

## TRAINING MANUAL

# MODEL 200EU / T200U NO<sub>y</sub> NITROGEN OXIDES ANALYZER



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## **1. PRINCIPLE OF OPERATION**



## **Measurement Principle**

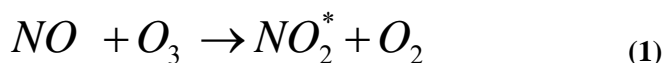
The M200EU NO<sub>y</sub> Nitrogen Oxides Analyzer is a microprocessor controlled instrument that determines the concentration of nitric oxide (NO), total nitrogen oxides (NO<sub>x</sub>, the sum of NO and NO<sub>2</sub>) and nitrogen dioxide (NO<sub>2</sub>) in a sample gas drawn through the instrument. It requires that sample and calibration gases be supplied at ambient atmospheric pressure in order to establish a constant gas flow through the reaction cell where the sample gas is exposed to ozone (O<sub>3</sub>), initiating a chemical reaction that gives off light (chemiluminescence). The instrument measures the amount of chemiluminescence to determine the amount of NO<sub>x</sub> present in the sample gas.

Calibration of the instrument is performed in software and usually does not require physical adjustments to the instrument. During calibration, the microprocessor measures the sensor output signal when gases with known amounts of NO<sub>x</sub> are supplied and stores these results in memory. The microprocessor uses these calibration values along with the signal from the sample gas and data of the current temperature and pressure of the gas to calculate a final NO<sub>x</sub> concentration.

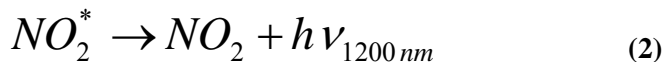
The concentration values and the original information from which it was calculated are stored in the unit's internal data acquisition system and reported to the user through a vacuum fluorescent display or several communication ports.

## **Chemiluminescence**

The principle of the M200EU NO<sub>y</sub>'s measurement method is the detection of chemiluminescence, which occurs when nitrogen oxide (NO) reacts with ozone (O<sub>3</sub>). This reaction is a two-step process. In the first step, one molecule of NO and one molecule of O<sub>3</sub> collide and chemically react to produce one molecule of oxygen (O<sub>2</sub>) and one molecule of nitrogen dioxide (NO<sub>2</sub>). Some of the NO<sub>2</sub> retains a certain amount of excess energy from the collision and, hence, remains in an excited state, which means that one of the electrons of the NO<sub>2</sub> molecule resides in a higher energy state than is normal (denoted by an asterisk in Equation 1).



Because thermodynamics requires that systems will always seek the lowest, stable energy state, the NO<sub>2</sub> molecule quickly returns to its ground state in a subsequent step by giving off the excess energy in form of a quantum of light ( $h\nu$ ) with wavelengths between 600nm and 3000nm, peaking at about 1200nm (Equation 2, Figure 1).



## **NO<sub>y</sub> Determination**

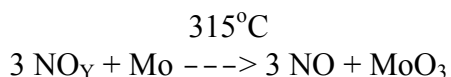
The API Model 200EU with NO<sub>y</sub> Option is designed to measure the concentration of NO, NO<sub>2</sub>, and other compounds that are too unstable to be measured when taken in through the normal ambient air sample inlet system. Please refer to the M200EU manual supplied with this system for a general discussion of the operation of a NO<sub>x</sub> analyzer. The suite of compounds known collectively as NO<sub>y</sub> is composed of roughly 30 compounds. There is some disagreement over whether certain compounds should be on the list. The NO<sub>y</sub> measurement is generally done in conjunction with a standard NO<sub>x</sub> measurement, with the difference between the two being the concentration of the unstable compounds, sometimes referred to as NO<sub>z</sub>.

$$NO_y = NO_x + NO_z \quad \text{or} \quad NO_z = NO_y - NO_x$$

The system is composed of 3 modules:

- The M200EU, without a moly converter
- A Bypass pump chassis containing:
  - Bypass pump
  - Flow control
  - Sample filtration
  - Moly temperature control
  - Pneumatic provisions for calibration
- An externally mounted molybdenum converter

The M200EU w/NO<sub>y</sub> Option system allows the converter to be mounted at the sample inlet point. This configuration provides minimal time delay between the sample inlet port and the remotely mounted molybdenum converter. Minimizing the transit time between the sample inlet and converter enables the conversion of labile components of NO<sub>y</sub>. The equation for the conversion is:



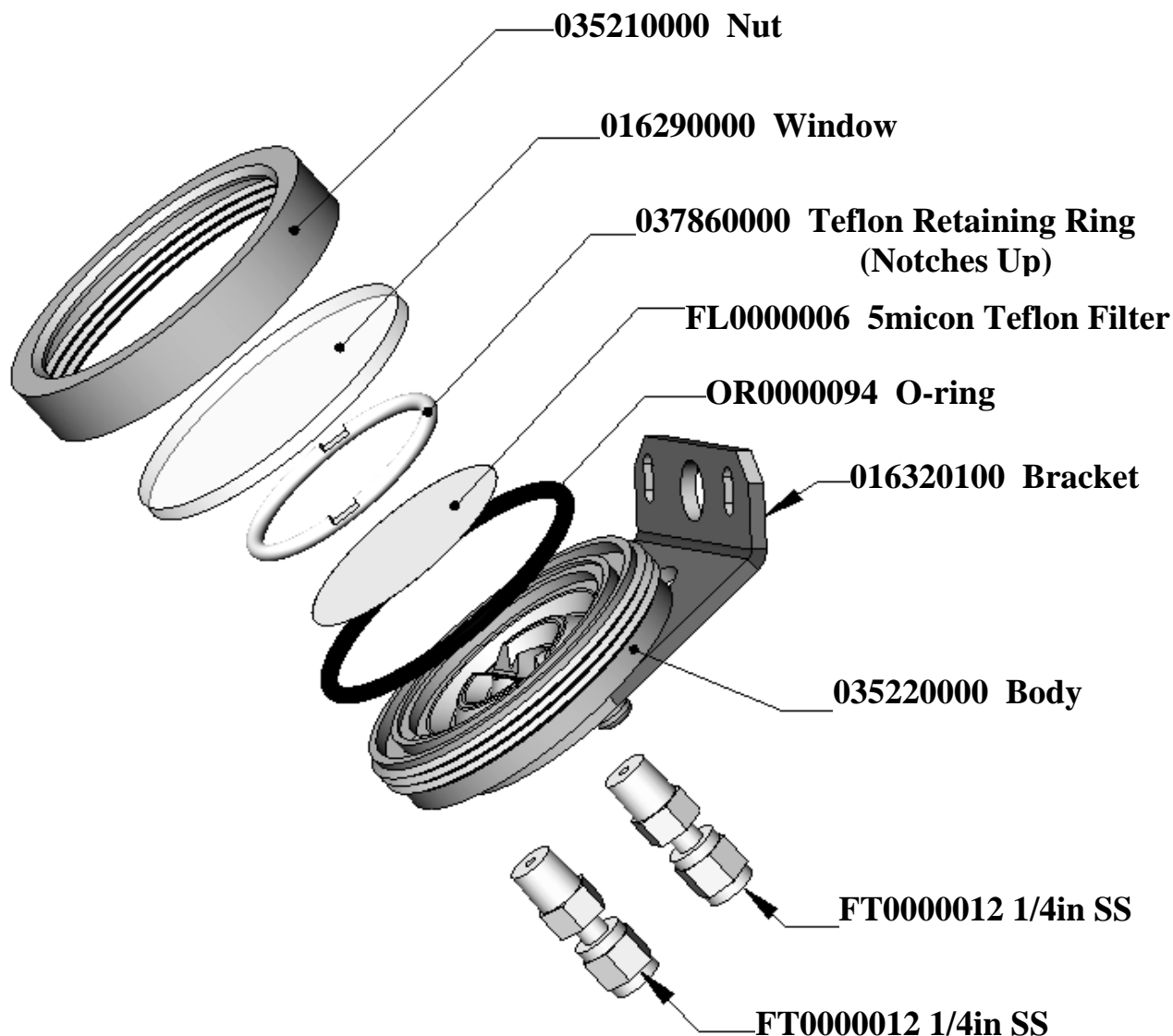
### **IMPORTANT NOTE ABOUT NO<sub>y</sub> MONITORING**

**It is very important to not put anything on the sample inlet fitting of the moly converter. Do not install a sample filter, tubing or anything else. The moly should be the point of sampling or else there will be a loss of NO<sub>y</sub> signal.**



## The Sample Particulate Filters

The particulate filters should be inspected often for signs of plugging or excess dirt. It should be replaced regularly even without obvious signs of dirt. Because the NO<sub>y</sub> analyzer uses a 5 micron pore size, it can clog up while retaining a clean look. We recommend handling the filter and the wetted surfaces of the filter housing with gloves and tweezers. We recommend not touching any part of the housing, filter element, PTFE retaining ring, glass cover and the O-ring with bare hands as this may cause the pores to clog quicker and surfaces to become dirty due to possible oils from your hands. The filters are located inside of the pump box assembly.



## **The Reaction Chamber**

The reaction cell of the M200EU NO<sub>y</sub> does not have critical flow orifices like all of the other chemiluminescent analyzers do. The orifices are located in different locations throughout the analyzer as specified in the critical flow orifice section of this manual.

## **The Pre-Reactor**

The pre-reactor is a volume of space before the reaction cell that allows all NO to react with the ozone before entering into the reaction cell. This causes no chemiluminescence in the reaction cell as it all occurred in the pre-reactor. This serves the same purpose as the A-Zero in the M200E NO<sub>x</sub> analyzer. The main difference is that we can now compensate for any interferences in the sample stream, as it is still flowing into the analyzer during the a-zero cycle.

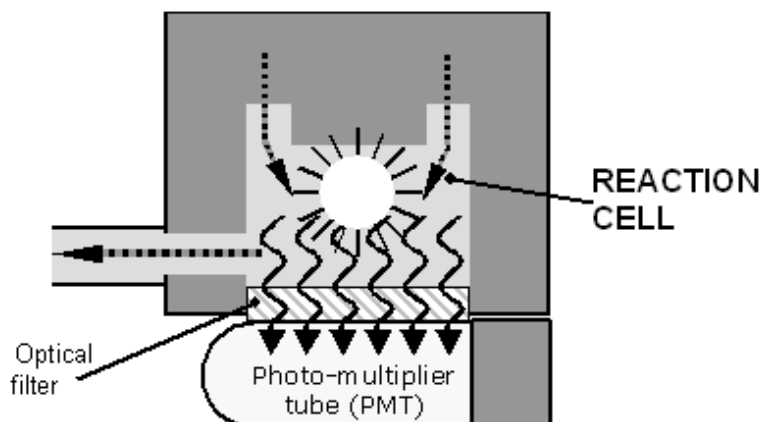
The main function of the pre-reactor is to measure the amount of Hydrocarbons that chemiluminesce, and once measured we can subtract this from the NO<sub>x</sub> and NO readings. Therefore we are only measuring NO<sub>x</sub> or NO. Some Hydrocarbons will chemiluminesce which typically is a few ppb of the NO<sub>x</sub> and NO reading if it is not removed.

The reason this works is the reaction of ozone to NO is very quick and the reaction of ozone to Hydrocarbons is slow. So the pre-reactor allows for all of the NO to react out to NO<sub>2</sub> before the sample gas is brought in front of the PMT. So in short, the pre-reactor valve triggers and we will then get a pre-reactor PMT reading. This value is then subtracted from the normal NO<sub>x</sub> and NO readings.

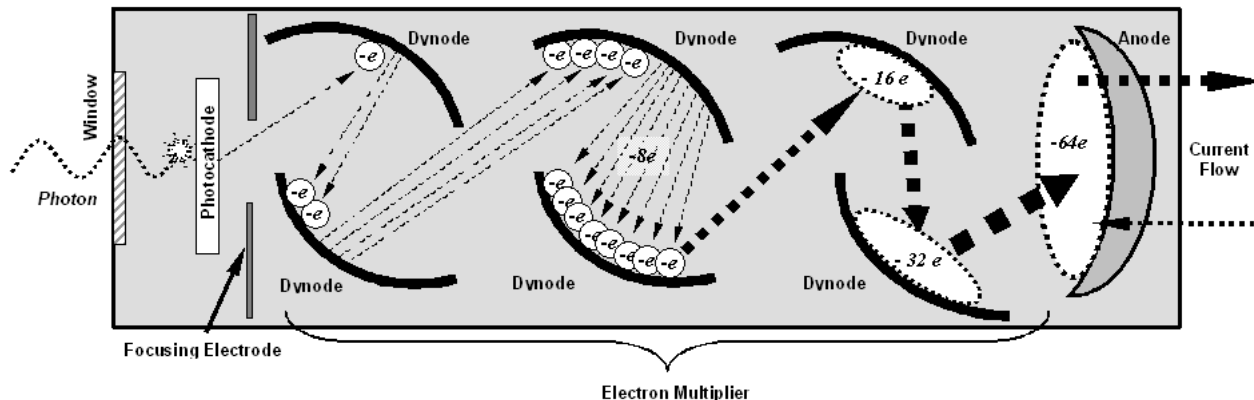
## The Photo Multiplier Tube

The M200EU NO<sub>y</sub> uses a photo-multiplier tube (PMT) to detect the amount of light created by the NO and O<sub>3</sub> reaction in the reaction cell.

A PMT is typically a vacuum tube containing a variety of specially designed electrodes. Photons enter the PMT and strike a negatively charged photo cathode causing it to emit electrons. These electrons are accelerated by an applied high voltage and multiply through a sequence of such acceleration steps (dynodes) until a useable current signal is generated. This current increases or decreases with the amount of detected light is converted to a voltage and amplified by the preamplifier board and then reported to the motherboard's analog inputs.



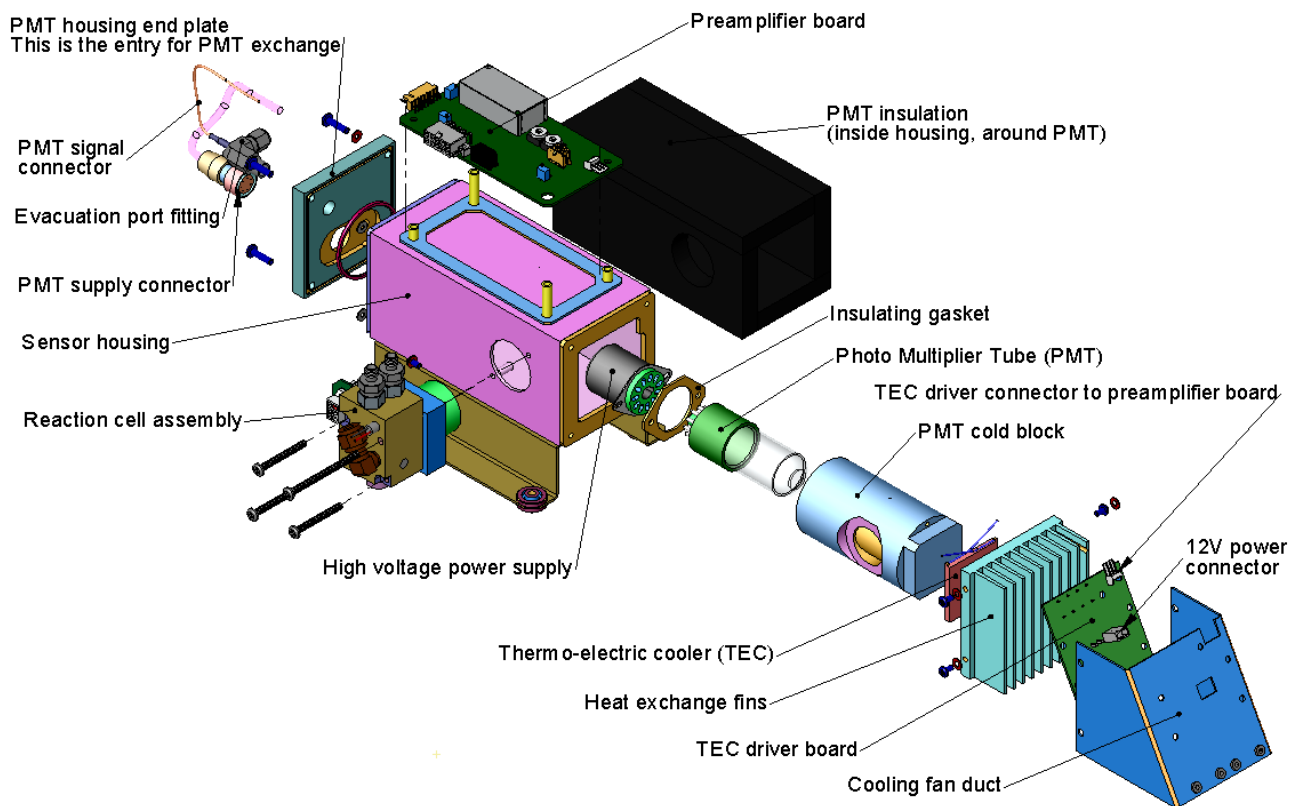
**Reaction Cell with PMT Tube**



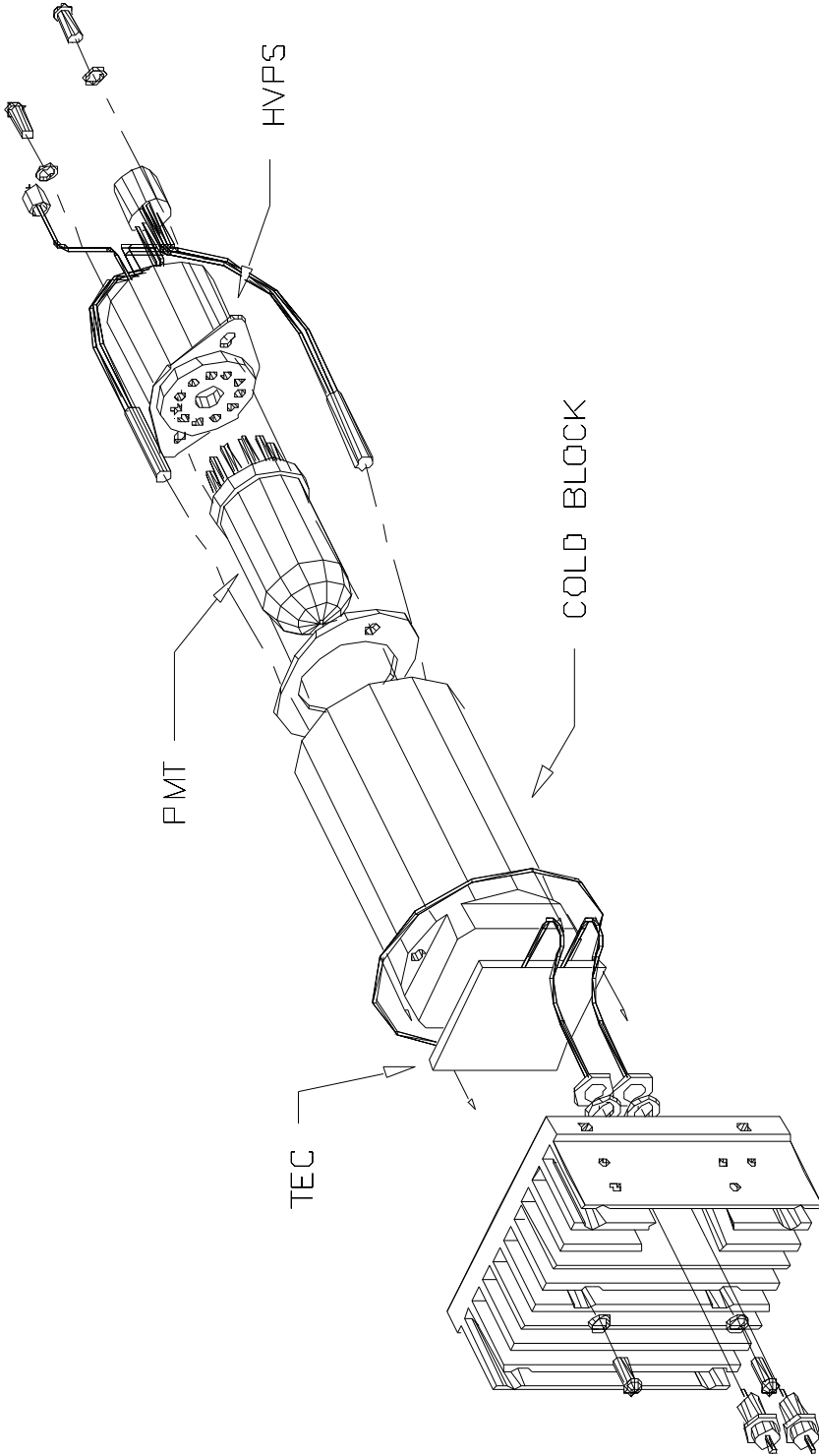
**Schematic of Basic PMT Design and Functionality**

A significant performance characteristic of the PMT is the voltage potential across the electron multiplier. The higher the voltage, the greater is the number of electrons emitted from each dynode of the electron multiplier, making the PMT more sensitive and responsive to small variations in light intensity but also increases random noise (dark noise). The gain voltage of the PMT used in the M200EU NO<sub>y</sub> is usually set between 450 V and 800 V. This parameter is viewable through the front panel as test function **HVPS** and usually does not need to be changed unless the PMT or the HVPS itself is changed.

The PMT is housed inside the sensor module assembly. This assembly also includes the high voltage power supply required to drive the PMT, an LED used by the instrument's optical test function, a thermistor that measures the temperature of the PMT and various components of the PMT cooling system, including the thermo-electric cooler (TEC).



M200EU NO<sub>y</sub> Sensor Assembly

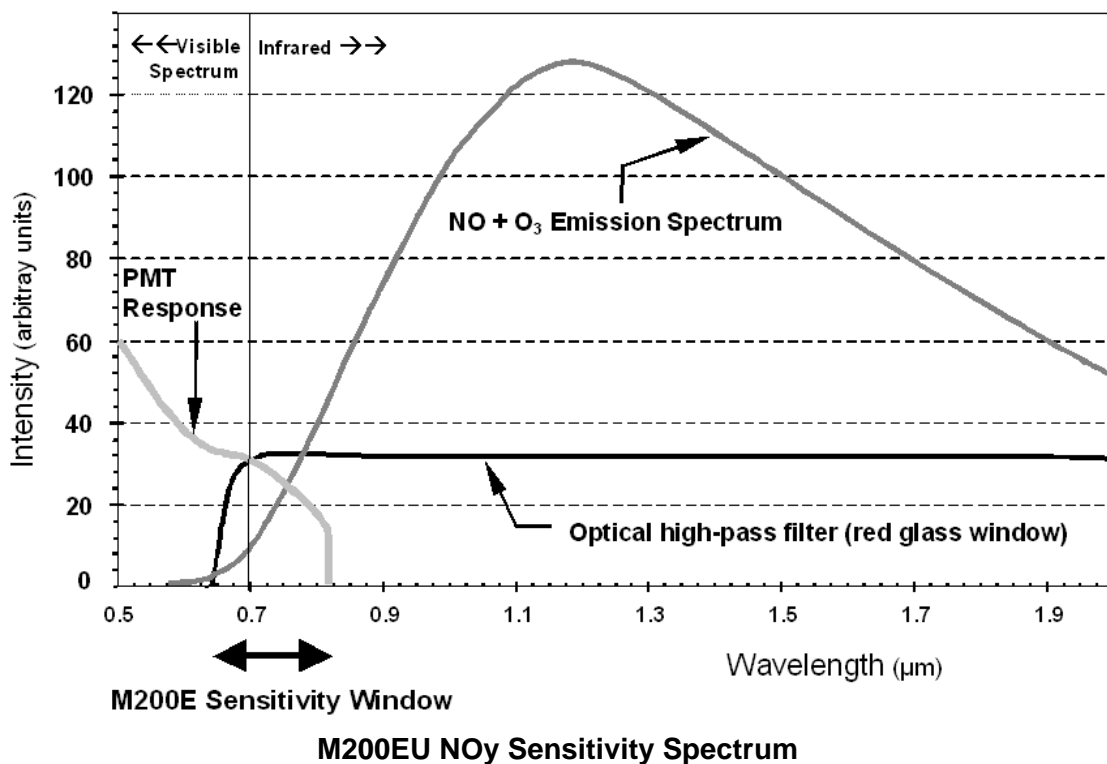


PMT COOLER ASSEMBLY

## Optical Filter

Another critical component in the method by which your M200EU NO<sub>y</sub> detects chemiluminescence is the optical filter that lies between the reaction cell and the PMT. This filter is a high pass filter that is only transparent to wavelengths of light above 665nm. In conjunction with the response characteristics of the PMT, this filter creates a very narrow window of wavelengths of light to which the M200EU NO<sub>y</sub> will respond.

THE NARROW BAND OF SENSITIVITY ALLOWS THE M200EU NO<sub>y</sub> TO IGNORE EXTRANEOUS LIGHT AND RADIATION THAT MIGHT INTERFERE WITH THE M200EU NO<sub>y</sub>'S MEASUREMENT. FOR INSTANCE, SOME OXIDES OF SULFUR CAN ALSO UNDERGO CHEMILUMINESCENCE WHEN IN CONTACT WITH O<sub>3</sub> BUT EMIT LIGHT AT SHORTER WAVELENGTHS (USUALLY AROUND 260NM TO 480NM).



## **Ozone Gas Air Flow**

The excess ozone needed for reaction with NO in the reaction cell is generated inside the analyzer because of the instability and toxicity of ozone. Besides the ozone generator itself, this requires a dry air supply and filtering of the gas before it is introduced into the reaction cell. Due to its toxicity and aggressive chemical behavior, O<sub>3</sub> must also be removed from the gas stream before it can be vented through the exhaust outlet. This is accomplished in two ways. First it will go through a catalytic ozone scrubber and then through a charcoal scrubber on the pump pack.

In contrast to the sample flow, the ozone flow is measured with a mass flow sensor which is mounted on the pneumatic sensor board just behind the PMT sensor assembly. As the flow value displayed on the front panel is an actual measurement (and not a calculated value), the flow variability may be higher than that of the sample flow, which is based on a calculation from (more stable) differential pressures. On the other hand, the drift, i.e. long-term change, in the ozone flow rate may be higher and usually indicates a flow problem. As with all other test parameters, we recommend monitoring the ozone flow over time for predictive diagnostics and maintenance evaluation.



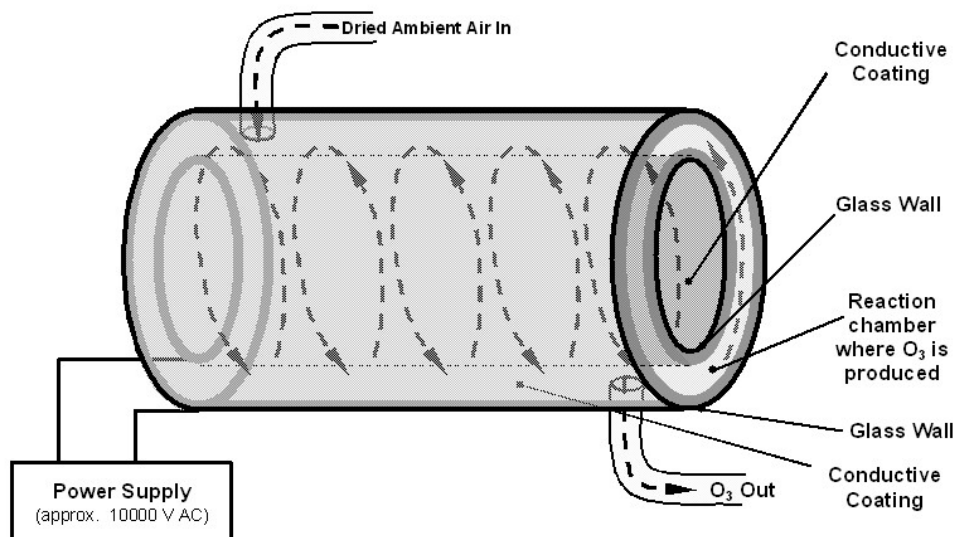
### **CAUTION**

**Ozone (O<sub>3</sub>) is a toxic gas. Obtain a Material and Safety Data Sheet (MSDS) for this gas. Read and rigorously follow the safety guidelines described there. Always make sure that the plumbing of the O<sub>3</sub> generation and supply system is maintained and leak-free.**



## O<sub>3</sub> Generator

The M200EU NO<sub>y</sub> uses a corona discharge (CD) tube for creating its O<sub>3</sub>. Corona discharge generation is capable of producing high concentrations of ozone efficiently and with low excess heat. Although there are many cell designs, the fundamental principle remains the same.



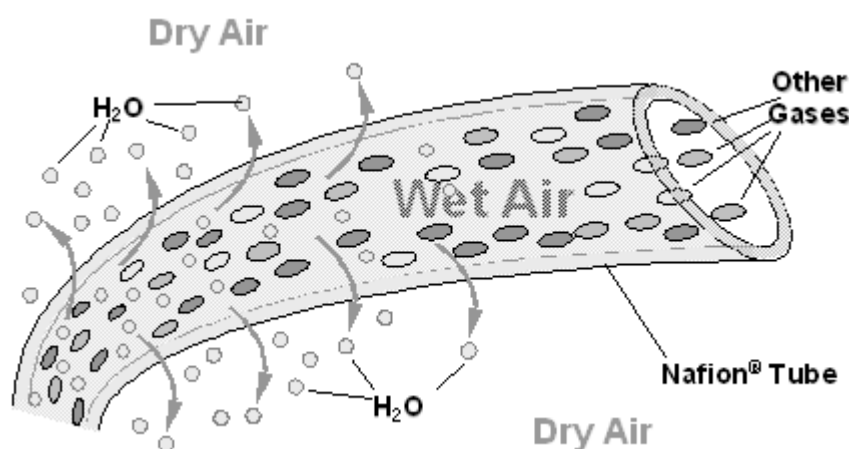
### Ozone Generator Principle

The M200EU NO<sub>y</sub> utilizes a dual-dielectric design. This method utilizes a glass tube with hollow walls. The outermost and innermost surfaces are coated with electrically conductive material. The air flows through the glass tube between the two conductive coatings, in effect creating a capacitor with the air and glass acting as the dielectric. The layers of glass also separate the conductive surfaces from the air stream to prevent reaction with the O<sub>3</sub>. As the capacitor charges and discharges, electrons are created and accelerated across the air gap and collide with the O<sub>2</sub> molecules in the air stream splitting them into elemental oxygen. Some of these oxygen atoms recombine with O<sub>2</sub> to form O<sub>3</sub>. The quantity of ozone produced is dependent on factors such as the voltage and frequency of the alternating current applied to the CD chamber. When enough high-energy electrons are produced to ionize the O<sub>2</sub> molecules, a light emitting, gaseous plasma is formed, which is commonly referred to as a corona, hence the name corona discharge generator.

## Perma Pure<sup>®</sup> Dryer

The air supplied to the O<sub>3</sub> generation system needs to be as dry as possible. Normal room air contains a certain amount of water vapor, which greatly diminishes the yield of ozone produced by the ozone generator. Also, water can react with other chemicals inside the O<sub>3</sub> Generator to produce chemicals that damage the optical filter located in the reaction cell such as ammonium sulfate or highly corrosive nitric acid.

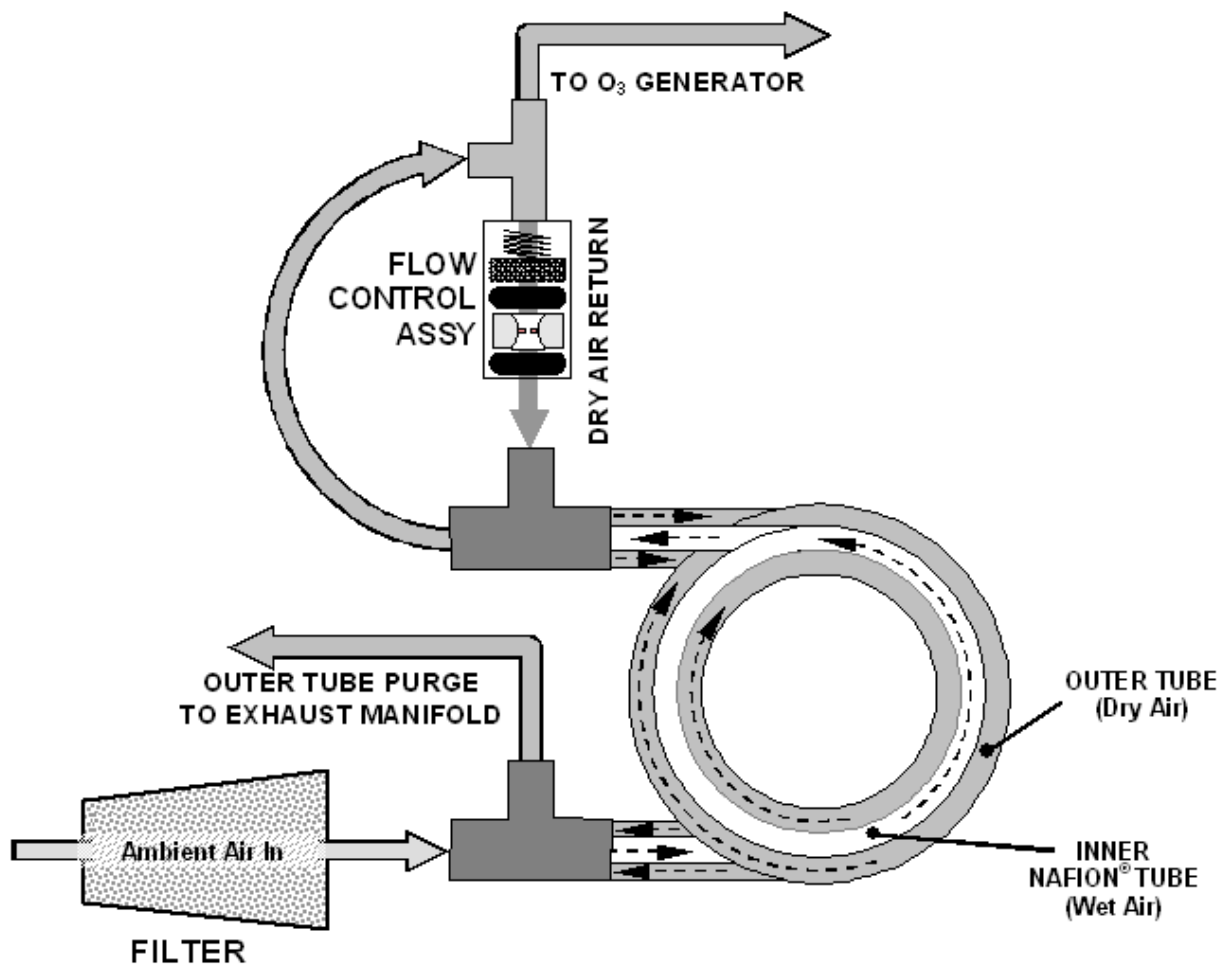
To accomplish this task the M200EU NO<sub>y</sub> uses a Perma Pure<sup>®</sup> single tube permeation dryer. The dryer consists of a single tube of Nafion<sup>®</sup>, a co-polymer similar to Teflon<sup>®</sup> that absorbs water very well but not other chemicals. The Nafion<sup>®</sup> tube is mounted within an outer, flexible plastic tube. As gas flows through the inner Nafion<sup>®</sup> tube, water vapor is absorbed into the membrane walls. The absorbed water is transported through the membrane wall and evaporates into the dry, purge gas flowing through the outer tube, countercurrent to the gas in the inner tube.



### Semi-Permeable Membrane Drying Process

This process is called per-evaporation and is driven by the humidity gradient between the inner and outer tubes as well as the flow rates and pressure difference between inner and outer tubing. Unlike micro-porous membrane permeation, which transfers water through a relatively slow diffusion process, per-evaporation is a simple kinetic reaction. Therefore, the drying process occurs quickly, typically within milliseconds. The first step in this process is a chemical reaction between the molecules of the Nafion<sup>®</sup> material and water, other chemical components of the gases to be dried are usually unaffected. The chemical reaction is based on hydrogen bonds between the water molecule and the Nafion material. Other small polar gases that are capable of hydrogen bonds can be absorbed this way, too, such as ammonia (NH<sub>3</sub>) and some low molecular amines. The gases of interest, NO and NO<sub>2</sub>, do not get absorbed and pass through the dryer unaltered.

To provide a dry purge gas for the outer side of the Nafion tube, the M200EU NO<sub>y</sub> returns some of the dried air from the inner tube to the outer tube. When the analyzer is first started, the humidity gradient between the inner and outer tubes is not very large and the dryer's efficiency is low at first but improves as this cycle reduces the moisture in the sample gas and settles at a minimum humidity.



### M200EU NO<sub>y</sub> Perma Pure<sup>®</sup> Dryer

Just like on startup, if the instrument is turned on after having been off for more than 30 minutes, it takes a certain amount of time for the humidity gradient to become large enough for the Perma Pure<sup>®</sup> Dryer to adequately dry the air. In this case, called a cold start, the O<sub>3</sub> Generator is not turned on for 30 minutes. When rebooting the instrument within less than 30 minutes of power-down, the generator is turned on immediately.

The Perma Pure<sup>®</sup> Dryer used in the M200EU NO<sub>y</sub> is capable of adequately drying ambient air to a dew point of  $\leq -5^{\circ}\text{C}$  (~4000 ppm residual H<sub>2</sub>O) at a flow rate of 1 standard liter per minute (slpm) or down to  $\leq -15^{\circ}\text{C}$  (~1600 ppm residual H<sub>2</sub>O) at 0.5 slpm. There is an additional Perma Pure<sup>®</sup> Dryer in the sample stream that is used to remove ammonia from the sample gas.

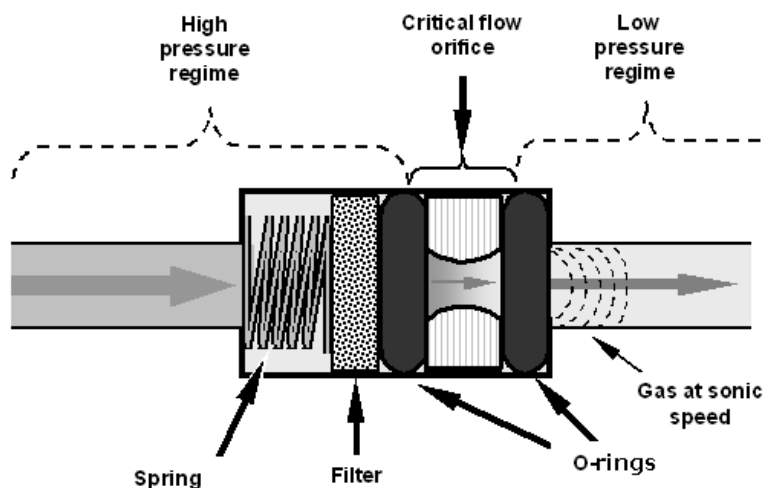
## Critical Flow Orifices

In order to maintain constant flow rates for both the O<sub>3</sub> supply air and the sample gas, the M200EU NO<sub>y</sub> uses a variety of critical-orifice flow control assemblies located at these places in the pneumatic system of the instrument:

- Pre-Reactor assembly, sample orifice
- Pre-Reactor assembly, ozone orifice
- Permapure ozone air dryer, purge flow control
- Permapure sample dryer, purge flow control
- Pump Pack module, cal gas bypass
- Pump Pack module, NO<sub>y</sub> bypass
- Pump Pack module, NO bypass

The most important component of each flow control assembly is the critical flow orifice. Critical flow orifices are a simple means to regulate stable gas flow rates. They operate without moving parts by taking advantage of the laws of fluid dynamics. By restricting the flow of gas through the orifice, a pressure differential is created. This pressure differential, created by the analyzer's external pump, draws the gas through the orifice.

As the pressure on the downstream side of the orifice (the pump side) continues to drop, the speed of the gas flowing through the orifice continues to rise. Once the ratio of upstream pressure to downstream pressure is greater than 2:1, the velocity of the gas through the orifice reaches the speed of sound and remains constant, regardless of any further pressure difference. As long as that ratio stays at least 2:1, the gas flow rate is unaffected by fluctuations, surges, or changes in downstream pressure because such variations only travel at the speed of sound themselves and are therefore cancelled out at the downstream exit of the critical flow orifice.



**Flow Control Assembly & Critical Flow Orifice**

The actual flow rate of gas through the orifice depends entirely on the size and shape of the aperture in the orifice and the upstream pressure. The larger the hole or the higher the upstream pressure, the more gas molecules pass through the orifice. The flow rate of the gas is also unaffected by small degradations in pump efficiency due to age as long as the 2:1 pressure difference is maintained.

**M200EU NO<sub>y</sub> Gas Flow Rates**

Location	Purpose	Orifice Diameter	Flowrate (nominal)
On port 2 of Pre-reactor valve	Controls rate of flow of sample gas into the reaction cell.	0.014" (14mil)	1000 cm <sup>3</sup> /min
On port 1 of the Pre-reactor valve	Controls rate of flow of ozone gas into the reaction cell.	0.004" (4mil)	80 cm <sup>3</sup> /min
Dry air return of Perma Pure <sup>®</sup> dryer	Controls flow rate of dry air return / purge air of the dryer.	0.004" (4mil)	80 cm <sup>3</sup> /min
Pump Pack	Cal gas line purge	0.003" (3mil)	50cm <sup>3</sup> /min
Pump Pack	NO <sub>y</sub> bypass flow	0.013" (13mil)	800cm <sup>3</sup> /min
Pump Pack	NO bypass flow	0.013" (13mil)	800cm <sup>3</sup> /min

Note that the diameter of the critical orifice may change with temperature because of expansion of the orifice material (ruby) and, hence, the most critical flow orifices in the M200EU NO<sub>y</sub> are maintained at a constant temperature inside special orifice holders located on the pre-reactor valve. These are the sample and O<sub>3</sub> flows. The table above shows the flow rates for each of the critical flow orifices of the M200EU NO<sub>y</sub>.

In addition to controlling the gas flows, the two critical flow orifices on the pre-reactor valve maintain a vacuum inside the reaction cell. This effectively reduces the number of molecules in the chamber and therefore increasing the chemiluminescence yield as the likelihood of third body quenching is reduced. The M200EU NO<sub>y</sub> sensitivity reaches a peak at about 2 in-Hg-A, below which the sensitivity drops due to a low number of molecules and decreased yield in the chemiluminescence reaction. The other components of the flow control assemblies are:

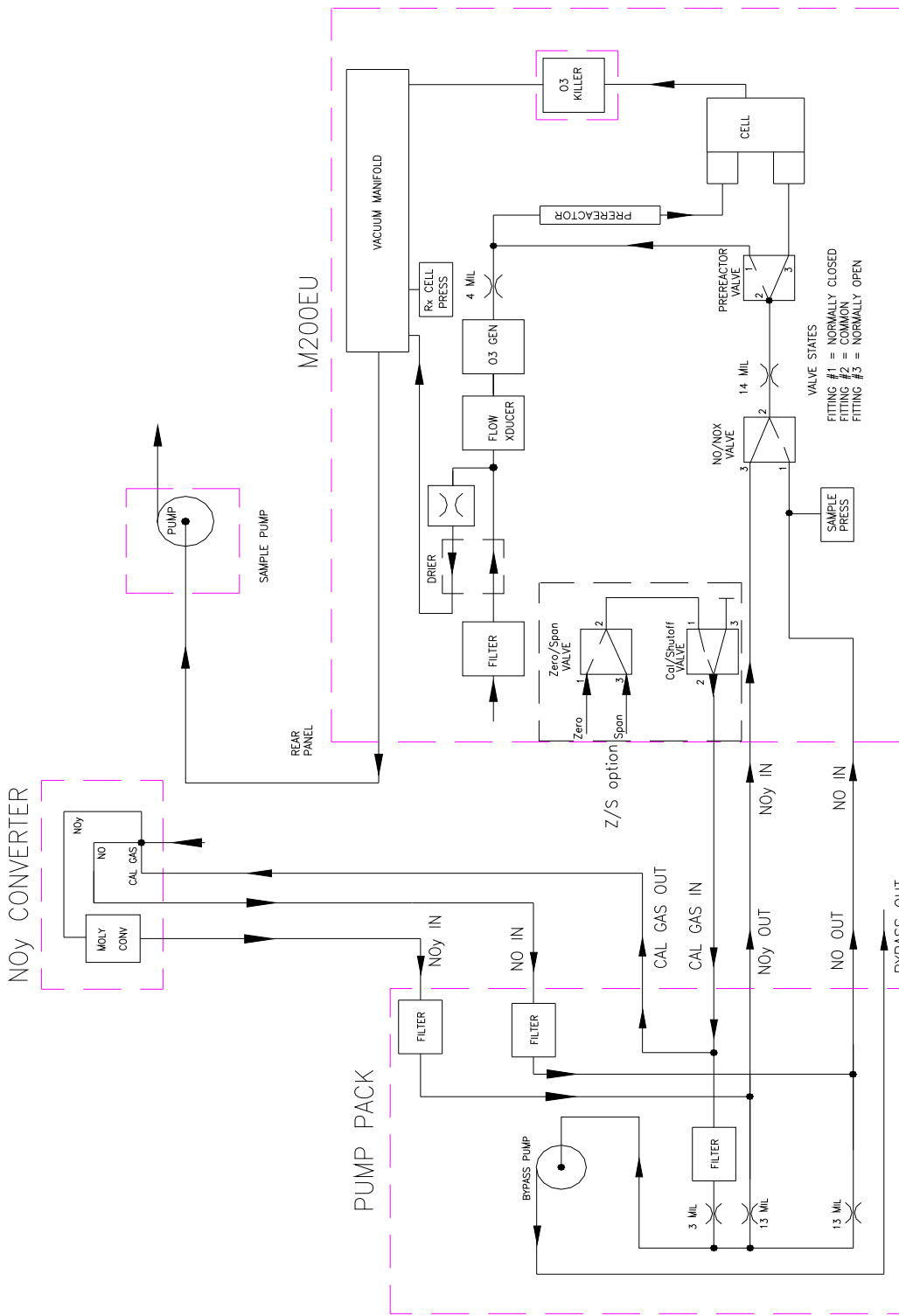
- A sintered stainless steel filter, which prevents particulates from entering the reaction cell and potentially plug the orifice. Note that very fine sub-micron particles may still accumulate on that filter and slowly clog up either the filter or the orifice over time.
- Two O-rings are located before and after the critical flow orifice to seal the gap between the walls of the assembly housing and the critical orifice and force all gas through the orifice opening.
- A spring applies mechanical force to form the seal between the o-rings, the critical flow orifice and the assembly housing and to prevent the components to float up and turn on sudden pressure drops.



## **2. PNEUMATICS**





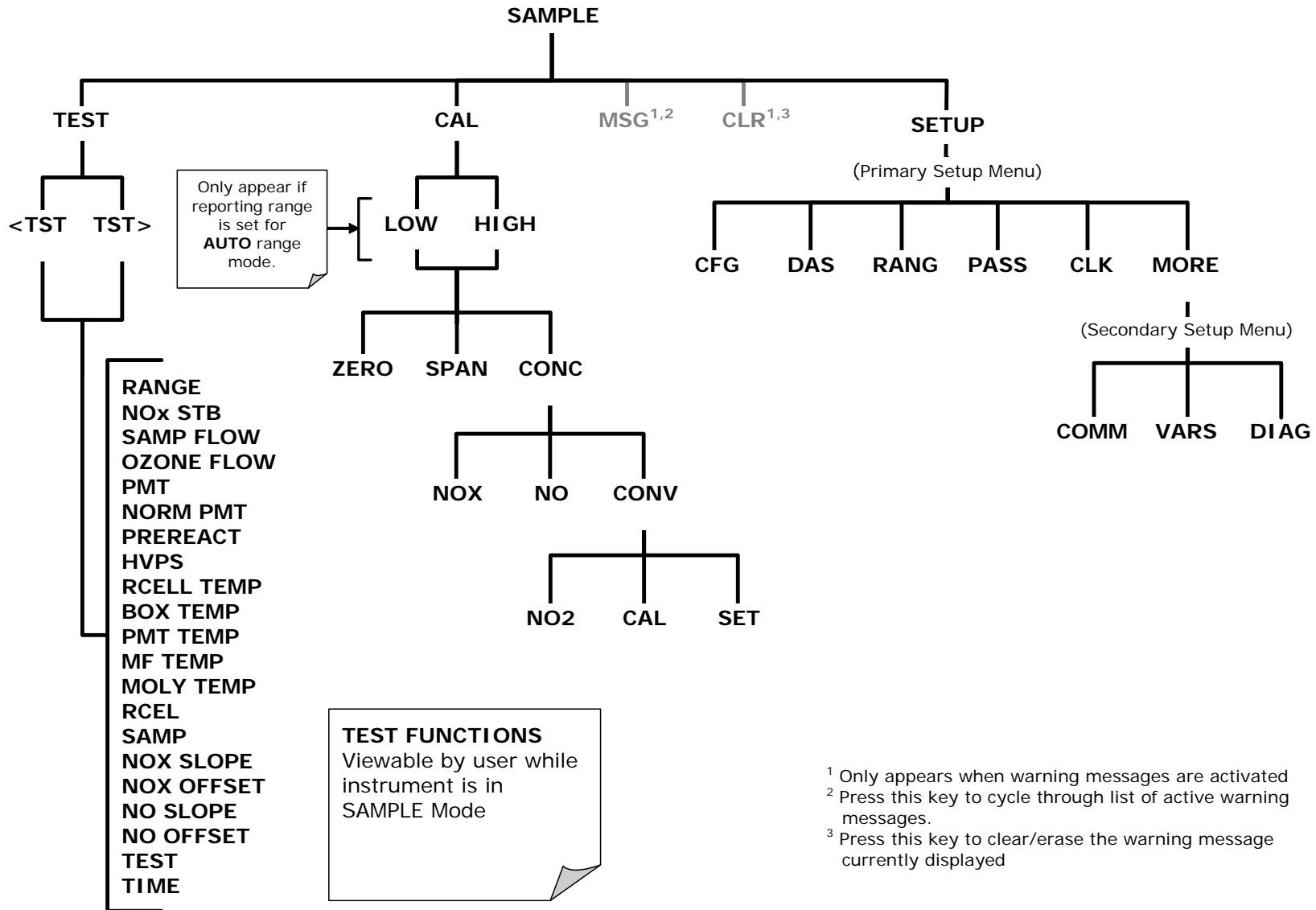


**M200EU NO<sub>y</sub> analyzer with Z/S valves**

**USER NOTES:**

### **3. MENU STRUCTURE**





**Figure A-1: Basic Sample Display Menu**

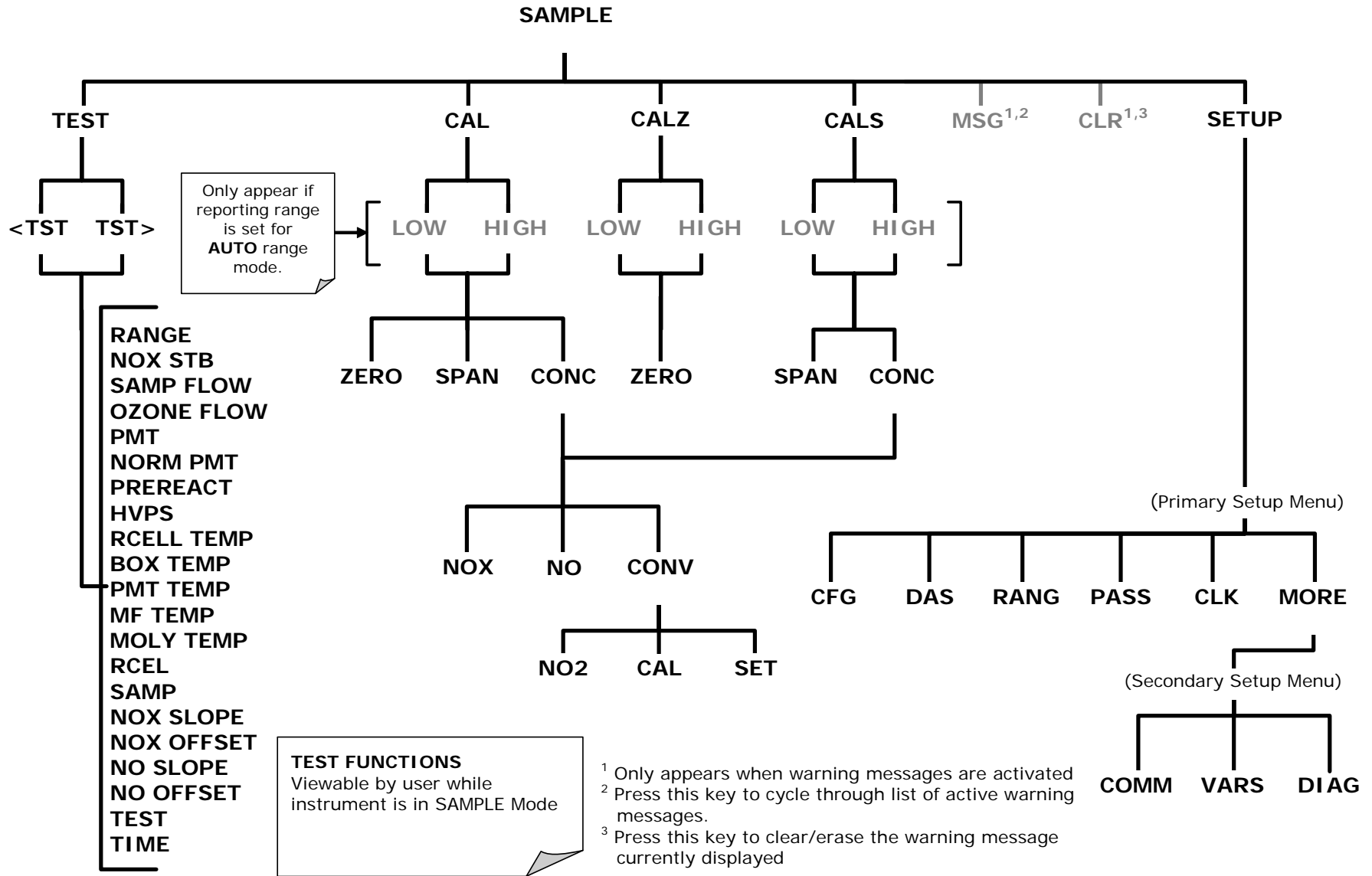
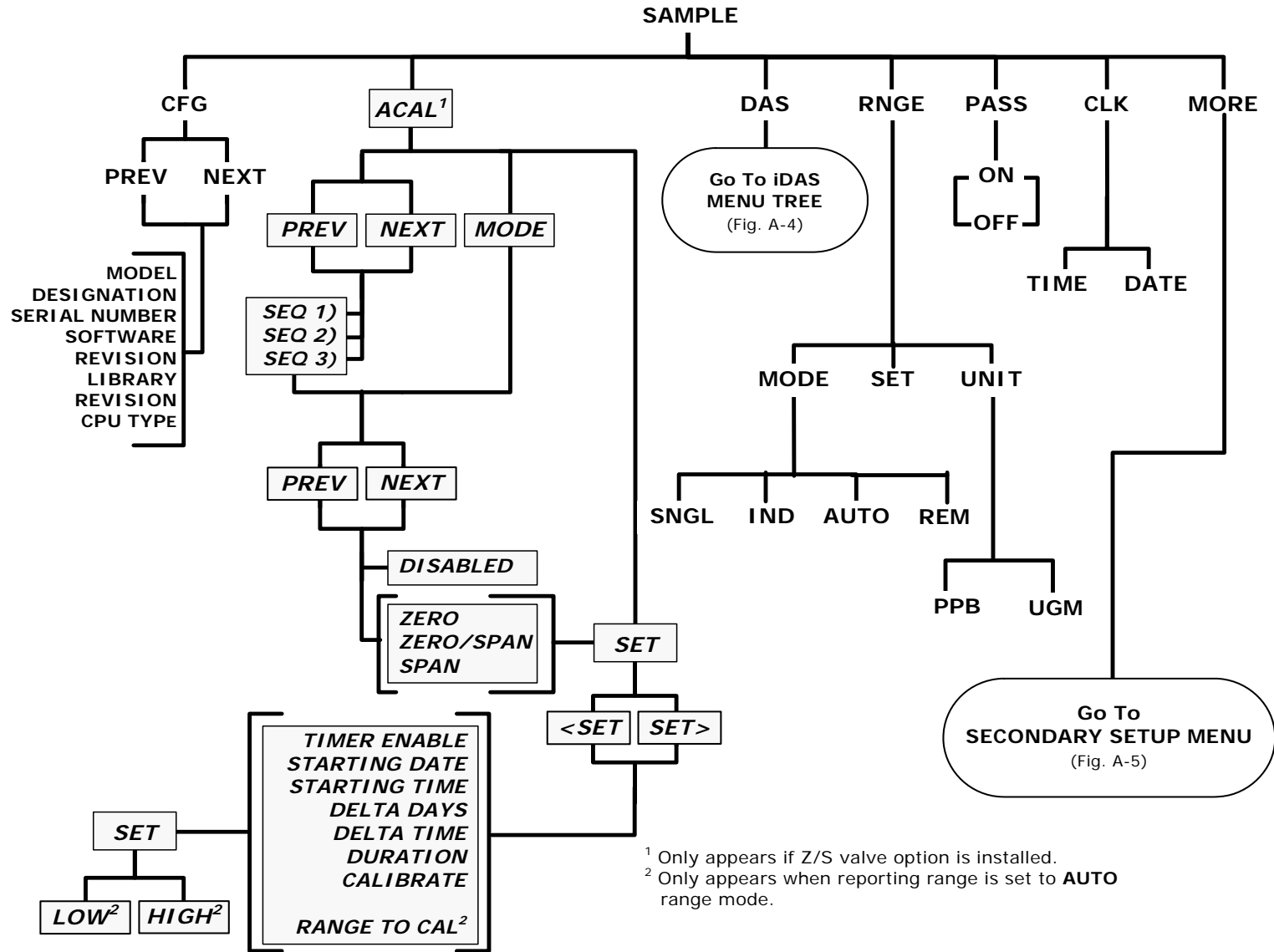
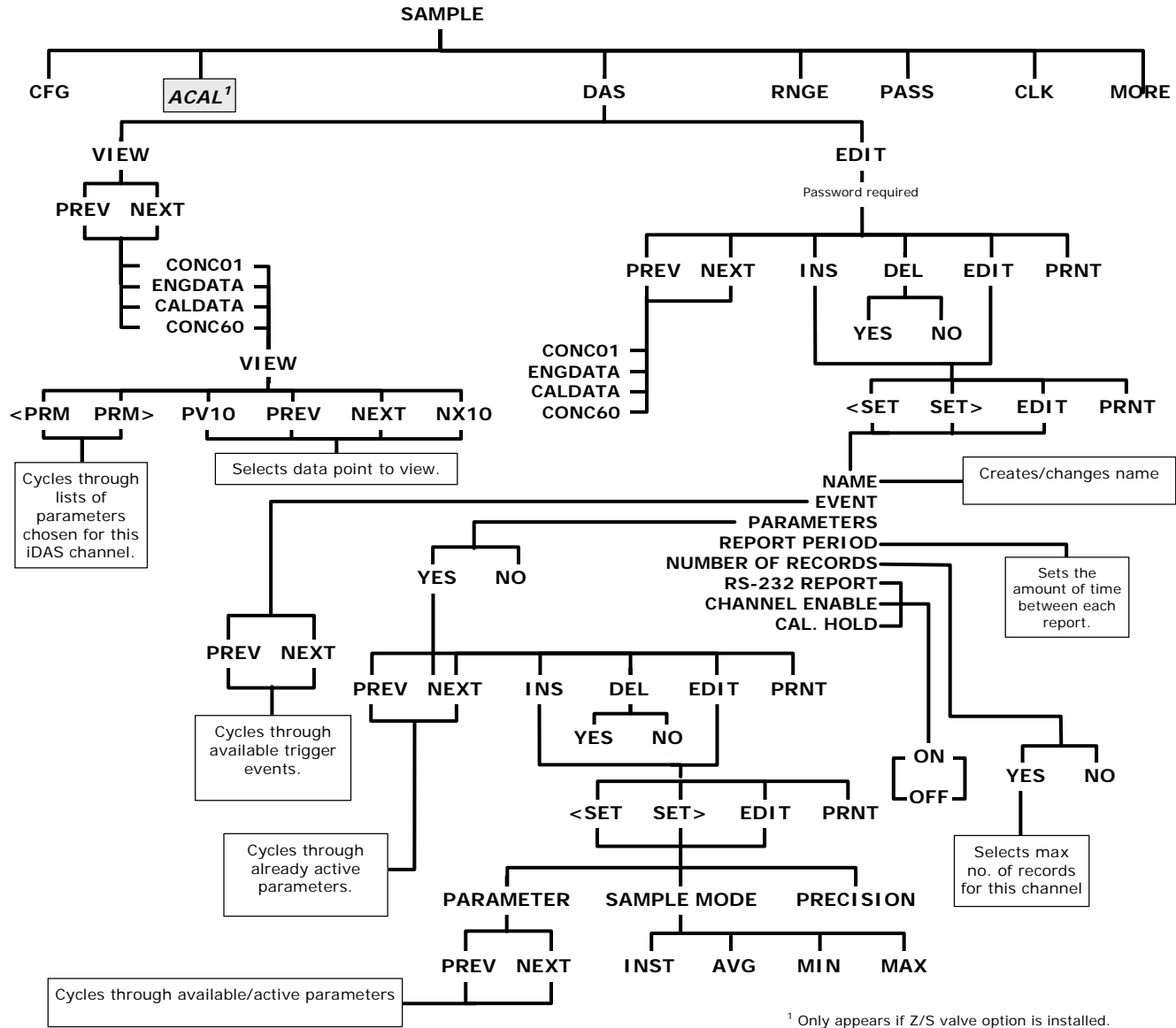


Figure A-2: Sample Display Menu - Units with Z/S Valve Option Installed



<sup>1</sup> Only appears if Z/S valve option is installed.  
<sup>2</sup> Only appears when reporting range is set to **AUTO** range mode.

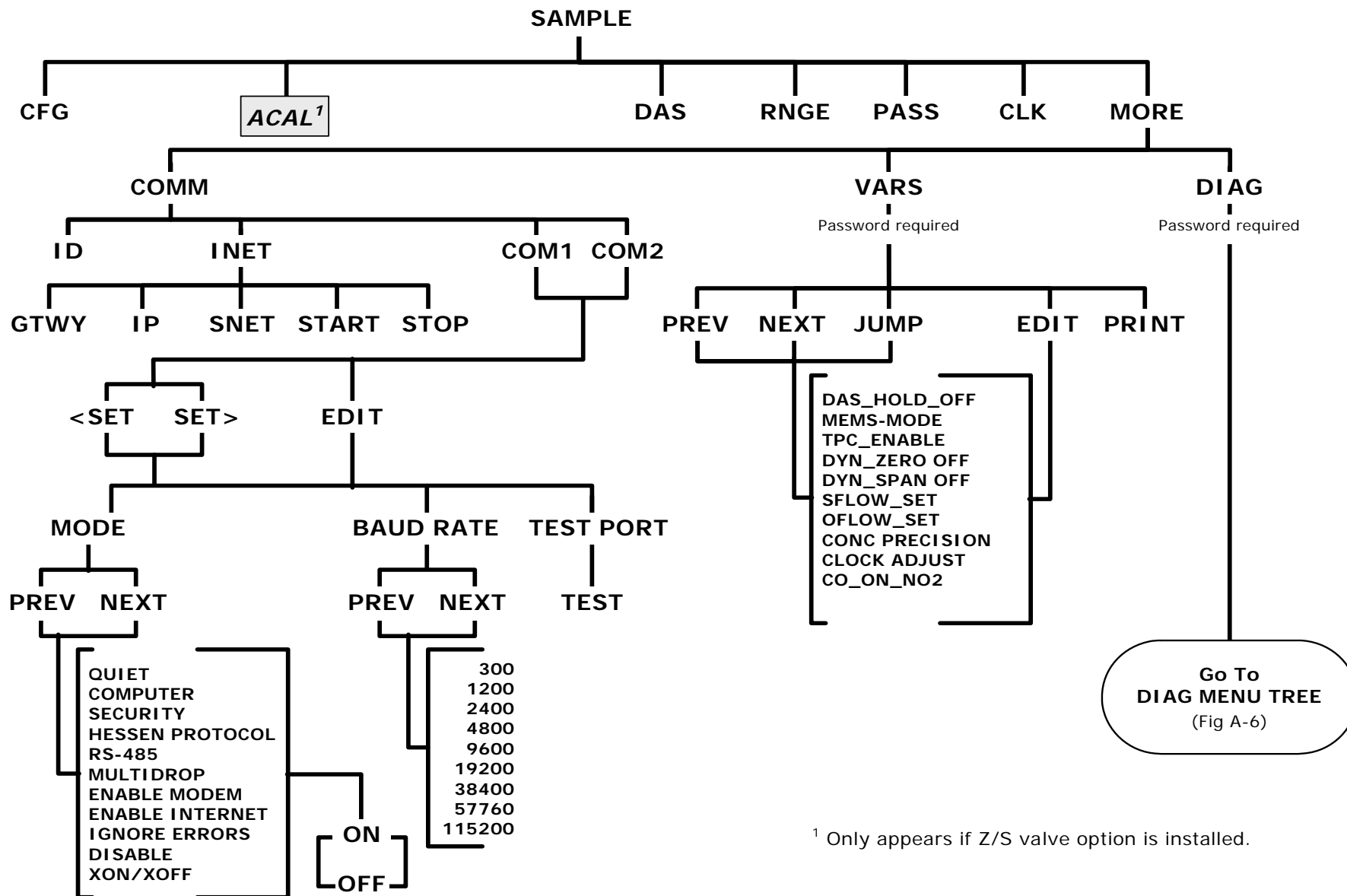
Figure A-3: Primary Setup Menu (Except iDAS)



<sup>1</sup> Only appears if Z/S valve option is installed.

Figure A-4: Primary Setup Menu (iDAS)



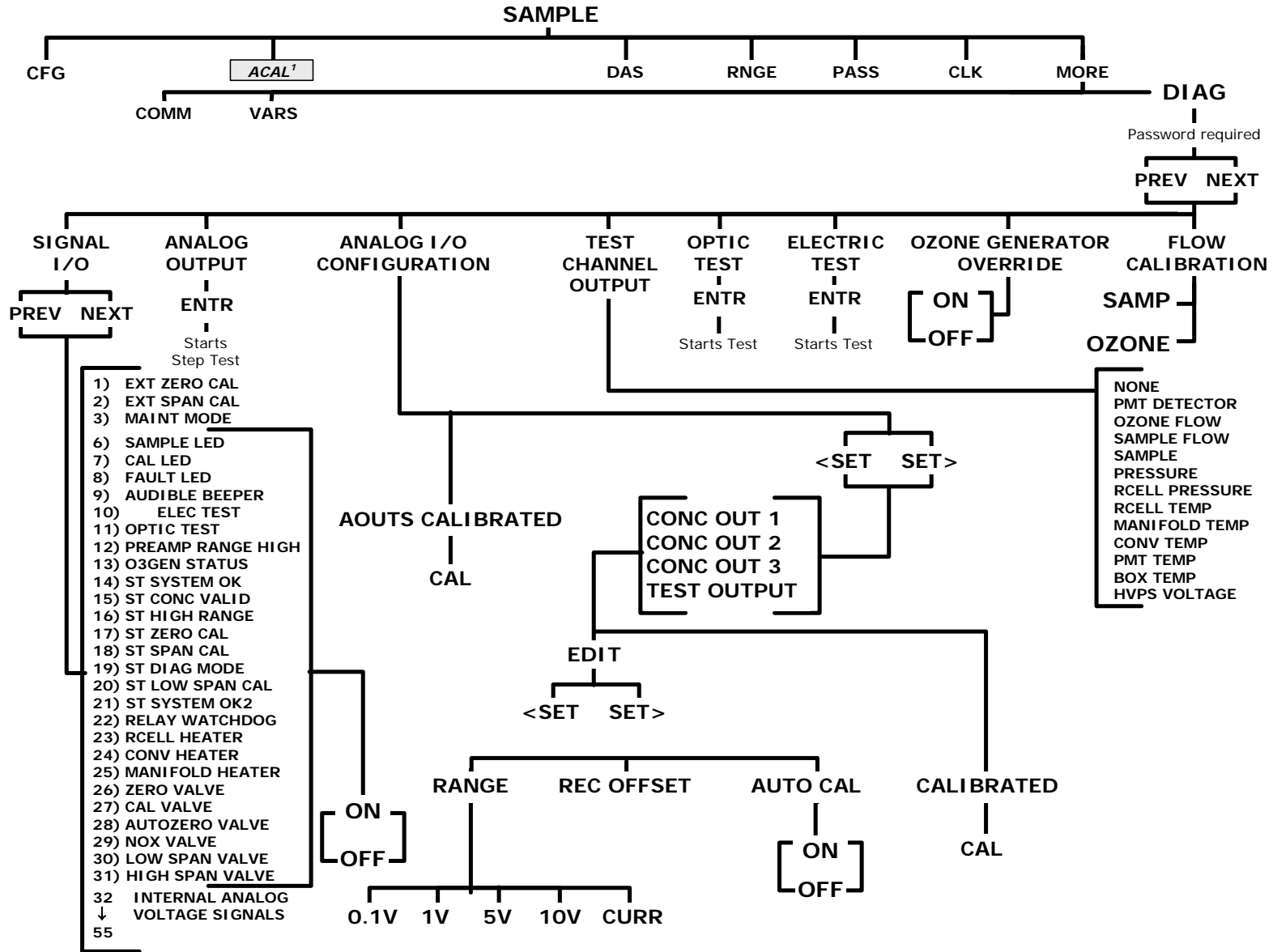


¹ Only appears if Z/S valve option is installed.

Figure A-5: Secondary Setup Menu (COMM & VARS)

# MODEL 200EU NO<sub>y</sub> NITROGEN OXIDES ANALYZER

## Training Manual



## **4. CALIBRATION PROCEDURE**



## **Calibration Information**

Unlike most NO<sub>x</sub> analyzers, the M200EU with the NO<sub>y</sub> option does not have a sample inlet port on the rear panel of the 200EU. The sample port is located on the External Converter; therefore zero/span calibration is different than a normal NO<sub>x</sub> instrument.

Follow the steps in the M200E/EU manual to:

- a. Enter the expected NO and NO<sub>x</sub> span gas concentrations in the M200EU.
- b. Do the zero calibration procedure
- c. Do the span calibration procedure

**The analyzer always routes the zero/span gas through the external converter. In standard configuration, the calibration gas needs to be input at the “Cal in” port of the M501 Pump pack. When Zero/Span valve option is installed, zero and span gases are to be provided at the 200EU zero and span ports. In all cases, the calibration gas delivered must be under a small amount of pressure (2-5 psig) to overcome the resistance of the hoses. Also, there must be no venting of the zero or span gas to atmosphere.**

**Calibration gas must be provided for both the bypass system and the 200EU analyzer. Flow requirements are 1.1 LPM for NO bypass, 1.1 LPM for NO<sub>x</sub> bypass and 1 LPM for the M200EU. Calibration gas flow must be in sufficient excess (~4 LPM) to prevent any ambient air from entering the sample port on the pole.**

The maximum 50 ft length of tubing between the Bypass Pump Module and the remote moly converter has been proven to generate too much backpressure for some brands of calibrators. Experience to date is that while NO calibration is correct, GPT can be incorrect due to errors in dilution of the ozone.

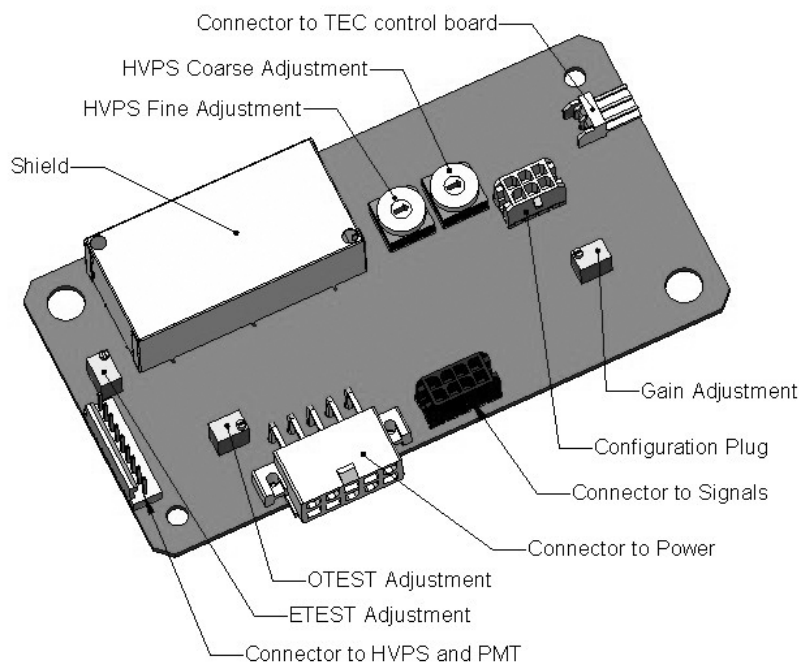
We strongly recommend that SPAN CALIBRATION be done with NO span gas. SPAN CHECKS can be done with either NO only, NO<sub>2</sub> only or a mixture of NO and NO<sub>2</sub> (GPT).

Zero air used for all calibration procedures, including GPT, should have <1 ppt NO and NO<sub>2</sub>, less than 1 ppt of major interferents such as SO<sub>2</sub>, NH<sub>3</sub>, hydrocarbons and a dew point of -5°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.

## Factory Calibration for a M200EU NO<sub>y</sub>

The sensor module hardware calibration adjusts the slope of the PMT output when the Instruments slope and offset values are outside of the acceptable range and all other more obvious causes for this problem have been eliminated.

- Set the instrument reporting range to **SNGL**.
- Perform a full zero calibration using zero air.
- Locate the Preamp board.
- Locate the Following Components On the Preamp board
  - HVPS coarse adjustment switch (Range 0-9, then A-F)
  - HVPS fine adjustment switch (Range 0-9, then A-F)
  - Gain adjustment potentiometer (Full scale is 12 turns)



**Pre-Amplifier Board Layout**

- Turn the gain adjustment potentiometer, R29, 12 turns clockwise to its maximum setting.
- Turn R29, the Gain Adjustment pot, 5 turns counter-clockwise to put it near the center of the potentiometer.
- While feeding span gas to the analyzer and waiting until the STABIL value is below 1.0 ppb, look at the front panel and scroll to the NORM PMT value. This value is what you are going to adjust to get a slope of 1.000. There are two different equations for calculating your TARGET

NORM PMT value. If you are on a range 2000ppb and below you will want to use the first equation, with a range 2000.1ppb and above you will use the second equation.

CONC=Span Gas in PPB

OFFSET=Offset reading from the front panel TST values

Ranges 2000.0ppb and below

**TARGET NORM PMT=(2\*CONC)+OFFSET**

Ranges 2000.1ppb and above

**TARGET NORM PMT=(0.2\*CONC)+OFFSET**

- Set the HVPS coarse adjustment switch to the lowest setting that will give you more then the calculated TARGET NORM PMT voltage.
- Adjust the HVPS fine adjustment such that the NORM PMT value is as close to the TARGET NORM PMT value. It may be necessary to go back and forth between coarse and fine adjustments if the proper value is at the threshold of the min/max coarse setting.

**NOTE**

**Do not overload the PMT by accidentally setting both adjustment switches to their maximum setting. This can cause permanent damage to the PMT.**

- Adjust the NORM PMT value with the gain potentiometer down to the TARGET NORM PMT value. This is the final very-fine adjustment.
- Perform software span and zero calibrations to normalize the sensor response to its new PMT sensitivity.
- Review the slope and offset values, the slopes should be  $1.000 \pm 0.100$  and the offset values should be -20 to +150 m
- If the slope is still out of spec, ensure that the analyzer is leak free, the Rcell Pressure is  $<10^{-2}$ , the concentration of the calibration gas I accurate, and the NORM PMT is at the correct target norm PMT value.

## Service Note

9480 Carroll Park Dr., San Diego, CA 92121-2251  
Phone (858) 657-9800 Fax: (858) 657-9818 Toll Free 1800 324-5190  
E-mail: [api-customerservice@teledyne.com](mailto:api-customerservice@teledyne.com) <http://www.teledyne-api.com>

03-020A

9 SEPTEMBER, 2003

### **HOW TO PERFORM A MANUAL DAC CALIBRATION ON "E" SERIES MACHINES**

#### **I. PURPOSE:**

The purpose of this service note is to give instructions on how to perform a manual Digital to Analog Calibration (D/A Calibration) on "E" series analyzers.

#### **II. TOOLS:**

Digital Voltmeter

#### **III. PARTS:**

None

#### **IV. PROCEDURE:**

Please follow the appropriate procedure below for either VOLTAGE or CURRENT output.

#### **VOLTAGE OUTPUT**

1. From the main menu press SETUP-MORE-DIAG-ENTR-NEXT until ANALOG I/O CONFIGURATION press ENTR.
2. Press SET> 5 times.
3. The top line should read A/IN CALIBRATED: YES
4. Press CAL to calibrate the analog inputs.
5. Press <SET 4 times.
6. The top line should read CONC\_OUT\_1: RANGE 5V
  - a. If this is the output voltage you desire then go to step 7
  - b. If this voltage is incorrect press EDIT and change to the output voltage desired, press ENTR and go to step 7.
7. Press EDIT, Press SET>. The top line should read CONC\_OUT\_1: REC OFFSET: 0mv
  - a. If you don't want a recorder offset go to step 8.
  - b. If you want a recorder offset press EDIT. Enter the OFFSET value and press ENTR. Go to step 8.
8. Press SET>. The top line should read CONC\_OUT\_1: AUTO CAL: ON
  - a. If this says AUTO CAL ON press EDIT and turn it OFF.
  - b. If this says AUTO CALL OFF go to step 9.
9. Press SET>. The top line should read CONC\_OUT\_1: CALIBRATED: YES
10. Now place your meter on pins 1 and 2 on the rear panel analog output connector and set your meter to read mvDC.



11. Press CAL on the front panel.
12. You should have some DN and UP buttons. And the top line should be say ZERO ADJUST or something similar.
13. The output on the meter should be as close as possible to  $0\text{mV} \pm 0.3\text{mV}$ .
  - a. If it is not then press DN or UP until the meter reads as close as possible to  $0\text{mV}$
  - b. If it does go to step 14
14. Press ENTR.
15. The top line should now say GAIN ADJUST and you should have DN and UP buttons again. The meter should now read 90% of your full-scale voltage (i.e. 1V, 5V, 10V) you will have to change the range on the meter to read Volts instead of Mili-volts. If you are on the 10V scale you will be adjusting to 4.5Vs instead of 90% of full scale.
16. Press the DN and UP buttons until the output on the meter reads 90% of your full-scale voltage  $\pm 1\text{mV}$ .
17. Press ENTR
18. That channel is now calibrated.
19. Do this for all channels and ensure that you move the meter on the output connector to the proper pins.

## **CURRENT OUTPUT**

1. From the main menu press SETUP-MORE-DIAG-ENTR-NEXT until ANALOG I/O CONFIGURATION press ENTR.
2. Press SET> 5 times.
3. The top line should read A/IN CALIBRATED: YES
4. Press CAL to calibrate the analog inputs.
5. Press <SET 4 times.
6. The top line should read CONC\_OUT\_1: CURRENT
  - a. If you desire Current output then go to step 7
  - b. If you do not desire Current output press EDIT and change to the output voltage desired, press ENTR and follow the steps in the Voltage Output procedure.
7. Press EDIT, Press SET>. The top line should read CONC\_OUT\_1: AUTO CAL: ON
  - a. If this says AUTO CAL ON press EDIT and turn it OFF.
  - b. If this says AUTO CALL OFF go to step 8.
8. Press SET>. The top line should read CONC\_OUT\_1: CALIBRATED: YES
9. Now place your meter on pins 1 and 2 on the rear panel analog output connector and set your meter to read mA.
10. Press CAL on the front panel.
11. You should have some DN and UP buttons. And the top line should be say ZERO ADJUST or something similar.
12. The output on the meter should be as close as possible to  $0\text{ma} \pm 0.01\text{ma}$  (if 0-20ma output),  $4\text{ma} \pm 0.01\text{ma}$  (if 4-20ma output).
  - a. If not then press DN or UP until the meter reads as close as possible to  $0\text{ma}$  or  $4\text{ma}$ .
  - b. If it does go to step 13
13. Press ENTR.
14. The top line should now say GAIN ADJUST and you should have DN and UP buttons again. The meter should now read your full-scale current output 20ma.
15. If it doesn't press the DN and UP buttons until the output on the meter reads your full-scale current output of  $20\text{ma} \pm 0.01\text{ma}$ .
16. Press ENTR

17. That channel is now calibrated.
18. Do this for all remaining channels that contain the Current option and ensure that you move the meter on the output connector to the proper pins for that channel.

## **Pressure Calibration**

To calibrate the pressure in the analyzer the first thing you will want to do is disconnect the pump. You can either do this pneumatically or electrically. Also disconnect any tubing connected to the sample inlet port on the back of the analyzer. This will put the analyzer at atmospheric, ambient, pressure.

Next, find out the current atmospheric pressure. This can be found from a barometer or contacting your local airport or weather station.

From the front panel of the analyzer press <SETUP><MORE><DIAG> and enter 929 for the password when ever it asks for it. Once in the DIAG menu, press next until you get to Pressure Calibration and hit ENTER. Now enter the current atmospheric pressure and press ENTER.

Exit back out to the main menu and scroll over to sample pressure and Rcell pressure. These should be equal to the atmospheric pressure now. Reconnect the pump and the pressure should drop about an inch and the Rcell pressure should drop below 5”Hg. Reconnect the sample inlet and the pressure should remain the same +/- 0.2”Hg. If the pressure changes more than this when you reconnect the sample line, you will have to troubleshoot the system as the analyzer is being pressurized or being put under a vacuum.

## **Flow Calibration**

With the analyzer on and the pump connected and running, connect an external flow meter to the NO<sub>y</sub> or the NO port on the back of the analyzer. Record the flow rate going into each port. This will fluxuate every 3-5 seconds. The flow rate going into each port should be about 1000cc/min, this is the sample flow. Then disconnect the 1/8<sup>th</sup>” ozone line going into the top of the reaction cell. This is the tubing going into the fitting marked .004. Measure the flow rate going into the fitting. It should be around 80cc, and record this reading, this is the ozone flow. Then from the front panel hit <SETUP><MORE><DIAG> enter 929 for the password when it asks you for it.

Once in the DIAG menu press Next until you get Flow Calibration and hit <ENTER><SAMP>. Now enter the value you measured with the external flow meter on the sample inlet and hit Enter. Next, do the same thing for the Ozone flow. This will calibrate the flow meters in the analyzer. Exit back out to the main menu and scroll through the TST values till you get Sample Flow and Ozone Flow. They should be reading close to the measured value.

Next, connect your flow meter to the sample inlet on the NO<sub>y</sub> converter box. This flow rate should be approximately 3.5Lpm +/- 0.5Lpm. Note this flow is the total flow used by the NO<sub>y</sub> analyzer.



## **5. MAINTENANCE**



## **INSTRUMENT MAINTENANCE**

Predictive diagnostic functions including data acquisition, failure warnings and alarms built into the analyzer allow the user to determine when repairs are necessary without performing unnecessary, preventative maintenance procedures. There is, however, a minimal number of simple procedures that, when performed regularly, will ensure that the analyzer continues to operate accurately and reliably over its lifetime.

### **NOTE**

**A span and zero calibration check must be performed following some of the maintenance procedures listed below. Refer to Chapter 6.**

### **CAUTION**

**Risk of electrical shock. Disconnect power before performing any operations that require entry into the interior of the analyzer.**



### **NOTE**

**The operations outlined in this chapter must be performed by qualified maintenance personnel only.**



## MAINTENANCE SCHEDULE

The table below is the recommended maintenance schedule for the M200EU NOy. Please note that in certain environments with high levels of dust, humidity or pollutant levels some maintenance procedures may need to be performed more often than shown.

**M200EU NOy Preventive Maintenance Schedule**

Item	Action	Priority	Frequency	Cal Check?	Date Performed													
Two Particulate Filters	Change particle filter	Mandatory	Weekly	No														
Zero/span calibration	Zero and span calibration	Mandatory	Every 3 months	Yes														
NOy converter check	Check conversion efficiency	Mandatory	Every 3 months	No														
Ozone filter	Change chemical	Mandatory	Annually	Yes														
Reaction cell window	Clean	Mandatory	Annually or as necessary	Yes														
DFU filter	Change particle filter	Mandatory	Annually	No														
Orifice O-rings and sintered filters	Replace	Mandatory	Annually	Yes														
Bypass and Sample Pump	Rebuild head	Mandatory	Annually or as necessary	Yes														
TEST functions	Review and evaluate	Recommend	Weekly	No														
Pneumatic sub-system	Check for leaks in gas flow paths	As Needed	Annually or after pneumatics repairs	Yes on leaks, else no														
PMT Sensor Hardware Calibration	Low-level hardware calibration	As Needed	If slope is outside of 1.0±0.3	Yes														
NOy converter	Replace converter	As Needed	If efficiency is <96%	Yes														



## **6. TROUBLESHOOTING & FAULTS**



## **Predictive Diagnostics**

The analyzer's test functions can be used to predict failures by looking at trends in their values. Table below can be used as a basis for taking action as these values change with time. The internal data acquisition system (iDAS) is a convenient way to record and track these changes. APICOM control software can be used to download and review these data even from remote locations.

**Predictive Uses for Test Functions**

<b>Function</b>	<b>Expected</b>	<b>Actual</b>	<b>Interpretation</b>
RCEL pressure	Constant to within $\pm 0.5$	Fluctuating	Developing leak in pneumatic system
		Slowly increasing	Pump performance is degrading. Replace pump head when pressure reaches 5 in-Hg-A
SAMPLE pressure	Constant within atmospheric changes	Fluctuating	Developing leak in pneumatic system
		Slowly increasing	Flow path is clogging up. Replace orifice filters
		Slowly decreasing	Developing leak in pneumatic system to vacuum (developing valve failure)
Ozone Flow	Constant to within $\pm 15$	Slowly decreasing	Flow path is clogging up. Replace orifice filters
Prereact	Constant within $\pm 20$ of check-out value	Significantly increasing	Developing AZERO valve failure
			PMT cooler failure
			Pneumatic Leak
NO <sub>2</sub> CONC	Constant for constant concentrations	Slowly decreasing signal for same concentration	Conversion efficiency of converter may be degrading. Replace converter
NO CONC	Constant for constant concentration	Decreasing over time	Drift of instrument response; clean RCEL window

## **Non-Linear Response**

The M200EU NO<sub>y</sub> was factory calibrated to a high level of NO and should be linear to within 1% of full scale. Common causes for non-linearity are:

- Leaks in the pneumatic system. Leaks can add a constant of ambient air, zero air or span gas to the current sample gas stream, which may be changing in concentrations as the linearity test is performed. Check for leaks as described in the Operator's Manual.
- The calibration device is in error. Check flow rates and concentrations, particularly when using low concentrations. If a mass flow calibrator is used and the flow is less than 10% of the full scale flow on either flow controller, you may need to purchase lower concentration standards.
- The standard gases may be mislabeled as to type or concentration. Labeled concentrations may be outside the certified tolerance.
- The sample delivery system may be contaminated. Check for dirt in the sample lines or reaction cell.
- Calibration gas source may be contaminated (NO<sub>2</sub> in NO gas is common).
- Dilution air contains sample or span gas.
- Ozone concentration too low because of wet air in the generator. Generator system needs to be cleaned and dried with dry supply air. Check the Perma Pure dryer for leaks. This mostly affects linearity at the low end.
- Ozone stream may be contaminated with impurities. An exhausted ozone filter chemical will let compounds such as HNO<sub>3</sub> and ammonia derivatives break through to the reaction cell. Check the contents of the ozone filter cartridge and replace as necessary. This also will affect linearity mostly at the low level.
- Sample inlet may be contaminated with NO<sub>x</sub> exhaust from this or other analyzers. Verify proper venting of the pump exhaust.
- Span gas overflow is not properly vented and creates a back-pressure on the sample inlet port. Also, if the span gas is not vented at all and does not supply enough sample gas, the analyzer may be evacuating the sample line. Make sure to create and properly vent excess span gas.
- Diffusion of oxygen into Teflon-type tubing can happen over long distances. PTFE, or related materials, can act as permeation devices. In fact, the permeable membrane of NO<sub>2</sub> permeation tubes is made of PTFE. When using very long supply lines (>1m) between high concentration span gases and the dilution system, oxygen from ambient air can diffuse into the line and react with the NO to form NO<sub>2</sub>. This reaction is dependent on the NO concentration and accelerates the increasing NO concentration, hence, affects linearity only at high NO levels. Using stainless steel for long span gas supply lines to avoid this problem.

## **M200EU NO<sub>y</sub> Troubleshooting Tree**

### **Troubleshooting Trees**

No Power

No front panel or locking up Display

Optical Test bad, Electrical Test OK

Bad Electrical Test

Unstable Reading at Zero, Zero noise

Unstable Reading at Span, Span noise

Unable to Zero (No Zero Button)

Unable to Span (No Span button or no response to Span gas)

Non-Linear Response

Slow Response to Zero or Span

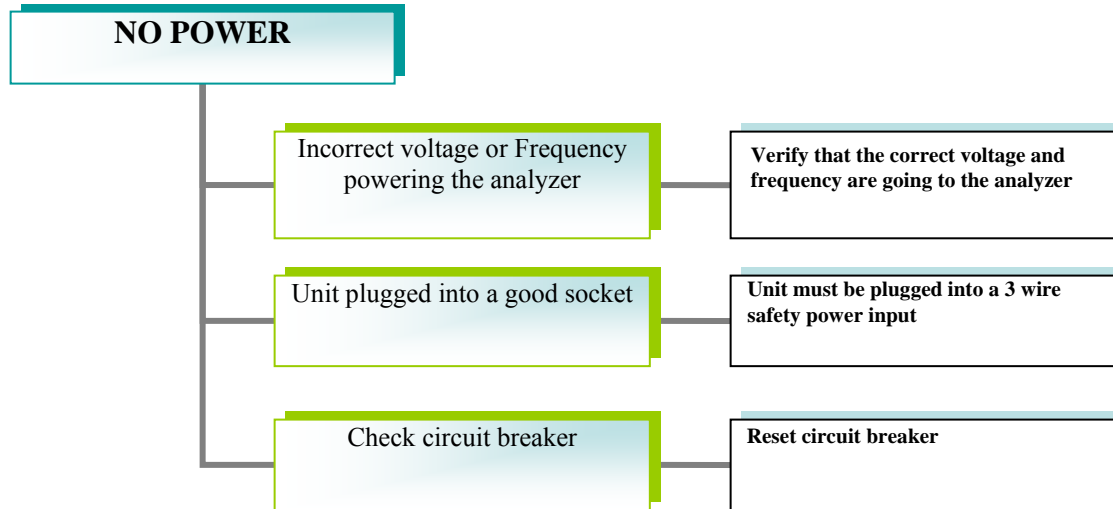
HVPS warning, after factory calibration

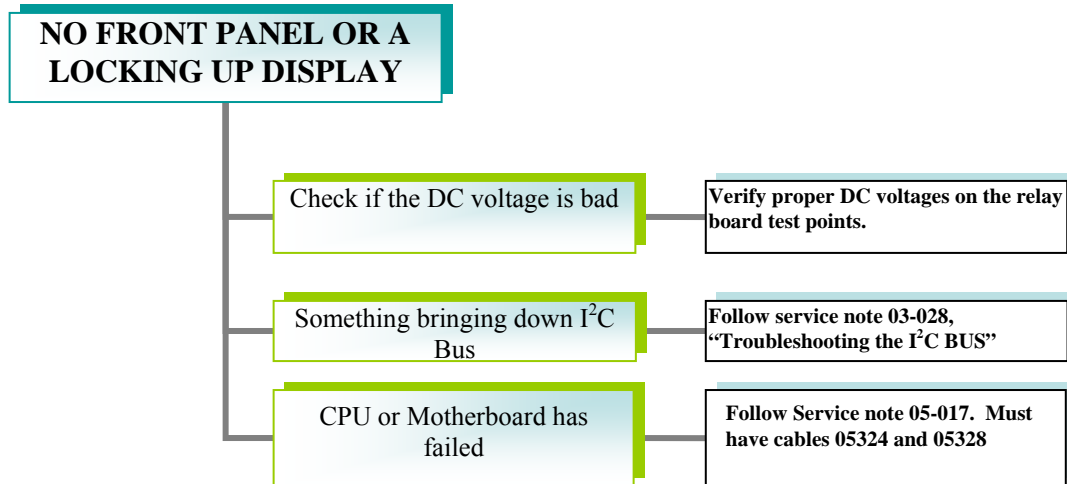
Auto-Zero Warning

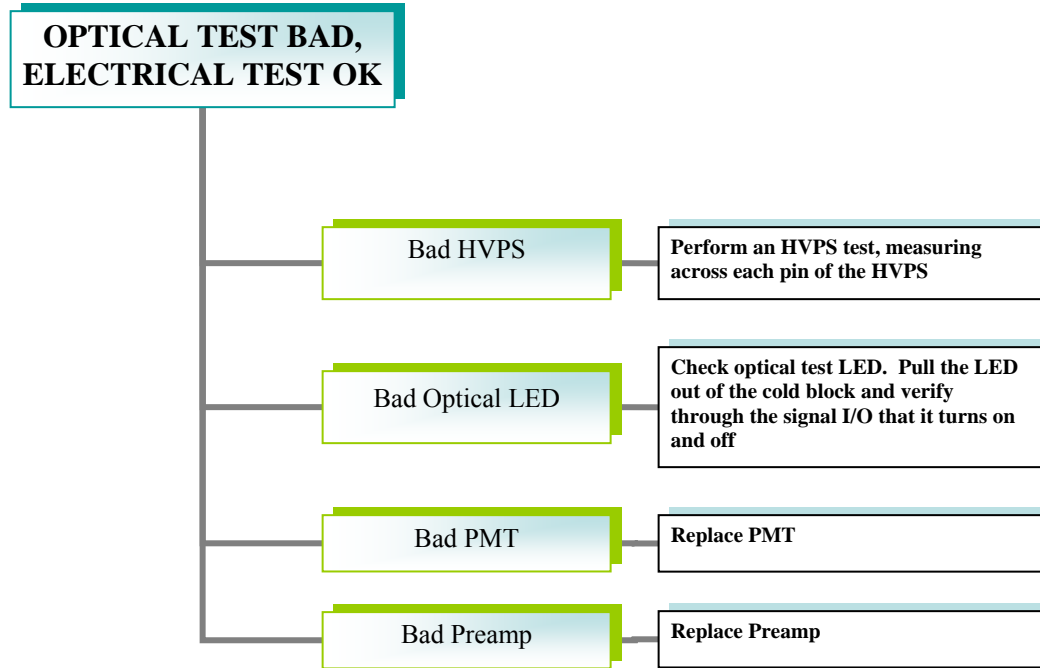
No Flow

No analog or incorrect analog output

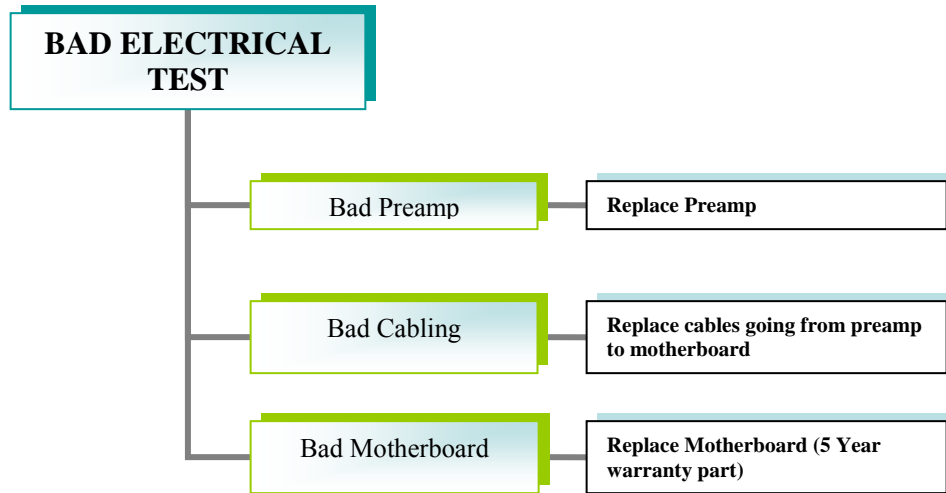
Any Temperature Warning







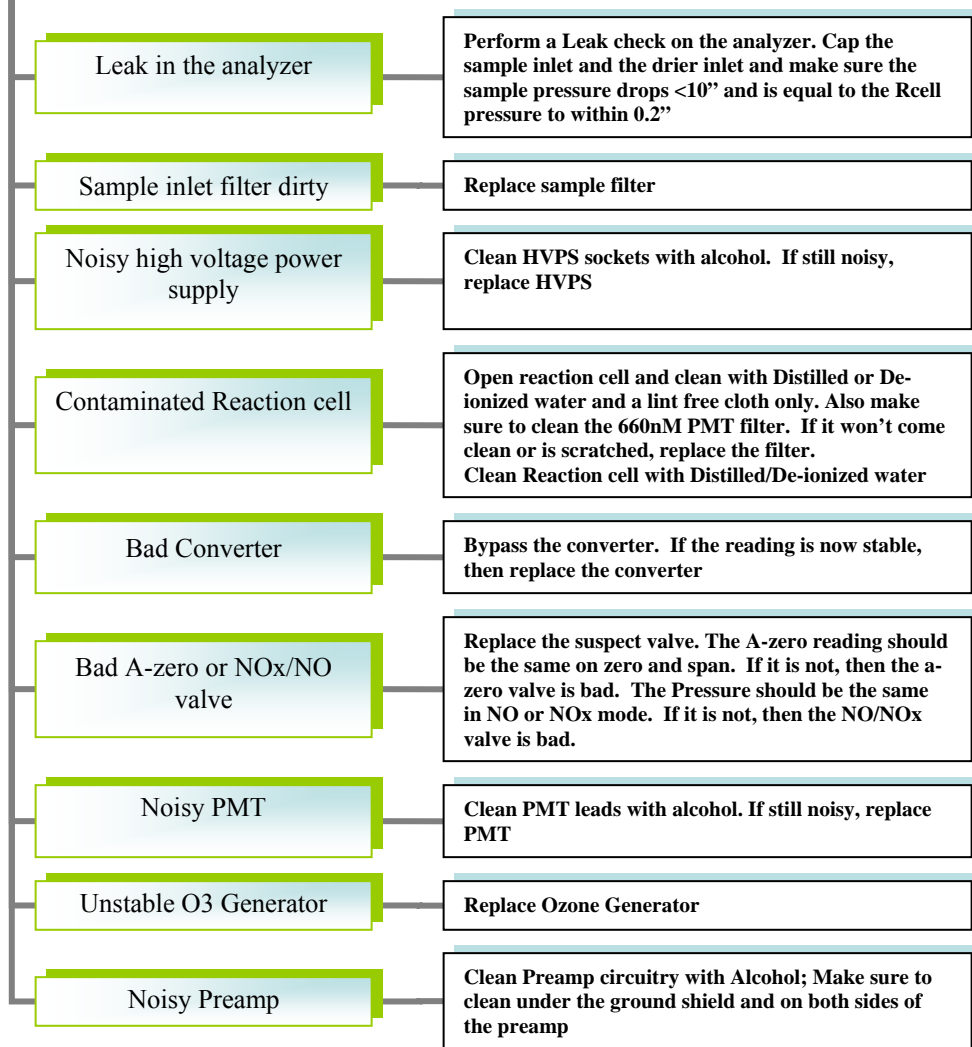




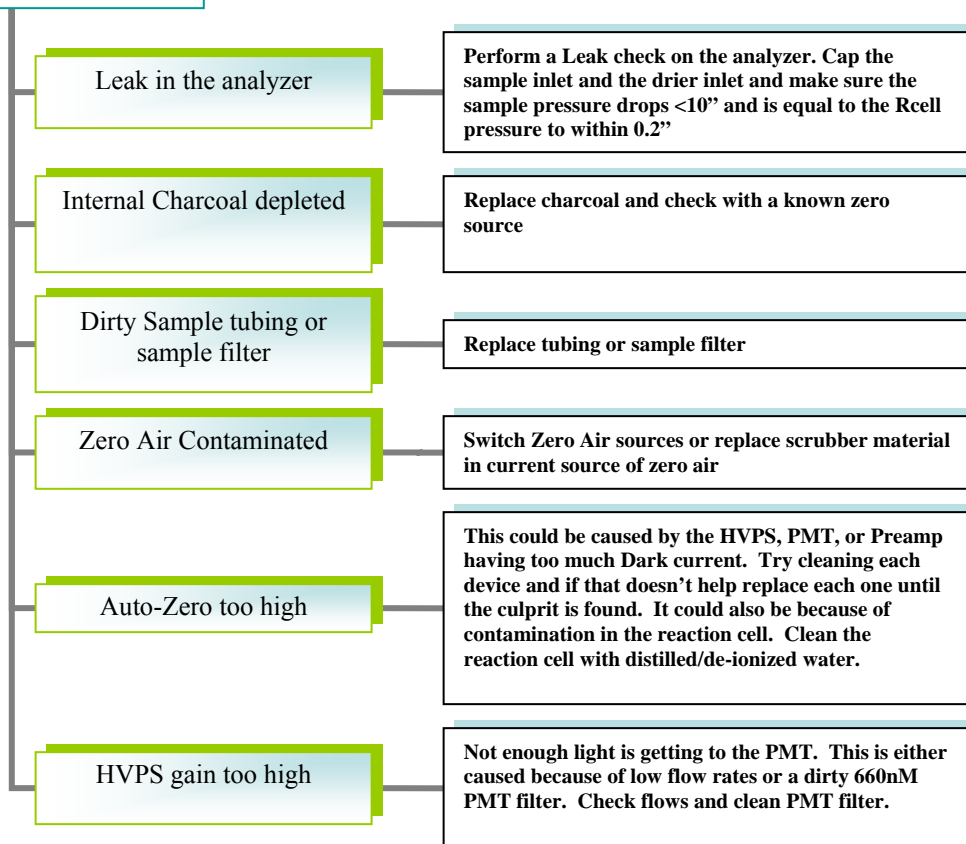
**UNSTABLE READING  
 AT ZERO, ZERO NOISE**

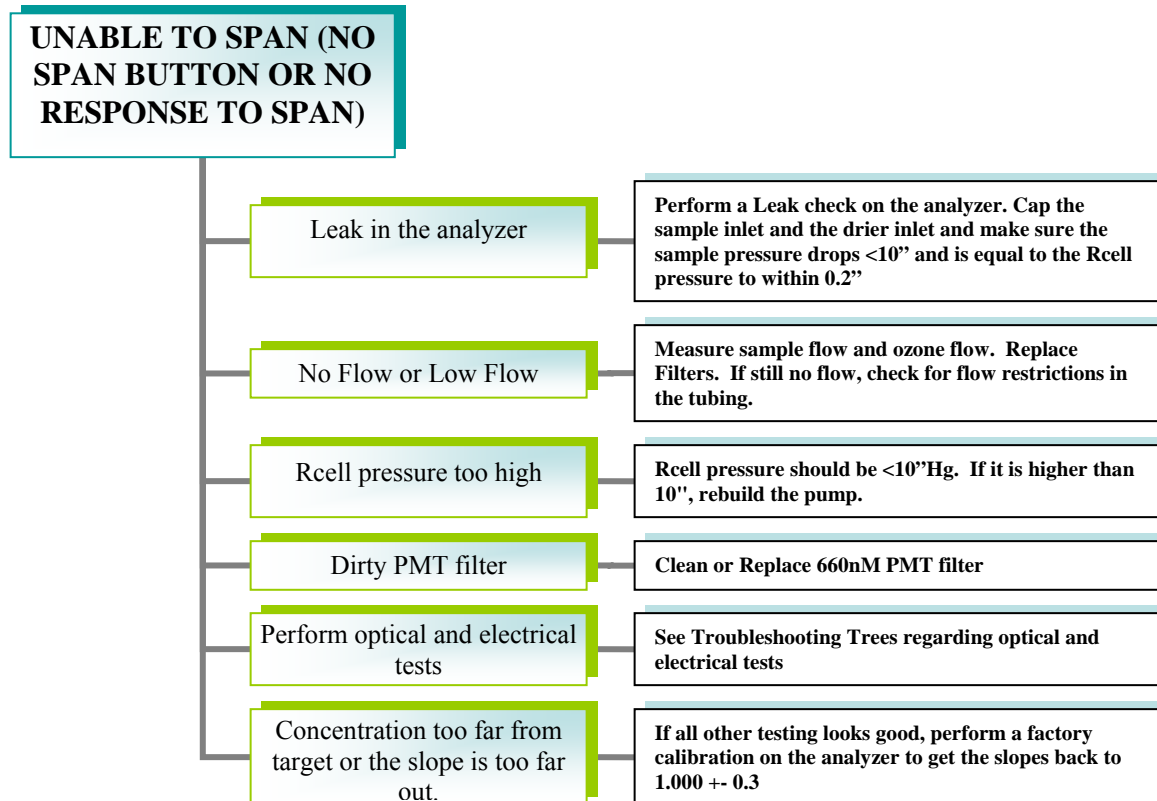


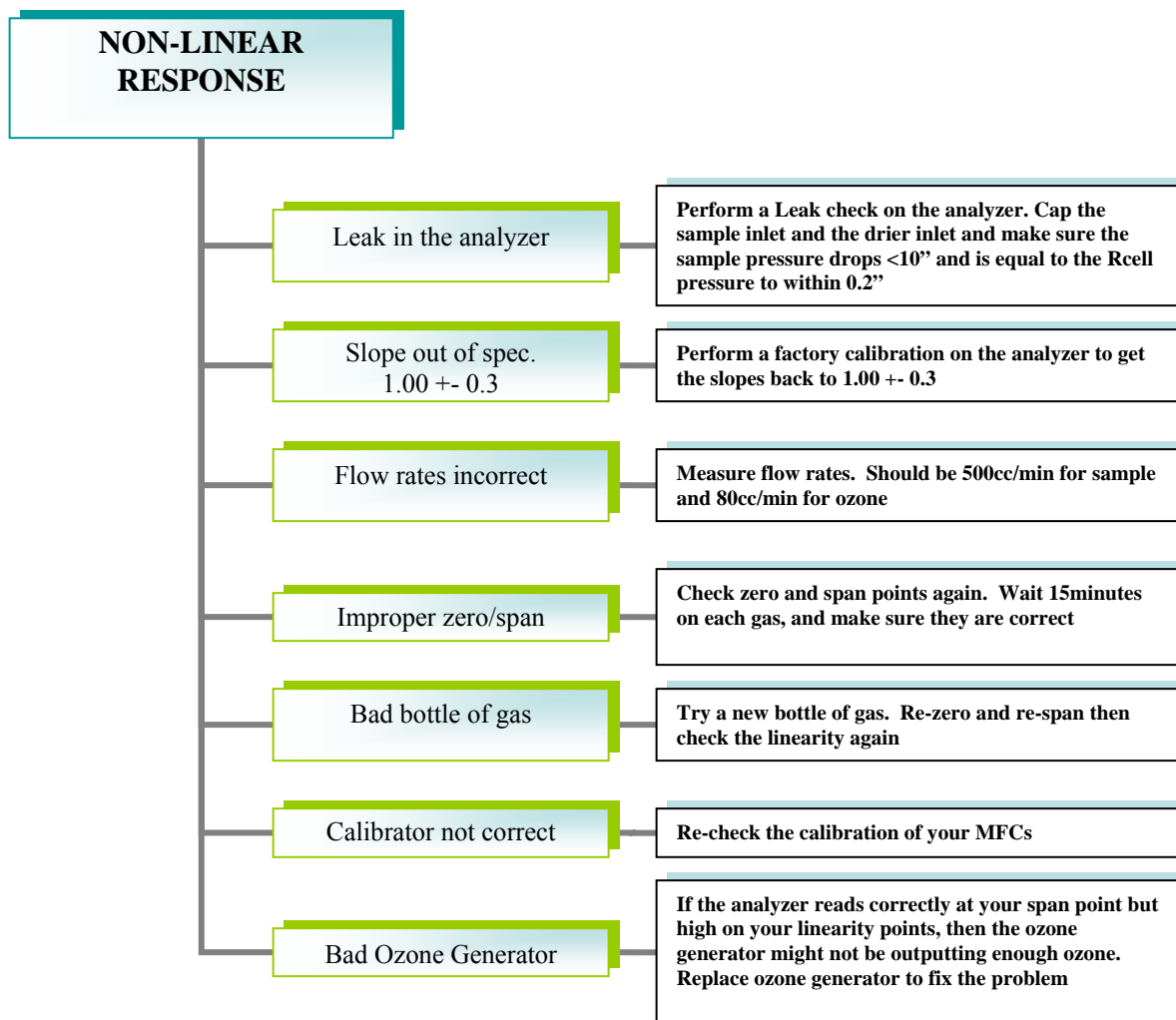
**UNSTABLE READING  
 AT SPAN, SPAN NOISE**



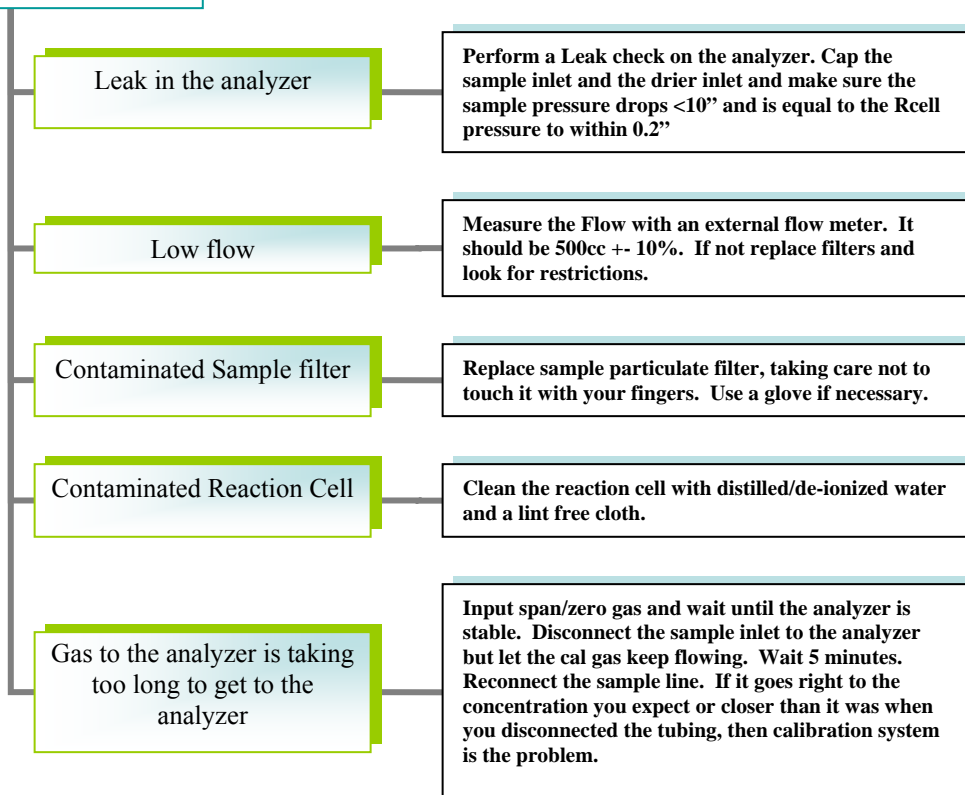
**UNABLE TO ZERO (NO  
ZERO BUTTON)**



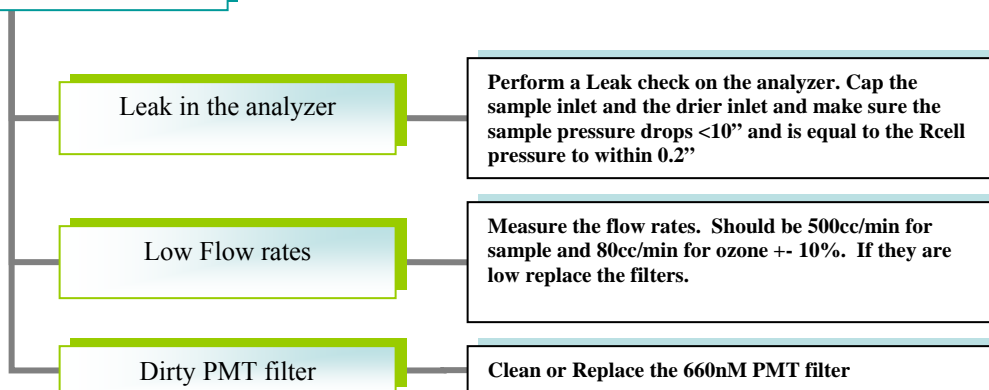




**SLOW RESPONSE TO  
ZERO OR SPAN**



## HVPS WARNING AFTER FACTORY CALIBRATION





## AUTO-ZERO WARNING

Auto-Zero Valve bad

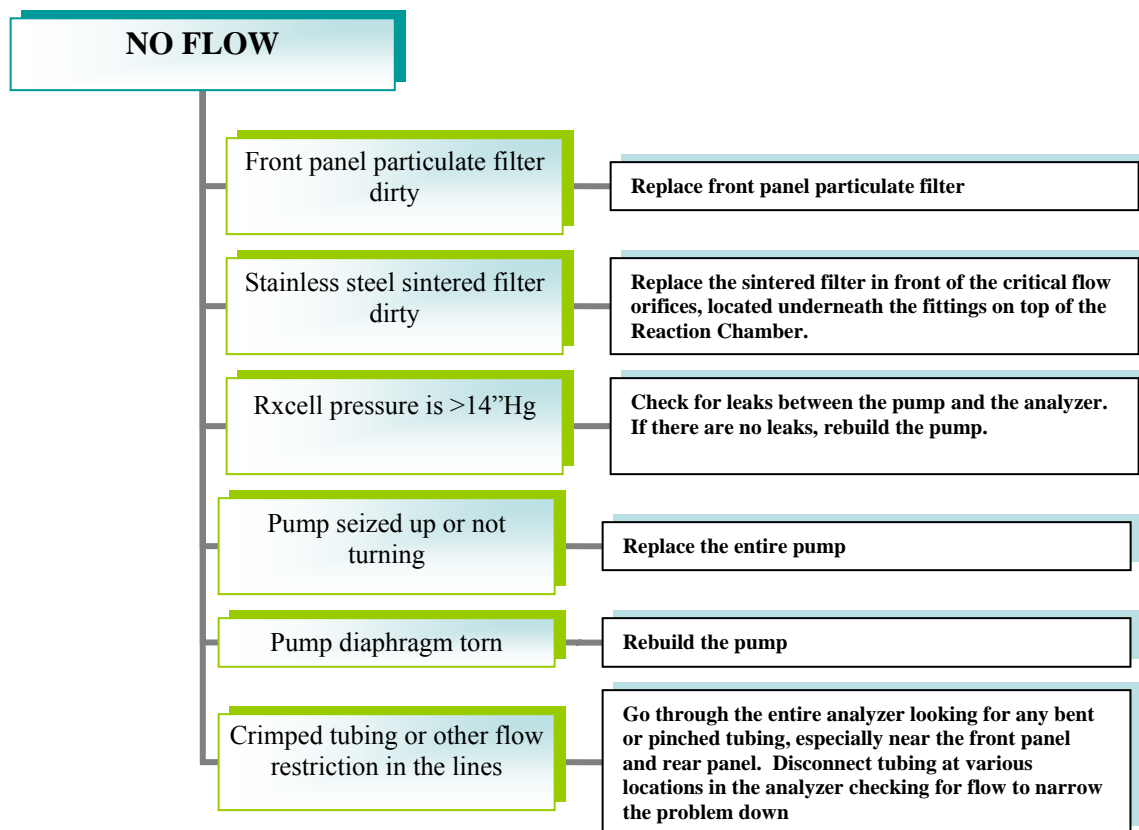
Record the A-Zero reading after 15minutes on span and then 15minutes on zero. It should be the same. If it is more then 2mV difference, replace the valve.

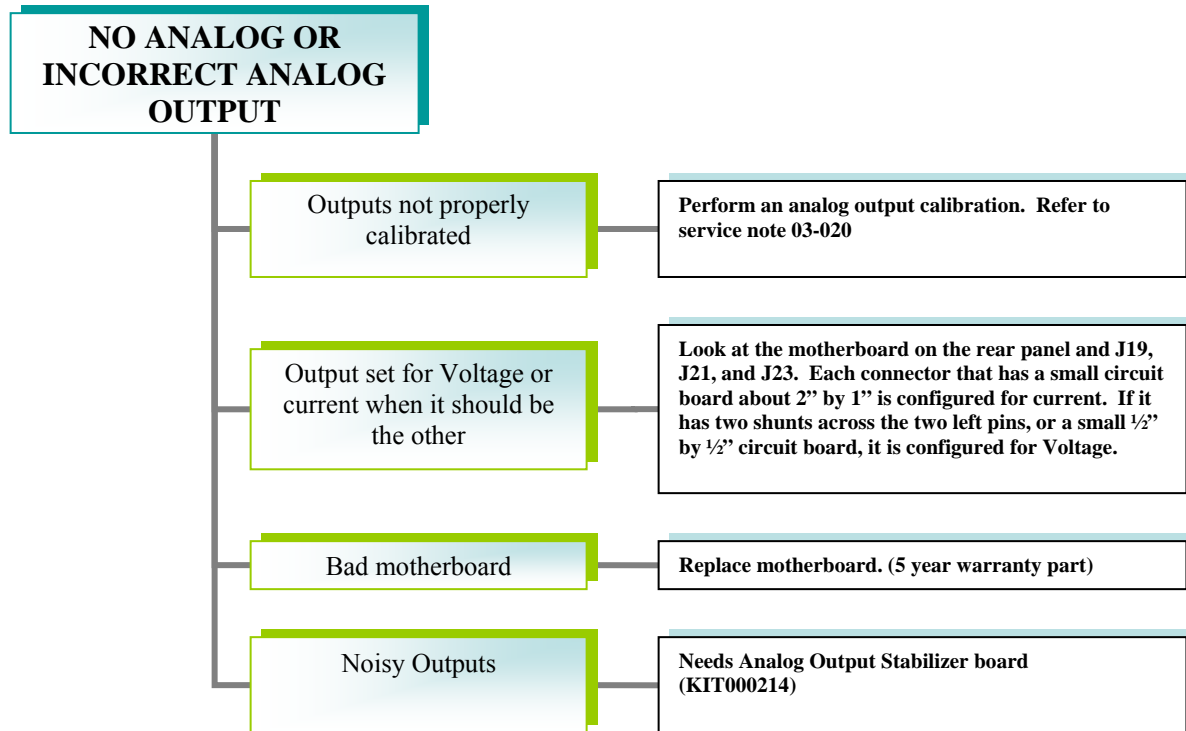
Contamination in the Rxcell

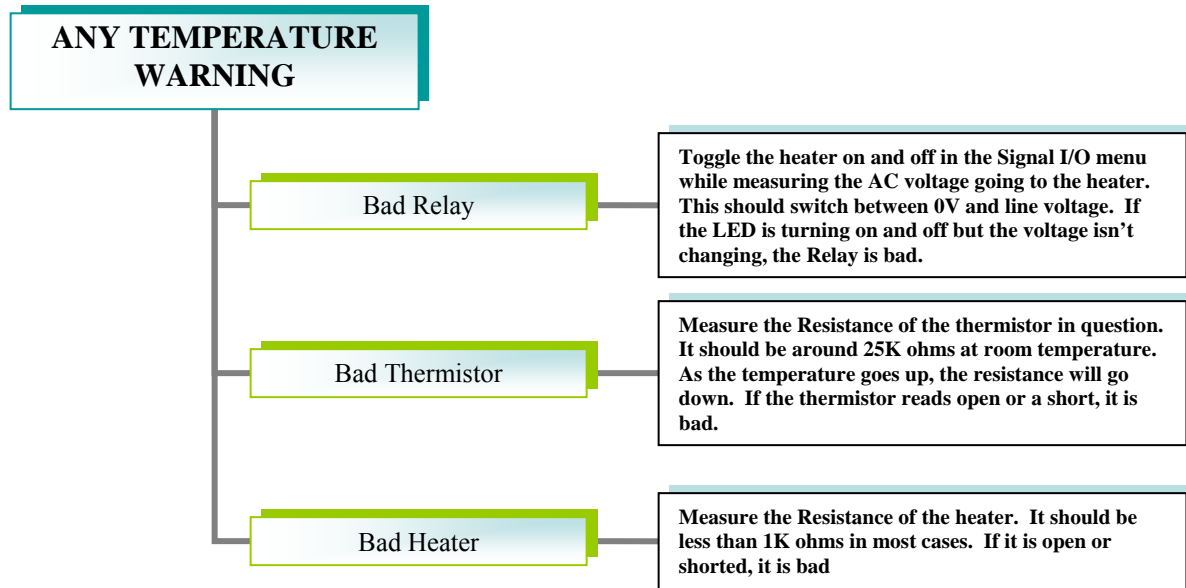
Input Zero gas, wait 15minutes, watch the PMT value and then disconnect the ozone generator from the top of the Reaction cell. If the PMT value drops, there is contamination in the reaction cell and should be cleaned

High Dark Offset

Either the PMT, HVPS, or Preamp is causing a high dark offset. Replace each part one at a time until the problem is solved.







*Model 200EU NO<sub>y</sub> Training Manual*

## Warranty/Repair Questionnaire Model 200EU NO<sub>y</sub>



CUSTOMER: \_\_\_\_\_ PHONE: \_\_\_\_\_

CONTACTNAME: \_\_\_\_\_ FAX NO. \_\_\_\_\_

SITE ADDRESS: \_\_\_\_\_

MODEL 200EU NO<sub>y</sub> SERIAL NO.: \_\_\_\_\_ FIRMWARE REVISION: \_\_\_\_\_

1. ARE THERE ANY FAILURE MESSAGES? \_\_\_\_\_

PLEASE COMPLETE THE FOLLOWING TABLE: **(NOTE: DEPENDING ON OPTIONS INSTALLED, NOT ALL TEST PARAMETERS SHOWN BELOW WILL BE AVAILABLE IN YOUR INSTRUMENT)**

\*IF OPTION IS INSTALLED

PARAMETER	RECORDED VALUE	ACCEPTABLE VALUE
RANGE	PPB/PPM	50 PPB TO 20 PPM
NO <sub>x</sub> STAB	PPB/PPM	≤ 1 PPB WITH ZERO AIR
SAMPLE FLOW	CM <sup>3</sup>	1000 ± 100
OZONE FLOW	CM <sup>3</sup>	80 ± 15
PMT SIGNAL WITH ZERO AIR	MV	-20 TO 150
PMT SIGNAL AT SPAN GAS CONC	MV PPB	0-5000MV 0-20,000 PPB
NORM PMT SIGNAL AT SPAN GAS CONC	MV PPB	0-5000MV 0-20000PPB
PREREACTION	MV	-20 TO 150
HVPS	V	400 – 900
RCELL TEMP	°C	40 ± 1
BOX TEMP	°C	AMBIENT ± 5°C
PMT TEMP	°C	-1 ± 2°C
MF TEMP	°C	40 ± 1
MOLY TEMP	°C	315 ± 5°C
RCEL PRESS	IN-HG-A	<5
SAMP PRESS	IN-HG-A	AMBIENT ± 1
NO <sub>x</sub> SLOPE		1.0 ± 0.3
NO <sub>x</sub> OFFSET		-50 TO +150
NO SLOPE		1.0 ± 0.3
NO OFFSET		-50 TO +150
ETEST	PMT MV	2000 ± 1000
OTEST	PMT MV	2000 ± 1000

Values are in the Signal I/O		
<b>REF_4096_MV</b>	MV	4096mv ±2mv Must be Stable
<b>REF_GND</b>	MV	0± 0.5 and Must be Stable

2. WHAT IS THE RCELL & SAMPLE PRESSURES WITH THE SAMPLE INLET ON REAR OF MACHINE CAPPED?

**RCELL PRESS** - \_\_\_\_\_ IN-HG-A    **SAMPLE PRESSURE** - \_\_\_\_\_ IN-HG-A

3. WHAT ARE THE FAILURE SYMPTOMS? \_\_\_\_\_

\_\_\_\_\_

4. WHAT TEST HAVE YOU DONE TRYING TO SOLVE THE PROBLEM? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

5. IF POSSIBLE, PLEASE INCLUDE A PORTION OF A STRIP CHART PERTAINING TO THE PROBLEM. CIRCLE PERTINENT DATA.

6. THANK YOU FOR PROVIDING THIS INFORMATION. YOUR ASSISTANCE ENABLES TELEDYNE API TO RESPOND FASTER TO THE PROBLEM THAT YOU ARE ENCOUNTERING.

**USER NOTES:**





## **7. SPECIFICATIONS**



## **Specifications**

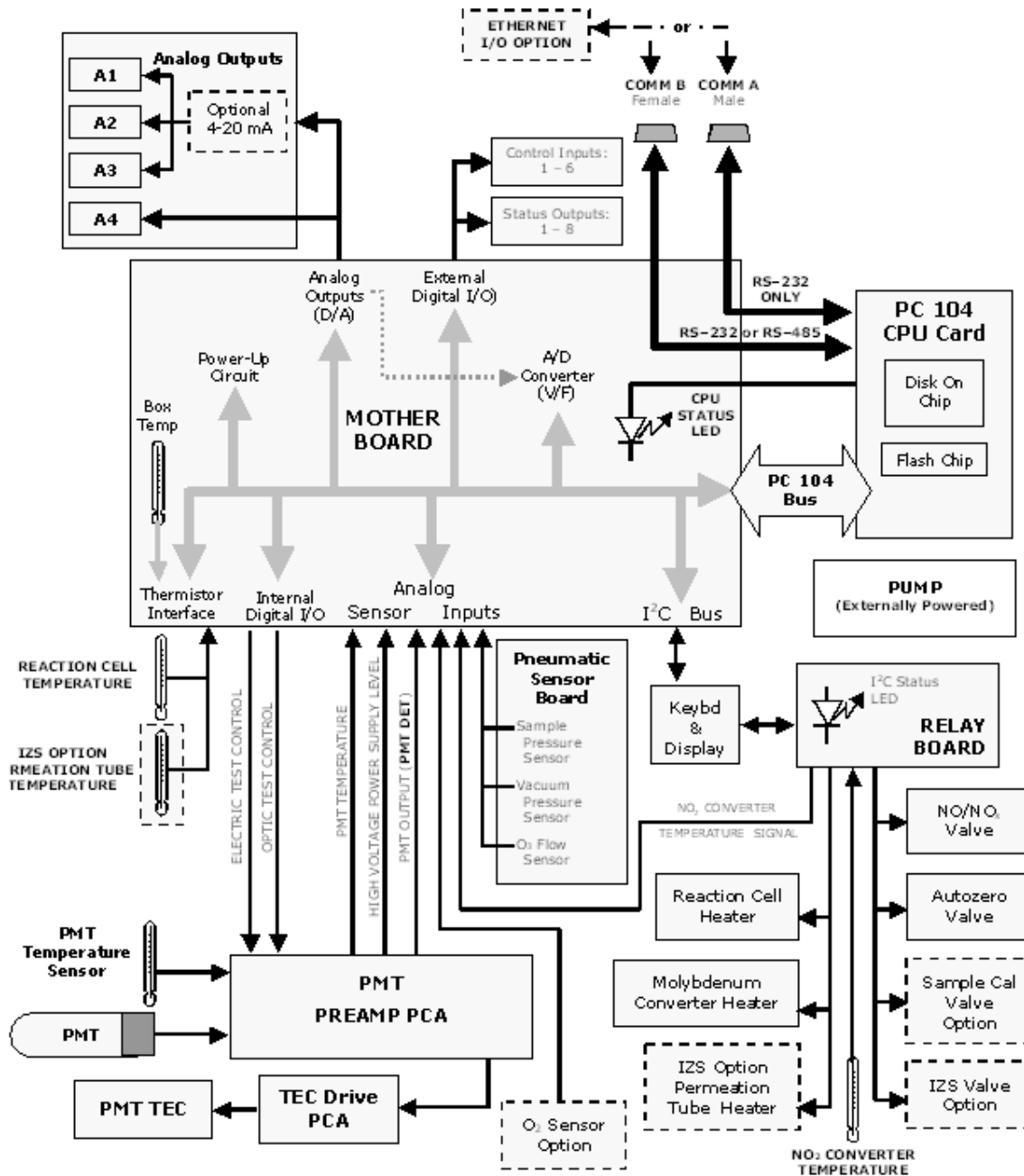
### Model 200E Basic Unit Specifications

Min/Max Range (Physical Analog Output)	Min: 0-50 ppb Max: 0-20 ppm
Measurement Units	ppb, ppm, $\mu\text{g}/\text{m}^3$ , $\text{mg}/\text{m}^3$ (user selectable)
Zero Noise <sup>1</sup>	0.2 ppb (RMS)
Span Noise <sup>1</sup>	<0.5% of reading above 50 ppb or 0.2 ppm, whichever is greater
Lower Detectable Limit <sup>2</sup>	0.4 ppb
Zero Drift (24 hours)	<0.5 ppb (at constant temperature and voltage.)
Zero Drift (7 days)	1 ppb (at constant temperature and voltage.)
Span Drift (7 Days)	<0.5% of full Scale (at constant temperature and voltage.)
Linearity	1% of full scale
Precision	0.5% of reading
Temperature Coefficient	< 0.1% per °C
Voltage Coefficient	< 0.1% per V
Lag Time <sup>1</sup>	20 s
Rise/Fall Time <sup>1</sup>	95% in <60 s
Sample Flow Rate	500 $\text{cm}^3/\text{min}$ . $\pm$ 10%
Temperature Range	5 - 40 °C operating and EPA equivalency
Humidity Range	0-95% RH non-condensing
Dimensions H x W x D	18 cm x 43 cm x 61 cm (7" x 17" x 23.6")
Weight, Analyzer	18 kg (40 lbs)
Weight, Ext Pump Pack	7 kg (16 lbs)
AC Power Rating	100 V, 50/60 Hz (3.25A); 115 V, 60 Hz (3.0 A); 220 - 240 V, 50/60 Hz (2.5 A)
Power, Ext Pump	100 V, 50/60 Hz (3.25A); 115 V, 60 Hz (3.0 A); 220 - 240 V, 50/60 Hz (2.5 A)
Environmental	Installation category (over-voltage category) II; Pollution degree 2
Analog Outputs	4 outputs
Analog Output Ranges	All Outputs: 0.1 V, 1 V, 5 V or 10 V (user selectable) Three outputs convertible to 4-20 mA isolated current loop. All Ranges with 5% under/over range
Analog Output Resolution	1 part in 4096 of selected full-scale voltage (12 bit)
Status Outputs	8 Status outputs from opto-isolators, 7 defined, 1 spare
Control Inputs	6 Control inputs, 4 defined, 2 spare
Serial I/O	1 RS-232; 1 RS-485 or RS-232 (configurable) Communication speed: 300 - 115200 baud (user selectable)
Certifications	USEPA: Reference Method Number EQOA-XXXX-XXX CE: XXNNNNN-N:NN + XN:NN + XN:NN, XXNNNNN - Class A
<sup>1</sup> As defined by the USEPA.	
<sup>2</sup> Defined as twice the zero noise level by the USEPA.	

M200EU NO<sub>y</sub> converter option specifications

Converter	Remotely mounted molybdenum converter with temperature controller in a NEMA – 4 enclosure.
Converter Temperature	315°C ± 7°C with read-out on front panel of bypass pump chassis.
Tube/Electrical Cable Assembly	Up to 50 feet (15 m) maximum length
Power, Bypass Pump Assembly	120V~ 60 Hz, 230V~ 50 Hz 360 watts
Power, Converter Assembly	120V~ 50/60 Hz, 60 watts
Converter Efficiency	>96% for NO <sub>2</sub>
Weight, Bypass Pump Assembly	35 lbs (16 kg)
Weight, Remote Converter	30 lbs (11 kg)
Bypass Pump Chassis Dimensions HxWxD	9" x17" x23.6" (23cm x 43cm x 61cm)
Remote Converter Assy Dimensions HxWxD	12"x19"x7" (31cm x 48cm x 18cm)
Environmental	Installation Category (Over-voltage Category) II Pollution Degree 2
Bypass Flowrate Cal gas Flowrate	1100 cc/min ± 20%, each channel 4000 cc/min (approx.)
Analog output	Converter temp analog output. 3.15 VDC = 315°C

## **8. MISC DIAGRAMS**



M200EU NO<sub>y</sub> Electronic Block Diagram

**USER NOTES**

**USER NOTES**



**USER NOTES**

## **9. T SERIES ADDENDUM**

## Front panel, rear panel, and display

### Getting Started

This section introduces you to the instrument components of the front and rear panel, which are unique to the T series analyzers.

### Front Panel

Figure 10-1 shows the analyzer's front panel layout, followed by a close-up of the display screen in Figure 10-2, which is described in Table 10-1. The two USB ports on the front panel are provided for the connection of peripheral devices:

- plug-in mouse (not included) to be used as an alternative to the touchscreen interface
- thumb drive (not included) to upload new versions of software (contact T-API Customer Service for information).
- plug-in keyboard (not included) to reach the touchscreen display calibration menu

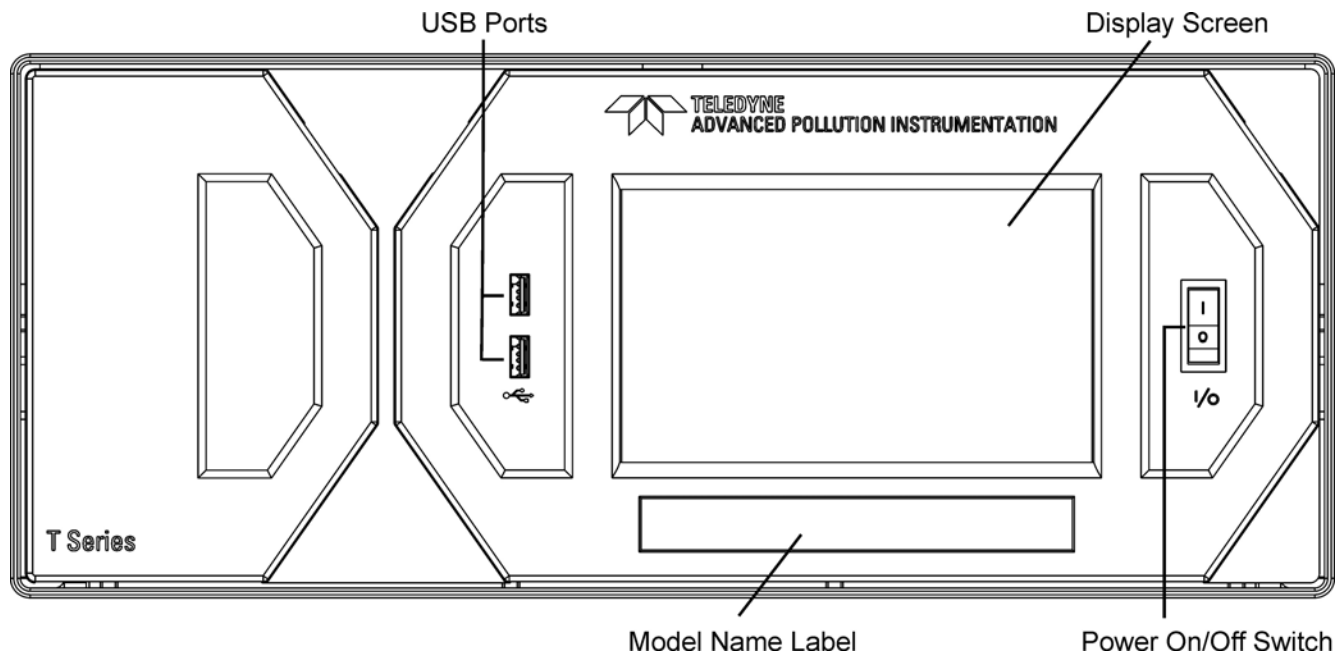


Figure 10-1: Front Panel Layout



**Figure 10-2: Display Screen and Touch Control**

The front panel liquid crystal display screen includes touch control. Upon analyzer start-up, the screen shows a splash screen and other initialization indicators before the main display appears, similar to Figure 10-2 above (may or may not display a Fault alarm). The lights on the display screen indicate the Sample, Calibration and Fault states; also on the screen is the gas concentration field (Conc), which displays real-time readouts for the primary gas and for the secondary gas if installed. The display screen also shows what mode the analyzer is currently in, as well as messages and data (Param). Along the bottom of the screen is a row of touch control buttons; only those that are currently applicable will have a label. Table 10-1 provides detailed information for each component of the screen.

**ATTENTION**

**COULD DAMAGE INSTRUMENT**

**Do not use hard-surfaced instruments, such as pens, to touch the control buttons.**

**Table 10-1: Display Screen and Touch Control Description**

Field	Description/Function			
Status	Lights indicating the states of Sample, Calibration and Fault, as follows:			
	Name	Color	State	Definition
	SAMPLE	Green	Off	Unit is not operating in sample mode, DAS is disabled.
			On	Sample Mode active; Front Panel Display being updated; DAS data being stored.
	CAL	Yellow	Off	Auto Cal disabled
On			Auto Cal enabled	
Blinking			Unit is in calibration mode	
FAULT	Red	Off	No warnings exist	
		Blinking	Warnings exist	
Conc	Displays the actual concentration of the sample gas currently being measured by the analyzer in the currently selected units of measure			
Mode	Displays the name of the analyzer's current operating mode			
Param	Displays a variety of informational messages such as warning messages, operational data, test function values and response messages during interactive tasks.			
Control Buttons	Displays dynamic, context sensitive labels on each button, which is blank when inactive until applicable.			

Figure 10-3 shows how the front panel display is mapped to the menu charts illustrated in this manual. The Mode, Param (parameters), and Conc (gas concentration) fields in the display screen are represented across the top row of each menu chart. The eight touch control buttons along the bottom of the display screen are represented in the bottom row of each menu chart.

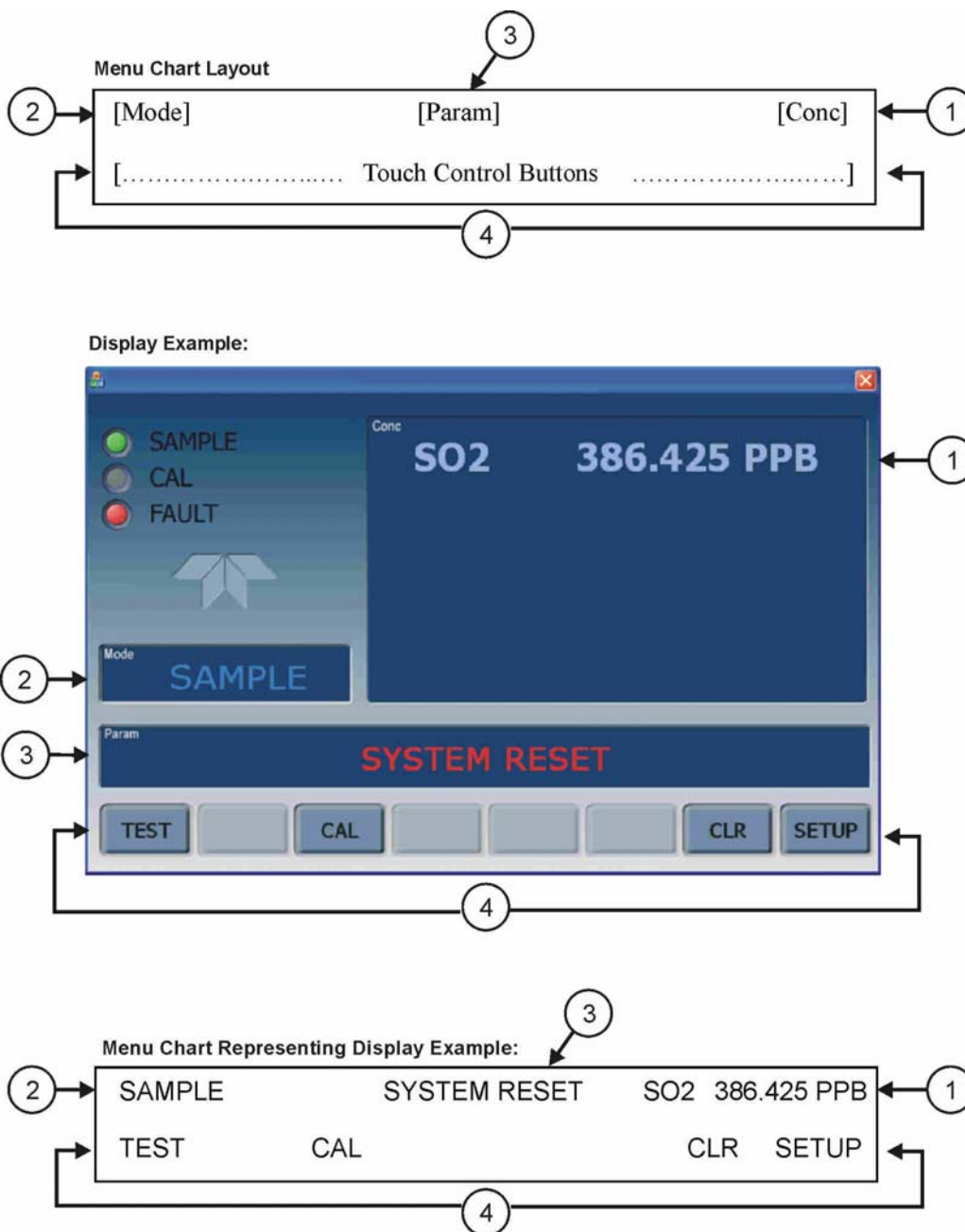


Figure 10-3: Display/Touch Control Screen Mapped to Menu Charts

## Front Panel/Display Interface

Users can input data and receive information directly through the front panel touch-screen display. The LCD display is controlled directly by the CPU board. The touchscreen is interfaced to the CPU by means of a touchscreen controller that connects to the CPU via the internal USB bus and emulates a computer mouse.

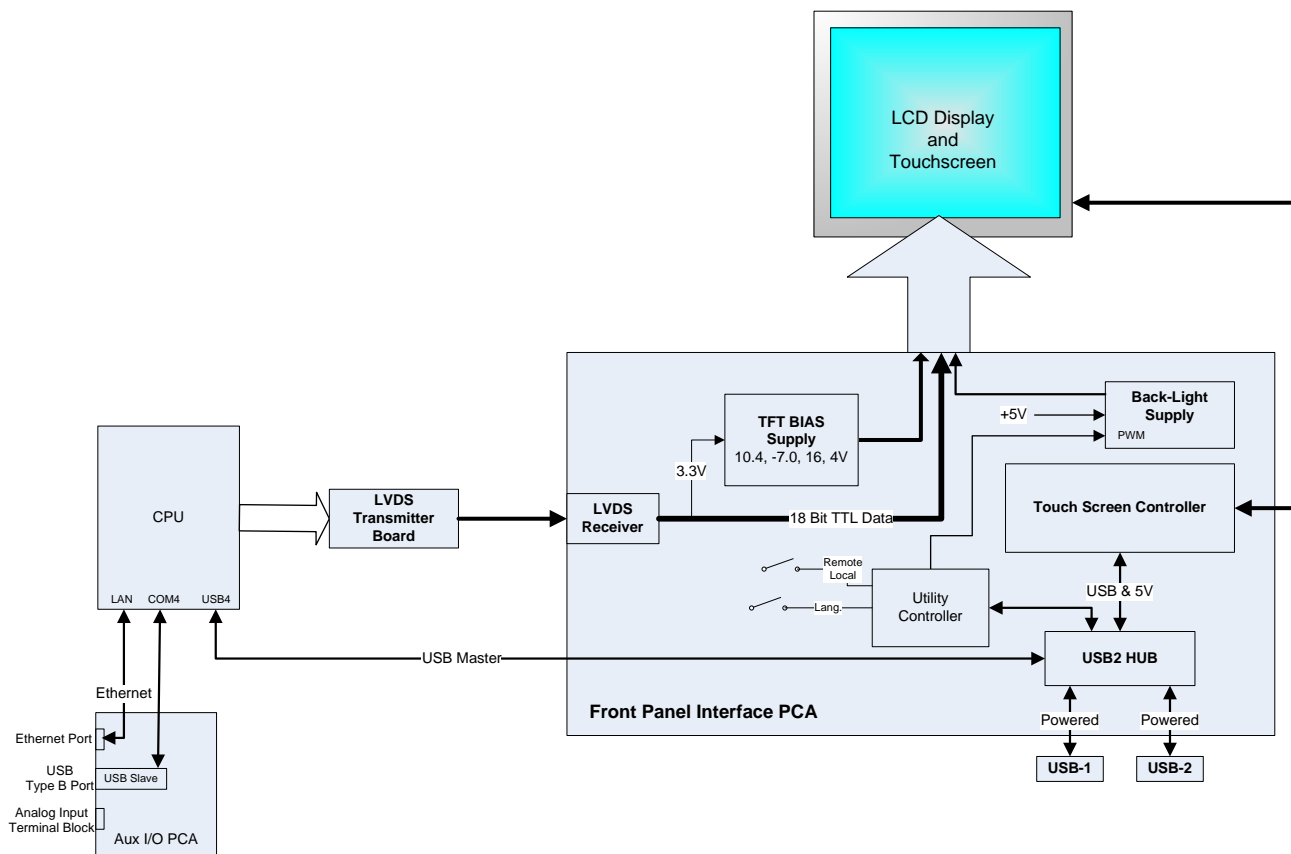


Figure 10-4: Front Panel and Display Interface Block Diagram

## LVDS Transmitter Board

The LVDS (low voltage differential signaling) transmitter board converts the parallel display bus to a serialized, low voltage, differential signal bus in order to transmit the video signal to the LCD interface PCA.

## Front Panel Interface PCA

The front panel interface PCA controls the various functions of the display and touchscreen. For driving the display it provides connection between the CPU video controller and the LCD display module. This PCA also contains:

- power supply circuitry for the LCD display module
- a USB hub that is used for communications with the touchscreen controller and the two front panel USB device ports
- the circuitry for powering the display backlight (current driven)

## Rear panel

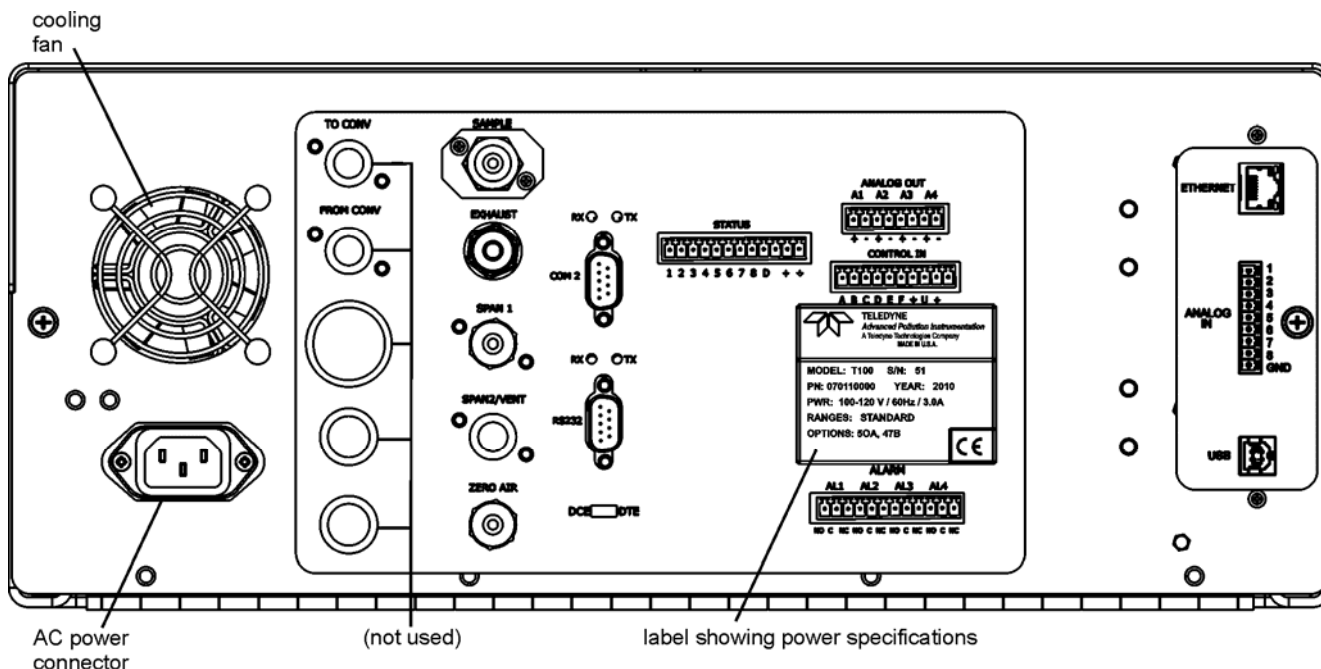


Figure 9-5: Rear Panel Layout

Table 10-2 provides a description of new components on the rear panel.

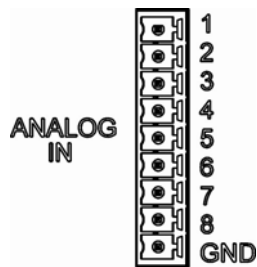
Table 10-2: Rear Panel Description

Component	Function
<b>ANALOG IN</b>	Option for external voltage signals from other instrumentation and for logging these signals
<b>USB</b>	Connector for direct connection to personal computer, using USB cable.

## Connecting Analog Inputs (Option)

The Analog In connector is used for connecting external voltage signals from other instrumentation (such as meteorological instruments) and for logging these signals in the analyzer’s internal DAS. The input voltage range for each analog input is 0-10 VDC.





**Figure 10-6: Analog In Connector**

Pin assignments for the Analog In connector are presented in Table 10-3.

**Table 10-3: Analog Input Pin Assignments**

PIN	DESCRIPTION	DAS PARAMETER <sup>1</sup>
1	Analog input # 1	AIN 1
2	Analog input # 2	AIN 2
3	Analog input # 3	AIN 3
4	Analog input # 4	AIN 4
5	Analog input # 5	AIN 5
6	Analog input # 6	AIN 6
7	Analog input # 7	AIN 7
8	Analog input # 8	AIN 8
GND	Analog input Ground	N/A

## USB Connection (Option)

For direct communication between the analyzer and a PC, connect a USB cable between the analyzer and desktop or laptop USB ports. (If this option is installed, the **COM2** port can only be used for Multidrop communication). The baud rate of the PC and the analyzer must match.

# Calibration & update procedures

## Display Calibration

The touchscreen display for the T series analyzer can be calibrated for the user's individual touch. To calibrate the display, you will need a USB keyboard. With the keyboard plugged into either USB port on the front panel, power off the instrument and then re-power.

A Teledyne logo will appear and flash, wait until a logo appears again with the words **System Booting** and a loading bar appear below the logo, and hold down the left shift and left control key on the keyboard throughout the rest of the boot up. This may take several minutes to reach the destination screen.

Once the screen becomes solid blue and a mouse cursor appears on the center of the display, release the left shift and left control keys. A red and white target will appear near the center of the screen. Press the target to start the calibration. The target will now appear in a different location. Press and hold each target following the instructions on the display until you are asked to hit either ACCEPT or CANCEL. Hit accept to accept the changes or cancel to decline the changes. After you hit accept, remove the keyboard and re-power the instrument.

## Analog Input Calibration

### Analog I/O Configuration for Analog In

**Table 9-4: DIAG - Analog I/O Functions (Example functions for a T100, AOUTS may vary)**

SUB MENU	FUNCTION
<b>AOUTS CALIBRATED:</b>	Shows the status of the analog output calibration (YES/NO) and initiates a calibration of all analog output channels.
<b>CONC_OUT_1</b>	<p>Sets the basic electronic configuration of the A1 analog output (SO<sub>2</sub>). There are three options:</p> <ul style="list-style-type: none"> <li>• <b>RANGE:</b> Selects the signal type (voltage or current loop) and full scale level of the output.</li> <li>• <b>REC_OFS:</b> Allows setting a voltage offset, not available when RANGE is set to Current Loop (<b>CURR</b>).</li> <li>• <b>AUTO_CAL:</b> Performs the same calibration as AOUT CALIBRATED, but on this one channel only.</li> </ul> <p>NOTE: Any change to RANGE or REC_OFS requires recalibration of this output.</p>
<b>CONC_OUT_2</b>	Same as for CONC_OUT_1 but for analog channel 2 (SO <sub>2</sub> )
<b>TEST OUTPUT</b>	Same as for CONC_OUT_1 but for analog channel 4 (TEST)
<b>CONC_OUT_3</b>	(Not available in the analyzer's standard configuration; applies when optional sensor installed).
<b>AIN CALIBRATED</b>	Shows the calibration status (YES/NO) and initiates a calibration of the analog input channels.
<b>XIN1</b> . . . <b>XIN8</b>	For each of 8 external analog inputs channels, shows the gain, offset, engineering units, and whether the channel is to show up as a Test function.

## AIN Calibration

This is the sub-menu to conduct the analog input calibration. This calibration should only be necessary after major repair such as a replacement of CPU, motherboard or power supplies. Navigate to the **ANALOG I/O CONFIGURATION MENU** from the DIAG Menu, then press:

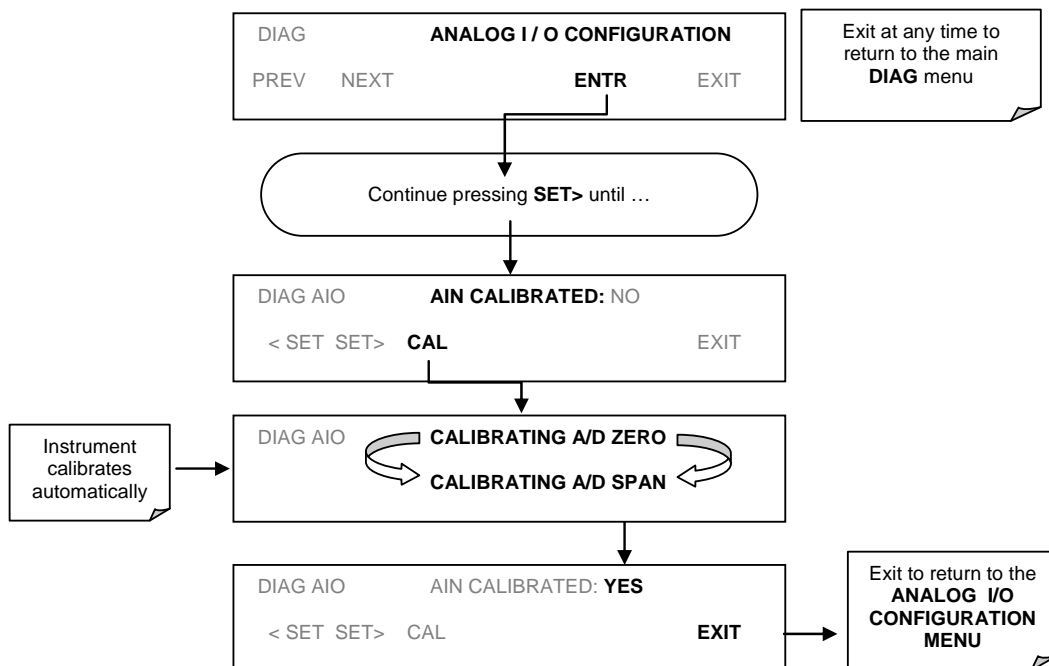


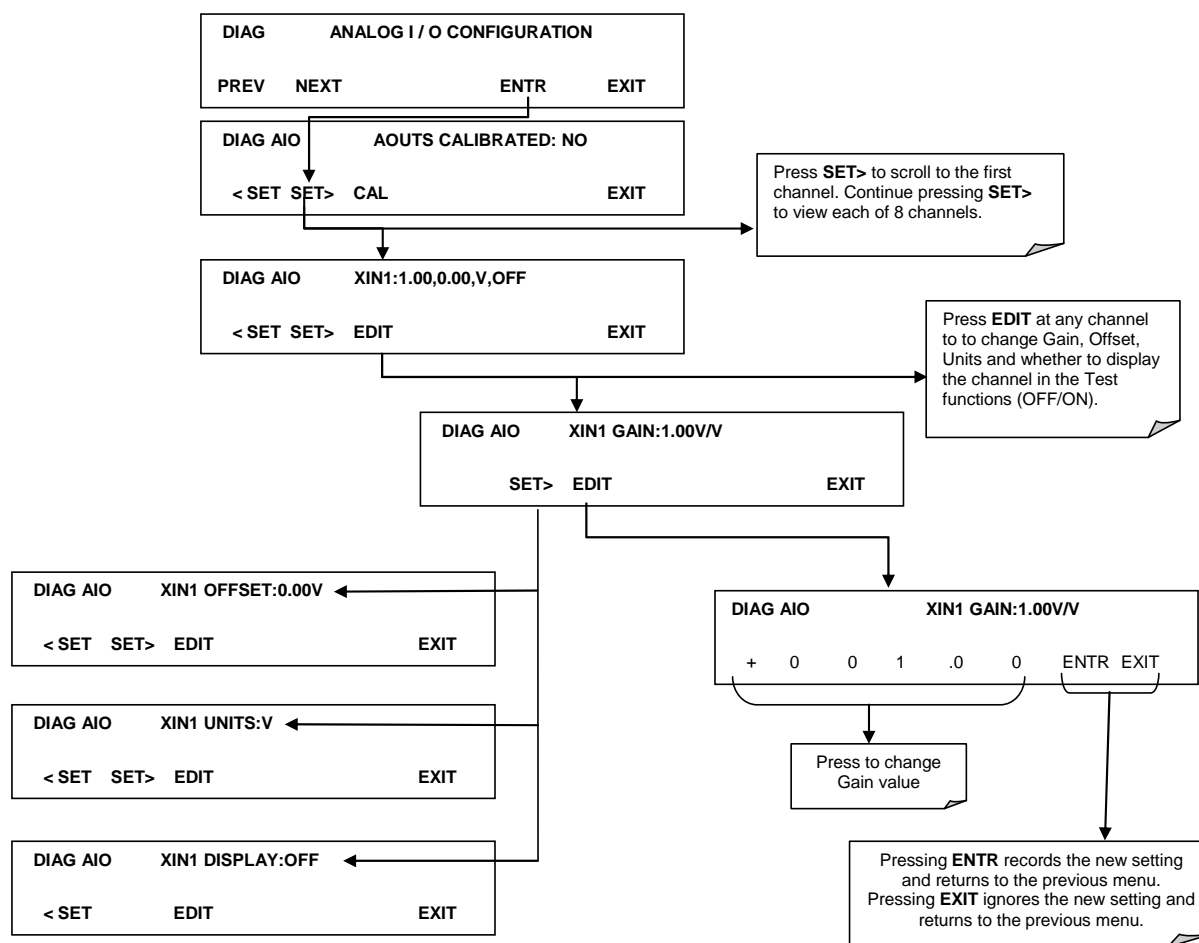
Figure 10-7: DIAG – Analog I/O Configuration – AIN Calibration

## Analog Inputs (XIN1...XIN8) Option Configuration

To configure the analyzer's optional analog inputs define for each channel:

- gain (number of units represented by 1 volt)
- offset (volts)
- engineering units to be represented in volts (each press of the touchscreen button scrolls the list of alphanumeric characters from A-Z and 0-9)
- whether to display the channel in the Test functions

To adjust settings for the Analog Input option parameters press:



**Figure 10-8 DIAG – Analog Inputs (Option) Configuration Menu**

## USB Configuration

After connecting a USB cable between your PC and the instrument, ensure their baud rates match (change the baud rate setting for either your PC’s software or the instrument). COM2 is the default setup menu for USB configuration.

Also, while there are various communication modes available, the default settings are recommended for USB, except to change the baud rate if desired.

Your computer may need the correct drivers in order to communicate via the USB port. These drivers will be available on TAPI’s website in the near future. You can contact API customer service if you need the drivers and instructions before then. Once the drivers are installed, the instrument’s USB port should work as a standard COM2 port.

## Firmware Updates via USB

The T series analyzers can receive firmware updates using a flash drive and the USB ports on the front panel. To update the firmware, locate the file you want to use for the update, and rename it to “update.exe” and copy to the flash drive. This file must not be in a folder on your flash drive in order to be recognized by the T series instrument. Plug in the flash drive and the instrument will give you a popup message with the model the firmware is intended for and the version of firmware, the analyzer will ask if you wish to continue, press yes to continue.

**\*Warning, the instrument will load any recognizable firmware you tell it to regardless of if it is intended for that instrument or not. Double check the firmware model and version before selecting continue.\***

## Troubleshooting faults

### Touch-screen Interface

Verify the functioning of the touch screen by observing the display when pressing a touch-screen control button. Assuming that there are no wiring problems and that the DC power supplies are operating properly, but pressing a control button on the touch screen does not change the display, any of the following may be the problem:

- The touch-screen controller may be malfunctioning.
- The internal USB bus may be malfunctioning.

You can verify this failure by logging on to the instrument using APICOM or a terminal program. If the analyzer responds to remote commands and the display changes accordingly, the touch-screen interface may be faulty.

### LCD Display Module

Verify the functioning of the front panel display by observing it when power is applied to the instrument. Assuming that there are no wiring problems and that the DC power supplies are operating properly, the display screen should light and show the splash screen and other indications of its state as the CPU goes through its initialization

### Touch-screen not working correctly

If you experience problems where the display reacts to touch in a different location to where you are pressing, you may need to re-calibrate the touch-screen. Also, if you are in the touch-screen calibration mode and press cancel at the end of the calibration sequence, you will lose the previous calibration and the display will be mis-calibrated. To correct this, follow the calibration procedure in the Display Calibration section.

# Diagrams and schematics

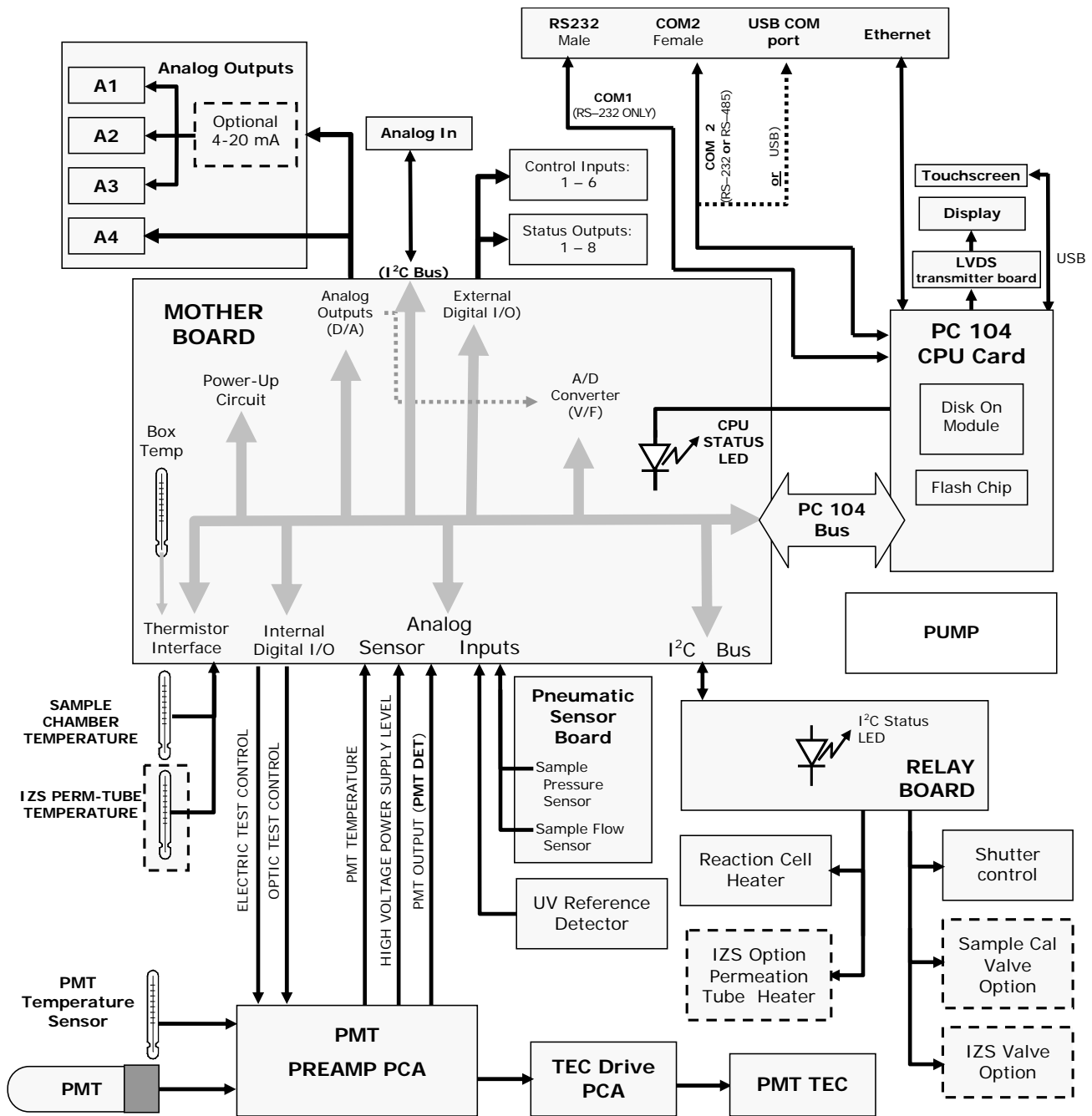


FIGURE 10-9, EXAMPLE OF AN ELECTRONIC BLOCK DIAGRAM (T100)

## **“E” series compatibility**

### **Incompatible components**

The following components are not compatible between E series and T series analyzers:

CPU  
Multidrop  
Display and Keyboard components  
Ethernet  
USB  
Analog Inputs