



MANUAL ADDENDUM

MODEL T201 AMMONIA ANALYZER

(For use with the T200 Operators Manual, P/N 06858)

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ABOUT THIS MANUAL

This addendum is to be used in conjunction with the T200 NOx Analyzer manual, p/n 06858, for operating the T201 analyzer.

Note

We recommend that this manual and the T200 manual be read in their entirety before any attempt is made to operate the instrument.

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SAFETY MESSAGES

Important safety messages are provided throughout this manual for the purpose of avoiding personal injury or instrument damage. Please read these messages carefully. Each safety message is associated with a safety alert symbol, and are placed throughout this manual; the safety symbols are also located inside the instrument. It is imperative that you pay close attention to these messages, the descriptions of which are as follows:



WARNING: Electrical Shock Hazard



HAZARD: Strong oxidizer



GENERAL WARNING/CAUTION: Read the accompanying message for specific information.



CAUTION: Hot Surface Warning



Do Not Touch: Touching some parts of the instrument without protection or proper tools could result in damage to the part(s) and/or the instrument.



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

This instrument should only be used for the purpose and in the manner described in this manual. If you use this instrument in a manner other than that for which it was intended, unpredictable behavior could ensue with possible hazardous consequences.

NEVER use any gas analyzer to sample combustible gas(es)!

Note

Technical Assistance regarding the use and maintenance of this instrument or any other Teledyne API product can be obtained by contacting Teledyne API's Technical Support Department:

Telephone: 800-324-5190

Email: sda_techsupport@teledyne.com

or by accessing various service options on our website at <http://www.teledyne-api.com/>

CONSIGNES DE SÉCURITÉ

Des consignes de sécurité importantes sont fournies tout au long du présent manuel dans le but d'éviter des blessures corporelles ou d'endommager les instruments. Veuillez lire attentivement ces consignes. Chaque consigne de sécurité est représentée par un pictogramme d'alerte de sécurité; ces pictogrammes se retrouvent dans ce manuel et à l'intérieur des instruments. Les symboles correspondent aux consignes suivantes :



AVERTISSEMENT : Risque de choc électrique



DANGER : Oxydant puissant



AVERTISSEMENT GÉNÉRAL / MISE EN GARDE : Lire la consigne complémentaire pour des renseignements spécifiques



MISE EN GARDE : Surface chaude



Ne pas toucher : Toucher à certaines parties de l'instrument sans protection ou sans les outils appropriés pourrait entraîner des dommages aux pièces ou à l'instrument.



Pictogramme « technicien » : Toutes les opérations portant ce symbole doivent être effectuées uniquement par du personnel de maintenance qualifié.



Mise à la terre : Ce symbole à l'intérieur de l'instrument détermine le point central de la mise à la terre sécuritaire de l'instrument.

MISE EN GARDE



Cet instrument doit être utilisé aux fins décrites et de la manière décrite dans ce manuel. Si vous utilisez cet instrument d'une autre manière que celle pour laquelle il a été prévu, l'instrument pourrait se comporter de façon imprévisible et entraîner des conséquences dangereuses.

NE JAMAIS utiliser un analyseur de gaz pour échantillonner des gaz combustibles!

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APPENDIX A - Model 501 Interconnects

1.0 T201 AMMONIA ANALYZER

This manual is to be used in conjunction with the T200 NO_x Analyzer manual, p/n 06858 supplied with this instrument. It is important that you familiarize yourself with the workings of the NO_x analyzer before proceeding with NH₃ measurements.

The T201 ammonia analyzer consists of a modified T200 nitrogen oxide analyzer and a 501 NH₃ ammonia converter. The analyzer measures the following individual gas concentrations: TN_x (NH₃ and NO_x), NO_x (NO and NO₂) and NO in the sample gas.

- The ammonia concentration is calculated by subtracting the NO_x reading from the TN_x measurement.
- The nitrogen dioxide concentration is calculated by subtracting the NO reading from the NO_x measurement.

The instrument comes in three pneumatic configurations: basic, with external calibrator option (ECO), and with zero/span valves.

- Figure 1-1 shows the T201 with ECO.
- Figure 1-2 shows the pneumatic flow for the basic system.
- Figure 1-3 shows the pneumatic flow for the Zero/Span valves.

Note

When connecting the T201 with the 501:

- The T201 rear panel port labeled “TO CONV” serves as the TN IN port plumbed from the “TN OUT” port of the 501.
 - The T201 rear panel port labeled “FROM CONV” serves as the TNX IN port plumbed from the “TNX OUT” port of the 501.
 - The ECO’s connection instructions can be found in its respective manual.
-

Note

For a T201 analyzer with Zero/Span option you must connect the umbilical cord P/N 02255 between the analyzer’s “MULTI” port and the external 501 NH₃ converter assembly’s “UMBILICAL” port.

If the analyzer is purchased without the Zero/Span option, then the zero and span calibration gases must be individually applied to the Sample port. Remember, the gases must be clean/dry and supplied at ambient pressure.



CAUTION

Do not pressurize the Sample/Span/Zero port above ambient.

In the following pneumatic connections illustration, the dashed line represents the stainless tubing for the Zero/Span (Z/S) valve option, which includes its own vent as shown. When the option is used, cap the calibrator rear output ports to avoid having more than one vent.

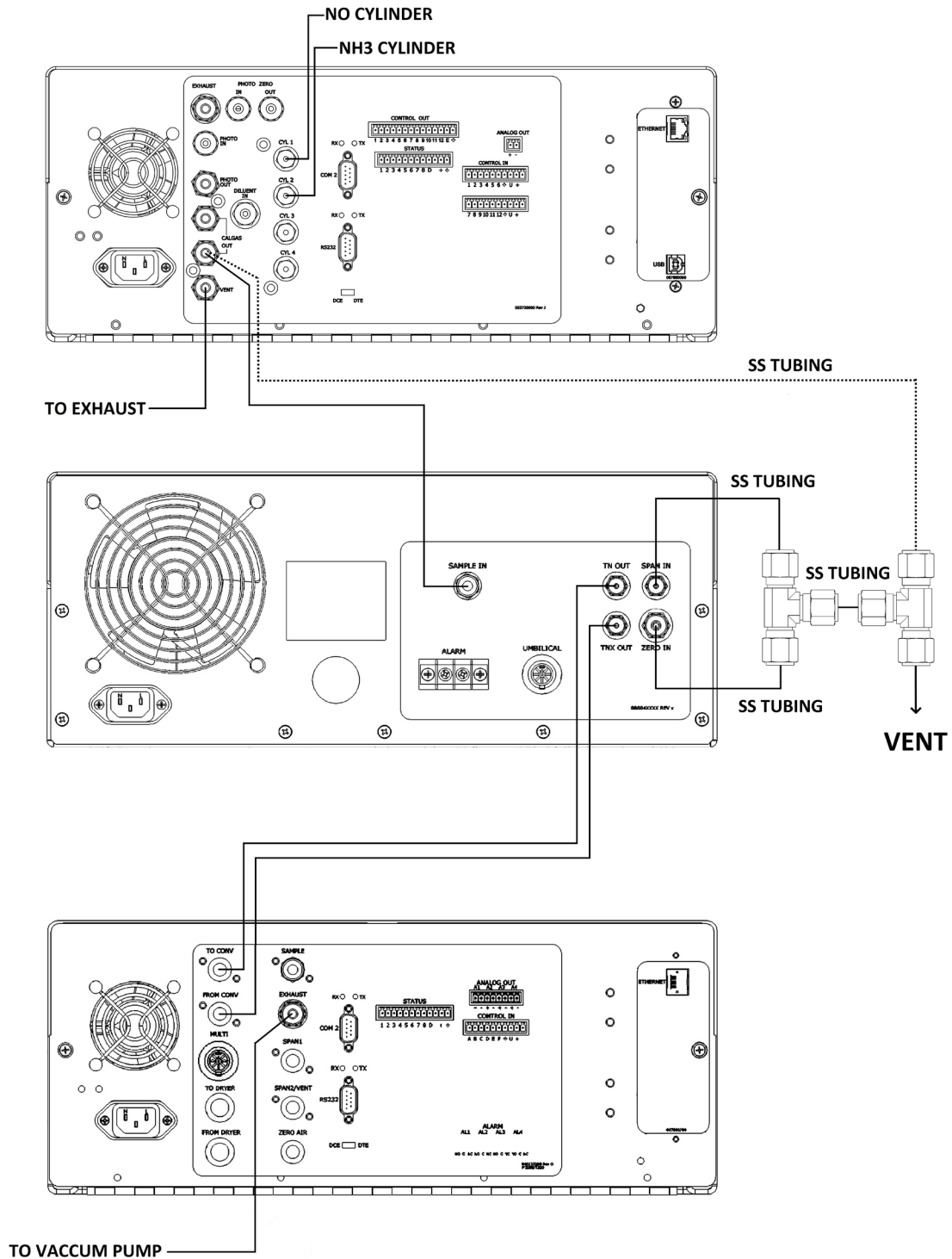


Figure 1-1. Pneumatic Connections (bottom to top) T201>501>External Calibrator Option (ECO)

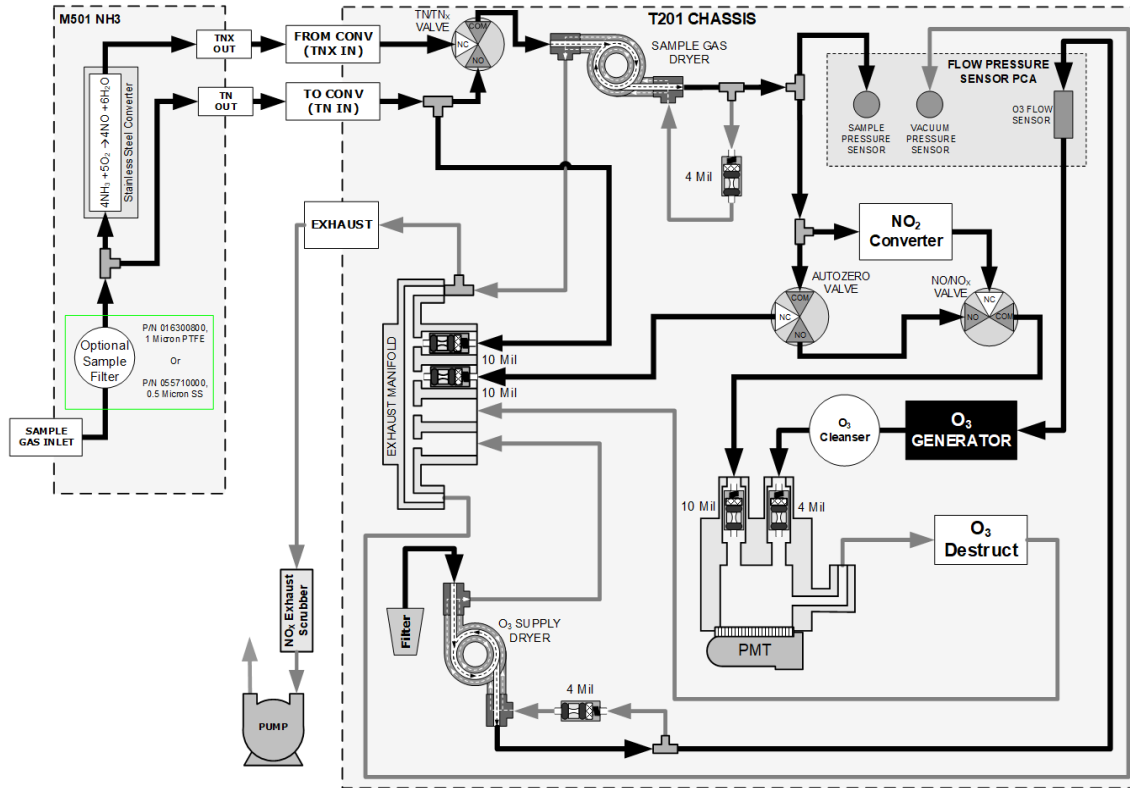


Figure 1-2. T201 and 501 NH₃ Pneumatic Flow

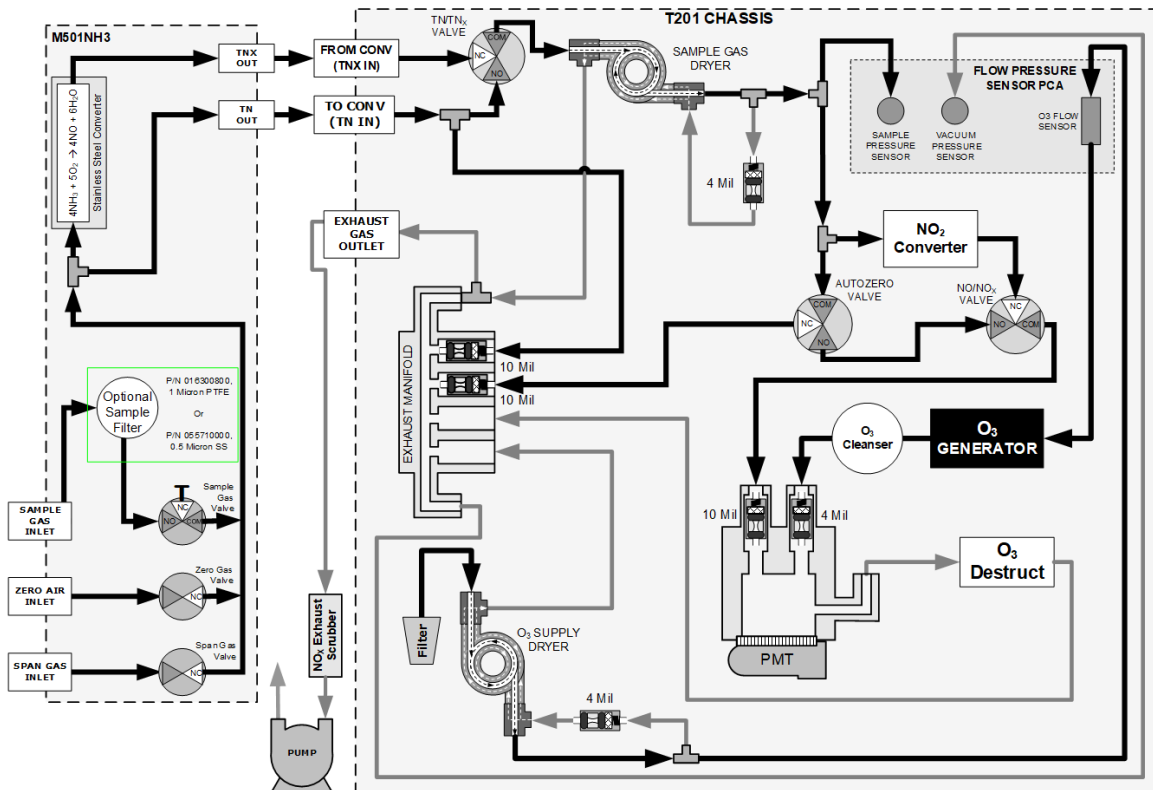
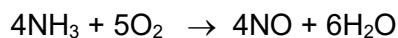


Figure 1-3. T201 and 501 NH₃ with Zero and Span Valve Options Pneumatic Flow

1.1 THEORY OF OPERATION

The Teledyne-API Model T201 analyzer measures ammonia by oxidizing it to nitric oxide by the following reaction:



The resulting nitric oxide is then measured by the chemiluminescent reaction with ozone. Consult Section 10.1 in the T200 manual (provided with this instrument) for more details on the nitric oxide measurement.

The analyzer uses two converters to oxidize the different sample gases. A high temperature catalytic converter, the 501 NH₃, converts NH₃ and NO_x into NO creating the TN_x channel. A second converter, housed inside the T201 analyzer and consisting of heated molybdenum, converts all of the NO_x in the sample to NO producing the NO_x channel. The nitric oxide channel is measured while bypassing both the 501 NH₃ and molybdenum converter. A Nafion® drier operated in reflux mode, is installed prior to the molybdenum converter and the AutoZero valve. The drier removes ammonia and water from the switched stream. The ammonia would have otherwise been converted by the molybdenum and registered as NO_x. This location provides the drier with continuous flow, thereby allowing it to stabilize faster.

Note

Due to the Nafion® dryer, the analyzer has a maximum ammonia range of 2.0 PPM.

The calculated gas concentrations, ammonia and nitrogen dioxide, are computed from the differences between the measured channels, as outlined in the following equations:

NO (Nitric Oxide) Concentration = Measured

TN_x (Total Nitrogen) Concentration = Measured (NH₃ + NO₂ + NO)

NO_x (Total Nitrogen – Ammonia) Concentration = Measured
(NO₂ + NO)

NH₃ (Ammonia) Concentration = Calculated as follows:

$$[(\text{TN}_x - \text{NO}_x) / (\text{NH}_3_CE_FACTOR1)]$$

NO₂ (Nitrogen Dioxide) Concentration = Calculated as follows:

$$[(\text{NO}_x - \text{NO}) / (\text{NO}_2_CE_FACTOR1)]$$

Note

The nitrogen dioxide efficiency factor (NO₂_CE_FACTOR1) must be calculated by conducting a GPT (gas phase titration) as described in Section 8.3.3 of the T200 manual and Section 6.0 of this manual. This value gives a good indication of how well the molybdenum is converting nitrogen dioxide into nitric oxide. In a properly functioning analyzer the value should be close to 1.0. It is recommended that the molybdenum efficiency be checked every three months.

The ammonia converter efficiency factor (NH₃_CE_FACTOR1) is discussed in more detail in Section 2.3 of this manual. The conversion efficiency of the 501 NH₃ should be checked prior to starting long term tests. Both efficiency factors can be accessed through the analyzer VARS MENU.

The actual formula for computation of the gas concentrations is more complicated than the above equations, as it includes sample, reaction cell pressure changes and averaging the PMT signal. Then the zero offset and slopes are applied to the separate channels (TN_x, NO_x, NO) to determine the concentrations. Concentration compensation occurs while the variable TP_FACTOR under the VARS MENU is switched ON. Otherwise the displayed concentration is uncompensated. It is recommended that the variable TP_FACTOR remain on at all times.

1.1.1 Minimizing PMT Drift

In order to account for PMT drift in the analyzer, the AutoZero valve switches once a minute allowing the analyzer to read zero background. The AutoZero valve directs the sample gas stream to completely bypass the reaction cell, while simultaneously filling the reaction cell with Ozone for dark noise measurement. This is then subtracted as a measurement offset from the raw PMT concentration signal. This process improves zero baseline stability by minimizing the effect of PMT sensor drift.

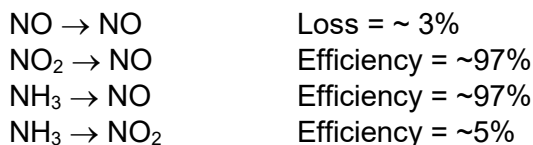
1.1.2 Purging the Reaction Cell

As with many chemical reactions the conversion of ammonia in the presence of other oxides of nitrogen is complicated. It is important to note that the valve DWELL time for an AZERO measurement has a default setting of 8 seconds. Shortening this value may not allow enough time to properly purge the reaction cell of excess nitric oxide from the previous measurements.

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



The 501 NH₃ ammonia 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.

1.2 SPECIAL CONSIDERATIONS FOR AMMONIA MEASUREMENT

Ammonia is a difficult gas to measure due to its chemical characteristics. The gas tends to adsorb onto surfaces and diffuse into many materials. The following precautions should be observed when designing ammonia sampling systems and connecting them to the T201 analyzer:

- Do *NOT* use copper tubing or fittings designed for household plumbing.
- Use *ONLY* Chromatography grade (cleaned, passivated) stainless steel tubing.
- Use *ONLY* glass for sample inlet manifold.
- *ALWAYS* keep the tubing from the calibrator to the analyzer as short as possible. *USE* stainless steel tubing throughout, especially from the ammonia calibration bottle to the calibrator.
- If possible *HEAT* the sample line and *DRY* the sample gas.
- Sample filters *will* cause response delays on both the rise and fall of the sample signal.

These rules apply also to your calibrator's internal plumbing. When used with the T201, the calibrator must have stainless steel plumbing throughout. Any calibrator that contains Teflon tubing and/or internal MFC's that can be affected by the ammonia gas is not recommended for use with the T201 analyzer. It is important to keep the sampling system well maintained.

1.3 SAMPLE FILTRATION

The instrument can be provided with an optional stainless steel sample filter P/N 05571. For minimum response time operation, the instrument should be supplied with clean sample gas at ambient pressure.

An additional filter resides in the T201 pneumatic pathway. The filter is a ¼" diameter stainless steel sintered filter used to protect the reaction cell flow control orifice from plugging. This filter will plug rapidly if contaminated sample gas is not filtered before entering the analyzer.

Note

In situations where the sample gas is known to be contaminated with particulate material, it is advisably to add extra filtration. However, it must be noted that the response time is directly extended through filter additions.

1.4 T201 ANALYZER SPECIFICATIONS

Table 1-1. T201 Operating Specifications

Ranges	Min: 0-50 ppb Full scale Max: 0-2000 ppb Full scale (selectable, independent NH ₃ , NO, NO ₂ , NO _x , TN _x ranges supported)	
Measurement Units	ppb, ppm, µm/m ³ , mg/m ³ (user selectable)	
Noise at Zero¹	≤ 0.5 ppb (RMS)	
Noise at Span¹	≤ 1.0% of reading (RMS) above 50 ppb	
Lower Detectable Limit²	< 1 ppb	
Zero Drift^{3, 5}	< 0.5 ppb / 24 hours (NO, NO _x)	
Span Drift⁵	≤ 1.0% of full scale / 24 hours	
Response Time⁴	< 340 seconds to 90%	
Linearity	NO calibration 1% of full scale NH ₃ calibration 2% of full scale	
Precision	0.5% of reading above 50 ppb	
Sample Flow Rate	1000 cc/min ± 10% (500 cm ³ /min bypass to vacuum manifold, 500 cm ³ /min to reaction cell)	
Temp Range	15-40 °C	
Dimensions H x W x D	7" x 17" x 23.6" (18cm x 43cm x 61cm)	
Weight, Analyzer	43 lbs (20 kg)	
Weight, Converter	22 lbs (10 kg)	
Power, Analyzer	Power Rating	Typical Power Consumption
	100-120 V, 220-240 V ~50/60 Hz	125 W
Power, Converter	100-120 V, 220-24- V ~50-60 Hz	480 W
Environmental	Installation Category Pollution Degree 2, Over-voltage Category II, Indoor use only	
Analog Output Resolution	1 part in 4096 of selected full-scale voltage (12 bit)	
Standard I/O	(1) Ethernet: 10/100Base-T; (2) RS-232 (300 – 115,200 baud) (2) USB device ports; (8) opto-isolated digital outputs; (6) opto-isolated digital inputs; (4) analog outputs	
Optional I/O	(1) USB com port; (1) RS485 (300 – 115,200 baud); (4) digital alarm outputs; Multidrop RS232; (3) 4-20mA current outputs	

¹ As defined by USEPA

² Defined as twice the zero noise level

³ At constant temperature and voltage

⁴ When pneumatics are conditioned with NH₃ overnight and the gases (zero air to NH₃) are manually switched at the sample inlet at the rear of the 501.

⁵ Applies when sampling NH₃; better results expected for NO/NO_x gas measurements.

2.0 CALIBRATION PROCEDURE

This section begins with a high-level overview of the calibration procedure for the T201 analyzer. Details are provided starting in Section 2.1.

- First, take the time to read the T200 manual to familiarize yourself with the Chemiluminescence process. It is important to remember that the analyzer is merely measuring different levels of nitric oxide sample gas on three separate channels (TN_x, NO_x, NO). The ammonia and nitrogen dioxide concentrations are then calculated using this information.
- Assemble the T201 analyzer according to the pneumatic configurations outlined in Figure 1-1. Remember: **DO NOT** pressurize the sample, span or zero ports (Zero/Span valves are optional) during calibration. Allow the analyzer to pull the gas through the system using the vacuum pump.



CAUTION!

If the presence of ozone is detected at any time, call Teledyne API Technical Support as soon as possible:

+1 800-324-5190 or email: api-techsupport@teledyne.com

Do NOT use these instruments in any way other than directed in their respective manuals. Never analyze/use combustible gases.

- Next, zero the analyzer using an approved zero air source, such as, bottled zero air, nitrogen or a Teledyne API zero air generator. This sets the zero offset for the three individual channels (TN_x_OFFS, NO_x_OFFS, NO_OFFS). Confirm that all displayed concentrations read zero.
- Span the analyzer using bottled nitric oxide gas diluted to a level set to 80% of the expected sample range, using a calibrator with stainless steel pneumatic tubing and fixtures. This sets the slope for the three individual channels (TN_x_SLOPE, NO_x_SLOPE, NO_SLOPE). Confirm that displayed concentrations TN_x, NO_x and NO display the correct span concentration.
- If you haven't done so recently, conduct a GPT (gas phase titration) and confirm the molybdenum is functioning accordingly. Section 8.3.3 of the T200 manual outlines the GPT procedure. Section 6.0 of this manual consists of a service note for checking the molybdenum converter. There should be no reason to adjust the molybdenum efficiency factor on a new analyzer. If a diluted bottled of nitrogen dioxide gas is used to determine the molybdenum efficiency, allow enough time for the span value to stabilize. Nitrogen dioxide exhibits similar hold up issues as ammonia gas. Therefore, it may take a number of hours before the NO_x reading stabilizes.
- Span the analyzer using bottled ammonia gas diluted to a level set to 80% of the expected sample range, using a calibrator as described above.

Note

The first time bottled ammonia is connected to the gas dilution system, regulator/calibrator, the TN_x reading may take a number of hours to stabilize.

2.1 ZEROING THE ANALYZER

The analyzer can be zeroed by either applying zero air straight to the sample port or through the optional Zero/Span valves, if installed. It is important to remember that if the analyzer was previously sampling ammonia gas, prior to conducting a Zero calibration, it will take some period of time before the zero baseline is reached. The process of zeroing the analyzer consists of delivering dry zero air to the analyzer. The operator then manually zeros the TN_x and NO_x channels individually through the user interface. The following Tables outline the steps necessary to zero the analyzer.

Table 2-1. Zero Calibration Procedure – Zero Gas through the SAMPLE Port

Important: Each channel (TN_x and NO_x) must be zeroed individually

Step No.	Action	Comment
1.	Press CAL	The T201 enters the calibrate mode from sample mode. Confirm zero gas is flowing past the sample port.
2.	Channel Selection	Press TN_x or NO_x then Press ENTR .
3.	Range Selection	Press LOW or HIGH range then Press ENTR . Always calibrate the LOW range, section 3.0 below.
4.	NH ₃ STB Reading	Wait for the displayed stability reading to fall below 1.0 PPB. The lower the stability reading the better the zero value.
5.	Press ZERO	If you change your mind after pressing ZERO , you can still press EXIT without zeroing the instrument. You don't have to enter concentration values. The analyzer knows to apply 0 PPB.
6.	Press ENTR	Pressing ENTR actually adjusts the Offset value for the selected channel.
7.	Press EXIT	The T201 returns to sampling mode.
8.	Check Concentrations /Offsets	All displayed concentrations should read zero. The offset values should be close to zero (-20 to 150 mv)

Table 2-2. Zero Calibration Procedure - Zero Gas through ZERO Port

Step No.	Action	Comment
1.	Press CALZ	The T201 enters the calibrate mode from sample mode. The zero gas is supplied through the ZERO inlet port on the rear panel of the 501 NH ₃ .
2	Table 2.1	Follow Steps 2 to 8 in Table 2-1.

Notes

- Since the zero gas concentration is defined as 0 ppb, it is not necessary to enter the expected concentration values.
- Both the TN_x and NO_x channels must be zeroed individually. When you zero the NO_x channel both the offsets for NO_x and NO are configured. All readings should display zero following this action.
- It is recommended that the calibration of both the TN_x and NO_x channels be done at one time.
- Always confirm that excess zero air is flowing past the sample or zero port, if the Zero/Span option is present, on the rear of the 501 NH₃ converter. There should always be some excess flow. If insufficient flow is supplied to the analyzer ambient gas will be entrained and the zero offset values will be incorrect. However, it is important not to over pressurize the analyzer.
- It is a good idea to allow the analyzer to sample zero gas for extended periods following zero calibration. Large drifts can signify leaks or indicate an issue with the zero air source.

2.2 SPANNING THE ANALYZER WITH NITRIC OXIDE GAS

The analyzer can be spanned by either applying nitric oxide gas straight to the Sample port or through the Zero/Span valve option, if installed. It is important to remember that if the analyzer was previously sampling ammonia gas, prior to conducting a nitric oxide span calibration, it will take some period of time before the TN_x channel stabilizes. The process of spanning the analyzer consists of diluting bottled gas, using a calibrator and delivering to the analyzer. The operator then manually spans the TN_x and NO_x channels individually through the user interface. The following Tables outline the manual steps necessary to span the analyzer.

Table 2-3. NO Calibration Procedure – NO Gas through the SAMPLE Port

Step No.	Action	Comment
1.	Press CAL	The T201 enters the calibrate mode from sample mode. Confirm that excess NO gas is flowing past the sample port.
2.	Channel Selection	Press TN_x or NO_x then Press ENTR .
3.	Range Selection	Press LOW or HIGH range then Press ENTR . Always calibrate the LOW range, Section 3.0below.
4.	Press CONC	<p>If NO_x was chosen previously then the following will be displayed: NO_x NO CONV Exit Press NO_x, If you are delivering 450 PPB of NO then Enter 450 PPB, Press ENTR. Repeat the same steps for NO. Press EXIT Once stability has been achieved, Press SPAN, ENTR, EXIT NOTE: Both NO_x and NO should read 450 PPB.</p> <p>If TN_x was chosen previously then the following will be displayed: TN_x CONV Exit Press TN_x enter 450 PPB, Press ENTR Press EXIT Once stability has been achieved, Press SPAN, ENTR, EXIT TN_x should read 450 PPB.</p>
5.	Check Slopes	The slopes should be close to 1.0 +/- 0.300

IMPORTANT

Each channel (TN_x and NO_x) must be Spanned individually.

Table 2-4. NO Calibration Procedure - NO Gas through the SPAN Port

Step No.	Action	Comment
1.	Press CALS	The T201 enters the calibrate mode from sample mode. The NO gas is supplied through the SPAN inlet port on the rear panel of the 501 NH ₃ .
2	Table 2.3	Follow Steps 2 to 5 in Table 2-3.

Notes

- Both the TN_x and NO_x channels must be spanned individually with nitric oxide gas. When you span the NO_x channel both the NO and NO_x concentrations must be manually inputted.
- It is recommended that the calibration of both the TN_x and NO_x channels be done at the same time.
- Always confirm that SPAN gas is flowing past the sample or span port on the rear of the 501 NH₃ converter. There should always be some excess flow. If insufficient flow is supplied to the analyzer ambient gas will be entrained and the span values will be incorrect. However, it is important not to over pressurize the analyzer.
- It is a good idea to allow the analyzer to sample span gas for extended periods following span calibration. Large drifts can signify leaks or indicate an issue with the span gas source.
- If after spanning with nitric oxide, the analyzer slopes are out of range conduct the following:
 - Confirm the gas sources are good. Usually the bottle is certified to a known level of nitric oxide. The bottle should be balanced with nitrogen.
 - Try not to use the same regulator for nitric oxide as was used on ammonia. This also holds for the tubing between the different bottles and the mixing source (calibrator).
 - Confirm the zero reading is good by delivering Zero gas.
 - Confirm that the concentration delivered to the analyzer is equal to what you entered under the CONC menu NO_x and TN_x.
 - Leak check both the 501 NH₃ and analyzer together.
 - Using section 11.6.5 of the T200 manual confirm that the PMT sensor hardware calibration is set correctly.

2.3 SPANNING THE ANALYZER WITH AMMONIA GAS

The most important criterion an individual can avail themselves of when spanning an analyzer with ammonia gas is “patience”. Ammonia is a very sticky gas and the response of the analyzer/calibration system depends on a number of factors. The following lists some important points the user should be aware of when calibrating:

- Is this the first time the analyzer/calibration system has seen ammonia gas in the last couple of days? If so, spanning to a fixed value will take considerably longer than normal: possibly 12 hours to completely stabilize.
- Is the tubing that is delivering span gas from the calibration bottles, made of stainless steel? Is the tubing from the rear of the calibrator to the analyzer, made of stainless steel? Where possible use stainless steel tubing.

Note

The operator is responsible for delivering a set amount of ammonia to the analyzer, calculating the converter efficiency of the 501 NH₃ and entering the efficiency value through the user interface, if required.

- Is the environment where the analyzer resides undergoing large temperature swings (+/- 5 °C about the norm temperature)? If so the sample line can absorb and desorb ammonia at concentration rates that are distinguishable to the analyzer. If possible, heat the sample line to a constant maximum ambient temperature.
- Does the sampling environment contain large amounts of particulates? If so, it may be necessary to add the sampling filter option. As outlined previously, this will affect the analyzer response.
- One method to increase the response of both the sampling system and the analyzer is to flow a larger concentration of ammonia gas through the pneumatics for a couple of hours. For example, if the expected range is 500 PPB of ammonia, then flowing 1000 PPB will speed up the absorption which occurs throughout the pneumatics. The long delays in ammonia response occur when the analyzer hasn't sampled the gas for some time. Ammonia desorbs from the pneumatics, these surfaces need to be rewetted before span stability is achieved.
- Prior to conducting the ammonia calibration, confirm that the ammonia converter efficiency is initially set to 1.000 using the following menu key selections:

Table 2-5. Confirming Ammonia Converter Efficiency

Step No.	Action	Comment
1.	Press CAL	The T201 enters the calibrate mode from Sample mode.
2.	Channel Selection	Press TN_x then Press ENTR .
3.	Range Selection	Press LOW range then Press ENTR .
4.	Press CONC	The following will be displayed: TN_x CONV Exit Press CONV enter 1.0000 , Press ENTR Press EXIT, EXIT

Table 2-6. NH₃ Calibration Procedure – NH₃ Gas through the SAMPLE Port

Step No.	Action	Comment
1.	Generate a known level of NH ₃ gas using a calibration gas source	Monitor the TN _x concentration until it has stabilized; this signifies that both the NO _x and NH ₃ gases have stabilized. This could range from 20 minutes to several hours depending on whether the analyzer / calibration system has recently been subjected to ammonia gas.
2.	NH ₃ Conversion efficiency calculation	When the TN _x channel is stable, note the concentration of NH ₃ displayed. The calculation for the NH ₃ Conversion efficiency is: (Displayed NH ₃ concentration) divided by (Delivered NH ₃ concentration) Example: The operator is delivering 450 PPB of NH ₃ . The displayed concentration for NH ₃ is 440 PPB then the efficiency factor = 440/450 = 0.9777
3.	Press CAL	The T201 enters the calibrate mode from Sample mode.
4.	Channel Selection	Press TN_x then Press ENTR .
5.	Range Selection	Press LOW range then Press ENTR .
6.	Press CONC	Since TN _x was chosen previously, then the following will be displayed: TN_x CONV Exit Press CONV enter 0.9777 , Press ENTR Press EXIT, EXIT

Note

In the example outlined above, the displayed ammonia concentration is being increased by 2.27%. Newer 501 NH₃ converters should have efficiency values very close to 1.00. Depending on the operator's acceptable level of error, it may not be necessary to change the efficiency factor from 1.00. Therefore, calibration with nitric oxide gas is all that is required.

Table 2-7. NH₃ Calibration Procedure – NH₃ Gas through the SPAN Port

Step No.	Action	Comment
1.	Press CALS	The T201 enters the calibrate mode from Sample mode. The ammonia gas is supplied through the SPAN inlet port on the rear panel of the 501 NH ₃ . Calculate the Efficiency factor as outlined in Steps 2 in table 2.5.
2	Table 2.5	Follow Steps 4 to 6 in table 2.5.

Note

The response time of the analyzer increases when using the Zero/Span valve option.

3.0 CONFIGURABLE ANALOG OUTPUT OVERVIEW

There are three different methods to extract concentration data from the analyzer: internal data acquisition system (DAS), hyperlink, or strip chart.

DAS

The user can set up an internal DAS configuration either through the user display or using TAPI's windows based software called APICOM. The analyzer stores data internally, which is available later for download through the RS-232 or Ethernet port.

Hyperlink

The user sends text based commands to retrieve data through the RS-232 port.

Strip Chart

The user interfaces a strip chart recorder and/or data-logger to the four analyzer analog output channels of the rear panel Analog Out connector (Figure 3-1). Table 3-1 presents the default configurations of the analog outputs, and Table 3-2 shows the Pin-outs for these four channels.

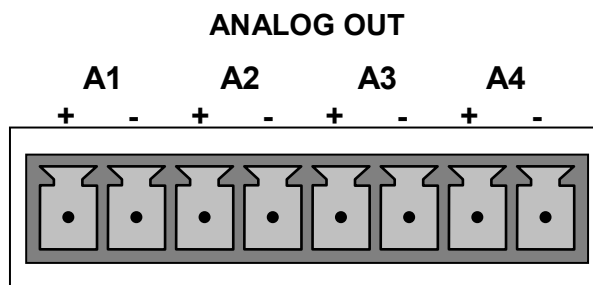


Figure 3-1. Analog Output Connector

Table 3-1. Analog Output Data Default Settings

ANALYZER	CHANNEL DEFAULT SETTING			
	A1	A2	A3	A4
T201	TNxCNC1	NH ₃ CNC1	NOCNC1	NO ₂ CNC1
	5 Volts	5 Volts	5 Volts	5 Volts
	500 PPB	500 PPB	500 PPB	500 PPB

Table 3-2. Analog Output Pin-Outs

PIN	ANALOG OUTPUT	VOLTAGE SIGNAL	CURRENT SIGNAL
1	A1	V Out	I Out +
2		Ground	I Out -
3	A2	V Out	I Out +
4		Ground	I Out -
5	A3	V Out	I Out +
6		Ground	I Out -
7	A4	V Out	N/A
8		Ground	N/A

Additionally A1, A2 and A3 may be equipped with optional 0-20 mA, or 4-20, current loop drivers. The 4-20 mA option is not available on A4.

Note

In actuality the analog output configuration of the analyzer may be different than stated above. The outputs can be configured differently at the factory depending on whether they were assigned during the procurement of the product. It is possible to check the configuration of the analyzer by accessing the **ANALOG I/O CONFIGURATION** through the **DIAG** menu.

The analyzer operates in Dual Mode during gas detection. This means each of the measured concentrations can have two separate slopes and offsets, one for the low range and one for the high range. Though uncommon, a user may decide to calibrate the analyzer with nitric oxide at, for example, 100 PPB using the LOW range and then perform another calibration at 450 PPB using the HIGH range. Through the analog outputs the user can then assign analog output A1 to TN_xCNC1 and output A2 to TN_xCNC2. Gases with the “1” designation use the slope and offset for the LOW range, while gases with the “2” designation will use the slope and offset for the HIGH range. It is recommended that both the LOW and HIGH ranges be calibrated at the same time. Independent of whether the HIGH range is actually being outputted to the analog outputs.

For analog output configuration, signal type and range selection and calibration, use the T200 manual.

4.0 MAINTENANCE SCHEDULE

The maintenance requirements of the T201 are the same as a standard T200 NO_x analyzer but with additional maintenance items (Table 4-1). Please refer to Section 13 in the T200 Operator Manual for the T200 maintenance schedule and for maintenance and repair procedures.

The T201 requires the following additional maintenance items.

Table 4-1. Preventative Maintenance Schedule

Item	Maintenance Interval	Reference Section
NO ₂ molybdenum converter	Test every three months	Section 8.2.3 T200 Manual
501 NH ₃ Converter	Test every three months Replace annually or as necessary	Section 4.1 of this manual
Reaction Cell	Clean annually or as necessary	Section 9.3.9 T200 Manual
AutoZero flow check	Quarterly as needed	Section 4.4 of this manual.

4.1 501 NH₃ MAINTENANCE

The 501 NH₃ external converter is operated at 825 °Celsius. Because of this the stainless steel ¼” tube internal to the converter slowly oxidizes and may require replacement. Over time the converter’s efficiency will degrade, due to aging of the internal catalyst. This is characterized by a CONV value on the TN_x channel of < 0.8 or > 1.2, despite the converter being at temperature. The efficiency of the converter should be checked quarterly. The converter should be cleaned out on a yearly basis by removing the outer tube and shaking the fine dust particles from both the outer and inner tubes. This is also a good time to replace the catalyst screen, if necessary.

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 4-2.

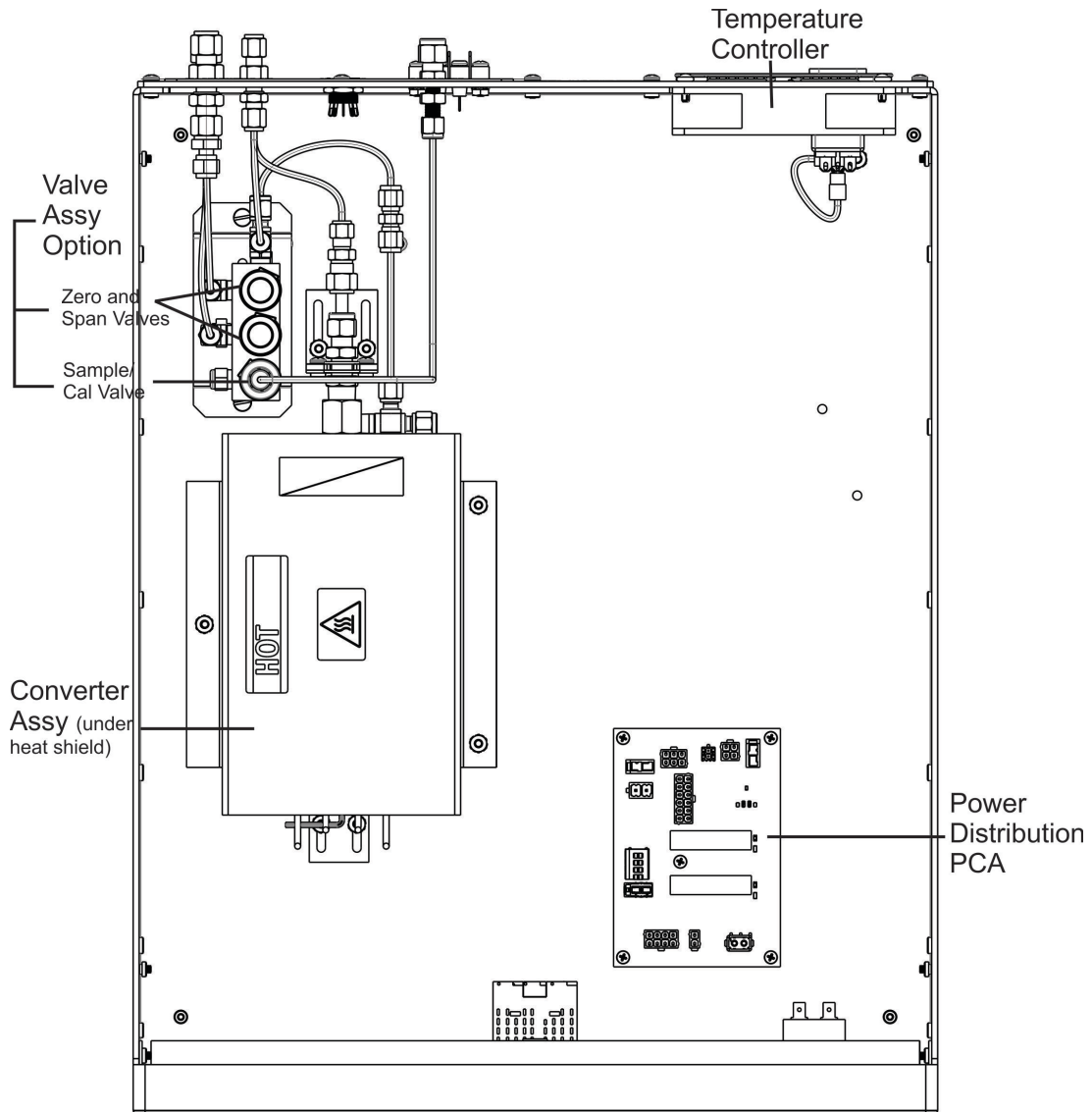


Figure 4-1. Model 501 Chassis Internal Layout

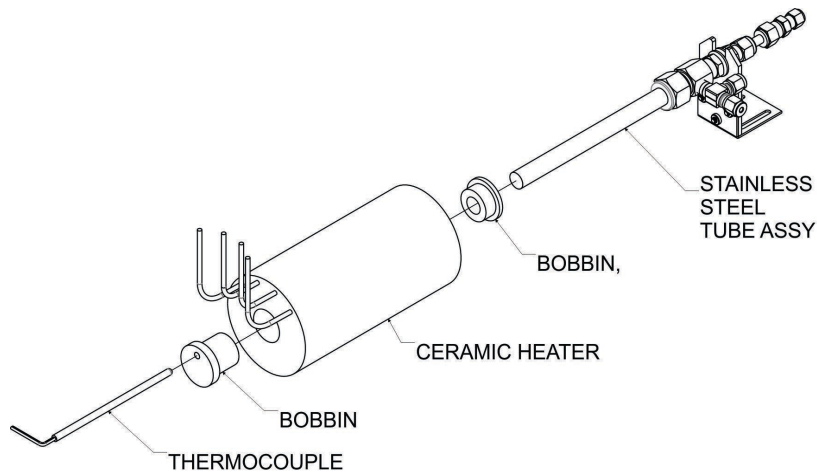


Figure 4-2. Model 501 Converter, Exploded View

Table 4-2. 501 NH₃ Converter Rebuild Parts List

Part No.	Description
KIT000193	RETROFIT, 501 NH ₃ INNER TUBE w/SCREEN
KIT000139	REBUILD, CERAMIC BUSHINGS, 501 NH ₃
HE0000007	CERAMIC HEATER, 220W@60V 501XX

4.2 REPLACING THE CATALYTIC CARTRIDGE

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 501 NH₃, 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 KIT000193.
7. Re-assemble the converter by doing the above steps in reverse order.

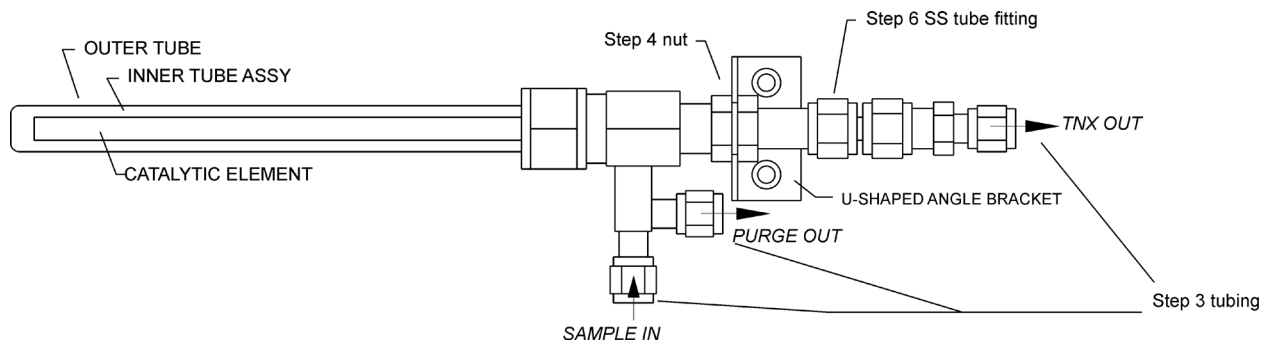


Figure 4-3. Catalytic Cartridge

4.3 REPLACING THE THERMOCOUPLE


The following instructions provide the necessary information to replace the existing thermocouple. Figure 4-4 is provided for reference.

You must obtain the following replacement parts kit from TAPI:

- Type S thermocouple

You will need the following tools:

- Nutdriver, $\frac{5}{16}$
- Nutdriver, $\frac{11}{32}$
- Diagonal Cutter
- Philips head Screwdriver #2



CAUTION

Avoid damage to the unit: use only Type S thermocouple in the 501 NH₃ converter. It can be distinguished by its wire colors: red and black. If you have any other thermocouple, do NOT install it; call TAPI to obtain the correct part.

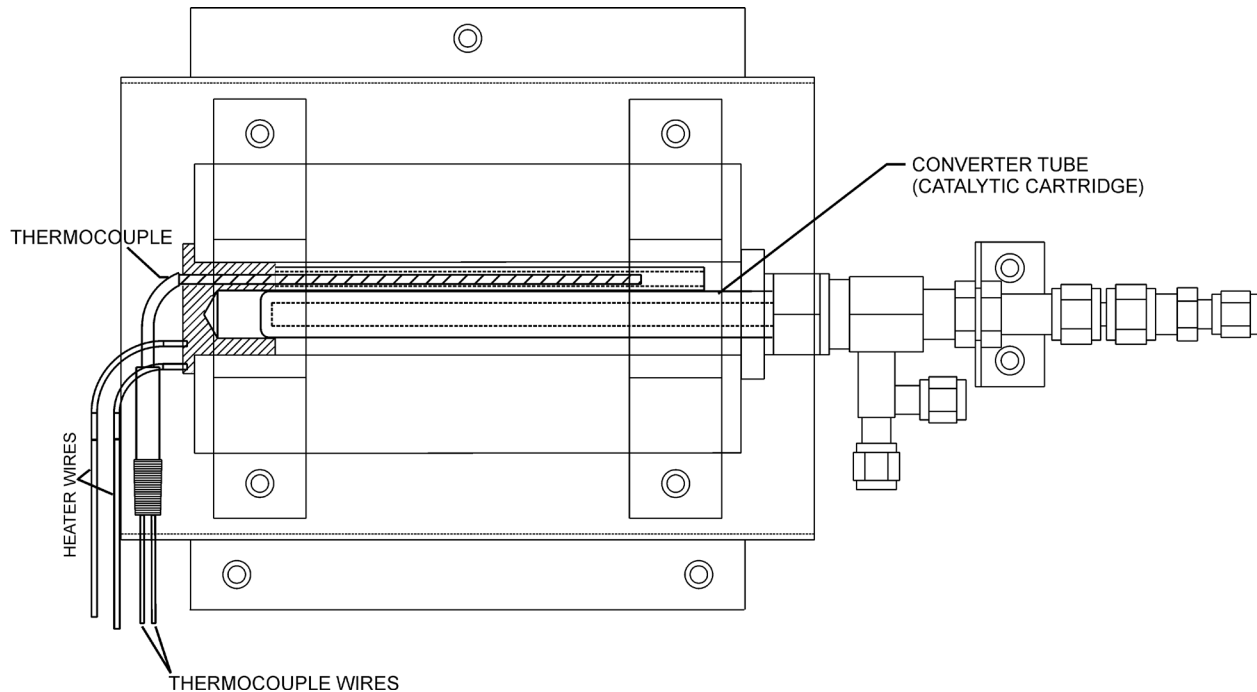


Figure 4-4. Thermocouple Location

Once you have the right tools and parts, referring to Figure 4-5 replace the thermocouple as follows:

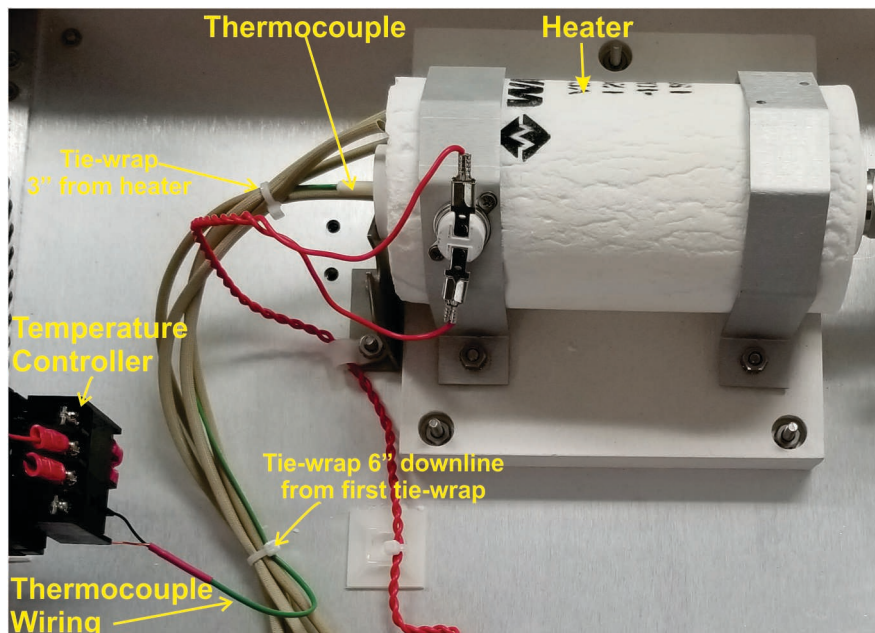


Figure 4-5. Thermocouple and Wiring Location

1. Ensure power is removed from the 501 NH₃ Converter. If the Converter has been operational you will need to wait for at least 2 hours for the Converter oven to cool before continuing with the replacement of the thermocouple.
2. Remove the cover from the Converter chassis.
3. Unscrew the (4) nuts that secure the front panel to the chassis. They are located just behind the front panel along the top.
4. Cut the tie-wraps that hold the lead wires and the thermocouple wires.
5. Loosen the terminals on the Temp Controller to release the thermocouple wire, noting which wire is connected to which pin.
6. Slide the thermocouple from the bobbin at the end of the heater.
7. Slide the replacement thermocouple into the bobbin of the heater, ensuring that $\frac{3}{4}$ " to 1" of thermocouple body (white portion) remains outside the bobbin.



CAUTION

Avoid damage to the component: the thermocouple wire can melt if closer to the heater than the recommended distance.

8. Connect the (2) wires of the new thermocouple to the corresponding terminals of the Temperature Controller (black wire to pin 1, red wire to pin 2).
9. Secure the lead wires and the thermocouple wires with tie-wraps, ensuring that the first tie-wrap is 3" from heater, and that the second tie-wrap is 6" from the first (this is important for stability to ensure that the thermocouple remains securely in place).
10. At this point, all connections have been made, both electrically and pneumatically. A leak check should be performed on the Converter to verify that all connections are leak free. If a leak is detected, the leak should be resolved before continuing.
11. Close the front panel and secure with the (4) nuts. Install the top cover on the Converter chassis.
12. The Converter is now ready for the application of power. You will be looking for an indication from the Temperature Controller that it is functioning correctly and driving the heater to the desired "set" temperature. Apply power now.
13. After the Converter comes to the regulated temperature, perform the Auto Tune function to tune the Temperature Controller to the new thermocouple. (Consult with Technical Support for this procedure).
14. After the Auto-Tune process is completed, verify that the "process" temperature is indicating that the desired temperature is stable and being regulated.

The converter is now ready for operation.

4.4 AUTOZERO FLOW CHECK

Since the T201 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. Remove the top cover of the analyzer. Locate the vacuum manifold at the center rear of the chassis. Locate the 1/8" tube fitting located on the very left side, as viewed from the rear of the analyzer. It will have a label of "0.010" indicating the flow orifice installed.
3. Remove the fitting and attach a calibrated flowmeter to the block fitting 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 FL0000001). This filter is meant to protect the orifice; it will usually become plugged and need replacement rather than the

orifice. Replace the filter, and then re-assemble the manifold. Restart the sample pump and recheck the flow.

Table 4-3. Flow Check

501 NH₃ CONVERTER SAMPLE FLOW CHECK		
Note: Connect both the Teflon™ tubes between analyzer and converter.		
Gas Port	Expected Flow (cc/min)	
"SAMPLE IN"	1000 +/- 10 %	
ANALYZER SAMPLE FLOW CHECK		
Note: Disconnect both the Teflon™ tubes between analyzer and converter.		
Gas Port	Expected Flow (cc/min)	
"TO CONV"	1000 or 500, +/- 10 %	When the analyzer is sampling TNx only, the bypass flow is measured. Therefore, the flow alternates between 500 and 1000 cc/min. This is the NOx channel.
"FROM CONV"	500 +/- 10%	This is the TNx channel.

5.0 ALARMS AND CAUTIONS

Please refer to the T200 Operation Manual for a functional block diagram of the analyzer.

5.1 ALARM

During initial warm up the internal Zero/Span factory option may exhibit a “Block Temperature” warning. This can be cleared once the block temperature stabilizes at 50 degrees Celsius. The block temperature is the actual temperature of the IZS block manifold inside the 501 NH₃ converter. If the block temperature warning exhibits a negative number such as (-37), then the umbilical cord is probably not attached or the Thermistor has become disconnected.

5.2 CAUTION

Be aware that the ammonia converter operates at 825 degrees Celsius. Do not flow highly flammable gases through the T201 analyzer. When the analyzer is not in use, it is advisable to turn off the 501 NH₃. If the converter hasn't been powered for an extended period of time it is recommend that the analyzer be operated overnight prior to use.

Before spanning the analyzer it is good practice to observe the NORM PMT signal. Its value should be equal to twice the concentration of the delivered span gas. A common error made during calibration is to span the analyzer with either too low a gas concentration or an incorrect value entered into the CONC menu for TN_x and NO_x. Commonly this will cause a slope value much greater than one.

Note

As a basic rule, always zero first, then span.

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6.0 CALCULATING MOLY CONVERTER EFFICIENCIES

6.1 PURPOSE

To provide instructions on how to calculate the efficiency of a Moly converter when using a GPT method of testing converters, by using the US EPA method, where the actual concentration of ozone is not a factor in the accuracy of the calculation of the converter efficiency. This procedure is based on the Code of Federal Regulations, Title 40, Chapter I, subchapter C, Part 50, Appendix F.

6.2 TOOLS

API T700 calibrator with O₃ Gen option (or equivalent)

Moly Test Data Sheet (provided on page following this procedure)

6.3 PARTS

NONE

6.4 PROCEDURE

For the purpose of providing an example, this procedure uses 450 PPB NO gas as the reference point, you don't have to pick these values, they are just an example. There is also an assumption that the analyzer has a good calibration done @ 450 PPB NO span gas. If this is not the case, then once you have finished the leak check on the analyzer, input your 450 PPB NO span gas and calibrate the analyzer.

Note

For the GPT to be performed correctly, there must be a minimum of 10% *more* NO than O₃ produced. For example, if the Ozone produced is 400 PPB then the NO used must be 440 PPB or more. Typically 450 PPB NO is titrated against 400 PPB of Ozone.

1. Leak check machine to ensure that there are no leaks in the analyzer.
2. For the duration of this test, set the CE factor to 1.0000 (100%) in the instrument firmware (this would be in the CAL-CONC-CONV-SET menu).

3. The first gas check is to test to see how much the converter is eating NO gas or out gassing NO gas. Bypass the converter in the machine, by placing a short piece of tubing in place of the converter. Perform a straight dilution with NO gas and air as a diluent gas. Input this 450 PPB NO gas into the analyzer, allow the machine to stabilize, and write down the NOx value on your data sheet on line 3.
4. Remove the converter bypass and install the converter back into the NOx sample stream, such that the NO sample goes through the converter again and allow the machine to stabilize. Write down your NOx value on your data sheet on line 4 AND line 6 of the data sheet.
5. Note the NO value and input that on line 9 of the data sheet.
6. Subtract line 3 from line 4 and write that number down on line 5. The spec on the data sheet is the value that we use here in house, and your spec might be a bit higher. We have found that on NEW Moly converters this spec is a good one that predicts a good performing Moly converter, but in an older converter might eat a bit more NO, and this would be acceptable. If it is a constant value, or changes little over time, this is not a problem the machine will calibrate this out.
7. The next step is to perform your GPT. Generate the same 450 PPB NO gas and input 400 PPB of O₃ (or generate 450 PPB NO and 400 PPB NO₂, if that's what your calibrator says). Allow the machine to stabilize for 10 minutes and then write down the NOx value on line 7 and the NO value on line 10.
8. Subtract line 7 from line 6 and put that onto line 8
9. Subtract line 10 from line 9 and put that onto line 11
10. Put the number from line 8 into the letter A on line 12 and put the number from line 11 into the letter B on line 12.
11. Divide A by B and multiply it by 100 and put it into letter C on line 12.
12. Put the number in letter C onto the C on line 13 and subtract that value from 100 and put it into letter D on line 13. this is the converter efficiency.
13. This value should be >96%. If below 96%, replace the converter.

MOLY TEST DATA SHEET

Line #	TEST	RESULT
2	LEAK-CHECK (WHEN HOT)	YES / NO
3	NO _x RESPONSE (MOLY BYPASSED)	_____
4	NO _x RESPONSE (MOLY IN-LINE)	_____
5	OUT-GASSING / EATING (NO – NO _x)	_____ (>-5 PPB, <5 PPB)
6	(NO _x ORIG) (NO _x mode, O ₃ off)	_____ PPB
7	(NO _x REM) (NO _x mode, O ₃ on)	_____ PPB
8	NO_x LOSS (9A - 10B) (<4% of NO _x ORIG; example: for 450PPB 4% is 18PPB)	_____ (A)
9	(NO ORIG) (NO mode, O ₃ off)	_____ PPB
10	(NO REM) (NO mode, O ₃ on)	_____ PPB
11	NO₂ (9B - 10A)	_____ (B) (>300PPB)
12	Efficiency LOSS [(A / B) x 100] = [(_____ A _____ / _____ B _____) x 100] = _____ C _____ %	
13	Total Conv Eff [100% – C] = 100% - _____ C _____ = _____ D _____ % (≥ 96%)	

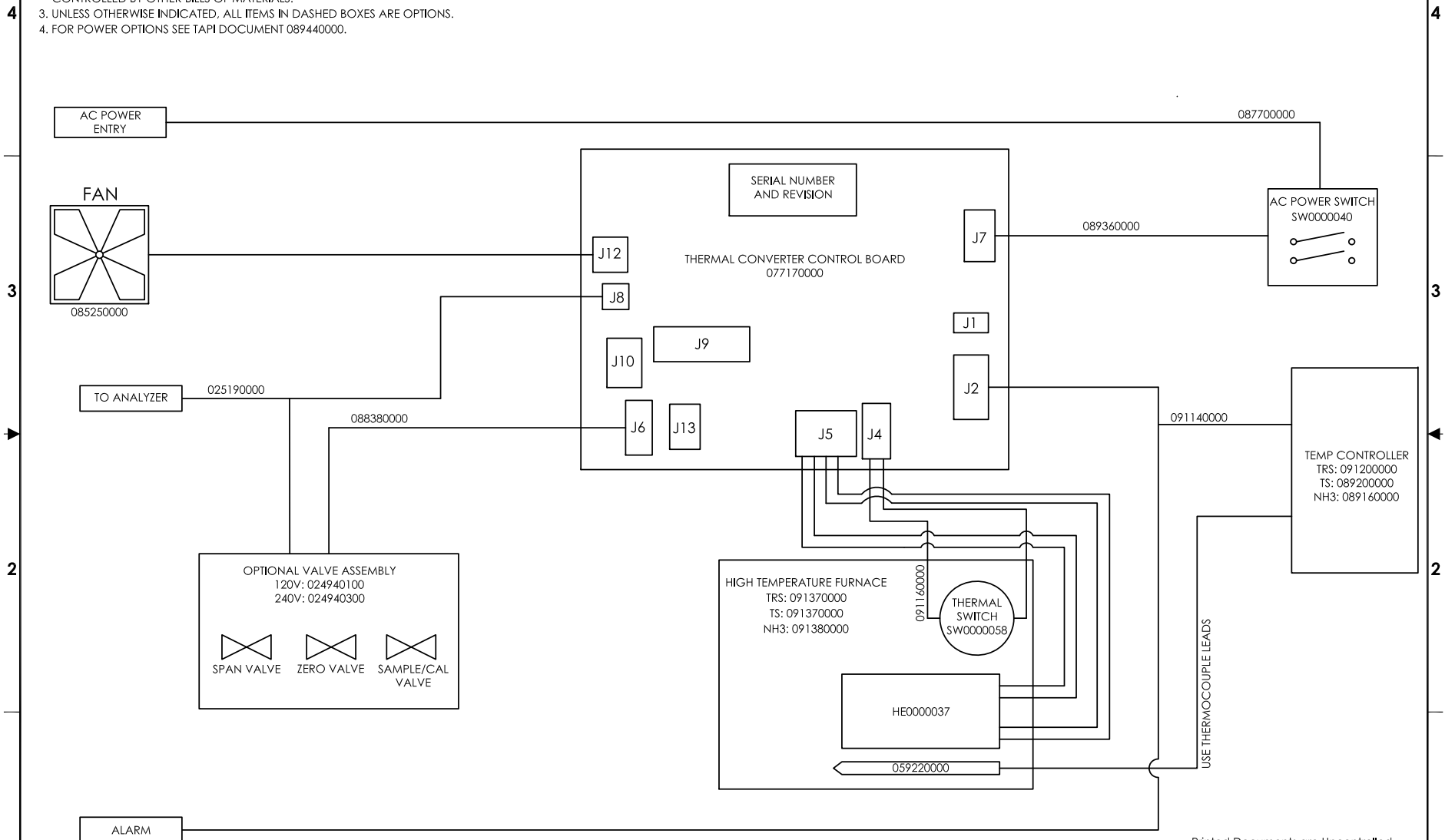
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Appendix A - Model 501 Interconnect

NOTES UNLESS OTHERWISE SPECIFIED:

- PART/ASSEMBLY MATERIALS AND PROCESSES USED DURING ASSEMBLY MUST ADHERE TO TAPI REGULATORY COMPLIANCE SPECIFICATION 083040000.
- ITEMS NOTED IN PARENTHESIS ARE FOR REFERENCE ONLY AND CAN BE CONTROLLED BY OTHER BILLS OF MATERIALS.
- UNLESS OTHERWISE INDICATED, ALL ITEMS IN DASHED BOXES ARE OPTIONS.
- FOR POWER OPTIONS SEE TAPI DOCUMENT 089440000.

REVISIONS				
REV	DESCRIPTION	DATE	DCN	APPROVED
A	INITIAL CREATION	11/19	8252	JTH



NH3 501 CONVERTER

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TOLERANCES ARE:	DIMINALS	ANGULAR														
FRACTIONS	±0.0075	±0.50														
DECIMALS	±0.00025															
<p>DO NOT SCALE DRAWING</p>		<p>APPROVALS</p> <table border="1"> <tr> <th>DATE</th> <th>DATE</th> </tr> <tr> <td>11/19</td> <td></td> </tr> </table>		DATE	DATE	11/19		<p>TITLE INTERCONNECT, DIAG, 501 CONVERTERS</p>								
DATE	DATE															
11/19																
<p>TREATMENT NA</p>		<p>DRAWN JTH</p>		<p>DWG. NO. 09217</p>												
<p>FINISH NA</p>		<p>CHECK JTH</p>		<p>REV A</p>												
<p>THIRD ANGLE PROJECTION</p>		<p>ISSUED</p>		<p>SCALE 1/1</p>												
		<p>FORM ENF0039A</p>		<p>SHEET 1 OF 2</p>												