

## MANUAL ADDENDUM

# ***MODEL 201A AMMONIA ANALYZER***

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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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## 1.0 M201A AMMONIA ANALYZER

This manual is to be used in conjunction with the M200A NO<sub>x</sub> Analyzer manual p/n 02246 supplied with this instrument.

The M201A Ammonia Analyzer consists of a modified M200A Nitrogen Oxides Analyzer and M501NH Ammonia Converter:

A functional block diagram of the system is shown in Figure 1.

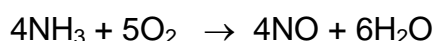
The instrument comes in three pneumatic configurations:

- The basic system is shown in Figure 3;
- The M201A with Z/S valves is shown in Figure 4;
- The M201A with External Calibrator Option (ECO) is shown in Figure 5.

Figure 2 can be used to connect the M201A system for installation. Please note that for a M201A with either a Zero/Span or ECO option, you must connect the umbilical cord, 02255, between the analyzer and the converter assembly.

### 1.1 Principle of Operation

The Teledyne API Model 201A Analyzer measures ammonia by converting NH<sub>3</sub> to nitric oxide by the following reaction:



The resulting NO is then measured by the chemiluminescent reaction of NO with ozone. Consult Section 4.1 in the M200A manual (provided with this instrument) for more details on NO measurement.

A molybdenum converter is continuously in the pneumatic pathway, providing the TN channel signal. The M501NH ammonia converter is periodically switched so both converters are in series, creating the TN<sub>x</sub> signal.

The ammonia concentration is computed by the difference between the TN<sub>x</sub> and TN channels, as shown in the following equation:



See the pneumatic diagram in Figure 1.

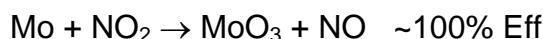
The actual formula for computation of ammonia concentration is more complicated than the above equation, as it includes converter efficiencies, plus sample temperature and pressure. The difficulty in ammonia measurement is that the molybdenum converter

converts some of the ammonia to NO, thus the TN channel data contains a small ammonia signal. Secondly, the ammonia converter does not convert all of the ammonia or ambient NO<sub>2</sub> to NO. Finally, the high temperature in the ammonia converter causes the oxygen and nitrogen in ambient air to react, creating a background of NO<sub>x</sub> which needs to be factored into computing the result. Fortunately, all of the above shortcomings have been overcome in the M201A by careful calibration, and calculation of the result. .

Periodically, the AutoZero valve switches allowing the analyzer to read zero background. The AutoZero readings are subtracted from all of the other readings. This improves zero baseline stability.

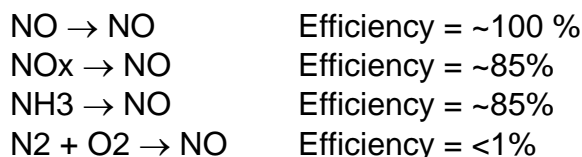
As with many chemical reactions the conversion of ammonia in the presence of other oxides of nitrogen is complicated.

In the molybdenum converter operating at 315°C, the following significant reactions are taking place:



Notice in the second reaction some of the ammonia is converted to NO by the molybdenum metal.

The M501NH NH<sub>3</sub> Converter operates at 825°C. At this high temperature, several reactions occur:



As can be seen from the above reactions, the calculation of the ammonia concentration and overall calibration of the instrument must be done carefully if accurate ammonia concentrations are to be measured. The calibration procedure is covered in Section 2.

### **1.1.1 Special Considerations for Ammonia Measurement**

Ammonia is a difficult gas to measure due to its chemical characteristics. Because of its large dipole moment, the gas tends to adsorb on surfaces and diffuse into many materials. The following precautions should be observed when designing an ammonia sampling system and connecting the M201A analyzer to the system:

Materials:

Do NOT use TEFLON tubing or fittings in contact with NH<sub>3</sub> sample or span gas.



Do NOT use copper tubing or fittings designed for household plumbing.  
Use ONLY Chromatography grade (cleaned, passivated) stainless steel tubing  
Use ONLY Glass tubing for sample inlet manifold.

These rules apply also to your calibrator's internal plumbing. Verify that the calibrator pneumatic pathway that contacts ammonia only uses stainless steel or glass tubing.

The M702SS calibrator supplied with the External Calibration Option is built with stainless steel fittings and tubing for all internal plumbing wetted by NH<sub>3</sub>.

Typical ambient NH<sub>3</sub> levels are < 15 ppb, unless there is some large source of ammonia nearby, so the sampling and analysis system must be carefully designed and well maintained.

### **1.1.2 Sample Filtration**

The M201A does not come with a sample filter installed. Depending on the options ordered, a sample filter may be separately packaged with the instrument. If the filter is installed, the instrument response time is significantly increased, due to its large surface area. Also, the condition of the filter (particulate loading and type) can adversely affect the response time.

For minimum response time operation, the instrument should be supplied with clean sample gas at ambient pressure.

If the sample filter is not included, the only additional filter in the M201A pneumatic pathway is a ¼" dia stainless steel sintered filter used to protect the flow control orifice from plugging. This filter will plug rapidly if the sample gas is not filtered before entering the analyzer. Some means of filtering the sample gas, such as an external stainless steel filter should be added upstream of the analyzer.

## 1.2 M201A Analyzer Specifications

Ranges	0-50 to 0-2000 ppb in 1 ppb increments
Range Modes	Single, Independent, AutoRange
Noise at Zero <sup>1</sup>	0.5 ppb RMS
Noise at Span <sup>1</sup>	< 1.0% of reading above 50 ppb
Lower Detectable Limit	1 ppb RMS
Zero Drift <sup>3</sup>	2 ppb / 24 hours
Span Drift	< 1.0% FS Range / 7 days
Lag Time	40 sec
Rise Time	90% 120 sec
Fall Time	90% 120 sec
Sample Flow Rate	1000 cc/min
Linearity	2% of full scale
Precision	1.0% of reading
Temp Range	10-30°C
Dimensions HxWxD	7" x 17" x 23.6" (18cm x 43cm x 61cm)
Weight, Analyzer	43 lbs (20 kg)
Weight, Converter	24 lbs (11 kg)
Weight, Pump	16 lbs (7 kg)
Power, Analyzer	100V ~50/60 Hz, 120V ~60 Hz, 220V ~50Hz, 240V ~50 Hz, 125 watts
Power, Analyzer <sup>5</sup>	230V ~50 Hz, 125 watts
Power, Pump	110V ~60 Hz, 220V ~50 Hz, 240V ~50 Hz, 295 watts
Power, Pump CEMark <sup>5</sup>	230 V ~50 Hz, 2.5 A peak
Environmental	Installation Category Pollution Degree 2, Over-voltage Category II
Analog Output	0-100, 0-1, 0-5, 0-10VDC bi-polar, 4-20mA isolated
Analog Resolution	1 part in 2048
Status Option	12 Status Outputs
Measurement Units	ppb, ug/m3

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

## 2.0 CALIBRATION PROCEDURE

Calibration of the M201A is done by first calibrating the TN and TNx channels with NO span gas diluted with zero air. In the second phase of calibration, ammonia span gas is introduced to measure the overall system efficiency for NH<sub>3</sub> conversion. Unlike NO<sub>x</sub> analysis, the NH<sub>3</sub> converter efficiency must be measured because it is considerably lower than 100% and may change as the converter ages.

If the instrument is configured as a basic model, all zero/span gasses are introduced through the sample port. If the Zero/Span valves option or the ECO option is ordered, the zero/span gas is introduced through the zero/span valves. There are several ways of automating the calibration or span check process, they are covered in Section 7 of the M200A manual. After reviewing the procedure described below, it should be simple to adapt the procedures in Section 7 to the M201A, if necessary.

### 2.1 Zero/Span Calibration – Basic Instrument

Since the zero gas concentration is defined as 0 ppb, it is not necessary to enter the expected zero value.

**Table 2.1 - Zero Calibration Procedure - Zero Gas Through the Sample Port**

<b>Step No.</b>	<b>Action</b>	<b>Comment</b>
1.	Press CAL	The M201A enters the calibrate mode from sample mode. Input zero gas through the sample port.
2.	Wait 20 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	M201A returns to sampling. Immediately after calibration, data is not added to the DAS averages.

**Table 2.2 - Enter the Expected Span Gas Concentrations Procedure**

<b>Step No.</b>	<b>Action</b>	<b>Comment</b>
1.	Press CAL-CONC-TNX	This key sequence causes the M201A to prompt for the expected TNX concentration. Enter the TNX 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 TNX span value.
3.	Press CAL-CONC-TN	Now enter the expected TN span concentration as in step one.
4.	Press ENTR	Pressing ENTR stores the TN span value and returns the prompt to the CONC menu.
5.	Press EXIT	Returns instrument to SAMPLE mode.

**Table 2.3 - Span Calibration Procedure - Span Gas thru Sample Port**

<b>Step No.</b>	<b>Action</b>	<b>Comment</b>
1.	Press CAL	The M201A enters the calibrate mode. Input NO span gas through the sample port.
2.	Press CAL-CONV-SET	Set the converter efficiency parameter to 1.0000, then press ENTR-EXIT.
2.	Wait 20 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 TN and TNx span concentrations.
5.	Press EXIT	M201A returns to sampling. Immediately after calibration, data is not added to the DAS averages.

## 2.1.1 Zero/Span Calibration with Z/S Valves or ECO Option

The zero gas enters through the zero gas inlet port on the rear panel. Make sure that the umbilical cord that makes the control connections between the analyzer and the converter is connected (see Figure 2 below). The zero gas valve can be activated by a variety of methods discussed in Section 7 of the M200A manual. The example below will use the front panel keyboard to activate the valves.

**Table 2.4 - Zero Calibration Procedure - Zero Gas from rear panel zero air inlet**

Step No.	Action	Comment
1.	Press CALZ	The M201A enters the calibrate mode from sample mode. The zero gas is supplied through the zero air inlet port on the rear panel.
2.	Wait 20 min	Wait for reading to stabilize at zero. If the instrument has recently been exposed to high levels of NH <sub>3</sub> , you may need to wait up to 2 hours for the instrument to return to zero.
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	M201A returns to sampling. This switches the ZS valves so that sample gas is coming in the sample port on the rear of the instrument. Immediately after calibration, data is not added to the DAS averages.

Since the zero gas concentration is defined as 0 ppb, it is not necessary to enter the expected zero value.

The expected value of the span gas is entered into the instrument by the following procedure.

Table 2.5 - Enter the Expected Span Gas Concentrations Procedure

Step No.	Action	Comment
1.	Press CAL- CONC- TNX	This key sequence causes the M201A to prompt for the expected TNX concentration. Enter the TNX 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 TNX span value.
3.	Press CAL- CONC-TN	Now enter the expected TN span concentration as in step one.
4.	Press ENTR	Pressing ENTR stores the TN span value and returns the prompt to the CONC menu.
5.	Press EXIT	Returns instrument to SAMPLE mode.

Table 2.6 - CALS - Span Cal Procedure - Gas from rear panel span gas inlet

Step No.	Action	Comment
1.	Press CALS	The M201A enters the calibrate mode. The Z/S valves are activated to route span gas into the analyzer.
2.	Press CAL-CONV-SET	Set the converter efficiency parameter to 1.0000, then press ENTR-EXIT.
2.	Wait 20 min	Wait for the 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 TN and TNx span concentrations.
5.	Press EXIT	M201A returns to sampling. Immediately after calibration, data is not added to the DAS averages.

### 2.1.2 TN/TNx Channel Calibration Quality

After the TN and TNx channel calibration it is important to check the slopes and offsets to make sure they fall within the acceptable range. The tolerances are different than a typical NOx analyzer primarily because of the performance of the M501NH ammonia converter.

Slopes can vary from 2.0 to 0.7, and should be within 20% of each other with the TNx slope typically smaller than the TN slope.

Offsets should be zero  $\pm$ 250 mV and be within 100mV of each other.

If the slope and offsets are within specifications, proceed on the ammonia channel calibration.



### 2.1.3 NH<sub>3</sub> Calibration

Since the system efficiency is less than 100%, it is necessary to determine a conversion efficiency factor for ammonia and enter it into the system.

1. Set the converter efficiency to 1.0000 by:

Press CAL-CONC-CONV-SET on the keyboard

Press the keys under the numbers until 1.0000 appears.

Press EXIT to return to the sample mode.

2. Introduce ammonia span gas of known concentration into the instrument. Allow time for instrument stabilization. The final readings will be less than the concentration calculated from flows. For example with 400 ppb NH<sub>3</sub> span gas:

$$TN = 40 \text{ ppb}$$

$$TNx = 380 \text{ ppb}$$

The 40 ppb TN reading is due to the fact that the moly converts a small amount of the NH<sub>3</sub> gas to NO. The 380 ppb TNx reading is due to ammonia conversion plus some conversion of nitrogen and oxygen in the dilution air.

3. Continuing with the example above, the instrument will report a NH<sub>3</sub> concentration value of 340 ppb. Divide the reported NH<sub>3</sub> concentration by the concentration computed from flow data.

$$\text{NH}_3 \text{ converter eff.} = [\text{NH}_3_{\text{M201A}}] / [\text{NH}_3_{\text{FLOWS}}]$$

From the above example :

$$\text{M201A NH}_3 \text{ reading} = 340 \text{ ppb}$$

$$\text{NH}_3 \text{ conc from flows} = 400 \text{ ppb}$$

$$340 / 400 = 0.85 \text{ NH}_3 \text{ converter system efficiency}$$

4. This value now is entered into the instrument.

Press CAL-CONC-CONV-SET

Press the buttons under the numbers until the desired value is entered, in this case 0.8500, then press ENTR.

Press EXIT to return to SAMPLE mode.

The instrument is now fully calibrated.

### **2.1.4 Channel Calibration Quality**

After the ammonia channel is calibrated via the converter efficiency parameter, it is important to check the calibration by sampling the NH<sub>3</sub> calibration gas and confirming that the instrument responds with the correct concentration. In the above example the M201A should report 400 ppb NH<sub>3</sub> concentration when measuring the 400 ppb NH<sub>3</sub> span gas used.

## 3.0 MAINTENANCE SCHEDULE

### 3.1 M201A Maintenance Schedule

The maintenance requirements of the M201A are essentially like a standard M200A NO<sub>x</sub> analyzer. Please refer to Table 8-1 in the M200A Operator Manual for the M200A maintenance schedule.

In Table 3.1 below, there are the extra maintenance items required by the M201A.

**Table 3.1: Preventative Maintenance Schedule**

Item	Maintenance Interval	Reference Section
M501NH <sub>3</sub> Converter	Check every 6 months	Section 3.2
Reaction Cell	Clean quarterly as necessary	Sect 9.3.8, Fig 8-3 in the M200A Manual
AutoZero flow check	Quarterly as needed	Section 3.3

### 3.2 Maintaining the M501NH Converter

The M501NH Converter is operated at very high temperature. The center tube in the converter slowly oxidizes and requires replacement. The most obvious indicator of failure is no ammonia conversion, despite the converter being at temperature. This is caused by the oxidized tube breaking off in the converter.

The following procedure describes how to disassemble and replace converter parts. The various parts in the converter become delicate and brittle after prolonged exposure to high temperatures. It is therefore a good idea to have a complete set of replacement parts on hand before starting, as listed in Table 3.1.

Table 3.2 – M501NH Converter Rebuild Parts List

Part No.	Description
KIT000191	Converter Rebuild Kit
KIT000139	Ceramic Bushings
HE0000007	Ceramic Heater 220W 60 VAC

Procedure:

1. Turn off power to the converter and allow to cool. **IT IS VERY IMPORTANT THAT THE CONVERTER BE COOL BEFORE ATTEMPTING ANY DISASSEMBLY OR REPAIRS.**



**CAUTION VERY HOT**

**Will cause severe burns – disassembly while hot will damage other converter components. Allow sufficient time to cool.**

2. Remove the chassis cover of the M501NH, remove the aluminum cover over the oven, remove the two U-shaped hold down clamps.
3. Disconnect the 1 stainless steel and 2 PTFE tubes from the converter cartridge.
4. Loosen the nut holding the cartridge assembly in the U-shaped angle bracket mounted on the chassis floor.
5. Gently lift and tilt the converter assembly out of the U-shaped bracket and slide the assembly out of the oven.
6. Loosen the ¼” SS tube fitting nearest the hold-down bracket, this fitting holds the central tube in the converter. Replace the tube that is part of KIT000191
7. Re-assemble the converter by doing the above steps in reverse order.

### 3.3 AutoZero Flow Check

Since the M201A is an ammonia analyzer, the flow through the AutoZero orifice is especially important. Check the AutoZero flow as follows:

1. This procedure should be performed with the sample pump running.
2. Fold down the rear panel on the M201A chassis. Locate the vacuum manifold at the center rear of the chassis. Locate the 1/8" tube fitting 2<sup>nd</sup> from the left. It will have a label of "0.010", indicating the flow orifice installed.
3. Remove the fitting and attach a calibrated flowmeter capable of measuring in the range of 500 cc/min. The flowmeter should indicate a flow of 500 cc/min  $\pm$ 10%.
4. If the flow is outside this range (most likely lower, due to plugging):
  1. Turn off the sample pump and instrument.
  2. Remove the 1/8" pipe-to-tube fitting and remove the 1/4" sintered filter (p/n FL0001). This filter is meant to protect the orifice, it will usually become plugged and need replacement rather than the orifice. Replace the filter, then re-assemble the manifold. Re-start the sample pump and re-check the flow.

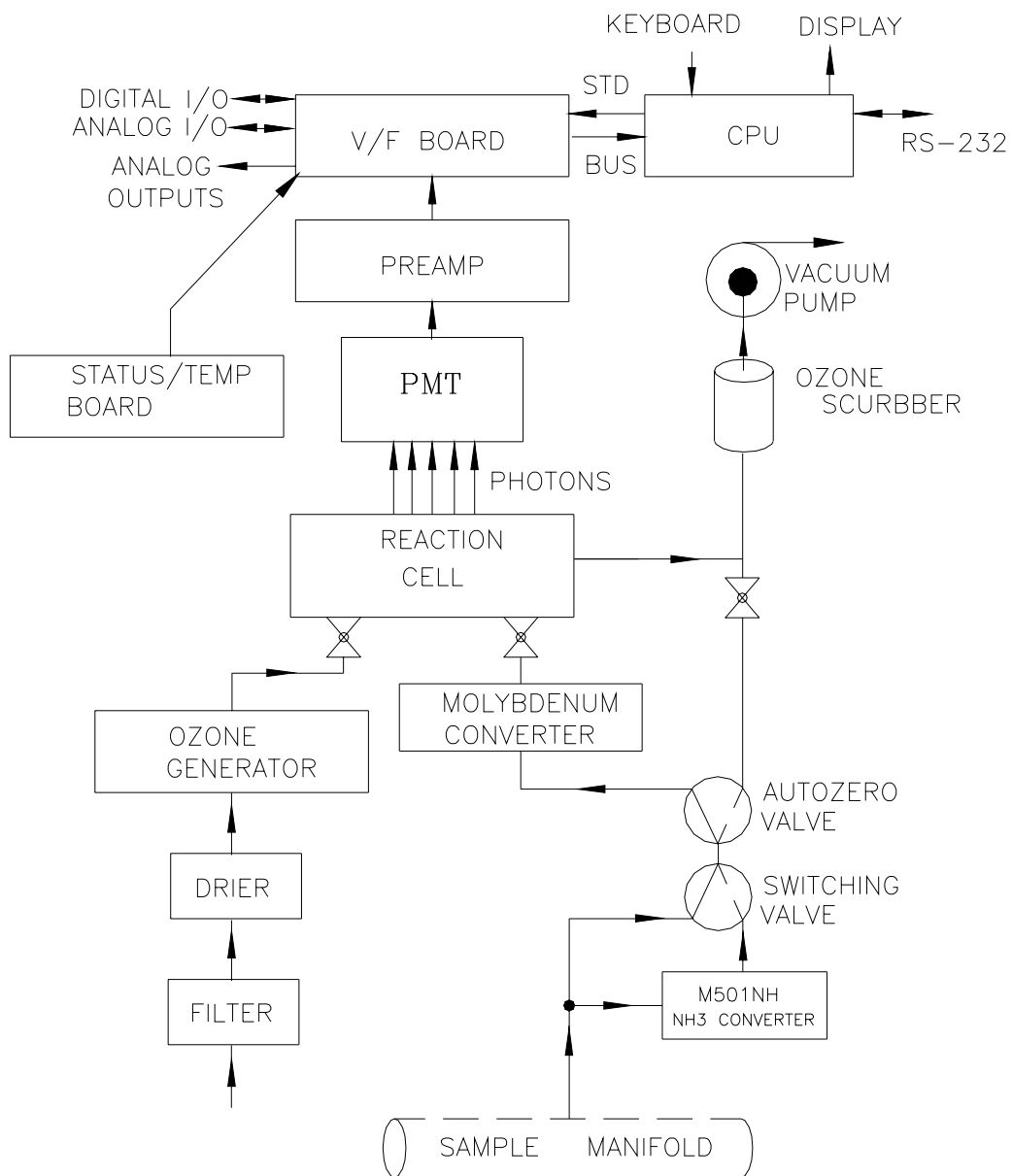


Figure 1 - M201A Ammonia Analyzer – Block Diagram

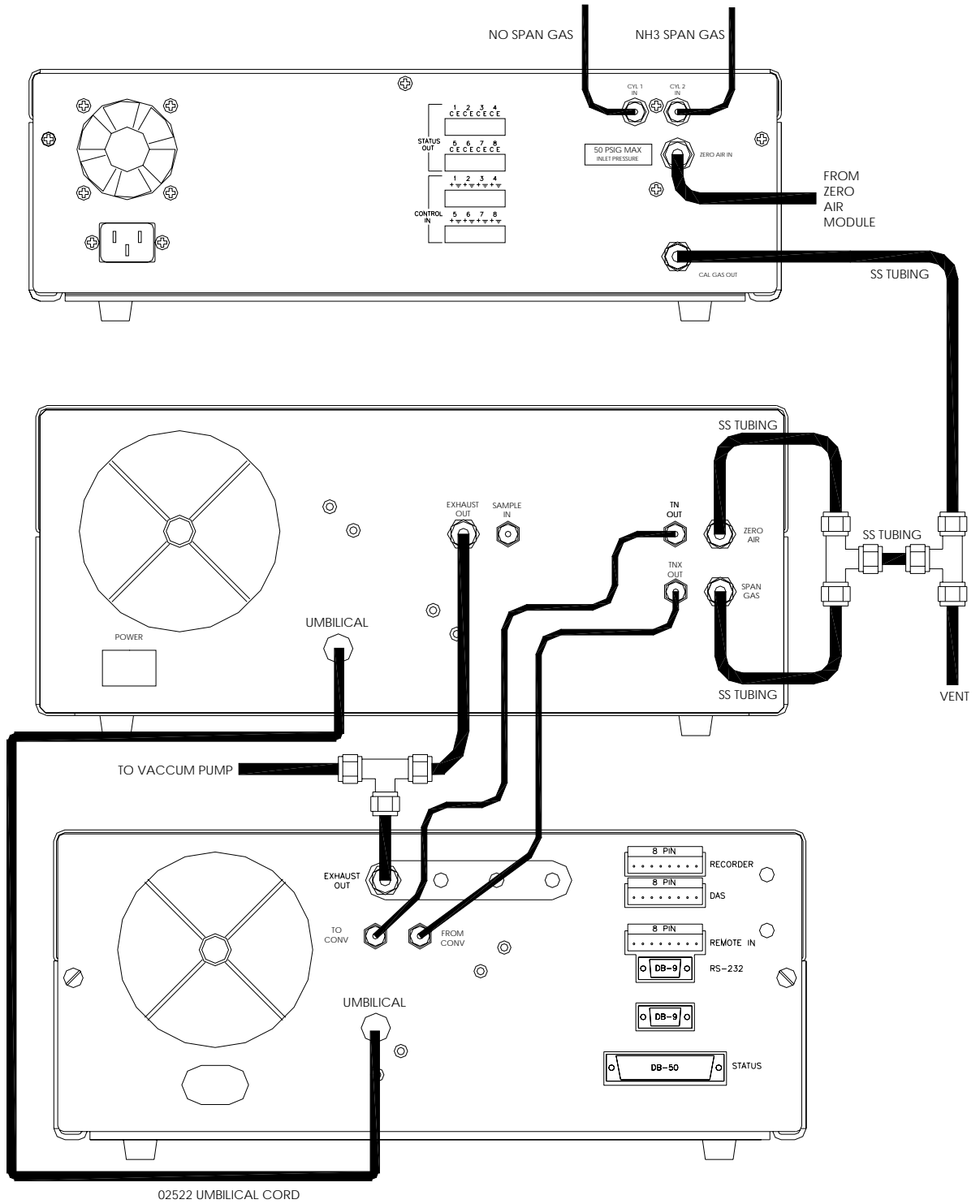


Figure 2 - M201A External Pneumatic Connection Diagram with ECO (External Calibrator Option)

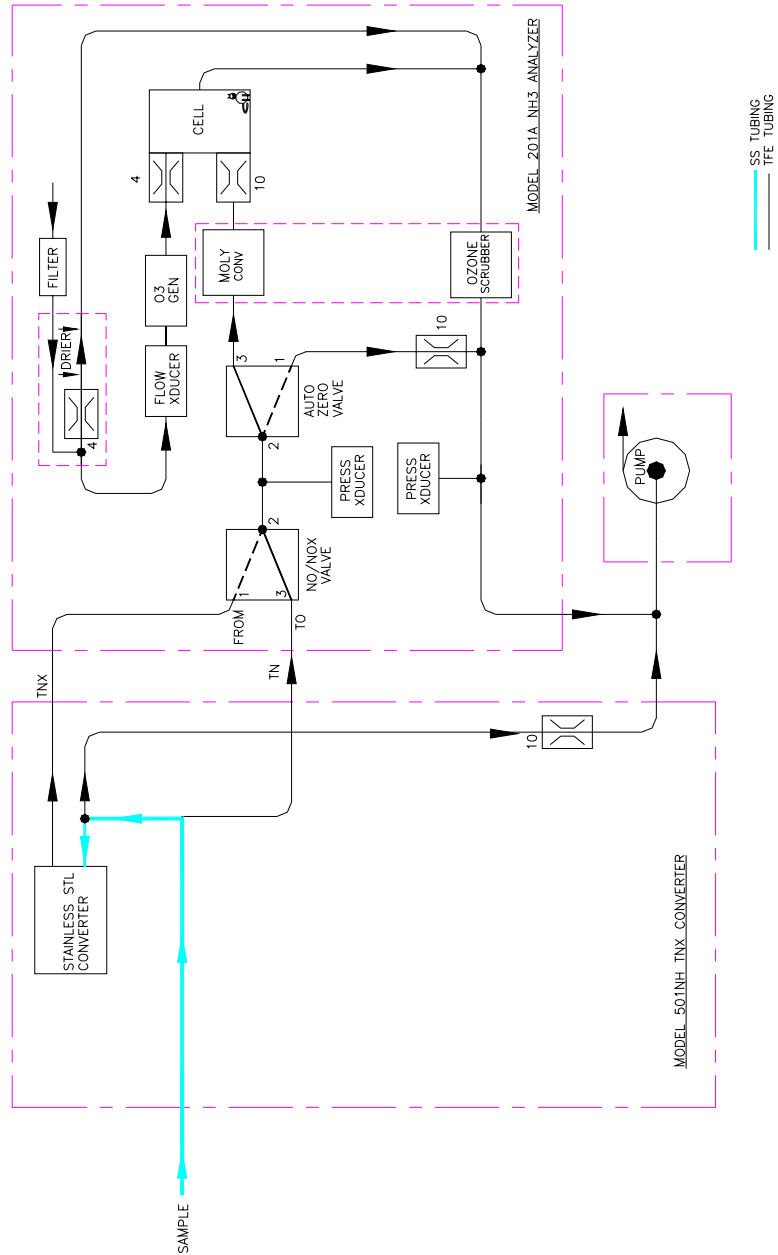


Figure 3 - M201A Pneumatic Diagram Basic



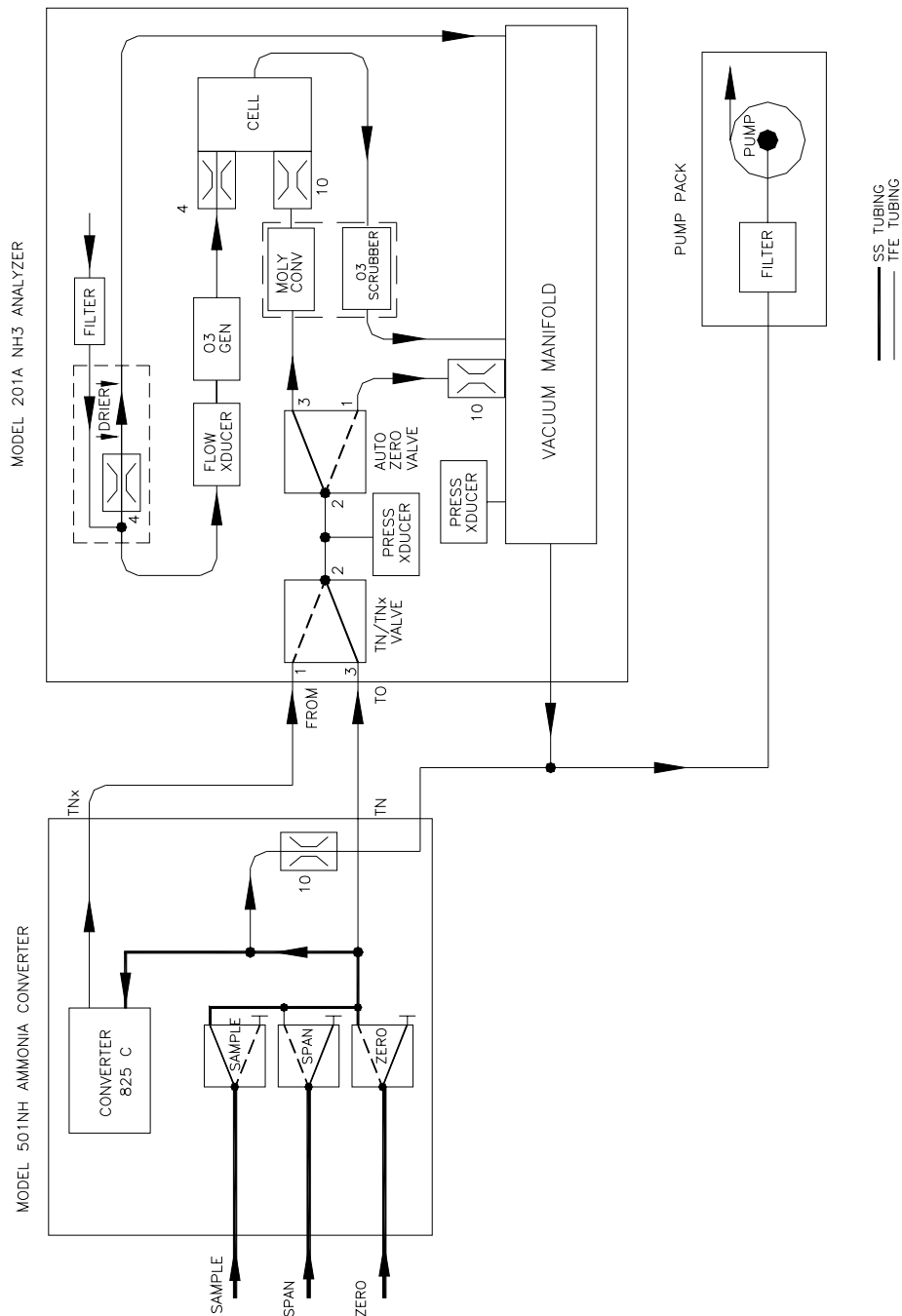


Figure 4 - M201A Pneumatic Diagram Z/S Option

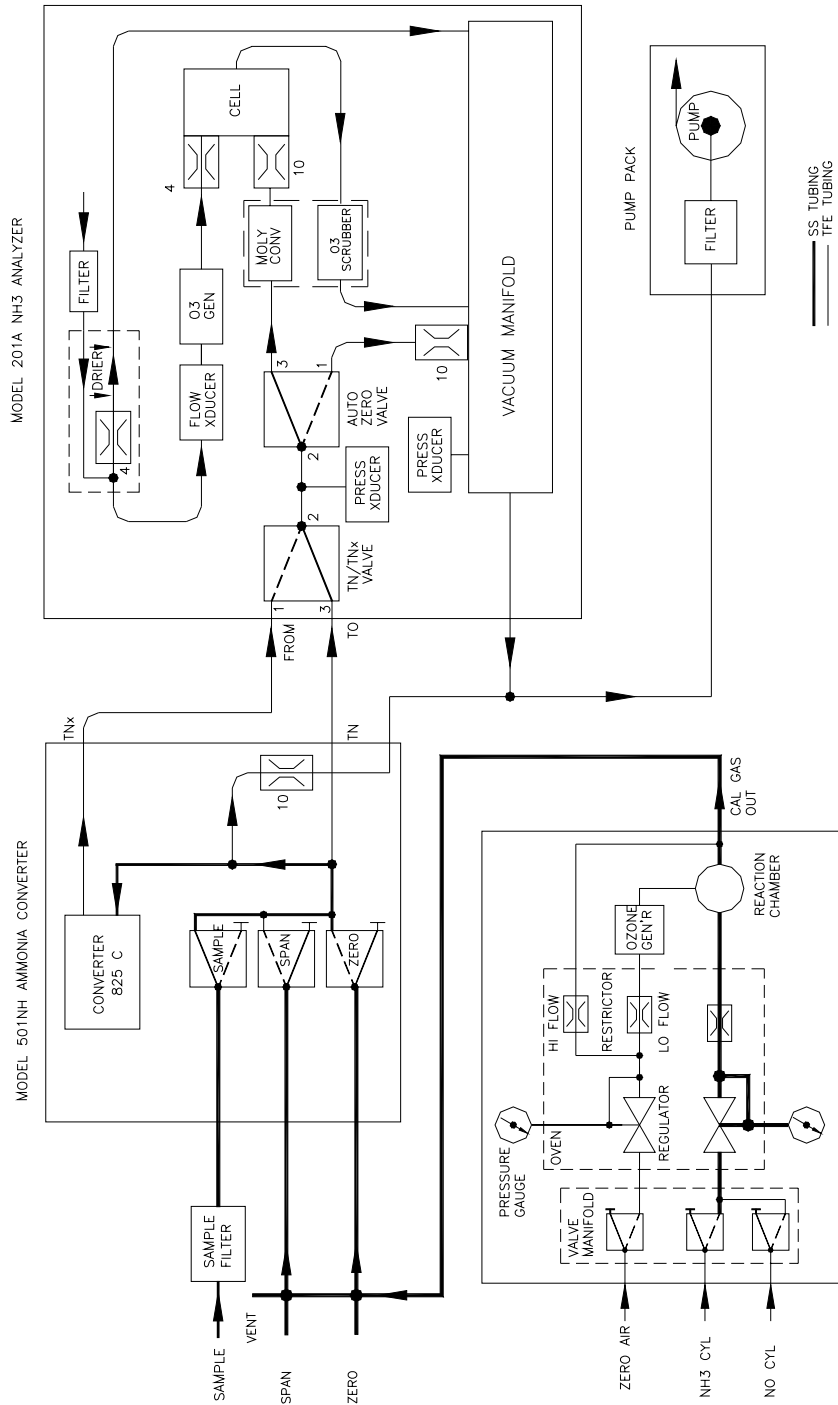


Figure 5 - M201A Pneumatic Diagram External Calibrator Option (ECO)

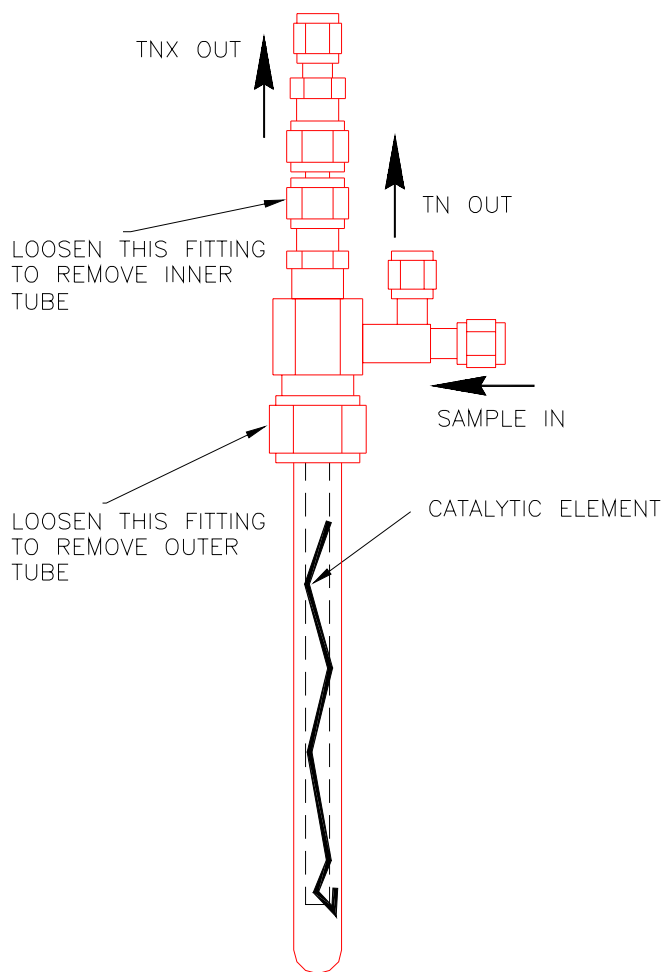


Figure 6 – M501NH Converter Cartridge



## 4.0 M201A SPARE PARTS LIST

000940400	Orifice, 4 mil, 80 cc, Rx Cell
000940600	Orifice, 10 mil, 500 cc, Rx Cell
002270100	Gasket (Rx Cell) Qty. 12
002730000	Window 665 NM
002761020	CPU Board (201A AMX))
003290000	Thermistor Assembly
004020200	Flow/Pressure Sensor Board
005140300	V/F Board
007040000	Keyboard
007280000	NEW Display
010680100	Heater, MOLY Converter
010860000	Status/Temperature Board
011310000	Drier Assembly Complete with Flow Control
011930000	PMT, NOx
011980000	Assembly, MOLY Thermocouple (Type J)
012360000	Fan, Power Supply Module
013140000	Fan, PMT Cooler
013570000	Thermistor Assembly (Cooler)
013600000	Operators Manual for M200A
014020300	M200A 37 mm 1 um Filter Expendables Kit
014020400	M200A 47 mm 1 um Filter Expendables Kit
014040000	M200A Level 1 Spare Parts Kit (for 10 units)
014040100	M200A Spares Kit for 1 Unit
014080100	Assembly, High Voltage Power Supply
014610000	Cooler Assembly

## M201A Spare Parts List (cont.)

016810200	O3 Generator Assembly for M200A/200AH Low Output
017230000	Dryer Material, Drierite
018720000	Welded Moly Conv. Assy, w/ O3 Scrubber, w/ valves
021070000	PMT Pre-amplifier Board Assembly
022300000	DC Power Supply Board
024710000	Tubing: 6', 1/8" CLR
024720000	Tubing: 6', 1/8" BLK
024730000	Tubing: 6', 1/4" BLK
024750000	Tubing: 6', 1/4" TYGON
046890000	M201A Manual Addendum
046570100	Catalytic Converter Insert
CB0000001	FUSE O3, 1A
CP0000014	Fuji Temperature Controller
DR0000002	PMT Desiccant Baggies
FL0000001	Sintered Filter
FL0000003	Filter, DFU
FM0000004	Flow Meter, 0-1000 cc
HE0000007	Ceramic Heater 220W 60 VAC
HE0000017	Heater, Reaction Cell, 12W
HE0000019	Heater, MOLY Converter
HW0000020	Spring, Flow Control
HW0000036	TFE Thread Tape (48 FT)
HW0000150	Clamp, Hose, Nylon, 1/4"
KIT000019	Replacement Cooler Assembly, M100A/M200A
KIT000021	Replacement PWR SW BD, 'A', M100A/200A
KIT000036	Retrofit, O3 Killer
KIT000041	Retrofit, Moly Valves, M200A
KIT000051	Rebuild Kit, RX Cell Ambient, M200/A/251/252
KIT000058	Leak Checker with Gauge
KIT000059	Leak Checker without Gauge
KIT000067	Retrofit, M200A Rcell Rebuild Kit
KIT000103	Replacement, Welded Moly Cart, Type J Tc, Heater
KIT000110	Repl, Welded Moly Type J Tc w/o valves, w/o O3 killer, in can

## M201A Spare Parts List (cont.)

KIT000129	Welded Moly, Cartridge only
KIT000191	Rebuild, NH <sub>3</sub> INNER TUBE & CATALYST
OR0000001	O-Ring, Flow Control
OR0000002	O-Ring, Bearing, Cell
OR0000010	O-Ring, S, O <sub>3</sub> Generator
OR0000012	O-Ring, Permeation Oven-Units with IZS
OR0000014	O-Ring, Permeation Oven
OR0000021	O-Ring, Scrubber
OR0000025	O-Ring, Zero Air Scrubber
OR0000034	O-Ring, Input/Output Mirror/Detector
OR0000042	O-Ring, Sensor Assembly
OR0000044	O-Ring, Reaction Cell
OR0000045	O-Ring, Sample Filter
PS0000010	15V Switching Power Supply
PU0000005	Pump 1150V/60Hz
PU0000006	Pump 220V/50Hz
PU0000011	607 Pump Rebuild Kit
RL0000003	Solid State Relay, 12 Vdc
RL0000007	3 AMP Opto Relay
RL0000008	Solid State Relay, 12 VDC
RL0000015	Solid State Relay, 115 Vac
SW0000006	Overheat SW, Cell/Oven
SW0000008	Pressure Sensor
VA0000007	Solenoid Valve, Stainless Steel, 12V
VA0000024	Manifold Valve, 3-Way, Vent