# MODEL 200E / T200
# NITROGEN OXIDES ANALYZER
**Also including the M200EM and M200EH**

## TRAINING MANUAL

**© TELEDYNE ADVANCED POLLUTION INSTRUMENTATION**
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# 1. PRINCIPLE OF OPERATION

# Measurement Principle

The M200E Nitrogen Oxides Analyzer is a microprocessor controlled instrument that determines the concentration of nitric oxide (NO), total nitrogen oxides ($NO_X$, the sum of NO and $NO_2$) and nitrogen dioxide ($NO_2$) 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 ($O_3$), initiating a chemical reaction that gives off light (chemiluminescence). The instrument measures the amount of chemiluminescence to determine the amount of $NO_X$ 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 $NO_X$ 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 $NO_X$ concentration.

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

# Chemiluminescence

The principle of the M200E's measurement method is the detection of chemiluminescence, which occurs when nitric oxide (NO) reacts with ozone ($O_3$). This reaction is a two-step process. In the first step, one molecule of NO and one molecule of $O_3$ collide and chemically react to produce one molecule of oxygen ($O_2$) and one molecule of nitrogen dioxide ($NO_2$). Some of the $NO_2$ retains a certain amount of excess energy from the collision and, hence, remains in an excited state ($NO^*_2$), which means that one of the electrons of the $NO_2$ molecule resides in a higher energy state than is normal (denoted by an asterisk in Equation 1).

$$NO + O_3 \rightarrow NO_2^* + O_2 \qquad \textbf{(1)}$$

Because thermodynamics requires that systems will always seek the lowest, stable energy state, the $NO_2$ 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 600 and 3000 ηm, peaking at about 1200 ηm (Equation 2).

$$NO_2^* \rightarrow NO_2 + h\nu_{1200\,nm} \qquad \textbf{(2)}$$

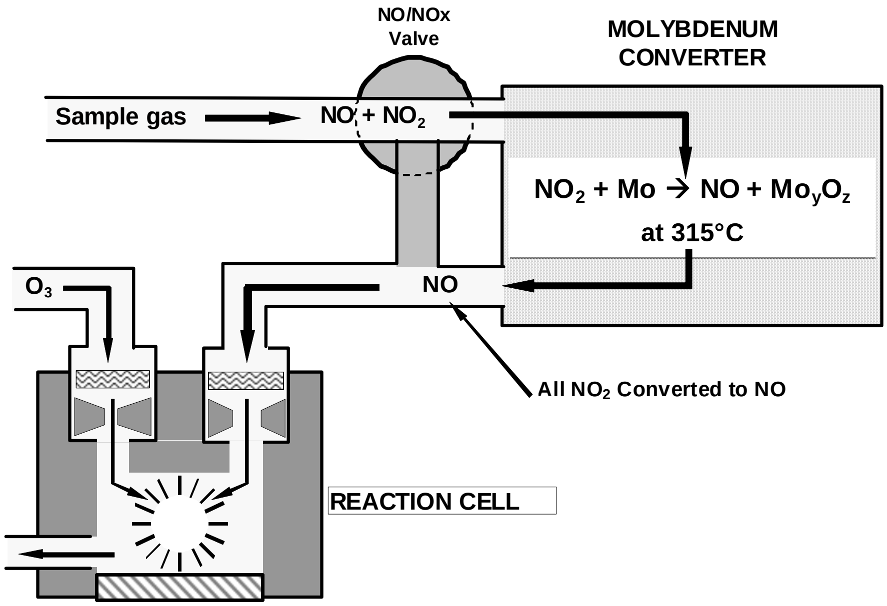
## $NO_X$ and $NO_2$ Determination

The only gas that is truly measured in the M200E is NO. Any $NO_2$ contained in the gas is not detected in the above process since $NO_2$ does not react with $O_3$ to undergo chemiluminescence.

In order to measure the concentration of $NO_2$ or $NO_X$ (which is the sum of NO and $NO_2$ in the sample gas), the M200E periodically switches the sample gas stream through a converter cartridge filled with molybdenum (Mo) chips heated to a temperature of 315° C. The heated molybdenum reacts with $NO_2$ in the sample gas and produces a variety of molybdenum oxides and NO.

$$xNO_2 + yMo \rightarrow xNO + M_yO_z \quad (at\ 315°C) \qquad \textbf{(3)}$$

Once the $NO_2$ in the sample gas has been converted to NO, it is routed to the reaction cell where it undergoes the chemiluminescence reaction described in Equations 1 and 2.

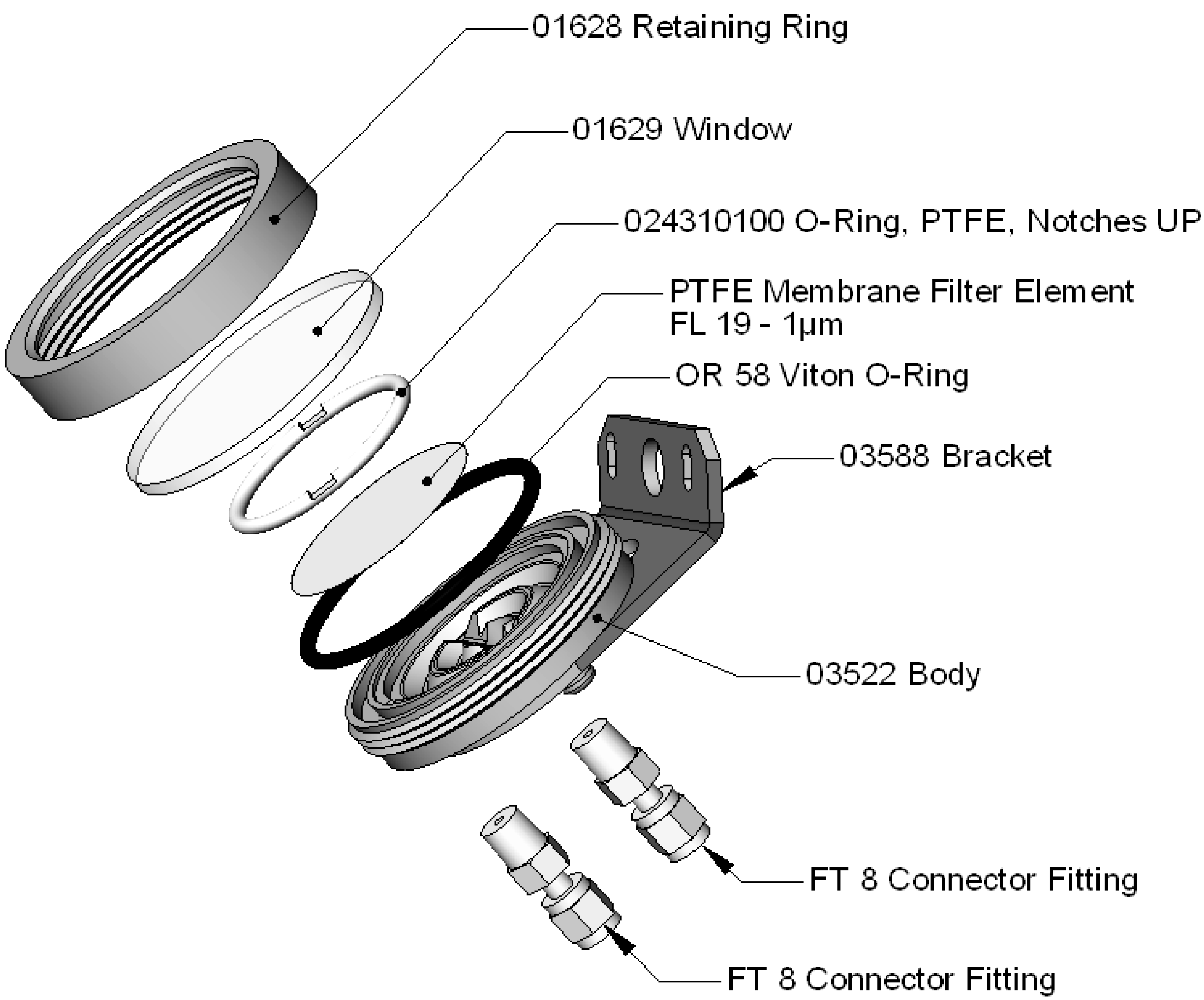



**$NO_2$ Conversion Principle**

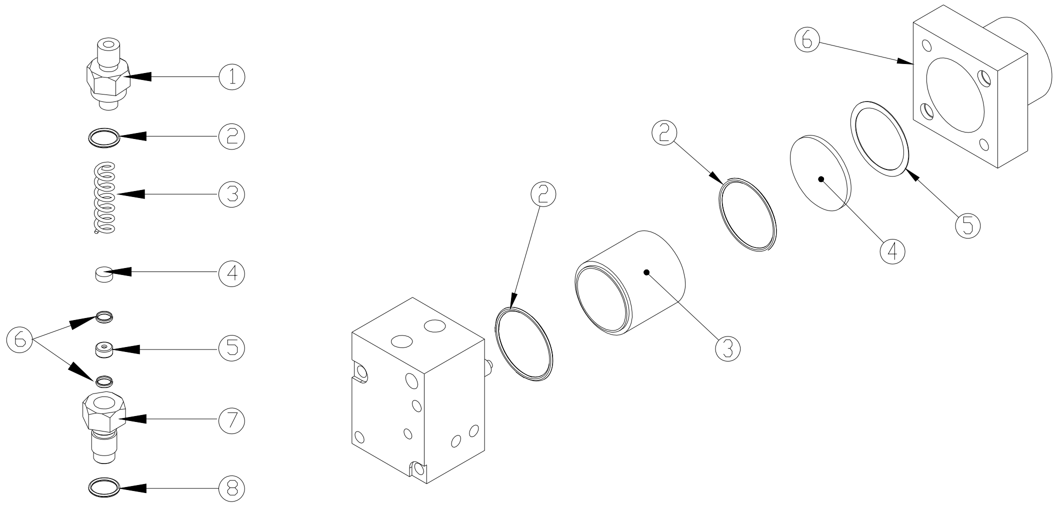
# The Sample Particulate Filter

The particulate filter should be inspected often for signs of plugging or excess dirt. It should be replaced weekly or as needed. Depending on the individual site location, will dictate exactly when to replace the filter. If you can see dirt, it is time to replace the filter. We recommend handling the filter and the wetted surfaces of the filter housing with gloves and Teflon tweezers. We recommend not touching any part of the housing, filter element, PTFE retaining ring, glass cover or the o-ring with bare hands, as contaminants may transfer from your hands, causing the filter pores to clog quicker and surfaces to become dirty.

Please note that the filter must be reassembled carefully in order to avoid leakage at this site, e.g., o-rings not oriented or seated properly, retaining ring slightly askew when twisted into place.



## The Reaction Chamber




## Orifice Holder Assy

1. FT0000010
2. OR0000034
3. HW0000020
4. FL0000001
5. 000940400 (Ozone)
5. 000940600 (Sample)
6. OR0000086
7. 040900000
8. OR0000039

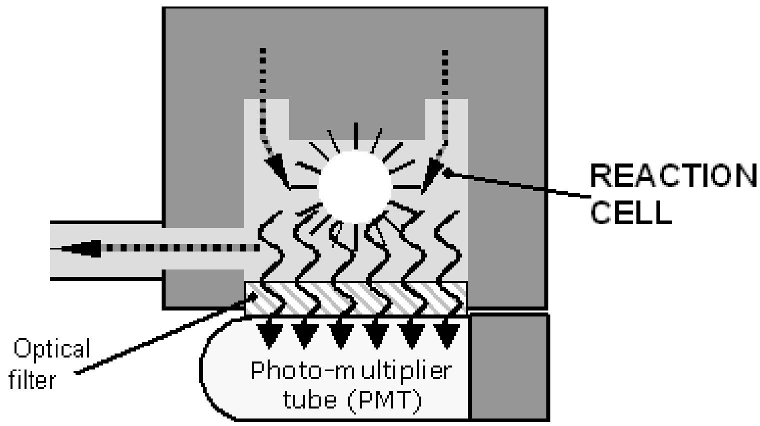
## Reaction Cell Assy

2. OR0000002
3. 001330000
4. 002730000
5. 002270000
6. 008840000

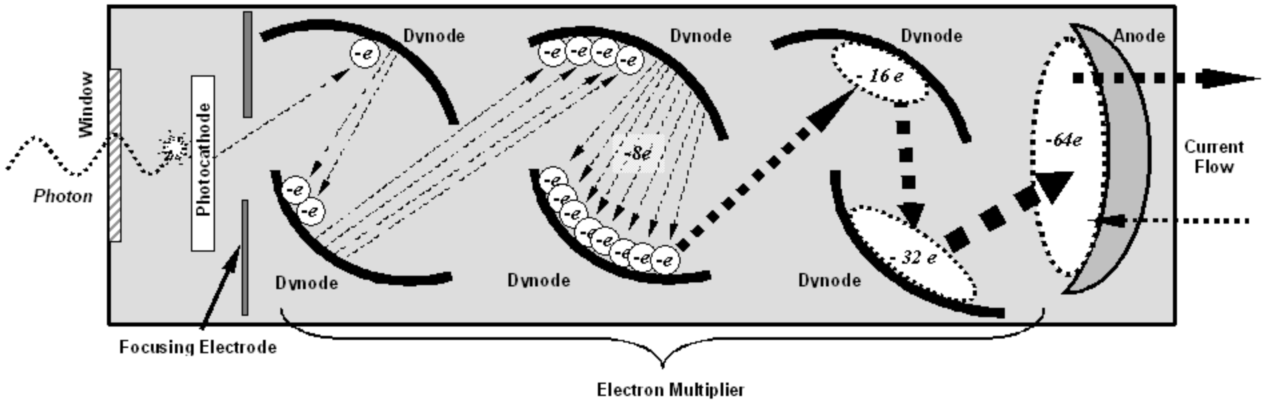
# The Photo Multiplier Tube

The M200E uses a photo-multiplier tube (PMT) to detect the amount of light created by the NO and $O_3$ 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, which 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.



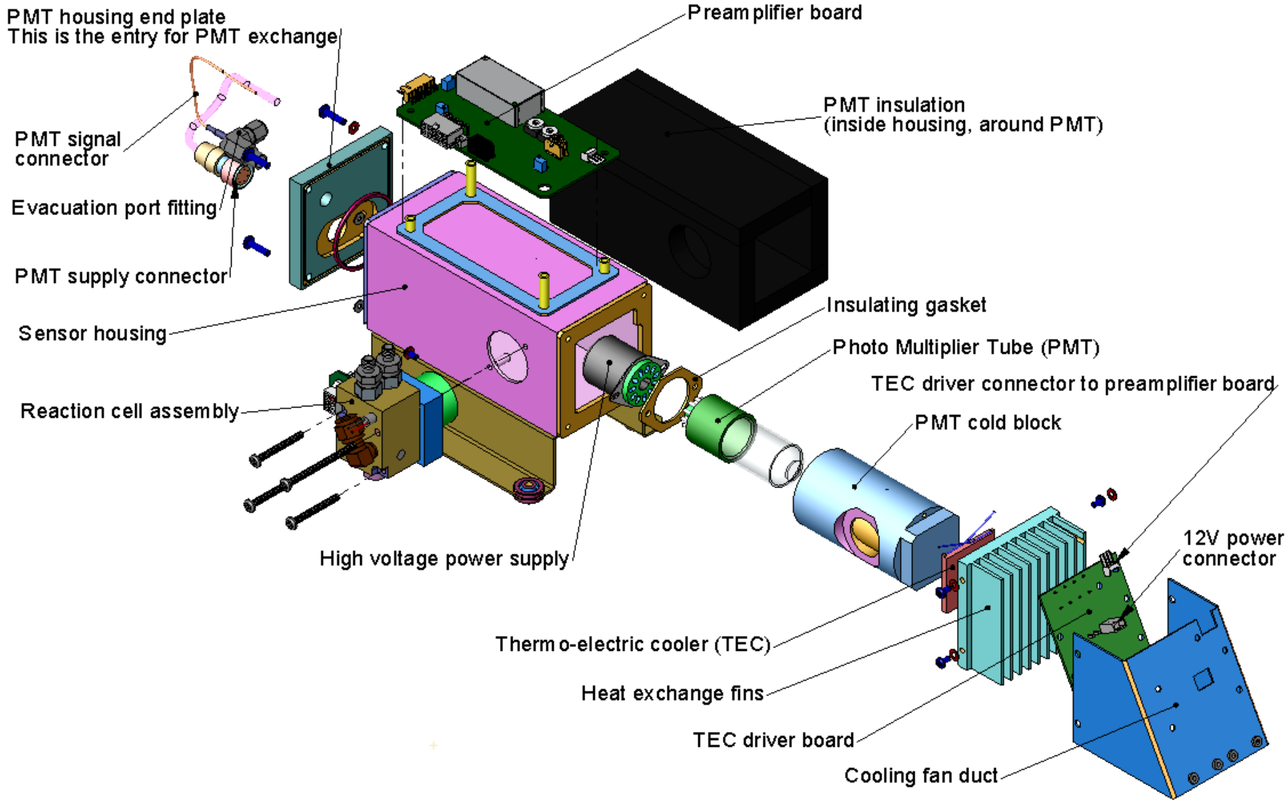

**Reaction Cell with PMT Tube**



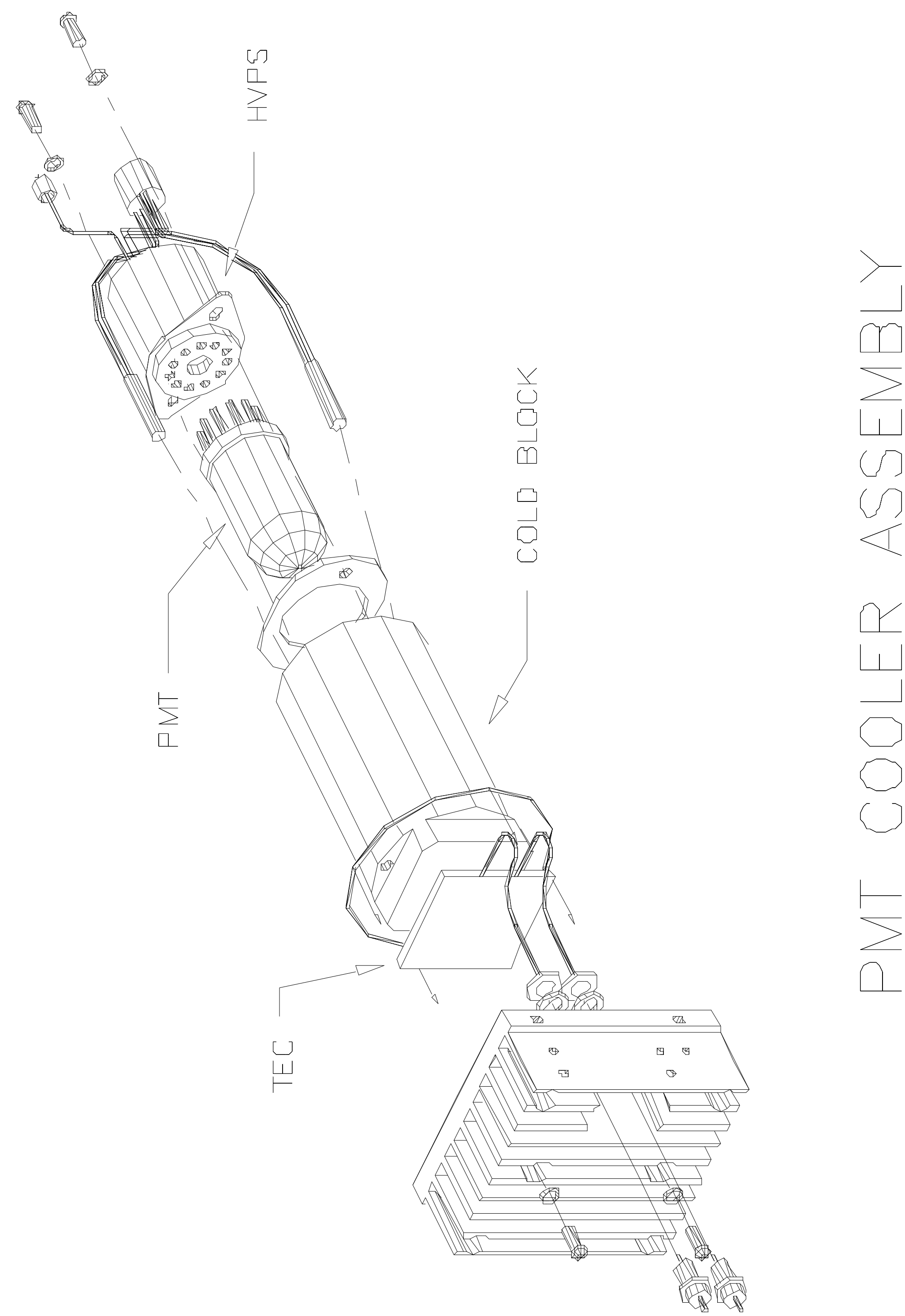

**Basic PMT Design and Functionality**

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 M200E is usually set between 450 V and 900 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 This can be changed by performing a factory calibration upon the analyzer.

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).



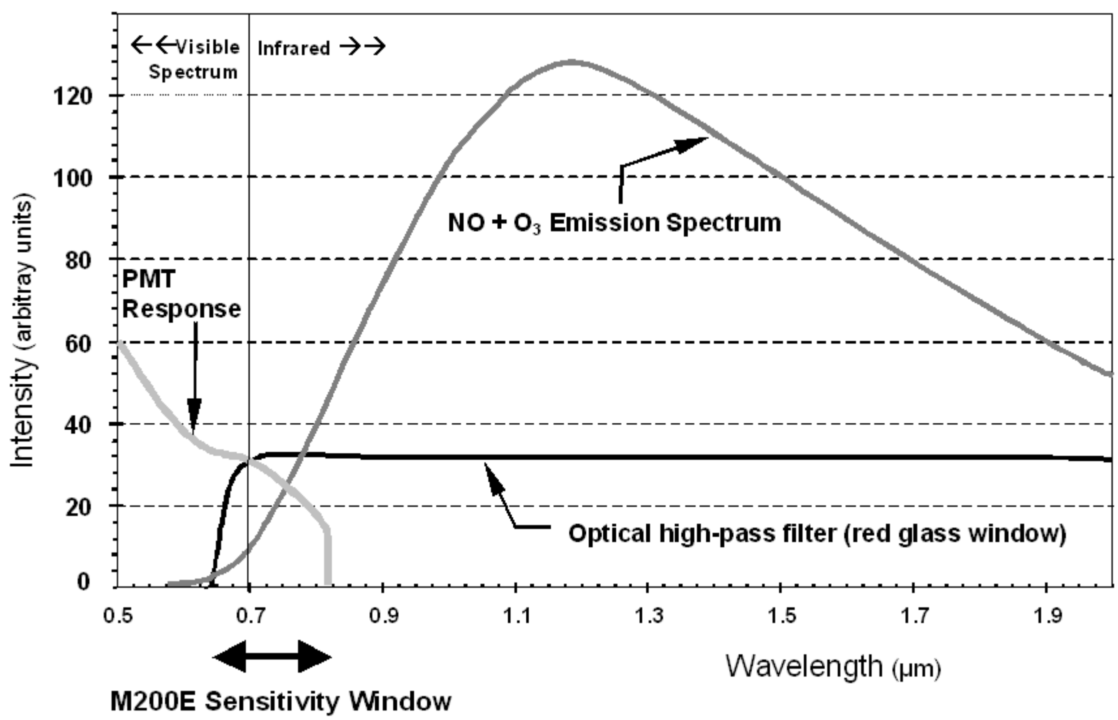

**M200E Sensor Assembly**


HVPS
COLD BLOCK
PMT
TEC
PMT COOLER ASSEMBLY

## Optical Filter

Another critical component in the method by which your M200E 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 665ηm. In conjunction with the response characteristics of the PMT, this filter creates a very narrow window of wavelengths of light to which the M200E will respond.

The narrow band of sensitivity allows the M200E to ignore extraneous light and radiation that might interfere with the M200E's measurement. For instance, some oxides of sulfur can also undergo chemiluminescence when in contact with $O_3$ but emit light at shorter wavelengths (Usually around 260ηm to 480ηm).




**M200E Sensitivity Spectrum**

# Ozone Gas Air Flow

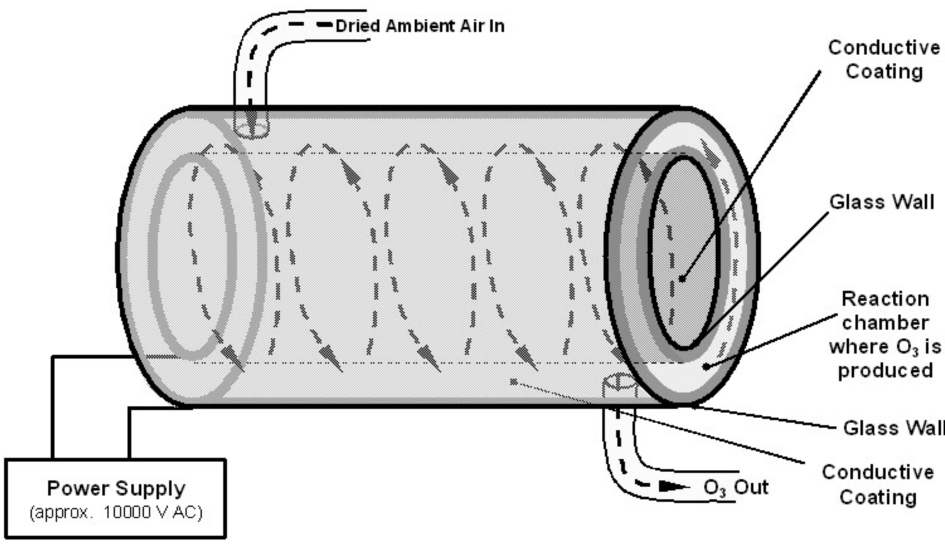
The excess ozone needed for reaction with NO in the reaction cell is generated inside the analyzer because of the instability and toxicity of ozone. In addition to the ozone generator itself, this requires a dry air supply and filtering of the gas before it is introduced into the reaction cell. Due to its toxicity and aggressive chemical behavior, $O_3$ must also be removed (via the $O_3$ Destruct) from the gas stream before it can be vented through the exhaust outlet.

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 ($O_3$) 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 $O_3$ generation and supply system is maintained and leak-free.**

# $O_3$ Generator

The M200E uses a corona discharge (CD) tube for creating its $O_3$. 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**

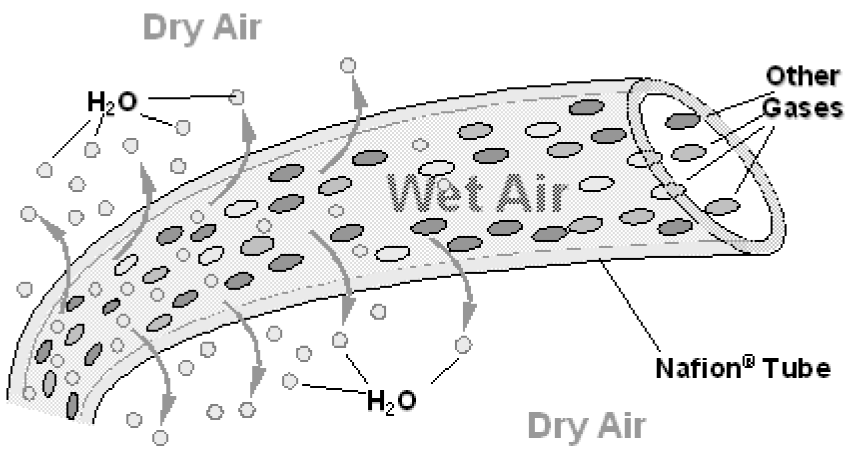
The M200E utilizes a dual-dielectric design. This method utilizes a glass tube with hollow walls. The outermost and innermost surfaces are coated with electrically conductive material. The air flows through the glass tube between the two conductive coatings, in effect creating a capacitor with the air and glass acting as the dielectric. The layers of glass also separate the conductive surfaces from the air stream to prevent reaction with the $O_3$. As the capacitor charges and discharges, electrons are created and accelerated across the air gap and collide with the $O_2$ molecules in the air stream splitting them into elemental oxygen. Some of these oxygen atoms recombine with $O_2$ to form $O_3$.

The quantity of ozone produced is dependent on factors such as the voltage and frequency of the alternating current applied to the CD cells. When enough high-energy electrons are produced to ionize the $O_2$ molecules, a light emitting, gaseous plasma is formed, which is commonly referred to as a corona, hence the name corona discharge generator.

# Perma Pure® Dryer

The air supplied to the $O_3$ generation system needs to be as dry as possible. Normal room air contains some 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 $O_3$ generator to produce chemicals that damage the optical filter located in the reaction cell, such as ammonium sulfate or highly corrosive nitric acid.

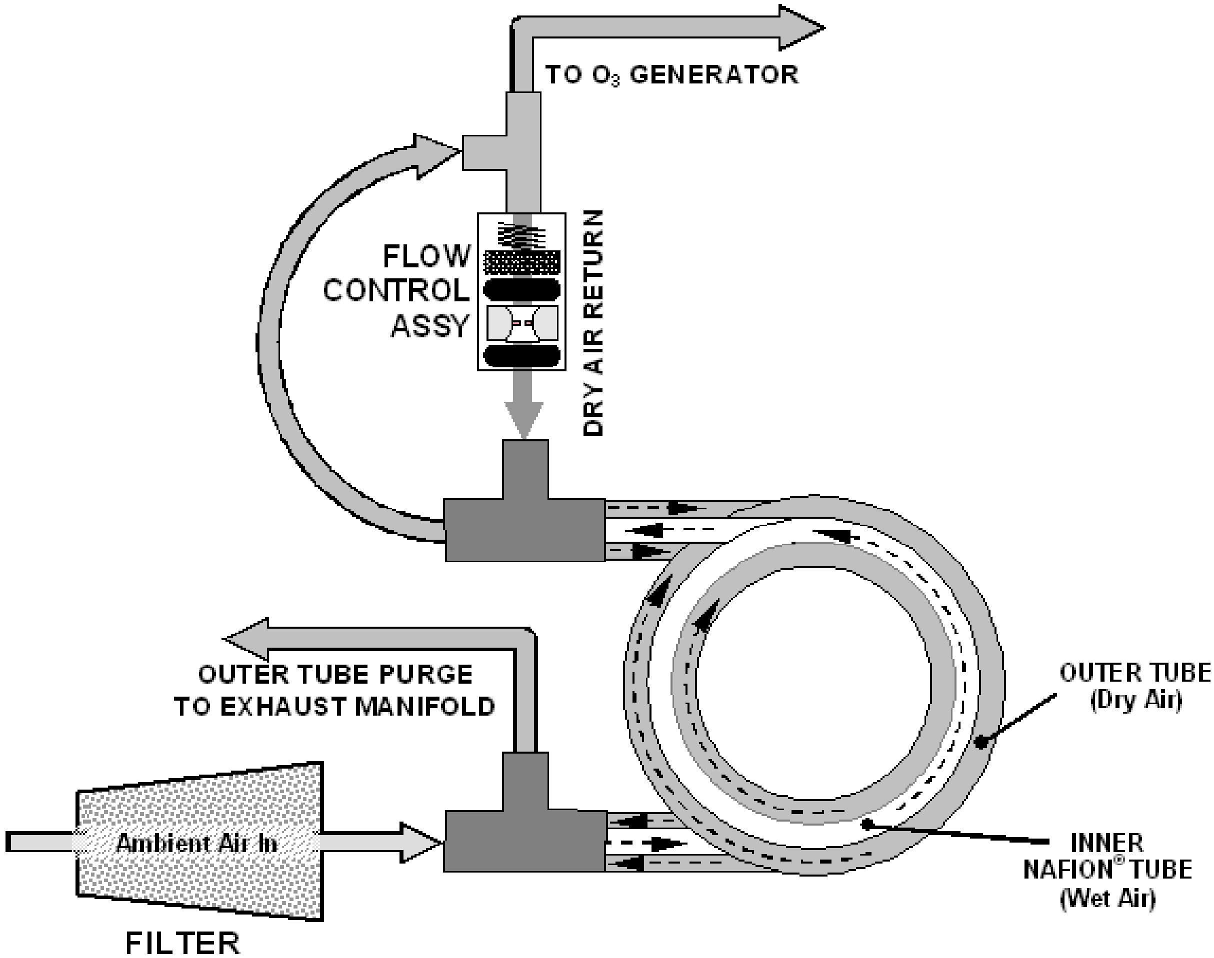
To accomplish this task the M200E uses a Perma Pure® single tube permeation dryer. The dryer consists of a single tube of Nafion®, a co-polymer similar to Teflon® that absorbs water very well but not other chemicals. The Nafion® tube is mounted within an outer, flexible plastic tube. As gas flows through the inner Nafion® 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® 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 ($NH_3$) and some low molecular amines. The gases of interest, NO and $NO_2$, do not get absorbed and pass through the dryer unaltered when used on the sample side of the analyzer.

To provide a dry purge gas for the outer side of the Nafion tube, the M200E 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.




**M200E Perma Pure® 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® Dryer to adequately dry the air. In this case, called a cold start, the $O_3$ 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® Dryer used in the M200E is capable of adequately drying ambient air to a dew point of ≤ -5˚C (~4000 ppm residual $H_2O$) at a flow rate of 1 standard liter per minute (slpm) or down to ≤ -15˚C (~1600 ppm residual $H_2O$) at 0.5 slpm. The Perma Pure® Dryer is also capable of removing ammonia from the sample gas up to concentrations of approximately 1 ppm.

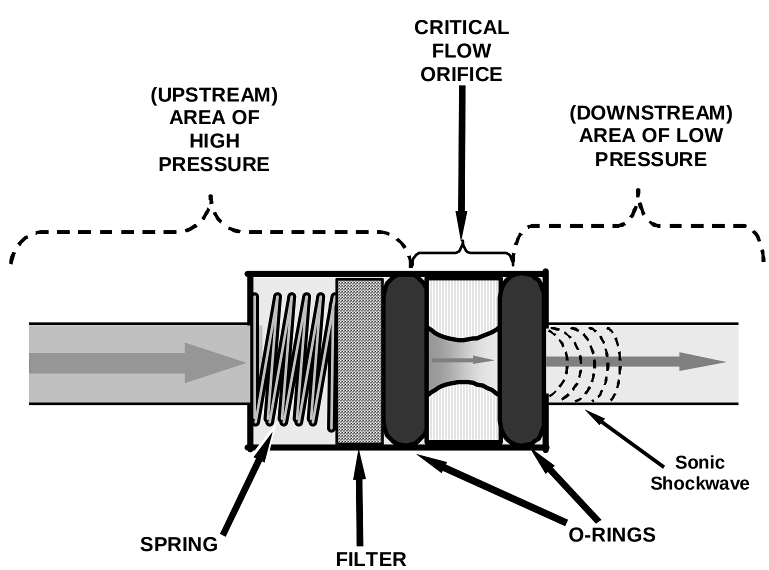
# Critical Flow Orifices

In order to maintain constant flow rates for both the $O_3$ supply air and the sample gas, the M200E uses a variety of critical-orifice flow control assemblies located at these places in the pneumatic system of the instrument:

- Reaction cell, sample inlet
- Reaction cell, ozone inlet
- Vacuum manifold, autozero exit
- Vacuum manifold, IZS purge (if installed )
- Permapure ozone air dryer, purge flow control
- Permapure sample or combo dryer, purge flow control (if installed)

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, the more gas molecules pass through the orifice. The flow rate of the gas is unaffected by small degradations in pump efficiency due to age as long as the 2:1 pressure difference is maintained.

**M200E Gas Flow Rates**

| Location | Purpose | Orifice Diameter | Flowrate (nominal) |
|---|---|---|---|
| Sample gas inlet of reaction cell | Controls rate of flow of sample gas into the reaction cell. | 0.010" (10mil) | 500 cm³/min |
| $O_3$ supply inlet of reaction cell. | Controls rate of flow of ozone gas into the reaction cell. | 0.004" (4mil) | 80 cm³/min |
| Dry air return of Perma Pure® dryer | Controls flow rate of dry air return / purge air of the dryer. | 0.004" (4mil) | 80 cm³/min |
| Vacuum manifold, auto-zero port. | Controls rate of sample gas flow when bypassing the reaction cell during the auto-zero cycle. | 0.010" (10mil) | 500 cm³/min |
| Vacuum manifold, IZS exhaust port | Controls rate of flow of zero purge gas through the IZS option (when installed and enabled) when inactive. | 0.003" (3mil) | 50 cm³/min |

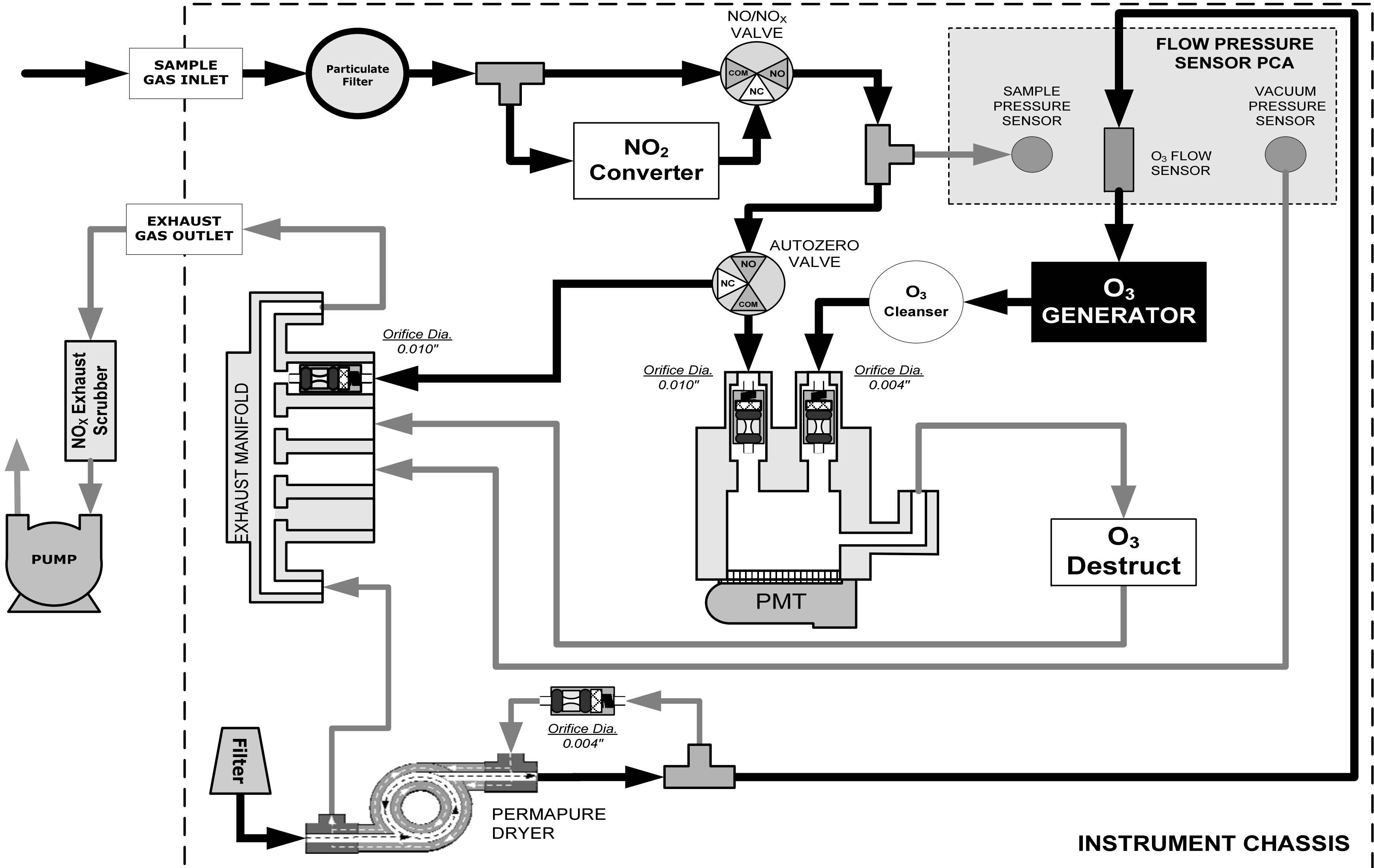
Note that the diameter of the critical orifice may change with temperature because of expansion of the orifice material (ruby) and, hence, the most critical flow orifices in the M200E are maintained at a constant temperature inside the reaction cell. These are the sample and $O_3$ flows. The table above shows the flow rates for each of the critical flow orifices of the M200E.

In addition to controlling the gas flows, the two critical flow orifices at the inlets of the reaction cell also maintain a low pressure inside the reaction cell. This effectively reduces the number of molecules in the chamber and therefore increases the chemiluminescence yield as the likelihood of third body quenching is reduced. The M200E 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.

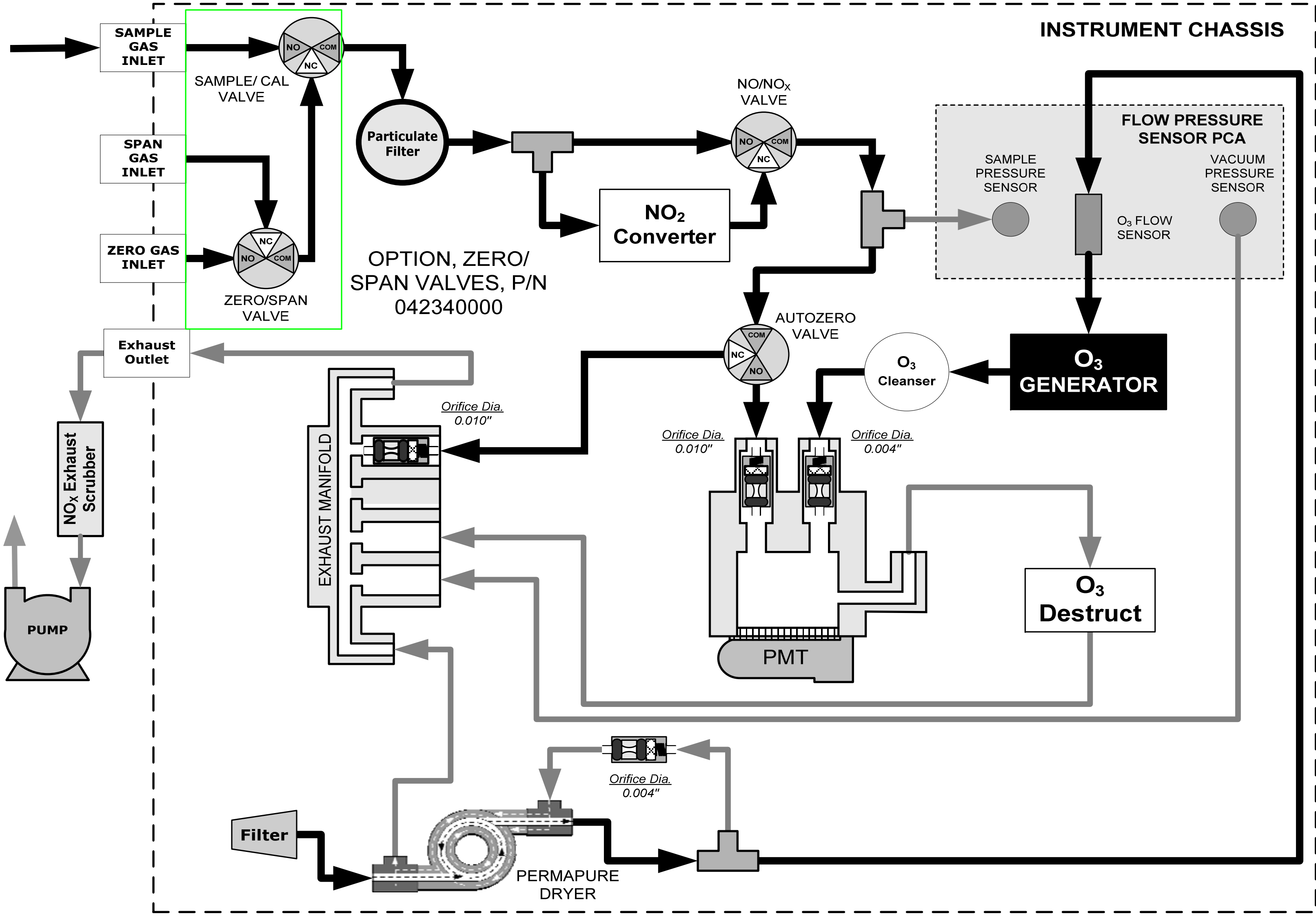
The other components of the flow control assemblies are:

- A sintered stainless steel filter, which prevents particulates from entering the reaction cell and potentially plugging the orifice.
- 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, thus forcing 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 from floating up and turning on sudden pressure drops.

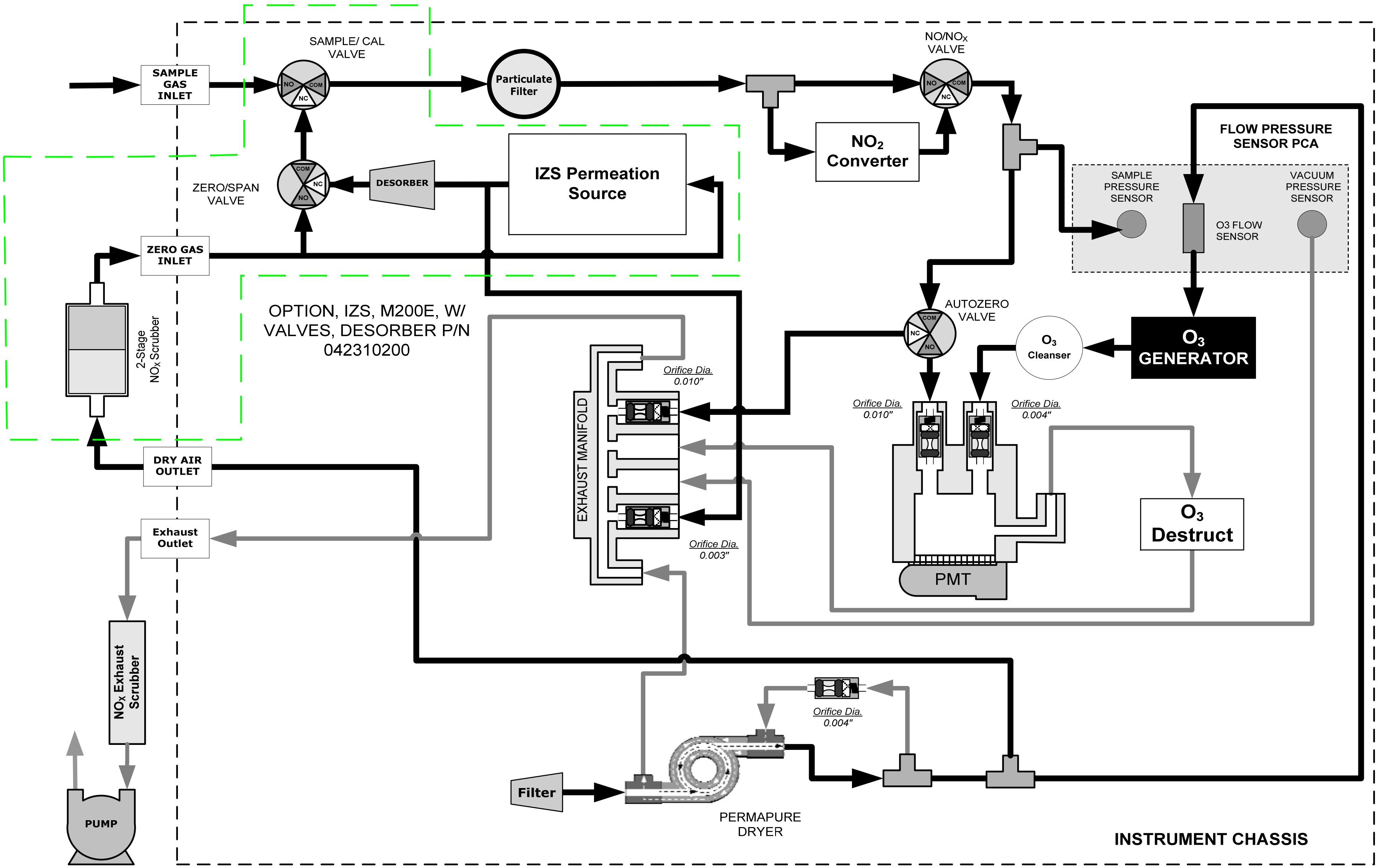
# 2. PNEUMATICS



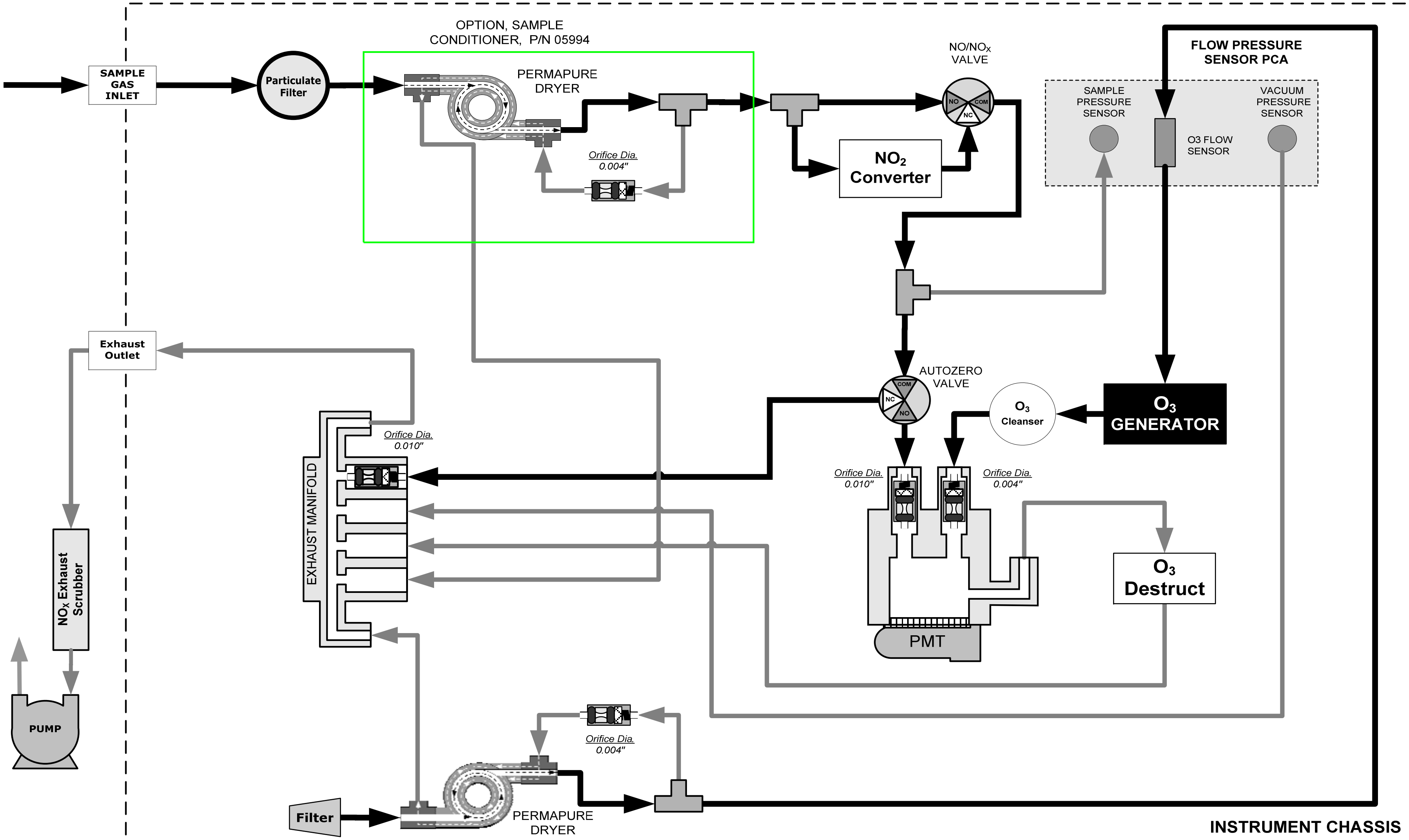

**M200E Pneumatic Diagram in Standard Configuration**




**M200E Pneumatic Diagram with Zero/Span Valves option**




## M200E Pneumatic Diagram with IZS option




**M200E Pneumatic Diagram with Sample Conditioner Option**

# USER NOTES:

# 3. MENU STRUCTURE

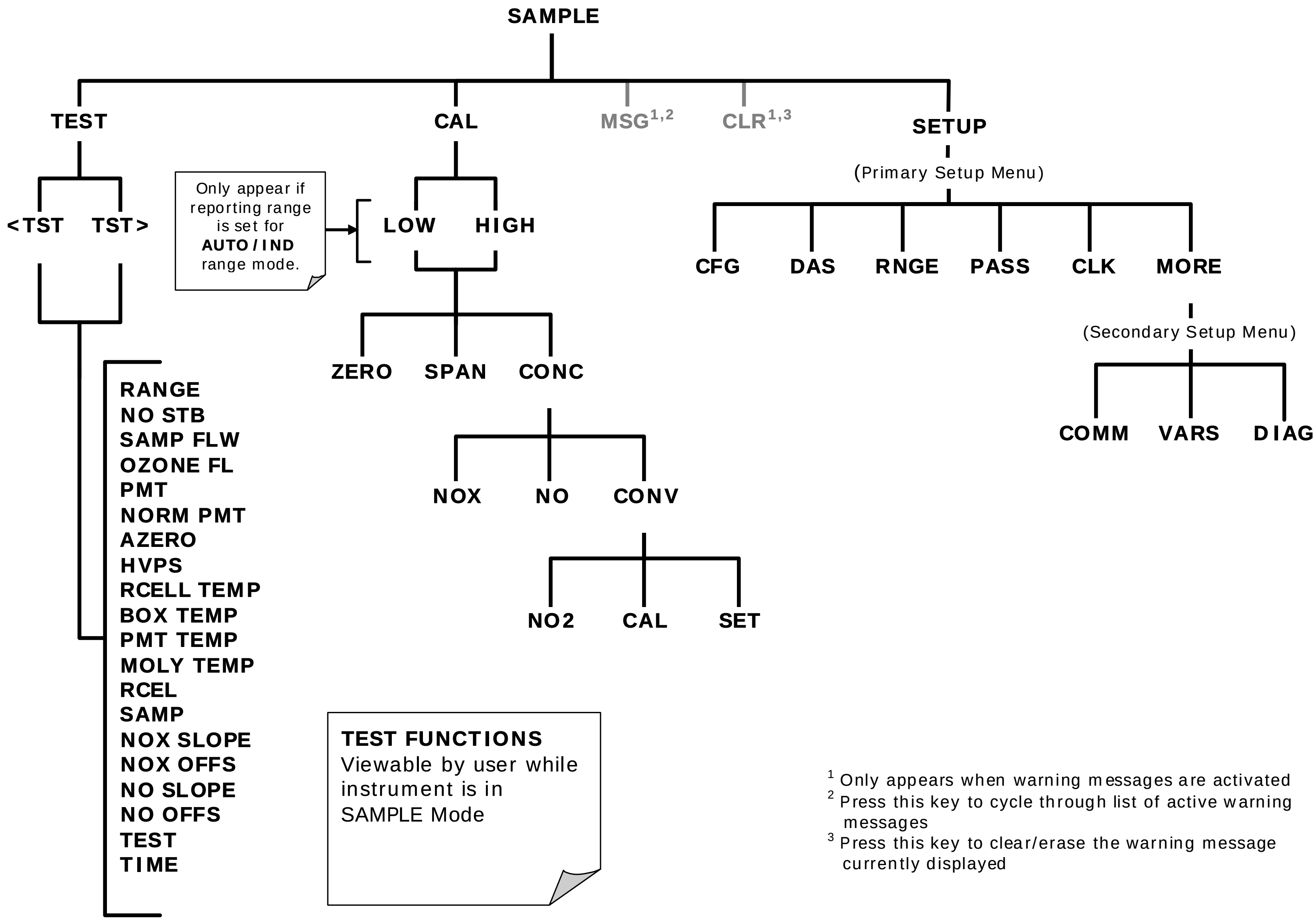



**Figure A-1: Basic Sample Display Menu**

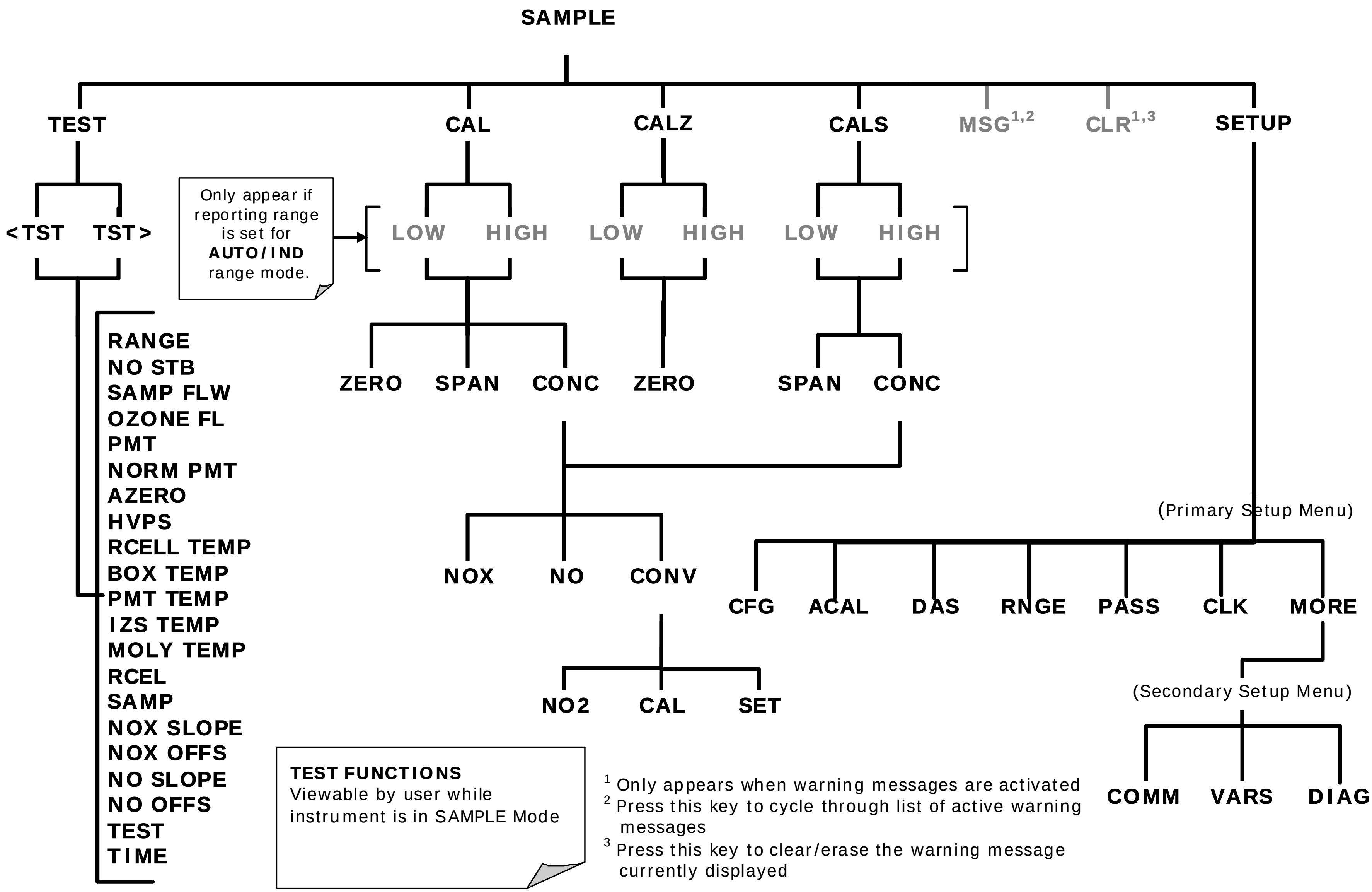
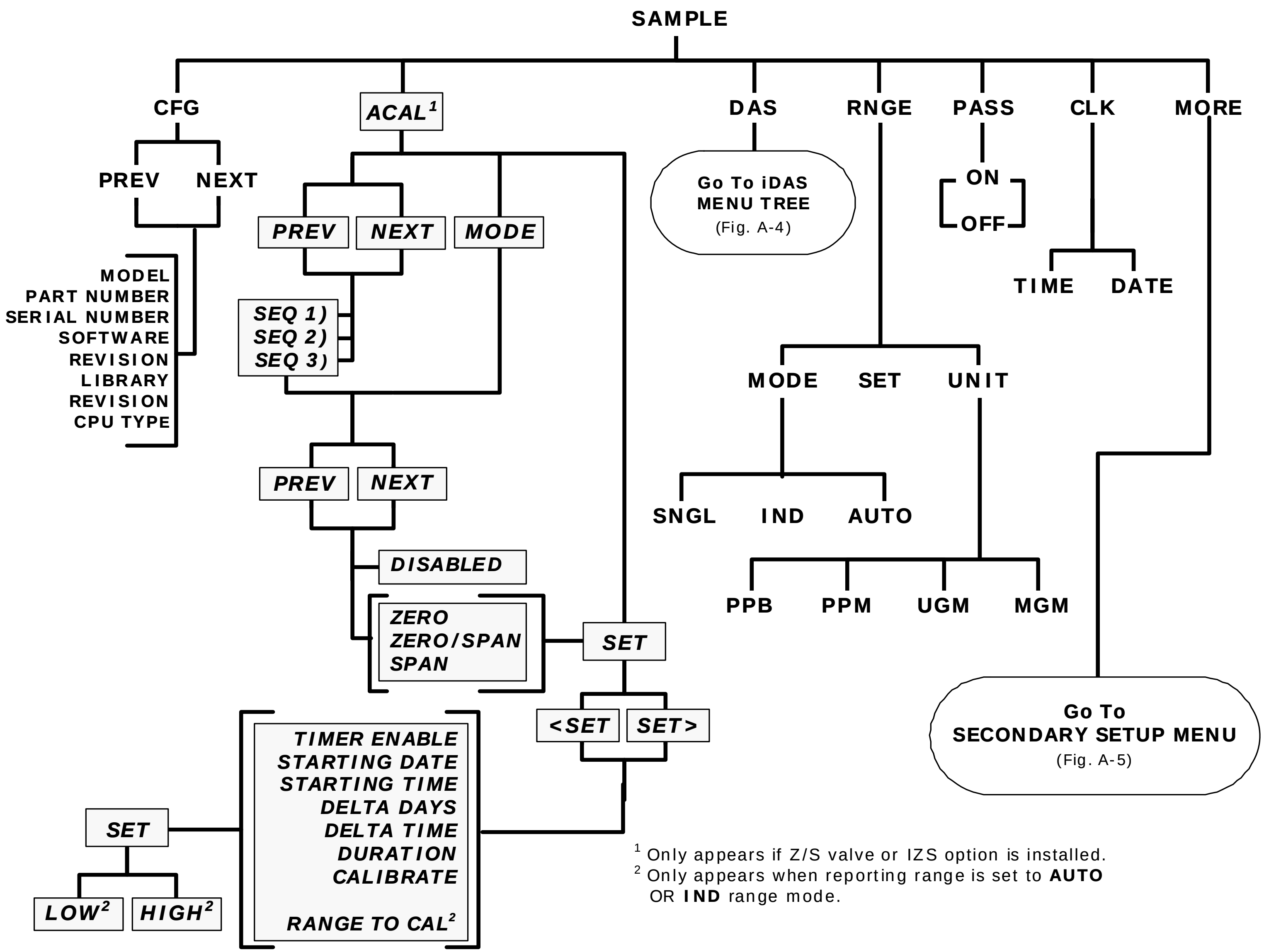



**Figure A-2: Sample Display Menu - Units with Z/S valves or IZS option installed**




[1] Only appears if Z/S valve or IZS option is installed.
[2] Only appears when reporting range is set to **AUTO** OR **IND** range mode.

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

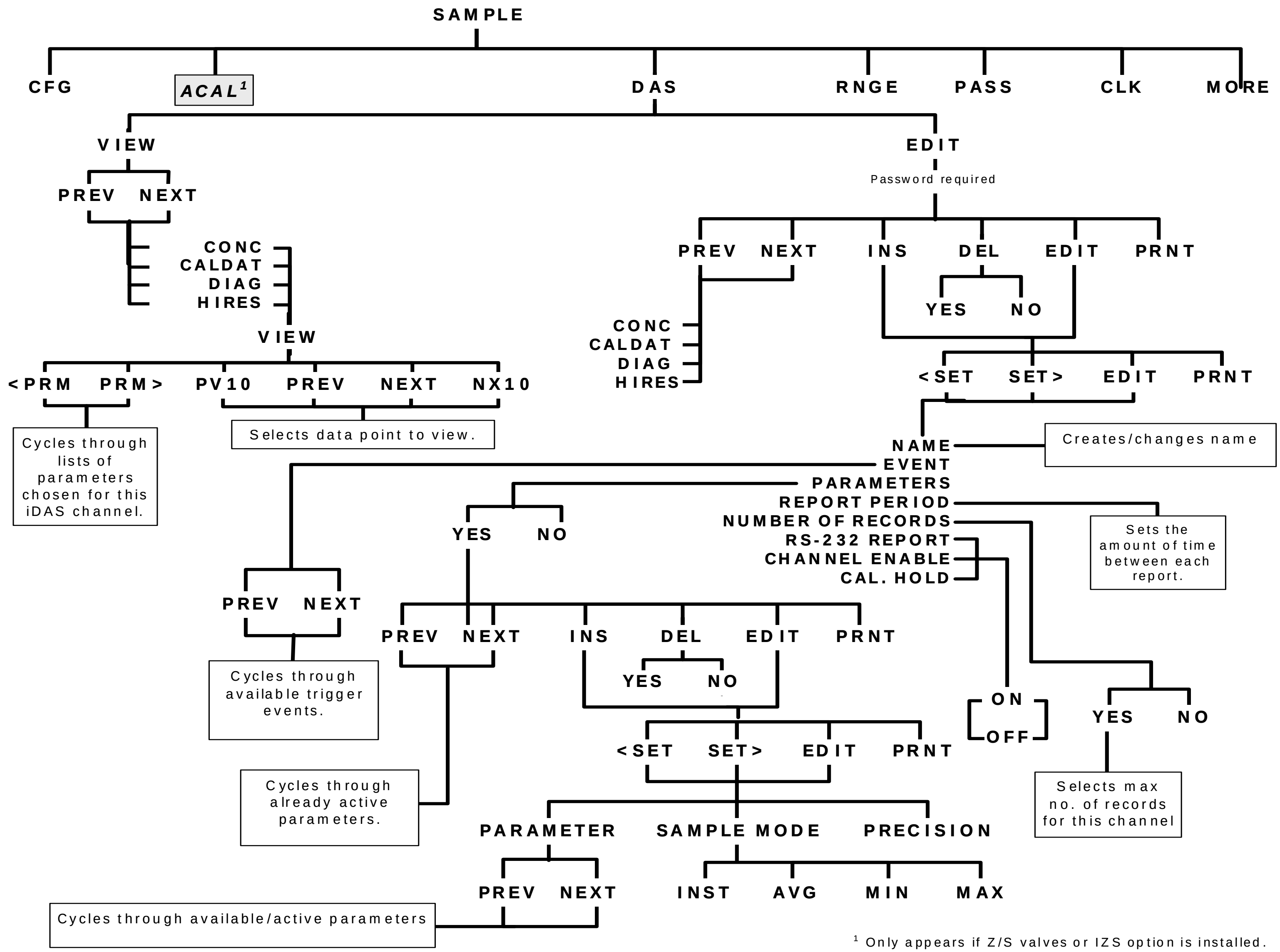
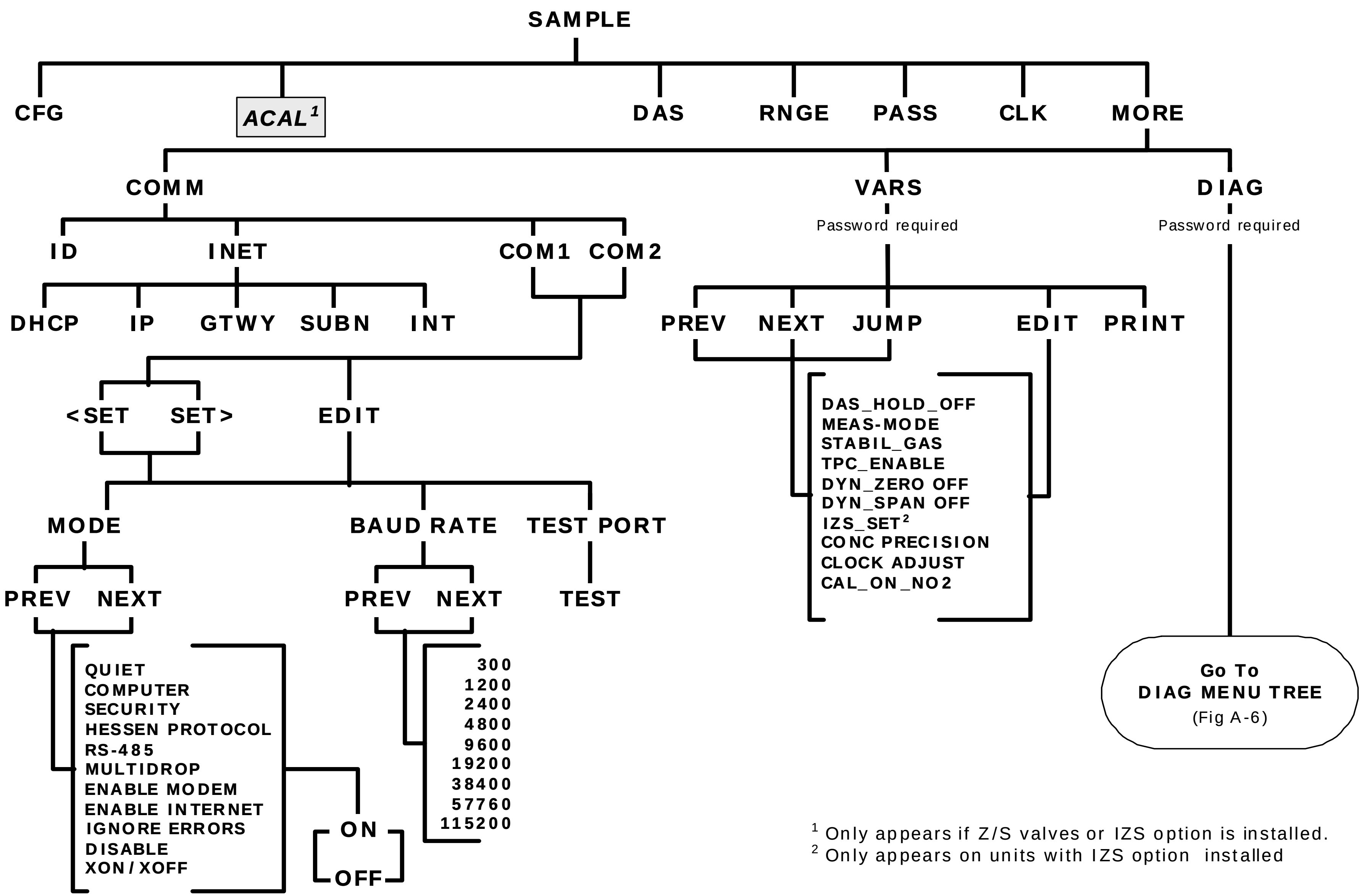
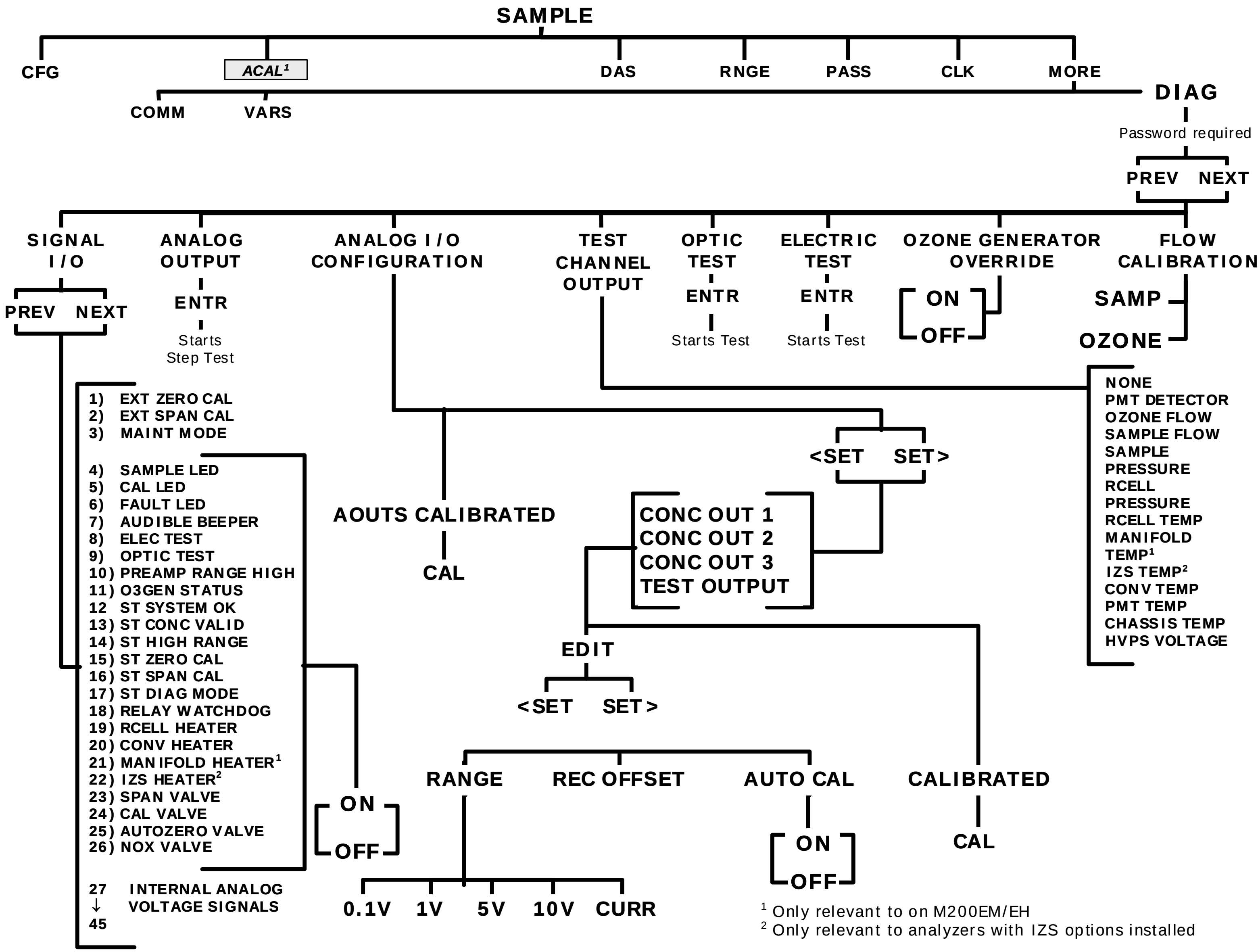



**Figure A-4: Primary Setup Menu (iDAS)**




[1] Only appears if Z/S valves or IZS option is installed.
[2] Only appears on units with IZS option installed

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




[1] Only relevant to on M200EM/EH
[2] Only relevant to analyzers with IZS options installed

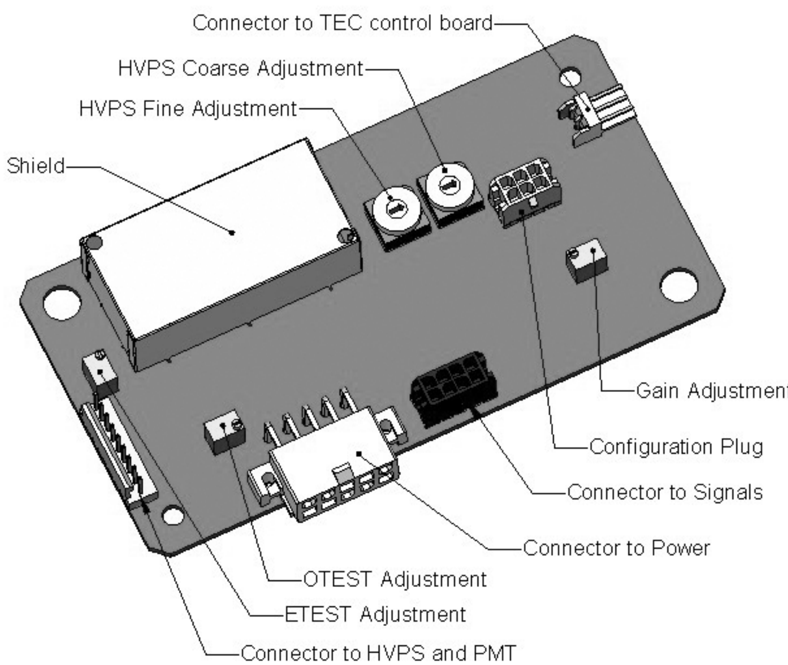
**Figure A-6: Secondary Setup Menu (DIAG)**

# 4. CALIBRATION PROCEDURES

# Factory Calibration for a M200E

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

- Let the instrument run for one hour to stabilize all. This is required to ensure proper scaling of the **NORM PMT** value.
- 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 2000 and below you will want to use the first equation, with a range 2000.1 and above you will use the second equation.

  CONC=Span Gas in PPB

  Ranges 2000.0 and below
  **TARGET NORM PMT=(2*CONC)**
  Ranges 2000.1 and above
  **TARGET NORM PMT=(0.182*CONC)**
- 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 as possible 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 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±0.100 and the offset values should be -20 to +150 mV.

# Service Note

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**03-020B**
**2 MAY, 2007**

## 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> until it reads read A/IN CALIBRATED:
3. Press CAL to calibrate the analog inputs.
4. Press <SET until the top line reads CONC_OUT_1 and press EDIT
   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.
5. 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.
6. 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.
7. Press SET>. The top line should read CONC_OUT_1: CALIBRATED: YES
8. Now place your meter on pins 1 and 2 on the rear panel analog output connector and set your meter to read mvDC.
9. Press CAL on the front panel.
10. You should have some DN and UP buttons. And the top line should be say ZERO ADJUST or something similar.

11. The output on the meter should be as close as possible to 0mV ±0.3mV.
    a. If it is not then press DN or UP until the meter reads as close as possible to 0mv
    b. If it does go to step 14
12. Press ENTR.
13. 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 voltage (i.e. 1V, 5V, 10V) you will have to change the range on the meter to read Volts instead of Mili-volts.
14. Press the DN and UP buttons until the output on the meter reads your full-scale voltage ±1mV.
15. Press ENTR
16. That channel is now calibrated.
17. 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 0ma ±0.01ma (if 0-20ma output), 4ma ±0.01ma (if 4-20ma output).
    a. If not then press DN or UP until the meter reads as close as possible to 0ma or 4ma.
    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 20ma ±0.01ma.
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 what the current atmospheric pressure is. This can be found from a barometer or by contacting your local airport or weather station.

From the front panel of the analyzer press <SETUP><MORE><DIAG> and enter 929 for the password whenever 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. Reconnect the pump and the pressure should drop about an inch and the rcell pressure should drop below 10"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 sample inlet port on the back of the analyzer. Record this flow rate. Then disconnect the 1/8" 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/min, and record this reading. Reconnect the 1/8" tubing you previously disconnected to the ozone fitting. 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 meter 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.

# 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.**

**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 M200E. 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.

| Item | Action | Priority | Frequency | Cal Check | Date Performed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEST functions | Review | Recomm-ended | Weekly | TEST functions | | | | | | | | | |
| Particulate filter | Change particle filter | Mandatory | Weekly or as needed | No | | | | | | | | | |
| Zero/span check | Evaluate offset and slope | As Needed | Weekly | **No** | | | | | | | | | |
| Zero/span calibration | Zero and span calibration | As Needed | Every 3 months | **Yes** | | | | | | | | | |
| External zero air scrubber (optional) | Exchange chemical | Mandatory | Every 3 months | No | | | | | | | | | |
| External dryer (optional) | Replace chemical | | When indicator color changes | No | | | | | | | | | |
| Ozone filter | Change chemical | As Needed | Annually | **Yes** | | | | | | | | | |
| Reaction cell window | Clean | Mandatory | Annually or as necessary | **Yes** | | | | | | | | | |
| DFU filters | Change particle filter | Mandatory | Annually | No | | | | | | | | | |
| Pneumatic sub-system | Check for leaks in gas flow paths | Recomm-ended | Annually or after repairs involving pneumatics | Yes if a leak is repaired | | | | | | | | | |
| Reaction cell O-rings & sintered filters | Replace | Mandatory | Annually | **Yes** | | | | | | | | | |
| PMT Sensor Hardware Calibration | Low-level hardware calibration | As Needed | On PMT/ preamp changes or if slope is outside of 1.0±0.3 | **Yes** | | | | | | | | | |
| Pump | Rebuild head | Mandatory | when RCEL pressure > 10 in-Hg-A | **Yes** | | | | | | | | | |
| $NO_2$ converter | Replace converter | Recomm-ended | 3 years or if conversion efficiency drops below 96% | **Yes** | | | | | | | | | |

# USER NOTES:

# 6. TROUBLESHOOTING & FAULTS

# Predictive Diagnostics

The analyzer's test functions can be used to predict failures by looking at trends in their values. The 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 this data from remote locations.

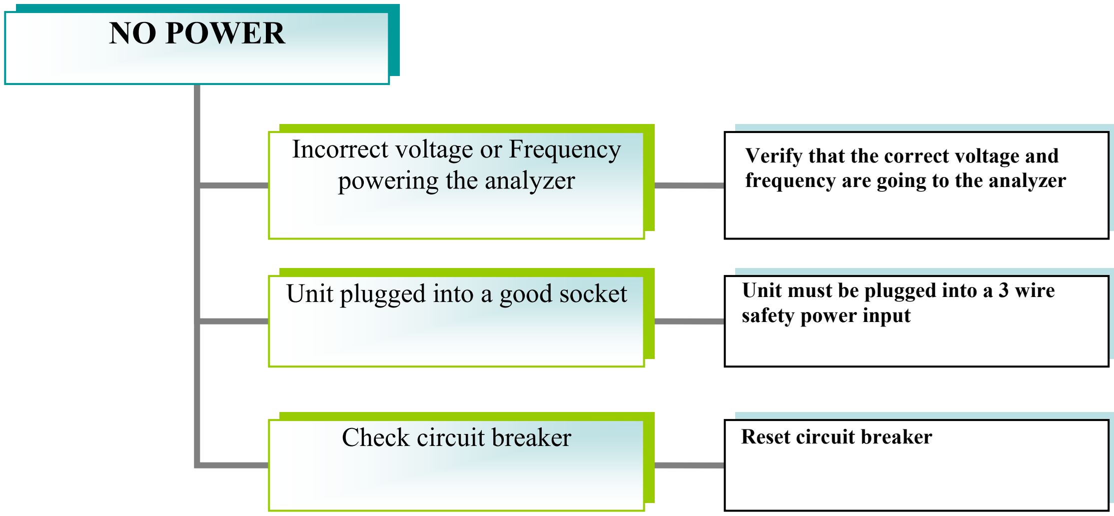
**Predictive Uses for Test Functions**

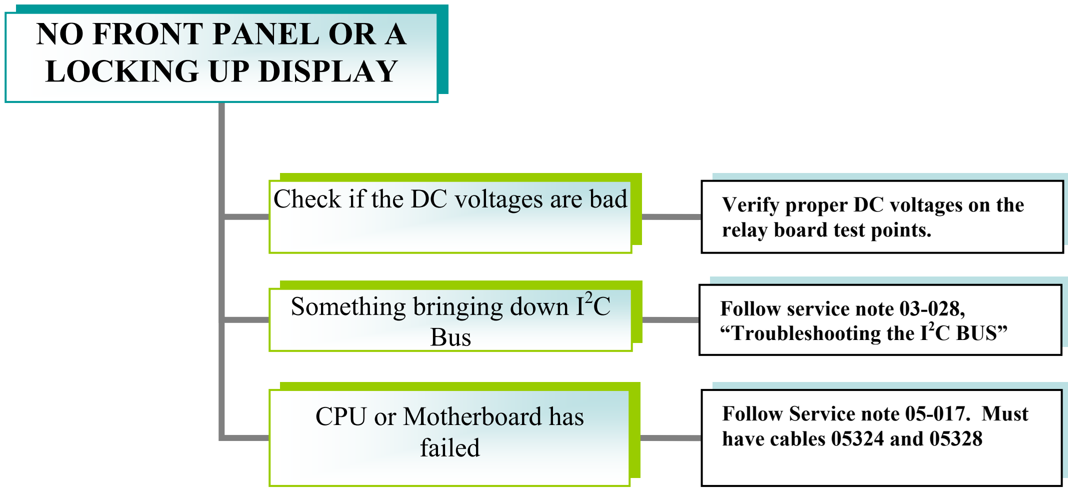
| Function | Expected | Actual | Interpretation |
|---|---|---|---|
| RCEL pressure | Constant to within ± 0.5 | Fluctuating | Developing leak in pneumatic system |
| | | Slowly increasing | Pump performance is degrading. Replace pump head when pressure reaches 10 in-Hg-A |
| SAMPLE pressure | Constant within atmospheric changes | Fluctuating | Developing leak in pneumatic system |
| | | Slowly decreasing | Flow path is clogging up. Replace orifice filters |
| | | Slowly increasing | Developing leak in pneumatic system to vacuum (developing valve failure) |
| Ozone Flow | Constant to within ± 15 | Slowly decreasing | Flow path is clogging up. Replace orifice filters |
| AZERO | Constant within ±20 of check-out value | Significantly increasing | Developing AZERO valve failure |
| | | | PMT cooler failure |
| | | | Developing light leak |
| $NO_2$ CONC | Constant for constant concentrations | Slowly decreasing signal for same concentration | Conversion efficiency of converter may be degrading. Replace converter |
| $NO_2$ CONC (IZS) | Constant response from day to day | Decreasing over time | Change in instrument response |
| | | | Degradation of IZS permeation tube |
| NO CONC | Constant for constant concentration | Decreasing over time | Drift of instrument response; clean RCEL window |

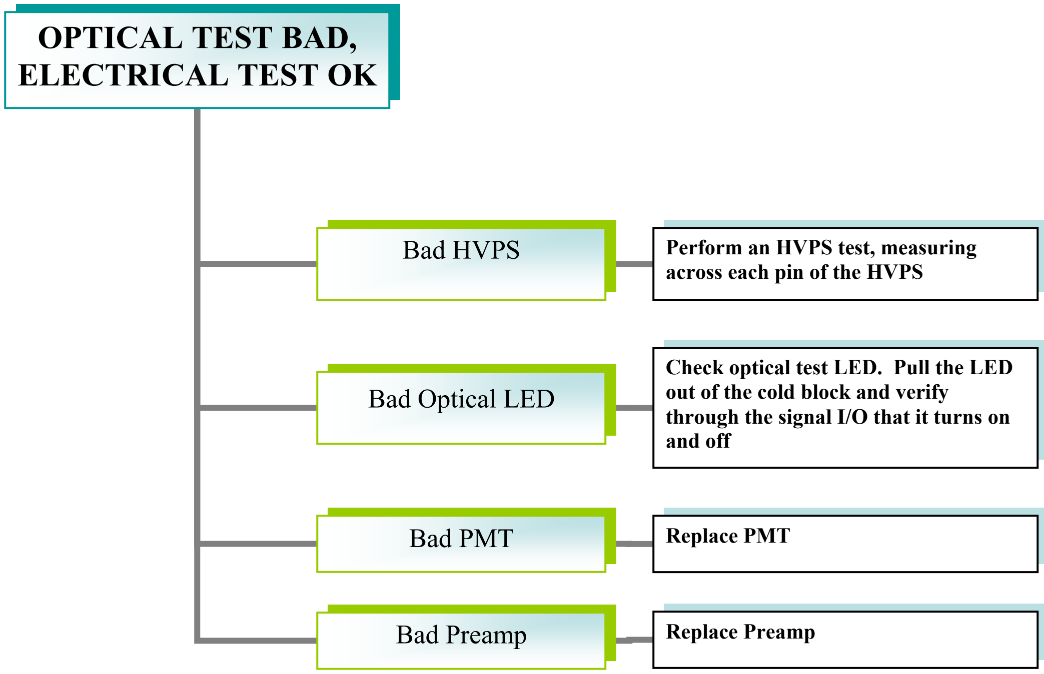
# M200E Troubleshooting Tree

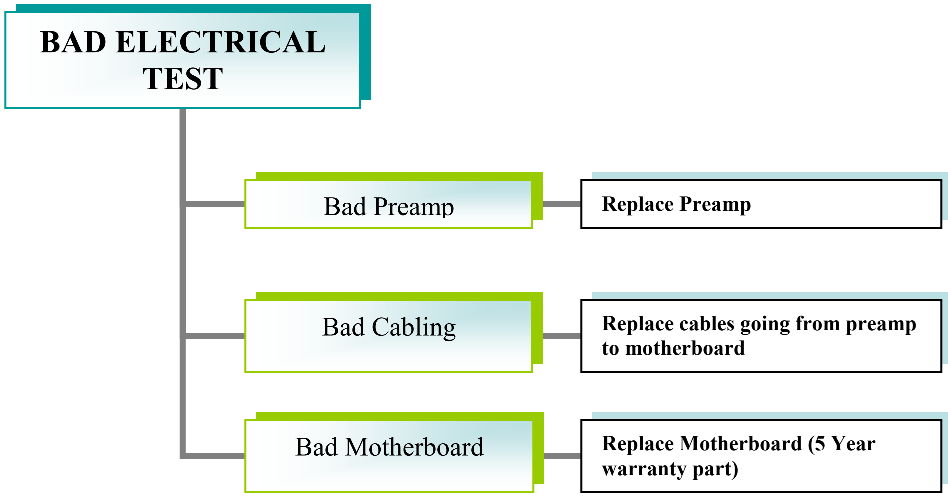
**Troubleshooting Trees**

- 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


NO POWER
Incorrect voltage or Frequency powering the analyzer
Verify that the correct voltage and frequency are going to the analyzer
Unit plugged into a good socket
Unit must be plugged into a 3 wire safety power input
Check circuit breaker
Reset circuit breaker


NO FRONT PANEL OR A LOCKING UP DISPLAY
Check if the DC voltages are bad
Verify proper DC voltages on the relay board test points.
Something bringing down I²C Bus
Follow service note 03-028, "Troubleshooting the I²C BUS"
CPU or Motherboard has failed
Follow Service note 05-017. Must have cables 05324 and 05328


OPTICAL TEST BAD, ELECTRICAL TEST OK
Bad HVPS
Perform an HVPS test, measuring across each pin of the HVPS
Bad Optical LED
Check optical test LED. Pull the LED out of the cold block and verify through the signal I/O that it turns on and off
Bad PMT
Replace PMT
Bad Preamp
Replace Preamp


BAD ELECTRICAL TEST
Bad Preamp
Replace Preamp
Bad Cabling
Replace cables going from preamp to motherboard
Bad Motherboard
Replace Motherboard (5 Year warranty part)

## UNSTABLE READING AT ZERO, ZERO NOISE

| Cause | Action |
| --- | --- |
| Leak in the analyzer | **Perform a leak check on the analyzer. Cap the sample inlet and the drier inlet and make sure the sample pressure drops <10” and is equal to the Rcell pressure to within 0.2”** |
| Internal charcoal depleted | **Replace charcoal and check with a known zero source** |
| Dirty sample tubing or sample filter | **Replace tubing or sample filter** |
| Zero air contaminated | **Switch zero air sources or replace scrubber material in current source of zero air** |
| Dirty reaction cell and PMT filter | **Open reaction cell and clean with distilled or de-ionized water and a lint free cloth only. Also make sure to clean the 665ηM PMT filter. If it won’t come clean or is scratched, replace the filter.** |
| Pressure difference from NO to NOx | **Watch the sample pressure. If it changes more than 0.5” between NO and NOx, bypass the converter. If the pressure is now stable replace the converter, if not replace the NO/NOx valves** |
| Excessive dark PMT noise | **Clean PMT contact leads with alcohol. If still noisy, Replace PMT** |
| Excessive dark HVPS noise | **Clean HVPS contact sockets with alcohol. If still noisy, Replace HVPS** |
| Excessive dark preamp Noise | **Clean shielded preamp area with alcohol. If still noisy, replace preamp board** |

# UNSTABLE READING AT SPAN, SPAN NOISE

| Cause | Action |
|---|---|
| Leak in the analyzer | **Perform a leak check on the analyzer. Cap the sample inlet and the drier inlet and make sure the sample pressure drops <10" and is equal to the Rcell pressure to within 0.2"** |
| Sample inlet filter dirty | **Replace sample filter** |
| Noisy high voltage power supply | **Clean HVPS sockets with alcohol. If still noisy, replace HVPS** |
| Contaminated Reaction cell | **Open reaction cell and clean with distilled or de-ionized water and a lint free cloth only. Also make sure to clean the 665ηM PMT filter. If it won't come clean or is scratched, replace the filter.<br>Clean Reaction cell with Distilled/De-ionized water** |
| Bad Converter | **Bypass the converter. If the reading is now stable, then replace the converter** |
| Bad A-zero or NOx/NO valve | **Replace the suspect valve. The A-zero reading should be the same on zero and span. If it is not, then the a-zero valve is bad. The pressure between the NO and NOx modes should not differ more then 0.5". If it is, then the NO/NOx valve is bad.** |
| Noisy PMT | **Clean PMT leads with alcohol. If still noisy, replace PMT** |
| Unstable $O_3$ Generator | **Replace ozone generator** |
| Noisy preamp | **Clean preamp circuitry with alcohol. Make sure to clean under the ground shield and on both sides of the preamp** |

## UNABLE TO ZERO (NO ZERO BUTTON)

| Cause | Action |
|---|---|
| Leak in the analyzer | **Perform a leak check on the analyzer. Cap the sample inlet and the drier inlet and make sure the sample pressure drops <10" and is equal to the Rcell pressure to within 0.2"** |
| Internal charcoal depleted | **Replace charcoal and check with a known zero source** |
| Dirty sample tubing or sample filter | **Replace tubing or sample filter** |
| Zero air contaminated | **Switch zero air sources or replace scrubber material in current source of zero air** |
| Auto-zero too high | **This could be caused by the HVPS, PMT, or preamp having too much dark current. Try cleaning each device and if that doesn't help replace each one until the culprit is found. It could also be because of contamination in the reaction cell. Clean the reaction cell with distilled/de-ionized water.** |
| HVPS gain too high | **Not enough light is getting to the PMT. This is either caused because of low flow rates or a dirty 665ηM PMT filter. Check flows and clean PMT filter.** |

## UNABLE TO SPAN (NO SPAN BUTTON OR NO RESPONSE TO SPAN)

| Cause | Action |
|---|---|
| Leak in the analyzer | **Perform a leak check on the analyzer. Cap the sample inlet and the drier inlet and make sure the sample pressure drops <10” and is equal to the Rcell pressure to within 0.2”** |
| No Flow or Low Flow | **Measure sample flow and ozone flow. Replace filters. If still no flow, check for flow restrictions in the tubing.** |
| Rcell pressure too high | **Rcell pressure should be <10”Hg. If it is higher than 10", rebuild the pump.** |
| Dirty PMT filter | **Clean or Replace 665ηM PMT filter** |
| Perform optical and electrical tests | **See Troubleshooting Trees regarding optical and electrical tests** |
| Concentration too far from target or the slope is too far out. | **If all other testing looks good, perform a factory calibration on the analyzer to get the slopes back to 1.000 +- 0.3** |

## NON-LINEAR RESPONSE

| Cause | Action |
|---|---|
| Leak in the analyzer | **Perform a leak check on the analyzer. Cap the sample inlet and the drier inlet and make sure the sample pressure drops <10” and is equal to the Rcell pressure to within 0.2”** |
| Slope out of spec. 1.00 +- 0.3 | **Perform a factory calibration on the analyzer to get the slopes back to 1.00 +- 0.3** |
| Flow rates incorrect | **Measure flow rates. Should be 500cc/min for sample and 80cc/min for ozone** |
| Improper zero/span | **Check zero and span points again. Wait 15 minutes on each gas, and make sure they are correct** |
| Bad bottle of gas | **Try a new bottle of gas. Re-zero and re-span then check the linearity again** |
| Calibrator not correct | **Re-check the calibration of your MFCs** |
| Bad ozone generator | **If the analyzer reads correctly at your span point but high on your linearity points, then the ozone generator might not be outputting enough ozone. Replace ozone generator to fix the problem** |

## SLOW RESPONSE TO ZERO OR SPAN

| Cause | Action |
|---|---|
| Leak in the analyzer | **Perform a leak check on the analyzer. Cap the sample inlet and the drier inlet and make sure the sample pressure drops <10” and is equal to the Rcell pressure to within 0.2”** |
| Low flow | **Measure the Flow with an external flow meter. It should be 500cc +- 10%. If not replace filters and look for restrictions.** |
| Contaminated sample filter | **Replace sample particulate filter, taking care not to touch it with your fingers. Use a glove if necessary.** |
| Contaminated reaction cell | **Clean the reaction cell with distilled/de-ionized water and a lint free cloth.** |
| Gas to the analyzer is taking too long to get to the analyzer | **Input span/zero gas and wait until the analyzer is stable. Disconnect the sample inlet to the analyzer but let the cal gas keep flowing. Wait 5 minutes. Reconnect the sample line. If it goes right to the concentration you expect or closer than it was when you disconnected the tubing, then the calibration system is the problem.** |

## HVPS WARNING AFTER FACTORY CALIBRATION

| Cause | Action |
|---|---|
| Leak in the analyzer | **Perform a leak check on the analyzer. Cap the sample inlet and the drier inlet and make sure the sample pressure drops <10" and is equal to the Rcell pressure to within 0.2"** |
| Low flow rates | **Measure the flow rates. Should be 500cc/min for sample and 80cc/min for ozone +- 10%. If they are low replace the filters** |
| Dirty PMT filter | **Clean or Replace the 665ηM PMT filter** |

## AUTO-ZERO WARNING

- Auto-Zero valve bad
  - **Record the A-Zero reading after 15minutes on span and then 15 minutes 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 15 minutes, 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.**

## NO FLOW

| | |
|---|---|
| Front panel particulate filter dirty | **Replace front panel particulate filter** |
| Stainless steel sintered filter dirty | **Replace the sintered filter in front of the critical flow orifices, located underneath the fittings on top of the reaction chamber.** |
| Rcell pressure is >14"Hg | **Check for leaks between the pump and the analyzer. If there are no leaks, rebuild the pump.** |
| Pump seized up or not turning | **Replace the entire pump** |
| Pump diaphragm torn | **Rebuild the pump** |
| Crimped tubing or other flow restriction in the lines | **Go through the entire analyzer looking for any bent or pinched tubing, especially near the front panel and rear panel. Disconnect tubing at various locations in the analyzer checking for flow to narrow the problem down** |

## NO ANALOG OR INCORRECT ANALOG OUTPUT

| | |
|---|---|
| Outputs not properly calibrated | **Perform an analog output calibration. Refer to service note 03-020** |
| Output set for voltage or current when it should be the other | **Look at the motherboard on the rear panel and J19, J21, and J23. Each connector that has a small circuit board about 2" by 1" is configured for current. If it has two shunts across the two left pins, or a small ½" by ½" circuit board, it is configured for voltage.** |
| Bad motherboard | **Replace motherboard. (5 year warranty part)** |
| Noisy outputs | **Needs analog output stabilizer board (KIT000214)** |

## ANY TEMPERATURE WARNING

- **Bad relay** — Toggle the heater on and off in the Signal I/O menu while measuring the AC voltage going to the heater. This should switch between 0V and line voltage. If the LED is turning on and off but the voltage isn't changing, the relay is bad.
- **Bad thermistor** — Measure the resistance of the thermistor in question. It should be around 25K ohms at room temperature. As the temperature goes up, the resistance will go down. If the thermistor reads open or a short, it is bad.
- **Bad heater** — Measure the resistance of the heater. It should be less than 1K ohms in most cases. If it is open or shorted, it is bad

*Model 200E Training Manual*

# Warranty/Repair Questionnaire Model 200E

_______________________

CUSTOMER:______________________________PHONE:____________________________

CONTACT NAME:________________________ FAX NO. ________________________

SITE ADDRESS: ______________________________________________________

MODEL 200E 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 |
| **NOx STAB** | PPB/PPM | ≤ 1 PPB WITH ZERO AIR |
| **SAMPLE FLOW** | $CM^3$ | 500 ± 50 |
| **OZONE FLOW** | $CM^3$ | 80 ± 15 |
| **PMT SIGNAL WITH ZERO AIR** | MV | -20 TO 150 |
| **PMT SIGNAL AT SPAN GAS CONC** | MV<br>PPB | 0-5000MV<br>0-20,000 PPB |
| **NORM PMT SIGNAL AT SPAN GAS CONC** | MV<br>PPB | 0-5000MV<br>0-20000PPB |
| **AZERO** | MV | -20 TO 150 |
| **HVPS** | V | 400 – 900 |
| **RCELL TEMP** | ºC | 50 ± 1 |
| **BOX TEMP** | ºC | AMBIENT ± 5ºC |
| **PMT TEMP** | ºC | 7 ± 2ºC |
| **IZS TEMP*** | ºC | 50 ± 1ºC |
| **MOLY TEMP** | ºC | 315 ± 5ºC |
| **RCEL PRESS** | IN-HG-A | <10 |
| **SAMP PRESS** | IN-HG-A | AMBIENT ± 1 |
| **NOx SLOPE** | | 1.0 ± 0.3 |
| **NOx 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 | |

| | | | |
|---|---|---|---|
| **REF_4096_MV** | | MV | 4096mv ±2mv Must be Stable |
| **REF_GND** | | 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.

# 7. SPECIFICATIONS

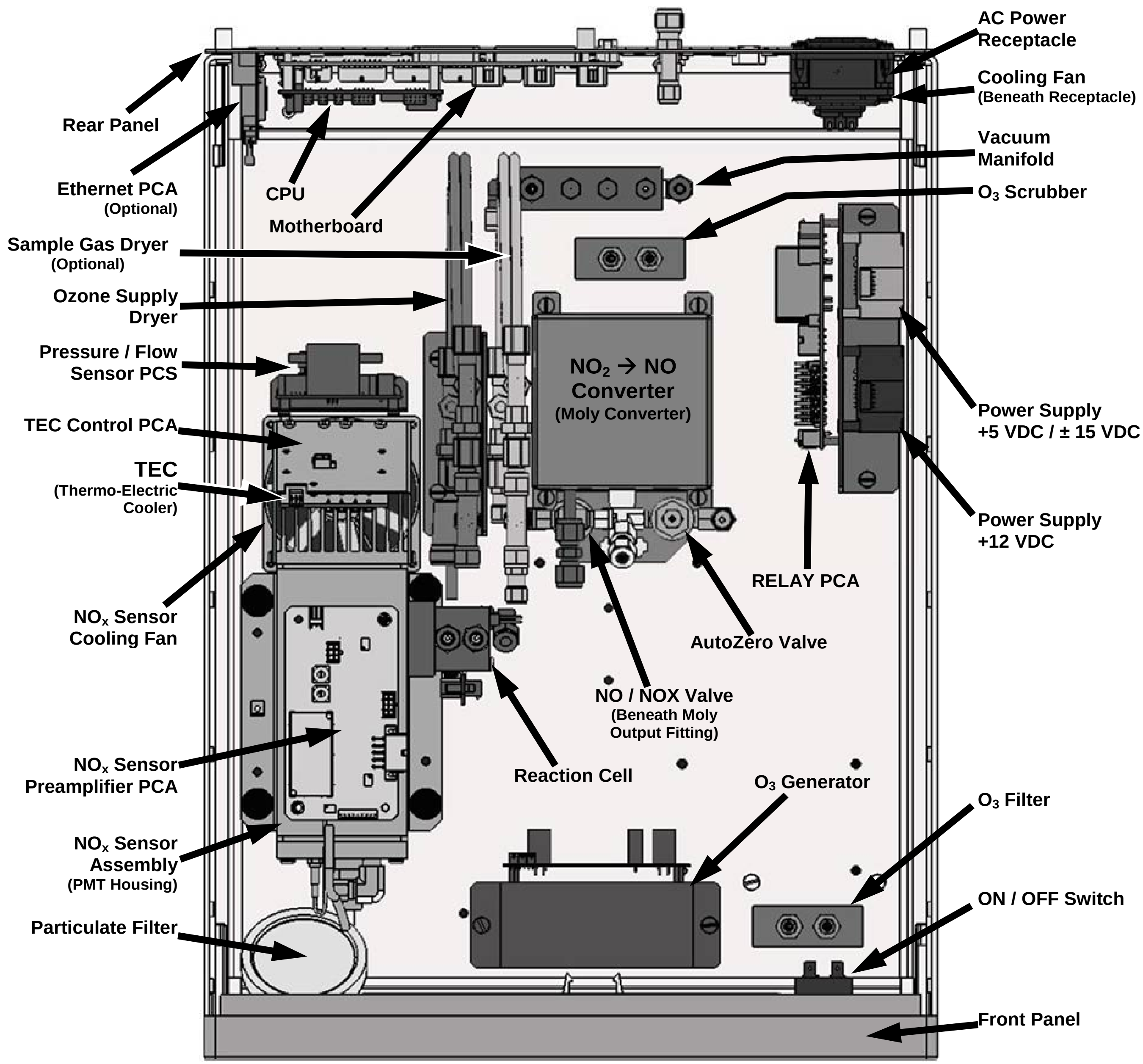
# Specifications

Model 200E Basic Unit Specifications

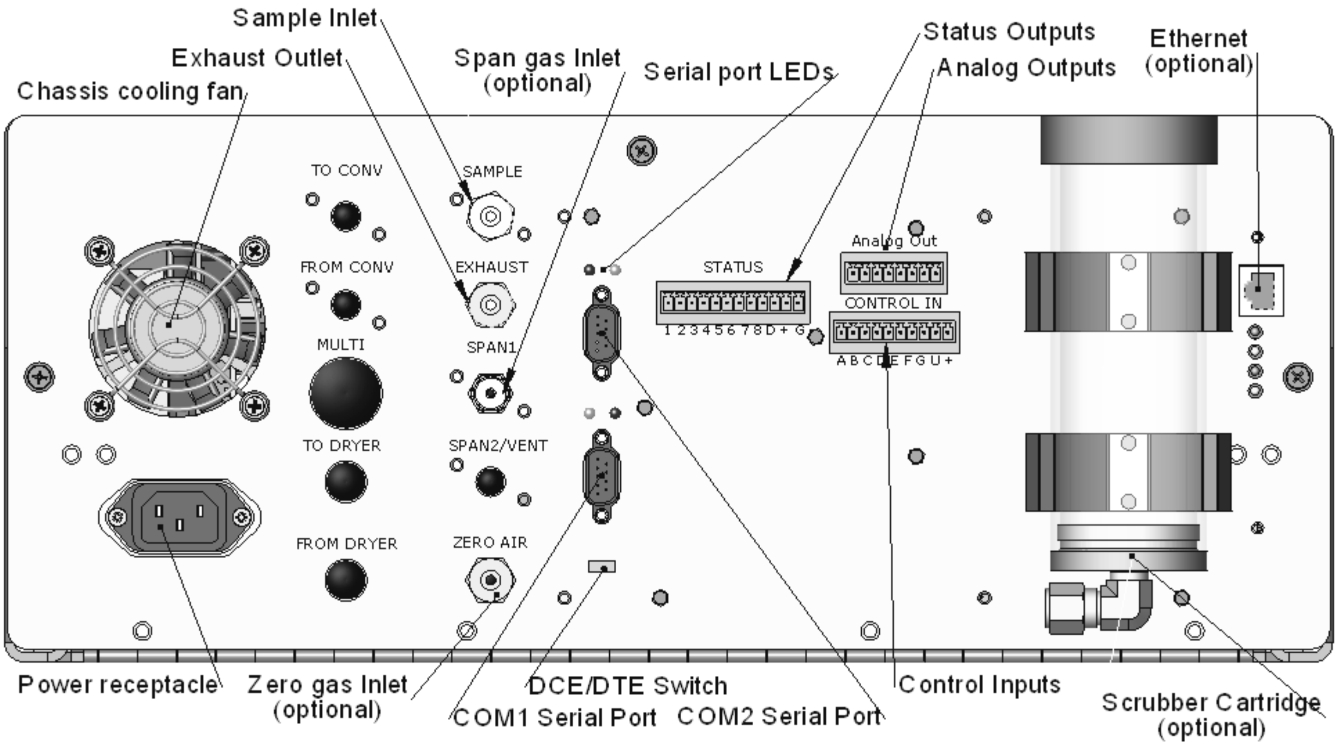
| | |
|---|---|
| Min/Max Range (Physical Analog Output) | Min: 0-50 ppb<br>Max: 0-20 ppm |
| Measurement Units | ppb, ppm, µg/m$^3$, mg/m$^3$ (user selectable) |
| Zero Noise[1] | 0.2 ppb (RMS) |
| Span Noise[1] | <0.5% of reading above 50 ppb or 0.2 ppm, whichever is greater |
| Lower Detectable Limit[2] | 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 $^o$C |
| Voltage Coefficient | < 0.1% per V |
| Lag Time[1] | 20 s |
| Rise/Fall Time[1] | 95% in <60 s |
| Sample Flow Rate | 500 cm$^3$/min. ± 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);<br>115 V, 60 Hz (3.0 A);<br>220 - 240 V, 50/60 Hz (2.5 A) |
| Power, Ext Pump | 100 V, 50/60 Hz (3.25A);<br>115 V, 60 Hz (3.0 A);<br>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)<br>Three outputs convertible to 4-20 mA isolated current loop.<br>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)<br>Communication speed: 300 - 115200 baud (user selectable) |
| Certifications | USEPA: Reference Method Number RFNA 1194-099<br>CE: EN61326 (1997 w/A1: 98) Class A, FCC Part 15 Subpart B Section 15.107 Class A, ICES-003 Class A (ANSI C63.4 1992) & AS/NZS 3548 (w/A1 & A2; 97) Class A |

[1] As defined by the USEPA.
[2] Defined as twice the zero noise level by the USEPA.

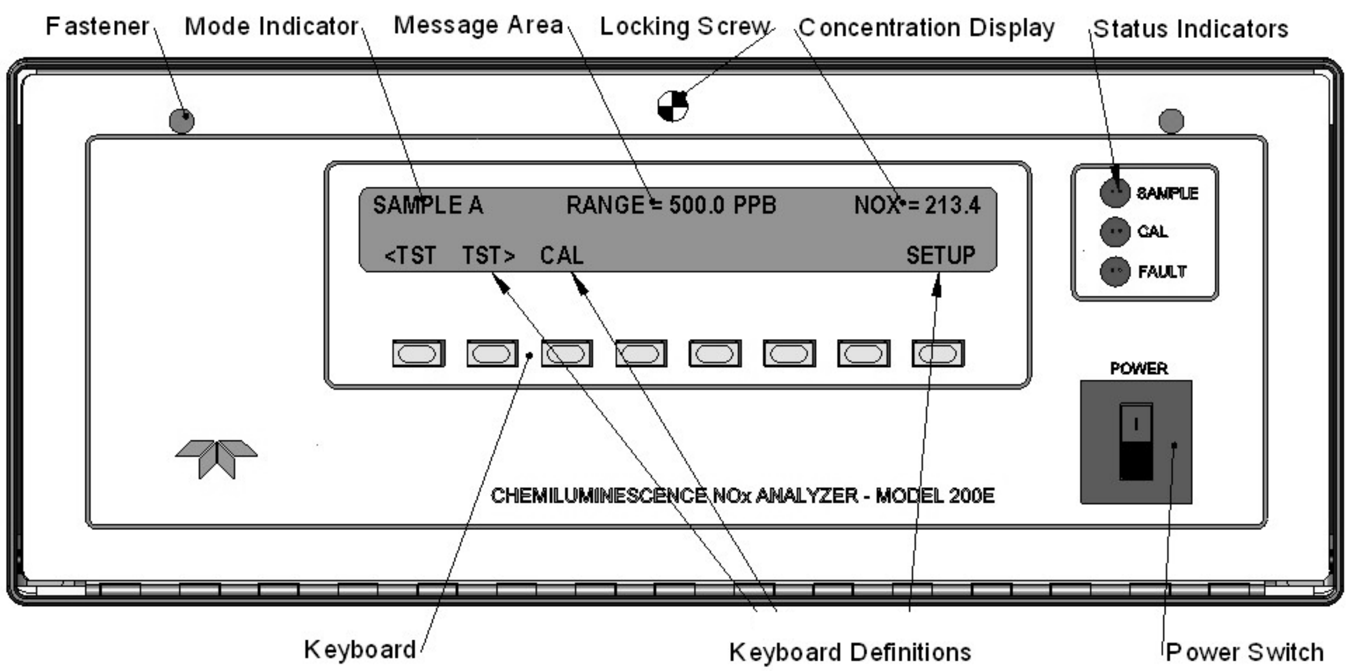
# 8. MISC DIAGRAMS



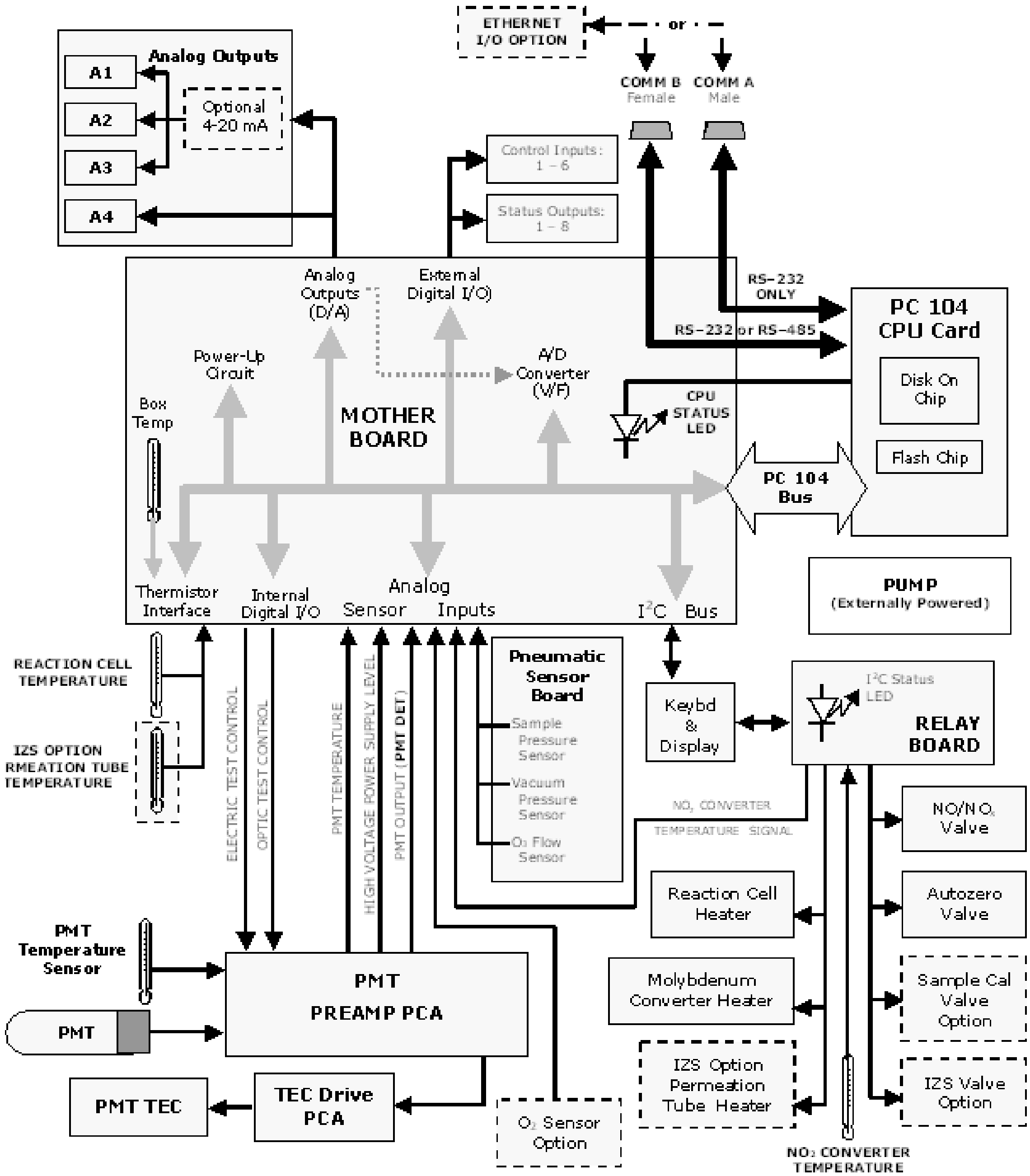

**M200E Layout**




**M200E Rear Panel Layout**




**M200E Front Panel Layout**




**M200E Electronic Block Diagram**

# 9. OTHER NOX ANALYZERS

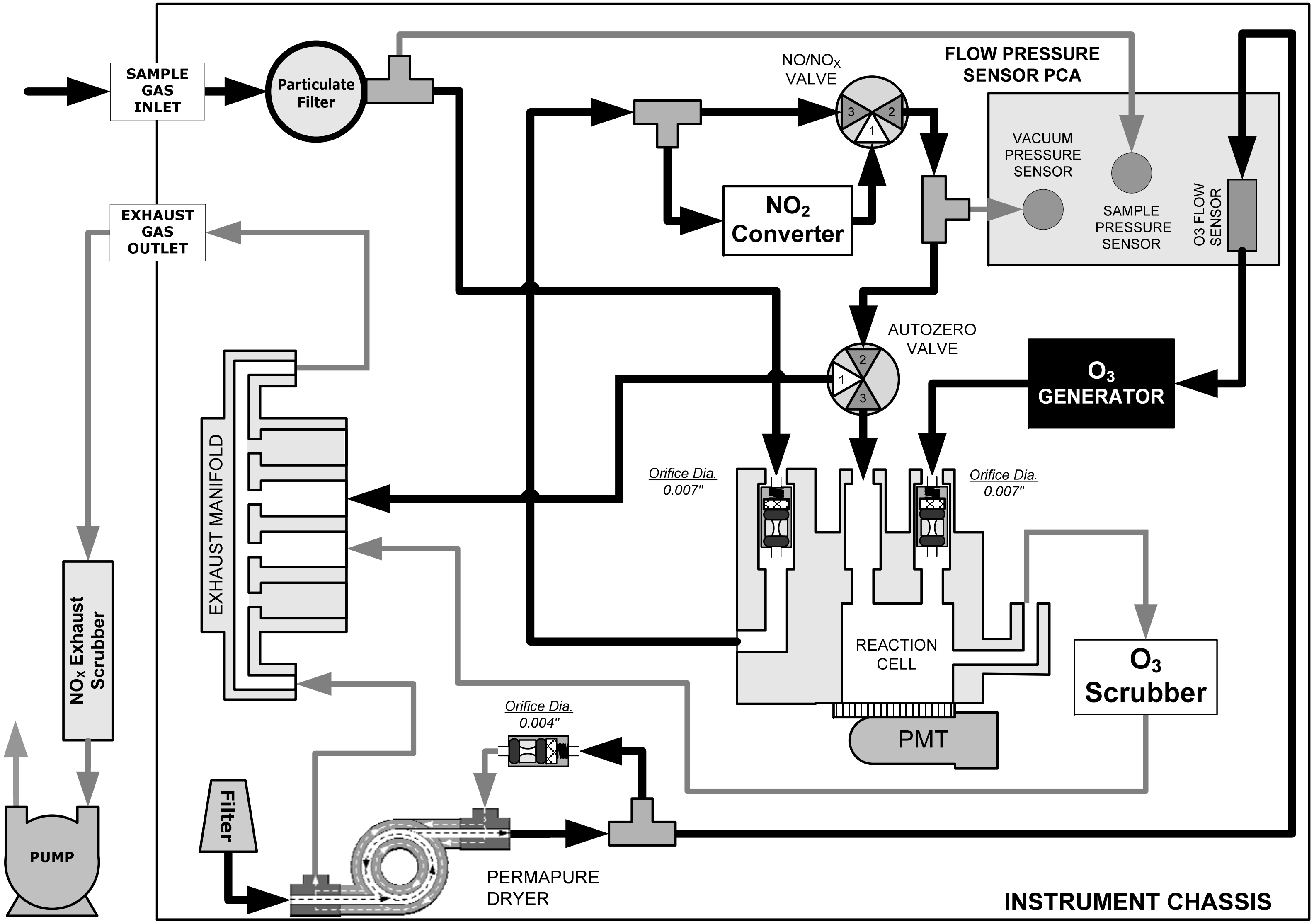
# M200EM

The M200EM is a mid-level NOx analyzer, designed to measure NOx in the ranges of 1ppm-200ppm. The principle of operation is exactly the same as the standard M200E NOx analyzer. There are only a few differences that allow the M200EM to read higher concentrations of NOx gas than the M200E.

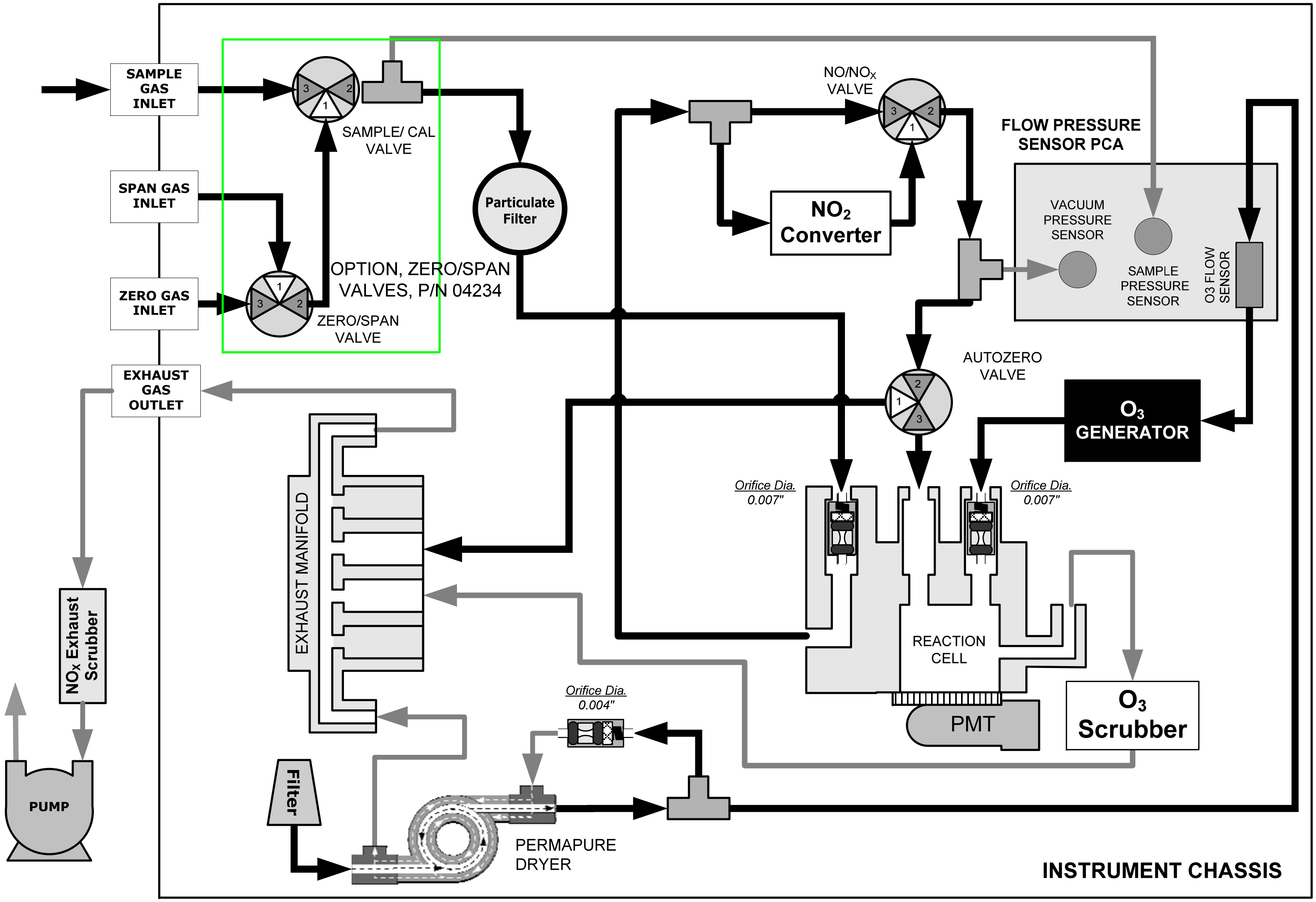
The first and main difference between the two analyzers is the flow rates. In order to read higher concentrations of NOx gas we must increase the amount of ozone flowing to the chamber and decrease the amount of NOx flowing to the reaction cell. See the flow chart below.

**M200EM Gas Flow Rates**

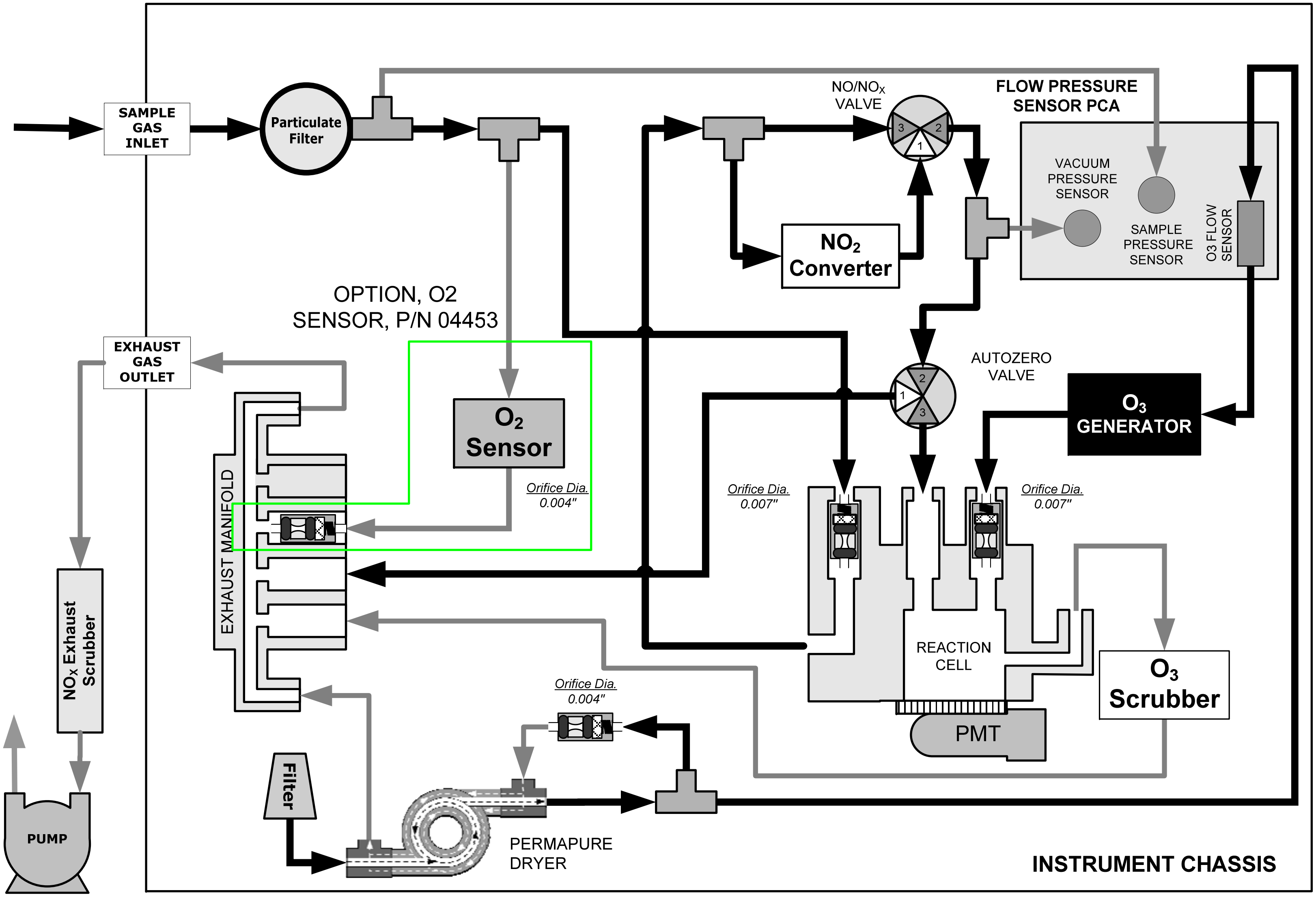
| **Location** | **Purpose** | **Orifice Diameter** | **Flowrate** (nominal) |
|---|---|---|---|
| In 3rd port of reaction cell (bypass flow) | Controls rate of flow of sample gas into the reaction cell. | 0.007" (7mil) | 250 $cm^3$/min |
| $O_3$ supply inlet of reaction cell. | Controls rate of flow of ozone gas into the reaction cell. | 0.007" (7mil) | 250 $cm^3$/min |
| Dry air return of Perma Pure® dryer | Controls flow rate of dry air return / purge air of the dryer. | 0.004" (4mil) | 80 $cm^3$/min |
| Vacuum manifold, $O_2$ flow orifice | Controls rate of flow of $O_2$ gas through the $O_2$ sensor. (Optional) | 0.004" (4mil) | 80 $cm^3$/min |




**M200EM Pneumatic Schematic**




**M200EM Pneumatic Schematic with Z/S valves option**

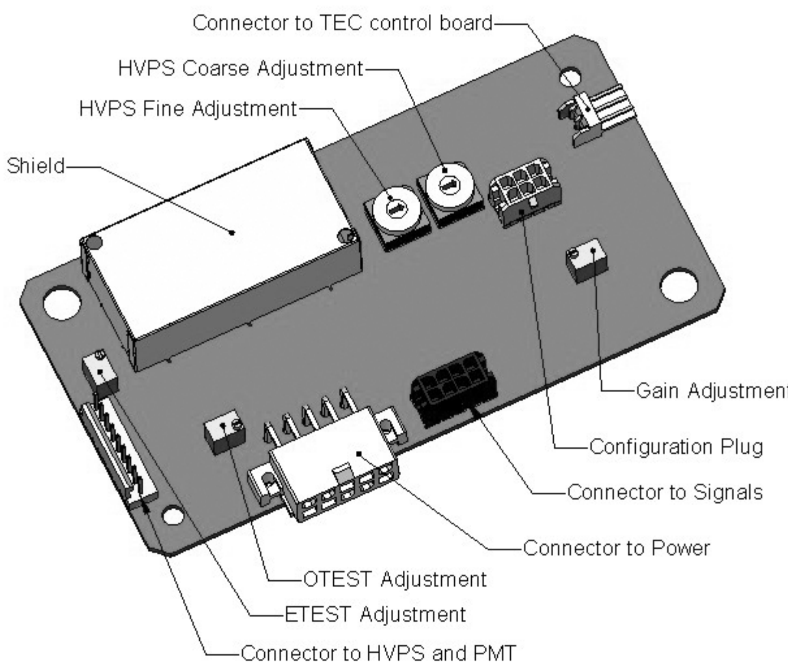



**M200EM Pneumatic Schematic with $O_2$ sensor**

# Factory Calibration for a M200EM

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

- Let the instrument run for one hour to stabilize all.  This is required to ensure proper scaling of the **NORM PMT** value.
- 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 0.5ppm, 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 20.0 ppm and below you will want to use the first equation, with a range 20.1ppm and above you will use the second equation.

  CONC=Span Gas in PPM

  Ranges 20.0 and below
  **TARGET NORM PMT=(200*CONC)**
  Ranges 20.1 and above
  **TARGET NORM PMT=(18.18*CONC)**
- 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 as possible 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 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±0.100 and the offset values should be -20 to +150 mV.

# Model 200EH/EM Basic Unit Specifications

| | |
|---|---|
| Min/Max Range<br>(Physical Analog Output) | 200EH: Min: 0-5 ppm; Max: 0-5000 ppm<br>200EM: Min: 0-1 ppm; Max: 0-200 ppm |
| Measurement Units | ppm, mg/$m^3$ (user selectable) |
| Zero Noise | <20 ppb (RMS) |
| Span Noise | <0.2% of reading above 20 ppm |
| Lower Detectable Limit | 40 ppb (2x noise as per USEPA) |
| Zero Drift (24 hours) | <20 ppb (at constant temperature and voltage.) |
| Zero Drift (7 days) | <20 ppb (at constant temperature and voltage.) |
| Span Drift (7 Days) | <1% of reading (at constant temperature and voltage.) |
| Linearity | 1% of full scale |
| Precision | 0.5% of reading |
| Lag Time | 20 s |
| Rise/Fall Time | 95% in <60 s (~10 s in NO only or $NO_X$ only modes) |
| Gas Flow Rates | 200EH: -40 $cm^3$/min sample gas through $NO_2$ converter & sensor module<br>-250 $cm^3$/min ± 10% though bypass manifold;<br>-290 $cm^3$/min total flow<br>200EM: -250 $cm^3$/min sample gas through $NO_2$ converter & sensor module<br>$O_2$ Sensor option adds 80 $cm^3$/min to total flow though M200EH/EM when installed; |
| Temperature Range | 5 - 40 °C operating range |
| 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) without options |
| Weight, Ext Pump Pack | 7 kg (16 lbs) |
| AC Power Rating | 100 V, 50/60 Hz (3.25A);<br>115 V, 60 Hz (3.0 A);<br>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);<br>220 - 240 V, 50/60 Hz (2.5 A) |
| Environmental | Installation category (over-voltage category) II; Pollution degree 2 |
| Analog Outputs | 4 user configurable outputs |
| Analog Output Ranges | All Outputs: 0.1 V, 1 V, 5 V or 10 V<br>Three outputs convertible to 4-20 mA isolated current loop.<br>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 |
| Alarm outputs | 2 relay alarms outputs (Optional equipment) with user settable alarm limits<br>- 1 Form C: SPDT; 3 Amp @ 125 VAC |
| Serial I/O | 1x RS-232; 1x RS-485 or RS-232 (configurable)<br>Communication speed: 300 - 115200 baud (user selectable) |
| Certifications | CE: EN61326 (1997 w/A1: 98) Class A, FCC Part 15 Subpart B Section 15.107 Class A,<br>ICES-003 Class A (ANSI C63.4 1992) & AS/NZS 3548 (w/A1 & A2; 97) Class A. |

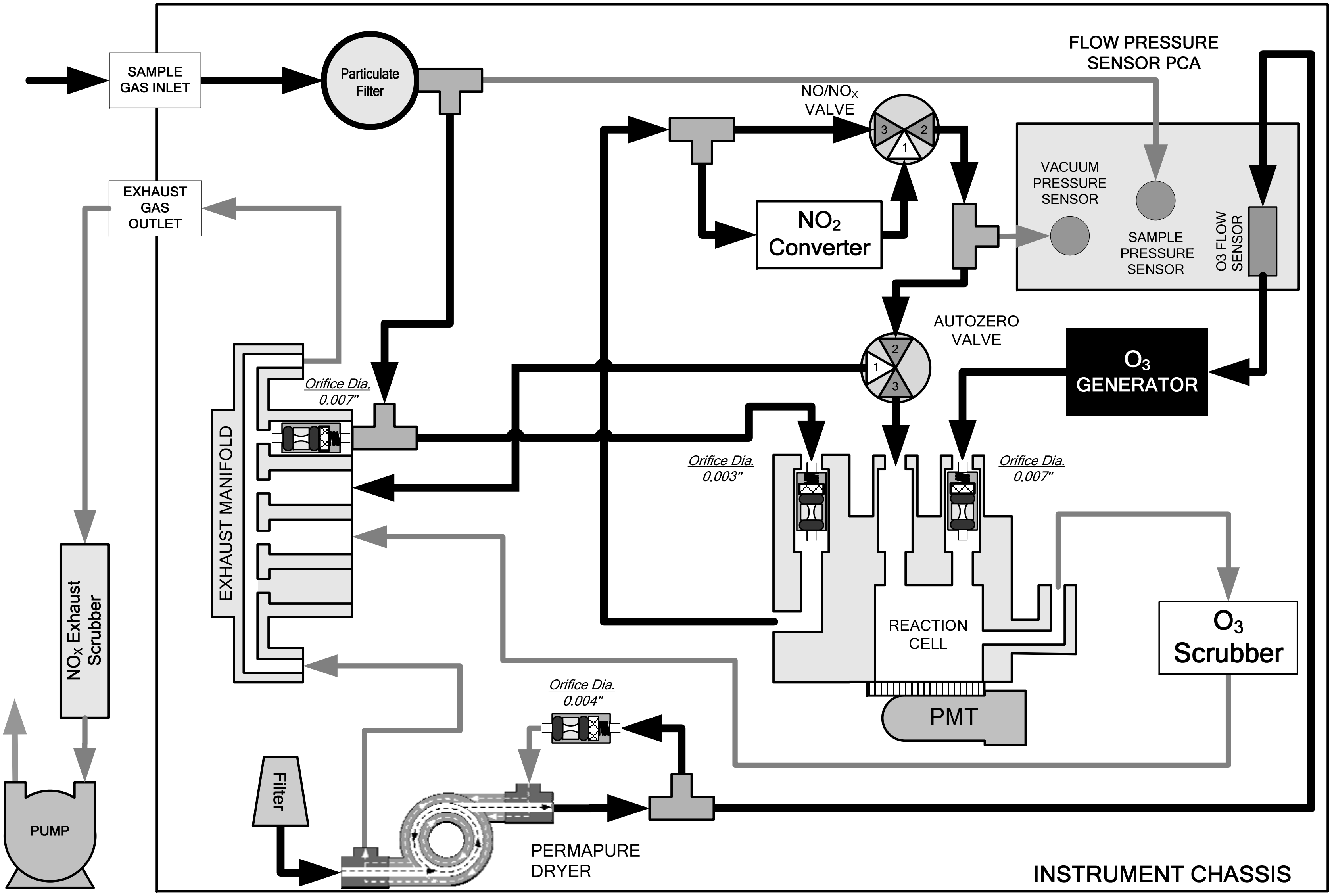
# M200EH

The M200EH is a high-level NOx analyzer, designed to measure NOx in the ranges of 5ppm-5000ppm. The principle of operation is exactly the same as the standard M200E NOx analyzer. There are only a few differences that allow the M200EH to read higher concentrations of NOx gas then the M200E.

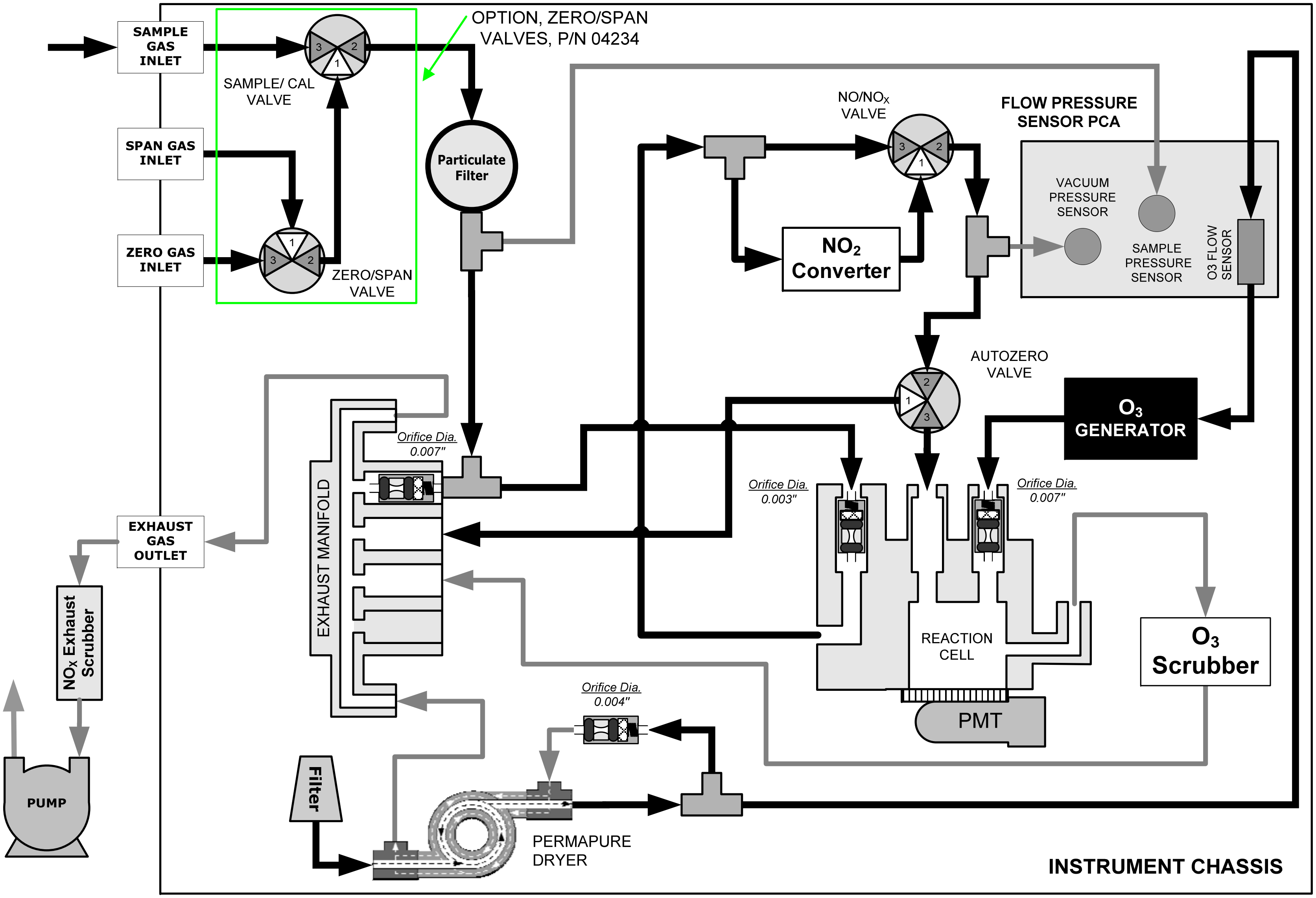
The first and main difference between the two analyzers is the flow rates. In order to read higher concentrations of NOx gas we must increase the amount of and decrease the amount of NOx flowing to the reaction cell. See the flow chart below.

**M200EH Gas Flow Rates**

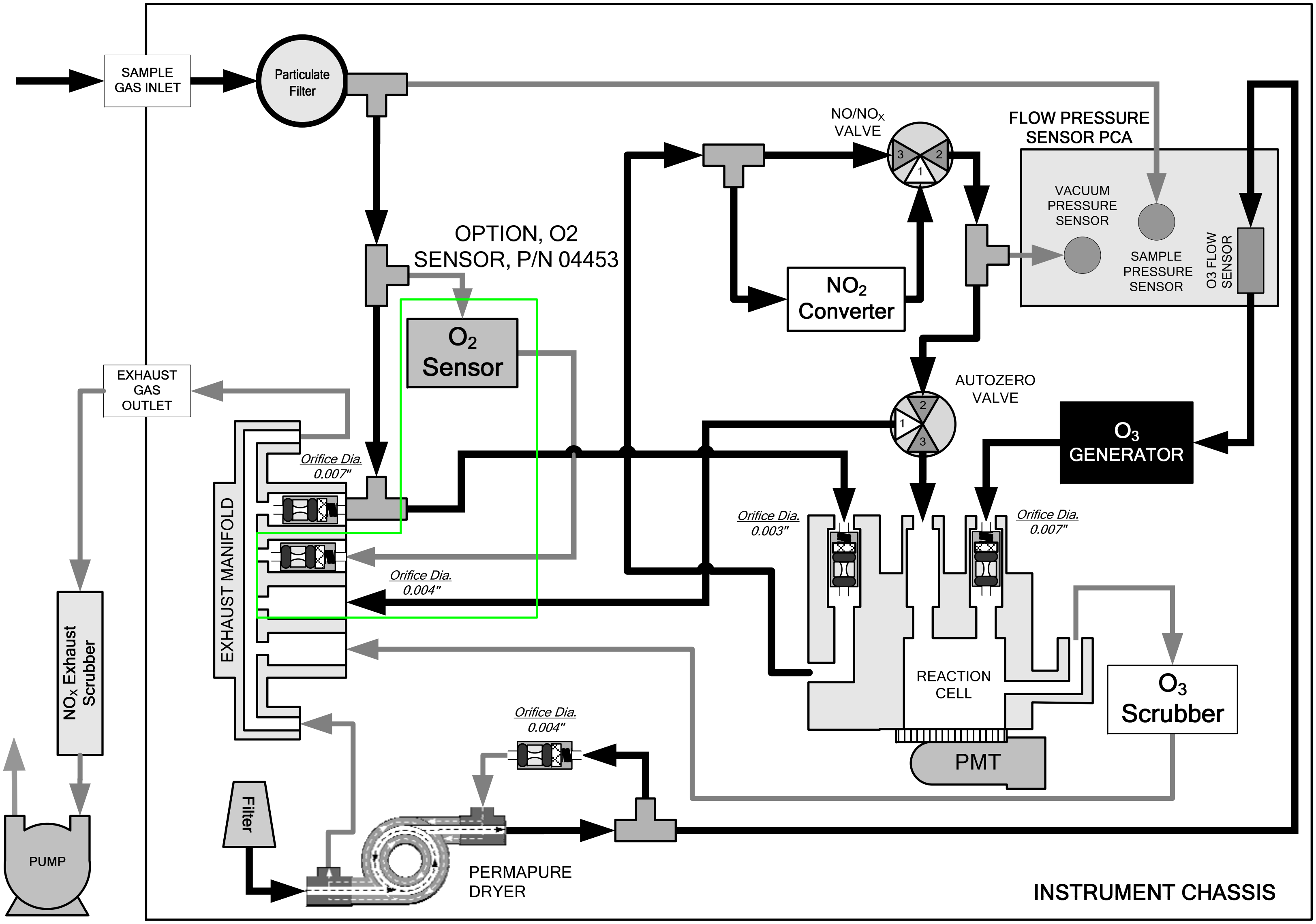
| **Location** | **Purpose** | **Orifice Diameter** | **Flowrate** (nominal) |
|---|---|---|---|
| In 3rd port of reaction cell (bypass flow) | Controls rate of flow of sample gas into the reaction cell. | 0.003" (3mil) | 50 $cm^3$/min |
| $O_3$ supply inlet of reaction cell. | Controls rate of flow of ozone gas into the reaction cell. | 0.007" (7mil) | 250 $cm^3$/min |
| Dry air return of Perma Pure® dryer | Controls flow rate of dry air return / purge air of the dryer. | 0.004" (4mil) | 80 $cm^3$/min |
| Vacuum Manifold, Bypass flow orifice | Controls flow rate of the bypass flow. | 0.007" (7mil) | 250 $cm^3$/min |
| Vacuum Manifold, $O_2$ flow orifice | Controls rate of flow of $O_2$ gas through the $O_2$ sensor. (Optional) | 0.004" (4mil) | 80 $cm^3$/min |




**M200EH Pneumatic Schematic**




**M200EH Pneumatic Schematic with Z/S valves option**

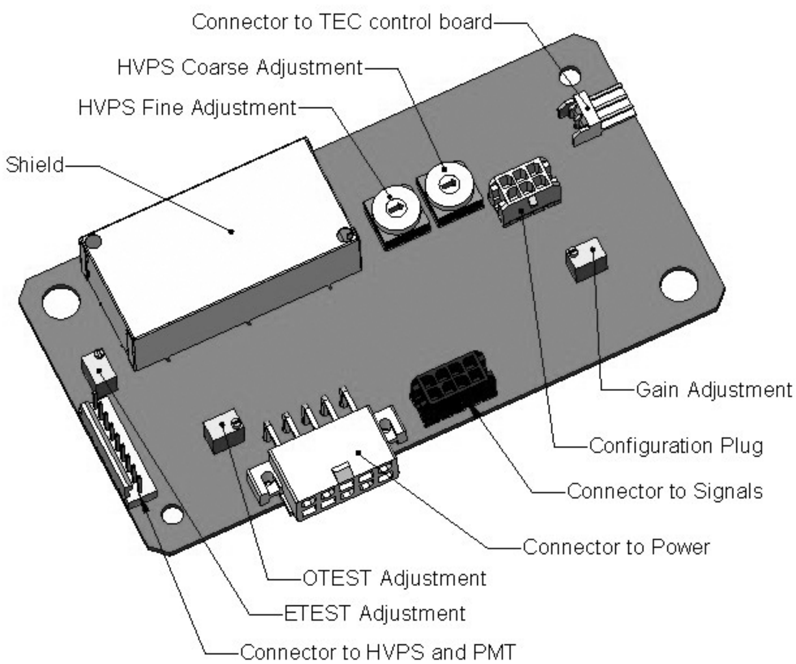



**M200EH Pneumatic Schematic with O2 option**

# Factory Calibration for a M200EH

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

- Let the instrument run for one hour to stabilize all. This is required to ensure proper scaling of the **NORM PMT** value.
- 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 0.5ppm, 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 500.0ppm and below you will want to use the first equation, with a range 500.1ppm and above you will use the second equation.

  CONC=Span Gas in PPM

  Ranges 500.0 and below

  **TARGET NORM PMT=(8*CONC)**

  Ranges 500.1 and above

  **TARGET NORM PMT=(0.727*CONC)**
- 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 as possible 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 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±0.100 and the offset values should be -20 to +150 mV.

# *Service Note*

9480 Carroll Park Drive, San Diego, CA 92121-2251
Phone (858) 657-9800 Fax: (858) 657-9818 Toll Free 1800 324-5190
E-MAIL: API-CUSTOMERSERVICE@TELEDYNE.COM HTTP://WWW.TELEDYNE-API.COM

***06-010B***
***18 JUNE, 2008***

## PROPER ADJUSTMENT OF AN O2 SENSOR IN AN "E" SERIES ANALYZER

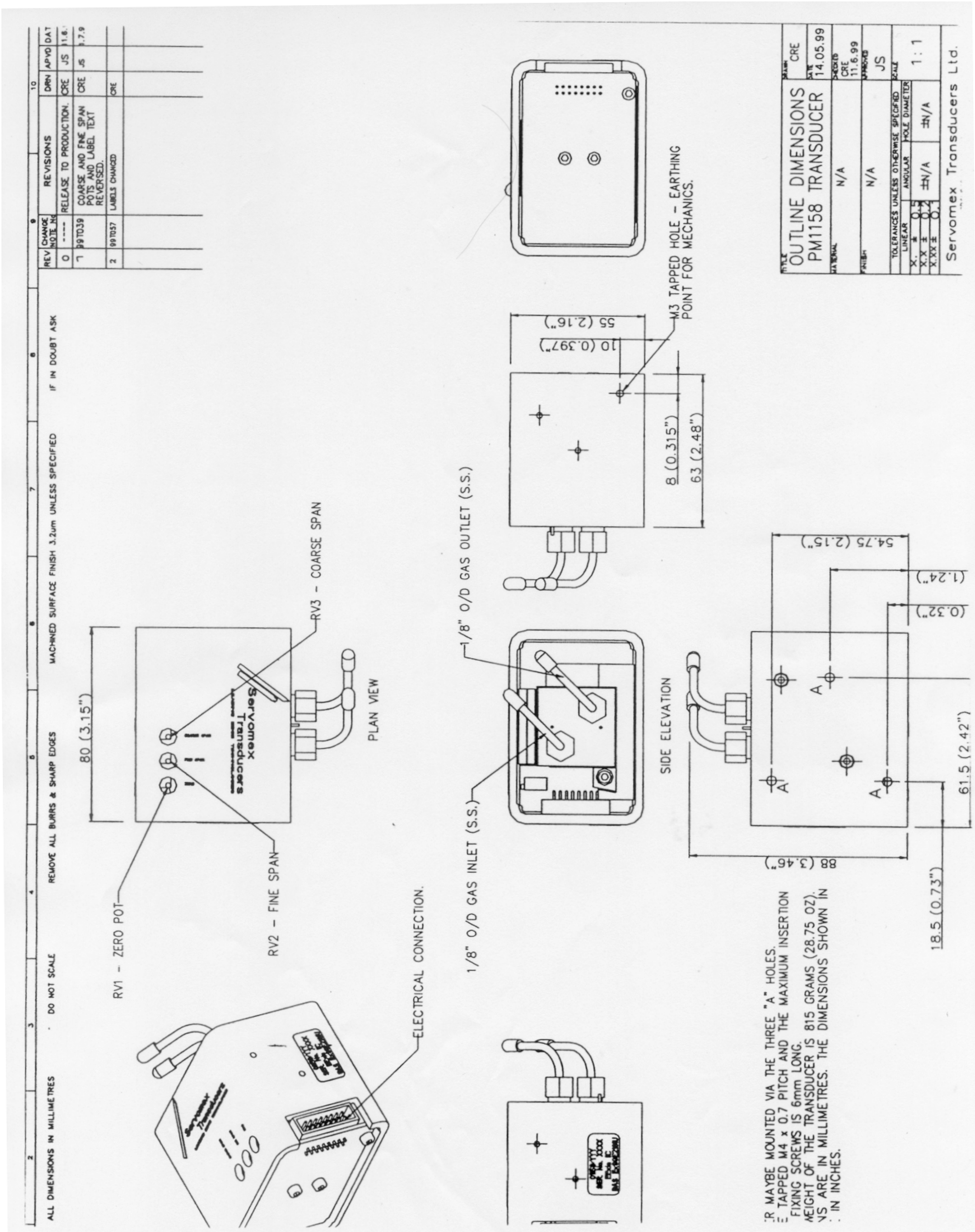
**I. PURPOSE:**
This service note provides instructions for properly adjusting the $O_2$ sensor in an "E" series analyzer.

**II. TOOLS:**
Potentiometer adjustment tool
Phillips head screwdriver
Slot head screwdriver

**III. PARTS:**
None

**IV. PROCEDURE:**

1. Remove cover from analyzer.
2. Input $N_2$ (or other $O_2$ free gas) to analyzer.
3. Monitor the voltage of the sensor in the Signal I/O, SETUP – MORE - DIAG - ENTR - SIGNAL I/O – ENTR – NEXT…. until ….O2_SENSOR.
4. After the analyzer has been on $N_2$ for 5 minutes, observe the voltage. If the voltage is not 0±5mV, you will need to adjust the zero pot on the $O_2$ sensor. This is done by removing the cover from the $O_2$ sensor and locating the three potentiometers on the $O_2$ sensor. Adjust the potentiometer marked "Zero" until the voltage reads 0±5mV (see attached drawing).
5. Exit to the main menu, allow the analyzer to stabilize for 5 minutes. Press CAL-O2-ENTR-ZERO-ENTR to zero the analyzer's $O_2$ channel.
6. Input $O_2$ span gas to the analyzer.
7. After the analyzer has been measuring the $O_2$ span gas for 5 minutes, go back to the O2_SENSOR in the Signal I/O and observe the voltage.
8. The correct voltage is based on the value of the span gas. Calculate using the following formula: $O_2$ concentration times 10 = voltage in mV. (I.E. For 20.9% $O_2$ this equals 209mV. For 22.5% this equals 225mV.)
9. If the voltage is not equal to the calculated voltage within ±5mV, you will need to adjust the $O_2$ sensor span potentiometer. Locate the "Coarse Span" and "Fine Span" potentiometers on the $O_2$ sensor. Adjust them as needed until the voltage is equal to the calculated voltage ±5mV.
10. Exit to the main menu and allow the analyzer to stabilize for 5 minutes.
11. Press CAL-O2-ENTR-CONC and enter the value of the span gas in percent. EXIT to the main menu.
12. Press CAL-O2-ENTR-SPAN-ENTR to span the $O_2$ sensor.


OUTLINE DIMENSIONS PM1158 TRANSDUCER
Servomex Transducers Ltd.
ALL DIMENSIONS IN MILLIMETRES
DO NOT SCALE
REMOVE ALL BURRS & SHARP EDGES
MACHINED SURFACE FINISH 3.2um UNLESS SPECIFIED
IF IN DOUBT ASK
REVISIONS
RELEASE TO PRODUCTION.
COARSE AND FINE SPAN POTS AND LABEL TEXT REVERSED.
LABELS CHANGED
RV1 - ZERO POT
RV2 - FINE SPAN
RV3 - COARSE SPAN
ELECTRICAL CONNECTION.
1/8" O/D GAS INLET (S.S.)
1/8" O/D GAS OUTLET (S.S.)
PLAN VIEW
SIDE ELEVATION
M3 TAPPED HOLE - EARTHING POINT FOR MECHANICS.
80 (3.15")
55 (2.16")
10 (0.397")
8 (0.315")
63 (2.48")
54.75 (2.15")
(1.24")
(0.32")
61.5 (2.42")
88 (3.46")
18.5 (0.73")
TAPPED M4 x 0.7 PITCH AND THE MAXIMUM INSERTION
FIXING SCREWS IS 6mm LONG.
WEIGHT OF THE TRANSDUCER IS 815 GRAMS (28.75 OZ).
ARE IN MILLIMETRES. THE DIMENSIONS SHOWN IN
IN INCHES.
14.05.99
11.6.99
1:1

# USER NOTES

# USER NOTES

# USER NOTES

# 10. 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

Figure10-1 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

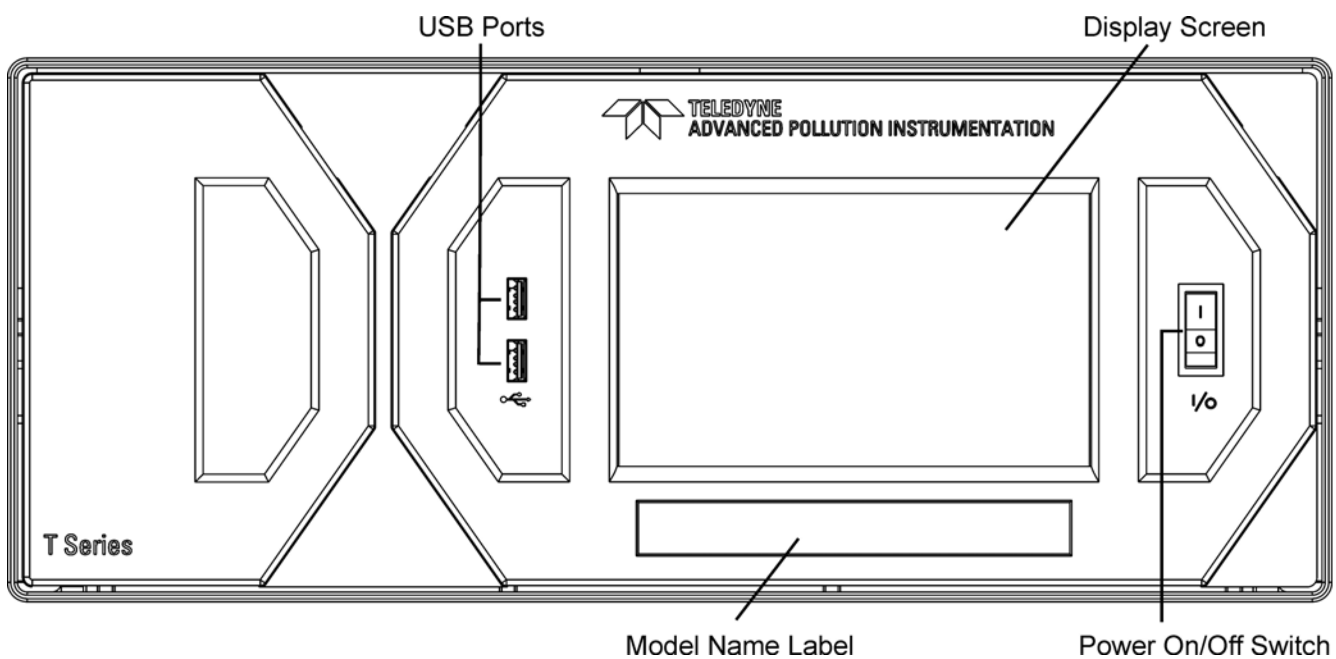



**Figure 10-1: Front Panel Layout**


**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**

<table>
<tr><th>Field</th><th colspan="4">Description/Function</th></tr>
<tr><td rowspan="5">Status</td><td colspan="4">Lights indicating the states of Sample, Calibration and Fault, as follows:</td></tr>
<tr><td>Name</td><td>Color</td><td>State</td><td>Definition</td></tr>
<tr><td>SAMPLE</td><td>Green</td><td>Off<br>On<br>Blinking</td><td>Unit is not operating in sample mode, DAS is disabled.<br>Sample Mode active; Front Panel Display being updated; DAS data being stored.<br>Unit is operating in sample mode, front panel display being updated, DAS hold-off mode is ON, DAS disabled</td></tr>
<tr><td>CAL</td><td>Yellow</td><td>Off<br>On<br>Blinking</td><td>Auto Cal disabled<br>Auto Cal enabled<br>Unit is in calibration mode</td></tr>
<tr><td>FAULT</td><td>Red</td><td>Off<br>Blinking</td><td>No warnings exist<br>Warnings exist</td></tr>
<tr><td>Conc</td><td colspan="4">Displays the actual concentration of the sample gas currently being measured by the analyzer in the currently selected units of measure</td></tr>
<tr><td>Mode</td><td colspan="4">Displays the name of the analyzer’s current operating mode</td></tr>
<tr><td>Param</td><td colspan="4">Displays a variety of informational messages such as warning messages, operational data, test function values and response messages during interactive tasks.</td></tr>
<tr><td>Control Buttons</td><td colspan="4">Displays dynamic, context sensitive labels on each button, which is blank when inactive until applicable.</td></tr>
</table>

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.

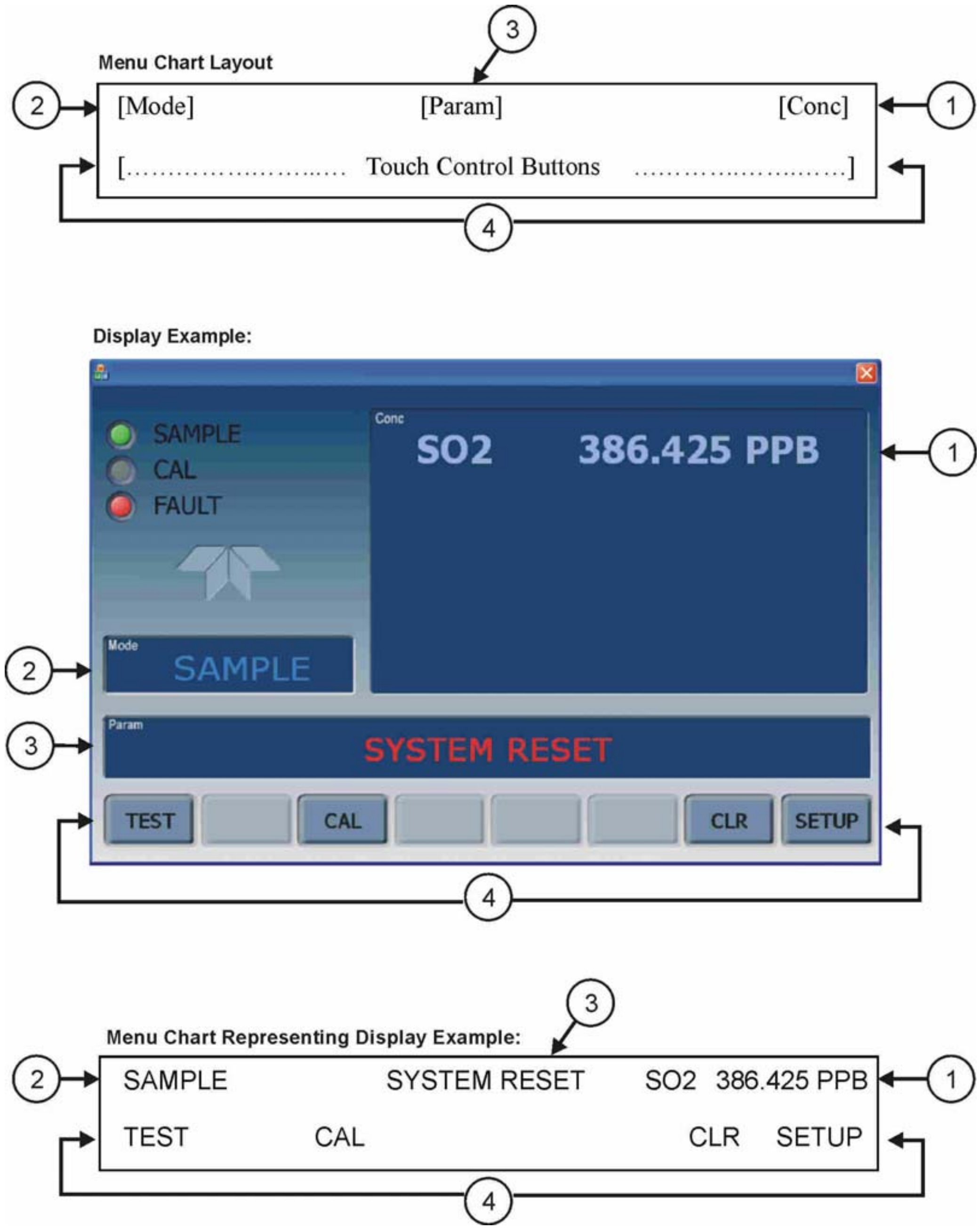



**Figure 10-3: Display/Touch Control Screen Mapped to Menu Charts**

# 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.

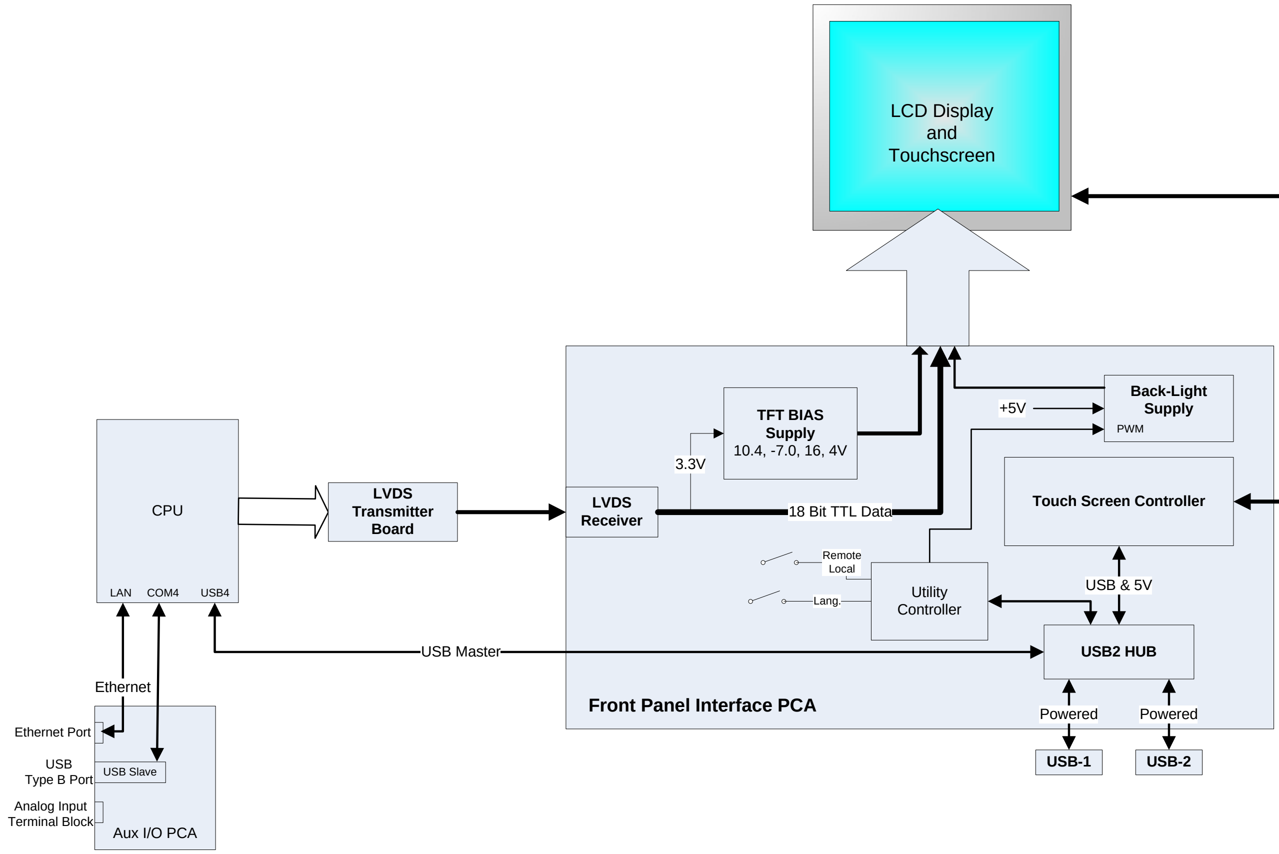



**Figure 10-4: Front Panel and Display Interface Block Diagram**

# 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

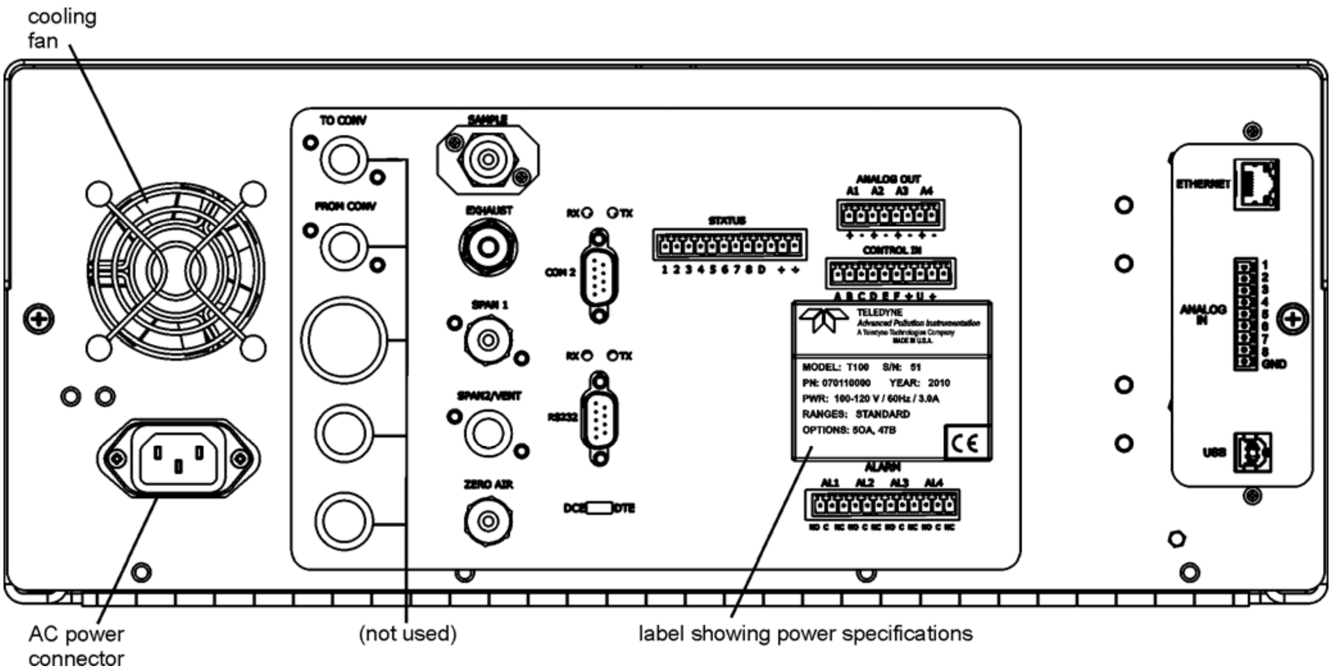



**Figure 9-5: Rear Panel Layout**

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

**Table 10-2: Rear Panel Description**

| Component | Function |
|---|---|
| **ANALOG IN** | Option for external voltage signals from other instrumentation and for logging these signals |
| **USB** | Connector for direct connection to personal computer (rear panel USB port only), 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, and the input impedance is nominally 20kΩ in parallel with 0.1µF.

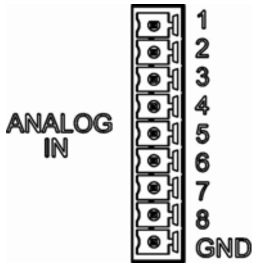



**Figure 10-6: Analog In Connector**

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

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

| PIN | DESCRIPTION | DAS PARAMETER[1] |
|---|---|---|
| 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).See section “USB Configuration” for setup instructions.

# 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 curser 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 |
|---|---|
| **AOUTS CALIBRATED:** | Shows the status of the analog output calibration (YES/NO) and initiates a calibration of all analog output channels. |
| **CONC_OUT_1** | Sets the basic electronic configuration of the A1 analog output ($SO_2$). There are three options:<br>• **RANGE:** Selects the signal type (voltage or current loop) and full scale level of the output.<br>• **REC_OFS:** Allows setting a voltage offset, not available when RANGE is set to Current Loop (**CURR**).<br>• **AUTO_CAL:** Performs the same calibration as AOUT CALIBRATED, but on this one channel only.<br>NOTE: Any change to RANGE or REC_OFS requires recalibration of this output. |
| **CONC_OUT_2** | Same as for CONC_OUT_1 but for analog channel 2 ($SO_2$) |
| **TEST OUTPUT** | Same as for CONC_OUT_1 but for analog channel 4 (TEST) |
| **CONC_OUT_3** | (Not available in the analyzer's standard configuration; applies when optional sensor installed). |
| **AIN CALIBRATED** | Shows the calibration status (YES/NO) and initiates a calibration of the analog input channels. |
| **XIN1**<br>**.**<br>**.**<br>**.**<br>**XIN8** | 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:

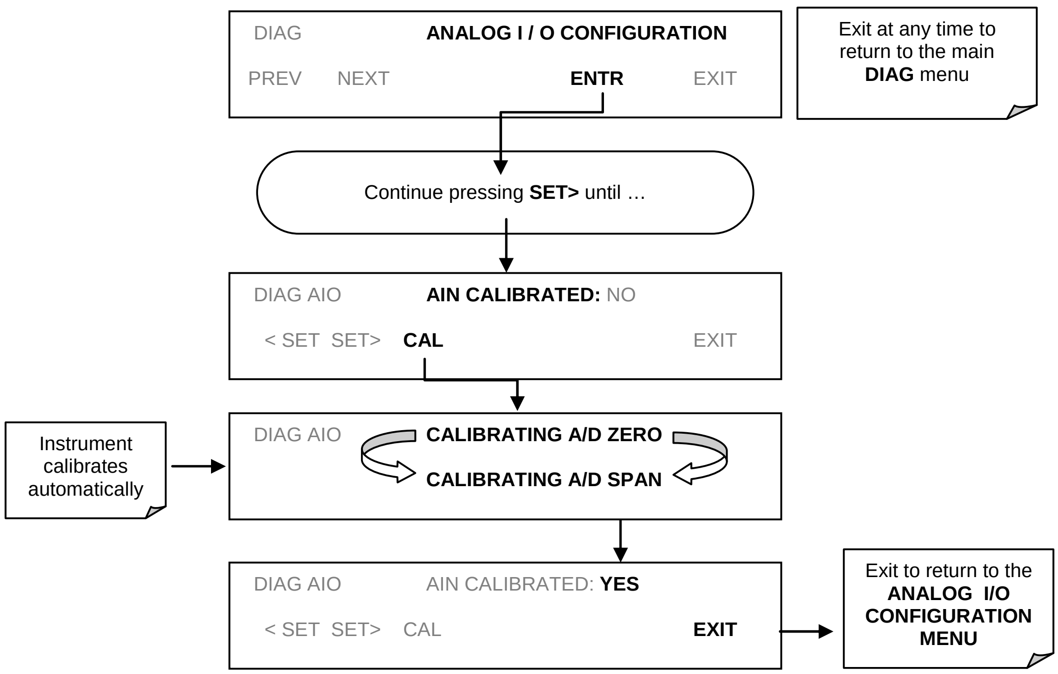



**Figure 10-7: DIAG – Analog I/O Configuration – AIN Calibration**

# 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:

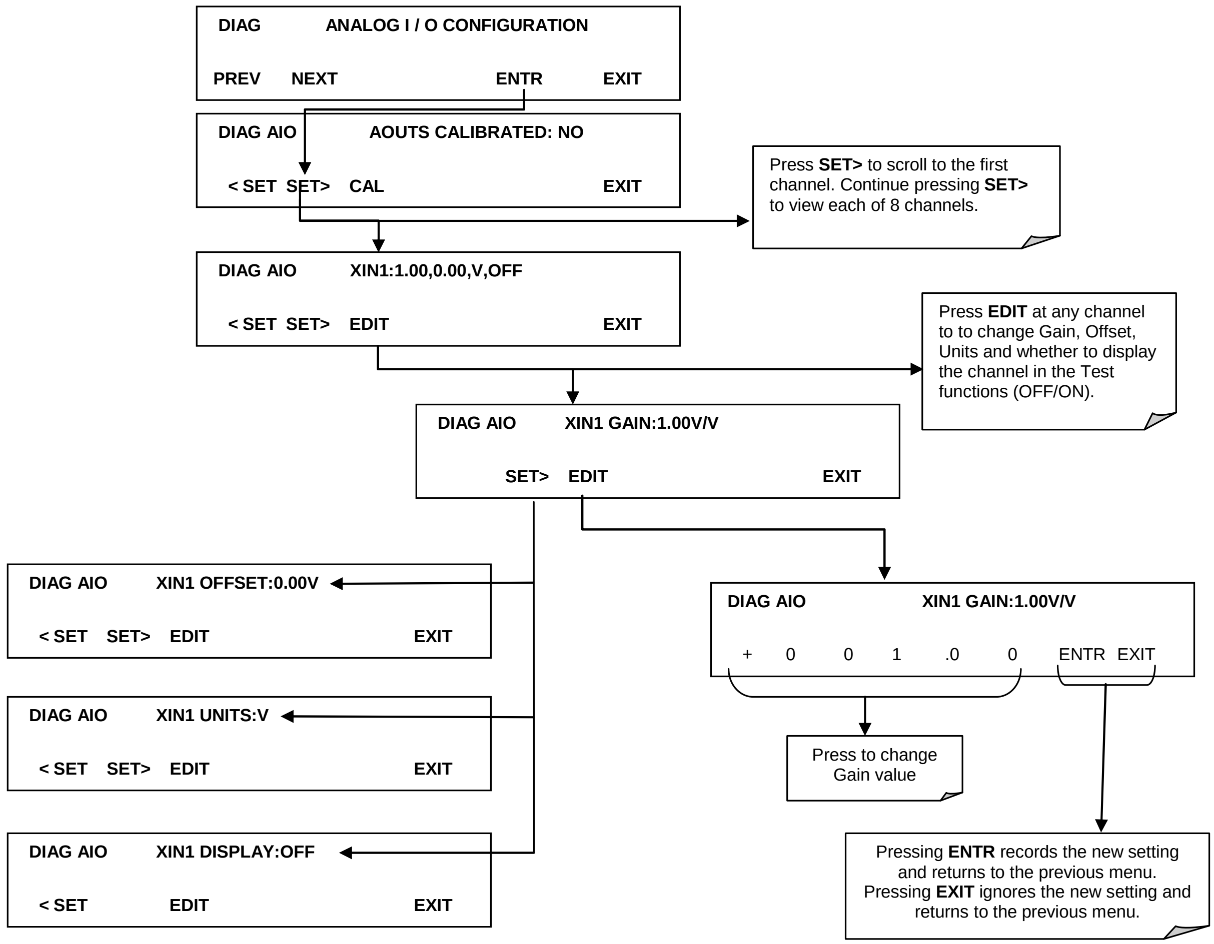



**Figure 10-8 DIAG – Analog Inputs (Option) Configuration Menu**

# USB Configuration

# 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 loose 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

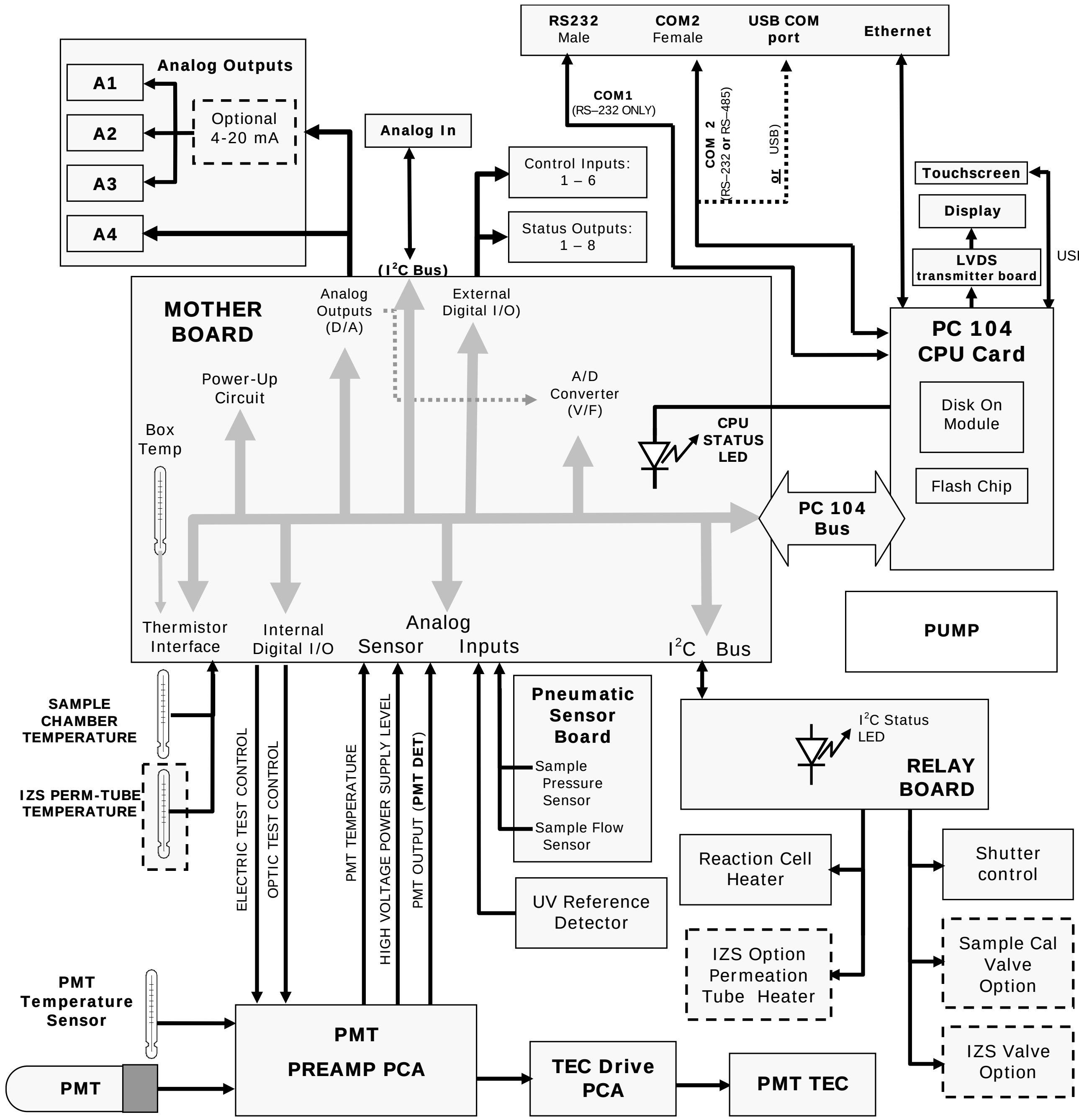



**FIGURE 10-9, EXAMPLE OF AN ELECTRONIC BLOCK DIAGRAM (T100)**

# "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