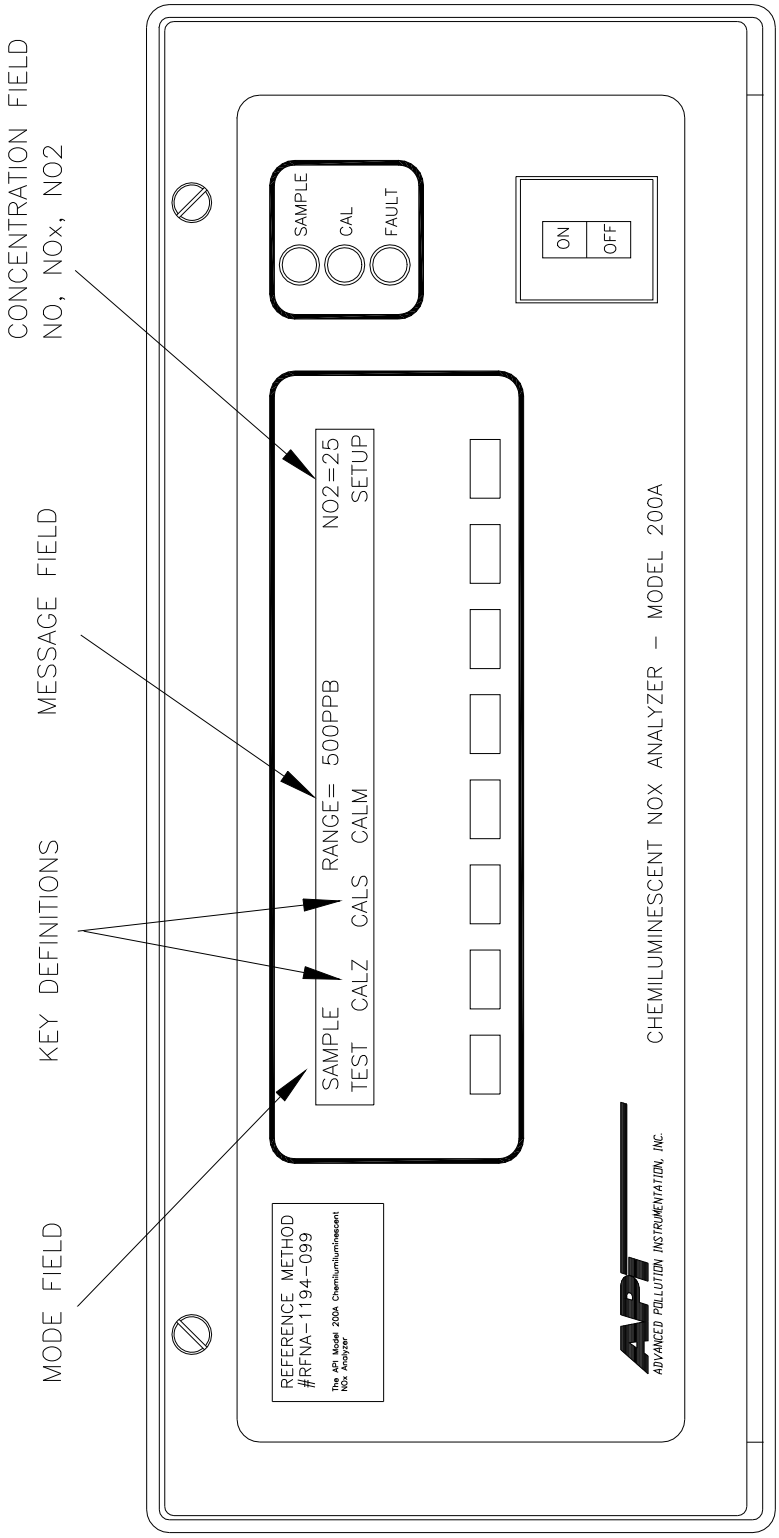


Table 2-2-4: Front Panel

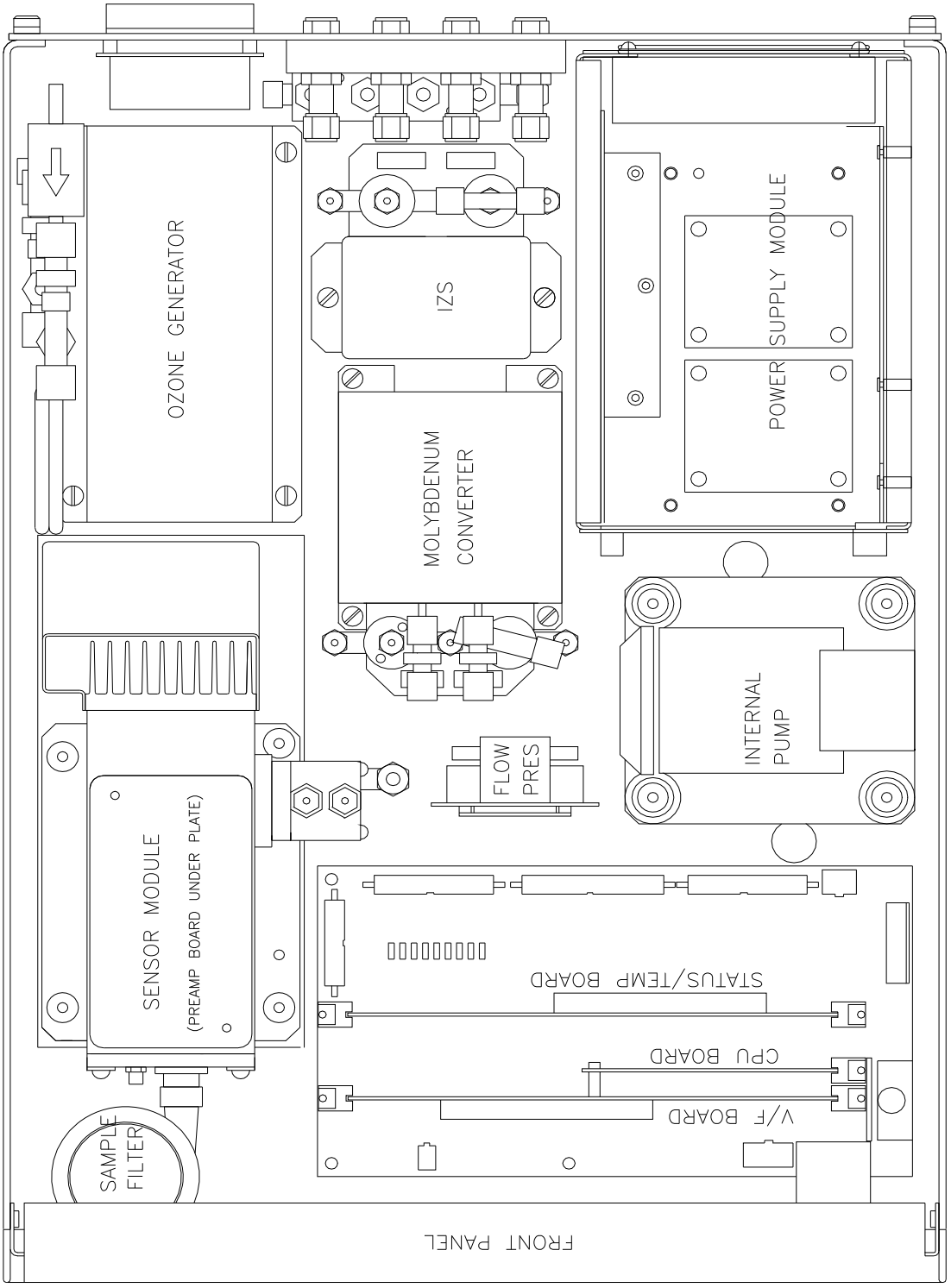


Table 2-2-5: Assembly Layout

Table 2-2-6: Final Test and Calibration Values

Test Values	Observed Value	Units	Nominal Range	Reference Section
RANGE		PPB	50-20,000	5.3.4
STABILITY (Zero Gas)		PPB	< 0.2	9.1.1, Table 9-9-1, 9.2.5
SAMP FLW		cc/min	500 ± 50	9.3.7, Table 9-9-1
OZONE FL		cc/min	60 - 90	9.3.6, 9.3.7
PMT		mV	0-5000	9.3.8.1, Table 9-9-1
AZERO		mV	-20 - 150	Table 9-9-1
HVPS		V	450 - 900 constant	9.3.8.5
DCPS		mV	2500 ± 200	9.3.5, 9.3.4
RCELL TEMP		°C	50 ±1	9.3.8.2
BOX TEMP		°C	8-48	9.3.4.1
PMT TEMP		°C	7 ± 1	9.3.8.4
IZS TEMP		°C	50 ± 0.4	9.3.9
MOLY TEMP		°C	315 ± 5	9.3.4.1
RCEL PRES		IN-Hg-A	4 - 10 constant	9.3.7
SAMP PRES		IN-Hg-A	25 - 30 constant	9.3.7
Electric Test & Optic Test				
Electric Test				
PMT Volts		mV	2000 ± 500	9.1.3.2
NO Conc		PPB	1000 ± 250	9.1.3.2
NO_x Conc		PPB	1000 ± 250	9.1.3.2
Optic Test				
PMT Volts		mV	2000 ± 1000	9.1.3.3
NO Conc		PPB	1000 ± 500	9.1.3.3
NO_x Conc		PPB	1000 ± 500	9.1.3.3

(table continued)

Table 2-1: Final Test and Calibration Values (Continued)

Parameter	Observed Value	Units	Nominal Range	Reference Section
NO Span Conc		PPB	20 - 20,000	Table 7-7-4
NO_x Span Conc		PPB	20 - 20,000	Table 7-7-4
NO Slope		-	1.0 ± 0.3	Table 7-7-21
NO_x Slope		-	1.0 ± 0.3	Table 7-7-21
NO Offset		mV	-10 to +150	Table 7-7-21
NO_x Offset		mV	-10 to +150	Table 7-7-21
Moly Efficiency		%	0.96 - 1.02	7.8.6, 5.2.2.6
Stability at Zero		PPB	< 0.2	Table 9-9-1
Stability at Span		PPB	< 2 ppb @ 400ppb span gas	Table 9-9-1
Measured Flows				
Sample Flow		cc/min	500 ± 50	9.3.7, Table 9-9-19
Ozone Flow		cc/min	60 - 90	9.3.7, Table 9-9-19
IZS Purge Flow		cc/min	60 ± 15	6.3

Factory Installed Options	Option Installed
Power Voltage/Frequency	
Rack Mount, w/ Slides	
Rack Mount, w/ Ears Only	
Rack Mount, External Pump w/ Slides	
Rack Mount, External Pump w/o Slides	
Stainless Zero/Span Valves	
Internal Zero/Span - IZS	
Permeation Tube Output Specification	

Current Loop - NO_x Chan	4-20 mA	0-20 mA	Isolated	Non-Isolated
Current Loop - NO Chan	4-20 mA	0-20 mA	Isolated	Non-Isolated
Current Loop - NO_2 Chan	4-20 mA	0-20 mA	Isolated	Non-Isolated
Current Loop - TST Chan	4-20 mA	0-20 mA	Isolated	Non-Isolated
Internal Pump				

PROM # _____ Serial # _____

Date _____ Technician _____

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3 SPECIFICATIONS, AGENCY APPROVALS, WARRANTY

3.1 Specifications

Ranges	In 1ppb increments from 50ppb to 20,000ppb
Range Modes	Single, Independent, AutoRange
Noise at Zero[1]	0.2 ppb RMS
Noise at Span[1]	<0.5% of reading above 50 ppb
Lower Detectable Limit[2]	0.4 ppb RMS
Zero Drift[3]	<0.5 ppb/24 hours
Zero Drift	1 ppb/7 days
Span Drift	<0.5% FS/7 days
Lag Time	20 sec
Rise Time	95% in <60 sec
Fall Time	95% in <60 sec
Sample Flow Rate	500 cc/min. ± 10%
Linearity	1% of full scale
Precision	0.5% of reading
Temperature Range	5-40°C
Temp Coefficient	< 0.1% per °C
Humidity	0-95% RH non-condensing
Voltage Coefficient	< 0.1% per V
Dimensions HxWxD	7" x 17" x 23.6" (18cm x 43cm x 61cm)
Weight, Analyzer	43 lbs (20 kg) w/external pump
Weight, Analyzer	55 lbs (25 kg) w/internal pump
Weight, Ext Pump Pack	16 lbs (7 kg)
Weight, Internal Pump	5 lbs (2 kg)
Power, Analyzer	100 V ~ 50/60 Hz, 120V~ 60 Hz, 220 V~ 50 Hz, 240 V~ 50 Hz, 125 watts
Power, Analyzer[5]	230 V ~ 50 Hz, 2.5A peak
Power, Ext Pump	110 V ~ 60 Hz, 220V~ 50 Hz, 240V~ 50Hz, 295 watts
Power, Ext Pump[5]	230 V ~ 50 Hz, 2.5A peak
Power, Int Pump	110 v/50/60 Hz, 60 watts
Environmental	Installation Category (Over-voltage Category) II Pollution Degree 2
Recorder Output[4]	0-100 mV, 0-1, 5, 10v
Analog Resolution	1 part in 1024 of selected voltage or current range
Status Option	12 Status Outputs from opto-isolator
Measurement Units	ppb, ppm, ug/m^3, mg/m^3

1. As defined by USEPA.
2. Defined as twice the zero noise level.
3. At constant temperature and voltage.
4. Bi-polar.
5. Electrical rating for CE Mark compliance.

3.2 EPA Equivalency Designation

Advanced Pollution Instrumentation, Inc., Model 200A Nitrogen Oxides Analyzer is designated as Reference Method Number RFNA-1194-099 as defined in 40 CFR Part 53, when operated under the following conditions:

1. Range: Any range from 50 parts per billion (ppb) to 1 ppm.
2. Ambient temperature range of 5 to 40°C.
3. Line voltage range of 105-125 VAC, 60Hz; 220-240 VAC, 50Hz.
4. With 5-micron TFE filter element installed in the internal filter assembly.
5. Sample flow of 500 ± 50 cc/min.
6. Vacuum pump (internal or external) capable of 10"Hg Abs pressure @ 2 slpm or better.
7. Software settings:

A. Dynamic span	OFF
B. Dynamic zero	OFF
C. Cal-on-NO2	OFF
D. Dilution factor	OFF
E. AutoCal	ON or OFF
F. Independent range	ON or OFF
G. Autorange	ON or OFF
H. Temp/Pres compensation	ON
I. Converter Eff.	Acceptable values of 0.96 to 1.02

Under the designation, the Analyzer may be operated with or without the following options:

1. Rack mount with slides.
2. Rack mount without slides, ears only.
3. Rack mount for external pump w/o tray.
4. Stainless steel zero/span valves.
5. Internal zero/span.
6. NO_2 permeation tube - uncertified 0.4ppm @ 0.7 lpm.
7. NO_2 permeation tube - certified 0.4ppm @ 0.7 lpm.
8. NO_2 permeation tube - certified 0.8ppm @ 0.7 lpm.
9. NO_2 permeation tube - uncertified 0.8ppm @ 0.7 lpm.
10. 4-20mA, isolated outputs.
11. Status outputs.
12. RS-232 output.
13. Internal pump or external pump.
14. 1 micron sample filter.

3.3 Warranty

ADVANCED POLLUTION INSTRUMENTATION DIVISION (T-API) (02024D) (DCN 4473)

Prior to shipment, T-API equipment is thoroughly inspected and tested. Should equipment failure occur, T-API assures its customers that prompt service and support will be available.

COVERAGE

After the warranty period and throughout the equipment lifetime, T-API stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting is to be performed by the customer.

NON-API MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by T-API is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturers warranty.

GENERAL

During the warranty period, T-API warrants each Product manufactured by T-API to be free from defects in material and workmanship under normal use and service. Expendable parts are excluded.

If a Product fails to conform to its specifications within the warranty period, API shall correct such defect by, in API's discretion, repairing or replacing such defective Product or refunding the purchase price of such Product.

The warranties set forth in this section shall be of no force or effect with respect to any Product: (i) that has been altered or subjected to misuse, negligence or accident, or (ii) that has been used in any manner other than in accordance with the instruction provided by T-API, or (iii) not properly maintained.

THE WARRANTIES SET FORTH IN THIS SECTION AND THE REMEDIES THEREFORE ARE EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, WHETHER EXPRESSED OR IMPLIED. THE REMEDIES SET FORTH IN THIS SECTION ARE THE EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONTAINED HEREIN. API SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATED TO THIS AGREEMENT OF T-API'S PERFORMANCE HEREUNDER, WHETHER FOR BREACH OF WARRANTY OR OTHERWISE.

TERMS AND CONDITIONS

All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.

4 THE M200A NO_X ANALYZER

4.1 Principle of Operation

The Teledyne API Model 200A Analyzer is designed to measure the concentration of nitric oxide [NO], total oxides of nitrogen [NO_X] and, by calculation, nitrogen dioxide [NO_2]. The instrument measures the light intensity of the chemiluminescent gas phase reaction of nitric oxide [NO] and ozone [O_3] as follows:

$$NO + O_3 \longrightarrow NO_2^* + O_2$$

$$NO_2^* \longrightarrow NO_2 + h\nu$$

The reaction of NO with ozone results in electronically excited NO_2 molecules as shown in the first equation above. The excited NO_2 molecules release their excess energy by emitting a photon and dropping to a lower energy level as shown in the second equation. It has been shown that the light intensity produced is directly proportional to the [NO] concentration present.

The Analyzer samples the gas stream and measures the [NO] concentration by digitizing the signal from the Analyzer's photomultiplier tube (PMT). A valve then routes the sample stream through a converter containing heated molybdenum to reduce any NO_2 present to NO by the following reaction:

315^{o} C

$$3NO_2 + Mo \longrightarrow 3NO + MoO_3$$

The Analyzer now measures the total NO_x concentration. The [NO_x] and [NO] values are subtracted from each other by the built-in computer yielding the [NO_2] concentration. The three results [NO], [NO_x], and [NO_2] are then further processed and stored by the computer yielding several instantaneous and long term averages of all three components. These readings are also stored internally in the M200A's data acquisition system (DAS).

The software uses an adaptive filter to accomodate rapid changes in concentration. The algorithm monitors the rate of change in concentration for both the NO and NO_x channels. When a change in concentration is detected, the software changes the sample filters to rapidly respond to the change. The filters are adjusted to minimize the errors introduced by the time delay between the NO_x and NO channel measurements; this assures accurate NO_2 measurements. When the rate of change decreases, the filters are lengthened to provide good signal/noise ratio. The parameters used to operate the adaptive filter have been tuned to match the electrical and pneumatic characteristics of the M200A.

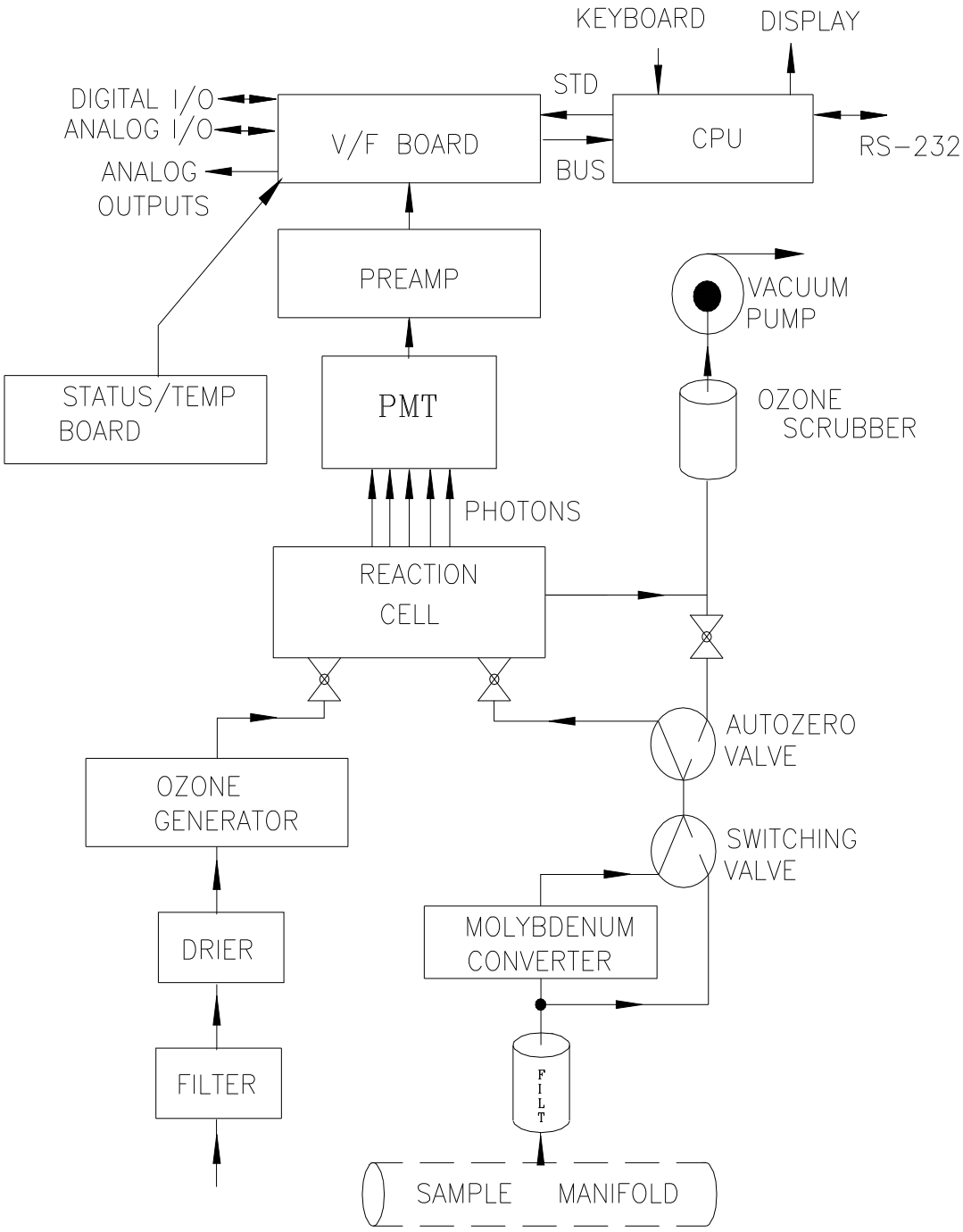


Table 4-4-1: Block Diagram

4.2 Operation Summary

4.2.1 Sensor Module, Reaction Cell, Detector

The sensor module (Table 9-9-20) is where the chemiluminescent reaction takes place and where the light from the reaction is detected. It is the most complicated and critical sub-assembly in the entire analyzer. It consists of the following sub-assemblies and functions:

1. The reaction cell and flow control module
2. Reaction cell heater/thermistor
3. Photo multiplier tube(PMT) and high voltage power supply
4. PMT cooler/cold block/heatsink/fan
5. Preamp assembly:
   A. Preamp range control hardware
   B. HVPS control
   C. PMT cooler temp control
   D. Electric test electronics
   E. Optic test electronics

4.2.2 Pneumatic Sensor Board

The sensor board consists of two pressure sensors and a flow sensor. One pressure sensor measures the pressure in the reaction cell,which is maintained at about one-quarter of atmospheric pressure. The second pressure sensor measures the pressure just upstream of the reaction cell, which is near ambient pressure. From these two pressures the sample flow rate can be computed and is displayed as sample flow in the TEST menu. Finally, a solid state flow meter measures the ozone flow directly. Likewise, it is displayed as a TEST function.

The M200A displays all pressures in inches of mercury-absolute (in-Hg-A). Absolute pressure is the reading referenced to a vacuum or zero absolute pressure. This method was chosen so that ambiguities of pressure relative to ambient pressure can be avoided.

For example, if the vacuum reading is 25" Hg relative to room pressure at sea level the absolute pressure would be 5" Hg. If the same absolute pressure was observed at 5000 ft altitude where the atmospheric pressure was 5" lower, the relative pressure would drop to 20" Hg, however the absolute pressure would remain the same 5" Hg-A.

4.2.3 Computer Hardware and Software

CPU Board

The M200A Analyzer is operated by an NEC V40 microprocessor. Computer communication is done via 2 major hardware assemblies, the V/F board and the front panel display/keyboard. The computer's multitasking operating system allows it to control the instrument, monitor test points, generate analog outputs and provide a user interface via the display, keyboard and RS-232 port. These operations appear to be happening simultaneously but are actually done sequentially based on a priority queuing system maintained by the operating system. The jobs are queued for execution only when needed, therefore the system is very efficient with computer resources. The M200A is a true computer based instrument. The microprocessor does most of the instrument control functions such as valve switching and temperature control. Data collection and processing are done entirely in the CPU with the final concentration values being sent to a D/A converter to produce the instrument analog output.

The computer memory is divided into 3 sections: ROM memory contains the multi-tasking operating system code plus the instructions that run the instrument. The RAM memory is used to hold temporary variables and current concentration data. The EEPROM memory contains the instrument set-up variables such as range and instrument ID number. The EEPROM data is non-volatile so the instrument can lose power and the current set-up information is preserved.

4.2.4 V/F Board

The V/F board is multifunctional, consisting of A/D input channels, digital I/O channels, and analog output channels. Communication with the computer is via a STD bus interface. The computer receives all of the instrument data and provides all control functions through the V/F board.

4.2.5 Front Panel

The front panel of the M200A is shown in Table 2-2-4. The front panel consists of a 2 line display and keyboard, 3 status LED's and power switch. Communication with the display, keyboard, and status LED's is done via the computer's on-board parallel port. The M200A was designed as a computer controlled instrument, therefore all major operations can be controlled from the front panel display and keyboard.

The display consists of 2 lines of 40 characters each. The top line is divided into 3 fields, and displays information. The first field is the mode field. A list of operating modes is given in Table 5-5-9.

The center field displays TEST values. The TEST functions allow you to quickly access many important internal operating parameters of the M200A. This provides a quick check on the internal health of the instrument. The right hand field shows current concentration values of NO, NO_x, and NO_2. The display scrolls between the 3 values every 4 seconds.

4.2.5.1 Keyboard

The second line of the display contains eight fields. Each field defines the key immediately below it. By redefining the keys dynamically it is possible to simplify the instrument electronics and user interface.

When entering data in the keyboard, if the entered value is not accepted, the M200A will "beep" to notify the user that the value keyed in was not accepted. The original value remains unchanged.

4.2.5.2 Status LED's

At the right of the display there are 3 status LED's. They can be in three states, OFF, ON, and Blinking. The meanings of the LED's are given in Table 4-4-2.

Table 4-4-2: Front Panel Status LED's

LED	State	Meaning
Green	On Off Blinking	Monitoring normally, taking DAS data NOT monitoring, DAS disabled Monitoring, DAS in HOLDOFF mode (1)
Yellow	Off On Blinking	Auto cal. disabled Auto/Dynamic cal. enabled Calibrating
Red	Off Blinking	No warnings exist Warnings exist
(1) This occurs during Calibration, DAS holdoff, power-up holdoff, and when in Diagnostic mode.		

4.2.5.3 Power Switch

The power switch has two functions. The rocker switch controls overall power to the instrument, in addition is a circuit breaker. If attempts to power up the M200A result in a circuit breaker trip, the switch automatically returns to the off position, and the instrument will not power up.

4.2.6 Power Supply Module

The Power supply module supplies AC and DC power to the rest of the instrument. It consists of a four output linear DC power supply and a 15 volt switching supply. In addition, it contains the switching circuitry to drive the DC operated valves and several switched AC loads that operate the Rx cell, IZS, and molybdenum converter heaters and the ozone generator. The only voltages not generated in the PSM are the high voltage DC required by the PMT which is generated inside the sensor module and the high voltage AC used by the ozone generator.

4.2.7 Pump, Valves, Pneumatic System

A standard M200A comes with two valves. The NO/NO_x valve switches sample gas into the reaction cell from either the sample inlet port or from the moly converter into the reaction cell. Periodically, the AutoZero valve shuts off sample flow to the reaction cell to measure the detector dark signal.

A catalytic scrubber contained in the moly converter assembly removes the ozone present in the exhaust stream.

If the external pump is selected, This option is not available with the internal pump.

The external Pump Pack includes a vacuum pump and optional charcoal NO_2 scrubber. By using this pump, it is possible to remove a significant source of acoustic noise and vibration from the immediate area of the analyzer. The pump pack is supplied with 0.25" tube fitting to connect to the exhaust fitting on the M200A rear panel. See Table 2-2-3 for hook-up information. Plugging the power cord into an AC outlet turns on the pump pack, see Table 4-4-3.

The internal pump has slightly lower performance specifications, and shorter MTBF, however it consumes significantly less power, and makes an instrument that has a single chassis. The NO_2 scrubber option.

A pump is supplied as standard equipment, however if another pump is used, it must have the following characteristics:

1. The pump must supply 1 slpm at 5"Hg-A.

2. The ozone scrubber must remove all ozone from the analyzer exhaust.

3. Connect the exhaust (Table 2-2-3) to a pump with <3 m of 1/4" PTFE tubing.

Failure to meet the performance specifications will result in poor analyzer performance, damage to the pump, damage to the analyzer, and may jeopardize warranty repairs. Teledyne API strongly recommends that the factory supplied pump be used with the M200A.

NOTE

On vacuum vs absolute pressure:
Many vacuum gauges read relative to ambient pressure, therefore a reading of 25" of mercury (Hg) at sea level (which would give an absolute pressure of about 5" Hg in the reaction cell) would read only 20" Hg at high altitude sites. Therefore in this manual the vacuum specification of 5" Hg pressure is given as an absolute pressure - 5"Hg-A - reference against zero absolute pressure (a perfect vacuum) thus removing ambiguities for high altitude sites.

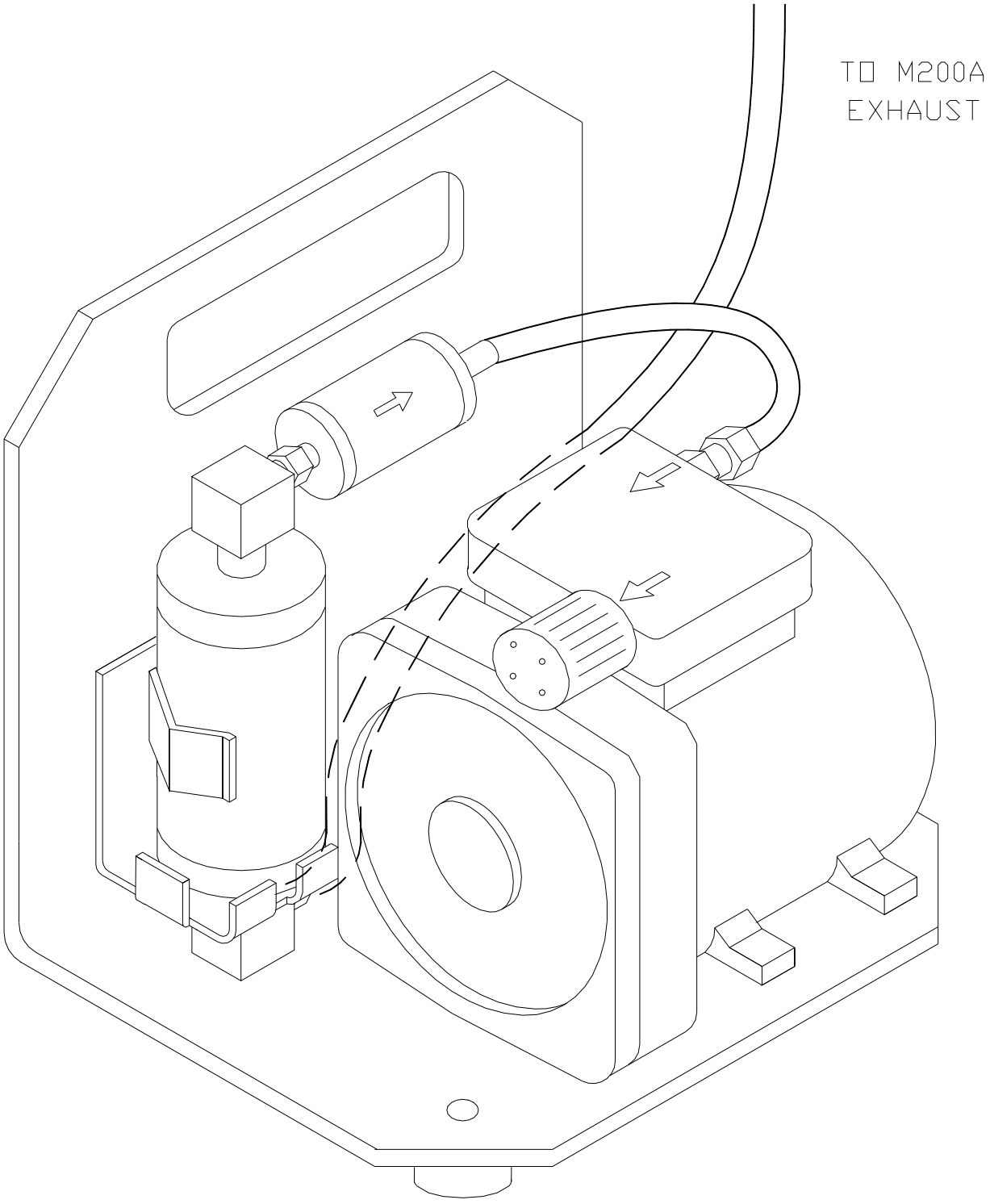


Table 4-4-3: External Pump Pack

4.2.8 Ozone Generator

Because of the instability of ozone, it is necessary to generate this gas inside the analyzer. The ozone generation module consists of a high voltage AC supply and silent discharge tube and permeation type air drier. A complete description of its function and service requirements can be found in Section 9.3.6.

CAUTION

Lethal voltages present inside ozone generator.

Do not defeat electrical interlock.



The dry air supply for the ozone generator uses a membrane drier to supply air with a dew point of 0^o C or less. The exhaust side of the membrane is connected to the vacuum manifold at the rear of the instrument.

Normal room air contains enough water vapor to damage the generator and components downstream. To prevent damage, the generator will be turned ON after 30 min following a cold start. Otherwise, the starting of the generator will follow the table below:

Table 4-4-4: Ozone Generator Start-up Timing

Ozone Gen State at Power-On	Instrument Action
ON	If instrument has been off for less than 30 min
OFF	If instrument has been off for more than 30 min

4.2.9 Molydbenum Converter

The molybdenum converter is a stainless steel cartridge containing molybdenum chips heated to 315° C. The converter's function is to reduce nitrogen dioxide NO_2 to nitric oxide NO. The temperature control for this module is done by the computer.

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5 SOFTWARE FEATURES

The M200A control software has two major operating modes. The SAMPLE mode is the normal mode when the instrument is taking data. The software menu that covers the SAMPLE mode is diagrammed in Table 5-5-1.

When the instrument is initially installed, or problems indicate a need for diagnostics, the SETUP menu is used. The SETUP menu is diagrammed in Table 5-5-2.

5.1 Index To Front Panel Menus

The next several pages contain two different styles of indexes that will allow you to navigate the M200A software menus. The first two pages show a "tree" menu structure to let you see at a glance where each software feature is located in the menu. The second menu contains a brief description of each key mnemonic and a reference to the section of the manual that describes its purpose and function in detail.

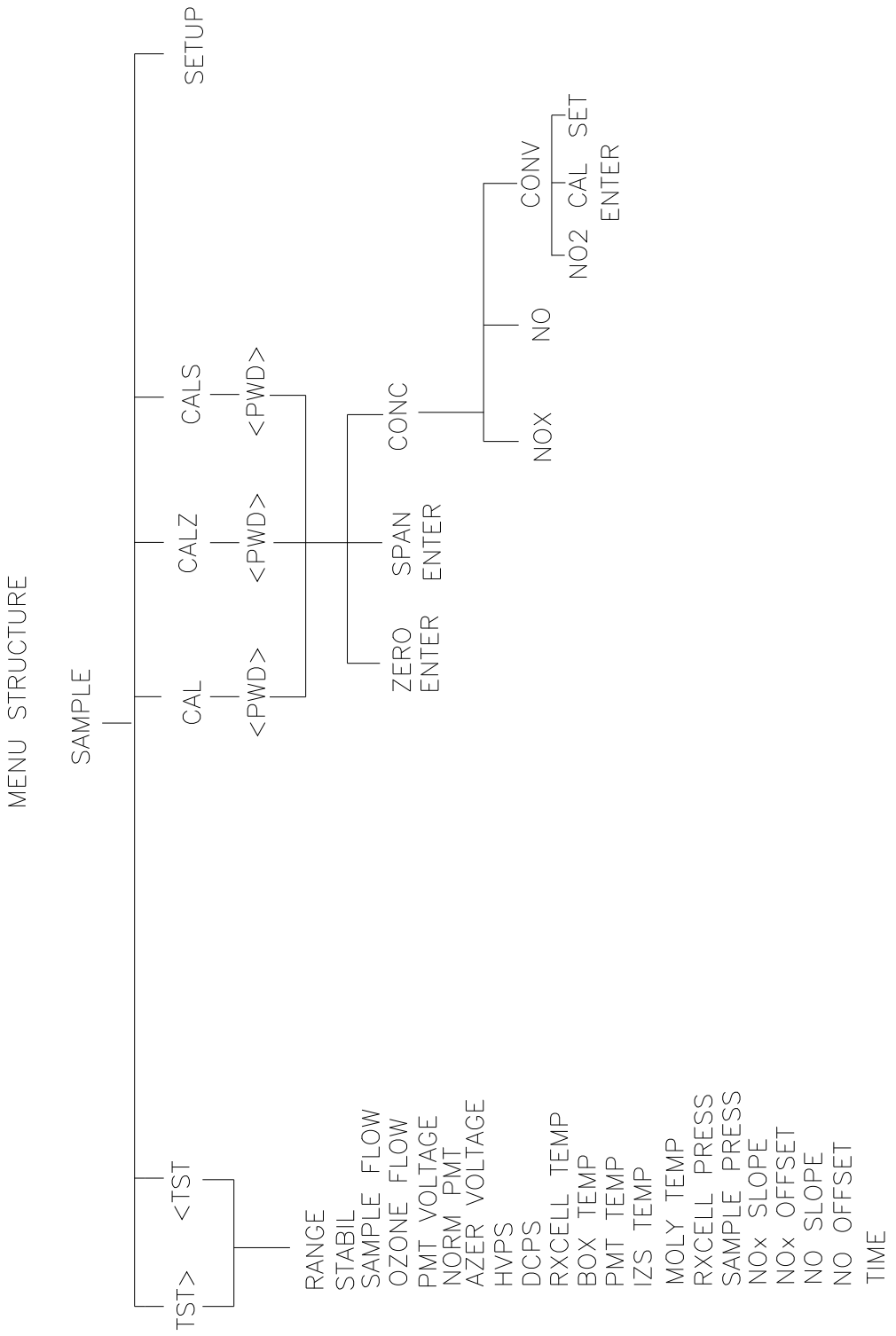


Table 5-5-1: Sample Menu Tree

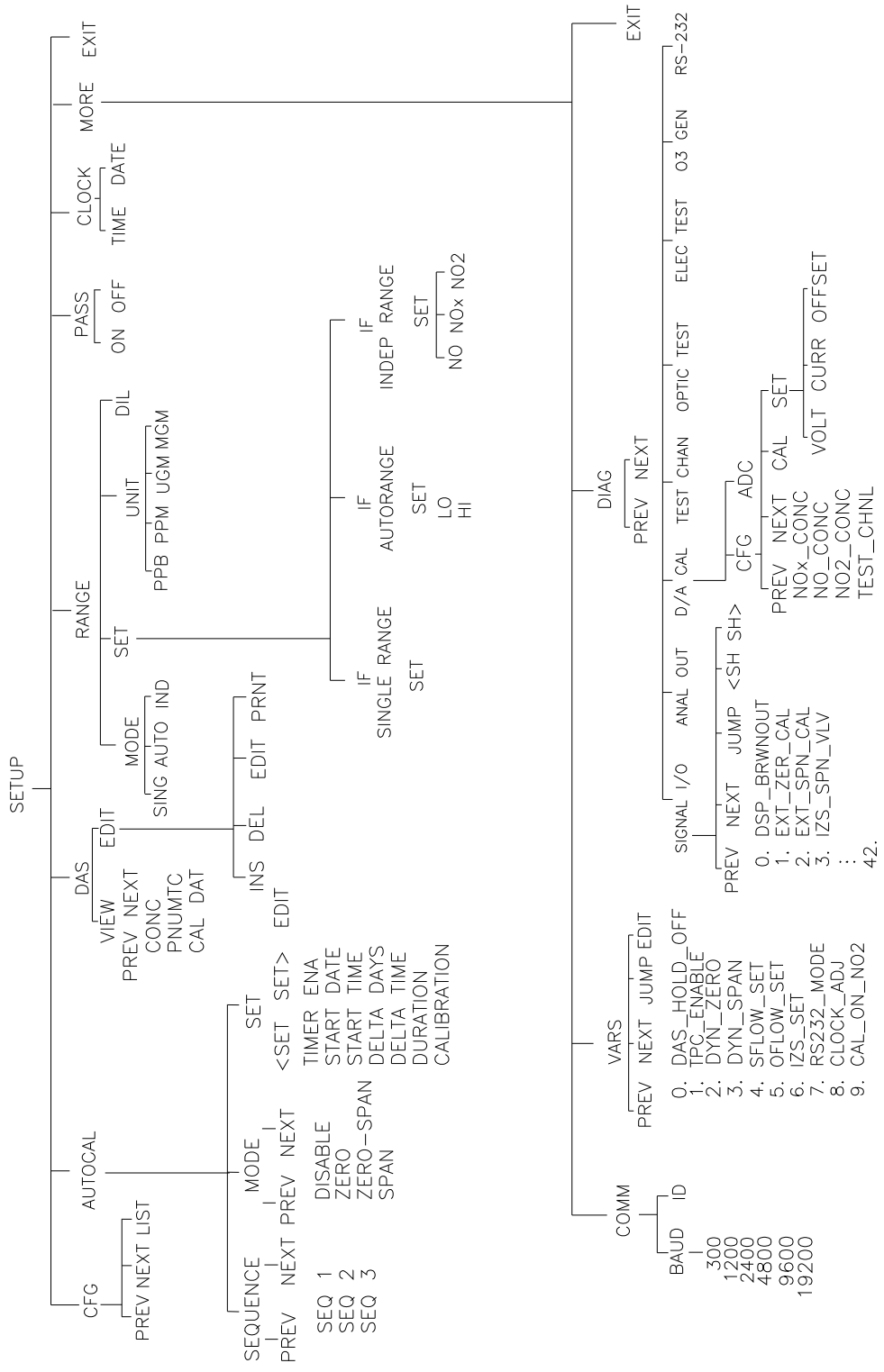


Table 5-5-2: Setup Menu Tree

5.1.1 Sample Menu

Table 5-5-3: M200A Sample Menu Structure

Menu Level					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
TEST TST>				Test functions	5.2.1, Table 9-9-1
CAL				Zero/Span calibration w/ gas through sample port	5.2.2.1, 7.3
CALZ				Zero calibration w/ zero gas from zero valve option or IZS option	5.2.2.2, 7.1, 7.2
CALS				Span calibration w/ span gas from span valve option or IZS option	5.2.2.3, 7.1, 7.2
	ZERO			Press ZERO then ENTR will zero analyzer	5.2.2.2, 7.1, 7.2
	SPAN			Press SPAN then ENTR will span analyzer	5.2.2.3, 7.1, 7.2
	CONC			Expected NO/ NO_x span concentrations and Moly conv. efficiency setup	Table 7-7-4
		NOX CONC		Enter expected NO_x span concentration	5.2.2, Table 7-7-4
		NO CONC		Enter expected NO span concentration	5.2.2, Table 7-7-4
		CONV		Sub-menu for converter efficiency setup and verification	5.2.2.6, 7.8.6
			NO2	Expected NO_2 concentration for converter efficiency calculation	5.2.2.6, 7.8.6
			CAL	Automatic converter efficiency calibration and entry	5.2.2.6, 7.8.6
			SET	Set the converter efficiency manually	5.2.2.6, 7.8.6
MSG				Displays warning messages	9.1.2
CLR				Clears warning messages	9.1.2
SETUP				The SETUP Menu - See next table below	Table 5-5-4

5.1.2 Set-Up Menu

Table 5-5-4: M200A Setup Menu Structure

Setup Menu #1					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
CFG				CFG is primarily used for showing special configuration options and factory special software	5.3.1
	PREV, NEXT, LIST			PREV, NEXT can be used to scroll through the configuration list. LIST automatically scrolls the list	5.3.1
AUTOCAL				Automatic span check or calibration	5.3.2, 6.4
	SEQUENCE			Selects Sequence	5.3.2, 6.4
		PREV-NEXT		Scrolls display to select calibration sequence 1, 2, or 3	5.3.2, 6.4
	MODE			Selects mode of calibration (zero, span, zero-span) plus disable	5.3.2, 6.4
	SET			For a given Sequence and Mode, sets timing and calibration attributes	5.3.2, 6.4
DAS				Data Acquisition System(DAS) - keeps 1 to 1500 minute averages of data	5.3.3
	VIEW			Select which DAS data collector to view	5.3.3
		PREV-NEXT		Scroll through data collectors CONC, PNUMTC, CAL DAT. The DAS data structure can be viewed as a list with the most recent data at the top. The pointer is initialized at the top - the most recent entry.	5.3.3
	EDIT	PREV		Move down the DAS data buffer to examine older data	5.3.3
		PREV10		Move down 10 entries in the DAS data buffer	5.3.3
		NEXT		Move up the DAS data buffer to display more recent data	5.3.3
		NEXT10		Move up 10 entries in the DAS data buffer	5.3.3

Table 5-5-5: M200A Menu Structure - Setup Menu #2

Setup Menu #2					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
RANGE				Range control menu	5.3.4
	MODE			Range mode select – Single, Autorange, Independent	5.3.4
	SET			Sets range if mode is Single range	5.3.4.1
		NO		Sets NO concentration if indep ranges enabled	5.3.4.3
		NO_x		Sets NO_x concentration if indep ranges enabled	5.3.4.3
		NO_2		Sets NO_2 concentration if indep ranges enabled	5.3.4.3
		LO		Sets low range if Autorange enabled	5.3.4.2
		HI		Sets high range if Autorange enabled	5.3.4.2
	UNITS			Unit selection menu	5.3.4.5
		PPB,PPM, UGM, MGM		Select units that instrument uses	5.3.4.5
	DIL			Enter dilution factor if connected to stack dilution probe	5.3.4.4
PASS				Password enable/disable menu	5.3.5
	ON-OFF			Enable/disable password checking	5.3.5
CLOCK	TIME			Adjusts time on the internal time of day clock	5.3.6
	DATE			Adjusts date on the internal time of day clock	5.3.6
MORE				Continue menus on next level down	Table 5-5-4
	COMM			RS-232 communications control menu	5.3.8, 5.5
		BAUD		Sets the BAUD rate to 300 - 19,200	5.3.8, 5.5
		ID		Sets the instrument ID - (included on all RS-232 messages)	5.3.8, 5.5

Table 5-5-6: M200A Menu Structure - Setup Menu #3

Setup Menu #3					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
	VARS			Internal variables	5.3.9, 9.2
		PREV, NEXT, JUMP, EDIT		PREV, NEXT scroll up and down through the VARS menu. JUMP will go to variable number selected, EDIT will allow editing of the selected variable	5.3.9, 9.2
	DIAG			Diagnostic menu	5.3.7, 9
		PREV, NEXT		PREV, NEXT scroll up and down through the DIAG menu	5.3.7, 9
			SIG I/O	Examines, changes analog and digital internal signals	9.1.3.1
			ANALOG OUT	Writes test voltages to analog outputs	9.1.3.5
			D/A CAL	Calibrates analog outputs	9.1.3.6
			OPTIC TEST	Activates Optic Test feature	9.1.3.3
			ELEC TEST	Activates Electric Test feature	9.1.3.2
			O3 GEN	Turns OFF/ON ozone generator	9.1.3.4
			RS-232	Writes test data to RS-232 port	9.1.3.7

5.2 Sample Mode

The M200A software has two major operating modes, the SAMPLE mode and the SETUP mode. The SAMPLE mode is the normal mode when the instrument is taking data. The SETUP mode is used when the instrument is initially installed, or when problems indicate a need for diagnostics.

One of the features of the SAMPLE mode is TEST functions. The TEST functions can be examined while the instrument is taking data, and can be used to determine if the instrument is set up and functioning properly.

Section 5.2.1 defines each TEST function and explains its use.

5.2.1 Test Functions

NOTE

In any of the following TEST functions, if a value of XXXX is displayed, that indicates an off scale and therefore meaningless reading.

To use the TEST functions to diagnose instrument faults, refer to Troubleshooting Section 9.1.

Range

The M200A can operate in one of three range modes:

1. In single range mode there is one range for all 3 outputs. This is the default range mode.
2. Independent range mode allows different ranges for each output. When enabled, there are three range values displayed, NO, NO_x and NO_2.
3. Auto range mode allows a low range and high range. The M200A will automatically switch to the other range dynamically as concentration values require. The TEST values will show the range the instrument is currently operating in, and will dynamically display the alternate range as the range changes occur.

NOTE

Each of the range modes Single range, Autorange, and Independent ranges are mutually exclusive.

Stability

The instrument noise is computed using the standard deviation of the last 10 minutes of data, with the value being computed at the end of each NO/ NO_x cycle. It is computed for the NO_x channel only. The value only becomes meaningful if sampling a constant concentration for more than 20 minutes, so the various software filters can stabilize. The value shown should be compared to the value observed in Table 2-2-6.

Sample Flow

The SAMPLE FLOW test function is computed from the pressure measured up-stream of the sample flow orifice. The pressure down-stream of the orifice is also checked to assure the assumptions of the equation are valid. SAMPLE FLOW will indicate variations in flow caused by changes in atmospheric pressure, but will not detect a plugged sample flow orifice. The nominal value is 500 ± 50 cc/min.

Ozone Flow

The OZONE FLOW test function is directly measured by a solid state flow meter. Variations in this value indicate variations in ozone flow. The nominal value for ozone flow is 60 - 90 cc/min.

PMT Voltage

The PMT VOLTAGE shows the PMT signal at the output of the preamp board. The waveform of the PMT voltage can be complex, and vary from near 0 mV when zero gas is in the reaction cell to 5000 mV when a high concentration of NO_x is being measured. If the PMT reading is consistently 5000 mV, that indicates an off-scale reading. Typical readings bounce around, which is normal.

Normalized PMT Voltage

Like the PMT Voltage TEST function above, the NORMALIZED PMT VOLTAGE measures the PMT signal at the output of the preamp board. The difference here is that several normalization functions are applied to this signal before it is displayed. The most important is the temperature and pressure compensation factors. If NORM PMT is used as suggested in the Factory Calibration Procedure (Section 9.1.6) the M200A will be correctly calibrated.

AZERO Voltage

This test measurement is the AUTOZERO voltage. It indicates the most recent reading from the AutoZero circuit. The units are mV and from – 20 to 150 are acceptable.

High Voltage Power Supply (HVPS)

The HVPS reading is a measure of the scaled-up HVPS programming voltage. The voltage used to set the HVPS output is generated on the Preamp board. Its value is between 0 and 1 volt, corresponding to a voltage of 0 to 1000 volts out of the HVPS. The HVPS front panel TEST measurement should be greater than 450 volts and will typically be around 600-800V.

DC Power Supply (DCPS)

The DCPS voltage is a composite of the 5 and ± 15 VDC voltages in the Power Supply Module. This is meant to be a quick indicator to show if the PSM is working correctly. The nominal value is 2500 mV ± 200 mV.

Reaction Cell Temperature

This is a measurement of the temperature of the reaction cell. It is controlled by the computer to 50 ± 1° C. Temperatures outside this range will cause the M200A output to drift.

Box Temperature

This TEST function shows the temperature inside the chassis of the M200A. The temperature sensor is located on the Status/Temp Board. Typically it runs 2 to 10° C higher than the ambient temperature. The M200A has been engineered to maintain stable output over 5 to 40° C ambient temperature range.

PMT Temperature

The temperature of the PMT is closely controlled by a dedicated proportional temperature controller. The nominal set-point is 7 ± 1° C. Readings outside this range will cause instrument drift due to gain changes in the PMT detector.

IZS Temperature

The IZS option has an oven for NO_2 permeation tubes. The oven temperature is nominally 50° C. The permeation tube temperature is stable to ± 0.1° C, although it is normal to see the temperature on the front panel move ± 0.4° C due to the proximity of the temp sensor to the heater. It can be adjusted from the front panel by pressing SETUP-MORE-VARS and selecting the IZS_SET item and entering the desired temperature. Using this adjustment, the permeation rate of the NO_2 permeation tube can be adjusted to a desired value. See Section 6.3 for information on adjusting the IZS temperature.

Moly Temperature

The moly temperature is controlled by the computer. The nominal set-point is 315 ± 5° C. The temperature sensor inside the moly is a type-J thermocouple. The thermocouple amplifier is located on the STATUS/TEMP board. If the thermocouple breaks, the reading will go to 500° C and turn off power to the heater.

Reaction Cell Pressure

The pressure in the reaction cell is measured by a solid state pressure sensor which measures absolute pressure. Absolute pressure was chosen because it is an unambiguous measure of cell pressure. This pressure will vary depending on several things.

1. The type of pump attached to the analyzer.
2. Variations in local weather will cause a ± 0.3in-Hg change in pressure.
3. The altitude of the analyzer will cause the cell pressure to change.

Nominal values are 3 to 10 in-Hg-A. Typical readings are about 5 in-Hg-A for the external pump, and about 8 in-Hg-A or better for the internal pump.

Sample Pressure

The pressure in the sample inlet line is measured by a solid state pressure sensor which measures absolute pressure. Absolute pressure was chosen because it is an unambiguous measure of sample pressure. This pressure typically runs 0.5" or so below atmospheric pressure due to the pressure drop in the sample inlet lines.

NO_x, NO Slope and Offset Values

The coefficients of two (NO_x and NO) straight line equations determine the calibration of the M200A. The values of these parameters can be used to determine the quality of the calibration. These 4 parameters contain valuable information about the quality and validity of the calibration.

Refer to Section 5.2.2.5 for more information on the formulas. Refer to Section 7.10 Calibration Quality for details on how to use these values.

Time

This is an output of the M200A's internal time of day clock.

5.2.2 CAL, CALS, CALZ, Calibration Functions

The calibration and zero/span checking of the M200A analyzer is treated in detail in Section 7, Table 7-7-1 summarizes types of calibration. The basic function of each of these keys is described here.

5.2.2.1 CAL, CALS, CALZ

The above keys control the calibration functions of the analyzer. In the CAL mode the analyzer can be calibrated with zero/span gas coming in through the sample input port on the rear panel. If the analyzer is equipped with the IZS option, or Zero/Span valves, there will be CALZ and CALS buttons also. These buttons operate the Zero/Span valves or IZS system. The setup of these options is covered in Section 6.3, and their operation is explained in Section 7.

5.2.2.2 Zero

Pressing the ZERO key along with ENTR will cause the instrument to adjust the OFFSET value of the internal formula so that the instrument reads zero. The M200A allows zero adjustment over a limited range of signal levels, therefore the signal does not have to be exactly zero for the instrument to be zeroed. The instrument will not, however, allow a zero cal on any signal level, therefore it is not possible to zero the instrument with span gas in the reaction cell. If the ZERO key does not come on as expected, check Section 9.2.9.

5.2.2.3 Span

Pressing the SPAN key along with ENTR will cause the instrument to adjust the SLOPE value of the internal formula so the instrument displays the span value. The expected NO_x and NO span concentrations must be entered before doing a SPAN calibration. See Table 7-7-4.

Like the Zero calibration, the Span cal cannot be done with any concentration of span gas. If the signal level is outside certain limits the, SPAN key will not be illuminated. If you encounter this condition see Section 9.2.9. It is also possible at low levels of span concentration that BOTH the ZERO and SPAN keys might be on, thus allowing you to either zero or span the instrument. In this case, care must be taken to perform the correct operation or the analyzer can become mis-calibrated.

5.2.2.4 NO, NO_x Cal Concentration

Before the M200A can be spanned, it is necessary to enter the expected span concentrations for NO and NO_x. This is done by using CAL-CONC-NOX or CAL-CONC-NO keys for NO_x and NO span concentrations, respectively. Concentration values from 30 to 19000 ppb are accepted.

5.2.2.5 Formula Values

The slope and offset terms should be checked after each calibration. The values for these terms contain valuable information about the internal health of the analyzer. The range of acceptable values and their meanings is given in Section 7.10.

To compute the NO_x and NO concentrations, the formula for a straight line is used.

Where:

y = the NO_x or NO concentration

m = the slope

x = the conditioned PMT tube output (normalized PMT voltage)

b = the offset

$y = mx + b$

In comparison with analog analyzers the slope term is equivalent to the "span pot" and the b term is equivalent to the "zero pot". Again, like an analog analyzer there is only a limited range of adjustment allowed for either term, and there are consequences of having the values near the high or low limits of their respective ranges.

The x term is the conditioned PMT signal. PMT signal is adjusted for the AutoZero background, range, temperature, and pressure.

The offset (b) term is the total background light with the AutoZero term subtracted out.

The AutoZero term measures detector dark current, amplifier noise, and ozone generator background. Therefore, in the case of the NO channel the b term should be very close to zero. In the NO_x channel the b term is composed mostly of the molybdenum converter background.

After every zero or span calibration, it is very important to check the QUALITY of the calibration. The calibration of the M200A involves balancing several sections of electronics and software to achieve an optimum balance of accuracy, noise, linearity and dynamic range.

See Section 7.10 for the calibration quality check procedure.

5.2.2.6 Automatic Converter Efficiency Compensation

The M200A can automatically compensate the NO_x and NO_2 readings for the molybdenum converter efficiency. There are 2 ways to enter the converter efficiency into the instrument. The first is to just type in the converter efficiency using the CAL-CONC-MOLY-SET menu. The second method is to have the M200A compute the efficiency using the CAL-CONC-MOLY-CAL menu. See the Calibration Section 7.8.6 - Molybdenum Converter Efficiency for details.

To disable the compensation, press CAL-CONC-MOLY-SET and enter 1.0000 as the efficiency. Factory default is 1.0000.

5.3 Set-Up Mode

5.3.1 Configuration Information (CFG)

This menu item will tell if the installed software has factory special features or other non-standard features. If you call Teledyne API service you may be asked for information from this menu.

5.3.2 Automatic Calibration (AutoCal)

The AutoCal feature allows the M200A to automatically operate the Zero/Span Valve or IZS option to periodically check its calibration. Information on setting up AutoCal is in Section 6.4.

5.3.3 Data Acquisition System (DAS)

The M200A contains a flexible and powerful built in data acquisition system (DAS) that enables the analyzer to store concentration data as well as diagnostic parameters in its battery backed memory. This information can be viewed from the front panel or printed out through the RS-232 port. The diagnostic data can be used for performing "Predictive Diagnostics" and trending to determine when maintenance and servicing will be required.

The logged parameters are stored in what are called "Data Channels." Each Data Channel can store multiple data parameters. The Data Channels can be programmed and customized from the front panel. A set of default Data Channels has been included in the M200A software. For more information on programming custom Data Channels, a supplementary document containing this information can be requested from Teledyne API.

5.3.3.1 Data Channels

The function of the Data Channels is to store, report, and view data from the analyzer. The data may consist of NO, NO_x, NO_2 concentration, or may be diagnostic data, such as the sample flow or reaction cell pressure.

The M200A comes pre-programmed with a set of useful Data Channels for logging concentration and predictive diagnostic data. The default Data Channels can be used as they are, or they can be changed by the user to fit a specific application. They can also be deleted to make room for custom user-programmed Data Channels.

The data in the default Data Channels can be viewed through the **SETUP-DAS-VIEW** menu. Use the **PREV** and **NEXT** buttons to scroll through the Data Channels and press **VIEW** to view the data. The last record in the Data Channel is shown. Pressing **PREV** and **NEXT** will scroll through the records one at a time. Pressing **NX10** and **PV10** will move forward or backward 10 records. For Data Channels that log more than one parameter, such as PNUMTC, buttons labeled **<PRM** and **PRM>** will appear. These buttons are used to scroll through the parameters located in each record.

The function of each of the default Data Channels is described below:

CONC: Samples NO_x, NO and NO_2 concentration data at one minute intervals and stores an average every hour with a time and date stamp. Readings during calibration and calibration hold off are not included in the data. The last 800 hourly averages are stored.

PNUMTC: Collects sample flow and sample pressure data at five minute intervals and stores an average once a day with a time and date stamp. This data is useful for monitoring the condition of the pump and critical flow orifice (sample flow) and the sample filter (clogging indicated by a drop in sample pressure) over time to predict when maintenance will be required. The last 360 daily averages (about 1 year) are stored.

CALDAT: Logs new slope and offset every time a zero or span calibration is performed, also records the sample concentration reading just prior to performing a calibration.

NOTE:
This Data Channel collects data based on an event (a calibration) rather than a timer. This Data Channel will store data from the last 200 calibrations. This does not represent any specific length of time since it is dependent on how often calibrations are performed. As with all Data Channels, a time and date stamp is recorded for every data point logged.

The attributes of the data collecting channels can be changed, and new data collectors can be defined. A comprehensive guide to programming the DAS interface is available separately from Teledyne API, order “DAS Manual” p/n 02837. Table 5-5-7 is an example of changing a DAS channel attribute.

Table 5-5-7: DAS Data Channel Editing

Step	Action	Comment
1.	Press **SETUP-DAS-EDIT**	Enter DAS menu to edit Data Channels
2.	Press **PREV/NEXT**	Select Data Channel to edit
3.	Press **EDIT**	Enter the Edit menu for the selected Data Channel
4.	Press **SET>** (5 times)	Scroll through Data Channel properties until RS-232 REPORT: OFF is displayed
5.	Press **EDIT**	Edit selected setup property
6.	Toggle **OFF** to **ON**	Change RS-232 REPORT property
7.	Press **ENTR**	Accepts change
8.	Press **EXIT** (4 times)	Exits back to sample menu

5.3.4 Range Menu

The instrument operates on any full scale range from 50 to 20,000 ppb. The range is the concentration value that equals the maximum voltage output on the rear panel of the instrument.

If the range you select is between 50 and 2000 ppb the front panel will read the concentration anywhere from 0 to 2000 ppb regardless of the range selected. If the range selected is from 2001 to 20,000 ppb the front panel will read from 0 to 20,000 ppb. The apparently wider range of front panel readouts is because the M200A has 2 internal hardware ranges, namely 0-2000 ppb and 0-20,000 ppb. The analog output is scaled for the range selected, however the front panel reading can display correct concentrations over the entire physical range.

NOTE

Only one of the following range choices can be active at any one time. If the range is changed such that the physical range switches, the instrument should be recalibrated. Since the gain is 10x lower on the 0-20,000 ppb range, the offsets may be a factor of 10 less also.

There are 3 range modes:

1. Single Range
2. Auto Range
3. Independent Ranges

5.3.4.1 Single Range

This range option selects a single range for all output channels (NO, NO_x, NO_2) of the M200A. To select Single Range press SETUP-RNGE-MODE-SING, then press ENTR. To set the value for the range press SETUP-RNGE-SET, enter the full scale range desired from 50 ppb to 20,000 ppm, then press ENTR.

5.3.4.2 Auto Range

Auto Range allows the NO, NO_x, NO_2 outputs to automatically range between a low range and a high range. There is only one low range and one high range for all outputs. The Hi range mode is signaled by a bit on the STATUS option, see Table 5-5-10. When the instrument output reaches 98% of the low range, it will automatically switch into Hi range. In Hi range, when the output decreases to 75% of low range, it will change to the lower range. If you select a Hi range that is less than Low range, the M200A will remain locked in Low range and behave as a Single Range instrument.

To set up Auto Range press SETUP-RNGE-MODE-AUTO, then press ENTR. To set the values press SETUP-RNGE-SET. The M200A will prompt you for LO, then HI which is the lower and upper ranges of Auto Range. Key in the values desired, then press ENTR.

5.3.4.3 Independent Ranges

Independent Ranges allows you to select different ranges for NO, NO_x, and NO_2.

To set up Independent Ranges press SETUP-RNGE-MODE-IND, then press ENTR. To set the values press SETUP-RNGE-SET. The M200A will prompt you for the range of NO, NOx and NO_2 channels. Key in the desired range for each channel, press ENTR after each value.

5.3.4.4 Dilution Ratio

The dilution feature allows the M200A display the undiluted concentration of a sample collected with a stack dilution probe. The dilution probe dilutes the gas by a fixed ratio so the analyzer is actually detects a much lower concentration than is actually present in the stack.

The software scales the diluted sample gas concentration readings so that the outputs show the actual stack concentrations. Also, when calibrating the instrument or setting the ranges, the values selected are scaled to reflect the actual stack concentrations. The scaled readings are sent to the display, analog outputs, and RS-232 port.

To use the Dilution feature:

1. SELECT UNITS

   For stack measurement, select PPM units. To set units, press SETUP-RANGE-UNIT-PPM. Press ENTR after the unit selection is made, then EXIT to return to upper level menus.

2. SET DILUTION RATIO

   The dilution ratio of the probe is entered by SETUP-RANGE-DIL. Accepted values are 1 to 1000. Press ENTR, and EXIT to return to upper level menus. A value of 1 disables the dilution feature.

3. SELECT RANGE

   The range selection is the same with dilution as with normal monitoring. See Section 5.3.4 for information on range selection. You should note however, the value entered should be the actual concentration of the calibration gas entering the dilution probe. The units of this number is ppm.

4. CALIBRATION

   When the above selections have been made, the instrument now must be calibrated through the dilution probe.

NOTE

Units are now in PPM. See Section 7 for calibration methods.

5.3.4.5 Concentration Units

The M200A can display concentrations in ppb, ppm, ug/m3, mg/m3 units. Concentrations displayed in mg/m^3 and ug/m^3 use 0° C, 760 mmHg for STP. Consult your local regulations for the STP used by your agency. The following equations give approximate conversions:

NO ppb x 1.34 = NO ug/m^3

NO ppm x 1.34 = NO mg/m^3

NO2 ppb x 2.05 = NO2 ug/m^3

NO2 ppm x 2.05 = NO2 mg/m^3

NH3 ppb x 0.76 = NH3 ug/m^3 - for use with the M201A NH3 analyzer

NH3 ppm x 0.76 = NH3 mg/m^3

To change the current units press SETUP-RNGE-UNIT from the SAMPLE mode and select the desired units.

NOTE

The expected span concentration values in the new units must be re-entered into the analyzer and the unit re-calibrated using one of the methods in Section 7.

Changing units affects all of the RS-232 values, all of the display values, and all of the calibration values.

Example:

If the current units are in ppb and the NO span value is 400 ppb, and the units are changed to ug/m^3. A new value must be entered for the expected span concentration.

5.3.4.6 Recorder Offset

If necessary, the analog outputs can be biased to allow operation with recorders that cannot show slightly negative readings. The output voltage of each channel can be offset ±10% of the current setting. It can also be used to bias the input to a datalogger to offset small external ground loop voltages that are sometimes present in monitoring systems.

The offset is set in the V/F calibration menu. Press SETUP-MORE-DIAG, scroll to A/D CALIBRATION, then press ENTR. Select CFG-SET-OFFSET, then enter the desired offset and press ENTR. Press EXIT to return to the SAMPLE mode.

5.3.5 Password Enable

If password protection is enabled, a password is required to access calibration or setup menus. In the VARS menu a password is always required. To enable passwords press SETUP-PASS-ON. A list of passwords is in Table 5-5-8.

Table 5-5-8: Calibrate, Setup Passwords

Password Usage		Password
Calibration Password	Use to get into CAL menus	512, 101
Setup Password	Use to get into SETUP menus	818, 101

5.3.6 Time of Day Clock

The instrument has an internal time of day clock. The time of day can be set by pressing SETUP-CLOCK-TIME and entering the time in 24hr format. In a similar manner the date can be entered by pressing SETUP-CLOCK-DATE and entering the date in a dd-mmm-yy format.

If you are having trouble with the clock running slow or fast, the speed of the clock can be adjusted by selecting the CLOCK_ADJ variable in the SETUP-MORE-VARS menu. The units of CLOCK_ADJ are seconds per day.

The M200A software and hardware has been designed and tested to operate properly during the year 2000 calendar rollover.

5.3.7 Diagnostic Mode

The M200A Diagnostic Mode allows additional tests and calibrations of the instrument. These features are separate from the TEST functions because each DIAG function has the ability to alter or disable the output of the instrument. While in DIAG mode no data is placed in the DAS averages. Details on the use of Diagnostic mode are in Section 9.1.3.

5.3.8 Communications Menu

The COMM menu allows the RS-232 BAUD rate to be set. To set the BAUD rate press SETUP-MORE-COMM-BAUD, select the appropriate BAUD rate, then press ENTR.

The instrument ID number can also be set. This ID number is attached to every RS-232 message sent by the M200A. To set the ID press SETUP-MORE-COMM-ID and enter a 4 digit number from 0000-9999, then press ENTR.

5.3.9 Variables Menu (VARS)

This menu enables you to change the settings on certain internal variables. The VARS Table 9-9-5 is located in the Troubleshooting Section 9.1.4.

5.3.10 M200A Operating Modes

The M200A has 2 main operating modes which were discussed in earlier in this section, namely SAMPLE and SETUP modes. In addition there are other modes of operation when the instrument is being diagnosed or calibrated. A list of M200A operating modes is given in Table 5-5-9.

Table 5-5-9: M200A Operating Modes

Mode	Description
ZERO CAL D	Automatic dynamic zero calibration
ZERO CAL A	Automatic zero calibration
ZERO CAL R	Remote zero calibration
ZERO CAL M	Manual zero calibration
SPAN CAL D	Automatic dynamic span calibration
SPAN CAL A	Automatic span calibration
SPAN CAL R	Remote span calibration
SPAN CAL M	Manual span calibration
M-P CAL	Manual multi-point calibration
DIAG ELEC	Electrical diagnostic test
DIAG OPTIC	Optical diagnostic test
DIAG OZONE	Ozone generator diagnostic test
DIAG AOUT	D/A output diagnostic test
DIAG	Main diagnostic menu
DIAG I/O	Signal I/O diagnostic
DIAG RS232	RS232 output diagnostic
SETUP x.x	Setup mode (x.x is software version)
SAMPLE ZS	Sampling; automatic dynamic zero and span calibration enabled
SAMPLE Z	Sampling; automatic dynamic zero calibration enabled
SAMPLE S	Sampling; automatic dynamic span calibration enabled
SAMPLE A	Sampling; automatic cal. enabled
SAMPLE	Sampling; automatic cal. disabled

5.4 Status Output

The status output is an option that signals Analyzer conditions via contact closures on the rear panel. The closures are available on a 50 pin connector on the rear panel. The contacts are NPN transistors which can sink 50 ma of current. The pin assignments are listed in Table 5-5-10.

Table 5-5-10: Status Output Pin Assignments

Output #	Pin #	Definition	Condition
1	1,2	ZERO CAL	CLOSED IN ZERO CAL
2	3,4	SPAN CAL	CLOSED IN SPAN CAL
3	5,6	FLOW ALARM	CLOSED IF FLOW WARNING
4	7,8	TEMP ALARM	CLOSED IF ANY TEMP WARNING
5	9,10	DIAG MODE	CLOSED IN DIAG MODE
6	11,12	POWER OK	CLOSED IF SYSTEM POWER OK
7	13,14	SPARE	
8	15,16	SPARE	
9	17,18	SPARE	
10	19,20	AUTORANGE - HI	CLOSED IF IN HIGH RANGE
11	21,22	SYSTEM OK	CLOSED IF NO FAULTS PRESENT
12	23,24	RX CELL PRESS	CLOSED IF ABS PRES > 15" HG

The Status Board schematic can be found in the Appendix.

5.5 RS-232 Interface

The RS-232 communications protocol allows the instrument to be connected to a wide variety of computer based equipment. The interface provides two basic functions in the M200A.

1. First is a comprehensive command interface for operating and diagnosing the analyzer in interactive fashion. This mode is for use by a human operator issuing commands to the instrument.
2. Second is the equivalent command interface described above, but with the interface set up to be operated by a computer program rather than interactive commands.
3. The interface can also provide an audit trail of analyzer events. In this function the port sends out messages about instrument events like calibration or warning messages. If these messages are captured on a printer or remote computer, they provide a continuous audit trail of the analyzers operation and status.

5.5.1 Setting Up the RS-232 Interface

The baud rate is set from the front panel by SETUP-MORE-COMM-BAUD. Select the baud rate appropriate for your application, 300, 1200, 2400, 4800, 9600, or 19,200. It is important to note that the other device must have identical settings in order for the communications to work correctly.

Second is physical wiring of the analyzer to the other unit. We have incorporated into the Analyzer LED's that signal the presence of data on the communications lines, and also switches to easily re-configure the analyzer from DCE to DTE if necessary. In addition the front panel diagnostics allow test data streams to be sent out of the port on command. This flexibility and diagnostic capability should simplify attaching our equipment to other computers or printers. If problems occur, see the Troubleshooting Section 9.3.2.

Setup from the Front Panel

There are 2 additional RS-232 setups that can be done via the front panel.

1. Set the instrument ID number by SETUP-MORE-COMM-ID, and enter a 4 digit number from 0000-9999. This ID number is part of every message transmitted from the port.
2. Set the RS-232 mode bit field in the VARS menu. To get to the variable press, SETUP-MORE-VARS, then ENTR and scroll to RS232_MODE, then press EDIT. The possible values are:

Table 5-5-11: RS-232 Port Setup - Front Panel

Decimal Value	Description
1	Turns on quiet mode (status messages suppressed)
2	Places analyzer in computer mode (no echo of chars)
4	Enables Security Features (Logon, Logoff)
8	Enables TELEDYNE API protocol and setup menus
16	Enable alternate protocol
32	Enable multidrop protocol
64	Enable modem setup string
128	Ignore RS-232 line errors
4096	Enable command prompt

NOTE

To enter the correct value, ADD the decimal values of the features you want to enable. For example if LOGON and front panel RS-232 menus are desired, the value entered would be 4 + 8 = 12.

Port Communication

The RS-232 can be set up in interactive or computer mode of communication. If the port is attached to a computer running an instrument interface program, it needs to have different characteristics than if used interactively by a human operator.

When an operator is communicating with the analyzer via a terminal, the analyzer should be placed into TERMINAL MODE, which echoes keystrokes, allows editing of the command line using the backspace and escape keys, and allows recall of the previous command. When a host computer or data logger is connected to the analyzer, it should be placed into COMPUTER MODE, which does not echo characters received or allow the special editing keys. See Table 6-6-5 for relevant commands.

Table 5-5-12: RS-232 Switching From Terminal Mode to Computer Mode

Key	Function
Control-T (ASCII 20 decimal)	Switch to terminal mode (echo, edit)
Control-C (ASCII 3 decimal)	Switch to computer mode (no echo, no edit)

If the command line doesn't seem to respond to keystrokes or commands, one of the first things you should do is send a Control-T to switch the command line interface into terminal mode. Also, some communication programs remove CTRL-T and CTRL-C characters from the byte stream, therefore these characters will not be sent to the analyzer. Check your communications program owners manual.

Entering Commands in Terminal Mode

In terminal mode, all commands must be terminated by a carriage return; commands are not processed until a carriage return is entered. While entering a command you may use the following editing keys:

Table 5-5-13: RS-232 Terminal Mode Editing Keys

Key	Function
CR (carriage return)	Execute command
BS (backspace)	Backspace one character to the left
ESC (escape)	Erase entire line

Words such as T, SET, LIST, etc. are called keywords and are shown on the help screen in uppercase, but they are not case-sensitive. You must type the entire keyword(s), separated by spaces; abbreviations are not accepted.

NOTE

To open the help screen, Type "?" and press the Enter key.

Security Feature

The RS-232 port is often connected to a public telephone line which could compromise instrument security. If the LOGON feature is implemented the port has the following attributes:

1. A password is required before the port will operate.
2. If the port is inactive for 1 hour, it will automatically LOGOFF.
3. Repeat attempts at logging on with incorrect passwords will cause subsequent logins (even with the correct password) to be disabled for 1 hour.
4. If not logged on, the only command that is active is the '?'.
5. The following messages will be given at logon.

`LOG ON SUCCESSFUL`	Correct password given
`LOG ON FAILED`	Password not given or incorrect
`LOG OFF SUCCESSFUL`	Logged off

The RS-232 LOGON feature must be enabled from the front panel by setting bit 4. See Table 6-6-4. Once the feature is enabled, to logon type:

```
LOGON 940331
```

940331 is the default password. The password can be changed to any number from 0 to 999999 by the variable RS232_PASS. To change the password enter the command:

```
V RS232_PASS=NNNNNN
```

which sets the password to the value NNNNNN.

Communication Protocols

The RS-232 port can communicate in the following protocols.

1. Teledyne API protocol – some of the features of this protocol are covered in Section 5.5.2. A comprehensive manual is available separately as p/n 01350 RS-232 Programming Notes.
2. Alternate protocol – this protocol is used for communicating on proprietary networks.
3. Multidrop protocol – used for communication with multiple Teledyne API instruments on a single RS-232 line. A manual is available separately as Teledyne API p/n 01842 Multidrop Programming Manual.

Communication with a modem

If this bit is set, the instrument will send a setup string out the RS-232 port at power-up. The string correctly sets up a US Robotics Sportster Modem. No other brands of modem are supported at this time.

RS-232 Line Errors

Allows the software to ignore certain errors involving the computation of parity.

Enable Command prompt

Setting this bit causes instrument to issue a command prompt after each command output. Useful when operating in Terminal Mode.

5.5.2 Command Summary

The information contained in the rest of this section covers commonly used commands that are required to operate the instrument from a remote terminal. If you are going to be writing computer programs to communicate with the M200A (i.e. operating the port in COMPUTER MODE) we suggest that you order a supplementary manual "The RS-232 Interface", Teledyne API part number 01350. This manual describes additional features of the port.

The Teledyne API RS-232 interface includes multidrop capability, to permit the connection of more than one analyzer to a single RS-232 line. To identify each Analyzer, an optional ID number is permitted for all commands. If you don't include the ID number in the command, all of the instruments connected to the RS-232 interface will respond. If you include the ID number in the command, only the instrument whose ID number matches will execute the command.

Table 5-5-14: RS-232 Command Summary

Commands	Definition
? [id]	Print help screen. *ID* is an optional instrument ID number
T [id] LIST	Print all active test messages
T [id] LIST name or T [id] name	Print single test message "name" from Table 5-15
W [id] LIST	Print all active warnings
W [id] CLEAR name or W [id] name	Clear single warning message "name" from Table 5-16
C [id] command	Execute calibration "command" from Table 5-17
D [id] LIST	Prints all I/O signal values
D [id] name	Print single I/O signal value/state
D [id] name=value	Sets I/O signal to new "value"
D [id] LIST NAMES	Lists diagnostic test names
D [id] ENTER name	Enters and starts 'name' diagnostic test
D [id] EXIT	Exits diagnostic mode
D [id] RESET	Resets analyzer(same as power-on)
D [id] RESET RAM	System reset, plus erases RAM. Initializes DAS, NO, NO_x, NO_2 conc readings, calib not affected.
D [id] RESET EEPROM	System reset, plus erases EEPROM (RESET RAM actions + setup variables, calibration to default values). Restores all factory defaults.
D [id] PRINT	Prints properties for all data channels (DAS)
D [id] PRINT "name"	Prints properties for single data channel. Quotes around name are required.
D [id] REPORT "name" [RECORDS=number] [COMPACT|VERBOSE]	Prints DAS records for a data channel. Quotes around name are required. Parameters in brackets are optional.
V [id] LIST	Print all setup variable names and values
V [id] name	Print individual setup variable value
V [id] name=value	Sets setup variable to new "value"
V [id] CONFIG	Print analyzer configuration
V [id] MODE	Print current analyzer mode

Table 5-5-15: RS-232 Command Summary

Terminal Mode Editing Keys	Definition
BS	Backspace
ESC	Erase line
CR	Execute command
^C	Switch to computer mode
Computer Mode Editing Keys	**Definition**
LF	Execute command
^T	Switch to terminal mode
Security Features	**Definition**
LOGON [id] password	Establish connection to analyzer
LOGOFF [id]	Disconnect from analyzer

General Output Message Format

Reporting of status messages for use as an audit trail is one of the two principal uses for the RS-232 interface. You can effectively disable the asynchronous reporting feature by setting the interface to quiet mode. All messages output from the analyzer (including those output in response to a command line request) have the format:

```
X DDD:HH:MM IIII MESSAGE
```

X is a character indicating the message type, as shown in the Table 5-5-16.

DDD:HH:MM is a time-stamp indicating the day-of-year (DDD) as a number from 1 to 366, the hour of the day (HH) as a number from 00 to 23, and the minute (MM) as a number from 00 to 59.

IIII is the 4-digit machine ID number.

MESSAGE contains warning messages, test measurements, DAS reports, variable values, etc.

The uniform nature of the output messages makes it easy for a host computer to parse them.

Table 5-5-16: RS-232 Interface Command Types

First Character	Message Type
C	Calibration
D	Diagnostic
T	Test measurement
V	Variable
W	Warning

There are 5 different types of messages output by the M200A. The meanings of the various messages are discussed elsewhere in the manual. The TEST, DIAGNOSTIC and WARNING messages are discussed in Section 9.1, 9.2, 9.3. DAS and VARIABLES are discussed in Section 5.3.3 and 5.3.9. CALIBRATE is discussed in Section 7.

5.5.3 TEST Commands and Messages

Table 5-5-17: RS-232 Test Messages

Name	Message	Description
RANGE[2]	RANGE=xxxxx PPB[3]	Analyzer range
NOXRANGE[1]	NOX RNG=xxxxx PPB[3]	Indep. Range for NO_x channel
NORANGE[1]	NO RNG=xxxxx PPB[3]	Indep. Range for NO channel
NO2RANGE[1]	NO2 RNG=xxxxx PPB[3]	Indep. Range for NO_2 channel
STABILITY	NOX STB=xxxx.xx PPB	Std. Deviation of last 10 min NO_x conc values
SAMPFLOW	SAMP FLW=xxx CC/M	Sample flow rate
OZONEFLOW	OZONE FL=xxxx CC/M	Ozone flow rate
PMT	PMT=xxxxxx MV	PMT output
NORMPMT	NORM PMT=xxxxxx MV	Normalized PMT output
AUTOZERO	AZERO=xxxxx MV	AutoZero filter value
HVPS	HVPS=xxxxx V	High voltage power supply
DCPS	DCPS=xxxxxx MV	DC power supply
RCELLTEMP	RCELL TEMP=xxx C	Reaction cell temperature
BOXTEMP	BOX TEMP=xxx C	Internal box temperature
PMTTEMP	PMT TEMP=xxx C	PMT temperature
IZSTEMP	IZS TEMP=xxxx C	IZS temperature
CONVTEMP	MOLY TEMP=xxx C	Molycon temperature
RCELLPRESS	RCEL=xxx.x IN-HG-A	Rx cell pressure
SAMPPRESS	SAMP=xxx.x IN-HG-A	Sample pressure
NOXSLOPE	NOX SLOPE=xxxxx	NO_x slope parameter
NOXOFFSET	NOX OFFS=xxxxx	NO_x offset parameter
NOSLOPE	NO SLOPE=xxxxxx	NO slope parameter
NOOFFSET	NO OFFS=xxxxxx	NO offset parameter
NO2CONC	NO2=xxxxx PPB	Instantaneous NO_2 concentration
NOXCONC	NOX=xxxxx PPB	Instantaneous NO_x concentration
NOCONC	NO=xxxxx PPB	Instantaneous NO concentration
TESTCHAN	TEST=xxxxx MV	Test channel diagnostic output
CLOCKTIME	TIME=HH:MM:SS	Time of day

[1]Displayed when independent range is enabled.
[2]Displayed when single or auto range is enabled.
[3]Depends on which units are currently selected.

The T **command** lists TEST messages. Examples of the T command are:

`T LIST`	Lists all active test messages
`T LIST ALL`	Lists all test messages
`T CONVTEMP`	Prints the temperature of the moly converter
`T LIST NOX`	Prints NO_x concentration message
`T NOX`	Prints NO_x concentration message

5.5.4 WARNING Commands and Messages

Table 5-5-18: RS-232 Warning Messages

Name	Message	Description
WSYSRES	SYSTEM RESET	Analyzer was reset/powered on
WRAMINIT	RAM INITIALIZED	RAM was erased
WSAMPFLOW	SAMPLE FLOW WARN	Sample flow out of spec.
WOZONEFLOW	OZONE FLOW WARNING	Ozone flow out of spec.
WRCELLPRESS	RCELL PRESS WARN	Rx cell pressure out of spec
WBOXTEMP	BOX TEMP WARNING	Box temp. out of spec.
WRCELLTEMP	RCELL TEMP WARNING	Reaction cell temp. out of spec.
WIZSTMP	IZS TEMP WARNING	IZS temp. out of spec.
WCONVTEMP	MOLY TEMP WARNING	Molycon temp. out of spec.
WPMTTEMP	PMT TEMP WARNING	Molycon temp. out of spec.
WAUTOZERO	AZERO WRN XXX.X MV	AutoZero filter received a reading out of limit spec.
WHVPS	HVPS WARNING	High voltage out of spec.
WDCPS	DCPS WARNING	DC Voltage out of spec.
WOZONEGEN	OZONE GEN OFF	Ozone generator is off
WDYNZERO	CANNOT DYN ZERO	Dynamic zero cal. out of spec.
WDYNSPAN	CANNOT DYN SPAN	Dynamic span cal. out of spec.
WVFDET	V/F NOT DETECTED	V/F board not installed or broken

Whenever a warning message is reported on the analyzer display, if the RS-232 interface is in the normal mode(i.e. not in quiet mode) the warning message is also sent to the RS-232 interface. These messages are helpful when trying to track down a problem with the analyzer and for determining whether or not the DAS reports are actually valid. The warning message format is for example:

```
W 194:11:03 0000 SAMPLE FLOW WARN
```

The format of a warning command is W command. Examples of warning commands are:

`W LIST` List all current warnings

`W CLEAR ALL` Clear all current Warnings

Individual warnings may be cleared via the front panel or the command line interface. To clear the sample flow warning shown above the command would be:

```
W WSAMPFLOW
```

5.5.5 CALIBRATION Commands and Messages

There are several methods of both checking the calibration and calibrating the M200A, these are discussed in Section 7. The C command executes a calibration command, which may be one of the following:

Table 5-5-19: RS-232 Calibration Commands

Command	Description
C [id] ZERO [1 or 2]	Start remote zero calibration. The number is optional and selects the range to calibrate. If not specified, the range defaults to range 1.
C [id] COMPUTE ZERO	Tells the instrument to compute a new slope and offset. Same as pressing ZERO-ENTR on front panel. Must be given after a C ZERO command.
C [id] SPAN [1 or 2]	Start remote span calibration.
C [id] COMPUTE SPAN	Tells the instrument to compute a new slope and offset. Same as pressing SPAN -ENTR on front panel. Must be given after a C SPAN command.
C [id] ASEQ number	Executes automatic calibration sequence (1, 2, or 3).
C [id] EXIT	Exits the current calibration step and goes to the next one.
C [id] ABORT	Aborts the entire calibration sequence.

Table 5-5-20: RS-232 Calibration Examples

Action	RS-232 Commands	Comments
Zero Calibration	C ZERO C COMPUTE ZERO C EXIT	Z/S valves switched to admit zero gas. Zero cal in Single Range mode.
Zero Calibration of low range - AutoRange Enabled	C ZERO 1 C COMPUTE ZERO C EXIT	Z/S valves switched to admit zero gas. Zero calibration of low range in Auto Range mode.
Span Calibration of high range - AutoRange Enabled	C SPAN 2 C COMPUTE SPAN C EXIT	Z/S valves switched to admit span gas. Span calibration of high range in Auto Range mode.
Zero Calibration with Dynamic Calibration enabled	C ZERO C EXIT	Z/S valves switched to admit zero gas. Instrument is zero calibrated if DYN CAL is enabled.
Zero Calibration	C ZERO C EXIT	Z/S valves switched to admit zero gas. Instrument zero is just checked, but not changed.
Execute AutoCal Sequence #2	C ASEQ 2	Execute a predefined AutoCal Sequence. Executes sequence immediately, ignoring time and date parameters.
Span Calibration Check	C SPAN C EXIT	Z/S valves switched to admit span gas. Instrument span is just checked, but not changed.

Whenever the analyzer starts or finishes an IZS calibration, it issues a status report to the RS-232 interface. If the RS-232 interface is in the normal mode, these reports will be sent. Otherwise, they will be discarded. Table 5-19 shows the format of the text of the calibration messages. An example of an actual sequence of calibration status messages is:

```
C DDD:HH:MM IIII START MULTI-POINT CALIBRATION

C DDD:HH:MM IIII NOX=xxxxx PPB NO=xxxxx PPB NO2=xxxxx PPB

C DDD:HH:MM IIII FINISH MULTI-POINT CALIBRATION
```

Table 5-5-21: RS-232 Calibration Messages

Message	Description
START ZERO CALIBRATION	Beginning IZS zero calibration
NOX[1]=xxxxx PPB[2] NO[1]=xxxxx PPB[2] NO2[1]=xxxxx PPB[2] FINISH ZERO CALIBRATION	Finished IZS zero calibration
START SPAN CALIBRATION	Beginning IZS span calibration
NOX[1]=xxxxx PPB[2] NO[1]=xxxxx PPB[2] NO2[1]=xxxxx PPB[2] FINISH SPAN CALIBRATION	Finished IZS span calibration
START MULTI-POINT CALIBRATION	Beginning multi-point calibration
NOX[1]=xxxxx PPB[2] NO[1]=xxxxx PPB[2] NO2[1]=xxxxx PPB[2] FINISH MULTI-POINT CALIBRATION	Finished multi-point calibration
[1]Depends on software options installed. [2]Depends on which units are currently selected.	

5.5.6 DIAGNOSTIC Commands and Messages

When Diagnostic mode is entered from the RS-232 port, the diagnostic mode issues additional status messages to indicate which diagnostic test is currently selected. Examples of Diagnostic mode messages are:

```
D DDD:HH:MM IIII ENTER DIAGNOSTIC MODE

D DDD:HH:MM IIII EXIT DIAGNOSTIC MODE
```

Example of turning on the Ozone Generator via the RS-232 port:

```
D ENTER SIG

D OZONE_GEN=ON

D EXIT
```

The following is a summary of the Diagnostic commands.

Table 5-5-22: RS-232 Diagnostic Command Summary

Command	Description
D [id] LIST	Prints all I/O signal values. See Table 9-4 for Sig I/O definitions.
D [id] name=value	Examines or sets I/O signal. For a list of signal names see Table 9-9-4 in Section 9. Must issue D ENTER SIG command before using this command.
D [id] LIST NAMES	Prints names of all diagnostic tests.
D [id] ENTER SIG D [id] ENTER OT D [id] ENTER ET	Executes SIGNAL I/O diagnostic test. Executes Optic Test diagnostic test. Executes Elect Test diagnostic test. Example of Ozone Generator diagnostic is in Section 9.3.6. Use D EXIT to leave these diagnostic modes.
D [id] EXIT	Must use this command to exit SIG, ET or OT Diagnostic modes.
D [id] RESET	Resets analyzer software (same as power on).
D [id] RESET RAM	Resets analyzer software and erases RAM. Erases NO, NO_x, NO_2 conc values. Keeps setup variables and calibration. (same as installing new software version).
D [id] RESET EEPROM	Resets analyzer software and erases RAM and EEPROM. Returns all setup variables to factory defaults, resets calibration, AutoZero values.

5.5.7 DAS Commands and Message

The M200A contains a flexible and powerful built in data acquisition system (DAS) that enables the analyzer to store concentration data as well as diagnostic parameters in its battery backed memory. This information can be printed out through the RS-232 port. The diagnostic data can be used for performing "Predictive Diagnostics" and trending to determine when maintenance and servicing will be required.

To print out the properties of all of the data channels enter:

```
D PRINT
```

To print the properties of just a single data channel enter:

```
D PRINT "name"
```

For example to print the properties of the CONC data channel enter:

```
D PRINT "CONC"
```

To print records from a DAS data channel enter:

```
D REPORT "name" RECORDS=nnn COMPACT|VERBOSE
```

Examples of reports are:

```
D REPORT "CONC" RECORDS=35 VERBOSE

D REPORT "CALDAT" RECORDS=10

D REPORT "PNUMTC" RECORDS=155 VERBOSE
```

Automatic RS-232 reporting can be independently enabled and disabled for each Data Channel. For all default data channels, automatic reporting is initially set to "OFF." If this property is turned on, the Data Channel will issue a report with a time and date stamp to the RS-232 port every time a data point is logged. The report format is shown below:

```
D 94:08:00 0200 CONC : AVG NXCNC1 = 1234.5 PPB

D 94:08:00 0200 CONC : AVG NOCNC1 = 1234.5 PPB

D 94:08:00 0200 CONC : AVG N2CNC1 = 1234.5 PPB
```

One CONC report consists of:

D	= Type of report (Diagnostic)
94:08:00	= Time and Date stamp (Julian day, Hr, Min)
0200	= Instrument ID number
CONC	= Data Channel name CONC = concentration data PNUMTC = pneumatic parameters CALDAT = calibration parameters
AVG	= Type of data AVG = average reading INST = instantaneous reading
NXCNC1 = 1234.5 PPB	= Name of the parameter NX = NOx, NO = NO N2 = NO2.

All of the default Data Channels sample more than one parameter, for these channels, each parameter is printed on a separate line.

There is also a compact format. If this attribute is enabled, all 3 concentration parameters are printed on one line as shown below:

```
D 94:08:00 0200 CONC : 20.0 120.0 100.0
```

The parameters are in the order of NO_2, NO_x, and NO.

To change any of the attributes of a particular data channel, the channel attributes are edited from the front panel. The following table uses the example of Automatic Reporting. Other attributes can be edited in a similar fashion.

5.5.8 Internal Variables

A list of M200A variables is shown in Table 9-5.

A list of variables and their settings can be requested over the RS-232 port by:

V LIST Lists internal variables and values

The output from this command is long and will not be shown here. The general format of the output is:

name = value warning_lo warning_hi (data_lo to data_hi)

Where:

name = name of the variable

value = current value of variable

warning_lo = lower limit warning (displayed if applicable)

warning_hi = upper limit warning (displayed if applicable)

data_lo = lower limit of allowable values

data_hi = upper limit of allowable values

Variables can be changed. Before changing the settings on any variables, please make sure you understand the consequences of the change. We recommend you call the factory before changing the settings on any variables. The general format for changing the settings on a variable is:

```
V name[=value [warn_lo [warn_hi]]]
```

For example to change the warning limits on the box temperature type:

```
V BOX_SET 30 10 50
```

and the CPU should respond with:

```
V DDD:HH:MM IIII BOX_SET=30 10 50 (0 to 60)
```

The CONFIG command lists the software configuration. To show the software configuration, type:

```
V CONFIG
```

In addition to SAMPLE and SETUP modes the M200A has a number of additional operational modes. They are listed in Table 5-5. To list the analyzer's current mode type:

```
V MODE
```

6 OPTIONAL HARDWARE AND SOFTWARE

Optional equipment offered with the M200A includes:

1. Rack mount with slides (P/N 01469)
2. Rack mount without slides, ears only (P/N 01470)
3. Rack mount for external pump w/o tray (P/N 0099701)
4. Stainless steel zero/span valves (P/N 01468)
5. Internal zero/span - IZS (P/N 01223)
6. 4-20mA, isolated outputs (P/N 01471)
7. Internal pump (P/N 01237)

6.1 Rack Mount Options

Rack Mount permits the Analyzer to be mounted in a standard 19" wide x 24" deep RETMA rack.

1. Rack mount with slides
2. Rack mount without slides

The external pump can be ordered in the following configurations:

1. External pump pack – standard configuration
2. Pump pack with rack mount tray to enable slide out servicing
3. Pump pack with rack mount - fixed tray

6.2 Zero/Span Valves

The Zero/Span Valve option consists of two stainless steel solenoid valves. Connections are provided on the rear panel for span gas and zero gas inputs to the valves, see Table 2-2-2. The valves can be actuated by several methods as shown in Table 6-1.

Table 6-6-1: Zero/Span Valve Operation

Mode	Description	Reference Section
1.	Front panel operation via CALS and CALZ buttons	Calibration Section 7 - Manual Zero/Span Check.
2.	Automatic operation using AUTOCAL	Setup and use of AUTOCAL is described in Table 6-2, and Section 7.4.
3.	Remote operation using the RS-232 interface	Setup described in Table 6-2. Operation of AUTOCAL described in Section 5.5 and Section 7 - Calibration. A complete description of the RS-232 interface is available. Order part number 01530.
4.	Remote operation using external contact closures	Section 7.7 - Automatic operation using external contact closures. Truth Table 7-9 and Section 9.3.4.3.

The Zero/Span valves have 3 operational states:

1. Sample mode. Here both valves are de-energized and sample gas passes through the sample/cal valve and into the analyzer.
2. Zero mode. The sample/cal valve is energized to the cal mode. The zero/span valve is de-energized in the zero mode, thus allowing zero gas to be admitted through the rear panel bulkhead fitting into the analyzer.
3. Span mode. The sample/cal valve is energized and in the cal mode. The zero/span valve is energized in the span mode. With both valves on, span gas is admitted through a rear panel bulkhead fitting into the analyzer.

Zero air and span gas inlets should supply their respective gases in excess of the 500 cc/min demand of the Analyzer. Supply and vent lines should be of sufficient length and diameter to prevent back diffusion and pressure effects. See Table 2-2-3 for fitting location and tubing recommendations.

Adequate zero air can be supplied by connecting a Purafil/charcoal scrubber and 5 micron particulate filter (Teledyne API P/N 000369) to the zero air inlet tubing. The zero air scrubber used in conjunction with the Zero/Span Valve option provides an inexpensive source of zero air. Another source of zero air is the Model 701 zero air generator.

6.3 Internal Zero/Span (IZS)

The IZS option includes the Zero/Span Valves described above, a temperature-controlled permeation tube oven, and a rear panel mounted zero air scrubber. The IZS system is activated by the same methods as described in Table 6-1 for the zero/span valves. The setup of the IZS is the same as that of the valves and is described in Table 6-2.

The IZS system operation is similar to the zero/span valve operation, except that the source of the zero air and span gas are supplied at the analyzer via a scrubber and permeation tube respectively. See Section 7.1 - calibration for operational details. A continuous purge flow of approximately 60 cc/min is drawn across the permeation tube to prevent span gas accumulation when the permeation tube is not in use.

If the instrument is going to be turned off for more than 8 hours, the permeation tube must be removed from the oven. The perm tube continues to release gas even while at room temp thus causing high concentrations of NO_2 gas to accumulate. The high NO_2 levels cause high background readings when operation is resumed.

6.4 Autocal - Setup of IZS and Zero/Span Valves

The Autocal system operates by executing SEQUENCES. It is possible to enable up to 3 sequences, each sequence operates in one of 4 MODES:

Table 6-6-2: IZS Sequence Modes

Mode No.	Mode Name	Action
1.	Disabled	Disables the Sequence
2.	Zero	Does a Zero Calibration
3.	Zero-Span	Does a Zero and Span Calibration
4.	Span	Does a Span Calibration

For each mode there are seven attributes that the MODE can have that control operational details of the SEQUENCE. They are:

Table 6-6-3: IZS Sequence Attributes

Attribute No.	Attribute Name	Action
1.	Timer Enabled	Turns on the Sequence timer
2.	Starting Date	Sequence will operate after Starting Date
3.	Starting Time	Time of day sequence will run
4.	Delta Days	Number of days to skip between each Seq. execution
5.	Delta Time	Number of hours later each "Delta Days" Seq is to be run
6.	Duration	Number of minutes the sequence operates
7.	Calibrate	Calibrate the instrument at end of sequence

Example of enabling sequence #2:

Do a span check ½ hour later every other day, lasting 15 minutes, without calibration.

Table 6-6-4: IZS Sequence Example

Mode and Attribute	Value	Comment
Sequence	2	Define Seq. #2
Mode	4	Select Span Mode
Timer Enable	ON	Enable the timer
Starting Date	Sept. 4, 1996	Start after Sept 4
Starting Time	01:00	First Span starts at 1:00AM
Delta Days	2	Do Seq #2 every other day
Delta Time	00:30	Do Seq #2 ½ hr later each time
Duration	15.0	Operate Span valve for 15 min
Calibrate	NO	Do not calibrate at end of Seq

Table 6-6-5: Example of AutoCal Setup

Step	Action	Comment
1.	Press SETUP-ACAL	This button sequence will cause the AUTOCAL menu to be displayed
2.	Press PREV-NEXT	Press PREV-NEXT until SEQ 2 is displayed
3.	Press MODE	Select the MODE menu
3.	Press PREV-NEXT	Press PREV NEXT to scroll to SPAN
4.	Press ENTR	ENTR selects the SPAN MODE
5.	Press SET	Select the SET menu to change the sequence attributes
6.	Press PREV-NEXT	Scroll the SET menu to TIMER ENABLE
7.	Press EDIT	Allows changing the TIMER ENABLE attribute, select ON
8.	Press ENTR	ENTR changes TIMER ENABLE to ON
9.	Press PREV-NEXT	Repeat steps 6-9 for each attribute
10.	Press EXIT	Press the EXIT key to return to upper level menus

6.5 Permeation Tube

NO_2 - nitrogen dioxide - is normally a gas at room temperature and pressure, but can be liquified at moderate pressures. The permeation tube consists of a small container of NO_2 liquid, with a small window of PTFE which is permeable to NO_2, see Table 6-6-6. The gas slowly permeates through the window at a rate in the nanogram/min range. If the tube is kept at constant temperature, usually about 50° C, the device will provide a stable source of NO_2 gas for a year or more. See below for permeation tube ordering information.

The NO_2 concentration is determined by the permeation tube specific output (ng/min @ 1 slpm @ 50^o C), the permeation tube temperature (^{o} C) and the air flow across it (slpm). The specific output in ng/min is a fixed function of the permeation tube and is noted on shipping container. The ng/min units can be converted to ppb units by the following equation:

$$ppb\ NO_2 = \left(\frac{permtube output(ng/min)}{46\,gr/mole NO_2}\right) \Big/ \left(\frac{560cc/min}{24{,}500cc/mole}\right)$$

Where:
perm tube output (ng/min) = The perm tube output in nanograms/minute
46 gr/mole NO_2 = The molecular weight of nitrogen dioxide (NO_2)
560 cc/min = The flow rate of zero air over the permeation tube
24,500cc/mole = The volume of air (at 25 C and 1 atm pressure) that contains 1 mole of air molecules

If an ammonia permeation tube is being used, substitute the molecular weight of NH_3 (17 g/mole) for that of NO_2.

The temperature is set at 50.0° C. Check SETUP-MORE-VARS and scroll to the IZS-SET variable to verify that the temperature is properly set. It should be set to 50° C with over-and-under temperature warnings set at 49° C and 51° C. There is a 60 cc/min flow across the permeation tube at all times to prevent build-up of NO_2 gas in the tubing.

If desired, the output of the permeation tube can be adjusted by adjusting the oven temperature up or down slightly. The adjust increment is 0.1° C to facilitate small adjustments of the setpoint temperature.

WARNING

Do not leave instrument turned off for more than 8 hours without removing the permeation tube. Do not ship the instrument without removing the permeation tube. The tube continues to emit NO_2, even at room temperature and will contaminate the entire instrument.



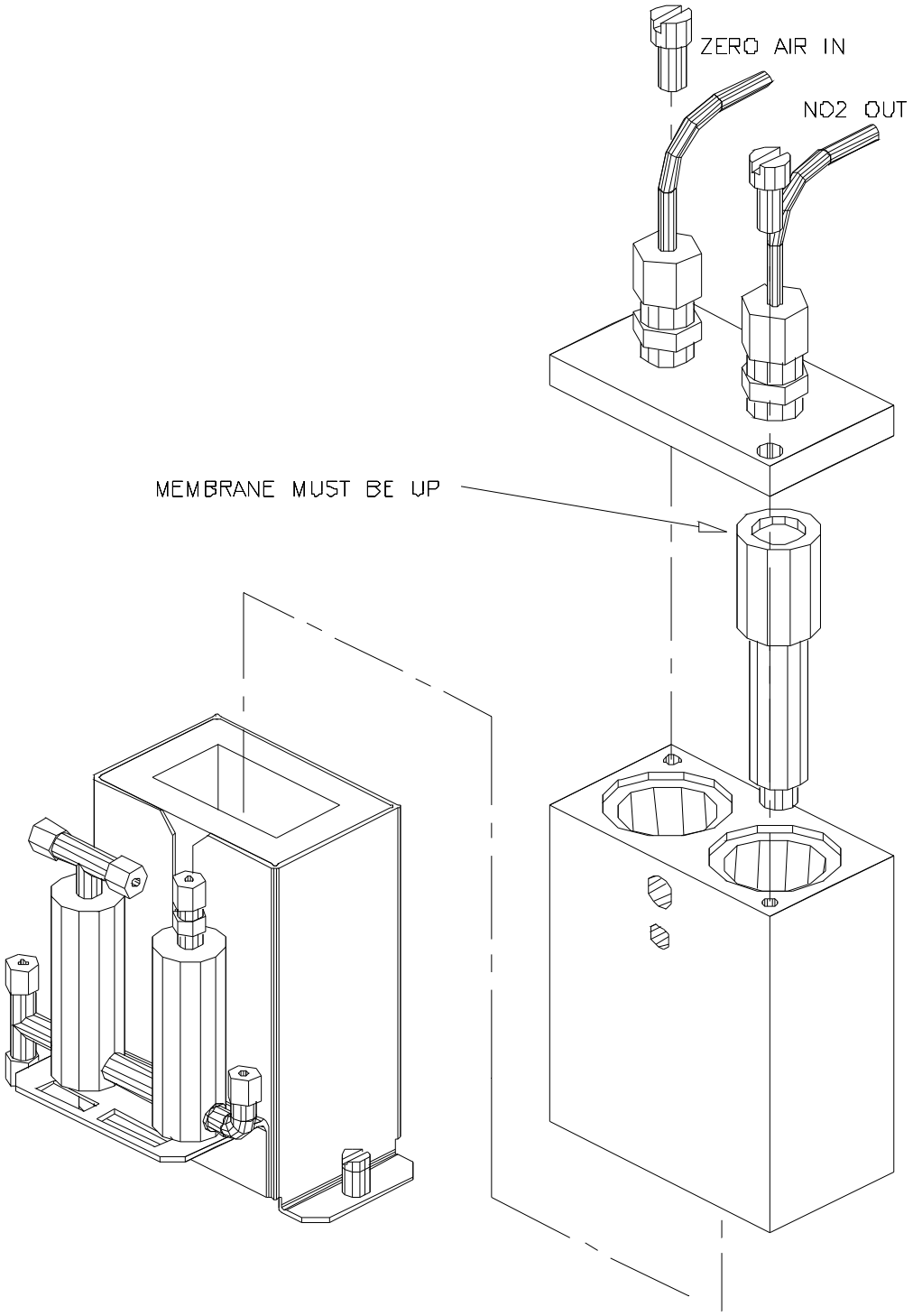


Table 6-6-6: IZS Option - Permeation Tube Installation

TELEDYNE API recommends that you purchase replacement permeation tubes from:

VICI METRONICS
2991 Corvin Drive
Santa Clara, CA 95051 USA
Phone 408-737-0550 Fax 408-737-0346

The M200A uses 560 cc/min of zero air over the perm tube. Therefore you should order a permeation tube with a SPECIFIC OUTPUT of 400 to 450 ppb at .560 liter/minute. This will give you a IZS Span response of 80 to 90% of full scale in the 500 ppb range. Refer to the above equation for calculating other concentrations and instrument flow rates.

Once the Analyzer and permeation tube have stabilized, the response to the permeation tube is not expected to change more than ± 5%. If, during a periodic span check, the response varies by more than 5%, or more importantly, shows drift, then there may be a problem with the Analyzer or permeation tube, see Section 9.3.9.

Suggested permeation tubes:

NO_2 Permeation tube - uncertified 0.4ppm @ 0.5 lpm

NO_2 Permeation tube - certified 0.4ppm @ 0.5 lpm

NO_2 Permeation tube - certified 0.8ppm @ 0.5 lpm

NO_2 Permeation tube - uncertified 0.8ppm @ 0.5 lpm

6.6 4-20 mA Current Loop Output

The current loop option replaces the voltage output of the instrument with an isolated 4-20 mA current loop. The current outputs come out on the same terminals that were used for voltage outputs, see Table 2-2-2. See Troubleshooting Section 9.3.3 for setup and calibration.

7 CALIBRATION AND ZERO/SPAN CHECKS

There are several ways to check and adjust the calibration of the M200A. These different methods are summarized in Table 7-7-1. In addition, all of the methods described in this section can be initiated and controlled via the RS-232 port.

We strongly recommend that SPAN CALIBRATION be done with NO span gas, although it is possible with NO_2 (see Section 7.6), or with gas from a GPT system. SPAN CHECKS can be done with either NO only, NO_2 only or a mixture of NO and NO_2 (GPT).

Zero air used for all calibration procedures, including GPT, should have < .1 ppb NO or NO_2, less than 1 ppb of major interferents such as SO2 and NH3, and a dew point of -5^o C or less. The calibration gasses should be from a reliable supplier, since the quality of the tank concentration values ultimately determines the accuracy of the analyzer. EPA protocol calibration gasses should be used for EPA monitoring, see Section 7.8.

NOTE

If you are using the M200A for EPA monitoring, only the calibration method described in Section 7.8 should be used.

NOTE

If there are any problems completing any of the following procedures, refer to Section 9.2.8 and 9.2.9 - Unable to Span or Zero.

Table 7-7-1: Types of Zero/Span Check and Calibration

Section	Type of Cal or Check	Description
7.1	Manual Z/S Check or Calibration through the sample port	This calibration option uses calibration gas coming in through the sample port. IZS and Zero/Span valves do not operate.
7.2	Manual Z/S Check or Calibration with Z/S Valves Option.	How to operate Zero/Span Valves Option. Can be used to check or adjust calibration.
7.3	Manual Z/S Check with IZS Option	How to operate IZS option. Can be used to check or adjust calibration.
7.4	Automatic Z/S Check with Z/S Valves or IZS Options	Operates Z/S valves or IZS once per day to check the calibration.
7.5	Dynamic Z/S Calibration with Z/S Valves or IZS Option	Operates Z/S valves or IZS once per day and adjusts calibration.
7.6	Calibrate using NO_2 Permeation Tube	Allows calibration using NO_2 gas from the IZS permeation tube.
7.7	Use of Z/S Valves or IZS with Remote Contact Closure	Operates Z/S valves or IZS with rear panel contact closures. Without valves or IZS, can be used to switch instrument into zero or span cal mode. Used for either checking or adjusting zero/span.
7.8	EPA Protocol Calibration	Covers methods to be used if data is for EPA equivalency monitoring.
7.9	Special Calibration Requirements for Independent Ranges or AutoRanging	Covers special requirements if using Independent Range or AutoRange.
7.10	Calibration Quality	Information on how to determine if the calibration performed will result in optimum instrument performance.
7.11	References	Contains a list of references on quality control and calibration.

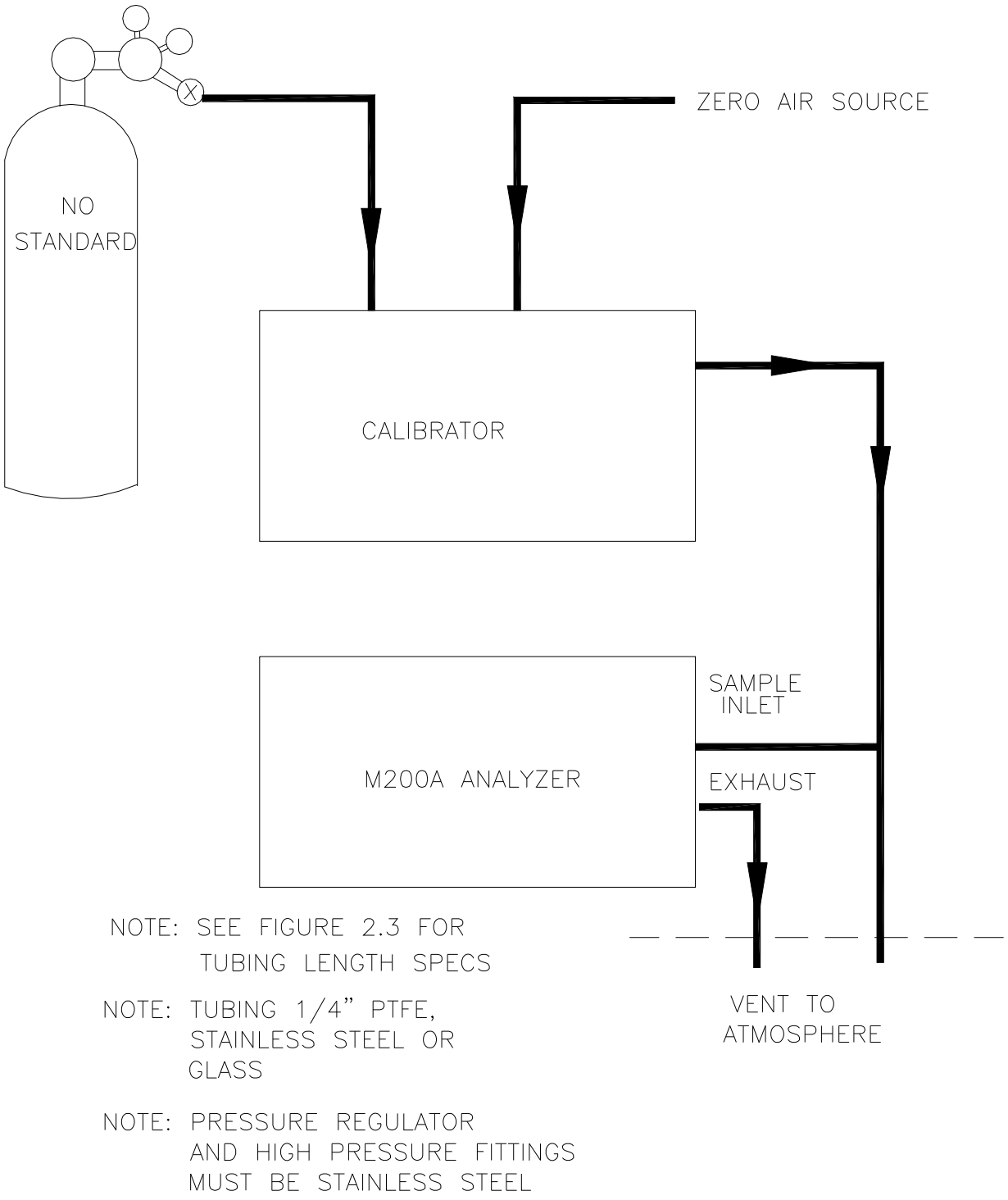


Table 7-7-2: Calibration Setup

7.1 Manual Zero/Span Check or Cal With Zero/Span Gas in the Sample Port

The calibration of the instrument can be checked or adjusted using gas from the sample port. This method is often used when the calibration gas is supplied from an external calibrator and valve system or when the Analyzer does not include the IZS or Z/S valves option.

Since the zero gas concentration is defined as 0 ppb, it is not necessary to enter the expected zero value. Table 7-7-3 details the zero calibrate procedure with zero gas coming in through the sample port.

Table 7-7-3: Manual Zero Calibration Procedure - Zero Gas Thru Sample Port

Step Number	Action	Comment
1.	Press CAL	The M200A enters the calibrate mode from sample mode. The zero gas must come in through the sample port.
2.	Wait 10 min	Wait for reading to stabilize at zero value.
3.	Press ZERO	If you change your mind after pressing ZERO, you can still press EXIT here without zeroing the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calculation equations.
5.	Press EXIT	M200A returns to sampling. Immediately after calibration, data is not added to the DAS averages.

Next, enter the expected NO_x and NO span gas concentrations:

Table 7-7-4: Enter Expected Span Gas Concentrations Procedure

Step Number	Action	Comment
1.	Press CAL-CONC-NOX	This key sequence causes the M200A to prompt for the expected NO_x concentration. Enter the NO_x span concentration value by pressing the key under each digit until the expected value is set. This menu can also be entered from CALS or CALZ.
2.	Press ENTR	ENTR stores the expected NO_x span value.
3.	Press CAL-CONC-NO	Now enter the expected NO span concentration as in step one.
4.	Press ENTR	Pressing ENTR stores the NO span value and returns the prompt to the CONC menu.
5.	Press EXIT	Returns instrument to SAMPLE mode.

If desired, compensation for moly converter efficiency (CE) can be included in the NO_x concentration calculation. The CE must be entered prior to calibration. Refer to Section 7.8.6 for the CE procedure.

Table 7-7-5: Manual Span Calibration Procedure - Span Gas thru Sample Port

Step Number	Action	Comment
1.	Press CAL	The M200A enters the calibrate mode. NO span gas should be fed to the sample port.
2.	Wait 10 min	Wait for reading to stabilize at span value.
3.	Press SPAN	If you change your mind after pressing SPAN, you can still press EXIT here without spanning the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calculation equations and causes the instrument to read the NO and NO_x span concentrations.
5.	Press EXIT	M200A returns to sampling. Immediately after calibration, data is not added to the DAS averages.

7.2 Manual Zero/Span Check or Calibration with Zero/Span Valves Option

The Zero/Span valve option can be operated from the front panel keyboard. In the Zero/Span valve option the zero and span gas come into the valves through ports on the rear panel of the instrument.

Table 7-7-6: Manual Zero Calibration Procedure - Z/S Valves

Step Number	Action	Comment
1.	Press CALZ	The analyzer enters the zero calibrate mode. This switches the sample/cal and zero/span valves to allow zero gas to come in through the zero gas inlet port in the rear panel.
2.	Wait 10 min	Wait for reading to stabilize at zero value.
3.	Press ZERO	If you change your mind after pressing ZERO, you can still press EXIT here without zeroing the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calculation equations, forcing the reading to zero.
5.	Press EXIT	M200A returns to sample mode. Immediately after calibration, readings do not go into the DAS averages.

Refer to Table 7-7-4 to enter expected NO and NO_x values.

Table 7-7-7: Manual Span Calibration Procedure - Z/S Valves

Step Number	Action	Comment
1.	Press CALS	The M200A enters the calibrate mode from sample mode. This operates the sample/cal and zero/span valves to allow span gas to come in through the cal gas inlet port in the rear panel or optional permeation tube.
2.	Wait 10 min	Wait for reading to stabilize at span value.
3.	Press SPAN	If you change your mind after pressing SPAN, you can still press EXIT here without spanning the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calculation equations.
5.	Press EXIT	M200A returns to sampling. Immediately after calibration, data is not added to the DAS averages.

7.3 Manual Zero/Span Check with IZS Option

The Internal Zero/Span (IZS) system can be operated from the front panel keyboard. When the M200A is in the SAMPLE mode, and the IZS option is installed, the CALS (Calibrate-Span) or CALZ (Calibrate-Zero) buttons will be visible. When the buttons are pressed, valves are switched to allow zero air or NO_2 gas to be input into the instrument.

It is not possible to calibrate the M200A on a NO_2 permeation tube unless the CAL-ON-NO2 option is enabled. This is because the NO_2 permeation tube contains no NO gas. We recommend a NO tank with calibration certificate for complete calibration or see CAL-ON-NO2 Section 7.6.

To do a manual zero check with the IZS Option, press CALZ, then wait about 10 minutes for the zero reading to stabilize. The zero value in the display, and analog output is the zero value. Press EXIT to return to SAMPLE mode. This procedure does not change the zero calibration of the instrument.

To do a manual NO_2 check, press CALS, then wait about 10 minutes for the NO_2 reading to stabilize. The concentration value in the display, and analog output is the span value. Press EXIT to return to SAMPLE mode. This procedure does not change the span calibration of the instrument.

7.4 Automatic Zero/Span Check

In a typical air monitoring application it is desirable to have the analyzer automatically check (AUTOCAL) its calibration each day. If equipped with Z/S valves or the IZS option, the M200A can provide a daily calibration check. There are many operational choices such as moving the check backwards or forwards a fixed time each day.

Setup of the AUTOCAL is covered in Table 6-6-2.

7.5 Dynamic Zero/Span Calibration

The AUTOCAL system described above can also optionally be used to calibrate the instrument once each 24 hours. The dynamic calibration is enabled by setting Dynamic Zero/Span buttons to ON.

Before proceeding with enabling DYNAMIC Z/S you must setup the AUTOCAL feature. Enabling AUTOCAL is described in Table 6-6-2. To enable DYNAMIC Zero/Span Calibration:

Table 7-7-8: Enabling Dynamic Zero/Span

StepNumber	Action	Comment
1.	Press SETUP-ACAL	Causes the M200A go to the AutoCal menu.
2.	Press PREV-NEXT	Select the sequence you want for dynamic calibration.
3.	Press SET	Select the SET menu.
4.	Press PREV-NEXT	Scroll through the SET menu to the CALIBRATE attribute.
5.	Press EDIT	Set the CALIBRATE attribute value to ON to enable Dynamic Span.
6.	Press EXIT	Causes the M200A to return to SAMPLE mode.

NOTE

If you try a Dynamic span calibration using the NO_2 permeation tube as a calibration gas source, the NO channel concentration will be zero due to the lack of NO in the NO_2 permeation tube. An error message will be displayed, CANNOT CALIBRATE. We recommend a calibrated NO tank for complete calibration. Also see the CAL-ON-NO2 option.

With dynamic calibration turned on, the instrument will re-set the slope and offset values for the NO and NO_x channel each day. This continual re-adjustment of calibration parameters can often mask subtle fault conditions in the analyzer. It is recommended that if Dynamic Cal is enabled, the TEST functions, and SLOPE and OFFSET values in the M200A are checked frequently to assure high quality and accurate data from the instrument.

7.6 Calibrate on NO_2 Permeation Tube

If the M200A is equipped with the IZS option, is possible to span the instrument on the permeation tube. If this feature is enabled, the instrument internal valves are set so that gas is routed through the permeation tube, then the moly converter, thus producing NO gas. The software is programmed to use this known NO gas concentration to span both the NO and NO_x channels of the instrument. Thus, if CAL-ON-NO2 is enabled, the CALS button now will span both the NO and NO_x channels of the instrument.

CAUTION

This feature has some unexpected side effects.



If CAL-ON-NO2 is enabled and you do a SPAN CHECK or SPAN CAL, the NO_2 concentration will be reported as ZERO! This is because all of the NO_2 gas is being routed through the molybdenum converter during both the NO and NO_x portions of the measurement cycle. Thus the instrument sees the SAME concentration of NO gas in the NO and NOx channels, and reports a NO_2 concentration of zero.

As long as CAL-ON-NO2 is enabled the instrument will never report any NO_2 during span calibration. This feature should be enabled only when a calibration is desired, otherwise leave it disabled so that NO_2 concentrations are reported correctly. See Table 7-7-9 to enable this feature.

NOTE

Note that this method of calibration is NOT approved by the USEPA. Permeation tubes are known to change as temperatures are cycled, and as they age. Also, this calibration relies on the moly converter to be working properly. (Converter efficiency can be compensated by enabling the Converter Efficiency option.) It is recommended that if CAL-ON-NO2 is used, the instrument calibration be checked frequently by independent means to assure accurate data.

Table 7-7-9: Enabling CAL-ON-NO2

Step Number	Action	Comment
1.	Press SETUP-MORE-VARS	Causes the M200A go to the VARS(Variables) menu
2.	Enter the VARS password, then ENTR	Password value is 8 1 8
3.	Scroll the VARS menu to select the CAL-ON-NO2 variable	By pressing NEXT or PREV
4.	Press EDIT	Once you have entered EDIT, set the value to ON
5.	Press ENTR	ENTR will enable the CAL-ON-NO2 feature
6.	Press EXIT	Each EXIT press returns the M200A to the next higher menu level. The highest level is the SAMPLE mode

Once CAL-ON-NO2 is enabled the procedure for zeroing and spanning the instrument is identical to that given in Section 7.2 for Zero/Span Valves.

7.7 Use of Zero/Span Valves or IZS with Remote Contact Closure

The Zero/Span valve or IZS options can be operated using Remote Contact Closures provided on the rear panel. See Table 2-2-2 for connector location and pinout. When the contacts are closed, the analyzer will switch to zero or span mode. The contacts must remain closed for at least 1 second, and will remain in zero or span mode as long as the contacts are closed. If Dynamic Zero/Span is enabled, the calibration is adjusted at the end of the zero or span time, otherwise zero or span is just checked, not adjusted.

In order to do another remote check, both contact closures should be held open for at least 1 second, then may be set again. Table 7-7-10 shows what type of check is performed based on the settings of the two contact closures.

Table 7-7-10: IZS or Z/S Valves Modes with Remote Contact Closure

Ext Zero CC	Ext Span CC	Operation
Contact Open	Contact Open	State when in SAMPLE mode, normal monitoring
Contact Open	Contact Closed	Span check or calibrate*
Contact Closed	Contact Open	Zero check or calibrate*

* Calibrate only if Dynamic Calibration is enabled.

7.8 EPA Protocol Calibration

If the M200A is to be used for EPA compliance monitoring, it must be calibrated in accordance with the instructions in this section.

In order to insure that high quality, accurate measurements are obtained at all times, the M200A must be calibrated prior to use. A quality assurance program centered on this aspect and including attention to the built-in warning features of the M200A, periodic inspection, regular zero/span checks and routine maintenance is paramount to achieving this.

In order to have a better understanding of the factors involved in assuring continuous and reliable information from the M200A, it is strongly recommended that Publication No. PB 273-518 Quality Assurance Handbook for Air Pollution Measurement Systems (abbreviated, Q.A. Handbook) be purchased from the NTIS (phone 703-487-4650). Special attention should be paid to Section 2.3 which deals with chemiluminescent-based NO_2 analyzers and upon which most of this section is based. Specific regulations regarding the use and operation of ambient oxides of nitrogen analyzers can be found in 40 CFR 50 and 40 CFR 58. Both publications are available from the U.S. Government Printing Office (phone 202-783-3238).

7.8.1 Calibration of Equipment

In general, calibration is the process of adjusting the gain and offset of the M200A against some recognized standard. The reliability and usefulness of all data derived from any analyzer depends primarily upon its state of calibration. In this section the term dynamic calibration is used to express a multipoint check against known standards and involves introducing gas samples of known concentration into the instrument in order to adjust the instrument to a predetermined sensitivity and to produce a calibration relationship. This relationship is derived from the instrumental response to successive samples of different known concentrations. As a minimum, three reference points and a zero point are recommended to define this relationship. The true values of the calibration gas must be traceable to NIST-SRM's (Section 2.0.7, Q.A. Handbook).

All monitoring instrument systems are subject to some drift and variation in internal parameters and cannot be expected to maintain accurate calibration over long periods of time. Therefore, it is necessary to dynamically check the calibration relationship on a predetermined schedule. Zero and span checks must be used to document that the data remains within control limits. These checks are also used in data reduction and validation. Table 7-7-11 summarizes the initial quality assurance activities for calibrating equipment. Table 7-7-12 is a matrix for the actual dynamic calibration procedure.

Table 7-7-11: Activity Matrix for Calibration Equipment and Supplies

Equipment/ Supplies	Acceptance Limits	Frequency And Method Of Measurement	Action If Requirements Are Not Met
Recorder	Compatible with output signal of analyzer; min chart width of 150 mm (6 in) is recommended	Check upon receipt	Return equimpent to supplier
Sample line and manifold	Constructed of PTFE, glass, or stainless steel	Check upon receipt	Return equipment to supplier
Calibration equipment	Meets guide-lines and Section 2.3.2 (Q. A. Handbook)	See Section 2.3.9 (Q. A. Handbook)	Return equipment/ supplies to supplier or take corrective action
Working standard NO cylinder gas or NO_2 permeation tube	Traceable to NIST-SRM Meets limits in traceability protocol for accuracy and stability. (Section 2.0.7, Q. A. Handbook)	Analyzed against NIST-SRM; see protocol in Section 2.0.7, Q.A. Handbook	Obtain new working standard and check for traceability
Recording forms	Develop standard forms	N/A	Revise forms as appropriate
Audit equipment	Must not be the same as used for calibration	System must be checked out against known standards	Loacte problem and correct or return to supplier

Calibrations should be carried out at the field monitoring site. The Analyzer should be in operation for at least several hours (preferably overnight) before calibration so that it is fully warmed up and its operation has stabilized. During the calibration, the M200A should be in the CAL mode, and therefore sample the test atmosphere through all components used during normal ambient sampling and through as much of the ambient air inlet system as is practicable. If the instrument will be used on more than one range, it should be calibrated separately on each applicable range, see Section 7.9. Calibration documentation should be maintained with each analyzer and also in a central backup file.

Table 7-7-12: Activity Matrix for Calibration Procedure

Equipment/ Supplies	Acceptance Limits	Frequency And Method Of Measurement	Action If Requirements Are Not Met
Calibration gases	Sec. 2.0.7, Subsec. 7.1 (Q.A. Handbook)	Assayed against an NIST-SRM quarterly, Sec. 2.0.7 (Q.A. Handbook)	Working gas standard is unstable, and/or measurement method is out of control; take corrective action such as obtaining new calibration gas.
Dilution gas	Zero air, free of contaminants; TAD[2] and Sec. 2.0.7, Subsec. 7.1 (Q.A. Handbook)	See TAD[2]	Return to supplier or take appropriate action with generation system
Multi-point calibration (GPT)	1. $t_R \leq 2$ minutes $P_R \geq$ 2.75 ppm/min 2. Use calibration procedure in Subsec. 2.4 (Q.A Handbook); also TAD[2] and Federal Register 3. Converter efficiency $\geq$ 96%	Method 1. Subsec. 8.4.2 (this manual) 2. Subsec. 8.5 (this manual), TAD[2], Federal Register and Table 8-8-3; see Subsec. 8.2 for frequency 3. Subsec. 8.6 (this manual) and Table 8-8-6 and Table 8-8-7	1. Adjust flow conditions and/or reaction chamber volume to meet suggested limits 2. Repeat the calibration 3. Replace or service the converter

7.8.2 Calibration Gas and Zero Air Sources

7.8.2.1 Production Of Zero Air

Devices that condition ambient air by drying and removal of pollutants are available on the commercial market such as the Teledyne API Model 701 Zero Air Generator. We recommend this type of device for generating zero air. Detailed procedures for generating zero air are in TAD[2].

7.8.2.2 Selection of NO Span Gas Standards

The NIST-SRM's provide references against which all calibration gas mixtures must be compared (Section 2.0.7, Q.A. Handbook). The procedure requires the comparison of the concentration of a commercial, working calibration standard to an NIST-SRM. This is described in Subsection 7.1 of Section 2.0.7, Q.A. Handbook. Subsections 7.1.4 and 7.1.5 describe the verification and reanalysis of cylinder gases.

Care must be taken to assure that no oxygen is allowed in the NO tank, regulator, or sample lines. If oxygen is present, it reacts with NO to produce NO_2 which can lead to significant errors in NO concentration measurement.

It is good practice to request a NO_x analysis from the supplier of the NO calibration gas. Generally the maximum NO_2 impurity that should be allowed is 1% of the NO concentration. The NO_2 impurity in the NO standard can be measured by the M200A. A procedure is given in the TAD for NO_2 measurement.

7.8.2.3 Use of NO_2 Permeation Tubes As Standards

The steps required to compare the concentration of a commercial working calibration standard to an NIST-SRM are described in Subsection 7.3.3 of Section 2.0.7, Q.A. Handbook. See Subsection 7.3.6 for the re-analysis of permeation tubes.

7.8.3 Data Recording Device

Either a strip chart recorder, data acquisition system or digital data acquisition system should be used to record the data from the M200A's RS-232 port or analog outputs. If analog readings are being used, the response of that system should be checked against a NIST referenced voltage source or meter. Data recording device should be capable of bi-polar operation so that negative readings can be recorded.

7.8.4 Gas Phase Titration (GPT) System

7.8.4.1 GPT Principle of Operation

Gas Phase Titration (GPT) is recommended for calibration of the M200A. Those using a NO_2 permeation tube should refer to TAD.[2]

The principle of GPT is based on the rapid gas phase reaction between NO and O_3 which produces stoichiometric quantities of NO_2 as shown by the following equation:

$$NO + O_3 \longrightarrow NO_2 + O_2$$

Given that the NO concentration is known for this reaction, the resultant concentration of NO_2 can be determined. Ozone is added to excess NO in a dynamic calibration system as shown in Table 7-7-13, and the NO channel of the chemiluminescent analyzer detects the changes in NO concentration. After the addition of O_3, the observed decrease in NO concentration 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 varying amounts of O_3 from a stable O_3 generator. All zero air used in this procedure should conform to the requirements stated in Section 7.

Dynamic calibration systems based on this principle are commercially available, or may be assembled by the user. A recommended calibration system is described in the Federal Register[1] and detailed in TAD.[2]

7.8.4.2 GPT Calibrator Check Procedure

It has been determined empirically that the NO-O_3 reaction goes to completion (<1% residual O_3) if the NO concentration in the reaction chamber (ppm) multiplied by the residence time (min.) of the reactants in the chamber is $\geq$2.75 ppm-min. The theory behind the development of this equation is in the Federal Register[1] and in TAD.[2]

The following procedures and equations should be used to determine whether an existing GPT calibration system will meet required conditions for a specific calibration.

For calibrators that have known pre-set flow rates, use equations 7-5 and 7-6 of steps 7 and 8 (below) to verify the required conditions. If the calibrator does not meet specifications, follow the complete procedure to determine what flow modifications must be made.

1. Select an NO standard gas that has a nominal concentration in the range of 50 to 100 ppm. Determine the exact concentration $[NO]_{STD}$ by referencing against an NIST-SRM, as discussed in Section 2.0.7 (Q.A. Handbook).
2. Determine the volume (cm^3) of the calibrator reaction chamber (V_{RC}). If the actual volume is not known, estimate the volume by measuring the approximate dimensions of the chamber and using an appropriate formula.
3. Determine the required minimum total flow output (F_T) using Equation 7-1:

$$F_T = \text{analyzer flow demand } (cm^3/min) \times 110/100 \quad \text{Equation 7-1}$$

If more than one analyzer is to be calibrated at the same time, multiply F_T by the number of analyzers.

4. Calculate the NO concentration $[NO]_{OUT}$ needed to approximate 90% of the URL of the NO_2 analyzer to be calibrated, using Equation 7-2:

$$[NO]_{OUT} = \text{URL of analyzer (ppm)} \times 90/100 \quad \text{Equation 7-2}$$

5. Calculate the NO flow (F_{NO}) required to generate the NO concentration $[NO]_{OUT}$, using Equation 7-3:

$$F_{NO} = \frac{[NO]_{OUT} \times F_T}{[NO]_{STD}} \quad \text{Equation 7-3}$$

6. Calculate the required flow through the ozone generator (F_O), using Equation 7-4:

$$F_o = \sqrt{\frac{[NO]_{STD} \times F_{NO} \times V_{RC}}{2.75 \text{ ppm - min}}} - F_{NO} \quad \text{Equation 7-4}$$

7. Verify that the residence time (t_R) in the reaction chamber is $\leq$2 min, using Equation 7-5:

$$t_R = \frac{V_{RC}}{F_O + F_{NO}} \leq 2 \text{ min} \quad \text{Equation 7-5}$$

8. Verify that the dynamic parameter specification (P_R) of the calibrator's reaction chamber is $\geq$2.75 ppm-min using Equation 7-6:

$$P_R = [NO]_{STD} \times \frac{F_{NO}}{F_O + F_{NO}} \times \frac{V_{RC}}{F_O + F_{NO}} \geq 2.75 \quad \text{Equation 7-6}$$

NOTE

If t_r is >2 minutes or if P_R is <2.75 ppm-min, changes in flow conditions (F_T, F_O, F_{NO}) or in the reaction chamber volume (V_{RC}), or both will have to be made, and t_r and P_R will have to be re-calculated.

9. After equations 7-5 and 7-6 are satisfied, calculate the diluent air flow (F_D) using Equation 7-7:

$$F_D = F_T - F_O - F_{NO} \quad \text{Equation 7-7}$$

7.8.4.3 Example GPT Calculation

Following is an example calculation that can be used to determine whether an existing GPT calibrator will meet the required conditions for a specific calibration. For this example, it is assumed that only the volume of the reaction chamber, V_{RC}, and the concentration of the NO standard, $[NO]_{STD}$, are known. All flow settings (F_{NO}, F_O, F_T, and F_D) will be calculated. In many uses, these flow settings are known and need only to be substituted in Equations 7-5 and 7-6 to verify the required conditions. Before doing any calculations, the URL and flow demand of the analyzer being calibrated must be known. Operating parameters are determined from the operations manual:

Upper range limit = 0.5 ppm, and

Flow demand = 500 cm^3/min.

Volume of calibrator reaction chamber is determined by physical measurement:

V_{RC} = 180 cm^3

The concentration of the NO standard gas to be used is determined by reference against an NIST-SRM (Section 2.0.7, Q.A. Handbook):

$[NO]_{STD}$ = 50.5 ppm

1. Determine the minimum total flow (F_T) required at the output manifold using Equation 7-1:

F_T = *500 cm^3/min (110/100) = 550 cm^3/min*

Because low flows are difficult to control and measure, it is often advantageous to set a higher total flow than needed. In this example, we will let F_T = 2750 cm3/min

2. Determine the highest NO concentration, $[NO]_{OUT}$, required at the output manifold, using Equation 7-2:

   $[NO]_{OUT}$ = 0.5 ppm (90/100) = 0.45 ppm

3. Calculate the NO flow (F_{NO}) required to generate the NO concentration $[NO]_{OUT}$, using Equation 7-3:

$$F_{NO} = \frac{0.45\,ppm \times 2750\,cm^3/min}{50.5\,ppm} = 24.5\,cm^3/min$$

4. Calculate the required flow rate through ozone generator (F_O) using Equation 7-4:

$$F_O = \sqrt{\frac{50.5\ ppm\ x\ 24.5\,cm^3/\text{min}\ x\ 180\,cm^3}{2.75\ ppm\text{-min}}} - 24.5\,cm^3/\text{min}$$

$$= \sqrt{80984\ cm^6/\text{min}^2} - 24.5\ cm^3/\text{min} = 260\ cm^3/\text{min}$$

5. Verify that the residence time (t_R) in the reaction chamber is $\leq$2 min using Equation 7-5:

$$t_R = \frac{180\,cm^3}{260\,cm^3/min + 24.5\,cm^3/min} = 0.63\,min$$

6. Verify the dynamic parameter specification (P_R) of the calibrator reaction chamber using Equation 7-6:

$$P_R = 50.5\,ppm \times \frac{24\,cm^3/min}{260\,cm^3/min + 24.5\,cm^3/min} \times \frac{180\,cm^3}{260\,cm^3/min + 24.5\,cm^3/min} = 2.75\,ppm - min$$

7. Calculate the diluent air flow (F_D) required at the mixing chamber, using Equation 7-7:

$F_D = 2750\ cm^3/min - 260\ cm^3/min - 24.5\ cm^3/min = 2465.5\ cm^3/min$

7.8.5 Dynamic Multipoint Calibration Procedure

The procedure for calibration of chemiluminescent NO_x analyzers by GPT is specified in the Federal Register.[1] This section applies the general procedure to the specific case of the M200A.

Calibration must be performed with a calibrator that meets all conditions specified in Subsection 2.3.2 (Q.A. Handbook). Flow settings used in the GPT calibration for NO_2 must be determined as illustrated in Section 7.8.4, this manual.

The user should be sure that all flow meters are calibrated under the conditions of use against a reliable standard. All volumetric flow rates should be corrected to 25° C (78°F) and 760 mm (29.92 in.) Hg. Calibrations of flow meters are discussed in TAD.[2]

Gas Phase Titration (GPT) requires the use of the NO channel of the analyzer to determine the amount of NO_2 generated by titration. Therefore it is necessary to calibrate and determine the linearity of the NO channel before proceeding with the NO_2 calibration. It is also necessary to calibrate the NO_x channel. This can be done simultaneously with the NO calibration. During the calibration the M200A should be operating in its normal sampling mode, and the test atmosphere should pass through all filters, scrubbers, conditioners, and other components used during normal ambient sampling and as much of the ambient air inlet system as is practicable. All operational adjustments to the M200A should be completed prior to the calibration. The following software features must be set into the desired state before calibration.

1. Automatic Converter Efficiency compensation. See Sections 7.8.6 and 7.9, this manual.
2. Independent range selection. See Sections 5.3.4 and 7.9, this manual.
3. Automatic temperature/pressure compensation. See Table 9-9-5.
4. Alternate units, make sure ppb units are selected for EPA monitoring. See Section 5.3.4.5.
5. Autoranging option. See Section 5.3.4.2.

Converter efficiency should be set prior to calibration since its value is used in the computation of the NO_x and NO_2 concentration outputs.

The analyzer should be calibrated on the same range used for monitoring.

If AutoRanging or Independent range options are selected the highest of the ranges will result in the most accurate calibration, and should be used.

Make sure the GPT calibration system can supply the range of concentrations at a sufficient flow over the whole range of concentrations that will be encountered during calibration.

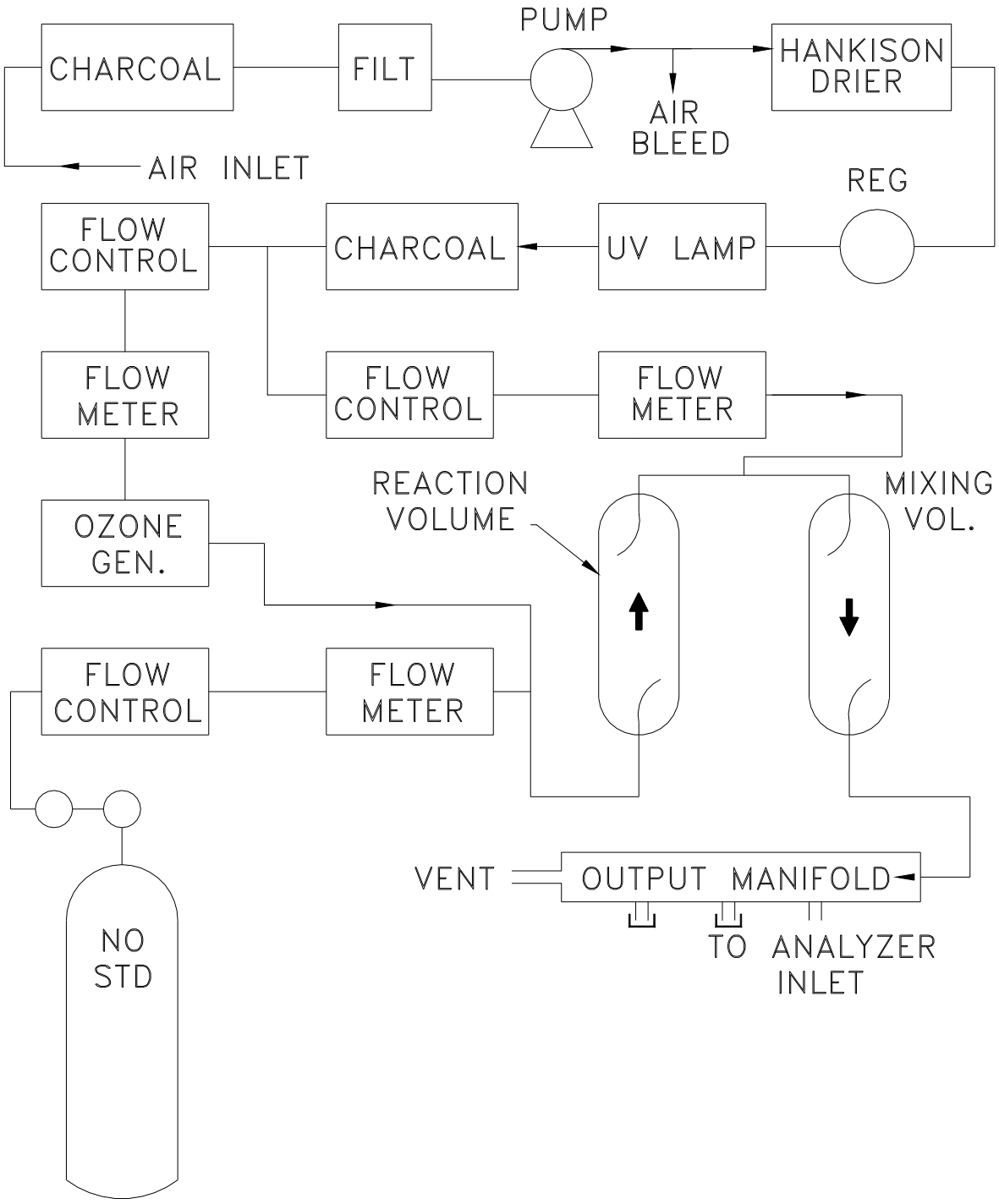


Table 7-7-13: Diagram of GPT Calibration System

7.8.5.1 Zero Calibration Procedure

Since the zero gas concentration is defined as 0 ppb, it is not necessary to enter the expected zero value. The following Table 7-7-14 details the zero calibration procedure.

Table 7-7-14: Zero Calibration Procedure

Step Number	Action	Comment
1.	Press CAL	The M200A enters the calibrate mode from sample mode. NOTE: The analyzer does not operate the zero/span valves in this mode, the zero gas enters through the sample port.
2.	Wait 10 min	Wait for reading to stabilize at the zero value.
3.	Press ZERO	If you change your mind after pressing ZERO, you can still press EXIT here without zeroing the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calculation equations.
5.	Press EXIT	M200A returns to the SAMPLE mode.

7.8.5.2 NO/NO_x Calibration Procedure

Adjust the NO concentration to approximately 80% of the URL of the NO channel. The expected NO and NO_x span concentrations can be determined by measuring the cylinder and diluent flows and computing the resulting concentrations. If there is any NO_2 impurity in the NO standard gas it should be taken into account when the NO_x concentration is entered during the NO/NO_x channel calibration. This is done by ADDING the impurity concentration to the NO concentration to get the NO_x concentration for calibration. Calculate the exact NO and NO_x concentrations as follows:

$$[NO]_{OUT} = \frac{F_{NO} \, x \, [NO]_{STD}}{F_T}$$ *Equation 7-8*Enter the respective concentrations using the procedure in Table 7-13. The expected span concentrations need not be re-entered each time a calibration is performed unless they are changed.

Enter the expected NO_x and NO span gas concentrations:

Table 7-7-15: Expected Span Gas Concentration Procedure

Step Number	Action	Comment
1.	Press CAL-CONC-NOX	This key sequence causes the M200A to prompt for the expected NO_x concentration. Enter the NO_x span concentration value by pressing the key under each digit until the expected value is set. This menu can also be entered from CALS or CALZ.
2.	Press ENTR	ENTR stores the expected NO_x span value.
3.	Press CAL-CONC-NO	Now enter the expected NO span concentration as in step one.
4.	Press ENTR	Pressing ENTR stores the NO span value and returns the prompt to the CONC menu.
5.	Press EXIT	Returns instrument to SAMPLE mode.

Sample the generated concentration until the NO and the NO_x responses have stabilized.

Span the instrument by the following procedure:

Table 7-7-16: Span Calibration Procedure

Step Number	Action	Comment
1.	Press CAL	The M200A enters the calibrate mode from sample mode.
2.	Wait 10 min	Wait for readings to stabilize at span values.
3.	Press SPAN	If you change your mind after pressing SPAN, you can still press EXIT here without spanning the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calculation equations.
5.	Press EXIT	M200A returns to SAMPLE mode.

The analog voltage output should measure 80% of the voltage range selected. (e.g. 4.00 VDC if 0-5V output is selected.) The readings on the front panel display should be equal to the expected NO and NO_x concentrations entered in the procedure given in Table 7-7-15 above. See the Troubleshooting Section 9.2.8 if there are problems. Also see the Calibration Quality Check procedure Section 7.10.

After the zero and the 80% URL points have been set, generate five approximately evenly spaced calibration points between zero and 80% URL without further adjustment to the instrument. Allow the instrument to sample these intermediate concentrations for about 10 minutes each and record the instrument NO and NO_x responses.

Plot the analyzer NO and NO_x responses versus the corresponding calculated concentrations to obtain the calibration relationships. Determine the straight line of best fit ($y = mx + b$) determined by the method of least squares.

After the best-fit line has been drawn for the NO and the NO_x calibrations, determine whether the analyzer response is linear. To be considered linear, no calibration point should differ from the best-fit line by more than 2% of full scale.

7.8.5.3 GPT - NO_2 Calibration Procedure

The M200A computes the NO_2 concentration by subtracting the NO from the NO_x concentration. Unlike analog instruments, this difference is calculated by the M200A's internal computer software. It is extremely unlikely that the NO_2 concentration will be in error. Therefore this procedure is a confirmation that the NO_2 subtraction algorithm in the computer is operating correctly.

NOTE

During this procedure do not make any adjustments to the instrument.

1. Generate an NO concentration near 90% of the URL. Dilution air and O_3 generator air flows should be the same as used in the calculation of specified conditions of the dynamic parameter according to Section 7.8.4. Sample this NO concentration until the NO and NO_x responses stabilize. Record the NO and NO_x concentrations.
2. Turn on and adjust the O_3 generator in the calibrator to produce sufficient O_3 to decrease the NO concentration to about 10% of full scale. This will be equivalent to 80% of the URL of the NO_2 channel. After the analyzer responses stabilize, record the resultant NO, NO_x, and NO_2 concentrations.

   MOLY CONVERTER EFFICIENCY

   IF THE NO_x READING SHOULD DROP TO LESS THAN 96% OF ITS STARTING VALUE DURING THIS STEP, IT INDICATES THE MOLY CONVERTER IS IN NEED OF TROUBLESHOOTING OR REPLACEMENT. SEE SECTION 7.8.6 FOR FURTHER DETAILS.
3. While maintaining all other conditions, adjust the ozone generator to obtain several other concentrations of NO_2 evenly spaced between the 80% URL point and the zero point. Record the NO, NO_x, and NO_2 concentrations for each additional point.

4. Calculate the resulting NO_2 concentrations as follows:

$$[NO_2]_{OUT} = [NO]_{ORIG} - [NO]_{REM} + \frac{F_{NO} * [NO_2]_{IMP}}{F_T} \quad \text{Equation 7-10}$$

Where:

$[NO]_{ORIG}$ is the NO concentration before the GPT ozone is turned on, and $[NO]_{REM}$ is the NO remaining after GPT.

5. Plot the NO_2 concentration output by the instrument on the y-axis against the generated NO_2 $[NO_2]_{OUT}$ on the x-axis. The plot should be a straight line within the ± 2% linearity criteria given for the NO_x and NO channels. If the plot is not linear the most likely cause is that the converter needs replacing. See Section 7.8.6 on Moly converter efficiency.

7.8.6 Moly Converter Efficiency

The moly efficiency should be 96 to 102% efficient. If it is outside these limits it should be replaced. The converter efficiency can be determined from the data collected in 7.8.5.3.

For each NO_2 concentration generated:

1. Calculate the concentration of NO_2 converted as:

$$[NO_2]_{CONV} = [NO_2]_{OUT} - ([NO_x]_{ORIG} - [NO_x])_{REM} \quad \text{Equation 7-11}$$

Where:

$[NO_x]_{ORIG}$ is the NO_x concentration before the GPT ozone is turned on, and $[NO_x]_{REM}$ is the NO_x remaining after GPT.

2. Plot the $[NO_2]_{CONV}$ concentration output by the instrument on the y-axis against the concentration generated $[NO_2]_{OUT}$ on the x-axis. The plot should be a straight line within the ± 2% linearity criteria given for the NO_x and NO channels.
3. Determine the best straight line fit of the plot either by inspection or least squares. The slope of the resulting straight line is the moly efficiency. The value should be between .96 and 1.02. If not, the moly needs to be replaced.
4. If you want the M200A to automatically compensate (Section 7.8.6.1) for converter efficiency, enter the efficiency value in the front panel by CAL-CONC-MOLY-SET, then key in the slope from step 3 followed by ENTR. Press EXIT to return to the SAMPLE menu.

7.8.6.1 Automatic Moly Converter Efficiency Compensation

The M200A can automatically compensate the NO_x and NO_2 readings for the molybdenum converter efficiency. There are 2 ways to enter the converter efficiency into the instrument. The first is to enter the efficiency as a decimal fraction using the CAL-CONC-MOLY-SET menu. The second method is to have the M200A compute the efficiency using the CAL-MOLY-CAL menu. The procedure is given in Table 7-7-17 below. To disable the compensation, press CAL-CONC-MOLY-SET and enter 1.0000 as the efficiency.

Table 7-7-17: Automatic Calculation of Converter Efficiency

Step Number	Action	Comment
1.	Press CAL-CONC-CONV-NO2	From the SAMPLE mode the M200A enters the Converter Efficiency menu and requests expected NO_2 cal gas concentration.
2.	Key in expected NO_2 concentration Then ENTR	Enter the expected NO_2 cal gas concentration. (We suggest you generate a NO_2 concentration of 80% of current range.)
3.	Press CAL-CONC-MOLY-SET Set CE to 1.0000	Reset the previous converter efficiency value to 1.00.
4.	Press CAL-CONC-CONV-CAL, wait 10 min. Then press ENTR	Allow the NO_2 concentration reading to stabilize. It may take time for the ENTR button to appear because the only valid values for CE are .96 to 1.02. The ENTR button will not come on unless the value is in this range. When ENTR is pressed, the M200A will compute the ratio of observed NO_2 concentration to expected NO_2 concentration and store the ratio.
5.	Press SET	After the instrument calculates the CE it is good practice to check the ratio.
6.	Press EXIT	The M200A will now compensate all readings for this converter efficiency value.

7.8.7 Calibration Frequency

To ensure accurate measurements of the NO, NO_x, and NO_2 concentrations, calibrate the analyzer at the time of installation, and re-calibrate it:

1. No later than three months after the most recent calibration or performance audit which indicated analyzer calibration to be acceptable.
2. An interruption of more than a few days in analyzer operation.
3. Any repairs which might affect its calibration.
4. Physical relocation of the analyzer.
5. Any other indication (including excessive zero or span drift) of possible significant inaccuracy of the analyzer.

Following any of the activities listed above, the zero and span should be checked to determine if a calibration is necessary. If the analyzer zero and span drifts exceed the calibration limits in Table 9-9-1 of Section 2.0.9, Subsection 9.1.3 (Q.A. Handbook), a calibration should be performed.

7.8.8 Other Quality Assurance Procedures

Precision is determined by a one-point check at least once every two weeks. Accuracy is determined by a three-point audit once each quarter.

Essential to quality assurance are scheduled checks for verifying the operational status of the monitoring system. The operator should visit the site at least once each week. Every two weeks a Level 1 zero and span check must be made on the analyzer. Level 2 zero and span checks should be conducted at a frequency desired by the user. Definitions of these terms are given in Table 7-7-18.

In addition, an independent precision check between 0.08 and 0.10 ppm must be carried out at least once every two weeks. Table 7-7-19 summarizes the quality assurance activities for routine operations. A discussion of each activity appears in the following sections.

To provide for documentation and accountability of activities, a checklist should be compiled and then filled out by the field operator as each activity is completed.

For information on shelter and sample inlet system, an in-depth study is in Field Operations Guide for Automatic Air Monitoring Equipment, Publication No. APTD-0736, PB 202-249 and PB 204-650, U.S. Environmental Protection Agency, Office of Air Programs, October 1972.

Table 7-7-18: Definition of Level 1 and Level 2 Zero and Span Checks

(from Section 2.0.9 of Q.A. Handbook for Air Pollution Measurment Systems)

LEVEL 1 ZERO AND SPAN CALIBRATION	LEVEL 2 ZERO AND SPAN CHECK
A Level 1 zero and span calibration is a simplified, two-point analyzer calibration used when analyzer linearity does not need to be checked or verified. (Sometimes when no adjustments are made to the analyzer, the Level 1 calibration may be called a zero/span check, in which case it must not be confused with a Level 2 zero/span check.) Since most analyzers have a reliably linear or near-linear output response with concentration, they can be adequately calibrated with only two concentration standards (two-point concentration). Furthermore, one of the standards may be zero concentration, which is relatively easily obtained and need not be certified. Hence, only one certified concentration standard is needed for the two-point (Level 1) zero and span calibration. Although lacking the advantages of the multipoint calibration, the two-point zero and span calibration--because of its simplicity--can be (and should be) carried out much more frequently. Also, two-point calibrations are easily automated. Frequency checks or updating of the calibration relationship with a two-point zero and span calibration improves the quality of the monitoring data by helping to keep the calibration relationship more closely matched to any changes (drifts) in the analyzer response.	A Level 2 zero and span check is an "unofficial" check of an analyzer's response. It may include dynamic checks made with uncertified test concentrations, artificial stimulation of the analyzer's detector, electronic or other types of checks of a portion of the analyzer, etc. Level 2 zero and span checks are not to be used as a basis for analyzer zero or span adjustments, calibration updates, or adjustment of ambient data. They are intended as quick, convenient checks to be used between zero and span calibrations to check for possible analyzer malfunction or calibration drift. Whenever a Level 2 zero or span check indicates a possible calibration problem, a Level 1 zero and span (or multipoint) calibration should be carried out before any corrective action is taken. If a Level 2 zero and span check is to be used in the quality control program, a "reference response" for the check should be obtained immediately following a zero and span (or multipoint) calibration while the analyzer's calibration is accurately known. Subsequent Level 2 check responses should then be compared to the most recent reference response to determine if a change in response has occurred. For automatic Level 2 zero and span checks, the first scheduled check following the calibration should be used for the reference response. It should be kept in mind that any Level 2 check that involves only part of the analyzer's system cannot provide information about the portions of the system not checked and therefore cannot be used as a verification of the overall analyzer calibration.

7.8.9 Summary of Quality Assurance Checks

The following items should be checked on a regularly scheduled basis to assure high quality data from the M200A. See Table 7-7-19 for a summary of activities; also the QA Handbook should be checked for specific procedures.

Table 7-7-19: Activity Matrix for Data Quality

Characteristic	Acceptance Limits	Frequency and Method of Measurement	Action if Requirements are not Met
Shelter temperature	Mean temperature between 22° C and 28° C (72° and 82°F), daily fluctuations not greater than ± 2° C	Check thermograph chart weekly for variations greater than ± 2° C (4°F)	1. Mark strip chart for the affected time period 2. Repair or adjust temperature control
Sample introduction system	No moisture, foreign material, leaks, obstructions; sample line connected to manifold	Weekly visual inspection	Clean, repair, or replace as needed
Recorder	1. Adequate ink & paper 2. Legible ink traces 3. Correct chart speed and range 4. Correct time	Weekly visual inspection	1. Replenish ink and paper supply 2. Adjust time to agree with clock; note on chart
Analyzer operational settings	1. TEST measurements at nominal values 2. M200A in SAMPLE mode	Weekly visual inspection	Adjust or repair as needed
Analyzer operational check	Zero and span within tolerance limits as described in Subsec. 9.1.3 of Sec. 2.0.9 (Q.A. Handbook)	Level 1 zero/span every 2 weeks; Level 2 between Level 1 checks at frequency desired by user	1. Find source of error and repair 2. After corrective action, re-calibrate analyzer
Precision check	Assess precision as described in Sec. 2.0.8 and Subsec. 3.4.3 (Ibid.)	Every 2 weeks, Subsec. 3.4.3 (Ibid.)	Calc, report precision, Sec. 2.0.8 (Ibid.)

7.8.10 ZERO and SPAN Checks

A system of Level 1 and Level 2 zero/span checks (see Table 7-1) is recommended. These checks must be conducted in accordance with the specific guidance given in Subsection 9.1 of Section 2.0.9 (Q.A. Handbook). Level 1 zero and span checks must be conducted every two weeks. Level 2 checks should be conducted in between the Level 1 checks at a frequency desired by the user. Span concentrations for both levels should be between 70 and 90% of the measurement range.

Zero and span data are to be used to:

1. Provide data to allow analyzer adjustment for zero and span drift;
2. Provide a decision point on when to calibrate the analyzer;
3. Provide a decision point on invalidation of monitoring data.

Items 1 and 2 are described in detail in Subsection 9.1.3 of Section 2.0.9 (Q.A. Handbook). Item 3 is described in Subsection 9.1.4 of the same section.

Refer to the Troubleshooting Section 9 of this manual if the instrument is not within the allowed variations.

7.8.10.1 Zero/Span Check Procedures

The Zero and Span calibration can be checked a variety of different ways. They include:

1. Manual Zero/Span Check

   Zero and Span can be checked from the front panel keyboard. The procedure is in Section 7.1 of this manual.

2. Automatic Zero/Span Checks

   After the appropriate setup, Z/S checks can be performed automatically every night. See Table 6-6-2 and Section 7.4 of this manual for setup and operation procedures.

3. Zero/Span checks via remote contact closure

   Zero/Span checks can be initiated via remote contact closures on the rear panel. See Section 7.7 of this manual.

4. Zero/Span via RS-232 port

   Z/S checks can be controlled via the RS-232 port. See Section 5.5 of this manual for more details.

7.8.10.2 Precision Check

A periodic check is used to assess the data for precision. A one-point precision check must be carried out at least once every 2 weeks on each analyzer at an NO_2 concentration between 0.08 and 0.10 ppm. The analyzer must be operated in its normal sampling mode, and the precision test gas must pass through all filters, scrubbers, conditioners, and other components used during normal ambient sampling. The standards from which precision check test concentrations are obtained must be traceable to NIST-SRM. Those standards used for calibration or auditing may be used.

7.8.10.3 Precision Check Procedure

1. Connect the analyzer to a precision gas that has an NO_2 concentration between 0.08 and 0.10 ppm. An NO_2 precision gas may be generated by either GPT or a NO_2 permeation tube. If a precision check is made in conjunction with a zero/span check, it must be made prior to any zero or span adjustments.
2. Allow the analyzer to sample the precision gas until a stable trace is obtained.
3. Record this value. NO and NO_x precision checks should also be made if those data are being reported. Information from the check procedure is used to assess the precision of the monitoring data; see Section 2.0.8 (Q.A. Handbook) for procedures for calculating and reporting precision.

7.8.11 Recommended Standards for Establishing Traceability

To assure data of desired quality, two considerations are essential: (1) the measurement process must be in statistical control at the time of the measurement and (2) the systematic errors, when combined with the random variation in the measurement process, must result in a suitably small uncertainty.

Evidence of good quality data includes documentation of the quality control checks and the independent audits of the measurement process by recording data on specific forms or on a quality control chart and by using materials, instruments, and measurement procedures that can be traced to appropriate standards of reference. To establish traceability, data must be obtained routinely by repeated measurements of standard reference samples (primary, secondary, and/or working standards). More specifically, working calibration standards must be traceable to standards of higher accuracy, such as those listed below in Table 7-7-20.

Table 7-7-20: NIST-SRM's Available for Traceability of Calibration and Audit Gas Standards

NIST-SRM[4]	Type	Size, at STP	Nominal Concentration
1683a	Nitric oxide in N_2	870	50 ppm
1684a	Nitric oxide in N_2	870	100 ppm
1685a	Nitric oxide in N_2	870	250 ppm

Permeation Tubes

NIST-SRM[4]	Type	Permeation rate, ug/min	Concentration, ppm at flow rates of: 1 L/min/5 L/min
1629	Nitrogen dioxide	1.0	0.5/0.1

Cylinders of working gas traceable to NIST-SRM's (called EPA Protocol Calibration Gas) are also commercially available (from sources such as Scott Specialty Gases, etc.).

7.8.12 Certification Procedures of Working Standards

NOTE

If the assayed concentration of NO_2 impurity in the NO cylinder, $[NO_2]_{imp}$, is greater than the 1 ppm value allowed in the calibration procedure, make certain that the NO delivery system is not the source of contamination before discarding the NO standard.

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 on a quarterly basis or more frequently, as required. Procedures are outlined below for certification against NO traceable standard. The simplest and most straightforward procedure is to certify against an NO standard.

7.8.12.1 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 converter. Refer to the calibration procedure described in Section 7.8.4.2.

Then, generate several NO concentrations by diluting the NO working standard. Use the nominal NO cylinder concentration, $[NO]_{NOM}$, to calculate the diluted concentrations. 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:

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

A procedure is presented in the TAD in Reference 2.

7.8.12.2 Other Methods of Establishing Traceability

They are:

1. NO working standard traced to NIST NO2 standard
2. NO_2 working standard traced to NIST NO2 standard
3. NO_2 working standard traced to NIST NO standard

NOTE

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

7.9 Calibration of Independent Ranges or Autoranging

There are additional considerations when AutoRange or Independent Ranges are selected. The M200A uses one physical range of 0-2000 ppb to cover all EPA concentration ranges. The dynamic range of the internal hardware and computer software is sufficient to cover this entire range. Internally the range only scales parts of the 0-2000 ppb physical range to cover the voltage range selected for the analog outputs.

7.9.1 Zero Calibration with AutoRange or Independent Range

Having one physical range to cover all EPA concentration ranges simplifies zero calibration. No matter what AutoRange or Independent Range values are selected the values computed from a zero calibration are the same. Therefore no special precautions need to be taken when doing a zero calibration.

7.9.2 Span Calibration with AutoRange or Independent Range

Observe the following guidelines when calibrating in AutoRange or Independent Range.

1. When doing a span calibration of the M200A use 80% of the highest of the ranges. This will result in the most accurate calibration.
2. When selecting concentrations for the NO/NO_x or NO_2 (GPT) dynamic calibrations use 80% of the highest AutoRange or the highest Independent Range. This will produce the most accurate calibration.
3. If the calibration data is obtained from the RS-232 port or from the front panel display, no special changes are necessary if the instrument is in AutoRange or Indep. Range. This is because the internal hardware and software has sufficient dynamic range to cover the entire EPA equivalent range, also those features only affect the analog outputs.
4. If using the analog outputs and a chart recorder or datalogger, be sure to note when AutoRange occurs so that the correct range is used. With Independent Ranges, change the ranges so that all ranges are equal to the highest range so that all calibration data is on scale.
5. Calibration curves or relationships should be obtained for each range used.

7.10 Calibration Quality

After calibration is complete, it is very important to check the QUALITY of the calibration. The calibration of the M200A involves balancing several sections of electronics and software to achieve an optimum balance of accuracy, noise, linearity and dynamic range.

The following procedure checks the Slope and Offset parameters in the equations used to compute the NO, and NO_x concentrations. It is important that they fall within certain limits with respect to themselves and to each other. For an explanation of the use of these terms in the concentration calculation see Section 5.2.2.5.

The slope and offset parameters are similar to the span and zero pots on an analog instrument. Just as in the analog instrument, if the slope or offset get outside of a certain range, the instrument will not perform as well.

The slope value will be slightly different on the NO and NO_x channels. This is due to slight differences in pneumatic resistance in each pathway. If the slopes are significantly different, there is a calibration error or a cross port leak in the switching valve. If there is a sudden change in slopes after a calibration, that usually indicates a change in reaction cell pressure. This generally requires a Factory Calibration covered in Section 9.1.6.

The offset value gives information about the background signal level. Check the observed offset value against the factory value in Table 2-2-6. If significantly higher, check Section 9.1.6. Also, after calibration check the AutoZero reading and compare it against the factory checkout value. Increasing readings are a predictor of problems.

Table 7-7-21: Calibration Quality Check

Step Number	Action	Comment
1.	Scroll the TEST function menu until the NO_x SLOPE is displayed	The SLOPE value for NO_x should be 1.0 ± 0.3. If the value is not in this range, check Section 9.1.6. If the SLOPE value is in the acceptable range the instrument will perform optimally.
2.	Scroll the TEST function menu until the NO SLOPE is displayed	The SLOPE value for NO should be 1.0 ± 0.3. If the SLOPE is in the acceptable range the instrument will perform optimally. If the value is not in this range, check Section 9.1.6. NOTE: The NO and NO_x slopes should be equal within ± 0.1.
3.	Scroll the TEST function menu until the NO_x OFFSET is displayed	This number should be near zero. A value of 0.0 – 20 + 150 indicates calibration in the optimal range. This number already has the AutoZero value subtracted out and is mainly the background signal due to the molybdenum converter. If the OFFSET value is outside this range, check Section 9.1.6.
4.	Scroll the TEST function menu until the NO OFFSET is displayed	The instrument will now display the NO OFFSET value. It should also have a value near zero (0.0 –20 + 150 mV). This number already has the AutoZero reading subtracted out and should be near zero. If the OFFSET value is outside this range, check Section 9.1.6.

After the above procedure is complete, the M200A is ready to measure sample gas.

7.11 References

1. Environmental Protection Agency, Title 40, Code of Federal Regulations, Part 50, Appendix F, Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence), Federal Register, 41 (232): pp 52688-52692, December 1976.
2. Ellis, Elizabeth C. Technical Assistance Document for the Chemiluminescence Measurement of Nitrogen Dioxide, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1976. 91 p.
3. Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS), Appendix A, Federal Register, Vol. 44, No. 92, pp 27574-27582, May 1979.
4. Catalog of NBS Standard Reference Materials. NBS Special Publication 260, 1975-76 Edition. U.S. Department of Commerce, NBS. Washington, D.C. June 1975.
5. Quality Assurance Handbook for Air Pollution Measurement Systems - Volume I, Principles. EPAN-600/9-76-005. December 1984.
6. Quality Assurance Handbook for Air Pollution Measurement Systems - Volume II, Ambient Air Specific Methods. EPA-600/4-77/027a, December 1986.
7. Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring, Appendix B, Federal Register, Vol. 44, No. 92, pp 27582-27584, May 1979.

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8 MAINTENANCE

8.1 Maintenance Schedule

NOTE

The operations outlined in this chapter are to be performed by qualified maintenance personnel only.



Table 8-8-1: Preventative Maintenance Schedule

Item	Maintenance Interval	Reference Section
TEST Functions	6 - 12 month intervals	Table 9-9-1
Zero/Span Calibration	Annually or after repairs	Section 7
Zero/Span Checks	Daily	Section 7, Table 6-6-2
Particulate Filter	Weekly as needed	Table 8-8-3
Ozone Scrubber on Pump Pack	Replace charcoal every 3 months	Section 4.2.7, Table 4-4-3
Filter for Ozone Scrubber	Replace every 12 months	Table 4-4-3
Filter for PermaPure Drier	Replace every 12 months	Table 9-9-18
Zero Air Canister	Refill every 3 months	Section 8.5
Reaction Cell Window	Clean annually or as necessary	Section 9.3.8, Table 8-8-5
Ozone Flow	Check every year	Table 9-9-20, Section 9.3.7
Sample Flow	Check every year	Table 9-9-20, Section 9.3.7
Moly Converter	Check efficiency every 6 months	Table 8-8-4, Section 8.6
Pneumatic Lines	Examine every 12 months, clean if necessary	Table 8-8-6, Table 8-8-7, Table 8-8-8
Factory Calibration	Calibrate each year or after repairs	Section 9.1.6
Leak Check	Check every year	Section 8.9
O-rings	Replace if seal is broken	Table 9-9-20, Table 9-9-21

Table 8-8-2: Preventative Maintenance Schedule

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Maintenance Interval
TEST Functions													6 - 12 month intervals
Zero/Span Calibration													Annually or after repairs
Zero/Span Checks													Daily
Particulate Filter													Weekly as needed
Ozone Scrubber on Pump Pack													Replace charcoal every 3 months
Filter for Ozone Scrubber													Replace every 12 months
Filter for PermaPure Drier													Replace every 12 months
Zero Air Canister													Refill every 3 months
Reaction Cell Window													Clean annually or as necessary
Ozone Flow													Check every year
Sample Flow													Check every year
Moly Converter													Check efficiency every 6 months
Pneumatic Lines													Examine every 12 months, clean if necessary
Factory Calibration													Calibrate each year or after repairs
Leak Check													Check every year
O-rings													Replace if seal is broken

8.2 Replacing the Sample Particulate Filter

The particulate filter should be inspected often for signs of plugging or contamination. It is also common for dirt particles to absorb NO_2, thus causing those readings to be low.

To check and change the filter:

1. Fold down the M200A front panel.
2. Locate the filter on the left side of the analyzer front panel. See Table 8-8-3 for an exploded view of the filter assembly.
3. Visually inspect the filter through the glass window.
4. If the filter appears dirty, unscrew the hold-down ring, remove the teflon o-ring and then the filter.
5. Replace the filter, being careful that the element is fully seated in the bottom of the holder. Replace the teflon o-ring, then screw on the hold-down ring and hand tighten.

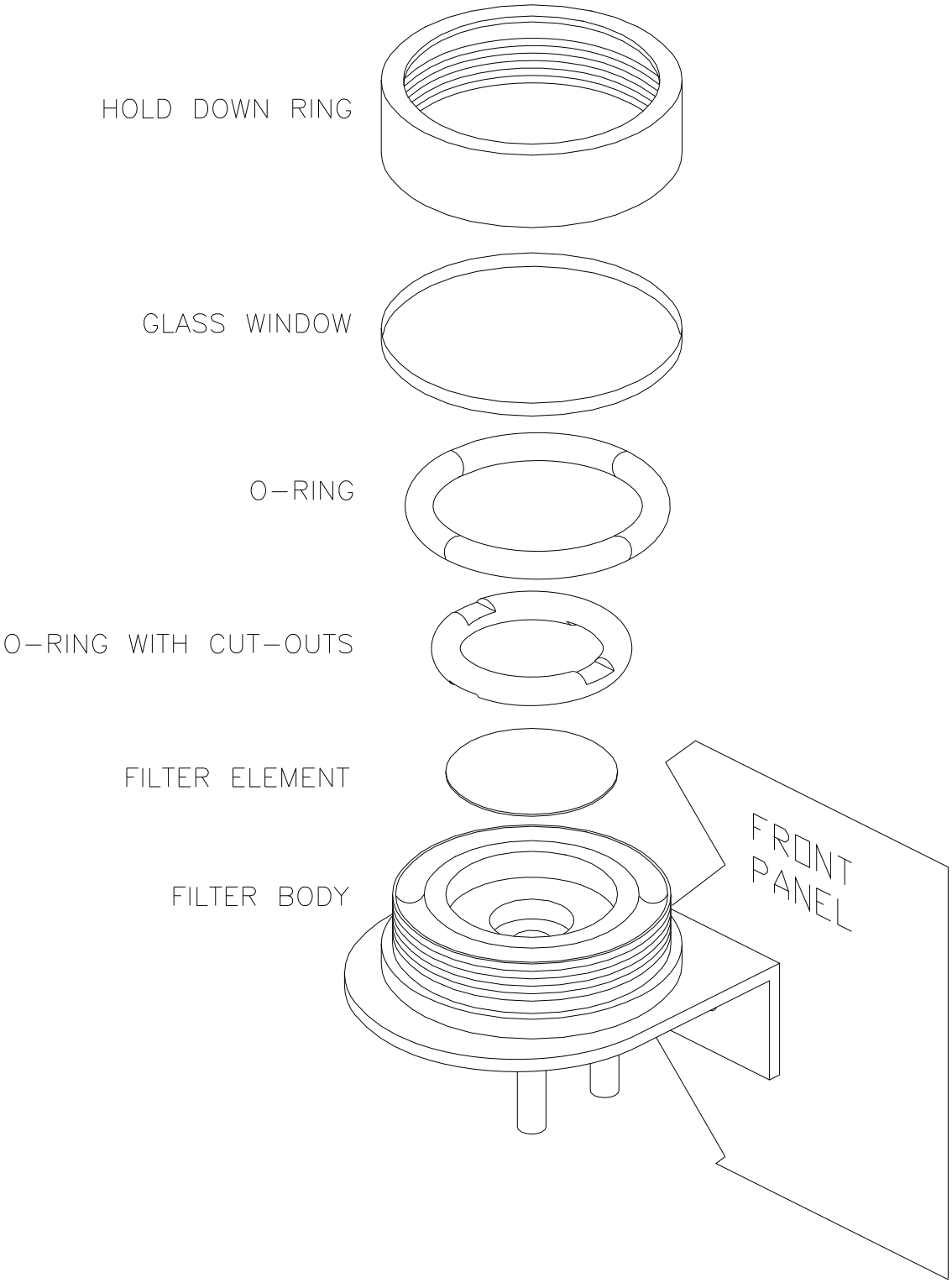


Table 8-8-3: Replacing the Particulate Filter

8.3 Replacing the Ozone Scrubber Charcoal

The Ozone scrubber consists of a charcoal filled canister mounted on the pump pack. See Table 2-2-3 for the scrubber location. To replace the charcoal:

1. Turn off the analyzer and pump.
2. Remove the scrubber from the pump pack by loosening the 1/4" tube fittings.
3. Unscrew the upper end cap of the scrubber and empty the contents.
4. Replace the charcoal with TELEDYNE API P/N 00596 or equivalent. Be sure the charcoal completely fills the canister so that flow channels will not form.
5. Replace the cap, then re-install the canister on the pump pack.

CAUTION

The charcoal used for the ozone scrubber should NOT be treated with halogen compounds (chlorine, iodine, etc), since explosive compounds may be formed on contact with ozone.



8.4 Replacing the Permeation

The permeation tube is contained in the oven at the rear - center of the instrument, refer to Table 2-2-5 for its location. See Table 6-6-6 for illustration.

1. Turn off the power to the M200A.
2. Remove the two pneumatic fittings and the rubber insulation from the top of the assembly.
3. Remove the oven cover by removing the two screws holding down the cover.

NOTE

That the fitting closest to the Ozone Generator is stainless steel. This chamber is where the permeation tube should be.

4. Remove the old permeation tube. Install the new permeation tube in the same chamber with the membrane facing UP.
5. Re-assemble the oven and turn on instrument power.

Permeation tubes require 48 hours at 50° C to reach a stable output. We recommend waiting this long before any calibration checks, adjustments, or conclusions are reached about the permeation tube.

NOTE

If the instrument is to be turned off for more than 8 hours, the perm tube must be removed from the IZS oven. Even at room temperature the perm tube continues to release NO_2. Concentrations can build up to very high levels inside the instrument causing contamination and high background readings.

8.5 Replacing the IZS Zero Air Scrubber

The IZS zero air scrubber is located on the rear panel of the instrument. Refer to Table 8-8-1 for recommended replacement interval. The entire cartridge can be replaced, or just the charcoal and Purafil inside the cartridge. To replace the scrubber materials:

1. Disconnect the scrubber from the rear panel pneumatic fitting and remove from the hold down clip. While removing the cartridge, check the DFU filter for contamination and dirt, replace if necessary.
2. Unscrew the top, remove the felt pad and empty the contents.
3. Inspect the upper and lower felt pads for signs of plugging, replace if necessary.
4. Replace with 50% Purafil(upstream) and 50% charcoal (downstream).
5. Re-install felt pad, screen and re-tighten cap. Make sure the o-ring in the cap is in good shape and squarely seated.
6. Leak check the assembly, then re-attach scrubber to fitting and clip on rear panel.

8.6 Replacing the Molybdenum Converter

The Molybdenum Converter is located in the center of the instrument, see Table 2-2-5 for location, and Table 8-8-4 for the assembly. The heater, thermocouple, converter is designed to be replaced as a single unit.

1. Turn off the power to the M200A and allow the converter to cool.
2. Remove the entire assembly from the chassis.
   A. Remove the pneumatic fittings from the valves.
   B. Remove the power to the valves, thermocouple wire and cartridge heater.
   C. Remove the converter assembly from the chassis by loosening the 4 captive screws that secure the assembly to the chassis.

CAUTION

The converter operates at 315º C. Severe burns can result if not enough time is allowed for the assembly to cool. Do not handle assembly until it is at room temperature.



3. Disconnect the gas fittings and power cable grounding from the can.
4. Remove the valve assembly and bottom bracket and re-attach those two parts to the replacement moly assembly.
5. Re-attach the pneumatic fittings and valve assembly to the can.
6. Install the assembly back into the analyzer. Re-attach the electrical and pneumatic fittings. Leak check the assembly when completed.
7. Turn the power back on. The insulation can emit a burnt odor for the first 24 hours, this is normal. Allow the converter to burn-in for 24 hours, then re-calibrate the instrument.

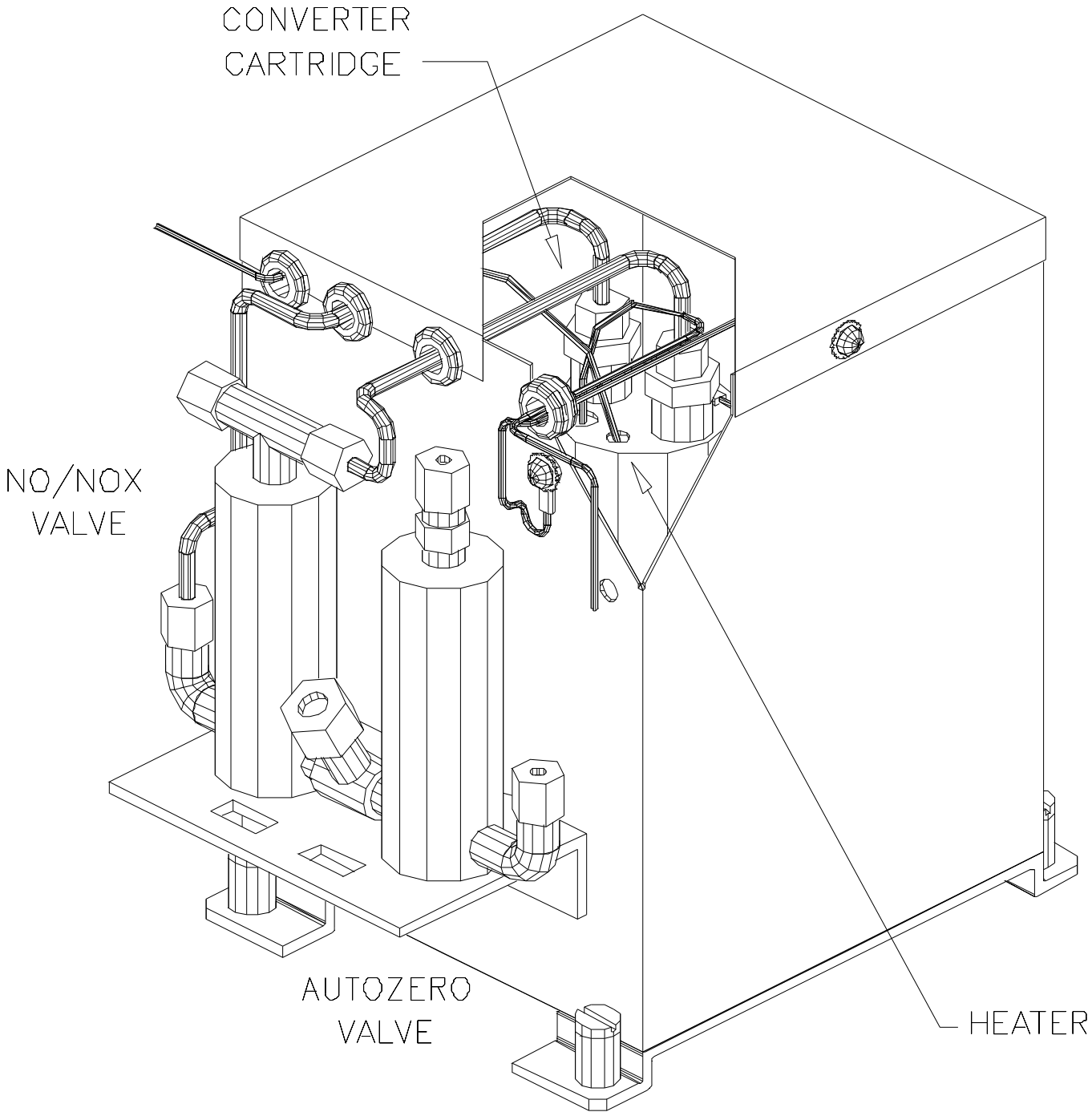


Table 8-8-4: Molybdenum Converter Assembly

8.7 Cleaning the Reaction Cell

The reaction cell should be cleaned whenever troubleshooting points to it as the cause of the trouble. A dirty cell will cause excessive noise, unstable zero or span, or low response.

To clean the reaction cell it is necessary to remove the reaction cell from the sensor housing. Use the following guide:

1. Turn off the instrument power and vacuum pump.
2. Loosen the hold down screws for pneumatic sensor assembly and move the assembly to the side.
3. Disconnect the exhaust fitting and inlet fittings. See Table 8-8-5.
4. Loosen four screws holding the reaction cell to the PMT housing.
5. Disconnect heater/thermistor and lift the cell away.
6. The reaction cell will separate into two halves:
   A. The manifold assembly.
   B. The reaction block with reaction sleeve and window.
7. The reaction sleeve and window should be cleaned with methanol and a clean tissue and dried.
8. Normally it is not necessary to clean the sample and ozone flow orifices since they are protected by fritted filters. If tests shows that cleaning is necessary then do the following:
   A. The manifold assembly should be cleaned by removing the O-ringed fittings, springs, fritted filter, orifices and O-rings. It is suggested that the orifice, filter and o-rings be replaced unless an ultrasonic cleaner and methanol or methylene chloride is available. Both orifice and sintered filter may be cleaned with an ultrasonic bath for 30 minutes in either solvent. Replace o-rings.
   B. After cleaning with solvent, flush copiously with tap water.
   C. Now, rinse parts in either D1 or distilled water.
   D. Dry parts prior to re-installation.
9. Do not remove the sample and ozone nozzles. They are Teflon threaded and require a special tool for reassembly. If necessary, the manifold with nozzles attached can be cleaned in an ultrasonic bath.
10. Reassemble in proper order and re-attach onto sensor housing. Reconnect pneumatics and heater connections, then re-attach the pneumatic sensor assembly and the cleaning procedure is complete.
11. After cleaning, the analyzer span response may drop 10 - 12% in the first 1-2 days as the reaction cell window conditions.

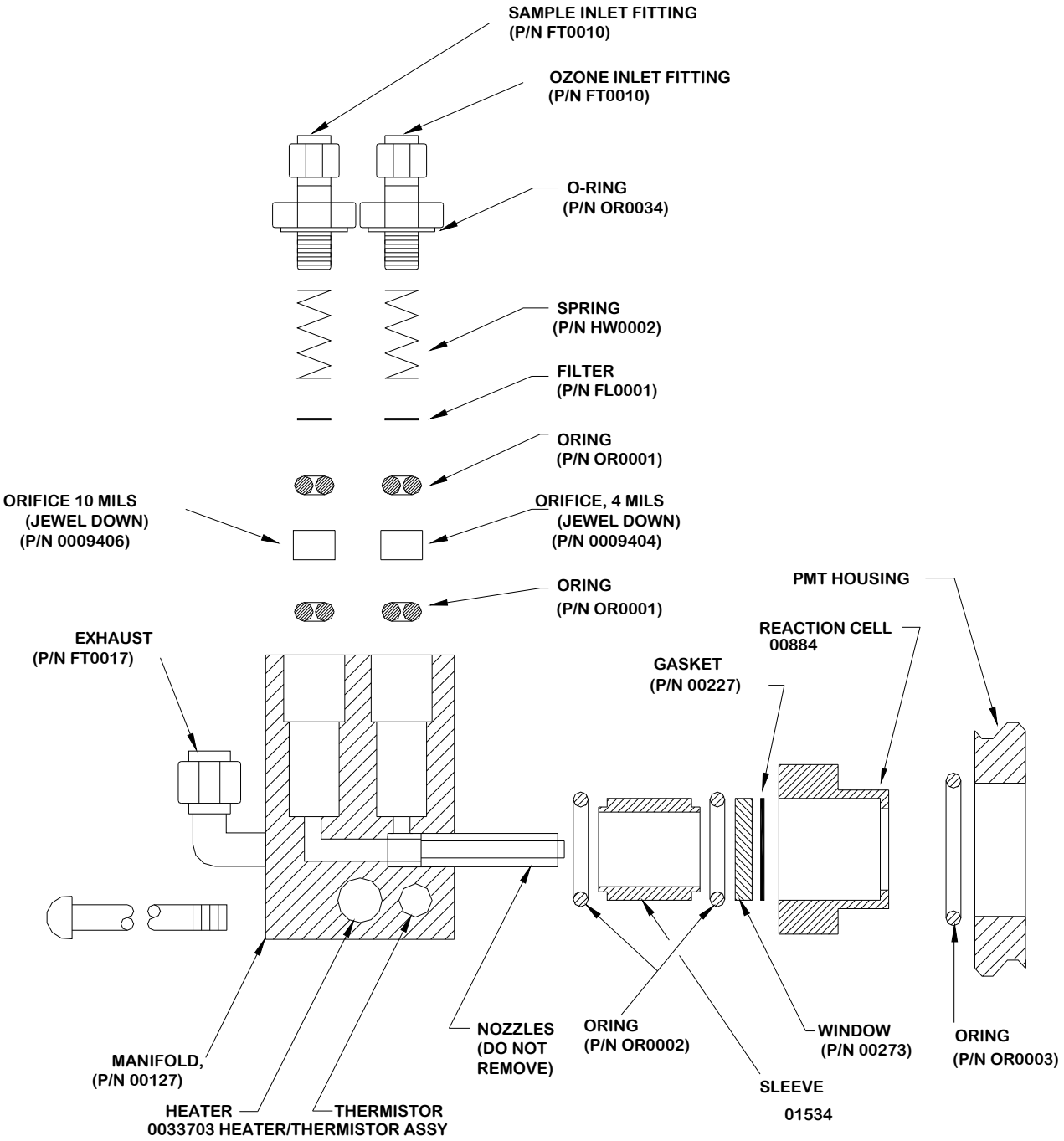


Table 8-8-5: Reaction Cell Assembly

8.8 Pneumatic Line Inspection

Particulate matter in the pneumatic lines will affect both flow rate and response time. It is important that the pneumatic system be periodically inspected and thoroughly cleaned if necessary. Clean by disassembling and passing methanol through three times. Dry with nitrogen or clean zero air.

Also inspect all pneumatic lines for cracks and abrasion on a regular basis. Replace as necessary. Refer to the pneumatic diagram in Table 8-8-6, Table 8-8-7, Table 8-8-8.

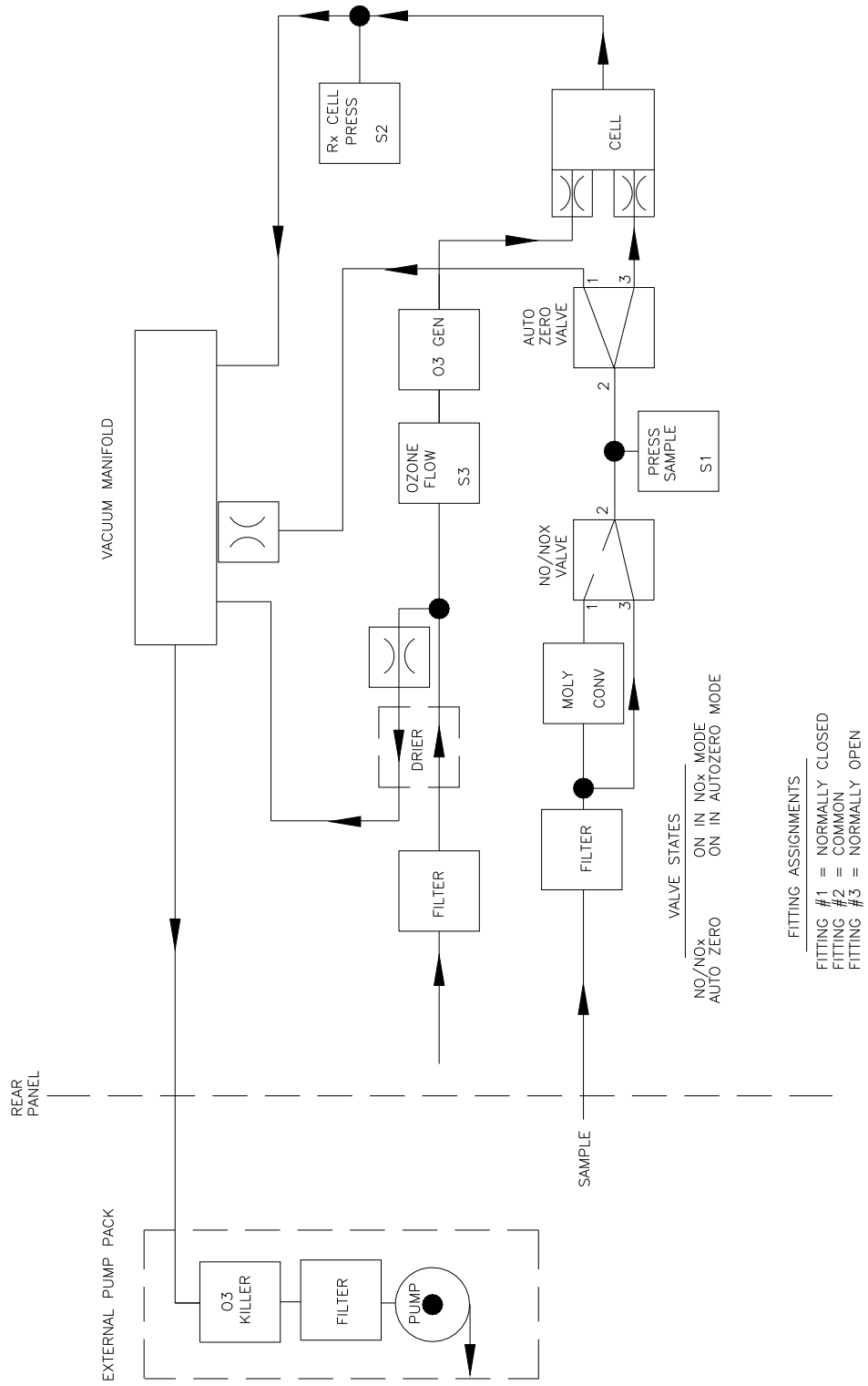


Table 8-8-6: Pneumatic Diagram - Standard Configuration

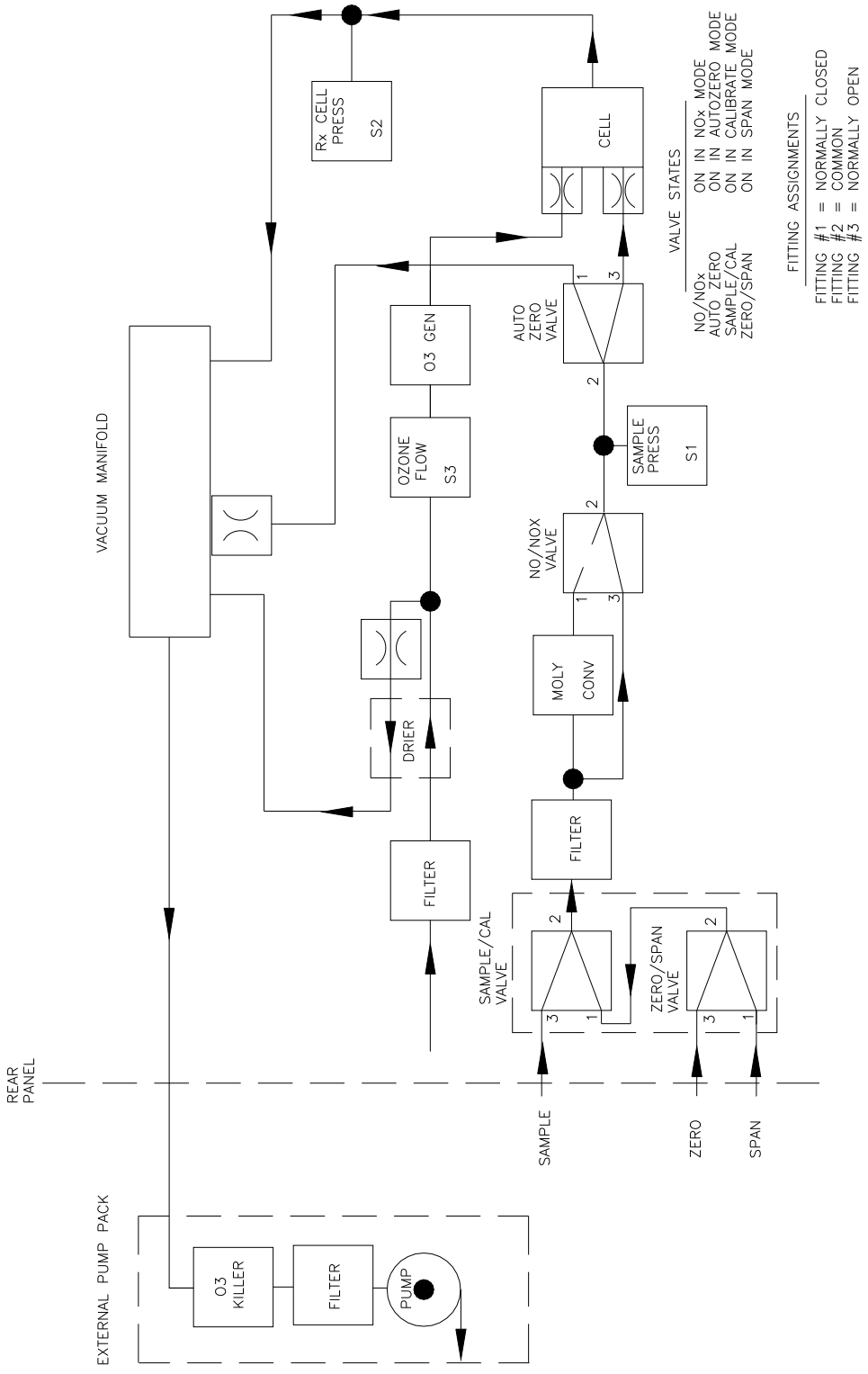


Table 8-8-7: Pneumatic Diagram with Zero/Span Valve Option

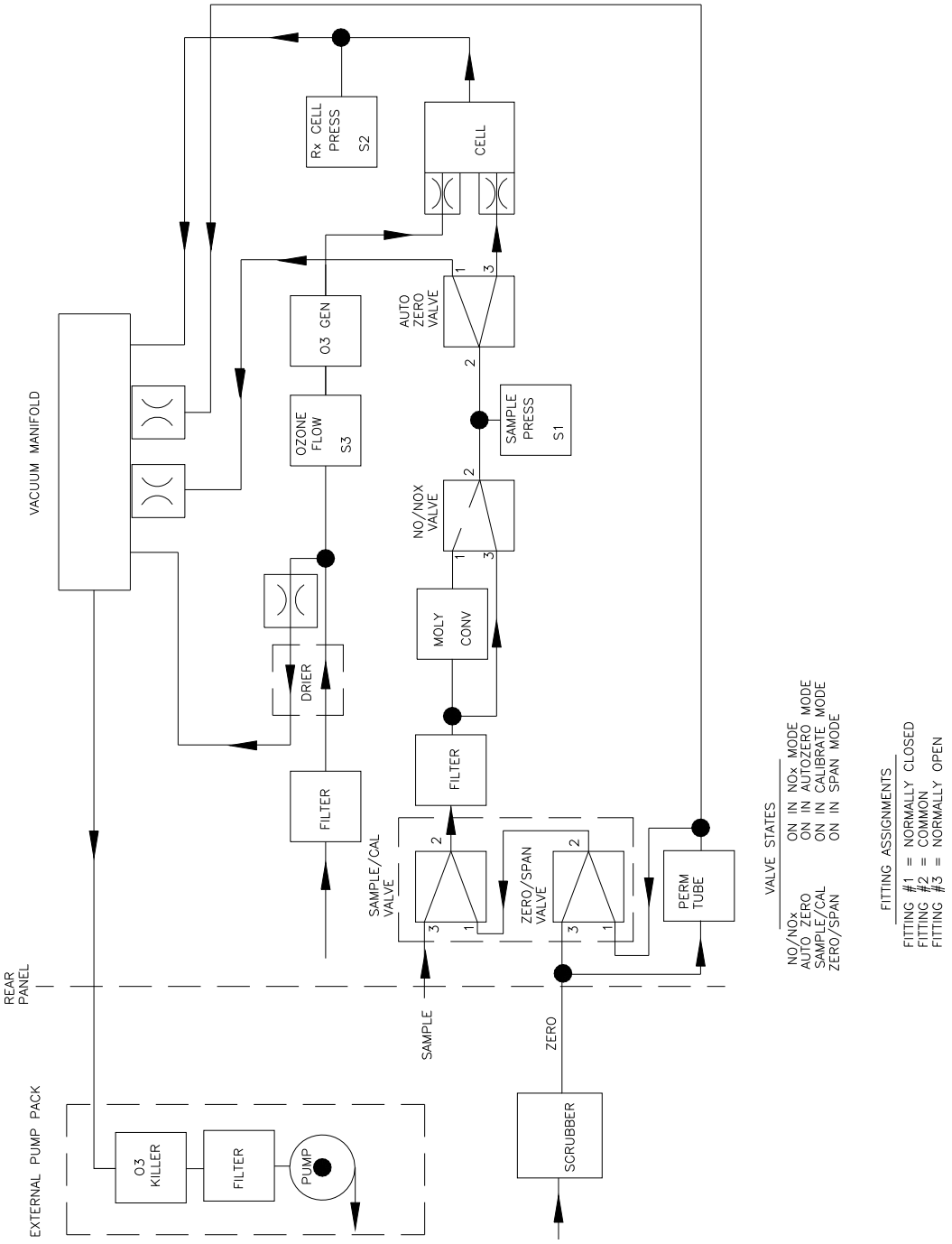


Table 8-8-8: Pneumatic Diagram with IZS Option

8.9 Leak Check Procedure

If a leak checker is not available, it is possible to leak check the instrument using the M200A's pump plus a shut-off valve.

1. Turn off instrument power and pump power.
2. Cap the sample inlet port, ozone generator air inlet, and zero air inlet (if IZS option present).
3. Insert a shut-off valve between the sample pump and the vacuum manifold at the rear of the instrument.
4. Turn on the sample pump and set the TEST function to RCEL, which measures the reaction cell pressure. Close the shutoff valve and monitor the cell pressure. The pressure should not drop more than 1"Hg(.5psi) in 5 minutes. If there is a leak, it is not possible by this method to tell where it is located. You can locate the leak by using a pressure leak checker described below.
5. The sensor module is equipped with a fitting at the top of housing near the heat sink fins. This fitting can be pressurized and the sensor checked for leaks. The leakdown rate is the same as above.

If you have a leak checker:

1. Turn off instrument power and pump power.
2. Disconnect pump at rear panel. Cap the sample inlet port, ozone generator air inlet, and zero air inlet (if IZS option present) and connect the leak checker to the exhaust port.

CAUTION

Pressure must be less than 15 psi.



3. Pressurize system and check for leaks by watching overall pressure. The pressure should not drop more than 2"Hg(1 psi) in 5 minutes.

If the instrument fails the pressure test, each fitting needs to be leak checked to find the location. Be careful that the system is always pressurized so as not to draw soap solution into the plumbing system. Make sure you dry off any accumulated bubble solution. Refer to Table 8-8-6, Table 8-8-7, Table 8-8-8 for pneumatic diagrams.

The Sensor module can be leak checked as a unit using a 1/8" tubing fitting on top of the assembly. The same rules as above apply.

1. Pressurize to <15 psi.
2. After turning off pressure tester, pressure should not drop more than 2" Hg in 5 minutes.

NOTE

If the black PMT cover for the Sensor Assembly is removed, ensure to replace the 5 dessicant bags inside the housing.

8.10 Light Leak Check Procedure

1. Scroll the TEST functions to PMT.
2. Input zero gas.
3. Shine a powerful flashlight or portable incandescent light at the inlet and outlet fitting, and at all the joints of the reaction cell. The PMT value should not respond to the light.

If there is a response, tighten the joints or replace the tubing with new black PTFE tubing. We often find light leaks are caused by o-rings being left out of the assembly.

8.11 Prom Replacement Procedure

Preparation: If any setup changes such as RANGE, AUTOCAL, IZS ON/OFF etc. have been made, record the changes because all settings should be checked after the PROM is changed. See Table 9-9-8 for location of prom on CPU card.

1. Turn the machine off.
2. Remove the hold down screw that holds in the V/F-CPU assembly to the motherboard. Disconnect the J9 power connector from the motherboard. Gently lift the assembly far enough out of the instrument to remove the connector to the display and the RS-232 connector.
3. The CPU board is attached to the larger V/F board.
4. Remove the board, laying it down on an insulating surface such that the board edge pins on the PCB are on the left. The PROM chip should be at the top center. The current chip should be labeled with something like "210H9 - - -". See Table 9-9-8 for prom location. Gently pry the chip from its socket and replace it with the new chip. Install the chip in the left end of the socket with the notch facing to the right. Make sure that all of the legs insert into the socket correctly.
5. Re-attach the CPU board to the V/F board, and re-attach the assembly to the motherboard.
6. Turn the M200A ON and observe the front panel display. As the machine goes through the setup the version number will be displayed on the front panel. It should read the same as the version number printed on the prom.
7. Re-enter any non-default settings such as RANGE or AUTOCAL. Re-enter the SPAN values in the CAL-CONC menu. Check all settings to make sure that expected setup parameters are present.
8. Re-calibrate the Analyzer so that the default slope and intercept are overwritten with the correct values.

9 TROUBLESHOOTING, ADJUSTMENTS

NOTE

The operations outlined in this chapter are to be performed by qualified maintenance personnel only.



This section of the manual contains information on diagnosing and repairing instrument performance problems. It contains information on how to use and interpret TEST and DIAGNOSTIC data as well as WARNING messages the instrument generates. There is information on how to troubleshoot the instrument subsystems. Finally there is information to perform adjustments such as DAC calibration procedures.

This manual provides troubleshooting procedures that address problems to the board level. For component level troubleshooting, consult the schematics for the appropriate board in Appendix A.1.

NOTE

The values of the readings shown on the front panel of the instrument may at times read XXXXXX. This means that the reading is off scale and therefore meaningless.

General Troubleshooting

1. If the fault is light on and it stays on after you clear the warning messages, see Section 9.1.2.
2. Think of the analyzer as three sections:

   Section 1: Pneumatics - Over 50% of all analyzer problems are traced to leaks in the pump assembly, sample filter, instrument internal pneumatics, calibrator or external sample handling equipment. Suspect a leak first, and check Section 9.2.

   Section 2: Electronics - data processing section. This can be readily checked out using Electric Test in Section 9.1.3.2.

   Section 3: Optics - Optical section consisting of PMT, HVPS, Preamp, and signal processing. Refer to Section 9.1.3.3 on use of Optical Test.

3. Check the TEST functions:

   A. Compare the TEST functions to the factory values in Table 2-2-6. This will often provide important clues as to the problem.

   B. Pay special attention to the NO and NO_x slopes:

   C. The slopes are the software equivalent of the span pot on an analog instrument. If the slopes are not 1.0 ±0.3, the gain has changed. Do the following: Check the AutoZero reading in the TEST functions. Compare it to the value in the factory checkout Table 2-2-6. If the reading is significantly greater than the factory test value, the reaction cell could be contaminated or there could be a light leak in the cell. Verify this fault by turning the ozone generator off and see if the reading drops more than 25 mV.

   D. Check for a change in cell pressure(vacuum) - compare to value in Table 2-2-6. - possible causes:

      1) Partially plugged ozone killer

      2) Change of pump or malfunctioning pump

      3) Plugged pneumatics

      4) Change in altitude

4. Check for pneumatic leaks - perform the leak check procedure in Section 8.9 If slopes are different from each other by > .1, this usually indicates a leak in the switching (NO/NO_x) valve or improper calibration.

5. Check for light leaks - Turn off the ozone generator, then wait 7 minutes. If the reading drops significantly, the reaction cell is contaminated. If not a light leak is indicated.

6. Incorrect span gas concentration - this could come either from the calibrator or entering the expected span gas concentration in the M200A incorrectly, see Table 7-7-4.

7. If the instrument does not respond to span gas, check Section 9.2.3.

The above should get you started in diagnosing and repairing the most common faults. If these reasons have been eliminated, the next thing to do is a Factory Calibration covered in Section 9.1.6 or check Section 9.2 for other fault diagnosis. If difficulties persist, contact our service department. The 800 telephone number is on the cover page of this manual.

9.1 Operation Verification-M200A Diagnostic Techniques

9.1.1 Fault Diagnosis with TEST Variables

Table 9-9-1 indicates possible fault conditions that could cause the TEST functions to be outside the acceptable range.

Table 9-9-1: Test Functions

Test Function	Factory Set-Up	Comment
RANGE	500PPB	This is the Range of the instrument. In standard configuration all 3 outputs have the same range. Independent range option allows different ranges for each output. When enabled, there will be 3 range values displayed. Auto range option allows 2 different ranges for all outputs, and will automatically switch to the other range dynamically as concentration values require. The TEST values will show the range the instrument is currently operating in, and will dynamically display the alternate range as the range changes occur.
STABIL	Check value in Final Test Values Table 2-2-6	The instrument stability is the Std. Deviation of the last 10 min of NO_x conc data. It is computed for the NO_x channel only. The noise value only becomes meaningful if sampling a constant concentration for more than 20 minutes. The noise value should be compared to the value observed in the factory check-out. Faults that cause high noise values are: 1. Gas leaks 2. Light leak 3. Faulty HVPS 4. Defective Preamp board 5. Outgassing Moly converter 6. PMT recently exposed to room light 7. Dirty/contaminated reaction cell 8. Mis-calibrated (slope - offset outside of limits)
SAMPLE FLW	500 cc/min ± 50	This is the instrument flow. It is computed using the up stream and down stream pressures across the sample flow orifice. This method can give a false flow indication if the orifice is plugged and the sample pump is creating a pressure drop. It should be taken into account when diagnosing instrument faults. - A rapid method of determining if the orifice is plugged is to disconnect the sample and ozone tubes from the reaction cell, then briefly put your finger over the fittings on the cell. You should feel the vacuum build up. Also note the difference between the high sample flow and the low ozone flow rate. - Another reliable method is to attach a rotameter or soap bubble flowmeter to the fittings to measure the flows. Flow rate will change ± a few cc/min due to changes in ambient air pressure such as cycling of air conditioning, or passing weather fronts. Changing altitude changes the ambient air pressure and therefore the sample flowrate. This effect is about 15-20 cc/min per 1000 feet of altitude change. If required the output of the instrument can be compensated for pressure. See Section 5.3.9, Table 9-9-5.

(table continued)

Table 9-1: Test Functions (Continued)

Test Function	Factory Set-Up	Comment
OZONE FL	60 - 90	This is the Ozone flow. It is measured by a solid state flow meter, and thus is a true indication of flow. If you suspect there is no ozone being generated, disconnect the tube at the reaction cell and rub the end of the tube on your fingertips, then sniff your fingers. The odor of ozone should be readily apparent.
PMT	0-5000 mV	This is the instantaneous output of the PMT. During normal operation the value varies widely as the M200A switches from NO to NO_x to AutoZero modes. Changes in reading will be synchronized with valve switching. The PMT voltage values will be relatively constant when: 1. Electric test - variation in the 2000 mV signal observed will be sampling errors of the V/F board and preamp noise. See Section 9.1.3.2. 2. Optic test - variation in the 2000 mV signal will be PMT dark current, preamp, HVPS plus item 1 above. See Section 9.1.3.3. 3. Sampling zero gas - signal from 1, 2 plus signal from ozone generator air 4. Sampling pure NO span gas - signal will be 1, 2, 3, above plus signal from chemiluminescent reaction. Slight pulsations will be noticed as the M200A switches from NO to NO_x. This is due to differences in flowrates in each channel. These differences are taken out in the calibration process resulting in slightly different slopes for the NO and NO_x channels. Large pulsations when switching to the NO_x channel is indicative of a bad moly converter. When sampling zero gas the PMT reading should be less than 150 mV and relatively constant. High or noisy readings could be due to: 1. Excessive background light which is caused by a possible contaminated reaction cell. 2. Humidity (undried ambient air) in the ozone generator feed air. 3. PMT recently exposed to room light. It takes 24-48 hours for the PMT to adapt to dim light. 4. Light leak in reaction cell. 5. 5Improper slopes.
NORM PMT	0-5000 mV	The Normalized PMT reading is to be used as the PMT reading during the FACTORY CALIBRATION procedure. In addition to the raw mV reading from the PMT this reading is adjusted using certain other factors to produce an accurate reading for the Factory Calibration procedure.

(table continued)

Table 9-1: Test Functions (Continued)

Test Function	Factory Set-Up	Comment
AZERO	Check value in Final Test Values Table 2-2-6	AZERO is the current value of the AutoZero circuit reading. Values are typically 0 mV -20/+150. For values outside this range, check the AutoZero and NO/NO_x valve for cross port leaks. Use Diagnostic mode to manually check the AutoZero valve for correct operation.
HVPS	450-900 VDC	This represents the scaled-up HVPS programming voltage to the HVPS. The design of the HVPS precludes taking a single reading that indicates the health of the supply. Refer to the HVPS Troubleshooting Section 9.3.8.5 for a procedure for testing the HVPS. This TEST function is used primarily to set the HVPS voltage value. A value not in the 450 to 900 volt range indicates problems with the HVPS supply.
DCPS	2500 ± 200 mV	DCPS is a composite of the +5 and ± 15 VDC supplies. It has been arbitrarily set at 2500 ± 200 mV. If it is not in this range one of the voltages in the supply is not working. Check the procedures for diagnosing the Power Supply Module in Section 9.3.5.
RCELL TEMP	50 ± 1° C	The reaction cell temperature is controlled to 50° C ± 1° C by the computer. It should only read other values when the instrument is warming up. If the value is outside the acceptable range, go to the procedure for diagnosing the Reaction cell temp supply in Section 9.3.8.2. The alarm limits are less than 45° C and greater than 55° C.
BOX TEMP	8-48° C	The Box Temp is read from a thermistor on the Status/Temp board (01086). It should usually read about 5° C above room temp. The M200A is designed to operate from 5 to 40° C ambient. Therefore the box temperature should be in the range of about 10 to 50° C. Temperatures outside this range will cause premature failures of components, and poor data quality. Warning limits are < 8° C and > 48° C.
PMT TEMP	7 ± 1° C	The PMT detector is very temperature sensitive. The PMT temperature should always be 7° C, except at power-up. Temperatures more than ±1° C from the set point indicate problems with the cooler circuit. See Section 9.3.8.4 for PMT cooler diagnostic and troubleshooting. Warning limits are < 5° C and > 15° C.
MOLY TEMP	315 ± 5° C	Moly temp is controlled by the CPU to 315° C. After cold start it requires about 30 min to come to temperature. After temperature is reached temperature should not vary more than ± 5° C. See Section 9.3.4 for troubleshooting. Warning limits are < 290° C and > 320° C.

(table continued)

Table 9-1: Test Functions (Continued)

Test Function	Factory Set-Up	Comment
IZS TEMP	50 ± 0.4° C	The IZS temperature is the temperature of the permeation tube oven. This temperature is controlled by the CPU and is adjustable in 0.1° C increments. This adjustment allows small changes in permeation tube temperature so the permeation rate can be adjusted to an even value. The control loop variations show a temperature swing at the control thermistor of a few tenths of a degree. Temperature fluctuations of the perm tube however are less than 0.1° C. Warning limits are < 45° C and > 55 ° C.
RCEL PRESS	5 ± 1 in-Hg-A (Thomas 607) 7 ± 2 in-Hg-A (ASF internal)	RCEL is the pressure in the Reaction Cell. The instrument is very sensitive to variations in reaction cell pressure. 10% change in output per 1"Hg pressure is typical. The pressure reading will change when going to the AutoZero cycle, otherwise it should remain constant. Higher altitudes will decrease cell pressure due to lower pump back pressure. Pressures out of the acceptable range will decrease instrument noise performance and sensitivity.
SAMP PRESS	29.5"Hg at sea level	The sample pressure is taken just upstream of the reaction cell. It usually runs about 0.5" less than ambient pressure due to the restrictions in the sample intake tubing. Sample pressure should be within ± 1"Hg of atmospheric pressure. The pressure sensor used reports absolute pressure and therefore is sensitive to altitude, weather fronts, and room air conditioning. Changes due to altitude is about 1" per 1000 ft., other changes are ± 0.4" maximum. Pressurizing the sample inlet will cause the M200A to be noisy and to shift its reading.
SLOPE	1.0 ± 0.3	This is the software slope value. It operates like a software gain pot. Refer to Table 7-7-21 on Calibration Quality for additional information.
OFFSET	0 ± 150	This is the software offset value. It operates like a software DC offset pot. Refer to Table 7-7-21 on Calibration quality for additional information.
TIME		This is the time of day clock readout. It is used to time the AutoCal cycles. The speed of the clock can be adjusted by the CLOCK_ADJ variable in the VARS menu. The clock can be set via SETUP-CLOCK-TIME from the front panel.

9.1.2 Fault Diagnosis with WARNING Messages

The M200A monitors several internal values for alarm conditions. If the condition for an alarm is met, the alarm is displayed on the front panel and the warning is transmitted out the RS-232 port. If a warning is present, it can be cleared by pressing the CLR key on the front panel. If uncleared warnings are present they can be examined by pressing the MSG button on the keyboard. Any time the instrument is powered up the SYSTEM RESET alarm will be displayed. Generally, it is ok to ignore warnings that are displayed shortly after power-up, only if they persist should they be investigated.

Table 9-9-2 shows the warning messages and gives some possible causes.

Table 9-9-2: Front Panel Warning Messages

Message	Description
SYSTEM RESET	Analyzer was reset/powered on. This warning occurs every time the instrument is powered up, as in a power failure. It can also occur if the RAM or EEPROM is reset.
RAM INITIALIZED	RAM was erased. The RAM contains the DAS averages which get erased when the RAM is initialized. It also contains temporary data used by the M200A to calculate concentrations. No setup variables are stored in the RAM.
SAMPLE FLOW WARN	The calculated sample flow is outside the hi/low limits. Since the flow is calculated, it probably means the pressure has gotten too low. This can be caused by a plugged sample inlet, or water in ozone line into the reaction cell.
OZONE FLOW WARNING	Ozone flow out of spec. warnings occur most often because of loss of vacuum, which causes the ozone flow to go to zero. They also can occur due to a flow sensor failure.
RxCELL PRESS WARNING	Vacuum out of spec. warnings are caused by leaks, pump failure or disconnected pump.
BOX TEMP WARNING	Box temp. out of spec. Instrument fan failure, enclosure temperature failure. Operation of the M200A in a too warm or cold environment will cause degradation of data quality and shorten the life of the instrument.
RCELL TEMP WARNING	Reaction cell temp. out of spec. The warning message is most often present during initial warm-up or if the connector to the heaters is not plugged in after dis-assembly. It has also occurred if the thermistor is not in position in the reaction cell.
IZS TEMP WARNING	IZS temp. out of spec. The warning message is most often present during initial warm-up or if the connector to the heaters is not plugged in after dis-assembly. Also check the position of the thermistor in permeation tube heater block. Check to see if there is a good seal at the top of the heater block.

(table continued)

Table 9-2: Front Panel Warning Messages (Continued)

Message	Description
PMT TEMP WARNING	PMT temp. out of spec. The PMT temp has its own proportional controller on the preamp (01141) board. Warnings will occur during initial operation. The warning can occur if the 7 pin connector to the interior of the sensor is not plugged in. The power connector to the PSM should be checked for proper voltage (+15 VDC ± 0.5).
MOLY TEMP WARNING	Molycon temp. out of spec. The Moly temp is controlled by the CPU. It has a thermocouple with amplifier on the 01086 Status/Temp board. Because of the high temperature of the Moly (315° C), the moly temp warning will tend to be the last warning to clear as the instrument is powered on.
CANNOT DYN ZERO	Dynamic zero cal. out of spec. The reading of the PMT was too high for the ZERO button to appear. Make sure the instrument is receiving zero gas. Check for dirty reaction cell. Do the factory calibration procedure located in Section 9.1.6.
CANNOT DYN SPAN	Dynamic span cal. out of spec. The reading of the PMT was too high or low for the SPAN button to appear. Make sure the instrument is receiving correct concentration span gas. Make sure the expected span concentration is entered. Check for dirty reaction cell. Do the factory calibration procedure located in Section 9.1.6.
OZONE GEN OFF	Ozone Generator is off. See Table 9-9-17for conditions.
AZERO WRN XXX.X MV	The AutoZero circuit compensates for detector dark current, and background light. Certain electrical faults cause high readings to be added to the filter. First, the cause of the high ZutoZero reading should be found and repaired, then wait 15 minutes for the AutoZero filter to clear itself out.
A/D NOT INSTALLED	V/F (00514) board has failed. The V/F board did not respond to commands from the CPU. This probably means 1. board not seated in socket 2. defective board 3. defective back plane connector.
HVPS WARNING	High Voltage Power Supply voltage out of limits. Limits are 400-900 VDC.
DCPS WARNING	DC Power Supply voltage out of limits. Limits are 2500 ± 500 mV.

9.1.3 Fault Diagnosis Using DIAGNOSTIC Mode

Diagnostic mode can be looked at as a tool kit of diagnostics to help troubleshoot the instrument.

To enter DIAG mode press SETUP-MORE-DIAG.

The diagnostic modes are summarized in Table 9-9-3. To access these functions, press SETUP-MORE-DIAG, then press NEXT, PREV to select the desired mode, then press ENTR to select that mode.

Table 9-9-3: Summary of Diagnostic Modes

DIAG Mode	Description
SIGNAL I/O	Gives access to the digital and analog inputs and outputs on the V/F board. The status or value of all of the signals can be seen. Some of the signals can be controlled from the keyboard. Table 9-9-4 gives details on each signal and information on control capabilities. NOTE: Some signals can be toggled into states that indicate warnings or other faults. These settings will remain in effect until DIAG mode is exited, then the M200A will resume control over the signals.
ANALOG OUTPUT	Causes a test signal to be written to the analog output DAC's. The signal consists of a scrolling 0%, 20%, 40%, 60%, 80%, 100% of the analog output value. The scrolling may be stopped by pressing the key underneath the % display to hold that value. The exact voltage values depend on the jumper settings on the analog output buffer amplifiers.
D/A CALIBRATION	The analog output is created by 4 digital-to-analog converters. This selection starts a procedure to calibrate these outputs. Refer to Section 9.3.3.1 for a detailed procedure.
TEST CHANNEL	Allows several different internal voltages to be routed to an analog output port. Useful for diagnosing intermittent instrument faults.
OPTICAL TEST	Sets the M200A into a known state and turns on an LED near the PMT to test the instrument signal path. See Section 9.1.3.3 for details on using this test.
ELECTRICAL TEST	Tests just the electronic portion of the PMT signal path. Used in conjunction with optic test, see Section 9.1.3.2.
O3 GEN OVERRIDE	This function controls the power to the ozone generator. It does not indicate status of the generator.
RS-232	Causes a 1 second burst of data to be transmitted from the RS-232 port. Used to diagnose RS-232 port problems. See Section 9.1.3.7, 9.3.2 for RS-232 port diagnostic techniques.

9.1.3.1 Signal I/O Diagnostic

Table 9-9-4: Diagnostic Mode - Signal I/O

No.	Signal	Control	Description
0	DSP_BROWNOUT	NO	Display brownout is used to keep the display from getting corrupted during low line voltage conditions. Circuitry on the Status/Temp board (01086) senses low line voltage and sets this bit. The CPU reads this and generates the BROWNOUT_RST signal described below.
1	EXT_ZERO_CAL	NO	Shows state of status input bit to cause the M200A to enter Zero Calibration mode. Use to check external contact closure circuitry.
2	EXT_SPAN_CAL	NO	Shows state of status input bit to cause the M200A to enter the Span Calibration mode. Use to check external contact closure circuitry.
3	SPAN_VALVE	YES	Switches the IZS Zero/Span valve. Use this bit to test the valve function.
4	CAL_VALVE	YES	Switches the IZS Sample/Cal valve. Use this bit to test the valve function.
5	NOX_VALVE	YES	Switches the NO/NO_x valve. Use this bit to test the valve function.
6	RCELL_HEATER	YES	Shows the status of the reaction cell heater. This has the same function as the LED in the Power Supply Module.
7	IZS_HEATER	YES	Shows the status of the IZS permeation tube heater. This has the same function as the LED in the Power Supply Module.
8	ELEC_TEST	YES	Turns on electric test bit in preamp. Should be used for troubleshooting Preamp logic lines. We recommend you use the ELEC TEST button in the DIAG menu to operate electric test.
9	OPTIC_TEST	YES	Turns on optic test bit in preamp. Should be used for troubleshooting Preamp logic lines. We recommend you use the OPTIC TEST button in the DIAG menu to operate optic test.

(table continued)

Table 9-4: Diagnostic Mode - Signal I/O (Continued)

No.	Signal	Control	Description
10	BROWNOUT_RST	YES	Brownout reset works in conjunction with DSP_BROWNOUT. When DSP_BROWNOUT is set, the CPU sends a signal to reset the display and clear the DSP_BROWNOUT.
11	CONV_HEATER	YES	Shows the status of the Moly heater. This has the same function as the LED in the Power Supply Module.
12	O3GEN_STATUS	YES	Switches ON/OFF power to the ozone generator.
13	AUTO_ZERO_VALVE	YES	Switches the AutoZero valve. Use this bit to test the valve function.
14	PREAMP_RANGE_HI	YES	Switches the preamp(01105) hardware range. Standard ranges are 2000 and 20,000 ppb. Logic high = 20,000 ppb; logic low = 2000 ppb. M200A will reset range to correct value based on user set range value.
15	ST_RCEL_PRESS	YES	Status Bit - Reaction Cell Pressure alarm Logic High = pressure out of acceptable range Logic Low = pressure inside acceptable range
16	ST_ZERO_CAL	YES	Status Bit - Zero Calibration mode Logic High = M200A in Zero cal mode Logic Low = Not in Zero cal mode
17	ST_SPAN_CAL	YES	Status Bit - Span Calibration mode Logic High = M200A in Span cal mode Logic Low = Not in Span cal mode
18	ST_FLOW_ALARM	YES	Status Bit - Flow alarm Logic High = Sample/Ozone flow out of spec Logic Low = Flows within spec
19	ST_TEMP_ALARM	YES	Status Bit - Temperature alarm Logic High = Rxcell, Moly, IZS, Box temps out of spec Logic Low = Temps within spec
20	ST_DIAG_MODE	YES	Status Bit - In Diagnostic mode Logic High = M200A in Diagnostic mode Logic Low = Not in Diag mode

(table continued)

Table 9-4: Diagnostic Mode - Signal I/O (Continued)

No.	Signal	Control	Description
21	ST_POWER_OK	YES	Status Bit - Power OK Logic High = Instrument power is on Logic Low = Instrument power is off
22	ST_SYSTEM_OK	YES	Status Bit - System OK Logic High = No instrument warnings present Logic Low = 1 or more alarms present
23	ST_HIGH_RANGE	YES	Status Bit - Autorange High Range Logic High = M200A in high range of autorange mode Logic Low = M200A in low range of autorange mode
24	PMT_SIGNAL	NO	Current PMT voltage. Same as PMT voltage in TEST menu. Bi-polar, typically in 0-5000 mV range. A constant value of 5000 mV indicates offscale.
25	SAMPLE_PRESs	NO	Sample pressure in mV. Typical sea level value = 4300 mV for 29.9" Hg-A.
26	RCELL_TEMP	NO	Reaction Cell temperature. Typically 3500 mV for 50° C.
27	BOX_TEMP	NO	Box Temperature. Typically 1800 mV for 25° C
28	IZS_TEMP	NO	IZS permeation tube oven temp. Typically 3500 mV for 50° C.
29	PMT_TEMP	NO	PMT cold block temperature. Typically 3600 mV for 10° C.
30	DCPS_VOLTAGE	NO	DC power supply composite voltage output. Typically 2500 mV.
31	RCELL_PRESS	NO	Reaction Cell Pressure in mV. Typically 1270 mV for 5" Hg-A at sea level. Is an absolute pressure so higher values means higher absolute pressures.
32	OZONE_FLOW	NO	Ozone flowmeter voltage. Typically 2000 mV at 80 cc/min.
33	CONV_TEMP	NO	Molybdenum Converter temp. Typically 3150 mV at 315° C.
34	HVPS_VOLTAGE	NO	HVPS programming voltage. Output of HVPS is 1000x value present. 700 mV = 700 VDC output.

(table continued)

Table 9-4: Diagnostic Mode - Signal I/O (Continued)

No.	Signal	Control	Description
35	DAC_CHAN_0	NO	Output of NO_x channel in mV.
36	DAC_CHAN_1	NO	Output of NO channel in mV.
37	DAC_CHAN_2	NO	Output of NO_2 channel in mV.
38	DAC_CHAN_3	NO	Test Channel output. Not implemented in current software.
39	NOX_CONC	YES	NO_x DAC programming voltage. The following 4 signals can be set to output specific voltages to each DAC. Use in conjunction with ANALOG OUTPUT test to check each DAC output channel. The value keyed in should appear on the the appropriate analog output channel. This value overrides data being written from the analyzer. Value reverts to instrument output when function is exited.
40	NO_CONC	YES	NO DAC programming voltage. See above for description.
41	NO2_CONC	YES	NO_2 DAC programming voltage. See above for description.
42	TEST_OUTPUT	YES	TEST channel programming voltage. See above for description.

9.1.3.2 Electric Test

This function injects a constant voltage between the preamplifier and the buffer amplifier on the preamp board. Electric test checks part of the preamp, the V/F and computer for proper functioning. The result of electric test should be a smooth quiet signal as shown by constant values for the NO, NO_x concentrations, the NO_2 concentration should be near zero. Likewise the analog outputs should produce a smooth quiet trace on a strip chart.

Procedure:

1. Scroll the TEST function to PMT.
2. Press SETUP-MORE-DIAG, then scroll to ELECT TEST by pressing the NEXT button. When ET appears, press ENTR to turn it on.

3. The value in PMT should come up to 2000 mV ± 500 mV in less than 15 sec.

   If the HVPS or the span gain adjust on the preamp card has been changed without doing a FACTORY CALIBRATE the reading in step 3 may be different than 2000 mV, since the overall calibration affects ELECTRIC TEST. See Section 9.1.6 for factory calibration procedure.

4. To turn off ET press EXIT.

   If ET is a steady 2000 ± 500 mV, that means the Power Supply Module, Preamp buffer amplifier, V/F, CPU, and display are all working properly.

9.1.3.3 Optic Test

Optic test turns on a small LED inside the PMT housing which simulates the signal from the reaction cell. OT tests the entire signal detection subsystem. By observing the level, noise and drift of this test, correct operation of many sections of the analyzer can be verified.

The implementation of OT involves several changes to the instrument operating conditions. The M200A does the following when switching to optic test:

1. Saves the current instrument setup as to autorange, indep range, current range and places the instrument into the 2000 ppb range.
2. Turns off power to the ozone generator to assure there is no interfering light from the reaction cell.
3. Disables the AUTOZERO circuit.
4. Turns on the OT LED, the PMT reading in TEST functions should be 2000 ± 1000 mV.

To turn on OT, press SETUP-MORE-DIAG, then scroll to OPTIC TEST, then press ENTR.

If the HVPS or the span gain adjust on the preamp card has been changed without doing a FACTORY CALIBRATE the reading in step 4 may be different than 2000 mV, since the overall calibration affects OPTIC TEST. See Section 9.1.6 for factory calibration procedure.

9.1.3.4 Ozone Gen Power

This diagnostic manually turns the power off and on to the ozone generator. When the M200A is powered up from a cold start the ozone generator is not immediately started. This is due to the fact that humid air may be present in the generator cartridge. Humid air can produce nitric acid aerosol which can permanently damage parts of the instrument down stream of the generator. Using this diagnostic, it is possible to turn on the generator before the warmup time has elapsed. If you turn the power on it will remain on after you exit the diagnostic.

9.1.3.5 Analog Out Step Test

The Step Test is used to test the functioning of the 4 DAC outputs on the V/F board. The test consists of stepping each analog output 0-20-40-60-80-100% of the output. If the analog outputs are set for 0-5V full scale the outputs would step 0-1-2-3-4-5 VDC. The stepping can be halted at any value by pressing the key under the percentage on the front panel. When the test is halted, square brackets are placed around the percentage value in the display. Pressing the key again resumes the test. This test is useful for testing the accuracy/linearity of the analog outputs.

9.1.3.6 DAC Calibration

The Digital to Analog Converters (DAC) are calibrated when the instrument is set up at the factory. Re-calibration is usually not necessary, but is provided here in case the V/F board needs to be replaced and re-calibrated. The procedure for using the DAC Calibration routines are in the Troubleshooting Section 9.3.3.1.

9.1.3.7 RS-232 Port Test

This test is used to verify the operation of the RS-232 port. It outputs a 1 second burst of the the ASCII letter 'w'. During the test it should be possible to detect the presence of the signal with a DVM on pin 2 or 3 (depending on the DTE/DCE switch setting) or by the flickering of the red test LED. A detailed procedure is given in the Troubleshooting Section 9.3.2.

9.1.4 M200A Internal Variables

The M200A software contains many adjustable parameters. Most of the parameters are set at time of manufacture and do not need to be adjusted for the lifetime of the instrument. Some of the variables are user adjustable, they are listed in Table 9-9-5.

To access the VARS menu press SETUP-MORE-VARS-ENTR. Use the PREV-NEXT buttons to select the variable of interest, then press EDIT to examine/change the value, then press ENTR to save the new value and return to the next higher menu. If no change is required, press EXIT.

TPC_ENABLE

The M200A has temperature and pressure compensation. T/P comp adjusts the output of the instrument for changes in sample temperature, reaction cell pressure, and atmospheric pressure.

The sample temperature is controlled by the temperature of the reaction cell. The setpoint is 50° C, and the value of the adjustment parameter is equal to 1.0000 when the reaction cell temperature is 50° C. The temperature compensation increases sample concentration with increasing temperature to compensate for the drop in density of gas in the reaction cell.

The reaction cell pressure compensation factor is equal to 1.0000 when the cell pressure is 5"-Hg-A. The compensation factor increases sample concentration with increasing cell pressure to compensate for increased quenching of the chemiluminescent reaction at higher pressures. The pressure compensation correction has been found to work adequately up to about 8000 ft (2400m) altitude.

The sample pressure compensation factor is equal to 1.0000 at 29.92"-Hg-A. This factor increases sample concentration with decreasing sample pressure to compensate for a lower head pressure on the sample flow orifice.

Taken together, the three factors change the output of the instrument very little. The sample temperature is essentially invariant, and the cell pressure and sample pressure factors tend to cancel each other. The resultant coefficient has no practical variation with pressure changes due to weather fronts. Changes in altitude of 1000 feet usually change the output of the instrument by about 0.5% if compensation is turned off, much less if it is operating.

Table 9-9-5: Model 200A Internal Variables

No.	Name	Units	Default Value	Value Range	Description
0	DAS_HOLD_OFF	min	15	0-60	Time that data is not put into DAS after CAL or DIAG modes
1	TPC_ENABLE	Logic	OFF	ON-OFF	Temp/Pres compensation enable
2	DYN_ZERO	Logic	OFF	ON-OFF	Enable zero calibration during rear panel contact closure zero mode
3	DYN_SPAN	Logic	OFF	ON-OFF	Enable span calibration during rear panel contact closure span mode
4	SFLOW_SET	cc/min.	500	400-1000	Nominal sample flow rate
5	OFLOW_SET	cc/min.	80	0-500	Nominal ozone flow rate
6	IZS_SET	° C	50	30-70	IZS temperature set point
7	RS232_MODE	Bit Field	0	0-99999	Value is SUM of following decimal numbers: 1=enable quiet mode 2=enable computer mode 4=enable security feature 8=enable front panel RS-232 menus 16=enable alternate protocol 32=enable multidrop protocol
8	CLOCK_ADJ	Sec.	0	+-60	Real-time clock speed adjustment
9	CAL_ON_NO2		OFF	ON-OFF	Enable calibrate on NO_2 perm tube

9.1.5 Test Channel Analog Output

Many of the TEST functions have an analog voltage associated with them. As a diagnostic aid it is possible to route the various test voltages out the 4th analog output.

Table 9-9-6: Test Channel Readings

TEST Channel	Minimum*	Maximum*	Description
PMT DETECTOR	0 mV	5000 mV	PMT detector output from the preamp. This signal has been amplified and filtered. Since the instrument is switched and uses AutoZero, normal values can vary from –100 to 5000 mV. Wide variations in this signal are normal. Values should be around 0 mV when sampling zero air.
OZONE FLOW	0 cc/min	1000 cc/min	This signal is the output from the ozone flowmeter. Values around 1150 mV indicate zero flow. Typical values for 80 cc/min ozone flow are around 1800 mV. Voltage should be steady, indicating stable flow.
SAMPLE FLOW	0 cc/min	1000 cc/min	The sample flow is calculated from the upstream pressure as measured by the SAMPLE PRESSURE transducer.
SAMPLE PRESSURE	0 " Hg-Abs	40 "-Hg-Abs	The sample pressure is measured by an absolute pressure meter. The absolute pressure at sea level is 29.92"-Hg. The exact reading will vary a few tenths due to passing weather fronts and daily temperature cycling. The reading will decrease about 1"-Hg with each 1000 ft gain in altitude. For example, the absolute pressure at 10,000-ft (3000 m) is about 20"-Hg-A. A typical value near sea level would be about 4200 mV.
RCELL PRESSURE	0 " Hg-Abs	40 "-Hg-Abs	Like the SAMPLE PRESSURE the RCELL pressure is an absolute pressure measurement. With the sample pump off, it should read about atmospheric pressure. With the pump operating, a typical value is 1300 mV for about 5"-Hg-A reaction cell pressure.
RCELL TEMP	0° C	70° C	Reaction Cell temperature is set to 50° C. At the setpoint, a typical reading is 3600 mV.
BLOCK TEMP	0° C	70° C	The Block temperature is set to 50° C. At the setpoint, a typical reading is 3600 mV.

(table continued)

Table 9-6: Test Channel Readings (Continued)

TEST Channel	Minimum*	Maximum*	Description
IZS TEMP	0° C	70° C	The IZS temperature is set to 50° C. At the setpoint, a typical reading is 3600 mV.
CONV TEMP	0° C	1000° C	The Converter temperature is 315° C. At the setpoint, a typical voltage is 3150 mV.
PMT TEMP	0° C	70° C	The PMT temperature is unique in that the voltage is inverse to the temperature. A typical reading for 8° C would be 4200 mV.
CHASSIS TEMP	0° C	70° C	The Chassis (Box) temperature is variable due to variable ambient air temperature. The Box temp generally runs about 5° C above the surrounding air temp. Thus in a 25° C room, the Box temp would be about 30° C and have a TEST channel voltage of about 2000 mV.
DCPS VOLTAGE	0 mV	5000 mV	The DCPS is a composite of several DC power supply voltages in the instrument. It has been arbitrarily set at 2500 mV, which is typical.
HVPS VOLTAGE	0 V	5000 V	The HVPS voltage is a scaled up reading of the programming voltage going to the HVPS. Zero to 1000 mV corresponds 0-1000 VDC for the HVPS, which is the maximum voltage possible. A typical reading would be 700 mV corresponding to 700 VDC for the HVPS.

* Minimum and Maximum readings depend on the DAC 3 switch settings of the V/F board. For the standard ±5 VDC range, minimum corresponds to 0 VDC and maximum corresponds to 5 VDC.

9.1.6 Factory Calibration Procedure

The Factory Cal procedure balances the PMT, preamp, and software gain factors so the instrument has optimum noise, linearity, and dynamic range. It should be used when you are unable to zero or span the instrument, when the slope and offset values are outside of the acceptable range, or when other more obvious reasons for problems have been eliminated.

Factory Calibration Procedure:

NOTE

In this procedure a range of 500 ppb and a span gas concentration of 400 ppb is used as an example. Other values can be used.

1. On the Preamp board (see Appendix for schematics), set S1 and S2 to 8. Turn R19 20 turns clockwise, then 3 turns counter-clockwise (see figure 2-5).
2. Set RANGE MODE to SNGL by SETUP-RNGE-MODE-SNGL to select single range operation.
3. Set the RANGE to 500 ppb by SETUP-RNGE-SET and key in 500, then press ENTR.
4. Input Zero gas into the sample port, and Scroll to the TEST function labeled PMT. Typical reading should be less than 50 mV. Readings above 150 mV indicate a pneumatic leak, light leak, contaminated reaction cell, bad zero gas, or wet air coming into the ozone generator. If readings are greater than ±150 mV, the instrument will not zero or span properly, see Sections 9.2.8, 9.2.9.
5. Allow the instrument to sample zero gas for at least 20 minutes to re-fill the internal data filters and autozero filter with zero readings. Then zero the instrument by CAL-ZERO-ENTR.
6. Set the expected span concentration to 400ppb. Enter the expected NO_x concentration of 400 ppb by pressing CAL-CONC-NOX. Then press CAL-CONC-NO, to enter the expected NO concentration of 400 ppb. Then press EXIT to return to the CAL menu.
7. Input 400 ppb of NO span gas in the sample inlet port.
8. Scroll to the NORM_PMT - TEST function.

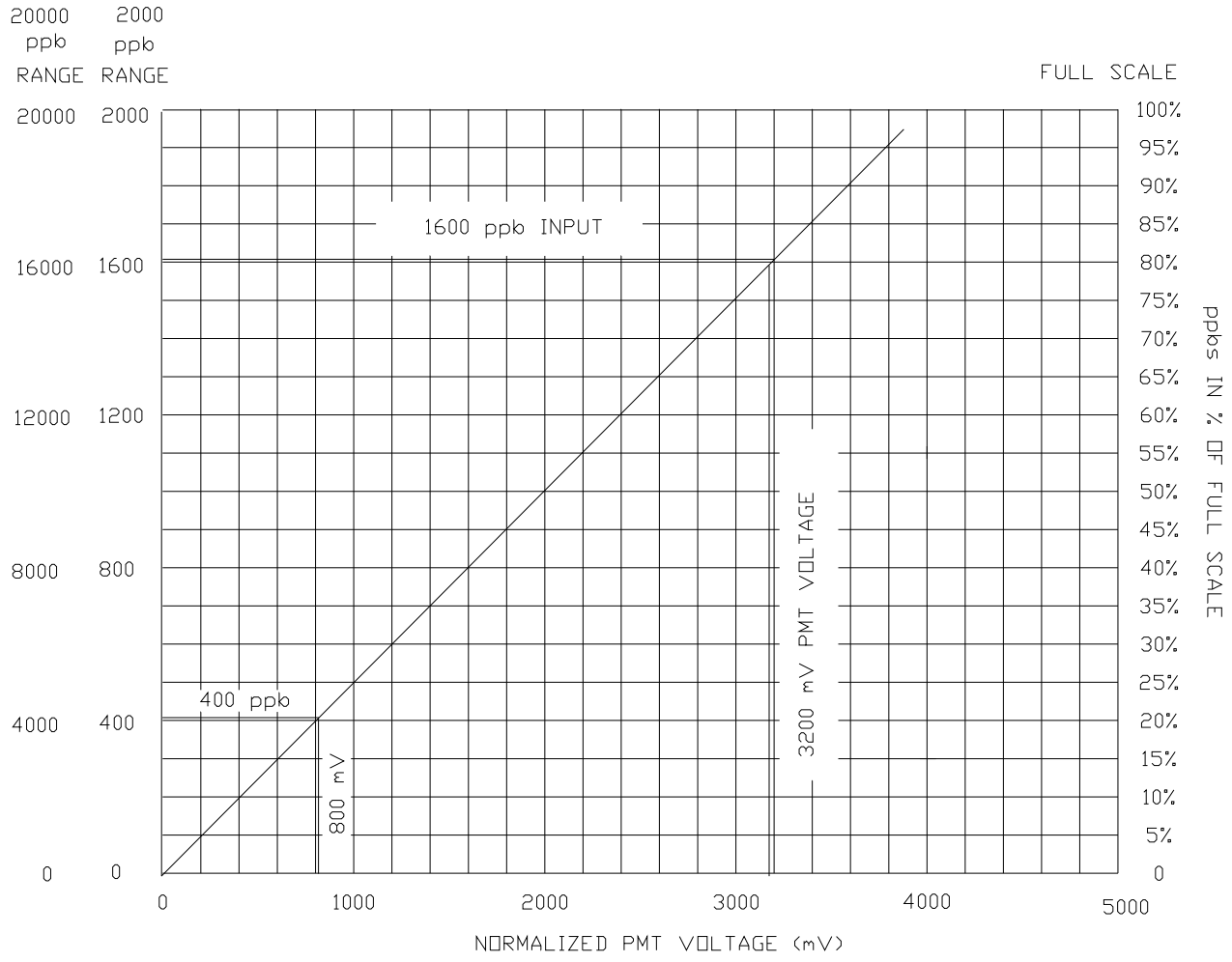
9. Calculate the expected NORM PMT mV reading.

   For ranges up to 2000 ppb, multiply the expected span value by 2 to get the mV reading.

   For ranges 2001 to 20000 ppb, multiply the expected span value by .2 to get the mV reading.

   In this example the expected span gas concentration is 400 ppb and therefore the expected voltage is 800 mV. As an alternate method, the voltage can be determined from the graph in Table 9-9-7. On the Y-axis find the calibration concentration in ppb, then determine the expected voltage from the X-axis.

10. Adjust S2, the HVPS coarse adjustment, on the preamp board to the setting that produces a signal that is closest to 800 mV. Adjust S1, the HVPS fine adjustment, to the setting that produces a signal that is closest to 800 mV. Use R19 to trim the reading to 800 ± 50 mV. The readings will periodically go to zero as the AutoZero circuit operates, ignore the zero readings.
11. Allow the instrument to sample span gas for 30 minutes. Then do a span calibration by CAL-SPAN-ENTR. After the span is completed, do the span quality check procedure in Table 7-7-21. This procedure is extremely important to assure that the instrument will operate with optimum noise, linearity, and dynamic range.



FOR RANGES 0 - 2000 PPB MULTIPLY THE PPB RANGE SETTING BY 2 TO GET THE NORMALIZED PMT mV SETTING

FOR RANGES 2001 TO 20,000 PPB MULTIPLY THE PPB RANGE SETTING BY .2 TO GET THE NORMALIZED PMT mV SETTING

FOR INFORMATION ON USING THIS FIGURE SEE SECTION 9.1.6 FACTORY CALIBRATION PROCEDURE

Table 9-9-7: Span Calibration Voltage

Electric Test (ET) Procedure:

1. To adjust ET press SETUP-MORE-DIAG, then scroll to ELEC TEST and press ENTR.
2. Scroll the TEST functions until PMT is displayed.
3. Adjust R27 until 2000 mV ± 100 is displayed.
4. Press EXIT to return to SAMPLE mode.

Optic Test (OT) Procedure:

1. To adjust OT press SETUP-MORE-DIAG, then scroll to OPTIC TEST and press ENTR.
2. Scroll the TEST functions until PMT is displayed.
3. Adjust R25 until 2000 mV ± 100 is displayed.
4. Press EXIT to return to SAMPLE mode.

If this procedure does not produce an instrument that will properly span, please contact your local distributor or the Teledyne API factory. Teledyne API's phone number is on the front page of this manual.

9.2 Performance Problems

When the response from a span check is outside the control limits, the cause for the drift should be determined, and corrective action should be taken. Some of the causes for drift are listed below:

NOTE

It has been our experience that about 50% of all analyzer performance problems are sooner or later traced to leaks in some part of the system.

1. Fluctuations in flow. Such as leaks or plugged orifices.
2. Lack of preventive maintenance.
3. Change in zero air source.
   A. Air containing NO leaking into zero air line.
   B. Saturation of charcoal and/or Purafil scrubbers.

4. Change in span gas concentration.
   A. Zero air or ambient air leaking into span gas line.
   B. Permeation tube or cal gas tank exhaustion.
5. Leak in NO/NO_x or AutoZero switching valves.
6. Loose pneumatic fittings.

9.2.1 AC Power Check

1. Check that power is present at main line power input. Verify that correct voltage and frequency is present. If unit is set for 240 VAC and is plugged into 115 VAC it will appear as a no power fault.
2. Check that the unit is plugged into a good socket. Analyzer must have 3-wire safety power input.
3. Check circuit breaker. The circuit breaker is part of the front panel power switch. It is set each time the instrument power is turned on. If there is an internal short causing a trip, the switch will automatically return to the OFF position when an attempt is made to turn it on.

9.2.2 Flow Check

1. Check TEST function RCEL - this is the absolute pressure in the reaction cell. It should be 5 - 10 in-Hg-A.
2. Check that pump is running. Check RCEL - TEST function for proper pressure.
3. Check that the pump tubing is connected to rear of analyzer.
4. Test that pump is producing vacuum by removing fitting at rear of analyzer and checking for suction at fitting.
5. Check for flow at reaction cell.
   A. Remove the 1/8" fitting that carries sample (this tube comes from the valve assembly on the moly converter). Plug the fitting on the reaction cell with your finger and note the vacuum produced.
   B. Remove the ozone fitting also and compare relative flow rates. Sample should be much higher (500 cc/min) than ozone (80 cc/min).
   C. Re-connect the sample and ozone lines, then check RCEL TEST function for proper vacuum reading. Should be 5 - 10"Hg-A.
6. Check for broken flow or pressure sensor.
7. Leak check analyzer. See Section 8.9 for leak check procedure.

9.2.3 No Response to Sample

1. Confirm correct operation of analog output by performing Analog Output Step Test in Section 9.1.3.5.
2. Confirm general operation of analyzer.
   A. Check for AC Power, Section 9.2.1.
   B. Do flow checks, Section 9.2.2.
   C. Confirm that sample gas contains NO or NO_2.
3. Check instrument electronics.
   A. Do ELEC TEST procedure in DIAGNOSTIC menu Section 9.1.3.2.
   B. Do OPTIC TEST procedure in the DIAGNOSTIC menu Section 9.1.3.3.

   If the M200A passes ET and OT, that means the instrument is capable of detecting light and processing the signal to produce a reading. Therefore, the problem is in the pneumatics or ozone generator.
4. Check ozone generator subsystem. Do diagnostic test of ozone generator subsystem, see Section 9.3.6.
5. Check for disconnected electrical cables to sensor module.

9.2.4 Negative Output

1. Mis-calibration. The 'zero' gas that was used to zero the M200A contained some NO gas - that is, it had more NO gas than that of the sample air. May also be caused by doing a zero calibration using ambient air. If NO/NOx OFFSET - TEST functions are greater than 150 mV, reaction cell contamination is indicated.
2. Corruption of the AutoZero filter. If a significant signal was detected during the AutoZero cycle, that higher reading can enter the AutoZero filter. The value of the AutoZero filter is subtracted from the current reading, thus producing a negative reading. High AutoZero readings can be caused by:
   A. Leaking AutoZero valve.
   B. Electronic fault in the preamp causing it to have a voltage on the PMT output pin during the AutoZero cycle.
   C. Reaction cell contamination causing high background (>40 mV) light readings.
   D. Broken PMT temperature control circuit, allowing high zero offset.

   After fixing the cause of the high AutoZero filter readings, the M200A will take 15 minutes for the filter to clear itself.
3. Check for leaks.
4. Check for used up zero air canister, if the instrument has the IZS option and the canister is being used to zero the instrument.

9.2.5 Excessive Noise

Common reasons for excessive noise are:

1. Leak in pneumatic system.
2. Light leak - check the sensor module with strong light.
3. HVPS noisy - see HVPS test procedure. See Section 9.3.8.5.
4. Defective electronic components on preamp board. - use optic test and electric test to check electronics, optics and observe noise.
5. Contamination of ozone generator and/or reaction cell - This can be wet air or impurities. This can be detected by high PMT readings with zero air as sample gas. Verify this condition by turning off the ozone generator using the DIAG mode command and observing a drop in PMT reading of more than 50 mV or 25 ppb. If the ozone generator or reaction cell is contaminated, disassemble and clean.
6. Broken PMT temperature control circuit. Check PMT TEMP - TEST function.
7. Mis-calibration. Check NO/NOx SLOPES in TEST function.
8. Reaction cell pressure too high. Check RCEL - TEST function.

9.2.6 Unstable Span

Common causes are:

1. Leak in pneumatic system.
2. Light leak - check the sensor module with strong light.
3. Instrument not fully warmed up.
4. Sample lines or sample filter dirty - clean or replace.
5. Plugged sample inlet orifice - clean with methanol and sonic cleaner.
6. Defective HVPS - see HVPS test procedure.
7. Bad or defective PMT detector - replace.
8. Reaction cell temp not stable - observe warning messages, or RCELL TEMP in TEST functions. Check diagnostic LED in Power Supply Module for normal cycling.
9. Large variations in ambient temperature - observe warning messages, or BOX TEMP in TEST functions.
10. Large variations in line voltage. - Line voltage should remain within +-10% of nominal.
11. Pump not maintaining steady vacuum - observe warning messages, or RCEL in TEST functions.
12. Sample vent line too short, allowing room air to mix with span gas. Line should be a minimum of 15" long.
13. Calibration gas source unstable - if equipped with IZS option, permeation tube could be nearing exhaustion or IZS oven temperature is unstable, check warning messages, or observe IZS TEMP in TEST function.
14. IZS permeation tube unstable -
    A. IZS subsystem leaking - leak check
    B. IZS zero air scrubber exhausted - replace charcoal and Purafil
    C. Moly converter efficiency unstable - check converter efficiency or replace
    D. IZS oven temperature unstable - verify stable temperature
    E. Permeation tube installed upside down or wrong side, see Table 6-6-6 for correct installation.
    F. Variations in humidity. The permeation tube changes output depending on the humidity of the dilution air. Room air is drawn into the zero air scrubber. If the room air has high humidity or if the humidity varies, the output of the permeation tube will be unstable.

9.2.7 Unstable Zero

Common causes are:

1. Leak in pneumatic system. Perform leak check, see Section 8.9.
2. Miscalibration. See Table 7-7-1.
3. Light leak - check the sensor module with strong light.
4. If equipped with IZS, zero air scrubber exhausted - replace charcoal and Purafil.
5. Sample lines or sample filter dirty - clean or replace.

9.2.8 Inability to Span

If the SPAN button is not illuminated when attempting to span, that means the reading is outside of the software gain ranges allowed. In an analog instrument it would be the equivalent to the span pot hitting the rotation stop.

Here are some things to check:

1. Check the expected span concentration values in CAL-CONC-NOX and CAL-CONC-NO, and compare them to the values of the calibration span gas being input. They should be nearly equal.
2. Check the PMT - TEST function. With NO span gas in the instrument, the value should be 2x the expected span concentration in step 1. above for range settings up to 2000 ppb. If over 2000 ppb, the value should be 0.2x the expected span concentration.
3. Check ET and OT for a response to 2000 mV on the PMT - TEST function.
4. If the above do not check out, perform the Factory Calibration Procedure Section 9.1.6.
5. If the PMT voltage is near zero with span gas, check fuse and power to ozone generator.

9.2.9 Inability to Zero

If the ZERO button is not illuminated when attempting to zero, that means the reading is outside of the software gain ranges allowed. In an analog instrument it would be the equivalent to the zero pot hitting the rotation stop. Check the following:

Select the PMT - TEST function. With zero gas going into the instrument, the value should be less than 150 mV, typically less than 50 mV. If you are getting a high reading, the probable reasons are:

1. The reading may be temporarily high if the PMT has been recently exposed to room light. If so, let the instrument run for several hours with zero gas to get the PMT accustomed to low light levels.
2. Leak that admits gas containing NO.
3. Contaminated reaction cell. Remove and clean cell.
4. Wet (i.e., undried ambient air) air into the ozone generator. Check the PermaPure drier and associated plumbing for leaks and correct operation.
5. Zero gas that isn't really zero. Make sure you're not trying to zero the machine with ambient air or span gas.
6. AutoZero filter is corrupted with high readings. To clear the AutoZero filter, input zero gas and wait for 15 minutes for the filter to clear.

9.2.10 Non-Linear Response

Common causes are:

1. Leak in pneumatic system, see Section 8.9.
2. High zero background - the PMT TEST function should be near 50 mV with zero gas. Readings above 100 mV indicate a light leak, contaminated reaction cell, bad zero gas, or wet air coming into the ozone generator. If the reading is not less than 150 mV, the instrument will not zero or span properly. Check Section 9.2.9.
3. Calibration device in error - re-check flowrates and concentrations. Especially at low concentrations. If you are using a Mass Flow calibrator and the flow is < 10% of the full scale flow on either flowmeter you may need to purchase lower concentration standards.
4. The standard gasses may be mis-labeled as to type or concentration. Labeled concentrations may be outside the certified tolerance.
5. Contamination in sample delivery system:
   A. Dirt in sample lines or reaction cell
   B. Contaminated cal gas source (NO_2 in NO cal gas is common)
   C. Dilution air contains sample or span gas
6. Ozone concentration too low:
   A. Wet air in generator - need to disassemble, clean, dry
   B. Electrical short circuit
   C. Transformer partial failure
7. Sample inlet vent line too short - should be at least 15".
8. Sample exhaust not properly vented, creating a backpressure at the sample inlet port of the instrument. See Table 2-2-3 for venting recommendations.

9.2.11 Slow Response

1. Contaminated or dirty sample delivery pneumatics.
   A. Dirty/plugged sample filter or sample lines.
   B. Dirty reaction cell.
2. Sample inlet line too long.
3. Wrong materials in contact with sample - use glass, stainless steel or Teflon.
4. Sample vent line located too far from instrument sample inlet. Locate sample inlet vent as close as possible to analyzer.
5. Insufficient time allowed for purging of lines upstream of analyzer.
6. Leaking NO/NO_x valve.
7. Insufficient time allowed for NO or NO_2 cal gas source to become stable.
8. Moly converter temperature too low.
9. Miscalibration, see Table 7-7-1.

9.2.12 Analog Output Doesn't Agree with Display Concentration

The analog output is proportional to the range. Zero volts output corresponds to zero ppb, and 5 volts corresponds to the maximum range setting in ppb. If this is not observed do the following:

1. V/F board DAC's out of calibration. Do DAC calibration and Factory Calibration.
2. Analog outputs electrically loaded down causing voltage to sag. Could be due to imput impedance to chart recorder or data logger being too low or improper grounding. The Recorder and DAS outputs do not have separate output drivers, the problem could be the combined load of both could be too high.

9.3 Subsystem Troubleshooting and Adjustments

9.3.1 Computer, Display, Keyboard

The purpose of this section is to determine if the computer subsystem electronics hardware are working properly. Asessment will be made at the board level.

9.3.1.1 Front Panel Display

The front panel display is a 2 line by 40 character display. It has its own microprocessor to decode commands and display characters. It contains a self test feature. To test the display:

1. Turn off the power to the instrument.
2. Fold down the M200A front panel.
3. Disconnect the 26 line flat ribbon cable (J2) that connects the computer parallel port to the keyboard.
4. Turn on the M200A power switch.
5. Observe the front panel display. If the display successfully completes its power on self test, it will display a single underline character "_" in the left most character of the top line of the display. If this character is present, the display is working properly.
6. Power down the analyzer, and re-attach the cable to J2, and proceed to the next test.

9.3.1.2 Single Board Computer

The SBC40 is a full function computer designed for instrument control applications. It consists of a 16 bit 8080 microprocessor, 2 serial and one parallel ports, standard bus interface, and 4 sockets for memory. The memory sockets consist of: 256k ROM containing the multitasking operating system and application code, 8k EE prom containing the setup variables, 256k RAM containing data collected by the instrument, and a time-of-day clock to provide event timing services. The overall function of this board is quite complex. Complete testing of this board's functions is not possible in the field.

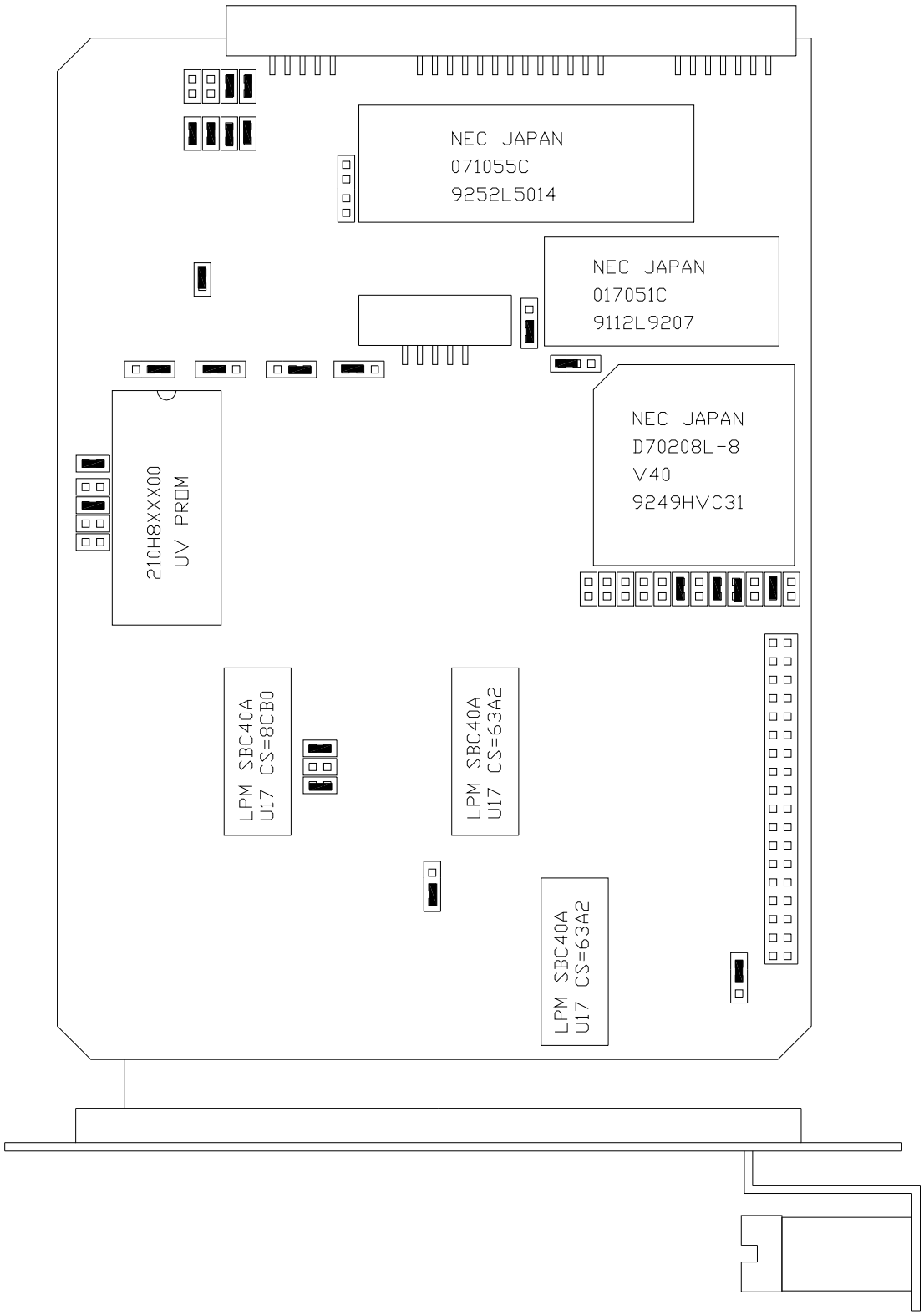


Table 9-9-8: CPU Board Jumper Settings

Like the display, the overall functioning of the CPU can be confirmed by a simple test.

1. Locate the CPU board on the mother board by referring to Table 2-2-5.
2. Power the instrument on.
3. Locate the red LED at the top left edge of the board.
4. It should be flashing at a frequency of about once per second.
5. This flashing indicates the board is powered up and is executing instructions.

Testing and operation of the CPU RS-232 port is described in Section 9.3.2. It is possible for the UART driver chip to malfunction in either or both of the input or output ports.

9.3.1.3 Front Panel Keyboard

The keyboard consists of 8 keys and 3 LED's. Key strokes are sent to the SBC40 computer's parallel port. The computer software detects the key strokes via interrupts. The bottom line of the display consists of 40 characters which is divided into 8 - 5 character fields. Each field defines the function of the key immediately below it. The definition of the keys is variable and depends on the menu level of the software.

To check the operation of the keyboard, each key should perform an operation indicated by its current definition shown on the second line of the display.

Example #1 - testing key#1 (left most key).

At the top level menu key #1 is defined as the TEST function. Pressing this key should cause the middle field of the top line of the display to show the various test functions.

Example #2 - testing key #8 (right most key). At the top level menu key #8 is defined as the SETUP key. pressing key #8 should cause the SETUP menu to be displayed.

Example #3 - If the 5 character field above any key is blank, the key is not defined, pressing the key has no effect.

9.3.1.4 Front Panel Status Indicators

The 3 status LED's indicate several functional states of the instrument such as calibration, fault, and sample modes. The state of the LED's is controlled by 3 lines on the parallel port of the SBC40. Functioning of the LED's can be checked by:

1. Turn off the M200A power.
2. While watching the LED's, turn on the instrument power.
3. When the power comes up, the computer momentarily applies power to all 3 LED's. If all the LED's are observed to light, they are working properly.

9.3.2 RS-232 Communications

The M200A uses the RS-232 communications protocol to allow the instrument to be connected to a variety of computer based equipment. RS-232 has been used for many years and is well documented. Generally, every manufacturer observes the signal and timing requirements of the protocol very carefully. Problems arise when trying to specify connectors, and wiring diagrams that attach the analyzer to various devices.

9.3.2.1 RS-232 Connection

If the RS-232 port is not working, check the following:

Physical Wiring

First is to get the physical wiring hooked up correctly. Refer to Table 9-9-9 for the wiring diagram of the DB-9 plug on the M200A rear panel. There are 2 features that make connecting the wiring easier. First is the red/green LED's on the rear panel. The M200A provides the power to run the red LED, the external equipment will provide the power for the green LED. If the wiring is hooked up correctly both LED's will be illuminated. Secondly, there is a DTE-DCE switch, this switch interchanges pin 2 & 3 on the DB-9 connector. Set the DTE-DCE switch so that both LED's are illuminated.

RS-232 Protocol (BAUD rate, Data bits, Parity)

Second is to get the communication protocol for each instrument to match. In Table 9-9-9 the default RS-232 parameters are listed. The BAUD rate can be changed in the software menus under SETUP-MORE-COMM-BAUD.

Data Communications Software for a PC

You will need to purchase a software package so your computer can transmit and receive on its serial port. There are many such programs, we use PROCOMM at Teledyne API. Once you set up the variables in PROCOMM and your wiring connections are correct, you will be able to communicate with the analyzer.

If connecting to a modem, check the following:

Modems are especially difficult because they may have pins that need to be at certain levels before the modem will transmit data. The most common requirement is the Ready to Send (RTS) signal must be at logic high (+5V to +15V) before the modem will transmit. The Teledyne API analyzer sets pin 8 (RTS) to 10 volts to enable modem transmission. Once the physical connection has been correctly established, it is necessary to establish the correct software settings in the modem. If the RS-232 bit field #64 in the VARS menu has been set, the M200A will transmit a modem setup string when the instrument is powered up. The contents of the string are set for a US Robotics Sportster modem. We strongly recommend using this model of modem to avoid modem connection problems.

To troubleshoot a modem connection first disconnect the RS-232 cable from the Analyzer and verify (use a DVM) that you are getting a signal on Pin 2 of the RS232 port on the Analyzer. The signal will be between -5V and -15V with respect to signal ground (pin 5). If not, there is a problem with the CPU board or the cable. This is the transmit (TD) signal out of the Analyzer. This should then be connected to TD input on the modem, normally Pin 2. You may need to switch the DTE/DCE switch.

Second: Go to the cable connected to the modem/terminal and verify (use a DVM) that you are getting a –5 V to –15 V signal on Pin 3 of the cable. This pin should be connected to Pin 3 of the Teledyne API Analyzer.

Third: (for modems) heck that the voltage level on Pin 8 of the Analyzer is between +5V and +15V. This pin should be connected (through the cable) to Pin 4 of the modem.

Now set the baud rate of the Analyzer to the speed required by the modem and it should work. If you are still experiencing problems, a cable adapter may be needed. Please contact the factory for assistance.

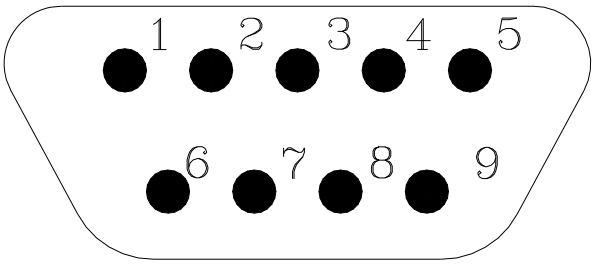
9.3.2.2 RS-232 Diagnostic

There are several features of the M200A to make connecting to RS-232 and diagnosing RS-232 faults easier.

There are two LED's on the rear panel Connector Board (01114) which are connected to pin 2 and 3 of the DB-9 connector on the board. If the switch is in the DCE position (default) the red LED is connected to pin 3 of the DB-9 connector. When data is transmitted by the M200A the red LED will flicker, indicating data present on this line. When the M200A is running, the LED will normally be ON, indicating logic low. A one second burst of data can be transmitted over the port by a command in the DIAGNOSTIC menu. Press SETUP-MORE-DIAG, then scroll to RS232 OUTPUT. Each time you press ENTR the instrument transmits a 1 sec burst of lower case "w"'s.

The green LED is connected to pin 2, if the switch is in the default DCE position. This is the pin on which the M200A receives data. The LED is ON if an outside device is connected. This LED gets its power from the outside device. When data is being transmitted by the outside device to the M200A this LED will flicker.

When you are attempting to configure the RS-232 port, if either of the LED's go out when the cable is connected, that generally means that there is a grounding problem. Switching the DCE-DTE switch should fix the problem. See the schematic and assembly drawings in the appendix.



PIN	FUNCTION
2	TX DATA[1]
3	RX DATA[1]
5	SIG GROUND
7	DSR
8	RTS

RS-232 CONFIGURATION PARAMETERS

19,200 BAUD DEFAULT*
8 DATA BITS
1 STOP BIT
NO PARITY

*SETTABLE 300-19,200 BAUD

[1] SWITCH SETTABLE ON REAR PANEL CONNECTOR BOARD

Table 9-9-9: RS-232 PIN Assignments

9.3.3 Voltage/Frequency (V/F) Board

The V/F Board consists of 16 analog input channels, each software addressable, 8 digital inputs, and 24 digital outputs, each line independently addressable, and 4 independent analog output channels. The analog input channels are connected to V/F converter capable of 80,000 counts, which is approximately 16 bit resolution. The integration period is software selectable from 40msec to 2.4 sec. Commands from the SBC40 computer and digitized values from the V/F section of the board are sent via the STD bus interface. The schematic for the board is in the Appendix 00514.

The overall operation of this board is quite complex. To fully check it out in all of its operational modes is not possible in the field. Therefore, a few simple tests are described here that test one analog input channel, the 4 analog output channels, one digital input, and one digital output.

1. V/F board analog input test.

   Each analog channel is routed through a programmable 16 channel multiplexer. Chances are that if one channel works, they all work.

   A. Turn on instrument.

   B. Press TEST key on front panel keyboard until DCPS test is displayed.

   C. The value displayed should read 2500 ± 200 mV.

      If the M200A passes this test, it has successfully digitized a 2500 mV composite voltage output from the Power Supply Module. The signal should also be quiet ± 25 mV.

2. Analog output channel test.

   In the DIAGNOSTIC menu on the front panel, there is a test that outputs a step voltage to the 4 analog outputs. This test is useful for calibrating chart recorders and dataloggers attached to the M200A. The test can also be useful in diagnosing faults in the V/F board.

   A. Turn on the instrument.

   B. Enter the SETUP-MORE-DIAG-ENTR menu.

3. Select the ANALOG OUTPUT test. This causes the M200A to output a 5 step voltage pattern to the 4 analog outputs on the rear panel. The status of the test is shown on the front panel display. The scrolling can be stopped at any voltage by pressing the key below the changing percentage display. The values are 0-20-40-60-80-100% of whatever voltage range has been selected. For example the voltages would be 0, 1, 2, 3, 4, 5V if the 5V range had been selected.

4. Use a DVM on each of the analog output channels to confirm the correct voltages.

   If the voltages step, but are the wrong values, the V/F board may be out of calibration. See Section 9.3.3 for information on how to calibrate the V/F board.

5. Digital input channel test.

   The digital I/O section of the V/F board has 8 input bits and 24 output bits. Two of the 8 input bits are assigned as calibration controls. See Section 7.7 for information on calibration using external contact closures.

   To test the digital inputs:

   A. Turn on the M200A.

   B. Connect a jumper wire across pins 1 and 2 of the rear panel connector as shown in Table 2-2-2.

   C. Shortly after closure is made the instrument should switch into zero mode as indicated on the front panel display.

   D. Remove the jumper.

6. Digital output channel test.

   There are 24 output bits on the V/F board. The 24 bits are made up of 3 - 8 bit ports. It is possible for a single 8 bit port or even a single bit within a port to fail.

   A quick observational test of the digital outputs is to observe the LED's in the Power Supply Module (Refer to Table 9-9-15 for the location of the LED's in the PSM) The state of the LED's can be checked from Table 4-4-2. The comments section assumes the M200A has been running for at least 45 minutes.

   A more detailed test is in the DIAGNOSTIC menu. See Diagnostic tests in Section 9.1.3.

9.3.3.1 ADC/DAC Calibration Procedure

Due to the stability of modern electronics, this procedure should only need to be performed if a major sub-assembly is exchanged or when the display voltage does not match the input voltage or current to the V/F card. After completion, a Factory Calibration Procedure should be performed, see Section 9.1.6.

Before the actual calibration is performed, switches on the V/F card must be correctly set and jumpers set on the mother board. **Jumper and switch setting changes must be performed with the instrument power OFF.**

Motherboard Jumpers

The motherboard contains 4 pairs of jumpers JP1 - JP8, one pair for each analog output channel. Each channel can be configured for either voltage or current output. Use the Table 9-9-10 to configure the jumpers.

Table 9-9-10: Motherboard Jumper Settings

Analog output	Terminal Pair Rear panel	Jumper Pair	Jumper Setting for Voltage Mode	Jumper Setting for Current Mode
DAC 0 - NOx	3-4	JP3 - JP4	B-C	A-B
DAC 1 - NO	5-6	JP1 - JP2	B-C	A-B
DAC 2 - NO2	1-2	JP5 - JP6	B-C	A-B
DAC 3 - TEST	7-8	JP7 - JP8	B-C	A-B

V/F Board Switch Settings

There are 2 different types of current outputs, Non-Isolated (std equipment) and Isolated. Each requires a different switch setting shown below. If you are operating the instrument in voltage output mode, the switches should be set to the desired voltage range.

Table 9-9-11: V/F Board Switch Settings

DAC #	Sw 1	Sw 2	Sw 3	Sw 4	Sw 5	Sw 6	Sw 7
0	ON*	OFF*					OFF*
1	ON*	OFF*					OFF*
2	ON*	OFF*					OFF*
3	ON*	OFF*					OFF*

*Required settings

10 V output or non-isolated current loop

Switch	State	Comment
3	ON	Use for non-isolated current loop or 10 V output
4	OFF	Use for non-isolated current loop or 10 V output
5	OFF	Use for non-isolated current loop or 10 V output
6	OFF	Use for non-isolated current loop or 10 V output

5 V output or isolated current loop

Switch	State	Comment
3	OFF	Use for isolated current loop or 5 V output
4	ON	Use for isolated current loop or 5 V output
5	OFF	Use for isolated current loop or 5 V output
6	OFF	Use for isolated current loop or 5 V output

1 V output

Switch	State	Comment
3	OFF	Use for 1 V output
4	OFF	Use for 1 V output
5	ON	Use for 1 V output
6	OFF	Use for 1 V output

100 mV output

Switch	State	Comment
3	OFF	Use for 100 mV output
4	OFF	Use for 100 mV output
5	OFF	Use for 100 mV output
6	ON	Use for 100 mV output

1. After the switches and jumpers are set, turn on instrument power and complete the following:

   A. Press SETUP-MORE-DIAG, then press ENTR. Scroll to D/A CALIBRATION, press ENTR.

   B. Press ADC to select the first task, which is to calibrate the A/D converter.

   C. Connect a DVM ground lead to TP3-AGND on the V/F board. Connect the positive lead to TP9-DAC0.

   D. The M200A will display a voltage near 1% of the voltage range set in the above procedure. See Table 9-9-12 for a table of approximate expected voltages. Adjust R27 until the displayed voltage matches the DVM voltage, then press ENTR.

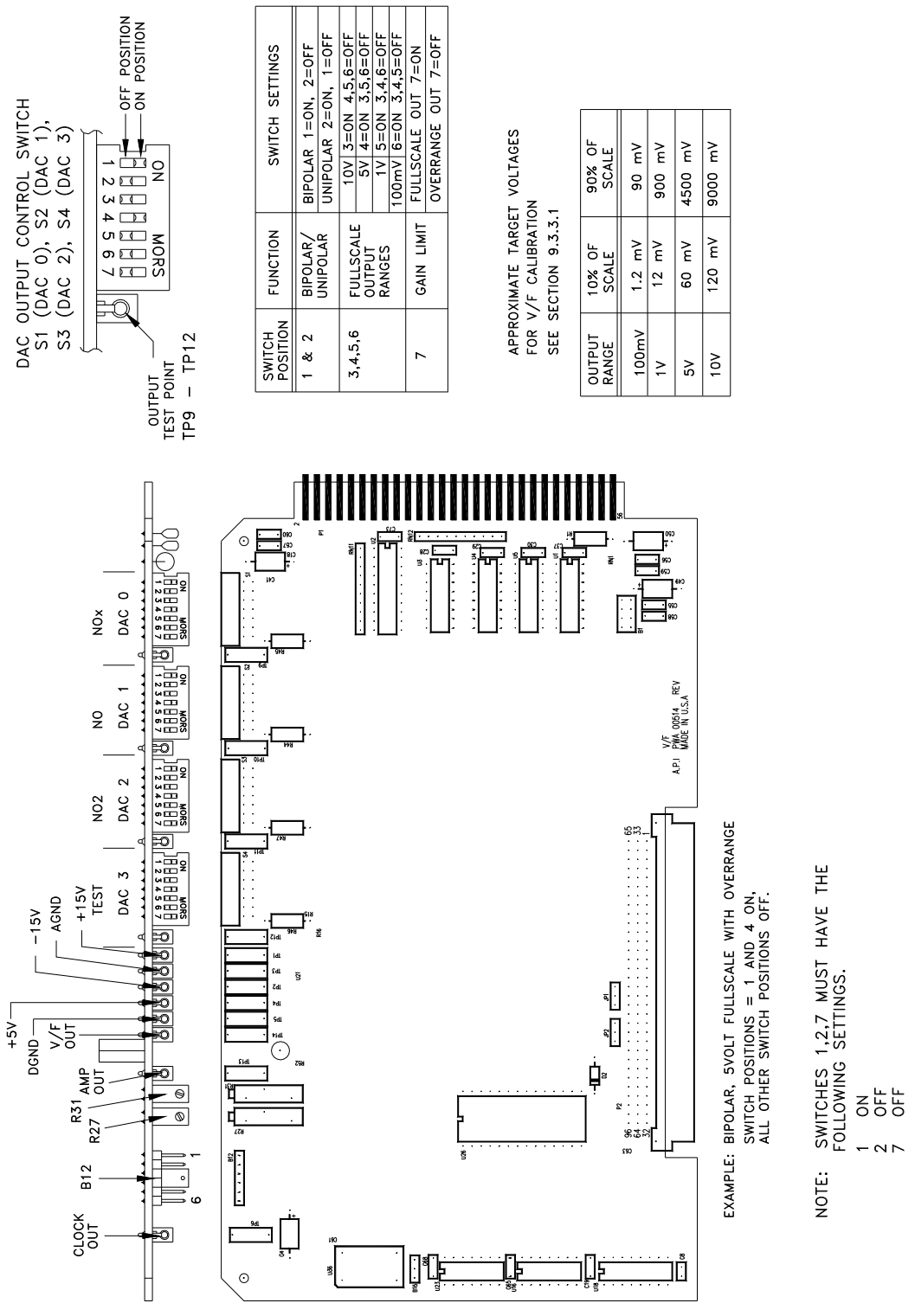
   E. The M200A will display a voltage near 90% of the voltage range set in the above procedure. Adjust R31 until the displayed voltage matches the DVM voltage, then press ENTR. This step calibrates the instrument A/D converter to the external DVM.

   F. The M200A will automatically scroll through the DAC output channels, calibrating each one. The display will update the progress of the calibration. If operating all analog outputs in voltage mode this completes the calibration procedure.

The calibration of each channel can be checked or recalibrated independently by scrolling the PREV-NEXT buttons and pressing CAL for the desired channel. Also a DC offset bias can be entered by pressing the OFFSET button for the appropriate channel.

Calibrating a channel for current loop operation:

1. BEFORE STARTING, make sure that hardware settings are correct as shown in Table 9-9-6 and Table 9-9-10.
2. Calibrate the A/D converter as described in item 2 above, if necessary.
3. Connect a 250 ohm resistor in series with a current meter to the correct pair of terminals on the rear panel, see Table 9-9-11 for terminal assignments.
4. In the D/A calibration Menu press CFG, then use PREV-NEXT to select the channel to be calibrated.
5. Press the SET button to select CURR for current loop operation, then press ENTR.
6. To enter the calibration routine press CAL.
7. To calibrate the 4 mA zero point, press the UP-UP10 - DN-DN10, then press ENTR.
8. The M200A will then output 20 mA. Press the UP-UP10 - DN-DN10 buttons to calibrate the span point, then press ENTR.
9. Repeat steps 2-6 for each channel that needs to be calibrated.



SWITCH POSITION	FUNCTION	SWITCH SETTINGS
1 & 2	BIPOLAR/ UNIPOLAR	BIPOLAR 1=ON, 2=OFF
		UNIPOLAR 2=ON, 1=OFF
3,4,5,6	FULLSCALE OUTPUT RANGES	10V 3=ON 4,5,6=OFF
		5V 4=ON 3,5,6=OFF
		1V 5=ON 3,4,6=OFF
		100mV 6=ON 3,4,5=OFF
7	GAIN LIMIT	FULLSCALE OUT 7=ON
		OVERRANGE OUT 7=OFF

OUTPUT RANGE	10% OF SCALE	90% OF SCALE
100mV	1.2 mV	90 mV
1V	12 mV	900 mV
5V	60 mV	4500 mV
10V	120 mV	9000 mV

Table 9-9-12: V/F Board Settings

9.3.3.2 Changing Output Voltage Ranges

Several different output voltage ranges can be selected by switchs on the V/F board. See Table 9-9-12 for the switch settings.

9.3.4 Status/Temp Board

The Status/Temp Board is a multifunction board that:

1. Converts the resistance readings of the thermistors to voltages
2. Conditions the thermocouple voltage for the V/F card
3. Provides status output circuitry
4. Provides circuitry for contact closure inputs
5. Provides circuitry for display brown-out/reset at low line voltage
6. Provides chip carriers for voltage-to-current modules

9.3.4.1 Temperature Amplifier Section

The Status/Temp board (01086) is a multifunction board consisting of 4 thermistor amplifiers that monitor:

1. IZS temperature
2. Reaction Cell temperature
3. Box temperature
4. Spare

All 4 amplifiers have a single gain control - R34. If necessary, you can adjust the temperature values by selecting the BOX TEMP - TEST function and adjusting R34 until the correct box temp is shown. Remember that the temperature inside the case runs several degrees higher than room temperature, which should be taken into account when setting BOX TEMP.

The voltages of the thermistor and thermocouple amplifier outputs are brought out to test points on the edge of the board. Refer to the schematic 01086 for details. The voltages can also be read using the DIAGNOSTIC - SIGNAL I/O feature. See Table 9-9-4 for details.

In addition there is a thermocouple amplifier for the Moly converter.

Thermistor Temperature Amplifier Adjustments

If the temperature readouts are in error:

1. Locate the Box temp thermistor on the board and place a calibrated thermometer near the thermistor.
2. Select the BOX TEMP - TEST function on the front panel.
3. Adjust R34 until the front panel readout matches the thermometer readout. This will cause all of the readouts to accurately measure their respective temperatures.

Molybdenum Converter Thermocouple Amplifier Adjustments

The molybdenum converter temperature is sensed by a thermocouple. The cold junction compensation and signal conditioning is done on the Temp/Status board.

The buffer amplifier from the thermocouple amplifier to the CPU for the Moly temperature has a gain adjustment. The voltage times 100 at pins 8-9 of U1 is the Moly temperature in degrees C. For example 3.15 VDC at pin 9 of U1 is 315^{o} C. The CPU is programmed to always drive the temp to 315° C, so the voltage at U1 must be used as the absolute reference as to the correct temperature. The temperature will vary ± 3 degrees due to the operation of the temperature control loop in the CPU.

The temperature can be adjusted by the R6 pot on the Status/Temp board. To adjust the molybdenum converter temperature:

1. Select the CONV TEMP - TEST function on the front panel.
2. Wait until the converter is up to temperature, usually 30-45 min after a cold start.
3. Adjust R6 until the voltage at pin 8-9 of U1 is 3.15 VDC. The CONV TEMP - TEST function will then read 315° C.
4. Recheck the temperature 15 min later and re-adjust if necessary.

9.3.4.2 Display Brownout

During low AC line conditions the display can lock up due to insufficient voltage. When low line conditions are approaching, this circuit senses the condition by monitoring the un-regulated +5 VDC in the Power Supply Module. If brownout conditions are met, the DISP_BROWNOUT line is asserted and the CPU sends a hardware RESET command to the display and sends a BRNOUT RESET pulse back to U4. Brownout conditions will be noticed by the display flashing every 8 seconds.

9.3.4.3 Status Output Lines, External Contact Closures

The Status lines consist of 2 active input lines, and 12 active output lines. Additional circuits are present on the board but currently unused. Individual lines are set or cleared under CPU control depending on the assigned alarm condition. The CPU also monitors the 2 input lines for remote calibration commands. The status inputs and outputs are terminated at the rear panel, see the Connector Board schematic in the Appendix.

The output lines are opto-coupled NPN transistors which can sink 50 ma max of current with a voltage of 30 VDC max.

The input lines are optically coupled with inputs pulled up to +5 VDC. External contacts can be contact closures or open collector transistor contacts. DO NOT apply any voltage, since +5 VDC is supplied internally.

Individual status lines can be set or cleared using the DIAGNOSTIC mode SIGNAL I/O. This can be useful for simulating fault conditions in the analyzer to see if external circuitry is working correctly. See Table 5-5-10 for pin assignments.

9.3.4.4 4-20 mA Current Output

4-20 mA current loop option replaces the voltage output of the instrument with an isolated 4-20 mA current output. The current outputs come out on the same terminals that were used for voltage outputs, see Table 2-2-2. It is programmable for 4-20mA or 0-20mA and has a 1500 V common mode voltage isolation and 240 V RMS normal mode voltage protection.

V_{loop} = 28V max which is sufficient to drive up to a 1000 ohm load.

9.3.5 Power Supply Module

The Power Supply Module consists of several subassemblies described in Table 9-9-13.

Table 9-9-13: Power Supply Module Subassemblies

Module	Description
Linear Power Supply Board	The linear power supply board takes multiple voltage inputs from the power transformer and produces +5, +15, -15, +12 VDC outputs. The outputs are routed to two external connectors, P2 and P3. See Table 9-9-14. The +5 is used for operating the CPU. The ± 15 is used in several locations for running op-amps and IC's. The +12 is used for operating fans and valves.
Switching Power Supply	The switching power supply supplies +15 VDC at 4 A to the PMT cooler control on the Sensor Module. The output is made available through J10 on the Switch Board. There is a load resistor on the Switch Board to keep the output stable when little current is required from the supply.
Switch Board	The Switch Board has many different functions. It takes logic signals from the V/F board and uses them to switch 4-115 VAC and 4-12 VDC loads. The board also contains the instrument central grounding tie point. It routes unswitched AC and DC power as needed. Connector J2 programs the power transformers to take 115, 220, and 240 VAC inputs.
Power Transformers	There are potentially 2 input power transformers in the instrument. The multitap transformer T1 is in every M200A and supplies input power for the Linear Power Supply board described above. A second transformer T2 is added if 220 or 240 VAC input is required. Input power selection is done via a programming connector P2 which provides the proper connections for either foreign or domestic power.
Circuit Breaker/Power Switch	The front panel contains a combination circuit breaker - input power switch. It is connected to the PSM through J6 on the Switch Board. If an overload is detected the switch goes to the OFF position. Switching the power back on resets the breaker also.

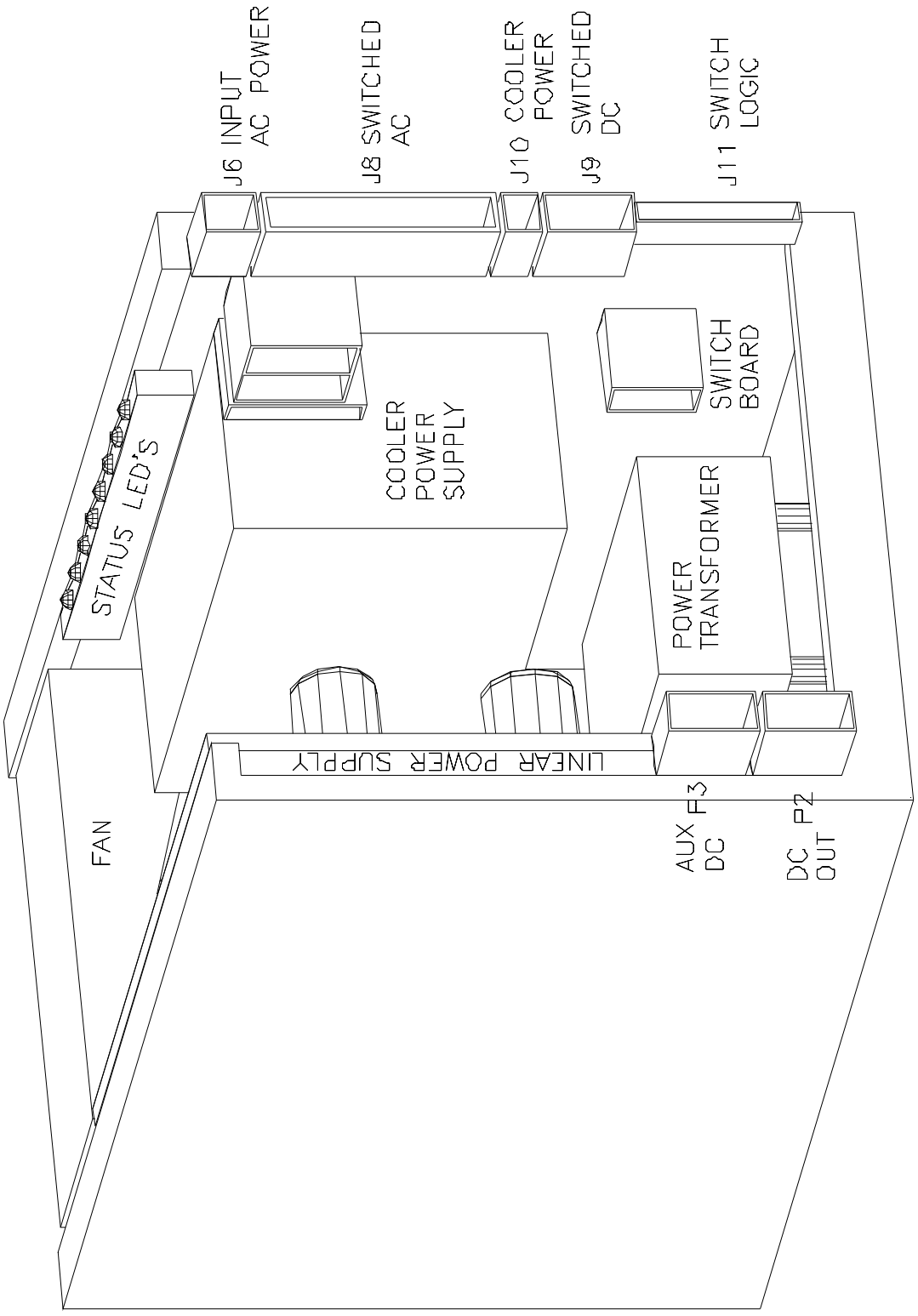


Table 9-9-14: Power Supply Module Layout

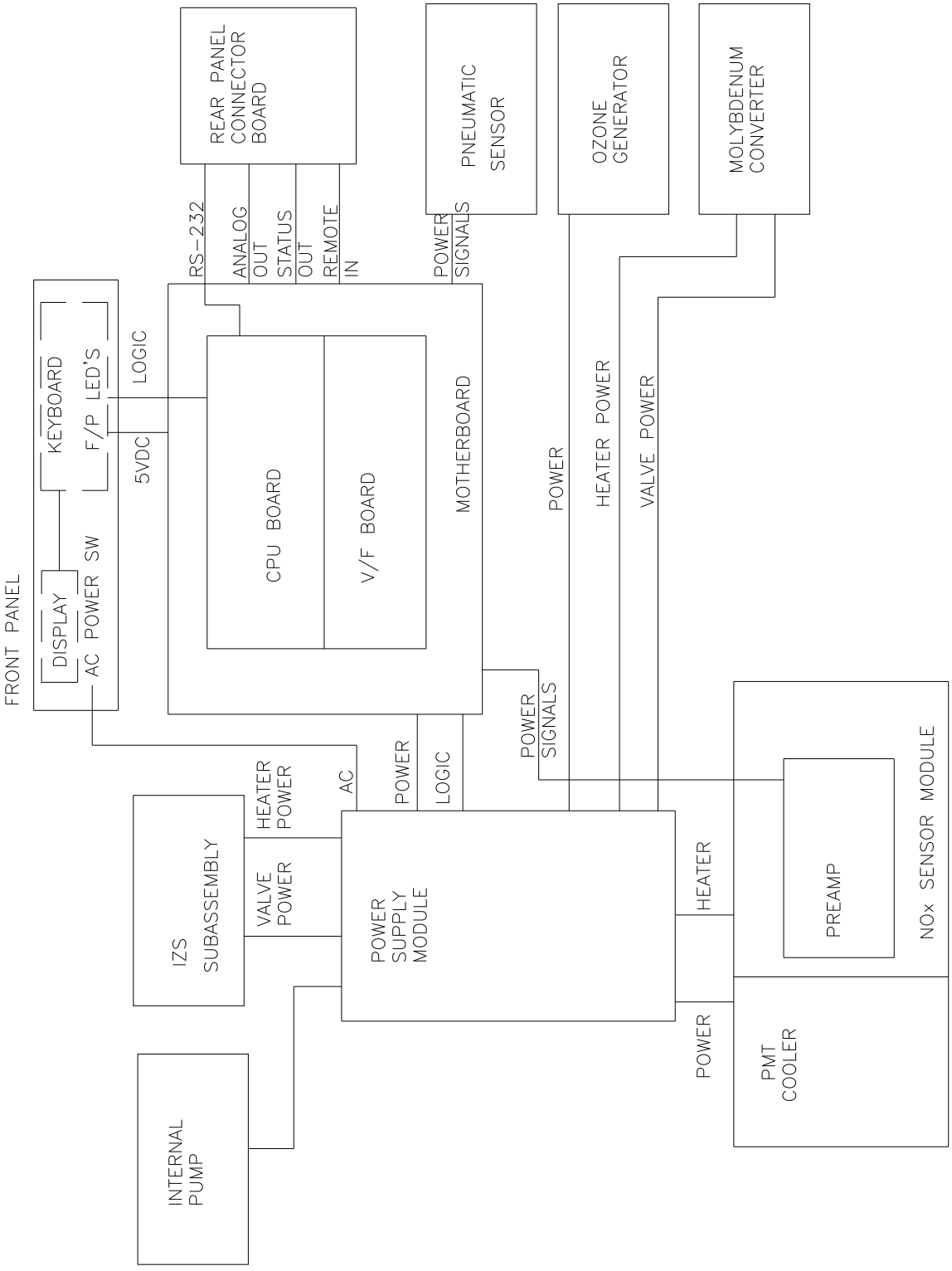


Table 9-9-15: Electrical Block Diagram

PSM Diagnostic Procedures

The Linear Power Supply board can be tested by checking the DCPS - TEST function on the front panel. It should read 2500 mV ± 200 mV. If the value is outside this range, individual output voltages can be tested on connector P3, see Schematic in the Appendix for pinouts.

The Switching Power Supply output can be tested by observing the temperature of the PMT cold block using the PMT TEMP - TEST function. The temperature should be constant 7± 2° C. The output voltage can be observed on J10 of the Switch Board. It should be 15 VDC ± 0.5.

The Switch Board can be tested by observing the diagnostic LEDS along the top edge of the board. The following Table 9-9-16 describes the typical operation of each LED.

Table 9-9-16: Power Supply Module LED Operation

No.	Function	Description
1.	NO/NO_x Valve	Should switch about every 5 sec. On(click sound) = NO_x mode Off(thud sound) = NO mode
2.	Zero/Span Valve	Should switch ON when CALZ or CALS button is pressed.
3.	Sample/Cal Valve	Should switch ON when CALS button is pressed.
4.	AutoZero Valve	ON when M200A in AutoZero mode. Happens once every 6 NO/NO_x cycles or about once per minute.
5.	Ozone Generator Power	The ozone generator will be on if it has been more than 30 min since power up.
6.	Sample flow control block heater	Should cycle ON-OFF every 20 sec to 2 min. On continuously until up to temp.
7.	Converter Heater	Should cycle ON-OFF every 20 sec to 2 min. On continuously until up to temp.
8.	Reaction Cell Heater	Should cycle ON-OFF every 20 sec to 2 min. On continuously until up to temp.

9.3.6 Ozone Generator

CAUTION - DANGER

Lethal voltages present inside Ozone Generator - DO NOT defeat electrical interlock. Turn off instrument before servicing. Unplug Generator before disassembling.



The ozone generator subsystem consists of a permeation drier, flowmeter, power supply - generator module, and power switch. The location of the components is illustrated in Table 9-9-18. Ozone is generated by drying ambient air, passing the air between two electrodes that have a large oscillating electric field generated by a high voltage transformer.

Common faults in the ozone generator are:

1. A leak or some other failure in the drier will let ambient air into the generator. There is enough water vapor in room air to cause the generator to make nitric acid aerosol. It is very corrosive and causes the generator cartridge to short out due to salt build-up. This reduces the ozone concentration generated which can cause the analyzer to be non-linear due to insufficient ozone concentration.
2. Blown fuse. The Ozone generator fuse is located on the upper end of the generator case.
3. Contaminated ozone generator cartridge. Dis-assemble and clean. Salts and oxgenated hydrocarbons can be removed by rinsing with 10% nitric acid at 50° C.
4. Shorts, open circuits, arcing inside the case. Because of the very high voltages, metallic components inside the ozone generator case can malfunction.
   A. Disconnect power.
   B. Remove ozone generator cover and inspect the wiring for evidence of arcing and open circuits. Typically arcing due to high voltage has a dusty - burnt look. Look for these areas inside the case and on the wiring that comes near the case.

Table 9-9-17: Ozone Generator Control Conditions

Condition	Description	Ozone Generator
1	Manual override off (**SETUP-MORE-DIAG-OZONE GEN**).	OFF
2	Manual override on.	ON
3	Ozone flow below low warning limit for 5 minutes (*OFLOW_SET* setup variable).	OFF
4	Instrument powered on for more than 30 minutes.	ON
5	Instrument powered off for less than 1 hour *and* ozone generator was on when instrument was powered off.	ON
6	Ozone flow above low warning limit for 0.5 minutes *and* condition 4 or 5 is true.	ON

NOTE

The ozone generator is independently controlled in the *SIGNAL I/O, OPTIC TEST,* and *ELECTRICAL TEST* diagnostics. After exiting these diagnostics, the ozone generator is restored to the state specified by the above conditions.

9.3.6.1 PermaPure Drier

The PermaPure drier is constructed of 2 concentric tubes. The inner tube is a special material that has an affinity for water vapor. The outer annulus is evacuated by the instrument pump. This creates a concentration gradient causing water in ambient air to diffuse into the outer annulus, thus the air in the inner tube becomes progressively drier as it progresses down the tube.

Due to the large number of connections and fittings on the drier, the most common drier fault is leaks. Before proceding with any other procedures check the drier for leaks.

Occasionally the drier gets contaminated. The manufacturer of the drier recommends replacing the drier rather than trying to clean it. If cleaning is chosen, the following options are available:

1. Dirt - Clean any solids from dryer inlet by brushing. Use clean dry air to blow any loose particles from the inlet. Deionized water or dilute (5-10% conc HCl in deionized water) hydrochloric acid can be passed through the dryer. This should be done only with the dryer and HCl at room temperature.
2. Organic liquids and freons - Rinse the inner and outer tubes using 1,1,1 trichlorethane. Follow the solvent with dry air to purge the solvent.
3. Inorganic salts and oxgenated hydrocarbons can be removed by rinsing with 10% nitric acid at 50° C.

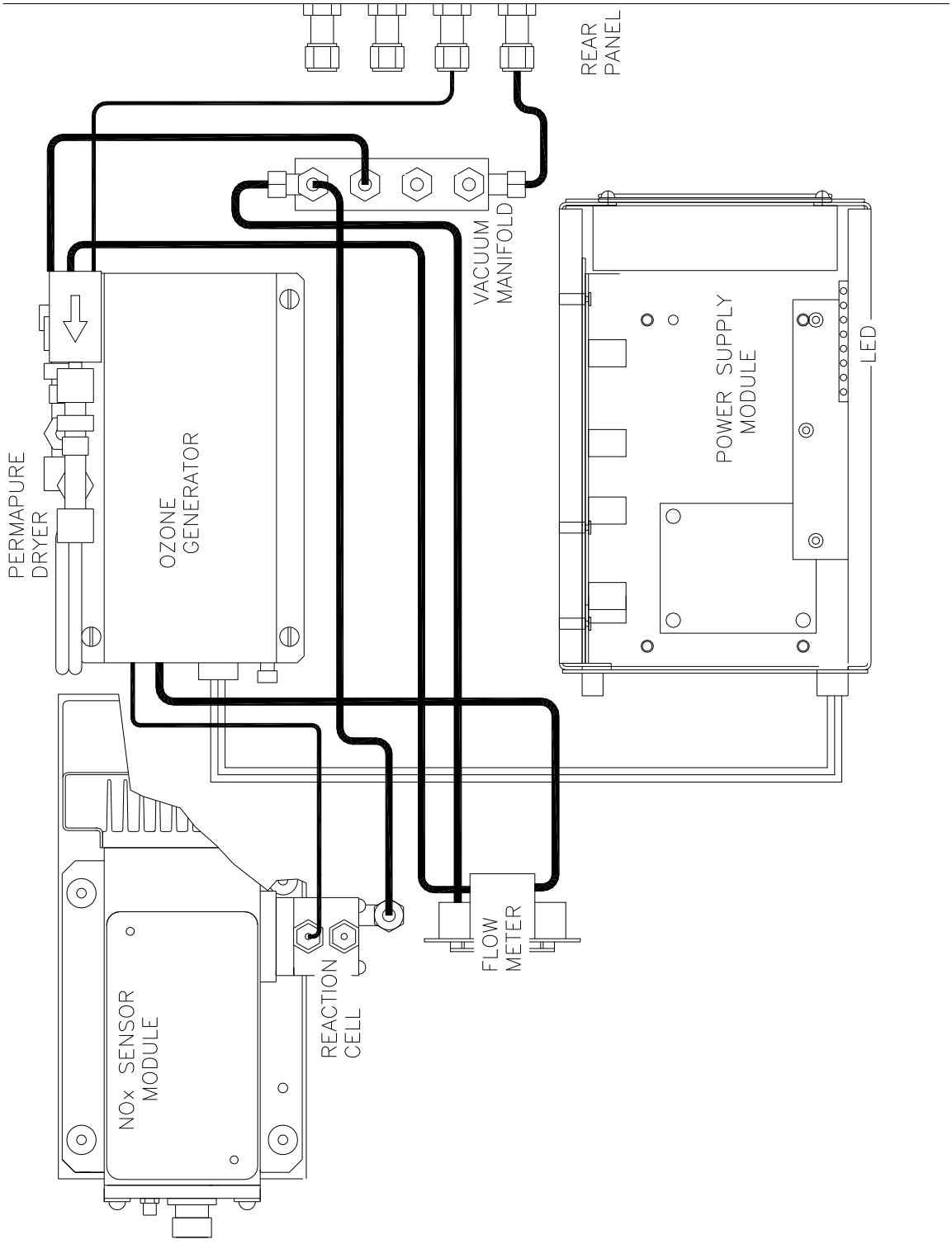


Table 9-9-18: Ozone Generator Subsystem

9.3.7 Flow/Pressure Sensor

The flow/pressure sensor board consists of 2 pressure sensors and a flow sensor. See Table 9-9-19 for a diagram of this board. From these three sensors four values are computed and displayed on the front panel TEST funcions. They are:

1. Ozone flow - measured directly - S3, R3
2. Reaction Cell Pressure - measured directly - S2, R2
3. Sample gas pressure - measured directly S1, R1
4. Sample Flow - computed from sample pressure and reaction cell pressure S1, S2

The above pressures and flows are filtered to produce the front panel readings. There is a small delay after adjustment for a steady reading when observing the TEST functions.

To adjust the OZONE flow:

1. Go to DIAG mode by pressing SETUP-MORE-DIAG, then select SIGNAL I/O, and press ENTR. Select OZONE_FLOW by using NEXT-PREV keys.
2. Adjust R3 so that OZONE_FLOW reads 2000 mV. This is the coarse adjustment.
3. Press EXIT to return to the SAMPLE mode. Select the OZONE FL - TEST function. Use a calibrated flow meter to make small adjustments in R3 to dial in correct flow.

To adjust the SAMPLE PRESSURE:

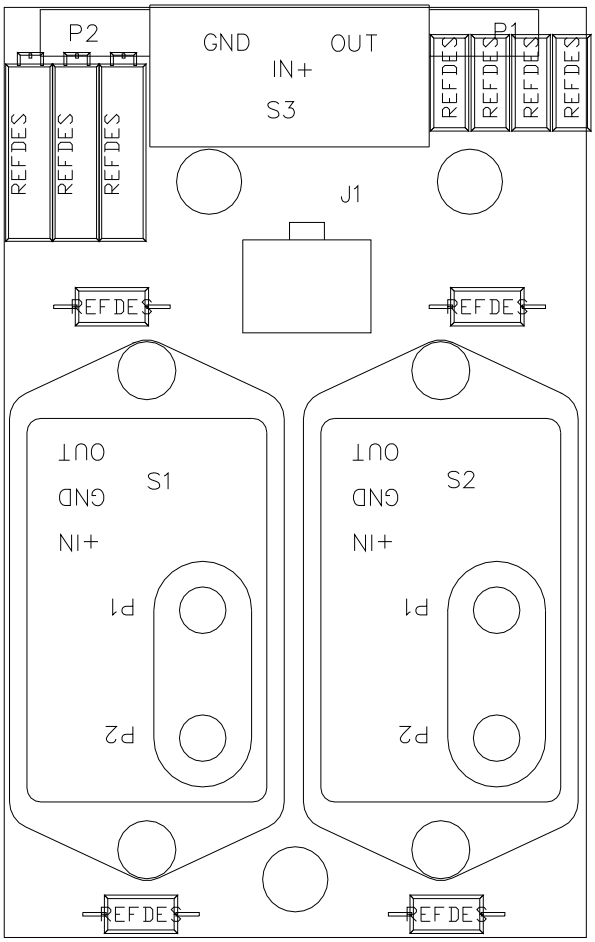
1. Go to DIAG mode by pressing SETUP-MORE-DIAG, then select SIGNAL I/O, and press ENTR. Select SAMPLE_PRESS by using NEXT-PREV keys.
2. Adjust R1 to read 4100 mV, which will give approximately the correct pressure.
3. Press EXIT to return to the SAMPLE mode. Select SAMP - TEST function. Use a calibrated absolute pressure meter to make small adjustments to R1 until the correct absolute pressure is displayed. 29.92 in-Hg-A is the target value at sea level. The rate of decrease is about 1"-Hg per 1000 ft of altitude.

To adjust the REACTION CELL PRESSURE:

1. Go to DIAG mode by pressing SETUP-MORE-DIAG, then select SIGNAL I/O, and press ENTR. Select RCELL_PRESS by using the NEXT-PREV keys.
2. Adjust R2 to read 1450 mV, which will give approximately the correct pressure.
3. Press EXIT to return to the SAMPLE mode. Select RCEL - TEST function. Use a calibrated absolute pressure meter to make small adjustments to R2 until the correct absolute pressure is displayed. The target value is about 5 in-Hg-A for the external Thomas pump in good condition at sea level.

To adjust the SAMPLE FLOW:

1. In SAMPLE mode, scroll the TEST functions to SAMP FLW. Observe the reading. Then subtract the observed reading from the desired reading.
2. Go to the VARS menu by SETUP-MORE-VARS, then pressing ENTR. Scroll to SFLOW_SET and press EDIT. The first value displayed is the SFLOW_SET:VALUE reading, ADD the value from step 1 to the reading shown and key in the new reading, then press ENTR. Check the low and high warning limits which are displayed as the next 2 values to make sure the new value does not exceed the warning limits. Press exit to return to SAMPLE mode.
3. Observe the SAMP FLW value. If necessary repeat step 2 to adjust the reading again to match the desired flow rate.



SENSOR, TESTPOINT, ADJUSTMENT	M200A FUNCTION
S1, TP1, R1	SAMPLE PRESS
S2, TP2, R2	Rx CELL PRESS
S3, TP3, R3	OZONE FLOW

Table 9-9-19: Flow/Pressure Sensor

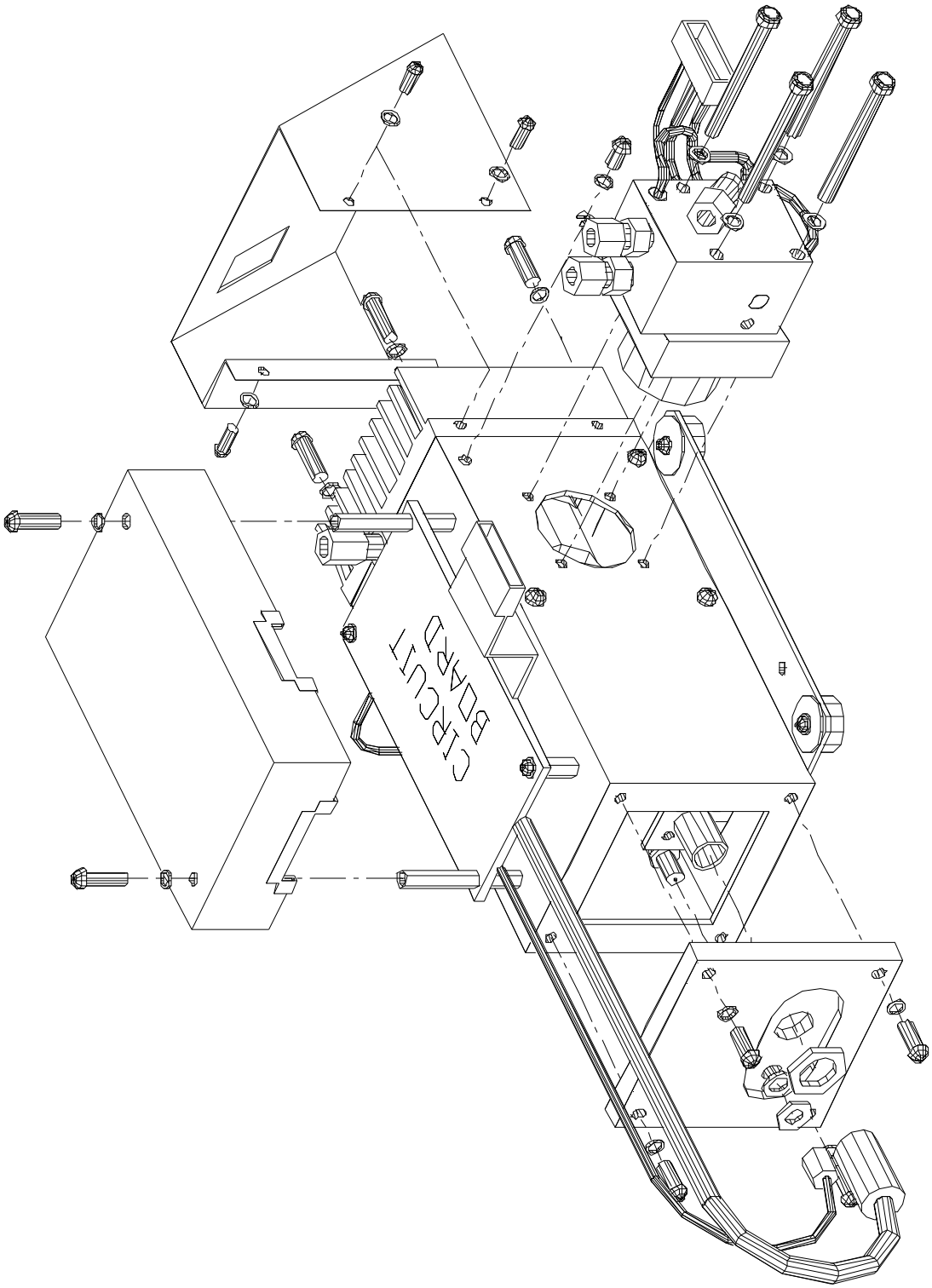


Table 9-9-20: NO_x Sensor Module

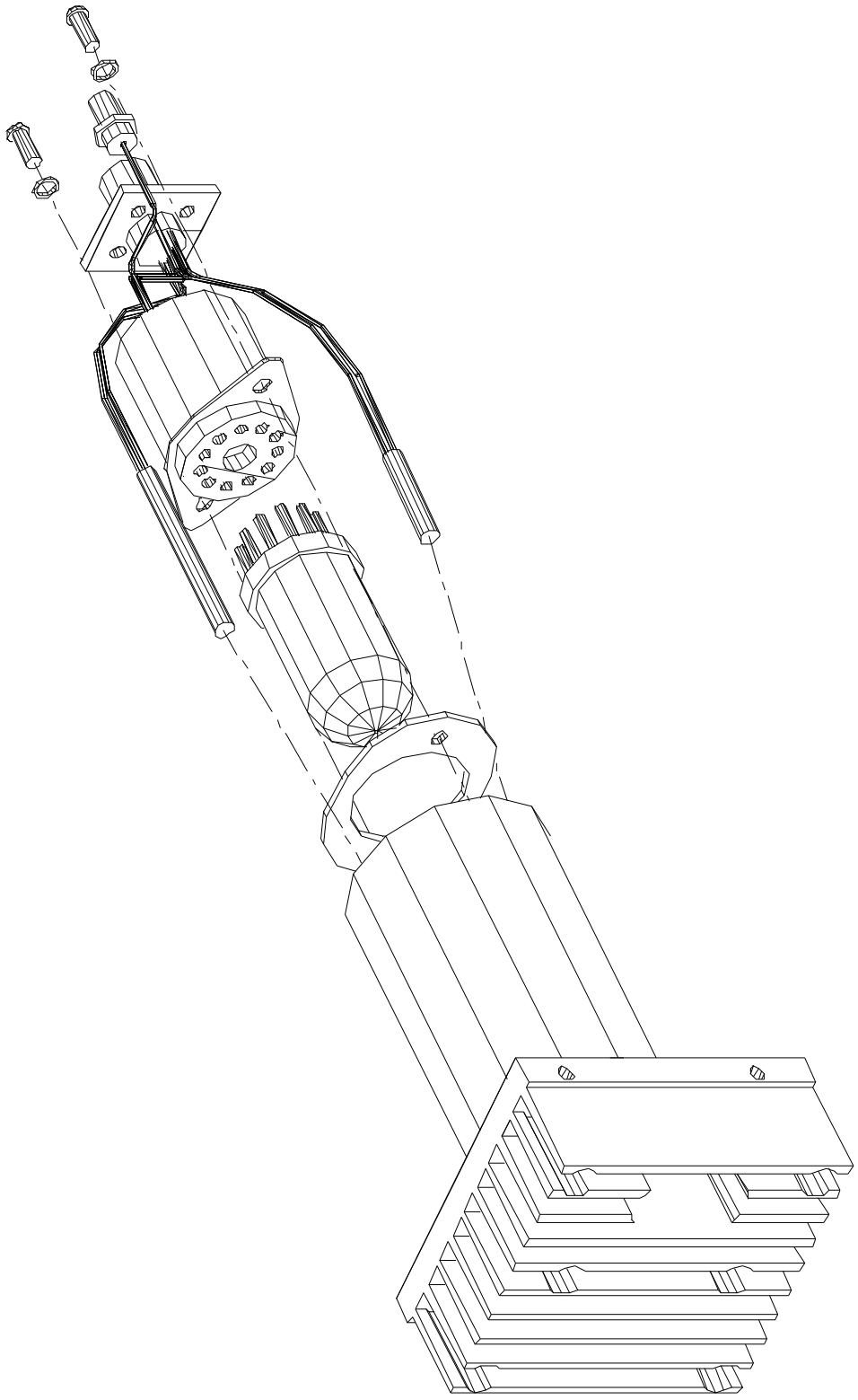


Table 9-9-21: NO_x Sensor Module

9.3.8 NO_x Sensor Module

Table 9-9-20 and Table 9-9-21 show the assembly of the NO_x sensor module.

9.3.8.1 PMT

The PMT detects the light emitted by the reaction of NO with ozone. It has a gain of about 500,000 to 1,000,000. It is not possible to test the detector outside of the instrument in the field. The best way to determine if the PMT is working is by using Optic Test. OT operation is described in Section 9.1.3.3.

The basic method to diagnose a PMT fault is to eliminate the other components using ET, OT and specific tests for other sub-assemblies.

9.3.8.2 Reaction Cell Temp

The reaction cell temperature is controlled by the CPU. It operates by reading a thermistor amplifier on the 01086 Status/Temp board. The CPU controls the temperature by toggling a bit on the V/F board. The V/F board TTL logic controls a solid state switch on the Switch Board in the PSM. The switched 115VAC comes out of the PSM to a connector near the underside of the reaction cell. A warning message may be present during initial warm-up or if the connector is not plugged in after cleaning the reaction cell.

9.3.8.3 Preamp Board

The NO_x Preamp Board is a multifunction board providing circuitry to support the following functions.

1. Preamp, buffer amplifier, physical range control hardware for the PMT detector.
2. Precision voltage reference and voltage generation, and control for the PMT - HVPS inside the sensor module.
3. Constant current generator and adjustment for the Optic Test LED.
4. Voltage generation and adjustment for Electric Test.
5. Thermistor amplifier, control signal generation for the PMT cooler.

The setup and adjustment of items 1-4 above is covered in the Factory Calibration procedure in Section 9.1.6. Item 5 has no adjustable features.

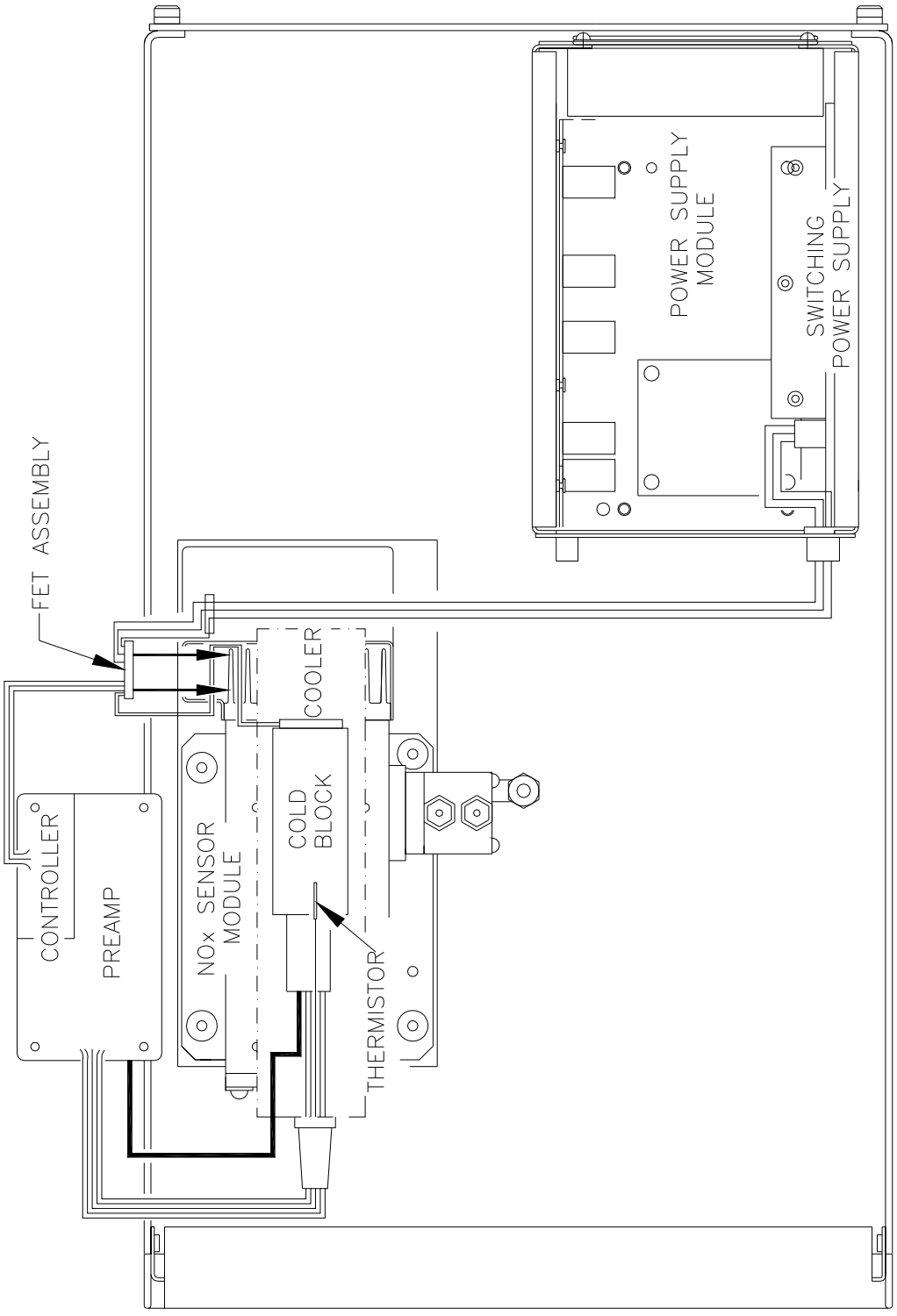


Table 9-9-22: PMT Cooler Subsystem

9.3.8.4 PMT Cooler

The PMT cooler uses a Peltier cooler supplied with DC current from the switching power supply in the Power Supply Module. An overall view is shown in Table 9-9-20. The temperature is controlled by a proportional temperature controller located on the Preamp board. Voltages applied to the cooler element vary from 0.1 to 12 VDC. The input voltage from the supply is 15 VDC. The actual 7° C setpoint will vary ± 1° C due to component tolerances. The temperature will be maintained within 0.1° C about the setpoint. The maximum temperature the control circuit is able to report is 15° C. The M200A reports this temperature when the unit initially powered on. If the temperature fails to drop after 30 minutes, there is a problem in the cooler circuit. If the control circuit on the Preamp card is faulty a temperature of -1° C is reported.

9.3.8.5 High Voltage P.S.

The HVPS is located in the interior of the Sensor Module, and is plugged into the PMT tube. It requires 2 voltage inputs. The first is +15 which powers the supply. The second is the programming voltage which is generated on the Preamp Board. This power supply is unlike a traditional PMT HVPS. It is like having 10 independent power supplies, one to each pin of the PMT. The test procedure below allows you to test each supply.

Adjustment of the HVPS is covered in the Factory Calibration Procedure in Section 9.1.6. To troubleshoot the HVPS:

1. Turn off the instrument.
2. Remove the cover and disconnect the 2 connectors at the front of the NO_x Sensor Module.
3. Remove the end cap from the sensor.
4. Remove the HVPS/PMT assembly from the cold block inside the sensor. Un-plug the PMT tube.
5. Re-connect the 7 pin connector to the Sensor end cap, and power-up the instrument.
6. Use Table 9-9-23 to check the voltages at each pin of the supply, and the overall voltage.
7. Turn off the instrument power, and re-connect the PMT tube, then re-assemble the sensor.

If any faults are found in the test, you must obtain a new HVPS as there are no user servicable parts inside the supply.

To test the HVPS, follow the procedure outlined in Section 9.3.8.5 of the manual. Then:

1. With the instrument disassembled as described and the power turned on, check the HVPS – TEST function on the front panel.
2. Divide the observed HVPS voltage by 10 and test the following pairs of points. The voltage should be 1/10 of the HVPS voltage for each pair.

For Example: If the voltage was 700VDC, the voltage at each stage would be 70VDC.

HVPS PINS	VOLTAGE
11–1	70
1–2	70
2–3	70
3–4	70
4–5	70
5–6	70
6–7	70
7–8	70
8–9	70

3. Each stage should have the same voltage. If so the HVPS is working.

Table 9-9-23: High Voltage Power Supply

9.3.9 Z/S Valves & IZS Permeation Tube Oven

The Z/S Valves and IZS are both options in the instrument. Before troubleshooting this sub-assembly, check that the options were ordered, and that they are enabled in the software.

Sections 7.2, 7.3 show how the Z/S valve and IZS options should be set-up, and how to use them with the AutoCal and Dynamic Cal features.

Check for the Z/S valves:

1. Check for the physical presence of the valves. See Table 2-2-5 for the Z/S Valve location.
2. Check front panel for option presence. The front panel display when the instrument is in SAMPLE mode should display CALS and CALZ buttons on the second line of the display. The presence of the buttons indicates that the option has been enabled in software.

Troubleshooting the Z/S valves:

1. It is possible to manually toggle each of the valves using the SIGNAL I/O selection of DIAGNOSTIC mode. Refer to Section 9.1.3 for information on using the DIAG mode. Also refer to Table 8-8-6, Table 8-8-7, Table 8-8-8 for a pneumatic diagram of the system.

Check for the IZS option:

1. Check for the physical presence of the IZS oven. See Table 2-2-5 for the Z/S Valve location.
2. Check front panel TEST functions for presence of IZS temperature. If IZS temperature is displayed, the IZS oven temperature control algorithm and temperature display has been enabled in the software.

Accuracy and Repeatability of NO_2 permeation tube.

The PTFE membrane of the permeation tube is affected by humidity. If the instrument is installed in an air conditioned shelter, the air is usually dry enough to produce good results. If the instrument is installed in a non-climate controlled site that has high humidity, variations in the perm tube output will occur. For these sites, if high accuracy is required an additional source of dry (dewpoint of -20 C or less) air, such as the M701 zero air module, should be attached to the zero air scrubber inlet.

9.3.10 Pneumatic System

The pneumatic system is diagramed in Table 8-8-6, Table 8-8-7, Table 8-8-8, depending on which options the instrument was ordered with.

9.3.10.1 Leak Check

CAUTION

When doing a leak check do not pressurize the M200A to greater than 15psi.

Damage to internal components will occur at higher pressures.



The basic cause of many performance problems is a leak. Refer to Section 8.9 for the leak check procedure.

9.3.10.2 Pump

The external sample pump is capable of maintaining the cell pressure at 5"Hg-A. If higher pressures are noted, the pump may need servicing. Check the pump/ozone scrubber for leaks or rebuild pump.

The internal sample pump pressures tend to run slightly higher than the external pump due to its smaller size. As in the case above, if higher pressures are noted the pump may need servicing. In the internal pump configuration, the ozone scrubber is integrated into the molybdenum converter.

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10 M200A SPARE PARTS LIST

Table 10-1: Teledyne API M200A Spare Parts List

Part No.	Description
020420000	TELEDYNE API MODEL 200A SPARE PARTS LIST
Includes:	
000940100	CD, ORIFICE, .003 GREEN
000940400	CD, ORIFICE, .004 BLUE
000940600	CD, ORIFICE, .010 BROWN
001450000	CAP, 03
001480300	ASSY, DISCHARGE TUBE, GLASS BEAD HI-PRES
002160000	ASSY, SCRUBBER, M200A/AH/M100AH, PUMPACK
002270100	AKIT, GASKETS, WINDOW, (12)
002730000	CD, FILTER, 665NM (KB)
002760200	ASSY, CPU, 128K PROM, M200A (XINU) CE *
002761000	ASSY, CPU, 512K PROM, M200A (AMX) CE *
003690000	AKIT, TFE FILTER, 37MM, 5UM (100) FL2
003690100	AKIT, TFE FILTER, (FL2) 37MM, 5UM (25)
003690200	AKIT, TFE FILTER, 37MM, 1UM (100)
003690300	AKIT, TFE FILTER, 37MM, 1UM (25)
004020200	PCA, SENSOR BD. NOX, w/FM4 & SW8
004330000	ZERO AIR SCRUBBER (NO/NO2)
005140300	PCA, V/F CARD, W/ SCHEMATIC (B/F)
005960000	AKIT, EXPEND, 6LBS ACT CHARCOAL
005970000	AKIT, EXPENDABLE, 6LB PURAFIL
006900000	RETAINER PAD CHARCOAL, SMALL, 1-3/4"
007040000	PCA, KEYBD DISPLAY, A SERIES *
007280000	ASSY, DISPLAY (DS25) FOR "A" SERIES
009690000	AKIT, TFE FLTR ELEM, 47MM, (FL6) (100)
009690100	AKIT, TFE FLTR, 47MM, (FL6) (30)
009690200	AKIT, TFE FLTR (FL19) ELEM, 47MM, (100)
009690300	AKIT, TFE FLTR ELEMENT, 47MM, 1UM (30)
010860000	PCA, STATUS/TEMP M200A,M101A W/TC
011310000	ASSY, DRYER, NOX
011320000	ASSY, MOLY CONV W/O3 KILLER, M200A *

Part No.	Description
011340000	ASSY, SENSOR, M200A (KB)
011410000	ASSY, PREAMP, M200A (OBS) *
011420000	ASSY, NOX CELL, M200A
011830000	RECHARGE KIT, MOLY CHIPS (2.62OZ)
011880000	WINDOW, SAM FLTR, 37MM, 200A
011900000	ASSY, SAMPLE FLTR, 37MM, SS 1/8, 5UM
011930000	CD, PMT (R928), NOX, M200A, M200E(KB)
011980000	ASSY, THERMOCOUPLE W/ CONN, TYPE J
012360000	ASSY, FAN, "A" PSM
013140000	ASSY, COOLER FAN (NOX/SOX)
013570000	THERMISTOR HOUSING ASSY,E SOX/NOX(KB)
013600000	MANUAL, OPERATORS, M200A
014010000	ASSY, MOLY SPARE, M200A (OBS) *
014020000	AKIT, EXP KIT, M200A
014020200	AKIT, EXP KIT, 47MM/1UM FLTR, M200A
014020300	AKIT, EXP KIT w/CH1 37MM/1UM FLTR, M200A
014020400	AKIT, EXP KIT w/CH1 47MM/1UM FLTR, M200A
014030000	AKIT, M200A/E EXPENDABLES, IZS
014040000	AKIT, LEVEL 1 SP, M200A
014040100	AKIT, LEVEL 1 SP, (1 UNIT), M200A
014060000	ASSY, NOX PROM W/SOFTWARE, M200A (XINU)
014080100	ASSY, HVPS, SOX/NOX
014610000	KIT, REPLACMENT COOLER ASSY, M100X/200X
016810200	ASSY, O3 GEN, M200A, LOW OUTPUT (WO)
017230000	ASSY, DESICCANT CANISTER
018080000	AKIT, DESSICANT BAGGIES, (12)
018720000	ASSY, MOLYCON, w/O3 DESTRUCT, M200A
018740000	ASSY, MOLY W/O3 KILL, M200A, (OBS)
019300000	PCA, KEYBOARD DISPLAY (CE) OPTIONS
021070000	PCA, PREAMP, M200A, M200AH
021890100	ASSY, MOLY CONV, LONG TC, M100A/M200A
022220000	PCA, PWR SUPPLY SWITCH BD, CE (SUBASSY)
022300000	PCA, DC POWER SUPPLY, CE, (SUBASSY)
030320000	ASSY, MOLY CARTRIDGE, WELDED, W/LONG TC
046550100	ASSY, MOLY CART,GRAVEL, LONG TC, TYPE J
051220000	SCRUBBER, W/FTGS O3, M200A *

Part No.	Description
052930100	ASSY, BAND HEATER TYPE J, M101A/M200A
059940000	OPTION, SAMPLE GAS CONDITIONER, M200A/E
CB0000001	FUSE, 3AG 1A
CP0000005	E2PROM, 8K x 8 BIT
DR0000002	DESSICANT *
FL0000001	FILTER, SS
FL0000003	FILTER, DFU (KB)
FM0000004	FLOWMETER (KB)
HE0000017	HTR, 12W/120V (50W/240V), CE AP (KB)
HE0000019	HEATER, 65W, 120V, 6" LEADS CE APPROVED
HW0000020	SPRING
HW0000030	ISOLATOR, M100/M200 A/E/H/U
HW0000031	FERRULE, SHOCKMOUNT
HW0000036	TFE TAPE, 1/4" (48 FT/ROLL)
HW0000037	TIE, CABLE 6"
HW0000099	STANDOFF, #6-32X.5, HEX SS
HW0000150	CLAMP, HOSE, NYLON, 1/4" K62 "AA"
KIT000002	RETROFIT, O3 GEN BRICK, M200A
KIT000011	RETROFIT, PREAMP/TEC CNTRL, M200A
KIT000019	REPLACEMENT COOLER ASSY, M100A/M200A
KIT000021	REPLACEMENT PWR SW BD, 'A', M100A/200A
KIT000028	REPLACEMENT, 37MM SAMPLE FILTER TFE RING
KIT000029	REPLACEMENT, 47MM SAMPLE FILTER TFE RING
KIT000036	RETROFIT, O3 KILLER, M200A/M201A
KIT000041	REPLACEMENT, MOLY VALVES
KIT000042	RETROFIT, Z/S VALVES, M200A
KIT000051	AKIT, REBUILD, RX CELL AMBIENT, M200A/2
KIT000052	REBUILD, RX CELL HI CONC, M200/A/251/252
KIT000055	RETROFIT, IZS, M200A (WITH VALVES) (KB)
KIT000056	RETROFIT IZS, M200A (W/O VALVES) (OBS)
KIT000067	AKIT, REBUILD KIT, RX CELL M200AH
KIT000103	REPLACEMENT, MOLY GUTS, LONG, TYPE J
KIT000110	REPLACEMENT, WELDED MOLY, M200A
KIT000122	ASSY, CPU, 128K PROM, W/PROGRAM (XINU)
KIT000124	ASSY, CPU, 512K PROM, PROGRAMED (AMX)
KIT000129	REPLACEMENT, MOLY CONV WELDED CARTRIDGE

Part No.	Description
OR0000001	ORING, 2-006VT *
OR0000002	ORING, 2-023V
OR0000010	ORING, 2-201S
OR0000012	ORING, 2-111V
OR0000014	ORING, 2-116V
OR0000021	ORING, 2-132V
OR0000025	ORING, 2-133V
OR0000034	ORING, 2-011V FT10
OR0000042	ORING, 2-148
OR0000044	ORING, 2-125V
OR0000045	ORING, 2-226V
PU0000005	PUMP, THOMAS 607, 115V/60HZ (KB)
PU0000006	PUMP, THOMAS 607, 220V/50HZ (KB)
PU0000011	REBUILD KIT, THOMAS 607(KB)
RL0000003	RELAY,SS,PVD1352
RL0000008	SS RELAY, +60V PK, 1.4A (KB)
RL0000014	RELAY, 3 AMP OPTO
RL0000015	RELAY, DPDT, (KB)
SW0000001	SWITCH, INTERLOCK
SW0000006	SWITCH, THERMAL, 60 C
SW0000008	PRESSURE TRANSDUCER (KB)
TN0000003	TRANSFORMER, 120V/60HZ OBS RPL W/ BRICK
VA0000007	VALVE, 3-WAY SS, 12VDC (KB)

Table 10-2: Teledyne API MODEL 200A 37 mm Filter Expendables Kit

Part No.	Description	
014020000	M200A 37 MM FILTER EXPENDABLES KIT	
Includes:		**Qty**
002270100	AKIT, GASKET (RX CELL) QTY. 12	1
003690100	AKIT, TFE FILTER ELEMENT, (FL2) 37MM, 5UM, QTY. 25	2
FL0000001	FILTER, SS (002-024900)	2
FL0000003	FILTER, DFU (036-040180)	1
HW0000020	SPRING, FLOW CONTROL	2
OR0000001	O-RING, FLOW CONTROL	4

Table 10-3: Teledyne API MODEL 200A 47 mm FiIter Expendables Kit

Part No.	Description	
014020200	M200A 47 MM FILTER EXPENDABLES KIT	
Includes:		**Qty**
002270100	AKIT, GASKET (RX CELL) QTY. 12	1
009690100	AKIT, TFE FILTER ELEMENT, 47MM, 1UM, QTY. 30	1
FL0000001	FILTER, SS (002-024900)	4
FL0000003	FILTER, DFU (036-040180)	1
HW0000020	SPRING, FLOW CONTROL	4
OR0000001 O-R	ING, 2-006VT	8
OR0000034	O-RING, 2-011V FT10	2

Table 10-4: Teledyne API MODEL 200A Expendables Kit - IZS

Part No.	Description	
014030000	M200A Expendables Kit - IZS	
Includes:		**Qty**
005960000	AKIT, Expendable, 6 LBS, ACT Charcoal	1
005970000	AKIT, Expendable, 6 LBS, Purafil	1
FL0000001	Filter, SS (002-024900)	2
FL0000003	Filter, DFU (036-040180)	1
HW0000020 Spring		2
OR0000001	O-Ring, Flow Control, 2-006VT	4

Table 10-5: Teledyne API MODEL 200A Level 1 Spares Kit

Part No.	Description	
014040000	M200A LEVEL 1 SPARES KIT	
Includes:		**Qty**
00402020A	FLOW/PRESSURE SENSOR BOARD	1
01131000A	DRIER ASSEMBLY COMPLETE WITH FLOW CONTROL	1
011930000	CD, PMT (R928), NO_X 1	
01408010A	ASSEMBLY, HIGH VOLTAGE POWER SUPPLY	1
014610000	KIT, REPLACEMENT COOLER ASSEMBLY	1
016810400 ASSY,	O_3 GEN, HI OUTPUT	1
021890100	ASSY, WELDED MOLY CONV. W/O VAL, LONG TC	1
HE0000017	HEATER, REACTION CELL, 12W	1
HW0000150	CLAMP, HOSE, NYLON, 1/4”	2
PU0000011	607 PUMP REBUILD KIT	1
RL0000008	SOLID STATE RELAY, 12 VDC	1
RL0000015	RELAY, DPDT, (KB)	1
VA0000007	SOLENOID VALVE, STAINLESS STEEL, 12V	1

Table 10-6: Teledyne API MODEL 200A Spares Kit for 1 Unit

Part No.	Description	
014040100	M200A SPARES KIT FOR 1 UNIT	
Includes:		**Qty**
01236000A	FAN ASSY, POWER SUPPLY MODULE, "A"	1
01314000A	FAN, PMT COOLER	1
CB0000001	FUSE O3AG, 1A	1
HE0000017	HEATER, REACTION CELL, 12W/120V (50W/240V), CE AP (KB)	1
PS0000010	POWER SUPPLY, 15V SWITCHING	1
RL0000015	RELAY, DPDT (KB)	1

Table 10-7: Teledyne API MODEL 200A 37 mm FiIter Expendables Kit with CH1

Part No.	Description	
014020300	AKIT, EXP KIT w/CH1 37MM/1UM FLTR, M200A	
Includes:		**Qty**
002270100	AKIT, GASKETS, WINDOW, (12)	1
003690300	AKIT, TFE FILTER, 37MM, 1UM (25)	2
005960000	AKIT, EXPEND, 6LBS ACT CHARCOAL	1
FL0000001	FILTER, SS	2
FL0000003	FILTER, DFU (KB)	1
HW0000020	SPRING	2
OR0000001	ORING, 2-006VT *	4
OR0000002	ORING, 2-023V	2
OR0000034	ORING, 2-011V FT10	2

Table 10-8: Teledyne API MODEL 200A 47 mm FiIter Expendables Kit with CH1

Part No.	Description	
014020400	AKIT, EXP KIT w/CH1 47MM/1UM FLTR, M200A	
Includes:		**Qty**
002270100	AKIT, GASKETS, WINDOW, (12)	1
005960000	AKIT, EXPEND, 6LBS ACT CHARCOAL	1
009690300	AKIT, TFE FLTR ELEMENT, 47MM, 1UM (30)	1
FL0000001	FILTER, SS	4
FL0000003	FILTER, DFU (KB)	1
HW0000020	SPRING	4
OR0000001	ORING, 2-006VT *	8
OR0000034	ORING, 2-011V FT10	2

APPENDIX A ELECTRICAL SCHEMATICS

Table A-1: Electrical Schematics

Part No.	Name
00402	Sensor Board Assembly
00403	Sensor Board Schematic
00514	V/F Board Assembly
00515	V/F Board Schematic
00704	Keyboard Assembly
00705	Keyboard Schematic
0108600	Status/Temp Assembly
01087	Status/Temp Schematic
01109	Motherboard Assembly
01110	Motherboard Schematic
01114	Connector Board Assembly
01115	Connector Board Schematic
0113912	PSM Overall schematic - CE Mark
01206	Switch Board Assembly
01207	Switch Board Schematic
01464	DC Power Supply Assembly
01465	DC Power Supply Schematic
01471	4-20 mA Output Option
0166803	Ozone Generator Power Supply Assembly
01669	Ozone Generator Power Supply Schematic
01839	Thermoelectric Cooler Control Assembly
01840	Thermoelectric Cooler Control Schematic
01916	Connector Board Schematic - CE MARK
01917	Connector Board Assembly - CE MARK
01930	Keyboard Assembly - CE MARK
01931	Keyboard Schematic - CE MARK

(table continued)

Table A-1: Electrical Schematics (Continued)

Part No.	Name
02034	A-Series Valve Driver Assembly
02035	A-Series Valve Driver Schematic
02037	ISBX I/O Port Assembly
02038	ISBX I/O Port Schematic
02107	Preamp Board Assembly
02108	Preamp Board Schematic
02222	Switch Board Assembly - CE MARK
02223	Switch Board Schematic - CE MARK
02230	DC Power Supply Assembly - CE MARK
02231	DC Power Supply Schematic - CE MARK
03172	M200A Interconnect Diagram
03173	M200AH Interconnect Diagram
03174	M200AU Interconnect Diagram
03175	M201A Interconnect Diagram

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