



**TELEDYNE API**  
Everywhereyoulook™



**User Manual**  
**Models N200, N200M, N200H**  
**NO/NO<sub>2</sub>/NO<sub>x</sub> Analyzers**



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## N200, N200M, N200H

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### TRADEMARKS

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## SAFETY MESSAGES

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



WARNING: Electrical Shock Hazard



HAZARD: Strong oxidizer



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



CAUTION: Hot Surface Warning



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



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



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





## N200, N200M, N200H

### CAUTION

This product should only be installed, commissioned, and used strictly for the purpose and in the manner described in this manual. If you improperly install, commission, or use this instrument in any manner other than as instructed in this manual or by our Technical Support team, unpredictable behavior could ensue with possible hazardous consequences.

Such risks, whether during installation and commission or caused by improper installation/commissioning/use, and their possible hazardous outcomes include but are not limited to:



| RISK  | HAZARD                          |
|---|---------------------------------|
| Liquid or dust/debris ingress                           | Electrical shock hazard         |
| Improper or worn power cable                            | Electrical shock or fire hazard |
| Excessive pressure from improper gas bottle connections | Explosion and projectile hazard |
| Sampling combustible gas(es)                            | Explosion and fire hazard       |
| Improper lift & carry techniques                        | Personal injury                 |

Note that the safety of a system that may incorporate this product is the end user's responsibility.

For Technical Assistance regarding the use and maintenance of this instrument or any other Teledyne API product, contact Teledyne API's Technical Support Department:

Telephone: +1 800-324-5190  
Email: [api-techsupport@teledyne.com](mailto:api-techsupport@teledyne.com)

or access any of the service options on our website at <http://www.teledyne-api.com/>



## CONSIGNES DE SÉCURITÉ

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



AVERTISSEMENT : Risque de choc électrique



DANGER : Oxydant puissant



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



MISE EN GARDE : Surface chaude



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



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



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



## N200, N200M, N200H

### MISE EN GARDE

Ce produit ne doit être installé, mis en service et utilisé qu'aux fins et de la manière décrites dans le présent manuel. Si vous installez, mettez en service ou utilisez cet instrument de manière incorrecte autre que celle indiquée dans ce manuel ou sous la direction de notre équipe de soutien technique, un comportement imprévisible pourrait entraîner des conséquences potentiellement dangereuses.

Ce qui suit est une liste, non exhaustive, des risques et résultats dangereux possibles associés avec une mauvaise utilisation, une mise en service incorrecte, ou causés mauvaise commission.



| RISQUE   | DANGER   |
|--|--|
| Pénétration de liquide ou de poussière/débris                            | Risque de choc électrique                      |
| Câble d'alimentation incorrect, endommagés ou usé                        | Choc électrique ou risque d'incendie           |
| Pression excessive due à des connexions de bouteilles de gaz incorrectes | Risque d'explosion et d'émission de projectile |
| Échantillonnage de gaz combustibles                                      | Risque d'explosion et d'incendie               |
| Techniques de manutention, soulèvement et de transport inappropriées     | Blessure corporelle                            |

Notez que la sécurité d'un système qui peut incorporer ce produit est la responsabilité de l'utilisateur final.



## WARRANTY

### WARRANTY POLICY (02024J)

Teledyne API (TAPI), a business unit of Teledyne Instruments, Inc., provides that: Prior to shipment, TAPI equipment is thoroughly inspected and tested. Should equipment failure occur, TAPI assures its customers that prompt service and support will be available. (For the instrument-specific warranty period, please refer to the “Limited Warranty” section in the Terms and Conditions of Sale on our website at [www.teledyne-api.com](http://www.teledyne-api.com)).

### COVERAGE

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

### NON-TAPI MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by TAPI is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturer’s warranty.

### PRODUCT RETURN

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

The complete Terms and Conditions of Sale can be reviewed on our website.

#### CAUTION – Avoid Warranty Invalidation



Failure to comply with proper anti-Electro-Static Discharge (ESD) handling and packing instructions and Return Merchandise Authorization (RMA) procedures when returning parts for repair or calibration may void your warranty. For anti-ESD handling and packing instructions please refer to the manual, Fundamentals of ESD, PN 04786, in its “Packing Components for Return to Teledyne API’s Customer Service” section. The manual can be downloaded from our website at <http://www.teledyne-api.com>. RMA procedures can also be found on our website.



## ABOUT THIS MANUAL

Support manuals, such as electrostatic discharge (ESD) prevention and NumaView™ Remote, are available on the TAPI website <http://www.teledyne-api.com>.

### Note

**We recommend that all users read this manual in its entirety before operating the instrument.**

## CONVENTIONS USED

In addition to the safety symbols as presented in the *Safety Messages* page, this manual provides *special notices* related to the careful and effective use of the instrument and related, pertinent information.

### ATTENTION

**COULD DAMAGE INSTRUMENT AND VOID WARRANTY**  
**This special notice provides information to avoid damage to your instrument and possibly invalidate the warranty.**

### Important

**IMPACT ON READINGS OR DATA**  
**Provides information about that which could either affect accuracy of instrument readings or cause loss of data.**

### Note

**Provides information pertinent to the proper care, operation or maintenance of the instrument or its parts.**



# TABLE OF CONTENTS

- Safety Messages ..... ii
- Warranty ..... vi
- Table of Contents ..... viii
- List of Figures ..... xii
- List of Tables ..... xiv
- 1. INTRODUCTION, SPECIFICATIONS, APPROVALS, & COMPLIANCE ..... 15
  - 1.1. Specifications ..... 16
  - 1.2. EPA Designation ..... 17
  - 1.3. Compliance and Certifications ..... 17
- 2. GETTING STARTED ..... 18
  - 2.1. Unpacking ..... 18
    - 2.1.1. Ventilation Clearance ..... 19
  - 2.2. Instrument Layout ..... 20
    - 2.2.1. Front Panel ..... 20
    - 2.2.2. Rear Panel ..... 20
    - 2.2.3. Internal Chassis ..... 22
  - 2.3. Connections and Startup ..... 24
    - 2.3.1. Electrical Connections ..... 24
      - 2.3.1.1. Connecting Power ..... 24
      - 2.3.1.2. Connecting Analog Outputs (Option) ..... 25
      - 2.3.1.3. Connecting the Digital I/O Expansion Board Option ..... 26
      - 2.3.1.4. Connecting Communications Interfaces ..... 27
    - 2.3.2. Pneumatic Connections ..... 28
      - 2.3.2.1. Critical Tubing, Pressure, Venting and Exhaust Requirements ..... 29
      - 2.3.2.2. Connections from Calibrator or Bottled Span Gas ..... 30
      - 2.3.2.3. Connections with Ambient Zero/Ambient Span (Z/S) Valves ..... 32
      - 2.3.2.4. Connections with Ambient Zero/Pressurized Span Valves Option ..... 33
      - 2.3.2.5. Zero Scrubber and Internal Span Source (IZS) ..... 34
      - 2.3.2.6. Connections with O<sub>2</sub> Sensor Option ..... 38
      - 2.3.2.7. Gas Conditioner Options ..... 38
    - 2.3.3. Pneumatic Flow Diagrams ..... 39
    - 2.3.4. Startup, Functional Checks and Calibration ..... 51
      - 2.3.4.1. Startup ..... 51
      - 2.3.4.2. Alerts: Warnings and Other Messages ..... 52
      - 2.3.4.3. Functional Checks ..... 53
      - 2.3.4.4. Calibration ..... 53
  - 2.4. Menu Overview ..... 54
    - 2.4.1. Home Page ..... 55
    - 2.4.2. Dashboard ..... 57
    - 2.4.3. Alerts ..... 59
    - 2.4.4. Calibration ..... 60
    - 2.4.5. Utilities ..... 61
    - 2.4.6. Setup ..... 61
  - 2.5. Setup Menu: Features/Functions Configuration ..... 62
    - 2.5.1. Setup>Data Logging (Data Acquisition System, DAS) ..... 62
      - 2.5.1.1. Configuring Trigger Types: Periodic ..... 64
      - 2.5.1.2. Configuring Trigger Types: Conditional ..... 65
      - 2.5.1.3. Downloading DAS (Data Acquisition System) Data ..... 65
    - 2.5.2. Setup>Events ..... 66
      - 2.5.2.1. Editing or Deleting Events ..... 68
      - 2.5.2.2. Using Events as Triggers for Data Logging ..... 69
    - 2.5.3. Setup>Dashboard ..... 69



# N200, N200M, N200H

|  |     |
|--|-----|
| 2.5.4. Setup>AutoCal (with Valve Option) .....                             | 70  |
| 2.5.5. Setup>Vars .....  | 70  |
| 2.5.6. Setup>Homescreen .....  | 71  |
| 2.5.7. Setup>Digital Outputs (Option).....                                 | 72  |
| 2.5.8. Setup>Analog Outputs (Option).....                                  | 73  |
| 2.5.8.1. Manual Calibration of Voltage Range Analog Outputs.....           | 76  |
| 2.5.8.2. Manual Adjustment of Current Range Analog Outputs .....           | 76  |
| 2.5.9. Setup>Instrument.....   | 77  |
| 2.5.10. Setup>Comm (Communications).....                                   | 77  |
| 2.5.10.1. COM .....  | 77  |
| 2.5.10.2. TCP Port1 .....  | 78  |
| 2.5.10.3. Network Settings .....   | 78  |
| 2.6. Transferring Configuration to Other Instruments .....                 | 80  |
| 3. COMMUNICATIONS AND REMOTE OPERATION .....                               | 81  |
| 3.1. Serial Communication .....  | 81  |
| 3.2. Ethernet.....   | 81  |
| 3.3. NumaView™ Remote.....   | 81  |
| 4. CALIBRATION .....   | 82  |
| 4.1. Important Precalibration Information .....                            | 82  |
| 4.1.1. Calibration Requirements .....                                      | 82  |
| 4.1.2. Zero Air .....  | 83  |
| 4.1.3. Calibration (Span) Gas .....  | 83  |
| 4.1.4. Span Gas for Multipoint Calibration .....                           | 83  |
| 4.1.5. Physical Range Measurements .....                                   | 84  |
| 4.1.6. Interferents .....  | 84  |
| 4.1.7. NO <sub>2</sub> Permeation Tubes (for IZS option in the N200) ..... | 85  |
| 4.1.8. Data Recording Devices .....  | 85  |
| 4.1.9. NO <sub>2</sub> Conversion Efficiency (CE) .....                    | 85  |
| 4.2. Calibration Procedures.....   | 86  |
| 4.2.1. Calibration and Check Procedures for Basic Configuration .....      | 87  |
| 4.2.1.1. Zero Calibration Check and Actual Calibration .....               | 87  |
| 4.2.1.2. Span Calibration Check and Actual Calibration .....               | 88  |
| 4.2.2. Calibration and Check Procedures with Valve Options Installed.....  | 89  |
| 4.2.2.1. Use of Zero/Span Valve with Digital Expansion Board Option.....   | 89  |
| 4.3. Automatic Zero/Span Cal/Check (Auto Cal) .....                        | 90  |
| 4.4. Calibration Quality Analysis .....                                    | 92  |
| 4.5. Conversion Efficiency (CE) Check.....                                 | 93  |
| 4.5.1.1. Simplified GPT Data Sheet.....                                    | 95  |
| 4.6. EPA Protocol Calibration.....   | 96  |
| 5. MAINTENANCE AND SERVICE .....   | 97  |
| 5.1. Maintenance Schedule.....   | 97  |
| 5.2. Predictive Diagnostics.....   | 99  |
| 5.3. Operational Health Checks .....                                       | 100 |
| 5.4. Software/Firmware Updates.....  | 100 |
| 5.4.1. Remote Updates .....  | 100 |
| 5.4.2. Manual Reload/Update Procedures.....                                | 101 |
| 5.4.3. Instrument Display Calibration (for earlier instruments).....       | 102 |
| 5.5. Time Zone Changes.....  | 103 |
| 5.6. Hardware Maintenance Procedures .....                                 | 104 |
| 5.6.1. Replacing the Sample Particulate Filter Option .....                | 104 |
| 5.6.2. Changing the DFU Sample Filter Option .....                         | 105 |
| 5.6.3. Changing the O <sub>3</sub> Dryer Particulate Filter.....           | 105 |
| 5.6.4. Changing the Ozone Cleanser Chemical (N200) .....                   | 106 |
| 5.6.5. Maintaining the External Sample Pump (Pump Pack).....               | 109 |
| 5.6.5.1. Rebuilding the Pump .....   | 109 |



# N200, N200M, N200H

|   |     |
|---|-----|
| 5.6.5.2. Replacing the Scrubber .....   | 109 |
| 5.6.6. Changing the Internal Span Gas Generator Permeation Tube (with IZS Option in N200) ..... | 109 |
| 5.6.7. Changing the External Zero Air Scrubber Option .....                                     | 110 |
| 5.6.8. Changing or Cleaning the NO <sub>2</sub> Converter .....                                 | 113 |
| 5.6.9. Cleaning the Reaction Cell .....   | 115 |
| 5.6.10. Servicing Critical Flow Orifices .....  | 116 |
| 5.6.11. Checking for Light Leaks .....  | 118 |
| 5.6.12. Checking for Pneumatic Leaks .....  | 119 |
| 5.6.12.1. Simple Vacuum Leak and Pump Check .....   | 119 |
| 5.6.12.2. Detailed Pressure Leak Check .....  | 119 |
| 5.6.12.3. Performing Flow Checks/Calibrations .....   | 120 |
| 5.7. Service and Troubleshooting .....  | 122 |
| 5.7.1. Fault Diagnosis with Alerts .....  | 123 |
| 5.7.2. Fault Diagnosis With Dashboard Functions .....   | 125 |
| 5.7.3. Using the Diagnostic Signal I/O Functions .....  | 126 |
| 5.7.4. Using the Analog Output Channels .....   | 126 |
| 5.7.5. Fault Diagnosis with Board LEDs .....  | 127 |
| 5.7.6. Flow Problems .....  | 129 |
| 5.7.6.1. Sample Flow is Zero or Low .....   | 130 |
| 5.7.6.2. Ozone Flow is Zero or Low .....  | 131 |
| 5.7.6.3. High Flow .....  | 132 |
| 5.7.6.4. Sample Flow is Zero or Low but Analyzer Reports Correct Flow .....                     | 132 |
| 5.7.7. Calibration Problems .....   | 133 |
| 5.7.7.1. Negative Concentrations .....  | 133 |
| 5.7.7.2. Absence of Analyzer Response to Sample Gas .....                                       | 134 |
| 5.7.7.3. Unstable Zero and Span .....   | 134 |
| 5.7.7.4. Inability to Span - Deactivated SPAN Button .....                                      | 135 |
| 5.7.7.5. Inability to Zero - Deactivated ZERO Button .....                                      | 135 |
| 5.7.7.6. Non-Linear Response .....  | 135 |
| 5.7.7.7. Discrepancy Between Analog Output and Display .....                                    | 136 |
| 5.7.7.8. Discrepancy Between NO and NO <sub>x</sub> Slopes .....                                | 137 |
| 5.7.8. Other Performance Problems .....   | 137 |
| 5.7.8.1. Excessive Noise .....  | 137 |
| 5.7.8.2. Slow Response .....  | 137 |
| 5.7.8.3. Auto Reference Alerts .....  | 138 |
| 5.7.9. Subsystem Check for Troubleshooting .....  | 139 |
| 5.7.9.1. AC Main Power .....  | 139 |
| 5.7.9.2. LCD/Display Module .....   | 140 |
| 5.7.9.3. RS-232 Communications .....  | 140 |
| 5.7.9.4. NO <sub>2</sub> > NO Converter .....   | 140 |
| 5.7.9.5. Photomultiplier Tube (PMT) Sensor Module .....   | 142 |
| 5.7.9.6. High Voltage Power Supply (HVPS) .....   | 142 |
| 5.7.9.7. O <sub>3</sub> Generator .....   | 143 |
| 5.7.9.8. Internal Span Gas Generator and Valve Options .....                                    | 144 |
| 5.7.9.9. Temperature Sensors .....  | 144 |
| 5.7.10. Service Procedures .....  | 144 |
| 5.7.10.1. O <sub>3</sub> Generator Replacement .....  | 145 |
| 5.7.10.2. Sample and Ozone Dryer Replacement .....  | 145 |
| 5.7.10.3. PMT Sensor Hardware Adjustment .....  | 146 |
| 5.7.10.4. Replacing the PMT, HVPS or TEC .....  | 147 |
| 5.7.10.5. Fuse Replacement Procedure .....  | 150 |
| 5.7.10.6. Module Replacement .....  | 151 |
| 5.8. Frequently Asked Questions .....   | 154 |
| 5.9. Technical Assistance .....   | 155 |
| 6. PRINCIPLES OF OPERATION .....  | 156 |
| 6.1. Measurement Principle .....  | 156 |





## N200, N200M, N200H

|   |     |
|---|-----|
| 6.1.1. Chemiluminescence Creation in the Reaction Cell.....         | 156 |
| 6.1.2. Chemiluminescence Detection in the Reaction Cell.....        | 158 |
| 6.1.2.1. The Photo Multiplier Tube (PMT) .....                      | 158 |
| 6.1.2.2. Optical Filter.....  | 158 |
| 6.1.3. NO <sub>x</sub> and NO <sub>2</sub> Determination .....      | 159 |
| 6.1.4. Auto Reference .....   | 160 |
| 6.1.5. Measurement Interferences .....                              | 161 |
| 6.1.5.1. Direct Interference .....                                  | 162 |
| 6.1.5.2. Third Body Quenching.....                                  | 163 |
| 6.1.5.3. Light Leaks .....  | 163 |
| 6.1.5.4. Reaction Cell Temperature Control.....                     | 163 |
| 6.2. Pneumatic Operation .....                                      | 164 |
| 6.2.1. Sample Gas Flow.....   | 164 |
| 6.2.1.1. Vacuum Manifold.....                                       | 165 |
| 6.2.1.2. Sample Gas Flow Valves and Routing.....                    | 166 |
| 6.2.2. Flow Rate Control - Critical Flow Orifices .....             | 166 |
| 6.2.2.1. Critical Flow Orifice.....                                 | 167 |
| 6.2.2.2. Locations and Descriptions of Critical Flow Orifices ..... | 167 |
| 6.2.3. Ozone Gas Generation and Air Flow.....                       | 169 |
| 6.2.3.1. The O <sub>3</sub> Generator .....                         | 170 |
| 6.2.3.2. Ozone Generator Dry Air Supply.....                        | 170 |
| 6.2.3.3. Ozone Supply Air Filter.....                               | 172 |
| 6.2.3.4. Ozone Destruct.....  | 172 |
| 6.2.4. Pneumatic Sensors .....                                      | 173 |
| 6.2.4.1. Sample Pressure Sensor.....                                | 173 |
| 6.2.4.2. Vacuum Pressure Sensor.....                                | 173 |
| 6.2.4.3. Sample Gas Flow Calculation .....                          | 173 |
| 6.2.4.4. O <sub>3</sub> Supply Air Flow Sensor .....                | 174 |
| 6.3. Electronic Operation.....                                      | 174 |
| 6.3.1. Modules.....   | 174 |
| 6.3.2. Power Switches.....  | 175 |
| 6.3.3. Photo Multiplier Tube (PMT).....                             | 175 |
| 6.3.3.1. PMT Cooling System.....                                    | 176 |
| 6.4. Software Operation .....                                       | 177 |
| 6.4.1. Adaptive Filter .....  | 177 |
| 6.4.2. Temperature/Pressure Compensation (TPC).....                 | 178 |
| 6.4.3. Calibration - Slope and Offset.....                          | 178 |
| Glossary .....  | 179 |



# LIST OF FIGURES

Figure 2-1. Front Panel Layout ..... 20

Figure 2-2. Rear Panel Layout..... 20

Figure 2-3. N200 Internal Chassis Layout with Options ..... 22

Figure 2-4. N200M, N200H Internal Chassis Layout with Options ..... 23

Figure 2-5. Analog Outputs Connectors Panel Option ..... 25

Figure 2-6. Digital I/O Connector Panel Option ..... 26

Figure 2-7. Mainboard JP1 Location and Pin Arrangements..... 28

Figure 2-8. Connections from Calibrator – Basic Configuration ..... 30

Figure 2-9. Connections from Bottled Span Gas – Basic Configuration..... 31

Figure 2-10. Connections with Z/S Valves Option ..... 32

Figure 2-11. Connections w/Ambient Zero/Pressurized Span Valves Option ..... 33

Figure 2-12. Connections w/Zero Scrubber and Internal Span Source (IZS) Option (N200 only) ..... 35

Figure 2-13. Connections for Precision Calibration when IZS Generator Option Present in N200 ..... 35

Figure 2-14. Gas Line Connections for Calibration when O<sub>2</sub> Sensor Option Installed ..... 38

Figure 2-15. N200 Pneumatic Flow, Basic Configuration ..... 39

Figure 2-16. N200M Pneumatic Flow, Basic Configuration ..... 40

Figure 2-17. N200H Pneumatics, Basic Configuration ..... 41

Figure 2-18. N200 Pneumatics with Zero/Span Valves Option ..... 42

Figure 2-19. N200M Pneumatics with Zero/Span Valves Option ..... 43

Figure 2-20. N200H Pneumatics with Zero/Span Valves Option..... 44

Figure 2-21. N200 Pneumatics with Ambient Zero/Pressurized Span Valves..... 45

Figure 2-22. N200 Pneumatics with the Internal Span Gas Generator Option..... 46

Figure 2-23. Pneumatics for Sample Conditioner Option ..... 47

Figure 2-24. N200 Pneumatics with O<sub>2</sub> Sensor Option..... 48

Figure 2-25. N200M Pneumatics with O<sub>2</sub> Sensor Option..... 49

Figure 2-26. N200H Pneumatic Flow with O<sub>2</sub> Sensor Option ..... 50

Figure 2-27. Status Screens at Startup..... 51

Figure 2-28. Home Page Example..... 52

Figure 2-29. Viewing Active Alerts Page..... 52

Figure 2-30. Sample Dashboard Page ..... 53

Figure 2-31. User Interface Orientation ..... 55

Figure 2-32. Concentration and Stability Graph (top) and Meter Graph (bottom) ..... 56

Figure 2-33. Dashboard Page..... 57

Figure 2-34. Navigating to the Active Alerts Page ..... 59

Figure 2-35. Active Alerts Cleared ..... 60

Figure 2-36. Utilities>Alerts Log of Active and Past Alerts and Events ..... 60

Figure 2-37. Datalog Configuration, New Log Page ..... 62

Figure 2-38. Datalog Configuration, Existing Log ..... 62

Figure 2-39. Creating a New Data Log ..... 63

Figure 2-40. Datalog Periodic Trigger Configuration ..... 64

Figure 2-41. Datalog - Conditional Trigger Configuration ..... 65

Figure 2-42. DAS Download Page..... 65

Figure 2-43. Events List ..... 66

Figure 2-44. Event Configuration ..... 67

Figure 2-45. Configured Event Sample..... 68

Figure 2-46. Edit or Delete an Event..... 68

Figure 2-47. Dashboard Display and Configuration..... 69

Figure 2-48. Homescreen Configuration..... 71

Figure 2-49. Digital Outputs Setup..... 72

Figure 2-50. Analog Output Configuration for Voltage Output, Example..... 73

Figure 2-51. Analog Output Configuration for Current Output, Example..... 74

Figure 2-52. Analog Output Calibration, Voltage or Current..... 75

Figure 2-53. Setup for Checking / Calibrating DCV Analog Output Signal Levels ..... 76



## N200, N200M, N200H

|  |     |
|--|-----|
| Figure 2-54. Setup for Checking / Calibration Current Output Signal Levels ..... | 77  |
| Figure 2-55. Communications Configuration, Network Settings .....                | 79  |
| Figure 2-56. Configuration Transfer .....  | 80  |
| Figure 4-1. Multi-Point Calibration Page .....                                   | 87  |
| Figure 4-2. Zero and Span Calibration Screens .....                              | 89  |
| Figure 4-3. Auto Cal Page .....  | 90  |
| Figure 5-1: Report Generation Page .....   | 100 |
| Figure 5-2. Remote Update Page .....   | 101 |
| Figure 5-3. Manual Update Page (and other utilities) .....                       | 101 |
| Figure 5-4. Touchscreen Calibration Page .....                                   | 102 |
| Figure 5-5. Time Zone Change Requirements .....                                  | 103 |
| Figure 5-6. Replacing the Particulate Filter .....                               | 104 |
| Figure 5-7. Particle Filter on O <sub>3</sub> Supply Air Dryer .....             | 106 |
| Figure 5-8. Ozone Cleanser Assembly .....  | 107 |
| Figure 5-9. Zero Air Scrubber Assembly .....                                     | 112 |
| Figure 5-10. NO <sub>2</sub> Converter Assembly (Moly Shown) .....               | 114 |
| Figure 5-11. Reaction Cell Assembly .....  | 115 |
| Figure 5-12. Critical Flow Orifice Assembly .....                                | 117 |
| Figure 5-13. Flow Calibration Menu .....   | 121 |
| Figure 5-14. Mainboard .....   | 128 |
| Figure 5-15. PMT Bench Module Board – Test Points and Indicator LEDs .....       | 128 |
| Figure 5-16. Ozone Brick Board .....   | 129 |
| Figure 5-17. HVPS Adjust Menu .....  | 147 |
| Figure 5-18. Sensor Assembly .....   | 148 |
| Figure 5-19. Fuse Access .....   | 151 |
| Figure 5-20. PMT Board Connectors .....  | 152 |
| Figure 5-21. Ozone Brick Board Connectors .....                                  | 153 |
| Figure 5-22. IZS Option Board Connectors .....                                   | 153 |
| Figure 5-23. Mainboard Connectors .....  | 154 |
| Figure 6-1. Reaction Cell with PMT Tube and Optical Filter .....                 | 158 |
| Figure 6-2. Sensitivity Spectrum .....   | 159 |
| Figure 6-3. NO <sub>2</sub> → NO Conversion .....                                | 159 |
| Figure 6-4. Pneumatic Flow during the Auto Reference Cycle .....                 | 161 |
| Figure 6-5. Vacuum Manifold, Standard Configuration .....                        | 165 |
| Figure 6-6. Flow Control Assembly & Critical Flow Orifice .....                  | 167 |
| Figure 6-7. Location of Flow Control Assemblies & Critical Flow Orifices .....   | 168 |
| Figure 6-8. Ozone Generator Principle .....                                      | 170 |
| Figure 6-9. Semi-Permeable Membrane Drying Process .....                         | 171 |
| Figure 6-10. Sample Dryer .....  | 171 |
| Figure 6-11. Basic PMT Design .....  | 175 |
| Figure 6-12. Typical Thermo-Electric Cooler .....                                | 176 |
| Figure 6-13. PMT Cooling System Block Diagram .....                              | 177 |



## LIST OF TABLES

|   |     |
|---|-----|
| Table 1-1. Specifications .....                                       | 16  |
| Table 2-1. Ventilation Clearance .....                                | 19  |
| Table 2-2. Rear Panel Description .....                               | 21  |
| Table 2-3. Analog Output Pin Assignments .....                        | 25  |
| Table 2-4. Digital Input/Output Pin Assignments .....                 | 26  |
| Table 2-5. JP1 Configurations for Serial Communication .....          | 28  |
| Table 2-6. Zero/Span Valves Operating States .....                    | 42  |
| Table 2-7. Zero/Span Valves Option's Operating States .....           | 43  |
| Table 2-8. Ambient Zero/Pressurized Span Valve Operating States ..... | 45  |
| Table 2-9. IZS Valve Option Operating States .....                    | 46  |
| Table 2-10. Menu Overview .....                                       | 54  |
| Table 2-11. Common Dashboard Parameters .....                         | 58  |
| Table 2-12. Utilities Submenu Descriptions .....                      | 61  |
| Table 2-13. List of Variables with Descriptions .....                 | 70  |
| Table 2-14. Analog Output Voltage/Current Range .....                 | 75  |
| Table 2-15. Setup>Instrument Menu .....                               | 77  |
| Table 2-16. COM Configuration .....                                   | 78  |
| Table 2-17. LAN/Ethernet Configuration Properties .....               | 79  |
| Table 3-1. Ethernet Status Indicators .....                           | 81  |
| Table 4-1. AUTO CAL States .....                                      | 91  |
| Table 4-2. Auto Cal Setup Combinations .....                          | 91  |
| Table 4-3. Auto Cal Programming Sequence Execution .....              | 92  |
| Table 4-4. Calibration Data Quality Evaluation .....                  | 93  |
| Table 5-1. Maintenance Schedule .....                                 | 98  |
| Table 5-2. Predictive Uses for Dashboard Functions .....              | 99  |
| Table 5-3. Warning Alerts, Fault Conditions and Possible Causes ..... | 123 |
| Table 5-4. Dashboard Functions - Indicated Failures .....             | 126 |
| Table 5-5. Analog Outputs as Diagnostic Tools .....                   | 127 |
| Table 6-1. List of Interferents .....                                 | 161 |
| Table 6-2. Valve Cycle Phases .....                                   | 166 |
| Table 6-3. Gas Flow Controls .....                                    | 168 |



# 1. INTRODUCTION, SPECIFICATIONS, APPROVALS, & COMPLIANCE

Teledyne API's Models N200, N200M, and N200H NO/NO<sub>2</sub>/NO<sub>x</sub> Analyzers use the proven chemiluminescence detection (see Principles of Operation, Section 6, this manual), coupled with state-of-the-art electronics to provide the sensitivity, stability and ease of use needed for requirements of nitric oxide (NO), nitrogen dioxide (NO<sub>2</sub>) and total nitrogen oxides (NO<sub>x</sub>). The N200 uses low level measurements for use as an ambient or dilution CEMS monitor, while the N200M uses medium level measurements and the N200H uses high level measurements, both for use in extractive type CEM systems.

Along with providing high accuracy, dependability, reliability, and repeatability, these analyzers track operational parameters and issue warnings if they fall outside diagnostic limits, and store easily retrievable data.

Proprietary software allows configurable data acquisition capability that can be triggered conditionally or periodically, enabling operators to perform predictive diagnostics and enhanced data analysis by tracking parameter trends. Reports can be downloaded onto a USB flash drive or via the I/O ports. Operators can also view real-time graphing with one touch of the interface screen.



# N200, N200M, N200H

## 1.1. SPECIFICATIONS

**Table 1-1. Specifications**

| PARAMETER  | SPECIFICATION  |   |   |
|--|--|---|---|
|  | N200   | N200M                                   | N200H                                   |
| Concentration Range<br>Min:<br>Max:                  | 0-50 ppb<br>0-20,000 ppb   | 0-1 ppm<br>0-2 0-200 ppm                | 0-5 ppm<br>0-5000 ppm                   |
| Measurement Units (selectable)                       | ppb, ppm, $\mu\text{g}/\text{m}^3$ , $\text{mg}/\text{m}^3$  | ppm, $\text{mg}/\text{m}^3$             | ppm, $\text{mg}/\text{m}^3$             |
| Zero Noise   | < 0.1 ppb (RMS)  | < 20 ppb (RMS)                          | < 20 ppb (RMS)                          |
| Span Noise   | < 0.2% of reading (RMS) above 50 ppb   | < 0.2% of reading (RMS) above 20 ppm    | < 0.2% of reading (RMS) above 20 ppm    |
| Lower Detectable Limit                               | < 0.2 ppb  | < 40 ppb                                | < 40 ppb                                |
| Zero Drift/24 hours                                  | < 0.5 ppb  | < 20 ppb                                | < 20 ppb                                |
| Span Drift/24 hours                                  | < 0.5% of full scale   | < 0.5% of reading                       | < 0.5% of reading                       |
| Response Time  | < 80 seconds to 95% (in switching mode)  | < 80 seconds to 95% (in switching mode) | < 80 seconds to 95% (in switching mode) |
| Linearity  | 1% of full scale   | 1% of full scale                        | 1% of full scale                        |
| Precision  | 0.5% of reading above 50 ppb   | 0.5% of reading above 5 ppm             | 0.5% of reading above 5 ppm             |
| Sample Flow Rate                                     | 500 cc/min $\pm$ 10%   | 250 cc/min $\pm$ 10%                    | 290 cc/min $\pm$ 10%                    |
| AC Power – Analyzer                                  | 100-240V~, 50/60 Hz, 3.0 A   | 100-240V~, 50/60 Hz, 3.0 A              | 100-240V~, 50/60 Hz, 3.0 A              |
| Typical Power Consumption                            | 55 W   | 100 W                                   | 150 W                                   |
|  | For models with internal pump, add ~25 W.  |   |   |
| AC Power – External Pump                             | Refer to External Pump Pack Manual PN 079000000 for external pump specifications.  |   |   |
| Power Entry Module Fuse                              | 5.0 A, 250 V AC, 5 mm x 20 mm, SLO-BLO   |   |   |
| Communications                                       |  |   |   |
| Standard I/O   | 1 Ethernet: TCP/IP<br>1 RS-232 (user-configurable) (300 – 115,200 baud)<br>2 front panel USB device ports  |   |   |
| Optional I/O   | Universal Analog Output Board (all user-definable):<br>4 x isolated voltage outputs (5 V, 10 V)<br>3 x individually isolated current outputs (4-20 mA)<br>Digital I/O Expansion Board includes:<br>3 x isolated digital input controls (fixed)<br>5 x isolated digital output controls (user-definable)<br>3 x form C relay alarm outputs (user-definable) |   |   |
| Operating Temperature Range                          | 0 - 45 °C  |   |   |
| Humidity Range                                       | 0-95% RH non-condensing  |   |   |
| Dimensions H x W x D                                 | 7" x 17" x 23.5" (178mm x 432 mm x 597 mm)   |   |   |
| Weight (basic configuration)                         | Analyzer: 40 lbs (18 kg)<br>External Pump Pack: 22 lbs (10 kg)   |   |   |
| Environmental Conditions                             | Installation Category (Over voltage Category) II Pollution Degree 2<br>Intended for Indoor Use Only at Altitudes $\leq$ 2000m  |   |   |
| All specifications are based on constant conditions. |  |   |   |



## N200, N200M, N200H

### 1.2. EPA DESIGNATION

Teledyne API's Model N200 nitrogen oxides analyzer is officially designated as US EPA Federal Reference Method (FRM), Designation Number RFNA-1194-099.

The official List of Designated Reference and Equivalent Methods is published in the U.S. Federal Register and specifies the instrument's settings and configurations..

### 1.3. COMPLIANCE AND CERTIFICATIONS

This product is CE compliant and adheres to the Low Voltage and ElectroMagnetic Compatibility directives.

For any other certifications, please refer to this product's specifications sheet on our website.



## 2. GETTING STARTED

This section addresses unpacking, connecting, and initializing the instrument, getting an overview of the menu system, and setting up/configuring the functions.

### 2.1. UNPACKING



#### CAUTION - GENERAL SAFETY HAZARD

To avoid personal injury, always use two persons and proper lift and carry techniques to move/relocate the analyzer.

#### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Printed Circuit Assemblies (PCAs) are sensitive to electro-static discharges too small to be felt by the human nervous system. Failure to use Electro-Static Discharge (ESD) protection when working with electronic assemblies will void the instrument warranty. Refer to the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at <http://www.teledyne-api.com>.

#### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Do not operate this instrument without first removing dust plugs from SAMPLE and EXHAUST ports on the rear panel.

#### Note

Teledyne API recommends that you store shipping containers and materials for future use if/when the instrument should be returned to the factory for repair and/or calibration service. See Warranty statement in this manual and Return Merchandise Authorization (RMA) on our Website at <http://www.teledyne-api.com>.

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

Included with your instrument is a printed record of the final performance characterization performed on your instrument at the factory. This record, titled Final Test and Validation Data Sheet, is an important quality assurance and calibration record and should be placed in the quality records file for this instrument.





## N200, N200M, N200H

With no power to the unit, carefully remove the top cover of the instrument and check for internal shipping damage by carrying out the following steps:

1. Carefully remove the top cover and check for internal shipping damage.
  - a. Remove the screws located on the instrument's sides.
  - b. Slide the cover backward until it clears the instrument's front bezel.
  - c. Lift the cover straight up.
2. Inspect the interior of the instrument to ensure all circuit boards and other components are intact and securely seated.
3. Check the connectors of the various internal wiring harnesses and pneumatic hoses to ensure they are firmly and securely seated.
4. Verify that all of the optional hardware ordered with the unit has been installed. These are listed on the paperwork accompanying the instrument.



### WARNING – ELECTRICAL SHOCK HAZARD

**Never disconnect or reconnect PCAs, wiring harnesses or electronic subassemblies while instrument is under power.**

### 2.1.1. VENTILATION CLEARANCE

Whether the instrument is set up on a bench or installed in a rack, be sure to leave sufficient ventilation clearance.

**Table 2-1. Ventilation Clearance**

| AREA                           | MINIMUM REQUIRED CLEARANCE |
|--------------------------------|----------------------------|
| Back of the instrument         | 10 cm / 4 in               |
| Sides of the instrument        | 2.5 cm / 1 in              |
| Above and below the instrument | 2.5 cm / 1 in              |



## 2.2. INSTRUMENT LAYOUT

Instrument layout includes front panel, rear panel connectors, and the internal chassis layout.

### 2.2.1. FRONT PANEL

The front panel (Figure 2-1) includes two USB ports for peripheral device connections, which can be used with mouse and keyboard as alternatives to the touchscreen interface, or with flash drive for uploads/downloads (devices not included).

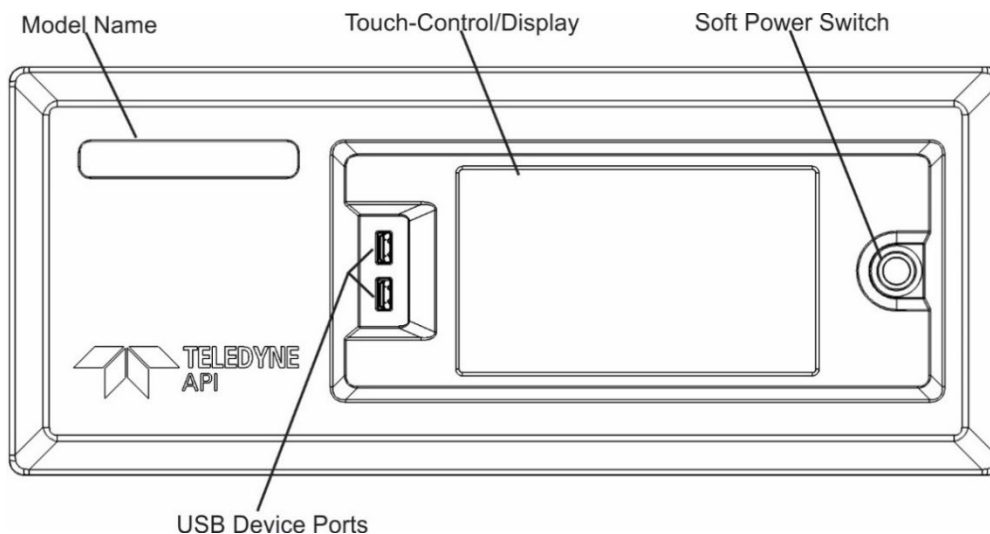


Figure 2-1. Front Panel Layout

### 2.2.2. REAR PANEL

Figure 2-2 shows the layout of the rear panel.

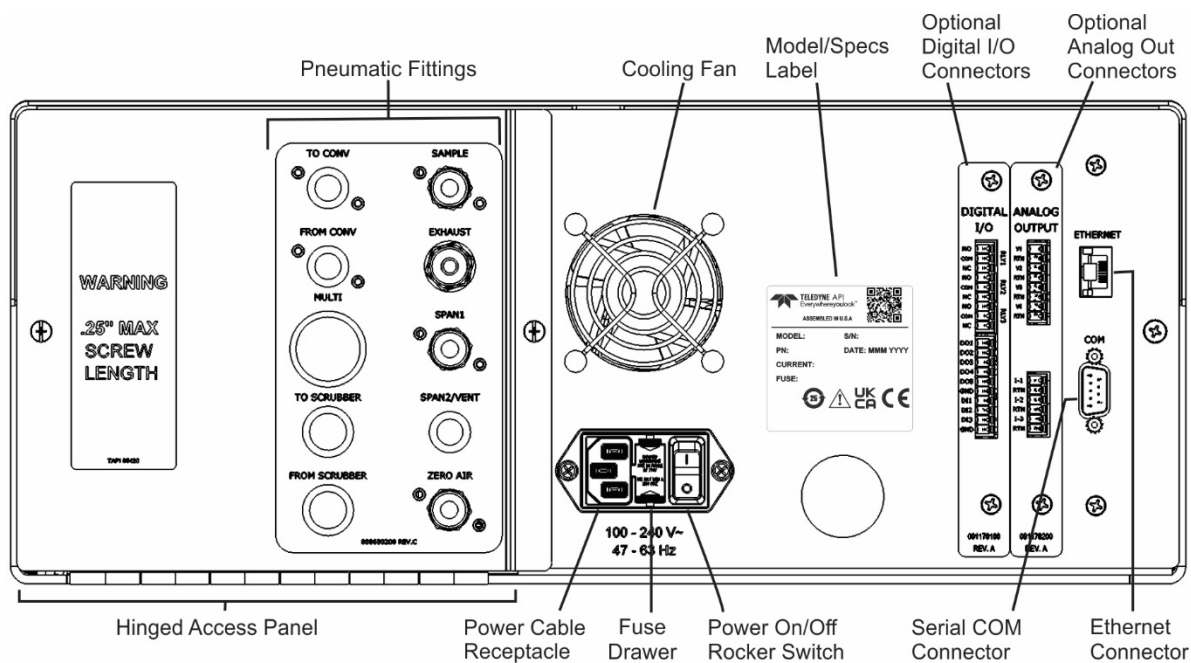



Figure 2-2. Rear Panel Layout



## N200, N200M, N200H

Table 2-2. Rear Panel Description

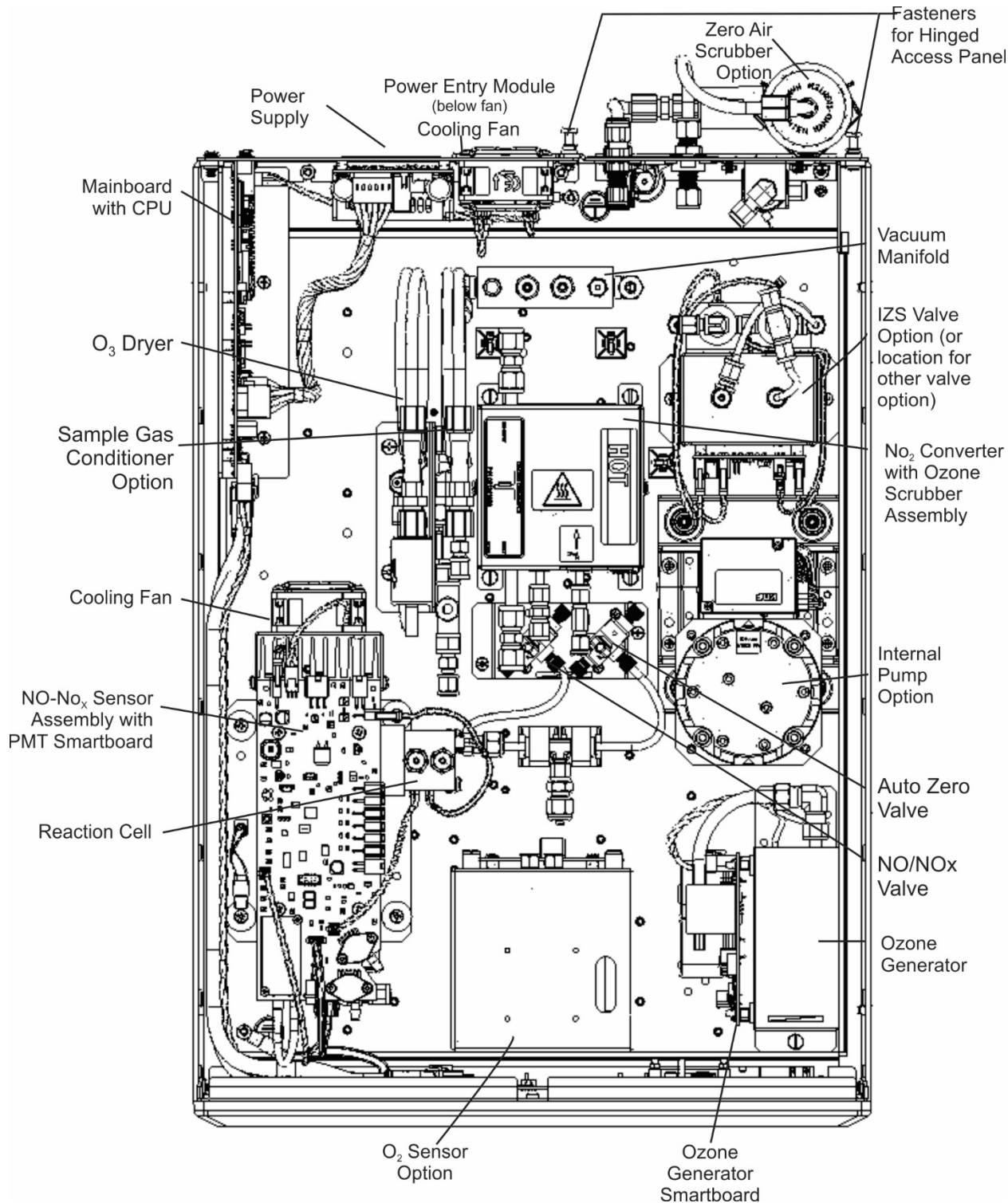
| COMPONENT   | FUNCTION  |   |
|---|---|---|
| TO CONV   | (not used)  |   |
| FROM CONV   | (not used)  |   |
| MULTI   | (not used)  |   |
| TO SCRUBBER   | (not used)  |   |
| FROM SCRUBBER   | Outlet for internal sample gas dryer; connect to external zero air scrubber (for IZS options only).   |   |
| <b>SAMPLE</b>   | Connect a gas line from the source of sample gas here. Calibration gases can also enter here on units without zero/span/shutoff valve options installed.  |   |
| <b>EXHAUST</b>  | Connect an exhaust gas line of not more than 10 meters long here that leads outside the shelter or immediate area surrounding the instrument. The line must be ¼" tubing or greater.  |   |
| <b>SPAN1</b>  | On units with zero/span valve option installed, connect a gas line to the source of calibrated span gas here.   |   |
| <b>SPAN2/VENT</b>   | On units with pressurized span valve option, used for venting.  |   |
| <b>ZERO AIR (with valve option)</b>   | On units with zero/span valve option installed, attach a gas line to the source of zero air here. If a permeation oven, also known as internal zero/span valve (IZS), option is installed attach the external zero air scrubber here. |   |
| <b>Cooling fan</b>  | Pulls ambient air into chassis through side vents and exhausts through rear.  |   |
| <b>Model/specs label</b>  | Identifies the analyzer model number and provides power specs.  |   |
|  | <b>Power cable connector</b>  | Connector for three-prong cord to apply AC power to the analyzer<br><b>CAUTION! The cord's power specifications (specs) MUST comply with the power specs on the analyzer's rear panel label</b> |
|   | <b>Power On/Off Switch</b>  | Rocker switch to power unit on or off.<br><b>CAUTION! Prior to powering OFF, use front panel button for preliminary internal "soft" power-down to protect against data loss.</b>                |
| <b>Fuse drawer</b>  | For circuit protection  |   |
| <b>DIGITAL I/O option</b>   | For remotely activating the zero and span check modes.  |   |
| <b>ANALOG OUTPUT option</b>   | For voltage or current loop outputs to a strip chart recorder and/or a data logger.   |   |
| <b>ETHERNET</b>   | Connector for network or Internet remote communication, using Ethernet cable.   |   |
| <b>COM</b>  | Serial communications port for RS-232   |   |



# N200, N200M, N200H

## 2.2.3. INTERNAL CHASSIS

Figure 2-3 and Figure 2-4 show internal chassis configurations with options.



**Figure 2-3. N200 Internal Chassis Layout with Options**



# N200, N200M, N200H

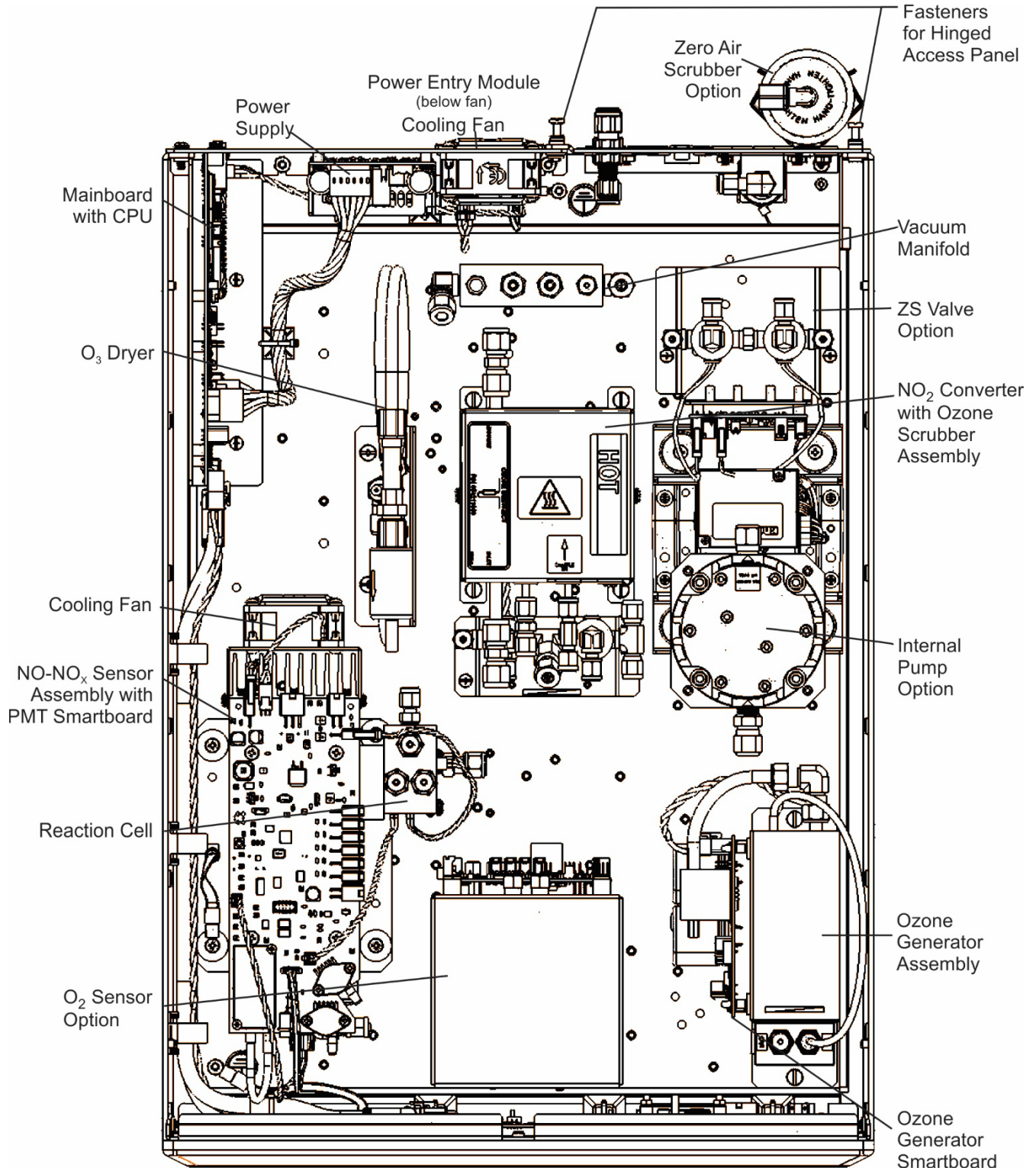


Figure 2-4. N200M, N200H Internal Chassis Layout with Options





## 2.3. CONNECTIONS AND STARTUP

This section presents the electrical (Section 2.3.1) and pneumatic (Section 2.3.2) connections for setting up and preparing the instrument for operation (Section 2.3.3).

### 2.3.1. ELECTRICAL CONNECTIONS

#### Note

To maintain compliance with EMC standards, cable length must be no greater than 3 meters for all I/O connections. Ensure that there is enough space to easily disconnect this instrument from the power source if necessary.



#### WARNING – Electrical Shock Hazard

- High Voltages are present inside the instrument's case.
- Power connection must have functioning ground connection.
- Do not defeat the ground wire on power plug.
- Turn off instrument power before disconnecting or connecting electrical subassemblies.
- Do not operate with cover off.



#### CAUTION – Avoid Damage to the Instrument

Ensure that the AC power voltage matches the voltage indicated on the instrument's model/specs label before plugging it into line power.

#### 2.3.1.1. CONNECTING POWER

#### Important

##### COULD CAUSE LOSS OR CORRUPTION OF DATA

Never power off the instrument from the rear panel Hard Power switch before using the front panel Soft Power switch, which triggers the Supervisory chip to safely run the internal computerized components shutdown process. Press and hold the front panel Soft Power switch until the instrument stops running; the LED state then changes from solid lit to blinking, at which time either the rear panel Hard Power switch can be used to finish powering off the instrument if needed, or the Soft Power switch can be pressed again later to restart the instrument.

Attach the power cord between the instrument's AC power connector and a power outlet capable of carrying at least the rated current at your AC voltage range and ensure that it is equipped with a functioning earth ground. It is important to adhere to all safety and cautionary messages.



### 2.3.1.2. CONNECTING ANALOG OUTPUTS (OPTION)

The optional rear panel Analog Output board offers several channels that can be mapped to reflect various operating values in the analyzer, including concentration values, temperatures, pressures, etc. These mappings are not configured by default and must be set by the user.

The four **voltage** outputs (0-5 V or 0-10 V) are isolated from the instrument but share a common ground. The three **current** outputs are individually isolated from each other and from the instrument.

To access these signals, attach a strip chart recorder and/or data-logger to the appropriate analog output connections, and configure through the Setup>Analog Outputs menu..

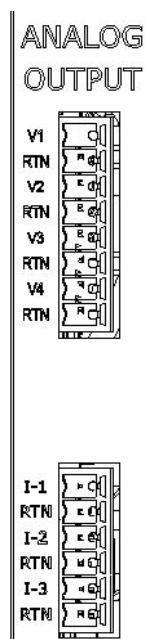


Figure 2-5. Analog Outputs Connectors Panel Option

Table 2-3. Analog Output Pin Assignments

| PIN                      | OUTPUT  | DESCRIPTION   |
|--------------------------|---------|---|
| Isolated Voltage Outputs |         |   |
| V1                       | V +     | User definable through the Setup>Analog Outputs menu. |
| RTN                      | Ground  |   |
| V2                       | V +     |   |
| RTN                      | Ground  |   |
| V3                       | V +     |   |
| RTN                      | Ground  |   |
| V4                       | V +     |   |
| RTN                      | Ground  |   |
| Isolated Current Outputs |         |   |
| I-1                      | I Out + | User definable through the Setup>Analog Outputs menu. |
| RTN                      | I Out - |   |
| I-2                      | I Out + |   |
| RTN                      | I Out - |   |
| I-3                      | I Out + |   |
| RTN                      | I Out - |   |



## N200, N200M, N200H

### 2.3.1.3. CONNECTING THE DIGITAL I/O EXPANSION BOARD OPTION

The connections on this board include three relay alarms, five digital outputs, and three isolated digital input controls. The **Relays** can be mapped to reflect various internal instrument conditions and states. The **Outputs** are isolated from the instrument and consist of open collector transistors with a common ground; they can be mapped to reflect various internal instrument conditions and states; they can be used to interface with devices that accept logic-level digital inputs, such as Programmable Logic Controllers (PLCs). The **Inputs** are also isolated but share the same ground as the Outputs; they will work with relays, open collectors, or 3.3 V – 24 V logic. Pull low to activate. DI1 and DI2 are fixed (not mappable) for remote zero and span calibrations.

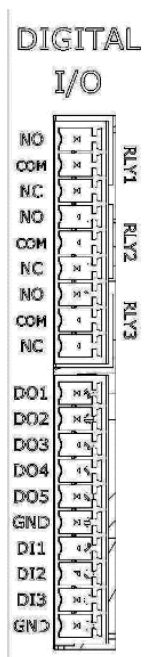


Figure 2-6. Digital I/O Connector Panel Option

Table 2-4. Digital Input/Output Pin Assignments

| PIN    | DESCRIPTION |   |
|--------|-------------|---|
| Relays |             |   |
| NO     | RLY 1       | Relay Alarms, user-configurable through the Setup>Digital Outputs menu. |
| COM    |             |   |
| NC     |             |   |
| NO     | RLY 2       |   |
| COM    |             |   |
| NC     |             |   |
| NO     | RLY 3       |   |
| COM    |             |   |
| NC     |             |   |





## N200, N200M, N200H

| PIN                        | DESCRIPTION  |
|----------------------------|--|
| Digital Outputs and Inputs |  |
| DO1                        | Digital Outputs mappable in the Setup>Digital Outputs menu, and viewable in the Utilities>Diagnostics>Digital Outputs menu |
| DO2                        |  |
| DO3                        |  |
| DO4                        |  |
| DO5                        |  |
| GND                        | Ground   |
| DI1                        | Digital Input1 = Remote Zero Cal   |
| DI2                        | Digital Input2 = Remote Span Cal   |
| DI3                        | (Digital Input3 not used)<br>View status in Utilities>Diagnostics>Digital Inputs menu                                      |
| GND                        | Ground   |

### 2.3.1.4. CONNECTING COMMUNICATIONS INTERFACES

#### ETHERNET CONNECTION

For network or Internet communication with the analyzer, connect an Ethernet cable from the analyzer's rear panel Ethernet interface connector to an Ethernet port. Although the analyzer is shipped with DHCP enabled by default, it should be manually configured with a static IP address.

#### SERIAL CONNECTION

Received from the factory, the analyzer COM port is set up for RS-232 communications with data communication equipment (DCE). This port can be reconfigured for RS-232 communications with data terminal equipment (DTE) by jumpering the pins on JP1 as indicated in Table 2-5 (view/edit software settings Table 2-16).



#### WARNING – ELECTRICAL SHOCK HAZARD

**Disconnect all power before performing any operation that requires entry into the interior of the analyzer. Contact Technical Support (Section 5.9) before reconfiguring the internal serial connector.**



# N200, N200M, N200H

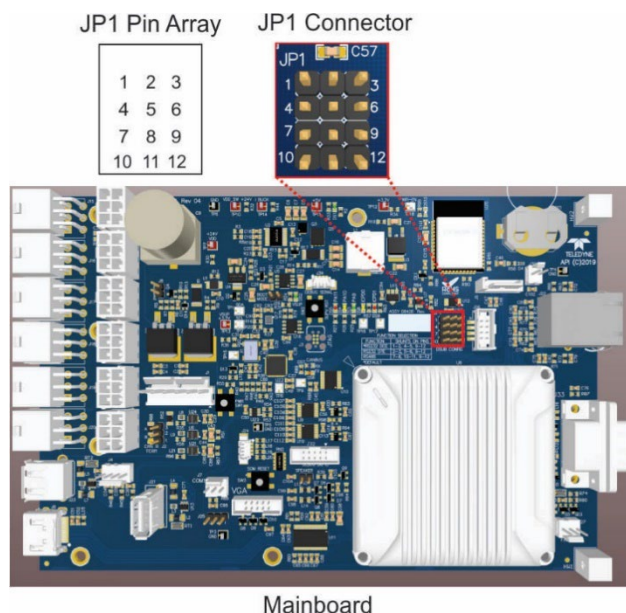


Figure 2-7. Mainboard JP1 Location and Pin Arrangements

Table 2-5. JP1 Configurations for Serial Communication

| Function            | Jumpers        | DSub Pins |       |
|---------------------|----------------|-----------|-------|
|                     |                | 2         | 3     |
| DCE RS232 (default) | 1-2, 4-5, 9-12 | 232Tx     | 232Rx |
| DTE RS232           | 2-3, 5-6, 9-12 | 232Rx     | 232Tx |


View/edit the Communications parameters in the Setup>Comm>COM1 menu.

- **Baud rate:** 115200 bits per second (baud)
- **Data Bits:** 8 data bits with 1 stop bit
- **Parity:** None

## 2.3.2. PNEUMATIC CONNECTIONS

This section provides pneumatic connection and setup instructions for basic and valve option configurations. Pneumatic flow diagrams are shown in Section 2.3.3. Calibration instructions are provided in Section 4.

Before making the pneumatic connections, carefully note the following cautionary and special messages:



**CAUTION – General Safety Hazard**  
Do not vent calibration gas or sample gas into enclosed areas.



**CAUTION – General Safety Hazard**



In units with a permeation tube option installed, vacuum pump must be connected and powered on to maintain constant gas flow through the analyzer at all times. Insufficient gas flow allows gas to build up to levels that will contaminate the instrument or present a safety hazard to personnel.

Remove the permeation tube when taking the analyzer out of operation and store in sealed container (use the original shipping packaging).

(See Figure 2-3 (“Sample Gas Conditioner Option”) for location and Section 5.6.6 for instructions on how to remove the permeation tube when the unit is not in operation).

**ATTENTION**

**COULD DAMAGE INSTRUMENT AND VOID WARRANTY**

**Vent Pressurized Gas:**

When any gas (span, zero air, sample) is received from a pressurized manifold, always provide a vent to equalize the pressure with the ambient atmosphere before it enters the instrument to ensure that the gases input do not exceed the instrument’s maximum inlet pressure, as well as to prevent back diffusion and pressure effects

**Remove Dust Plugs:**

Remove dust plugs from rear panel exhaust and supply line fittings before powering on the instrument.

Keep dust plugs for reuse in future storage or shipping to prevent debris from entering the pneumatics.

**Important**

**IMPACT ON READINGS OR DATA**

Sample and calibration gases should only come into contact with PTFE tubing.

Run a leak check once the appropriate pneumatic connections have been made; check all pneumatic fittings for leaks per Section 5.4.12.1 (or Section 5.4.12.2 for detailed check if any leaking is suspected).

**2.3.2.1. CRITICAL TUBING, PRESSURE, VENTING AND EXHAUST REQUIREMENTS**

The requirements presented in this section apply to all pneumatic connection instructions. All other connection instructions are provided with their respective instrument configurations in Sections 2.3.2.2 through 2.3.2.5.

**Tubing:**

- PTFE material
- Outer diameter (OD) minimum ¼” .
- Min/max length 2 meters to 10 meters.



## N200, N200M, N200H

### Pressure:

- All Sample gas pressure must be at ambient atmospheric pressure, no greater than 1.0 psig.

### Venting (to prevent back diffusion and pressure effects):

- Run tubing outside the enclosure or at least away from immediate area surrounding the instrument.

### Exhaust Outlet:

- Run tubing outside the enclosure.

### 2.3.2.2. CONNECTIONS FROM CALIBRATOR OR BOTTLED SPAN GAS

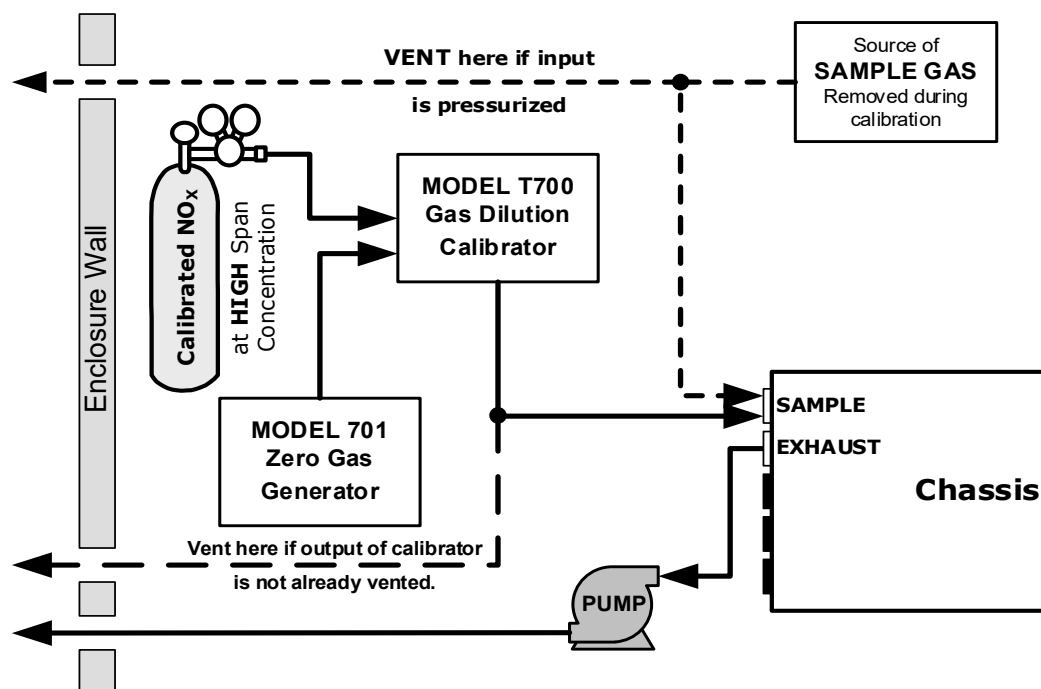


Figure 2-8. Connections from Calibrator – Basic Configuration



## N200, N200M, N200H

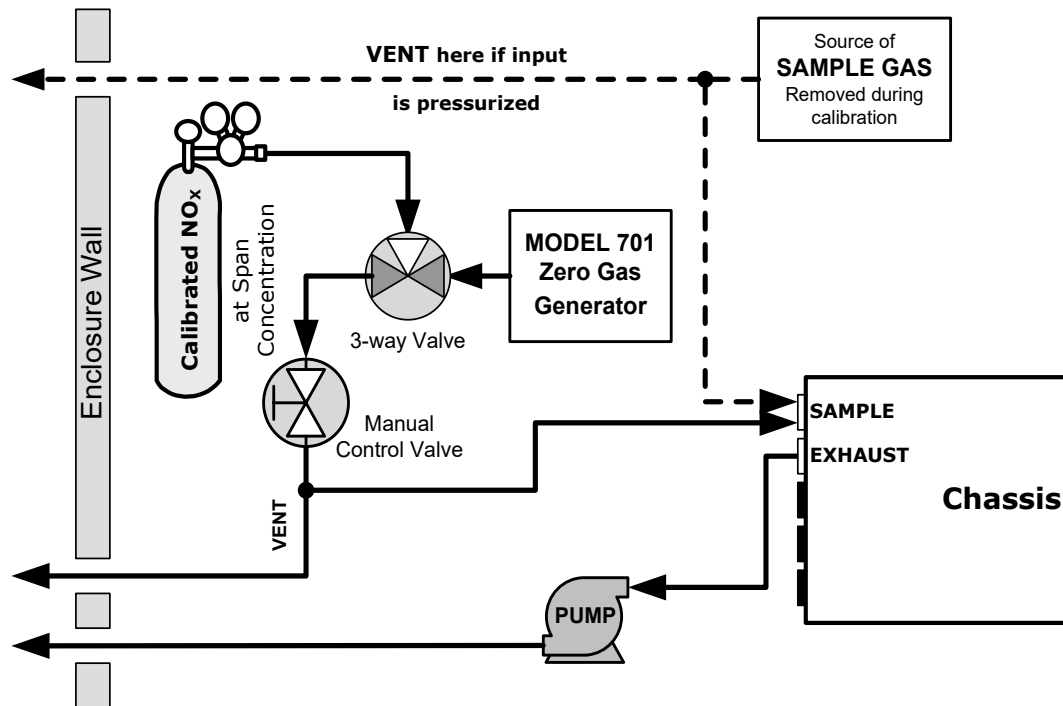


Figure 2-9. Connections from Bottled Span Gas – Basic Configuration

For the analyzer's basic configuration, in addition to tubing, pressure, venting, and exhaust requirements set out in Section 2.3.2.1, attach the following pneumatic lines:

### SAMPLE GAS SOURCE

Connect a sample gas line to the SAMPLE inlet.

### CALIBRATION GAS SOURCES

CAL GAS & ZERO AIR SOURCES: The source of calibration gas is attached to the SAMPLE inlet, but only when a calibration operation is actually being performed.

### VENTING

Vent the output of the calibrator if calibrator not already vented.



### 2.3.2.3. CONNECTIONS WITH AMBIENT ZERO/AMBIENT SPAN (Z/S) VALVES

This valve package includes two solenoid valves located inside the analyzer that allow the user to switch either zero, span or sample gas to the instrument's sensor.

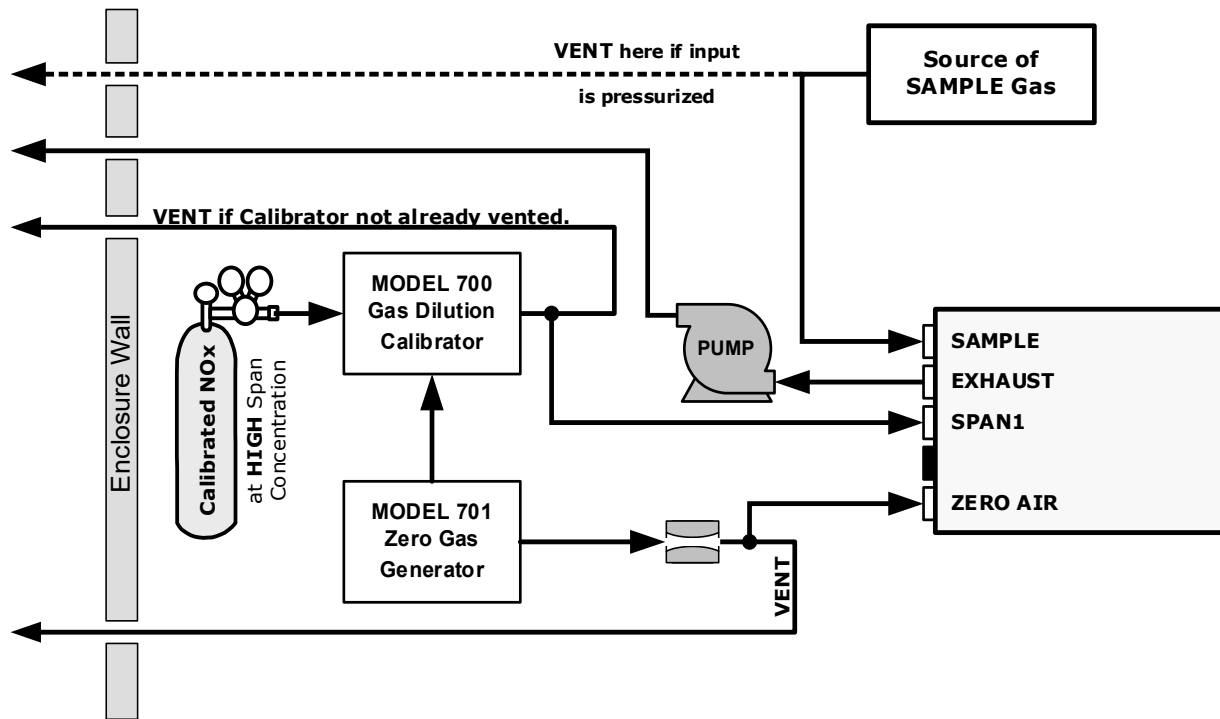


Figure 2-10. Connections with Z/S Valves Option

In addition to tubing, pressure, venting, and exhaust requirements set out in Section 2.3.2.1, attach the following pneumatic lines:

#### SAMPLE GAS SOURCE

Attach a sample inlet line to the SAMPLE inlet fitting.

- In applications where the sample gas is received from a pressurized manifold, vent the sample gas line.

#### CALIBRATION GAS SOURCES

**SPAN GAS** Attach a gas line from the source of calibration gas (e.g. a Teledyne API's T700 Dynamic Dilution Calibrator) to the SPAN inlet.

**ZERO AIR** Zero air is supplied by the zero air generator such as a Teledyne API's T701. Attach a gas line from the source of zero air to the ZERO AIR inlet.

#### VENTING

Vent both the span gas and zero air supply lines.



## 2.3.2.4. CONNECTIONS WITH AMBIENT ZERO/PRESSURIZED SPAN VALVES OPTION

This calibration valve package is appropriate for applications where span gas is being supplied from a pressurized source such as bottled NIST SRM gases. This option includes:

- a critical flow orifice and vent to maintain the span gas supply at 1 ATM
- a shutoff valve to preserve the span gas source when it is not in use
- two solenoid valves for the user to switch either zero, span or sample gas to the instrument's sensor

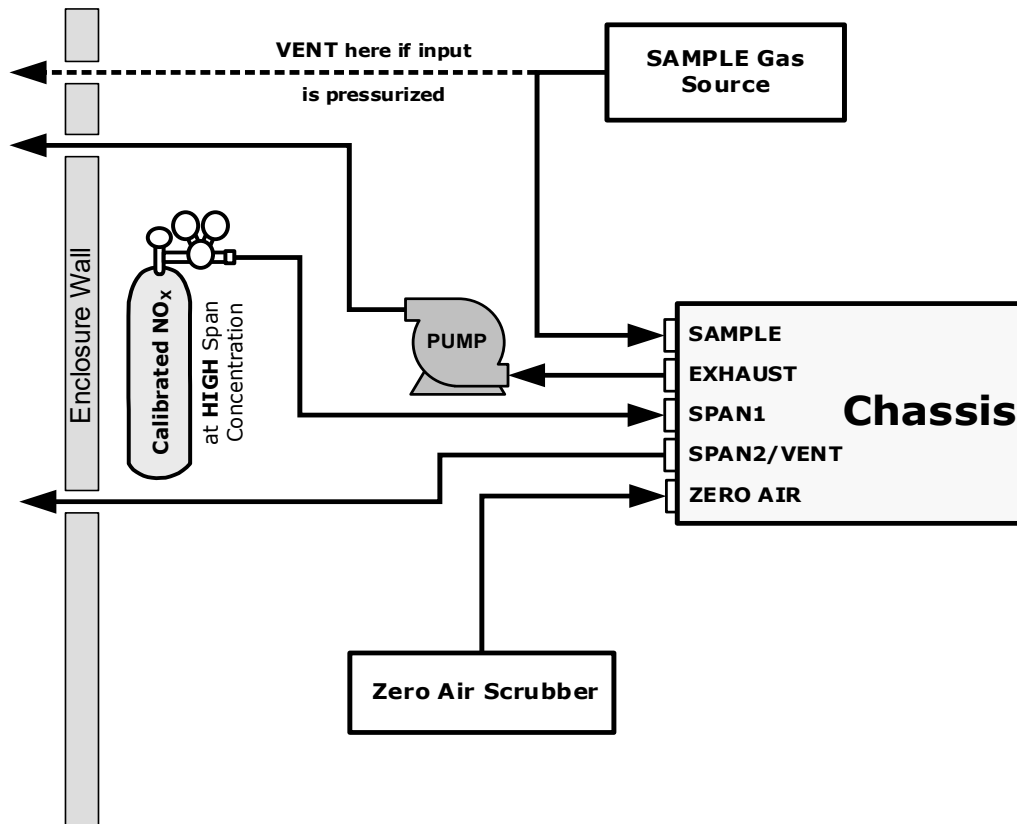


Figure 2-11. Connections w/Ambient Zero/Pressurized Span Valves Option

In addition to tubing, pressure, venting, and exhaust requirements set out in Section 2.3.2.1, attach the following pneumatic lines:

### SAMPLE GAS SOURCE

Attach a sample inlet line to the SAMPLE inlet fitting.

- In applications where the sample gas is received from a pressurized manifold, vent the sample gas line.



## N200, N200M, N200H

### CALIBRATION GAS SOURCES

**SPAN GAS** Attach a gas line from the pressurized source of calibration gas (e.g. a bottle of NISTSRM gas) to the SPAN inlet. Use PTFE tubing, minimum O.D ¼”.

**ZERO AIR** (the dual-stage zero Air Scrubber makes zero air)

### VENTING

Vent the SPAN2/VENT outlet.

#### 2.3.2.5. ZERO SCRUBBER AND INTERNAL SPAN SOURCE (IZS)

This option is available for the N200 model only. The internal NO<sub>2</sub> span gas generator and calibration valve option is intended for applications where there is a need for frequent automated calibration checks without access to an external source of span gas. (See the end of this subsection for important information about “Internal Span Gas Generation”). It does require a permeation tube specific to the application for which it is being used.

This valve package includes:

- a 2-stage external scrubber for producing zero air
  - 50% Purafil Chemisorbant® (for conversion of NO →NO<sub>2</sub>)
  - 50% charcoal (for removal of the NO<sub>2</sub>)
  - a heated enclosure for an NO<sub>2</sub> permeation tube (This option package DOES NOT contain an actual permeation tube. Contact Sales for assistance in specifying the correct permeation tube for each application).
- a special desorber that removes all HNO<sub>3</sub> from the calibration gas stream
- one additional gas inlet port (ZERO AIR)
- one additional gas outlet port (FROM SCRUBBER)
- two internal valves for switching between the sample gas inlet and the output of the zero/span subsystem





# N200, N200M, N200H

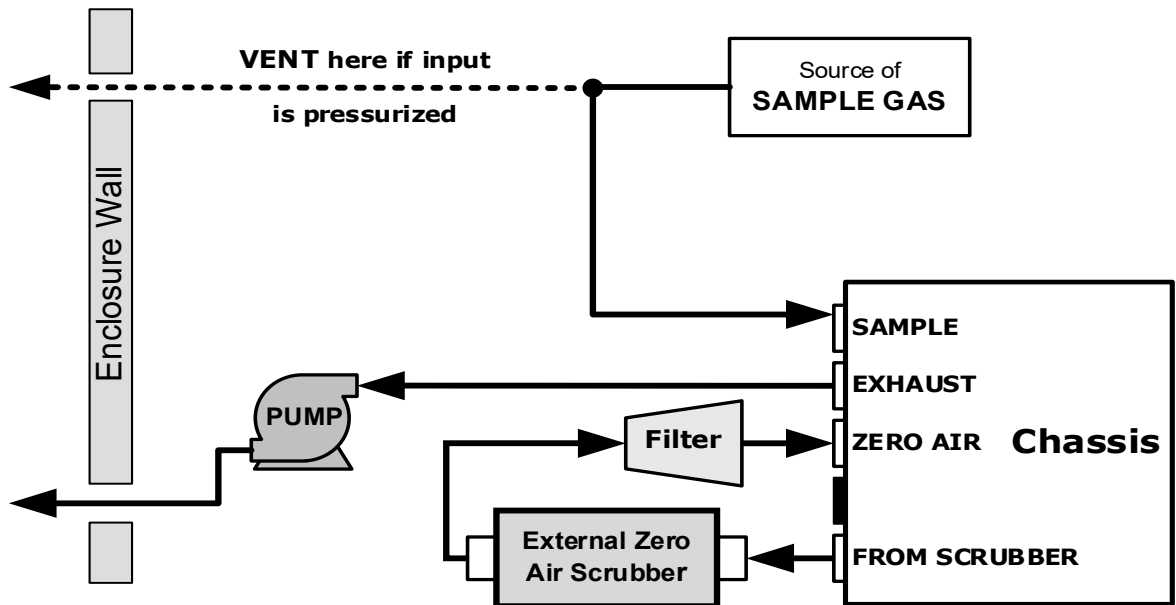


Figure 2-12. Connections w/Zero Scrubber and Internal Span Source (IZS) Option (N200 only)

The internal span gas generator utilizes an NO<sub>2</sub> permeation tube as a span gas source (see the section on “Internal Span Gas Generation” that follows). The accuracy of these devices is only about ±5%. Whereas this may be sufficient for frequent automated calibration checks (Figure 2-12), we recommend using certified NO gases for precise calibration (Figure 2-13).

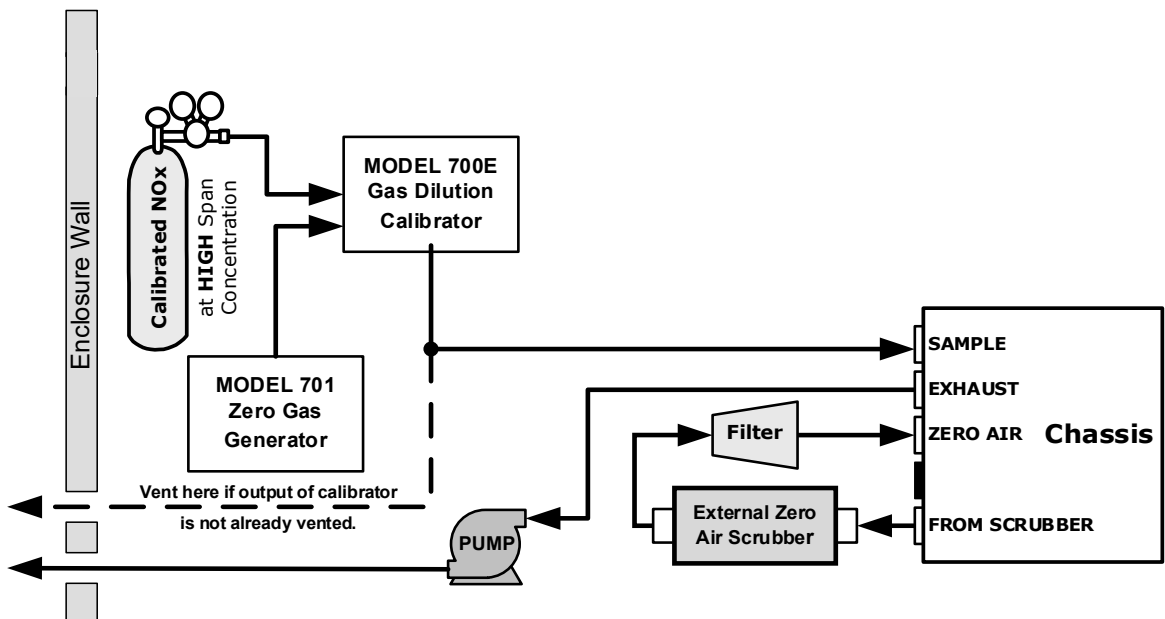


Figure 2-13. Connections for Precision Calibration when IZS Generator Option Present in N200



## N200, N200M, N200H

In addition to tubing, pressure, venting, and exhaust requirements set out in Section 2.3.2.1, attach the following pneumatic lines:

### SAMPLE GAS SOURCE

Connect a sample gas line to the SAMPLE inlet, and:

- In applications where the sample gas is received from a pressurized manifold and the analyzer is not equipped with one of the N200's pressurized span options, a vent must be placed on the sample gas line.

### CALIBRATION GAS SOURCES

- Internal: Uses the IZS generator.
- External (for precision calibration):
- CAL GAS & ZERO AIR SOURCES: The source of calibration gas is attached to the SAMPLE inlet.

### VENTING

Vent the Sample line if input is pressurized.

### INTERNAL SPAN GAS GENERATION

This information applies to the N200 with the IZS valve option. The primary component of the internal span option is a permeation tube containing liquid NO<sub>2</sub>. As zero air is passed over a permeable membrane on the end of the tube, molecules of NO<sub>2</sub> slowly pass through the membrane mixing with the zero air.

The resulting concentration of the NO<sub>2</sub> span gas is determined by three factors:

- size of the membrane (the larger the area of the membrane, the more permeation occurs)
- temperature of the NO<sub>2</sub> (increasing the temperature of the permeation tube increases the pressure inside the tube, thereby increasing the rate of permeation)
- flow rate of the zero air (if the previous two variables are constant, the permeation rate of the NO<sub>2</sub> into the zero air stream will be constant; therefore, a lower flow rate of zero air produces higher concentrations of NO<sub>2</sub>)

The permeation tube enclosure is heated to a constant 50° C (10° above the maximum operating temperature of the instrument) in order to keep the permeation rate constant. A thermistor measures the actual temperature which is then reported for control feedback.

The flow rate of zero air across the permeation tube is maintained at 50 ± 10 cc/min by a critical flow orifice located in the analyzer's exhaust manifold.



### NITRIC ACID AND THE CHEMISTRY OF NO<sub>2</sub> PERMEATION TUBES

H<sub>2</sub>O reacts with NO<sub>2</sub> to form HNO<sub>3</sub> (nitric acid). The analyzer mitigates this reaction by passing the air supply for the span gas generator through a special dryer; however, the permeable membrane of the NO<sub>2</sub> tube will still allow H<sub>2</sub>O from the ambient environment to slowly collect in the tube at increasingly higher concentrations. Over time this results in the presence of HNO<sub>3</sub> in the permeation tube which is exuded into the analyzer's pneumatics along with NO<sub>2</sub>.

HNO<sub>3</sub> is a liquid at room temperature, so once the HNO<sub>3</sub> is released by the permeation tube, it condenses and collects along the analyzer's wetted surfaces. While liquid HNO<sub>3</sub> does not directly affect the quality of NO<sub>x</sub> measurements, it does give off small amounts of gaseous HNO<sub>3</sub> which is converted into NO by the NO<sub>x</sub> → NO converter, resulting in an artificially high NO<sub>2</sub> concentration by 8% to 12%. This is particularly bothersome when the analyzer is attempting to measure a zero point, such as during calibration, since the NO<sub>2</sub> concentration will only reach a true zero point once the majority of the HNO<sub>3</sub> coating the wetted surfaces has reverted to NO<sub>2</sub> and this can take a very long time.

To resolve this, the N200 includes a special HNO<sub>3</sub> desorber, which eliminates any HNO<sub>3</sub> given off by the permeation tube before it can be converted into NO by the analyzer's converter.



### 2.3.2.6. CONNECTIONS WITH O<sub>2</sub> SENSOR OPTION

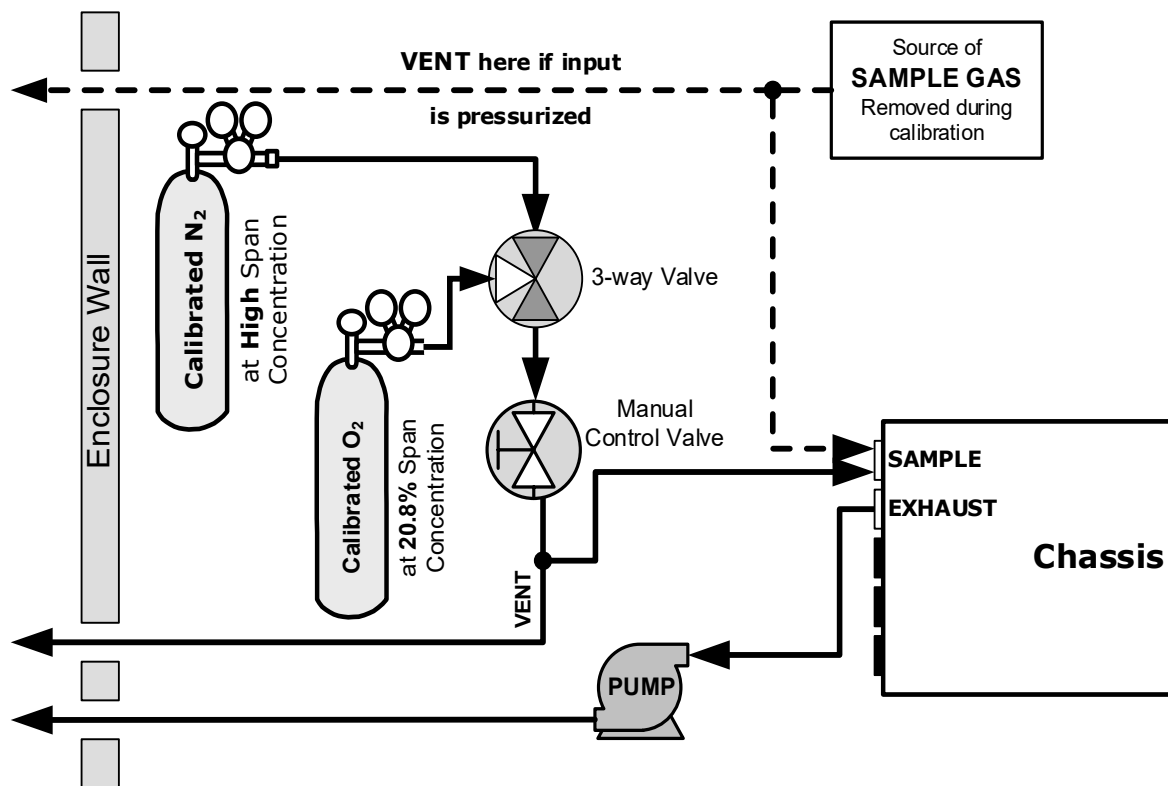


Figure 2-14. Gas Line Connections for Calibration when O<sub>2</sub> Sensor Option Installed

**O<sub>2</sub> SENSOR ZERO GAS:** Teledyne API recommends using pure N<sub>2</sub> when calibrating the zero point of your O<sub>2</sub> sensor option.

**O<sub>2</sub> SENSOR SPAN GAS:** Teledyne API recommends using 21% O<sub>2</sub> in N<sub>2</sub> when calibrating the span point of your O<sub>2</sub> sensor option.

### 2.3.2.7. GAS CONDITIONER OPTIONS

#### AMMONIA REMOVAL SAMPLE CONDITIONER OPTION

The N200 includes an option for a permeation gas exchange tube to remove H<sub>2</sub>O from the ozone generator supply gas stream to a dew point of about -20° C (~600 ppm H<sub>2</sub>O) and effectively remove concentrations of ammonia (NH<sub>3</sub>) up to about 1 ppm.

An additional sample conditioner can be added to the N200's sample gas stream.



### 2.3.3. PNEUMATIC FLOW DIAGRAMS

This section shows the basic pneumatic flow diagram followed by flow diagrams with options. Tables with the valve operating states follow each of the flow diagrams with valve options.

#### PNEUMATIC FLOW FOR BASIC CONFIGURATION

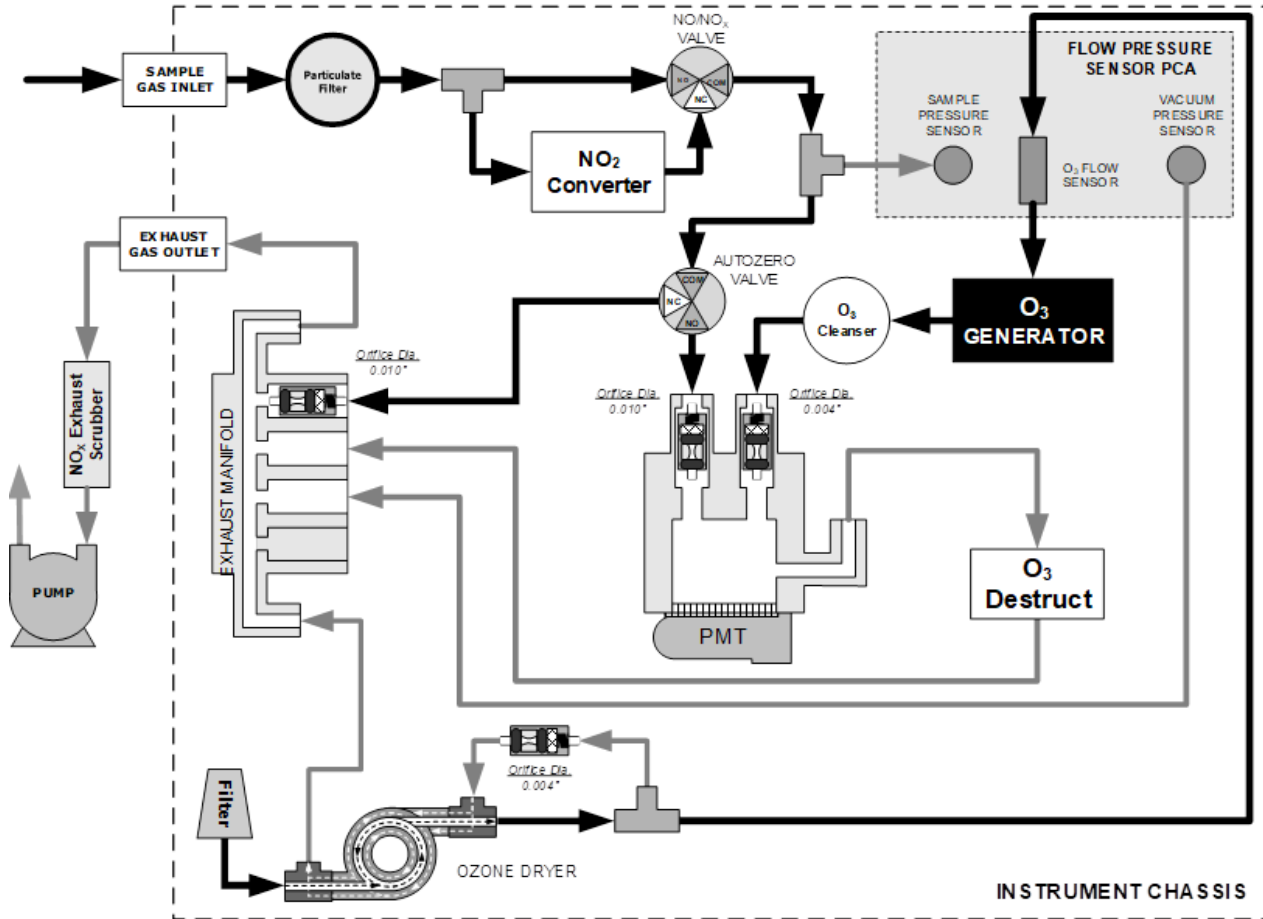


Figure 2-15. N200 Pneumatic Flow, Basic Configuration



# N200, N200M, N200H

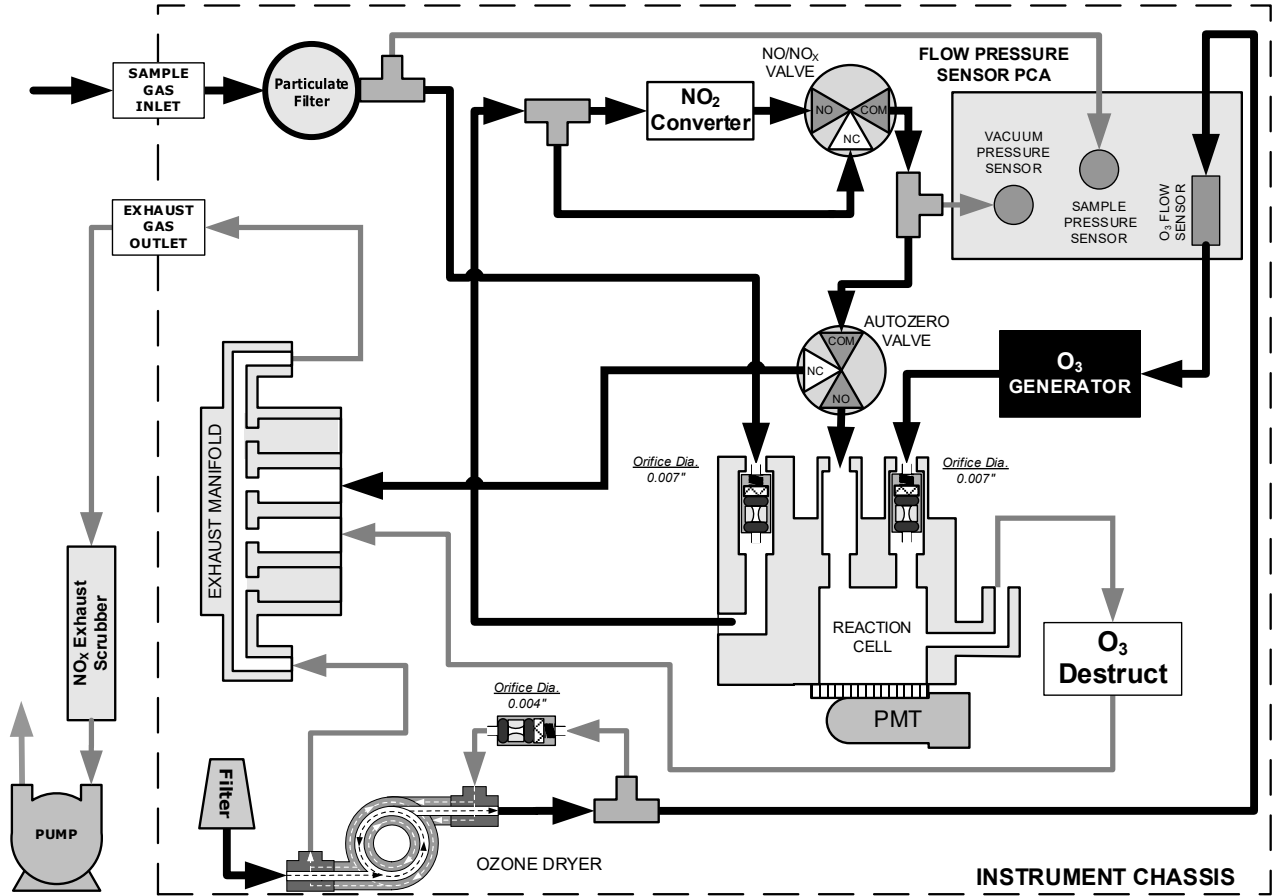


Figure 2-16. N200M Pneumatic Flow, Basic Configuration



# N200, N200M, N200H

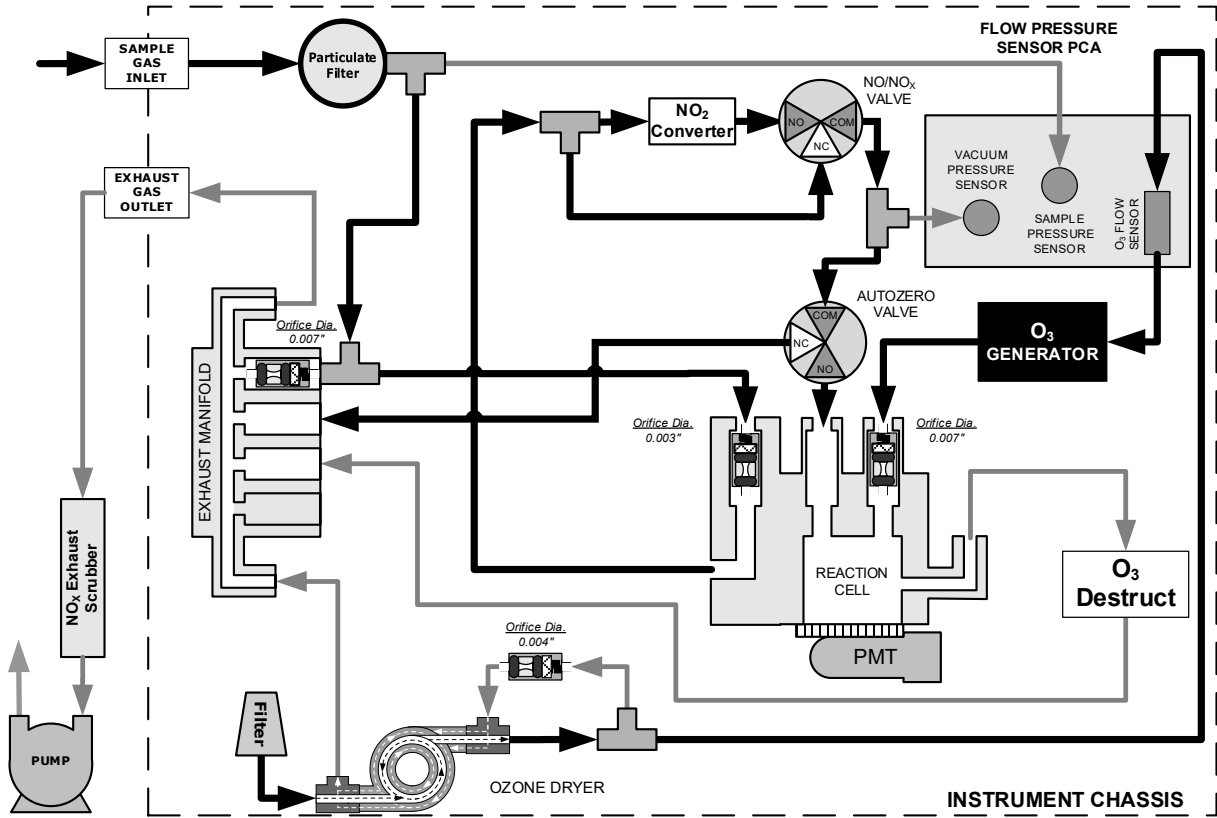


Figure 2-17. N200H Pneumatics, Basic Configuration



# N200, N200M, N200H

## PNEUMATIC FLOW FOR AMBIENT ZERO/AMBIENT SPAN VALVES OPTION

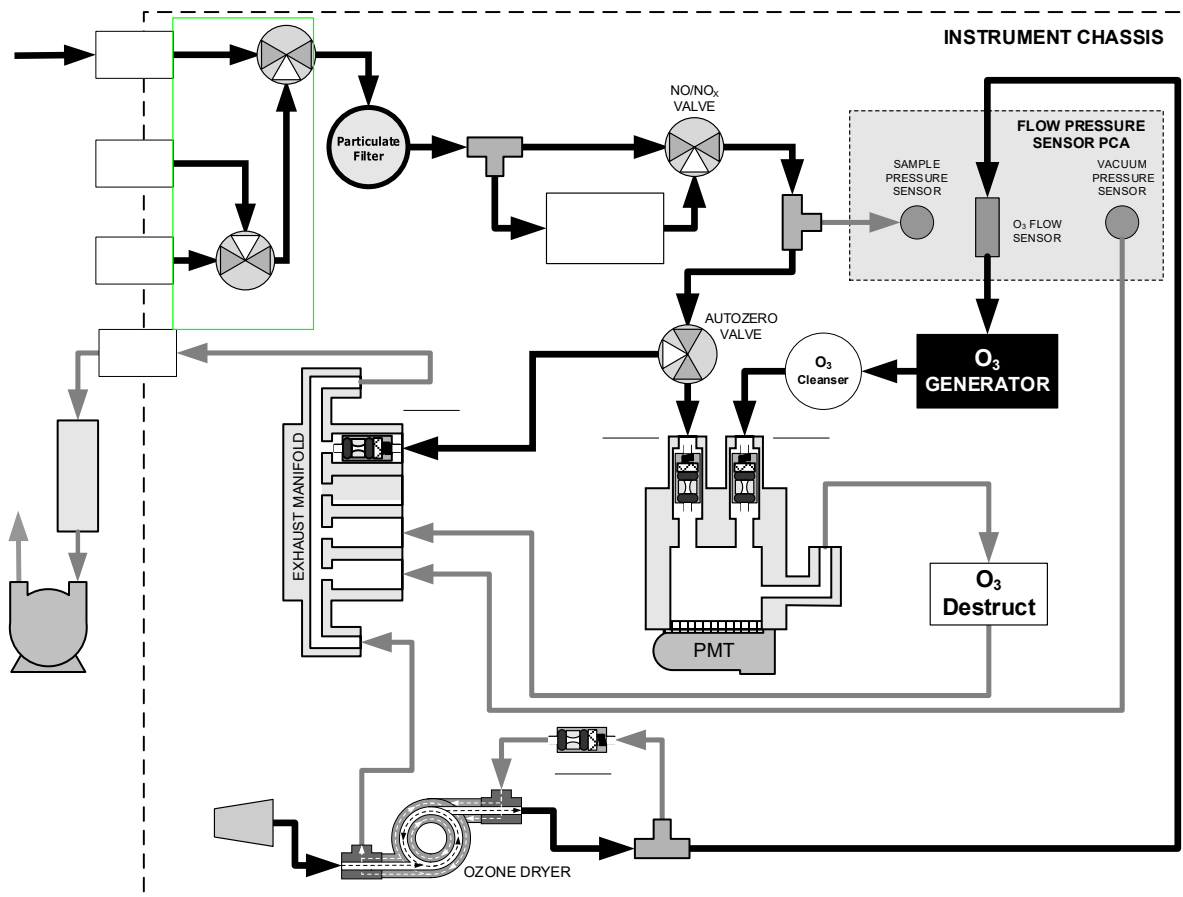


Figure 2-18. N200 Pneumatics with Zero/Span Valves Option

Table 2-6. Zero/Span Valves Operating States

| MODE     | VALVE      | CONDITION               | VALVE PORT STATUS |
|----------|------------|-------------------------|-------------------|
| SAMPLE   | Sample/Cal | Open to SAMPLE inlet    | NO → COM          |
|          | Zero/Span  | Open to ZERO AIR inlet  | NO → COM          |
| ZERO CAL | Sample/Cal | Open to ZERO/SPAN Valve | NC → COM          |
|          | Zero/Span  | Open to ZERO AIR inlet  | NO → COM          |
| SPAN CAL | Sample/Cal | Open to ZERO/SPAN Valve | NC → COM          |
|          | Zero/Span  | Open to SPAN inlet      | NC → COM          |





# N200, N200M, N200H

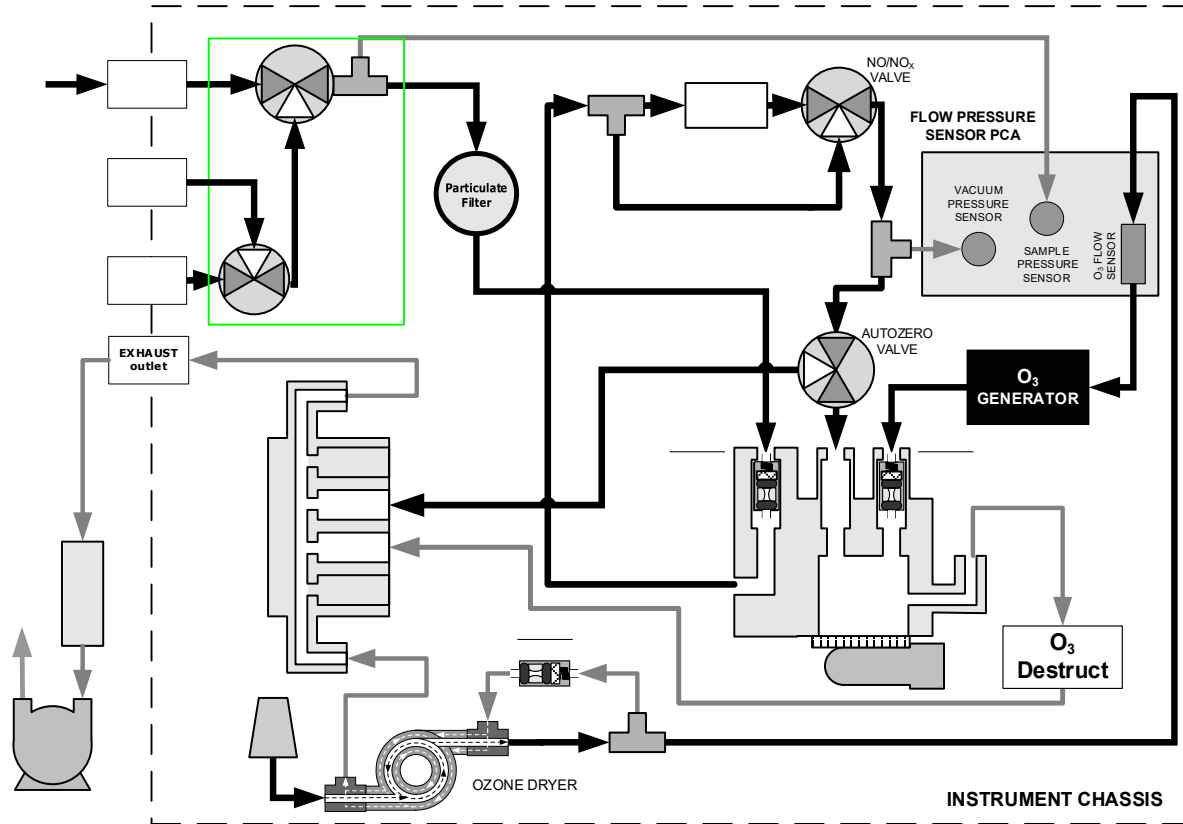


Figure 2-19. N200M Pneumatics with Zero/Span Valves Option

Table 2-7. Zero/Span Valves Option's Operating States

| MODE     | VALVE      | CONDITION                                |
|----------|------------|--|
| SAMPLE   | Sample/Cal | Open to SAMPLE gas inlet                 |
|          | Zero/Span  | Open to ZERO AIR inlet                   |
| ZERO CAL | Sample/Cal | Open to ZERO/SPAN inlet (activated)      |
|          | Zero/Span  | Open to ZERO AIR inlet                   |
| SPAN CAL | Sample/Cal | Open to ZERO/SPAN inlet (activated)      |
|          | Zero/Span  | Open to SPAN inlet / IZS gas (activated) |



# N200, N200M, N200H

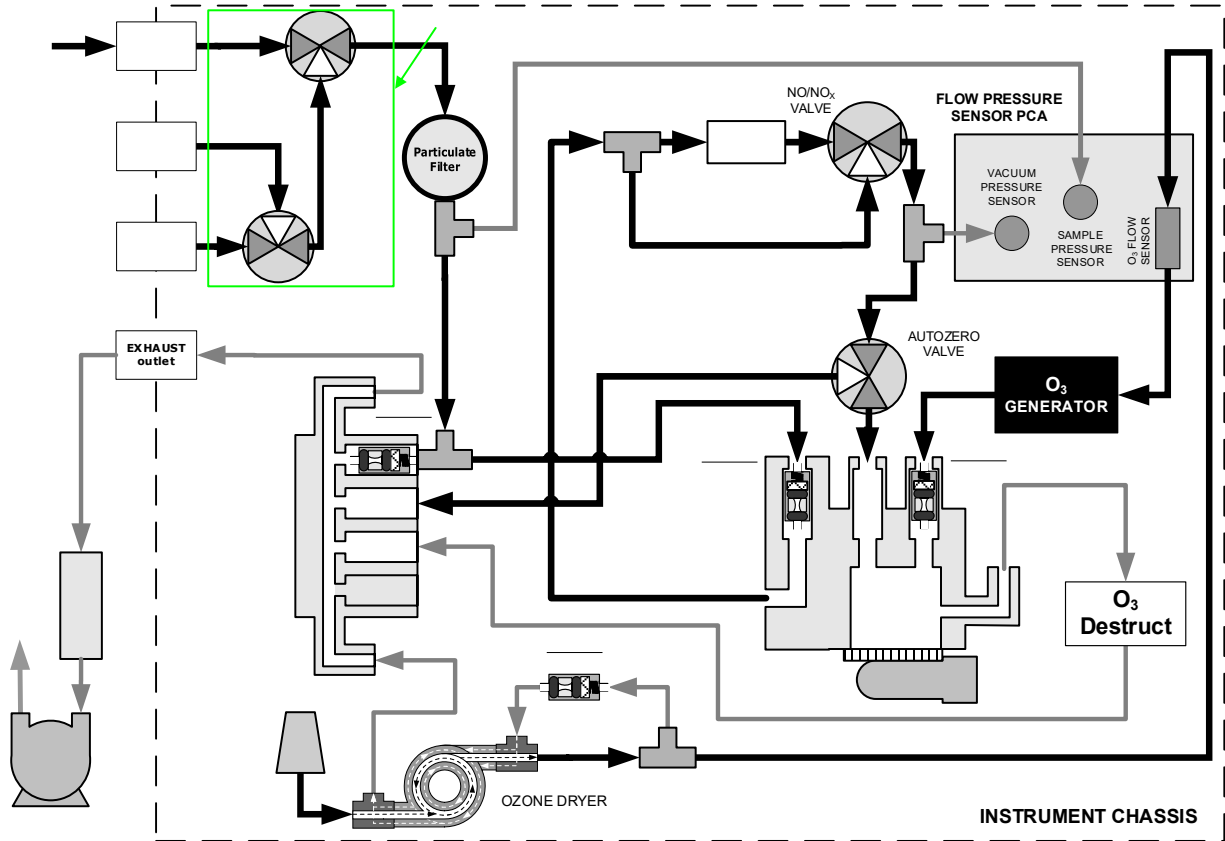


Figure 2-20. N200H Pneumatics with Zero/Span Valves Option



PNEUMATIC FLOW FOR AMBIENT ZERO/PRESSURIZED SPAN VALVES OPTION

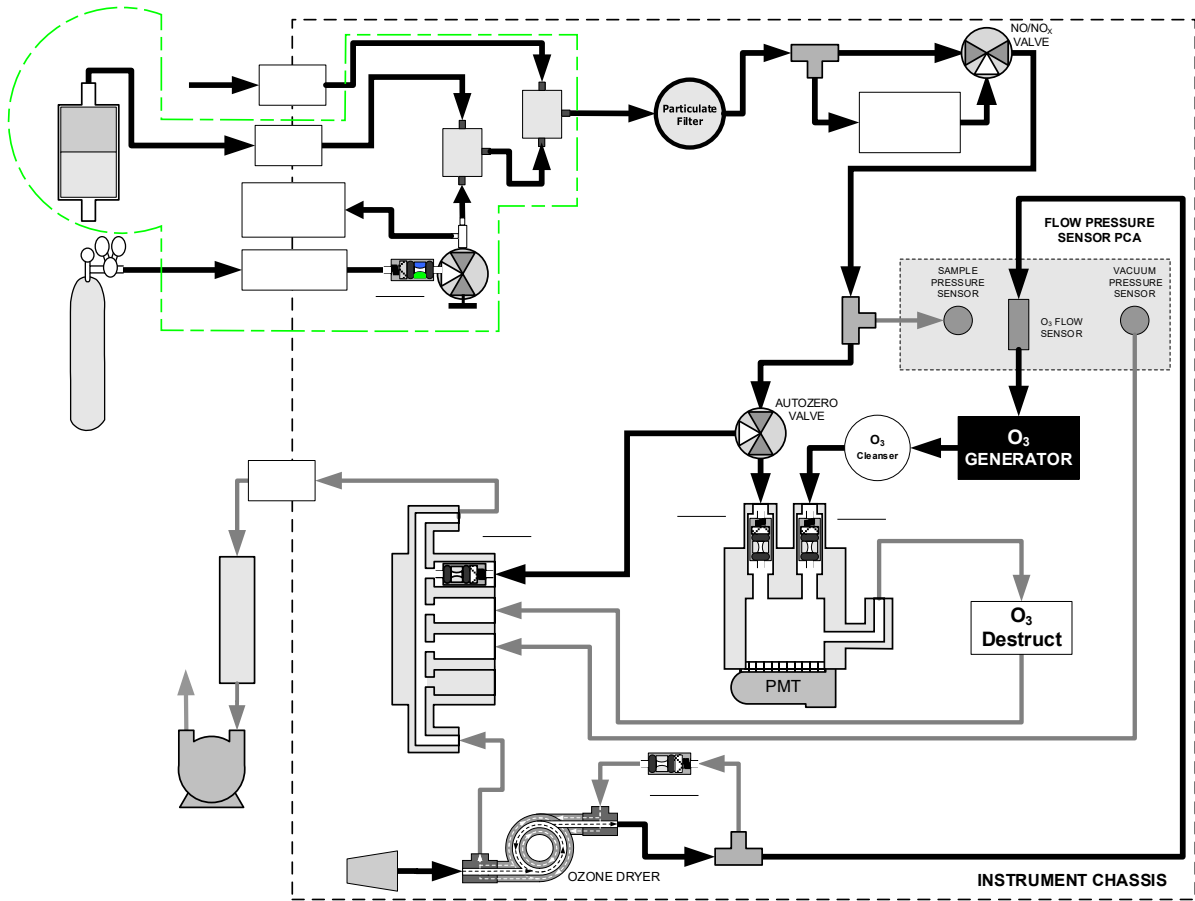


Figure 2-21. N200 Pneumatics with Ambient Zero/Pressurized Span Valves

Table 2-8. Ambient Zero/Pressurized Span Valve Operating States

| MODE     | VALVE                         | CONDITION               | VALVE PORT STATUS |
|----------|-------------------------------|-------------------------|-------------------|
| SAMPLE   | Sample/Cal                    | Open to SAMPLE inlet    | NO → COM          |
|          | Zero/Span                     | Open to ZERO AIR inlet  | NO → COM          |
|          | Span Shutoff                  | Closed                  |                   |
|          | Zero Air Shutoff              | Closed                  |                   |
| ZERO CAL | Sample/Cal                    | Open to ZERO/SPAN Valve | NC → COM          |
|          | Zero/Span                     | Open to ZERO AIR inlet  | NO → COM          |
|          | Span Shutoff                  | OPEN                    |                   |
|          | Zero Air Shutoff <sup>1</sup> | Closed                  |                   |
| SPAN CAL | Sample/Cal                    | Open to ZERO/SPAN Valve | NC → COM          |
|          | Zero/Span                     | Open to SPAN inlet      | NC → COM          |
|          | Span Shutoff                  | Closed                  |                   |
|          | Zero Air Shutoff              | OPEN                    |                   |



# N200, N200M, N200H

## PNEUMATIC FLOW FOR ZERO SCRUBBER AND IZS OPTION

This option is available for the N200 only.

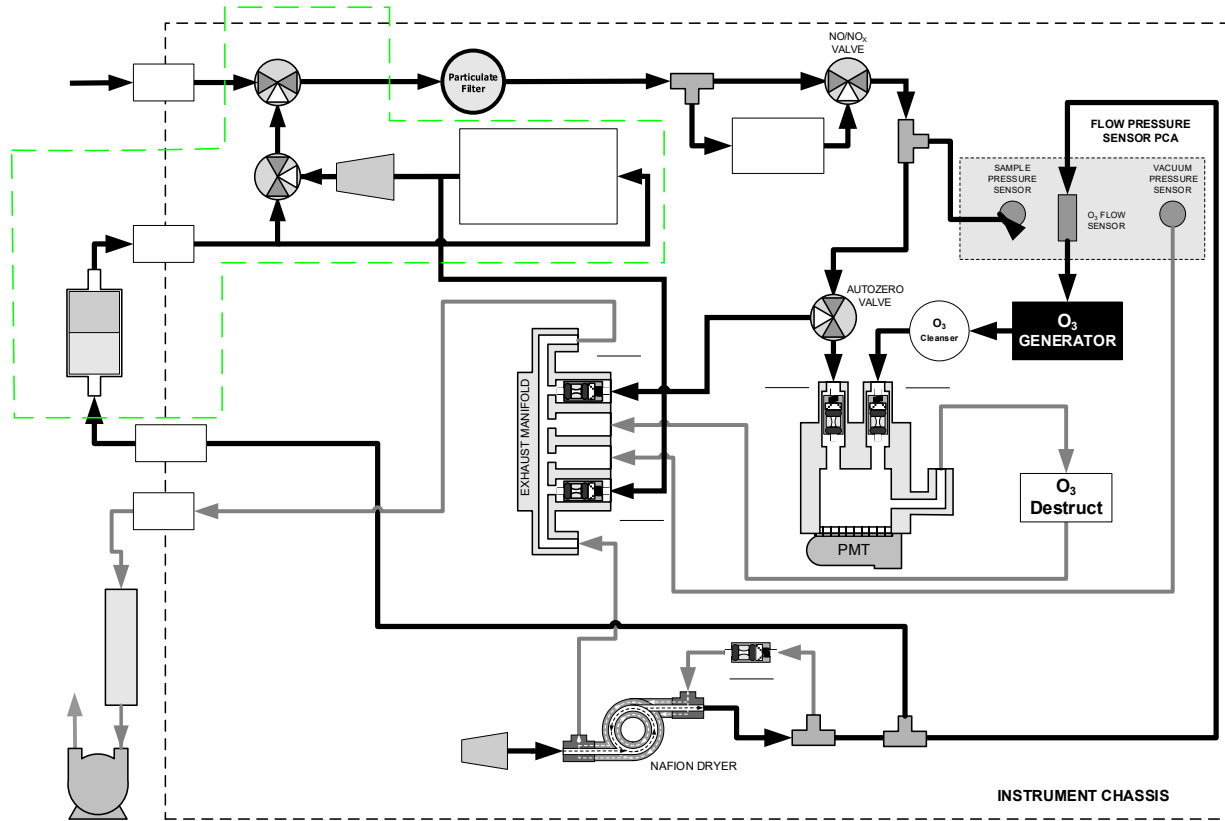


Figure 2-22. N200 Pneumatics with the Internal Span Gas Generator Option

Table 2-9. IZS Valve Option Operating States

| MODE     | VALVE      | CONDITION               | VALVE PORT STATUS |
|----------|------------|-------------------------|-------------------|
| SAMPLE   | Sample/Cal | Open to SAMPLE inlet    | NO → COM          |
|          | Zero/Span  | Open to ZERO AIR inlet  | NO → COM          |
| ZERO CAL | Sample/Cal | Open to ZERO/SPAN valve | NC → COM          |
|          | Zero/Span  | Open to ZERO AIR inlet  | NO → COM          |
| SPAN CAL | Sample/Cal | Open to ZERO/SPAN valve | NC → COM          |
|          | Zero/Span  | Open to SPAN inlet      | NC → COM          |



# N200, N200M, N200H

## PNEUMATIC FLOW FOR AMMONIA REMOVAL SAMPLE CONDITIONER

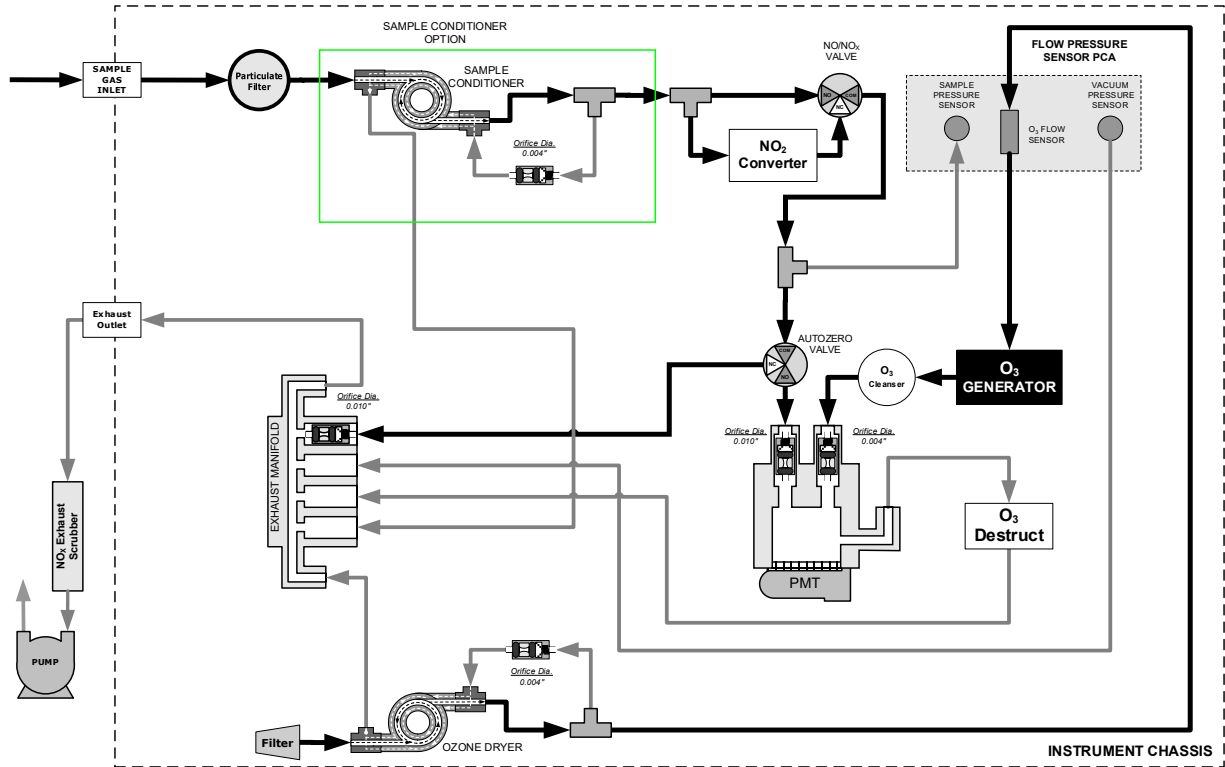


Figure 2-23. Pneumatics for Sample Conditioner Option



# N200, N200M, N200H

## PNEUMATIC FLOW FOR O<sub>2</sub> SENSOR OPTION

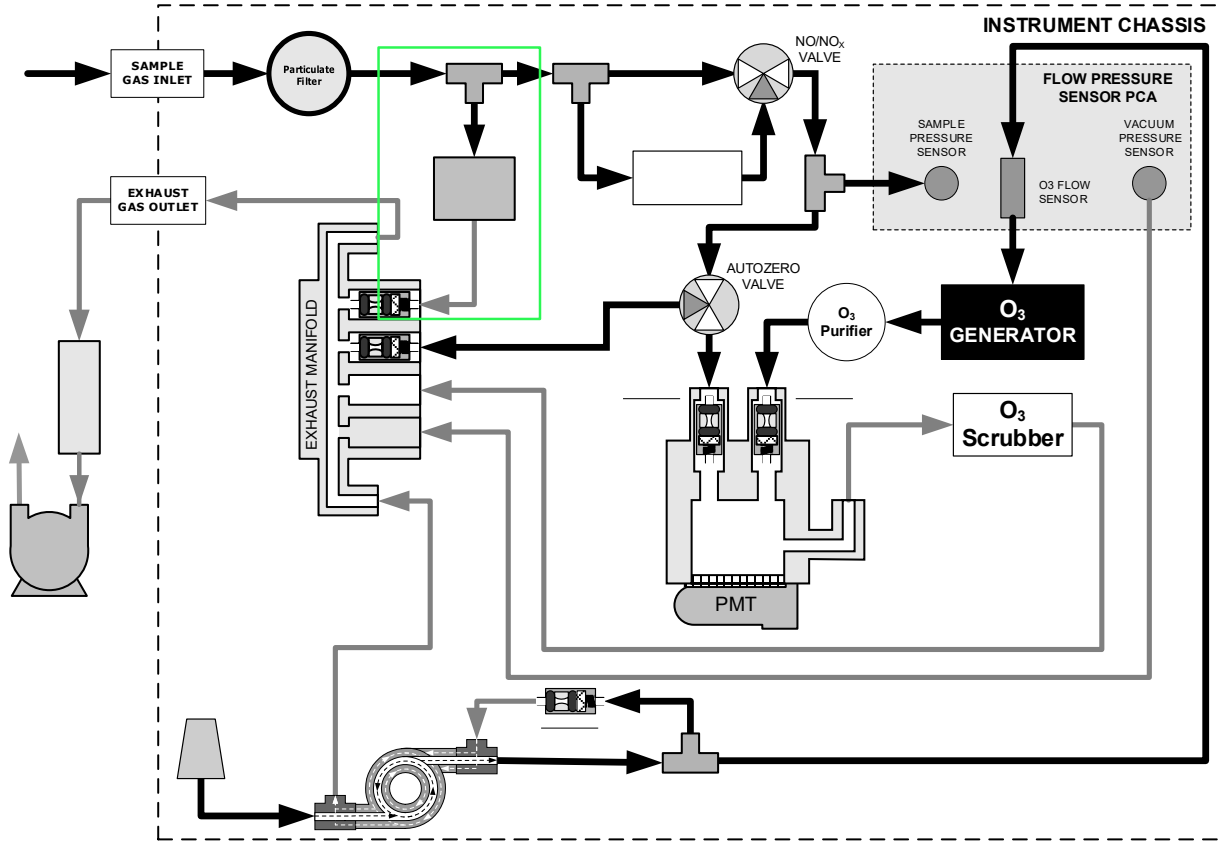


Figure 2-24. N200 Pneumatics with O<sub>2</sub> Sensor Option



# N200, N200M, N200H

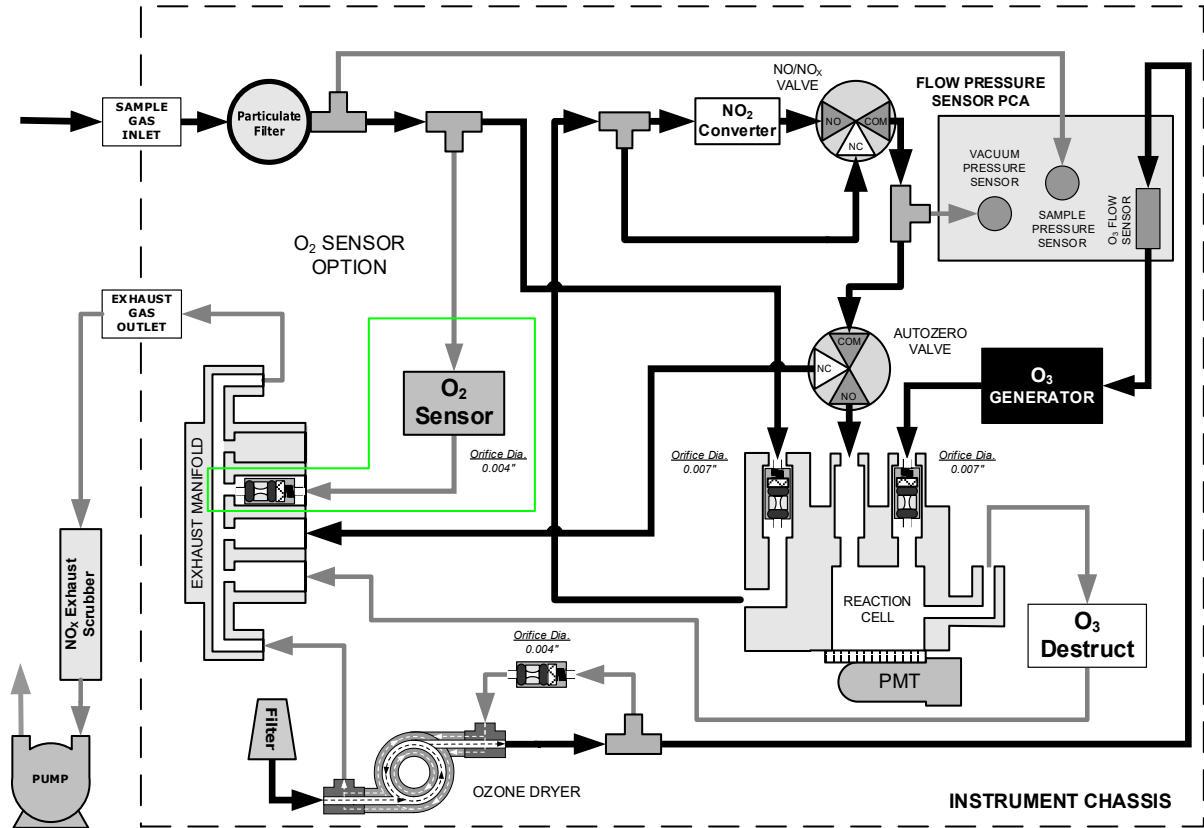


Figure 2-25. N200M Pneumatics with O<sub>2</sub> Sensor Option



# N200, N200M, N200H

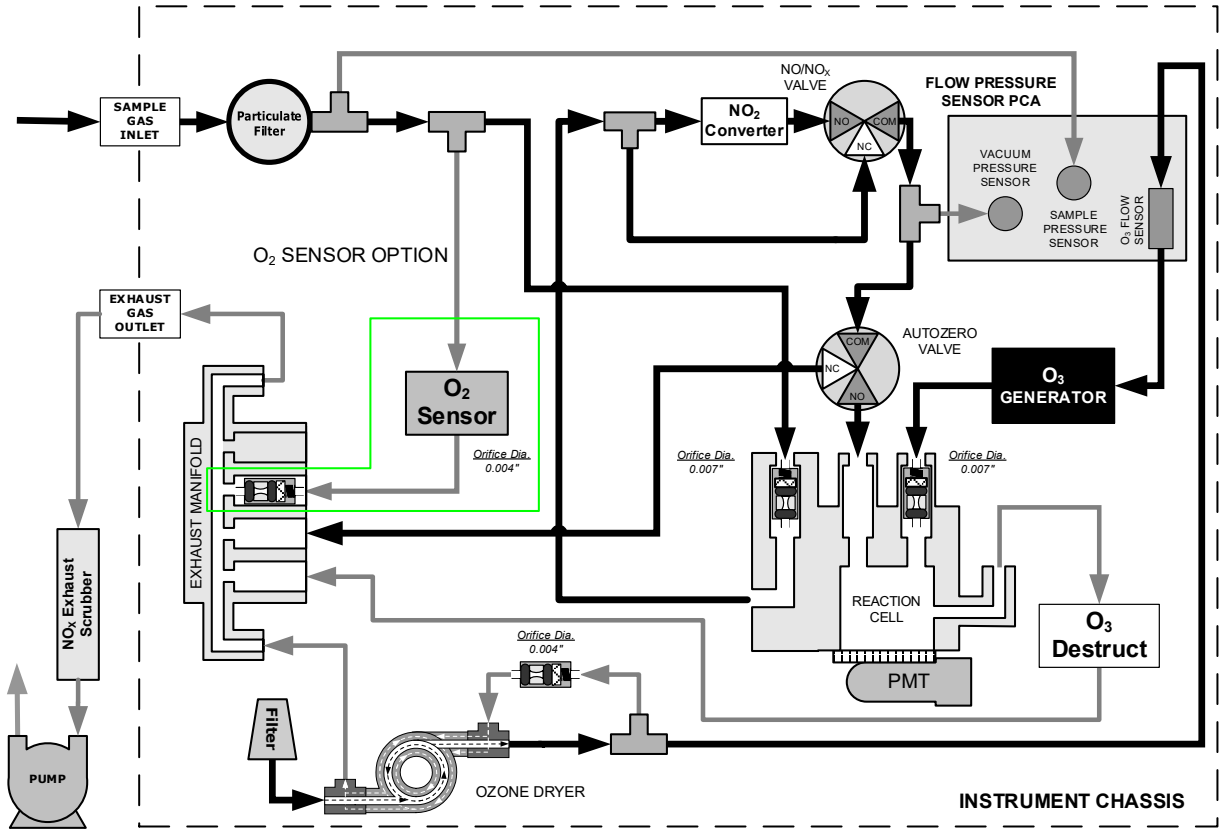


Figure 2-26. N200H Pneumatic Flow with O<sub>2</sub> Sensor Option





## 2.3.4. STARTUP, FUNCTIONAL CHECKS AND CALIBRATION

We recommend reading Section 6 to become familiar with the principles of operation.

When the instrument is first started (Section 2.3.4.1), check its functionality (Section 2.3.4.3) and run an initial calibration (Section 2.3.4.4). Section 2.4 introduces the menu system, and Section 2.5 provides setup/customization instructions.



### CAUTION!

If the presence of ozone is detected at any time, power down the instrument and contact Teledyne API Technical Support as soon as possible:

+1 800-324-5190 or email: [api-techsupport@teledyne.com](mailto:api-techsupport@teledyne.com)

### 2.3.4.1. STARTUP

Upon initial startup, a sequence of status screens (Figure 2-27) appear prior to the Home page (Figure 2-28).

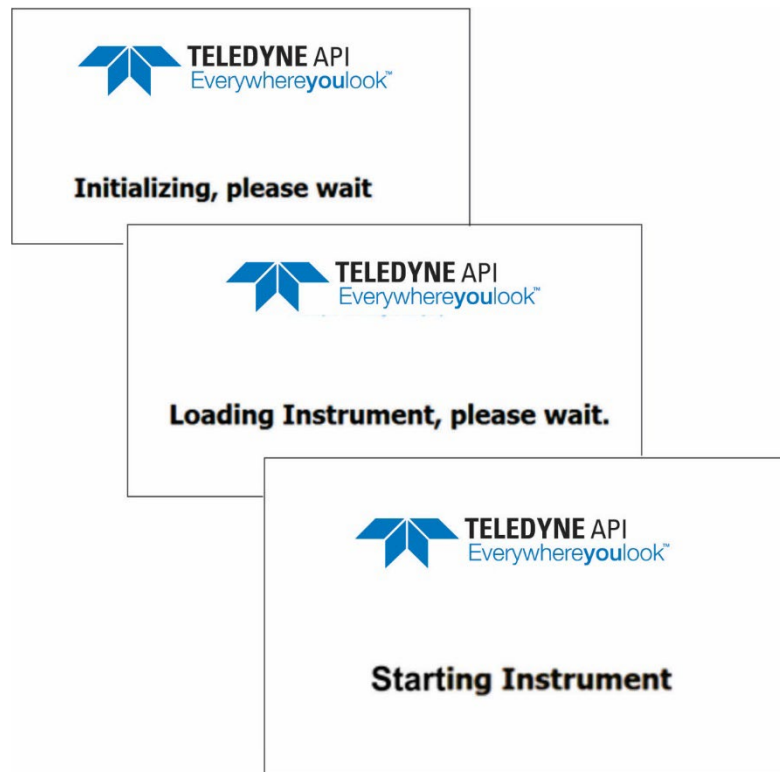


Figure 2-27. Status Screens at Startup



## N200, N200M, N200H

Upon any startup, this instrument should warm up for approximately one hour before reliable measurements can be taken.

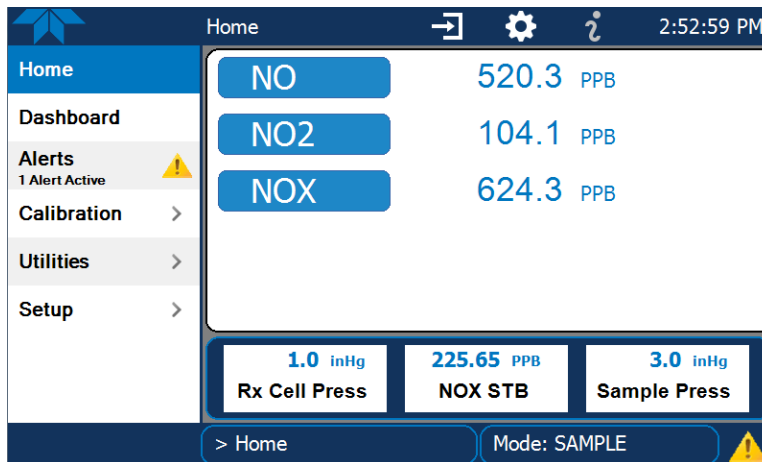


Figure 2-28. Home Page Example

### 2.3.4.2. ALERTS: WARNINGS AND OTHER MESSAGES

Because internal temperatures and other conditions may be outside the specified limits during the warm-up period, the software will suppress most Alerts for 30 minutes after power up. The Alerts page (Figure 2-29) shows the status of any active warning conditions or user-configured Events. (Section 2.4.3 provides more detailed information about Alerts, and Section 2.5.2 addresses Events).

Alerts can be viewed and cleared via either the Alerts menu or the Alerts shortcut (Caution symbol, bottom right corner of the screen). Although these alerts can be cleared from the Active Alerts page, a history of all alerts remains in the Utilities>Alerts Log page.

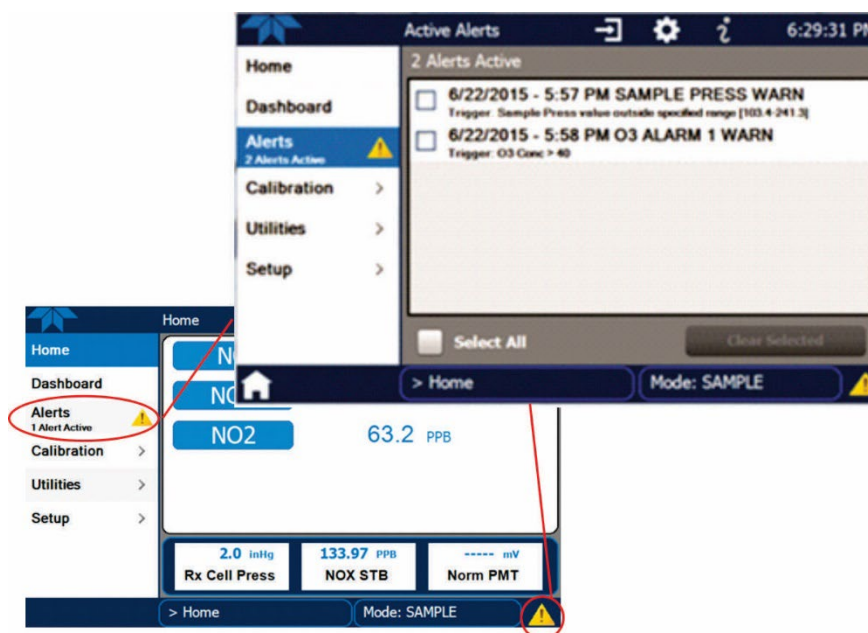


Figure 2-29. Viewing Active Alerts Page



## N200, N200M, N200H

If Alerts about warning conditions persist after the warm up period or after being cleared, investigate their cause using the troubleshooting guidelines in Section 5.7.

### 2.3.4.3. FUNCTIONAL CHECKS

After warm-up, verify that the software properly supports any hardware options that are installed (Setup>Instrument menu), and that the instrument is functioning within allowable operating parameters. Check the Dashboard page against the instrument's *Final Test and Validation Data sheet*, which lists these values as they appeared before the instrument left the factory. (If any functional parameters are not displayed, configure the Dashboard through the Setup>Dashboard menu to add them; see Section 2.4.2).

These functions are also useful tools for diagnosing problems (information provided in Section 5.7.2).

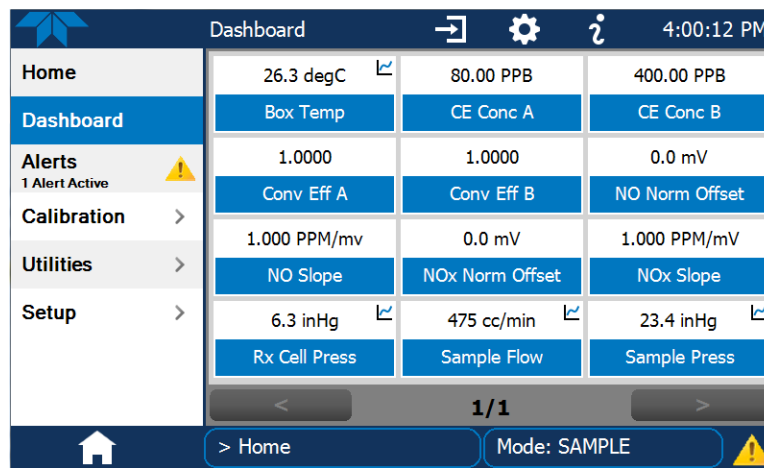


Figure 2-30. Sample Dashboard Page

### 2.3.4.4. CALIBRATION

Before operation begins, the analyzer requires zero and span calibrations, and possibly HVPS adjustment, followed by calibration of the converter efficiency (CE) points. Also, any time an analyzer is moved or its configuration changed, it must undergo a calibration check. The method for performing a calibration, or a basic calibration check, differs slightly depending on whether or not any of the available internal zero air or valve options are installed. Follow the appropriate calibration instructions presented in Section 4.



## 2.4. MENU OVERVIEW

Table 2-10 describes the main menus and provides cross-references to the respective sections with configuration details.

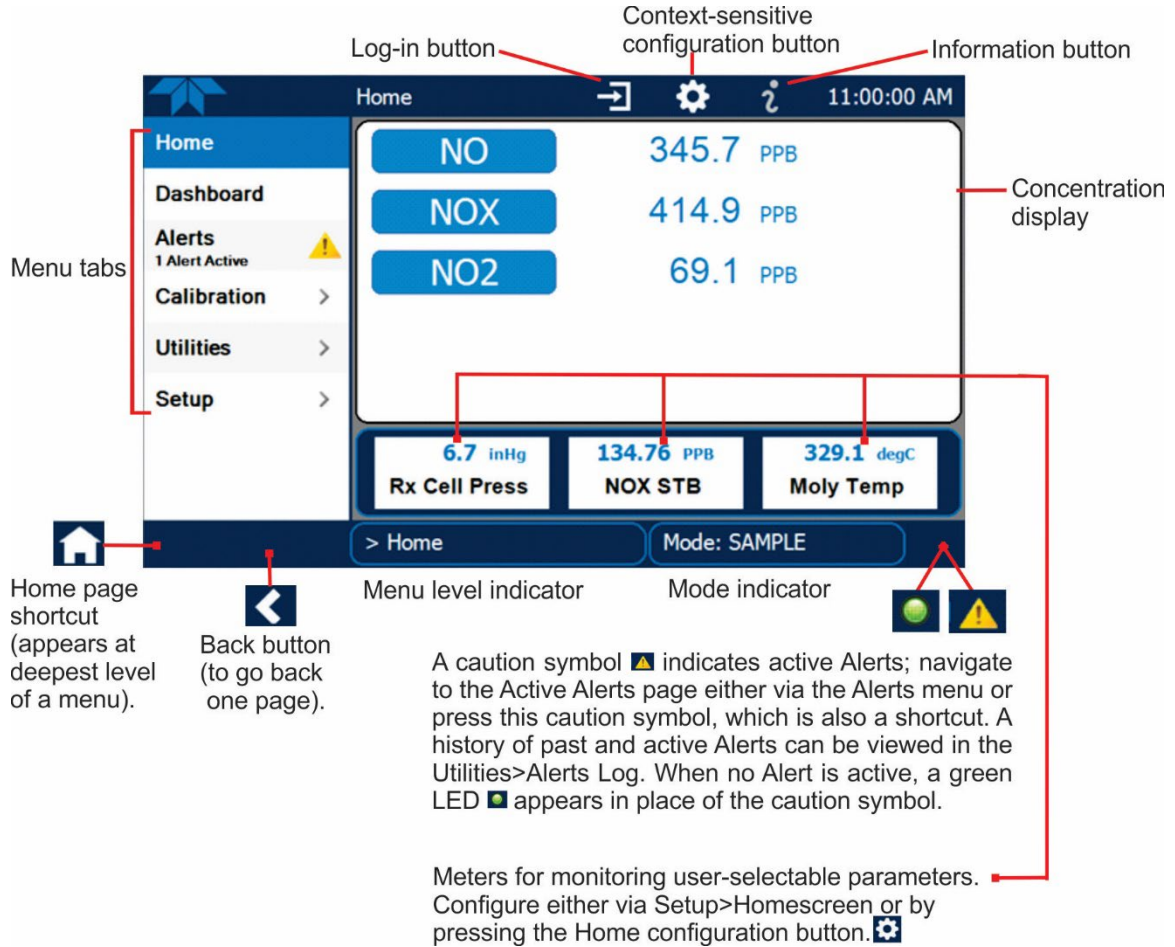
**Table 2-10. Menu Overview**

| MENU                             | DESCRIPTION   | LOCATION             |
|----------------------------------|---|----------------------|
| Home                             | View and plot concentration readings and other selectable parameter values (Figure 2-32).   | Section 2.4.1        |
| Dashboard                        | View user-selected parameters and their values, some of which can be displayed in a live-plot graph (Figure 2-33).  | Section 2.4.2        |
| Alerts                           | View and clear active Alerts that were triggered by factory-defined Events as well as user-defined Events. (Active and past Alerts are recorded in the Utilities>Alerts Log).   | Section 2.4.3        |
| Calibration                      | Run calibrations on the NO and NO <sub>x</sub> channels and calibrate converter efficiency points.  | Sections 2.4.4 and 4 |
| Utilities                        | View logs, download data and firmware updates, copy configurations between instruments, and run diagnostics.  | Section 2.4.5        |
| Setup                            | Configure a variety of features and functions through these submenus for customized operation.  | Section 2.5          |
| Datalogging                      | Track and record concentration and calibration data and selectable diagnostic parameters, the reports for which can be viewed in the Utilities>Datalog View menu (Section 2.4.5) and downloaded to a flash drive via the Utilities>USB Utilities menu (Section 2.4.5).<br>Also, select configured Events (Section 2.5.2) and create customized triggers for data logging functions. | Section 2.5.1        |
| Events                           | Select parameters and define the conditions by which they are to be flagged and recorded in the Alerts log (Section 2.4.3) when they are triggered. Once configured, Events can be used to trigger Datalogs. (Section 2.5.1). Note that some Events are predefined and are not editable.  | Section 2.5.2        |
| Dashboard                        | Monitor instrument functionality (Figure 2-30) via selectable parameters.   | Section 2.5.3        |
| Auto Cal<br>(with valve options) | When zero/span valve options installed, configure sequences for automatic calibration functions.  | Section 4.3          |
| Vars                             | Manually adjust several software variables that define specific operational parameters.   | Section 2.5.5        |
| Homescreen                       | Select up to three parameters to be displayed in the meters (Figure 2-31).  | Section 2.5.6        |
| Digital<br>Outputs<br>(option)   | Map the rear-panel digital outputs to a variety of signals present in the instrument to monitor the status of operating conditions or custom Events.  | Section 2.5.7        |
| Analog<br>Outputs<br>(option)    | Send user-selected parameter readings in the form of user-defined voltage or current loop signals as outputs to a strip chart recorder and/or the data logger.  | Section 2.5.8        |
| Instrument                       | View product and system information, including list of options, if any; view network settings; view/adjust Date and Time settings*; and check for firmware updates when connected to a network that is connected to the Internet.<br>*Time Zone change requires special procedures (Section 5.5).   | Section 2.5.9        |
| Comm                             | View and configure network and serial communications.   | Section 2.5.10       |



## 2.4.1. HOME PAGE

Figure 2-31 presents an orientation to the main display screen; Figure 2-32 shows that pressing the gas name or its concentration value or a meter below displays a live plot of their respective readings. Section 2.5.6 provides configuration instructions.



**Figure 2-31. User Interface Orientation**



# N200, N200M, N200H

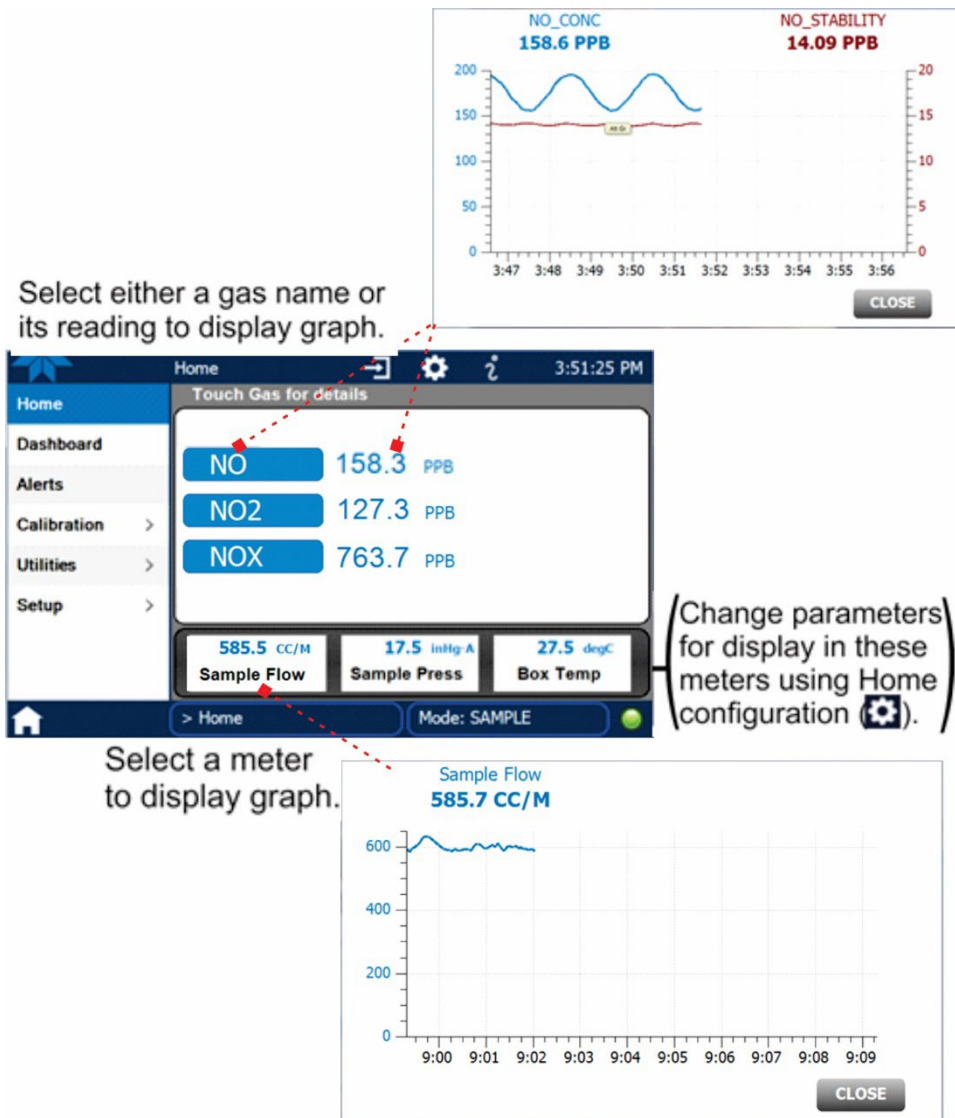


Figure 2-32. Concentration and Stability Graph (top) and Meter Graph (bottom)

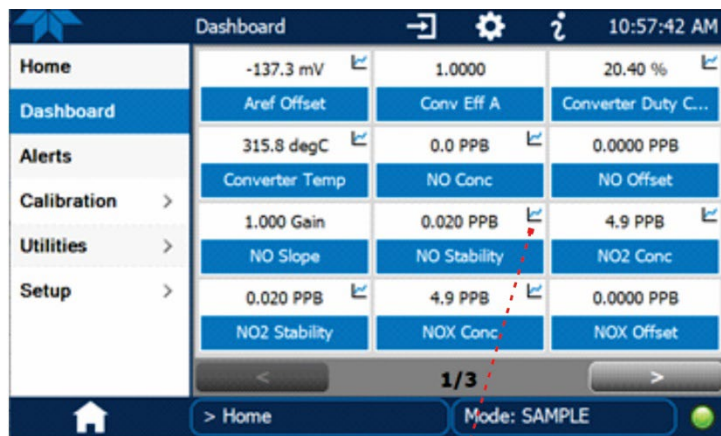




## N200, N200M, N200H

### 2.4.2. DASHBOARD

The Dashboard displays an array of user-selectable parameters and their values (Section 2.5.3 provides configuration instructions). If there is a graphing icon in the upper right corner of a parameter, pressing that parameter displays a live plot of its readings as in Figure 2-33.



Select a graphable parameter in the Dashboard page to view a live plot.

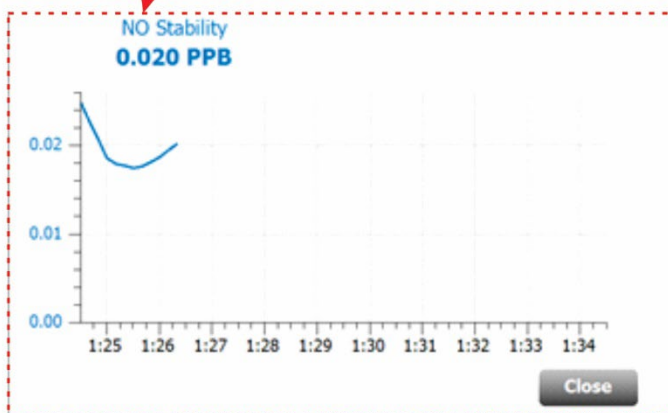


Figure 2-33. Dashboard Page



## N200, N200M, N200H

Common parameters and their descriptions are presented in Table 2-11.

**Table 2-11. Common Dashboard Parameters**

| PARAMETER           | UNITS   | DESCRIPTION   |
|---------------------|---------|---|
| Box Temp            | °C      | The temperature inside the analyzer chassis.  |
| [gas] Offset        | MV      | The offset calculated during the most recent [NO or NO <sub>x</sub> ] zero/span calibration.  |
| [gas] Slope         | -       | The slope calculated during the most recent [NO, or NO <sub>x</sub> ] zero/span calibration.  |
| [gas] Stability     | PPB     | The standard deviation of concentration readings of the selected gas. <ul style="list-style-type: none"><li>• Data points are recorded every ten seconds. The calculation uses the last 25 data points.</li></ul> |
| O <sub>3</sub> Flow | CC/MIN  | Gas flow rate of O <sub>3</sub> gas into the reaction cell.   |
| PMT [gas]           | MV      | The raw signal output of the gas PMT.   |
| PMT Temp            | °C      | The temperature of the PMT.   |
| RCell Pressure      | IN-HG-A | The current pressure of the sample gas in the reaction cell as measured at the vacuum manifold.   |
| RCell Temp          | °C      | The temperature of the gas inside the reaction cell.  |
| Sample Flow         | CC/MIN  | Gas flow rate of the sample gas into the reaction cell.   |
| Sample Press        | IN-HG-A | The current pressure of the sample gas as it enters the reaction cell, measured between the NO/NO <sub>x</sub> and Auto-Zero valves.  |





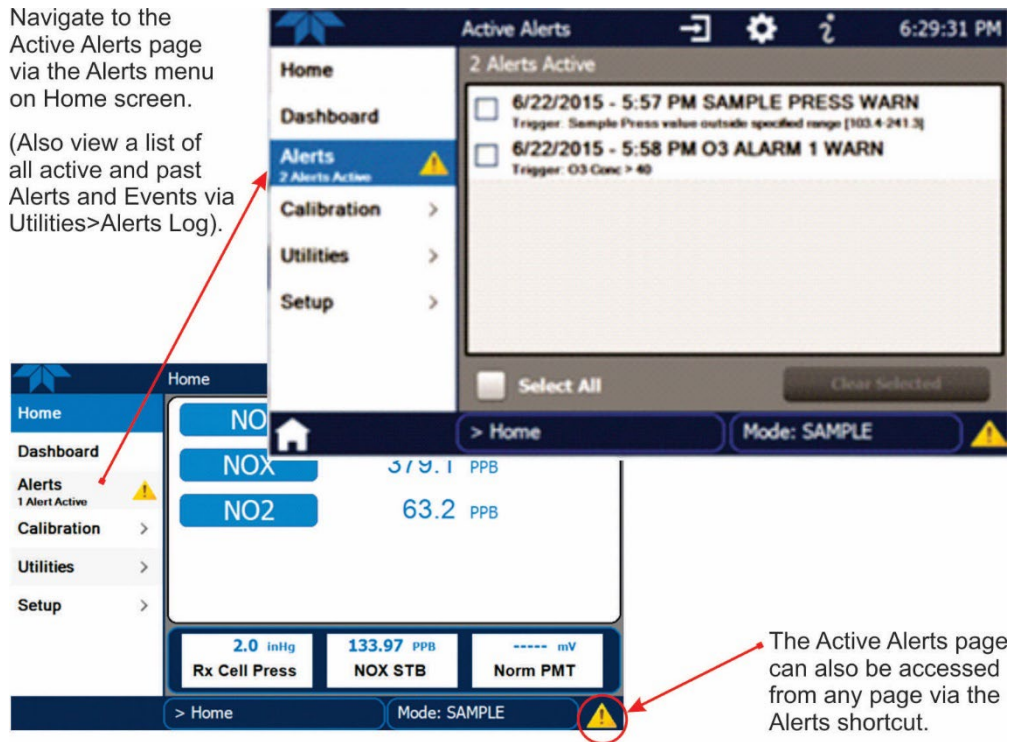
## 2.4.3. ALERTS

Alerts are notifications triggered by specific criteria having been met by either factory-defined conditions (standard and not editable) or user-defined Events (Section 2.5.2). The Active Alerts page shows the status of any active warning conditions or Events that have been triggered.

When Alerts are triggered, a caution symbol appears in both the Alerts menu tab and in the bottom right corner of the software interface, which serves as a shortcut to the Alerts page from any other page. View a list of currently active Alerts by pressing either the Alerts menu on the Home screen or by pressing the Alerts shortcut (Figure 2-34).

While Alerts can be cleared from the Active Alerts page, they remain recorded in the Utilities>Alerts Log menu.

Navigate to the Active Alerts page via the Alerts menu on Home screen.  
(Also view a list of all active and past Alerts and Events via Utilities>Alerts Log).



The Active Alerts page can also be accessed from any page via the Alerts shortcut.

**Figure 2-34. Navigating to the Active Alerts Page**

Alerts can be configured as either latching (appears in Active Alerts screen when Event is triggered and must be cleared by the user) or non-latching (Active Alerts screen continuously updates based on the Event criteria, clearing on its own). See Section 2.5.2.

To clear Alerts from the Active Alerts page, either check individual boxes to choose specific Alerts, or check the Select All box to choose all Alerts, then press the Clear Selected button.



## N200, N200M, N200H

When all Alerts are cleared, the Alerts menu tab no longer shows the caution symbol, and a green LED replaces the caution symbol in the bottom right corner of the interface (Figure 2-35). However, Alerts can reappear if the conditions causing them are not resolved. For troubleshooting guidance, refer to Section 5.7.

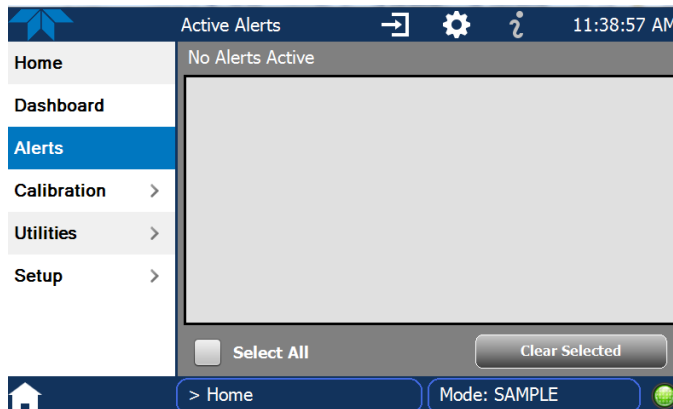


Figure 2-35. Active Alerts Cleared

Alerts and Events remain recorded in the Utilities>Alerts Log (Figure 2-36).

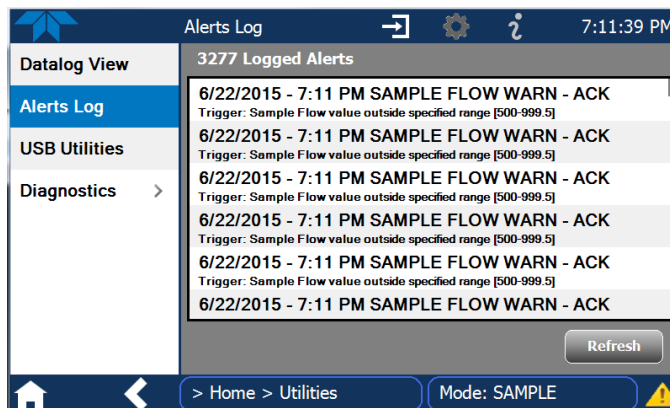


Figure 2-36. Utilities>Alerts Log of Active and Past Alerts and Events

### 2.4.4. CALIBRATION

The Calibration menu is used for zero/span/multipoint calibrations and for external calibration with valve options installed. Calibration procedures are presented in Section 4.



### 2.4.5. UTILITIES

The Utilities menu has a variety of functions as described next in Table 2-12.

Table 2-12. Utilities Submenu Descriptions

| UTILITIES MENU           | DESCRIPTION  |
|--------------------------|--|
| <b>Datalog View</b>      | Displays the data logs that were configured via the Setup>Data Logging menu. From this list a log can be selected and filters applied to view the desired data. (For details on setting up and running the Data Logger, see Section 2.5.1).  |
| <b>Alerts Log</b>        | Displays a history of alerts that are triggered by factory-defined and user-defined Events, such as warnings and alarms (See Section 2.5.2 for Events configuration).  |
| <b>USB Utilities</b>     | Serves multiple purposes using a flash drive connected to the instrument's front panel USB port: <ul style="list-style-type: none"> <li>• download data from the instrument's Data Acquisition System (DAS), the Data Logger, to a flash drive (Section 2.5.1.3)</li> <li>• update firmware (Section 5.3)</li> <li>• transfer instrument configuration from/to other same-model instruments (Section 2.6)</li> <li>• download a basic operation functionality report (Section 5.3).</li> </ul> |
| <b>Diagnostics</b>       | Provides access to various pages that facilitate troubleshooting and to sensor calibrations.   |
| Analog Inputs            | Show raw voltage of several internal analog input parameters. These can be logged in the internal data acquisition system (DAS) by configuring the Data Logger in the Setup menu.  |
| Analog Outputs (option)  | Show the voltage or Current signals for the functions selected and configured in the Setup>Analog Outputs option menu. (Section 2.3.1.3 presents the rear panel connections).  |
| Digital Inputs (option)  | Show and change the ON/OFF state of specific, available features with the Digital I/O option.  |
| Digital Outputs (option) | Show and change the ON/OFF state of user-defined (Setup>Digital Outputs menu) outputs and relays with the Digital I/O option.  |
| Flow Cal                 | Used to calibrate the sample gas flow reading with actual flow measured by an external device. (See Section 5.6.12.3).   |
| Ozone Flow Cal           | Used to calibrate the ozone gas flow reading with actual flow measured by an external device. (See Section 5.6.12.3).  |
| HVPS Adjust              | Used to change the gain of the PMT output when instrument's slope and offset values are outside acceptable values, after other possible causes addressed and eliminated.   |
| O3 Gen Override          | Used to override the Ozone Generator state when needed, such as for service (Section 5.7.9.6).   |

### 2.4.6. SETUP

The Setup menu is used to configure the instrument's various features, functions, and data log. Section 2.5 provides details for the menus under Setup.



## 2.5. SETUP MENU: FEATURES/FUNCTIONS CONFIGURATION

Use the Setup menu to configure the instrument's software features, to gather information on the instrument's performance, and to configure and access data from the Datalogger, the instrument's internal data acquisition system (DAS). Once the setups are complete, the saved configurations can be downloaded to a USB drive through the Utilities>USB Utilities menu and uploaded to other instruments of the same model (Section 2.6).

### 2.5.1. SETUP>DATA LOGGING (DATA ACQUISITION SYSTEM, DAS)

The Datalogger can be configured to capture and store user-defined data, which then can be viewed in the Alerts page, if elected, as well as downloaded from the instrument to a USB flash drive or using NumaView™ Remote software for examination and analysis.

Figure 2-37 shows a new log; Figure 2-38 shows a sample existing log, which can be edited or deleted, and Figure 2-39 provides illustrated instructions for setting up a new log, with Sections 2.5.1.1 and 2.5.1.2 providing additional details.

To transfer captured instrument data to a flash drive see Section 2.5.1.3.

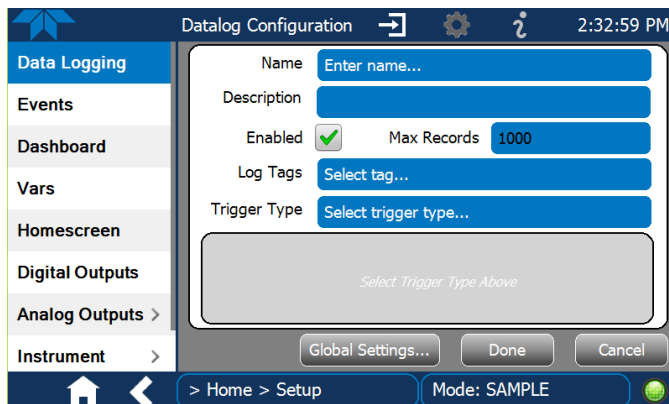


Figure 2-37. Datalog Configuration, New Log Page

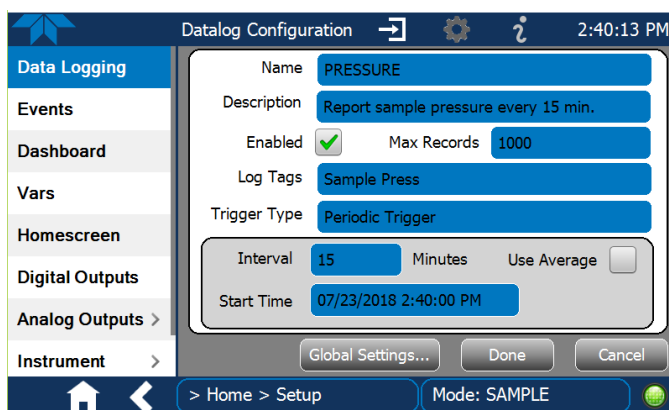


Figure 2-38. Datalog Configuration, Existing Log



# N200, N200M, N200H

Press the Name field and use the keyboard pop-up to label the new log.

Press the Description field and use the keyboard pop-up to describe the log.

Press the Max Records field and use the keypad pop-up to set a maximum.

Leave the Enabled box checked to allow data capture of this log, or press to uncheck and suspend data capture.

Press the Log Tag field to select the parameters to be tracked.

Press the Trigger Type field to select either Periodic or Conditional.

Press Global Settings to set time format.

When **Periodic** is selected as the Trigger Type, the field below it is populated with the Interval and Date/Time windows.

When **Conditional** is selected as the Trigger Type, the field below it is populated with the Trigger Tag and Condition definition windows.

(Please refer to the section on Configuring Trigger Types for details).

**Figure 2-39. Creating a New Data Log**

The parameters available in the list of Log Tags include the names of Events configured in the Events page (Section 2.5.2).



### 2.5.1.1. CONFIGURING TRIGGER TYPES: PERIODIC

The Periodic trigger is a timer-based trigger that is used to log data at a specific time interval. Periodic Trigger requires an interval that is set to number of minutes and a start time that is set to date and clock time.

Press the Interval field and use the keypad pop-up to edit the amount of time in seconds (default 60) between capturing data for the selected Log Tags.

Press the Start Time field and use the Time and Date pop-ups to select the time and the date to start capturing data for the parameters that were selected in the Log Tags field.

(toggle)

Figure 2-40. Datalog Periodic Trigger Configuration





## 2.5.1.2. CONFIGURING TRIGGER TYPES: CONDITIONAL

Conditional Trigger tracks/records data for user-selected parameters that meet specified conditions.

Press the Trigger Tag field and select a parameter to be tracked/logged. A default Condition associated with the selected Tag will populate the Condition field.

Press the Condition field to select a different choice from the condition list.

Either the Threshold field appears, or the Low and High fields appear if a condition requires either a threshold value or range values. Press a Value... field and use the keypad.

(Other condition lists include True/False and Enabled/Disabled)

Figure 2-41. Datalog - Conditional Trigger Configuration

## 2.5.1.3. DOWNLOADING DAS (DATA ACQUISITION SYSTEM) DATA

To download DAS data collected by the Datalogger from the instrument to a flash drive, navigate to the Utilities>USB Utilities>DAS Download menu.

1. Insert a flash drive into a front panel USB port and wait for the Status field to indicate that the drive has been detected; available buttons will be enabled.

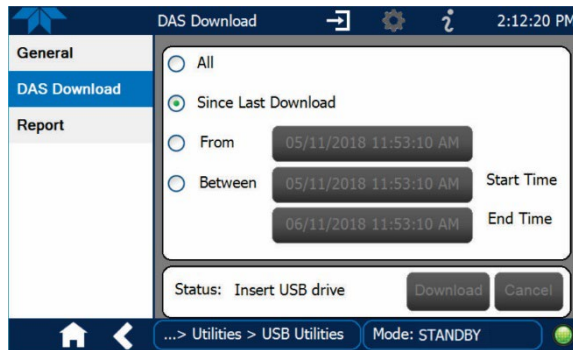


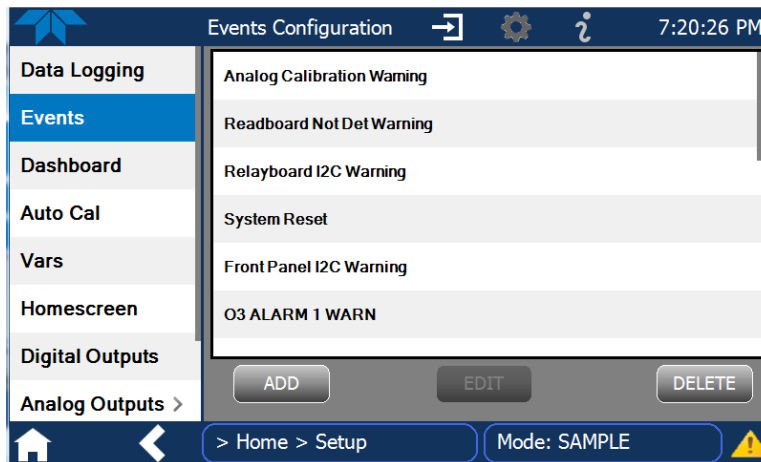
Figure 2-42. DAS Download Page

2. Select all or define a period from which to download the collected data.
3. Press the Download button, and when complete, as indicated in the Status field, press the Done button (changed from “Cancel”) and remove the flash drive.



## 2.5.2. SETUP>EVENTS

Events are occurrences that relate to any operating function, and are used to define the conditions that can be set to trigger Alerts (Section 2.4.3). Events can provide diagnostic information about the instrument, typically referred to as “Warnings”, or they can provide other information on instrument functionality, such as concentration alarms. Some Events are standard and not editable while others are user-configurable, described here. Existing Events are listed in the Events page (Figure 2-43) under the Setup menu.



**Figure 2-43. Events List**

Access the Events Configuration page either from the Active Alerts page (Alerts Menu) by pressing the configuration button, or through the Home>Setup>Events menu (Figure 2-43). Press ADD to create a new Event (refer to Figure 2-44 for details), or select an existing Event to either Edit or Delete it (Figure 2-46).





# N200, N200M, N200H

Press the Name field and use the keyboard pop-up to name the new event.

Press the Description field and use the keyboard pop-up to describe the event.

Choose whether to make the event enabled, visible, and/or latching.

Press the Trigger Tag field to select a tag from the list of parameters for the trigger event.

Press the Condition field to select from a list of conditions to be applied to the trigger.

(Gray scroll bar indicates additional choices available; drag list to scroll).

Either the Threshold field appears, or the Low and High fields appear in this area, only when a condition requires either a threshold value or range of values; then a numeric keypad pops up for entering the value(s).

**Figure 2-44. Event Configuration**

- Enabled  allows the choice of whether to track and record the Event (uncheck this box to “turn off” or deactivate the Event without deleting it). An Event must be enabled in order to use the Visible and the Latching options.
- Visible  allows the choice of whether or not to display the Event in the Alerts page when it is triggered (it will still be recorded and can be viewed in the Utilities>Alerts Log). To use this option, the Event must be enabled.
- Latching  allows the choice of whether or not to keep an Event visible even if the conditions that triggered it were to correct themselves. (Latching requires that the user interact with the Active Alerts screen to manually clear the Alert and internal Event state. Non-latching allows the entry in the Active Alerts screen and the internal Event state to continuously update based on the Event criteria, requiring no user interaction to clear the Alert or Event state).



# N200, N200M, N200H

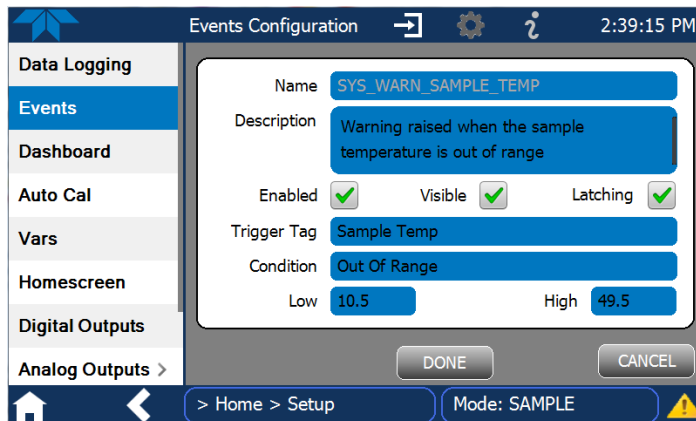


Figure 2-45. Configured Event Sample

## 2.5.2.1. EDITING OR DELETING EVENTS

Select an Event from the list (Figure 2-43) and press the Edit button to view or edit the details (Figure 2-45), or press the Delete button to delete the Event.

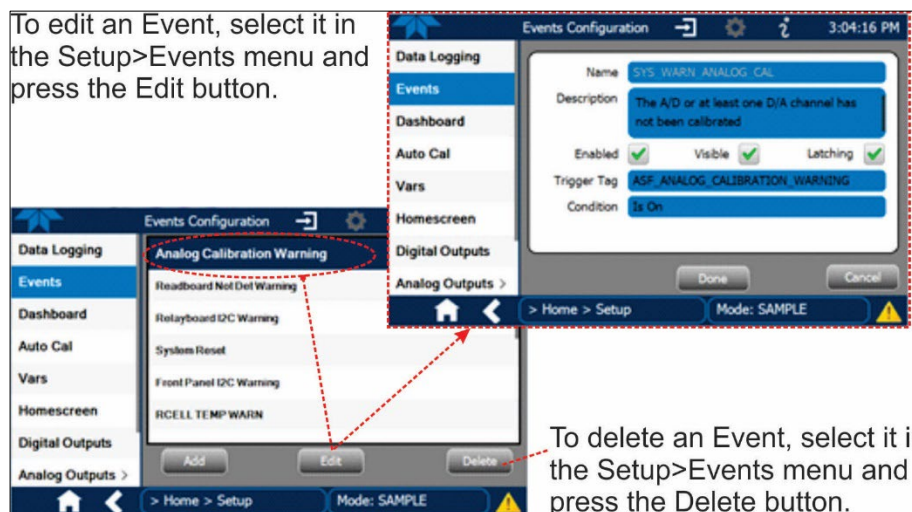


Figure 2-46. Edit or Delete an Event

**Note**

Some default Events that cannot be entirely deleted may return after reboot.



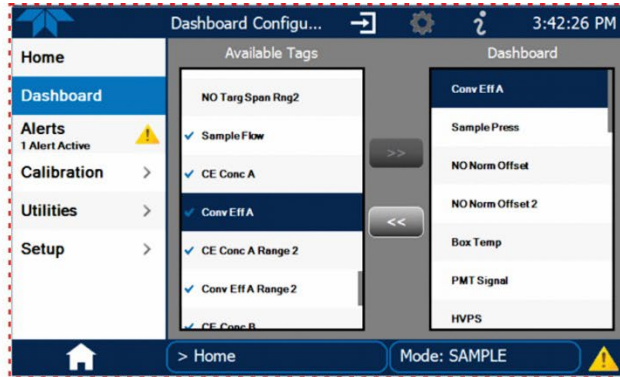
# N200, N200M, N200H

## 2.5.2.2. USING EVENTS AS TRIGGERS FOR DATA LOGGING

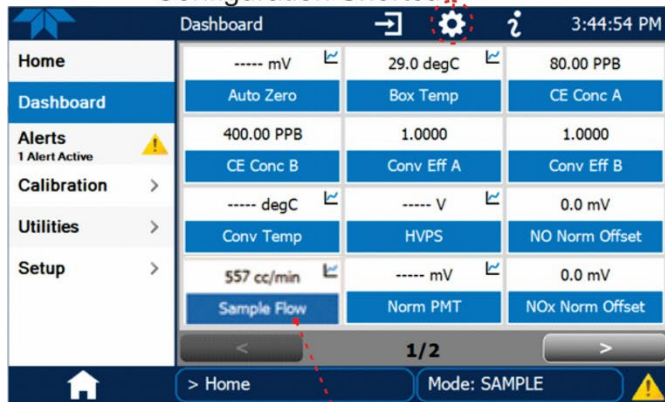
Events can also be used to create customized triggers for data logging functions. The name entered in the Name field of the Events Configuration page will appear in the list of Log Tags of the Datalog Configuration page. The Data Logger is presented in Section 2.5.1.

## 2.5.3. SETUP>DASHBOARD

To navigate to Dashboard Configuration, either press the configuration shortcut in the Dashboard page, or use the Setup>Dashboard menu.



Configuration Shortcut



Configuration editing:

To add a parameter to the Dashboard, select it in the "Available Tags" list and press the right-pointing arrows button. (Checkmarks in the "Available Tags" list indicate parameters that are currently in the Dashboard).

To remove a parameter from the Dashboard, select it from the "Dashboard" list and press the left-pointing arrows button.

Select a graphable parameter in the Dashboard page to view a live plot.

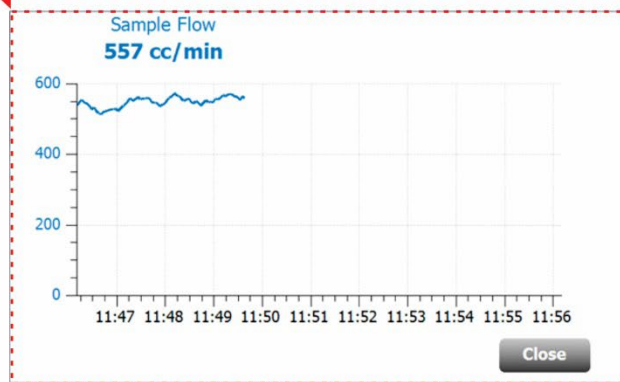


Figure 2-47. Dashboard Display and Configuration



## N200, N200M, N200H

### 2.5.4. SETUP>AUTOCAL (WITH VALVE OPTION)

Auto Cal is available with installed valve options (see Section 4.3).

### 2.5.5. SETUP>VARS

Vars are software variables that define operational parameters automatically set by the instrument's firmware, and are user-adjustable through this menu. Access the menu to see the list of variables; select a variable to view its description; touch the Edit button to change its setting(s).

**Table 2-13. List of Variables with Descriptions**

| VARIABLE   | DESCRIPTION   |
|--|---|
| NOTE: This list includes several of the most common Vars; selecting any Var in the NumaView™ software interface will display its description in the information field to its right. Depending on configuration, some, all, or more of these variables appear in your instrument's Vars menu. |   |
| Conc Precision (or PRIGAS/SECGAS Precision)  | Sets the number of significant digits to the right of the decimal point display of concentration and stability values. ("PRIGAS" = primary gas with two or more other gases; "SECGAS" = secondary gas)  |
| Daylight Savings Enable  | Enable or disable Daylight Savings Time (also see Setup>Instrument>Date/Time Settings)  |
| Dilution Factor Option   | <p>Sets the instrument to compensate for diluted sample gas, such as in continuous emission monitoring (CEM) where the quality of gas in a smoke stack is being tested while the sampling method used to remove the gas from the stack dilutes the gas. Once the amount of dilution (dilution ratio) is known, this feature allows the user to add an appropriate scaling factor to the analyzer's gas concentration calculations so that the true (undiluted) concentration values are shown on the instrument's front panel display and reported via the instrument's various outputs. To add the appropriate scaling factor:</p> <ol style="list-style-type: none"> <li>1. First, check that the analyzer's measurement units are the same as those used for determining the amount of dilution. (The analyzer's measurement units can be changed in the Setup&gt;Vars&gt;User Units menu).</li> <li>2. Then, set the Dilution Factor Var as a gain to reflect the dilution ratio that was determined. For example, if the amount of dilution is found to be 20 parts diluent to 1 part sample gas (a dilution ratio of 20:1), the gain to be input into the Setup Vars Dilution Factor should be 20 (most common dilution ratio is 100:1).</li> <li>3. Calibrate the analyzer; ensure that the calibration span gas is either supplied through the same dilution system as the sample gas or has an appropriately lower actual concentration (a concentration that matches the diluted gas concentration prior to having input the Dilution Factor).</li> </ol> |
| Dynamic Zero Enable  | Dynamic zero automatically adjusts offset and slope of the NO and NO <sub>x</sub> response when performing a zero point calibration during an AutoCal (Section 4.3).  |
| Dynamic Span Enable  | Dynamic span automatically adjusts the offsets and slopes of the NO and NO <sub>x</sub> response when performing a span point calibration during an AutoCal (Section 4.3).  |
| Enable Software Maintenance Mode   | Set instrument to continue sampling, while ignoring calibration, diagnostic, and reset instrument commands.   |

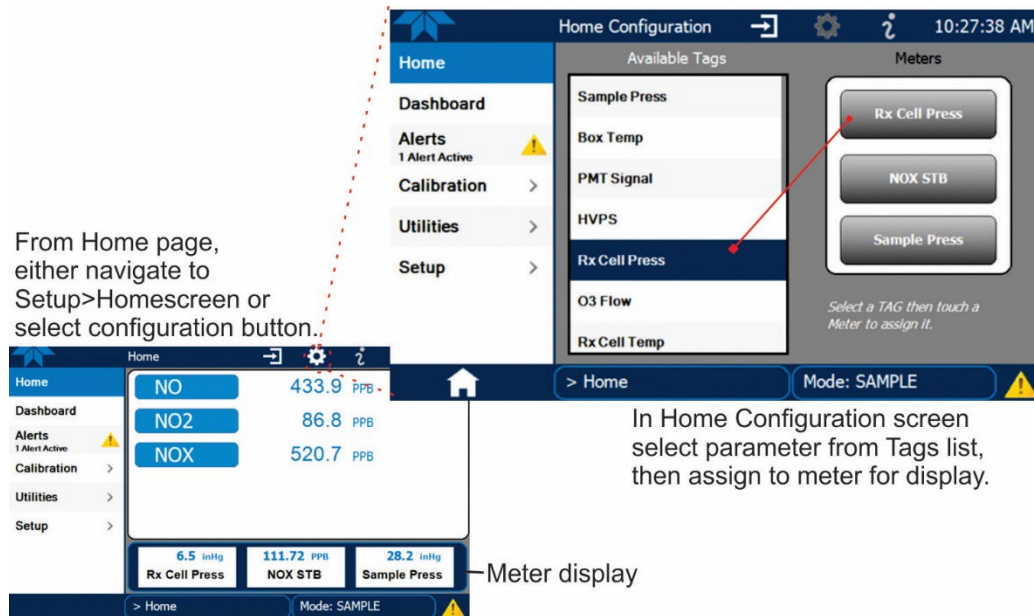


## N200, N200M, N200H

| VARIABLE      | DESCRIPTION   |
|---------------|---|
| Instrument ID | Set unique identifier number for the instrument when it is connected with other instruments on the same Ethernet LAN, or when applying MODBUS protocol.   |
| PMT Range     | Set to Low or High according to the level of concentration expected: Low for Min Range or High for Max Range specification, as this is used by the CPU to adjust physical ranges. (Section 4.1.5 provides more information).  |
| Measure Mode  | Selects the gas measurement mode in which the instrument is to operate: NO <sub>x</sub> only, NO only, or NO <sub>x</sub> and NO simultaneously.  |
| Modbus Units  | If this Var is changed, the instrument must be restarted. LEGACY units is for Modbus registers to be in PPB; where DYNAMIC units is for Modbus registers to be user selected.<br><br>NOTE that if you change the analyzer's Modbus Units to "DYNAMIC" it is recommended that you confirm your data logger settings since some data loggers have settings to convert PPB units to PPM. |
| Range Mode    | Controls range mode, single (SNGL) or dual (DUAL).  |
| System Hours  | Total system runtime hours  |
| TPC Enable    | Enables or disables the Temperature and Pressure Compensation (TPC) feature (For information on TPC, see Section 6.4.2).  |
| User Units    | Change the concentration units of measure.  |

### 2.5.6. SETUP>HOMESCREEN

To select a parameter (“tag”) for display in each of the three meters at the bottom of the Home page, navigate to the Homescreen configuration page through either the Setup>Homescreen menu or from Home page using the configuration icon (Figure 2-48).



**Figure 2-48. Homescreen Configuration**

An orientation to the Homescreen was presented in Section 2.4.1, including Figure 2-31 and Figure 2-32.





## 2.5.7. SETUP>DIGITAL OUTPUTS (OPTION)

Specify the function of each digital output (connected through the rear panel Digital I/O option connector, Figure 2-6) by mapping the output to a selection of “Signals” present in the instrument. Create custom “Signals” in the Setup>Events menu (Section 2.5.2). The three Relays can also be connected, and functions assigned.

To map Digital Outputs to Signals, select a pin in the Outputs list (DO1 thru DO5), then make a selection from the Signals list and press the Map button; if/as needed, change the polarity by pressing the Polarity button. Save any changes by pressing the Apply button, or discard the changes by pressing the Home or the back button (a pop-up provides a warning that the changes will be lost, and will prompt for confirmation to apply changes or not). Map the Digital Relays in the same manner.

Navigate to the Utilities>Diagnostics>Digital Outputs menu to change the state (ON/OFF) of individual digital outputs.

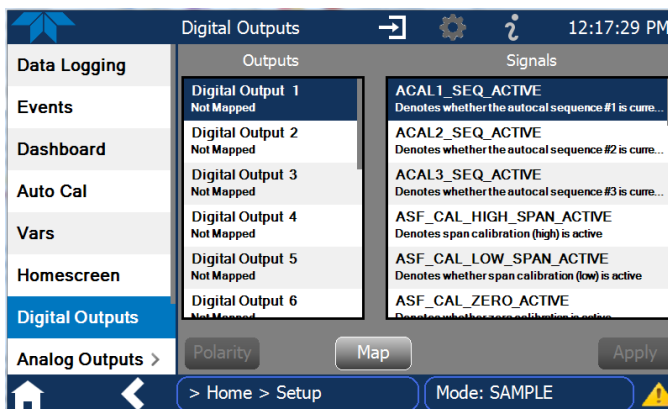


Figure 2-49. Digital Outputs Setup



### 2.5.8. SETUP>ANALOG OUTPUTS (OPTION)

Map the four user-configurable Analog Outputs (either four Voltage or three Current) to any of a wide variety of “Signals” present in the instrument and customize their respective configurations.

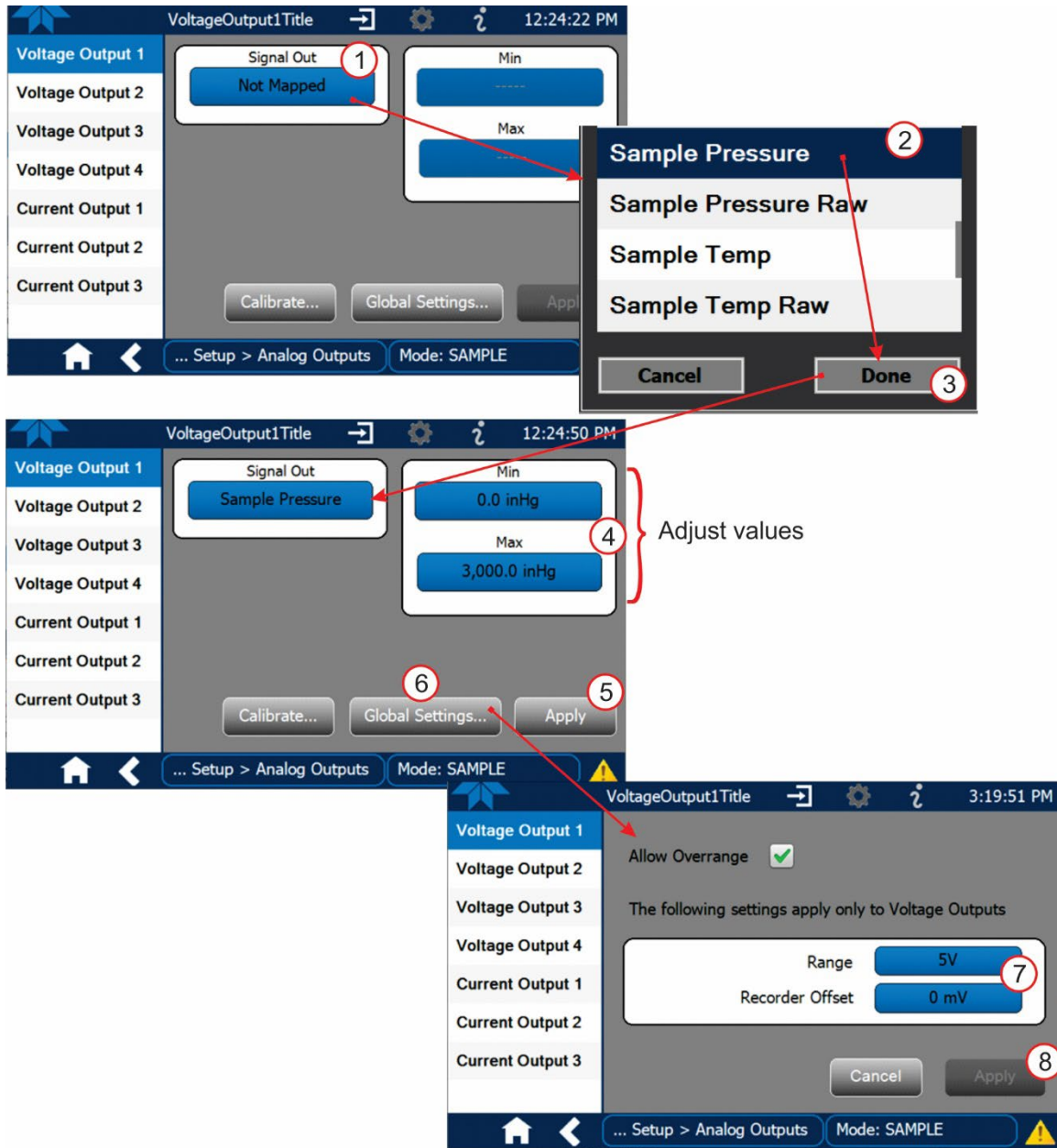
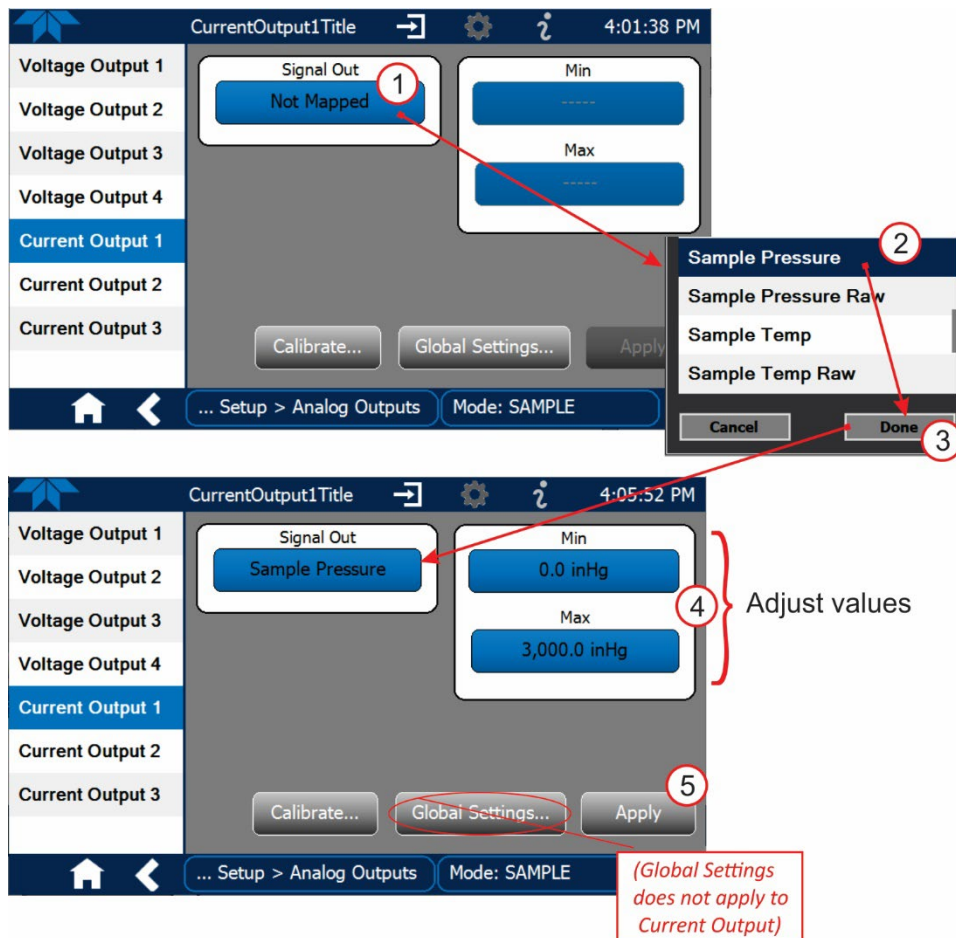


Figure 2-50. Analog Output Configuration for Voltage Output, Example



## N200, N200M, N200H



**Figure 2-51. Analog Output Configuration for Current Output, Example**

Refer to Figure 2-50 (Voltage output) or to Figure 2-51 (Current output), and to Table 2-14 for the following:

1. Signal Out: select a Signal for the output and press Done.
2. Min/Max: edit Min and Max fields with realistic values for the selected Signal.
3. Global Settings:
  - For Voltage output, select a Range, and in the Recorder Offset field, add a zero offset for recording slightly negative readings from noise around the zero point. Either check "Allow Overrange" to allow a  $\pm 5\%$  over-range, or uncheck to disable over-range if the recording device is sensitive to excess voltage: assign a voltage or select.
  - For Current output, Global Settings does not apply. Skip to Step 5.
4. After completing the configurations, press the (Apply or Accept) button.
5. To calibrate, press the Calibrate button, then press the Start button to view the reading, and use the buttons in the Manual Adjust field to make incremental adjustments as needed (for Current output, press the +100 button several times to get the setting close to 4mA), noting the range and the minimum/maximum outputs shown in (Table 2-14).
6. Press the Accept button when adjustment complete.





# N200, N200M, N200H

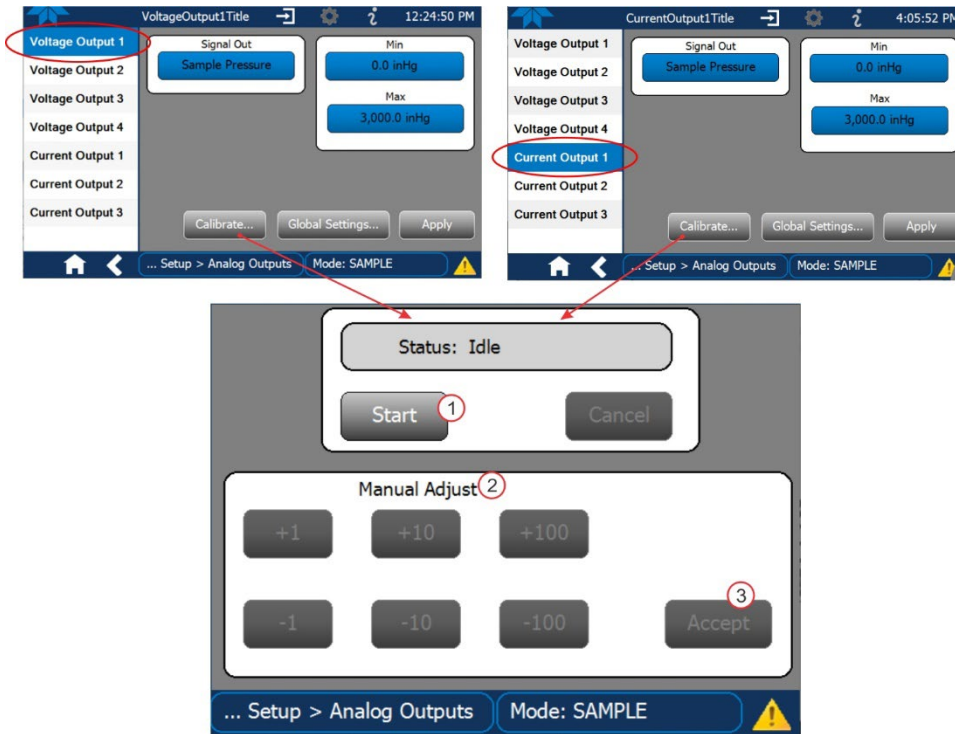
**Table 2-14. Analog Output Voltage/Current Range**

| RANGE <sup>1</sup>   | RANGE SPAN | MINIMUM OUTPUT | MAXIMUM OUTPUT |
|----------------------|------------|----------------|----------------|
| 5V                   | 0-5 VDC    | -1 VDC         | 6 VDC          |
| 10V                  | 0-10 VDC   | - 2 VDC        | 12 VDC         |
| Current <sup>2</sup> | 4-20 mA    | 3 mA           | 21 mA          |

<sup>1</sup> Each range is usable from -5% to +5% of the rated span.

<sup>2</sup> While these are the physical limits of the current loop modules, typical applications use 2-20 mA or 4-20 mA for the lower and upper limits.

For manual calibration adjustments, see Section 2.5.8.1 for voltage and Section 2.5.8.2 for current.



**Figure 2-52. Analog Output Calibration, Voltage or Current**



## N200, N200M, N200H

### 2.5.8.1. MANUAL CALIBRATION OF VOLTAGE RANGE ANALOG OUTPUTS

To manually calibrate the voltage signals, use a voltmeter connected across the output terminals (Figure 2-53) and change the output signal level when Manual is selected in the Calibration Type field of the Analog Output screen (Figure 2-52).

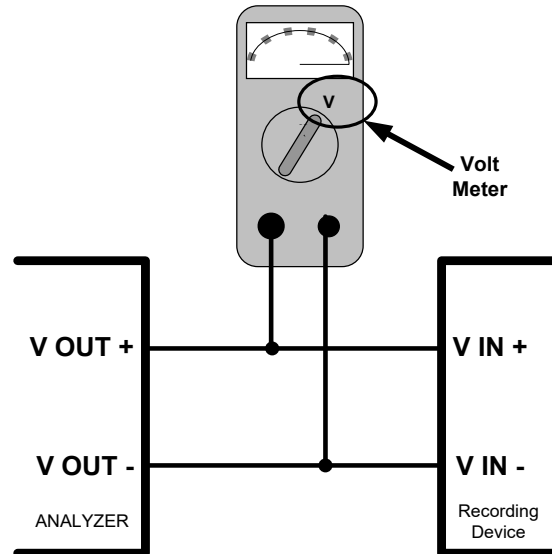


Figure 2-53. Setup for Checking / Calibrating DCV Analog Output Signal Levels

### 2.5.8.2. MANUAL ADJUSTMENT OF CURRENT RANGE ANALOG OUTPUTS

To manually calibrate the current signals, use an ampmeter (Figure 2-54) connected across the Current output terminals (see Figure 2-5 for pin assignments and diagram of the analog output connector) and changing the output signal level in the Manual Adjust field of the Analog Outputs Current Output Calibration screen. While the software allows this adjustment to be made in 100, 10 or 1 count increments, the adjustments here would need several presses of the +100 button to arrive at a realistic starting point for 4mA.



#### CAUTION!

Do not exceed 60 V peak voltage between current loop outputs and instrument ground.



## N200, N200M, N200H

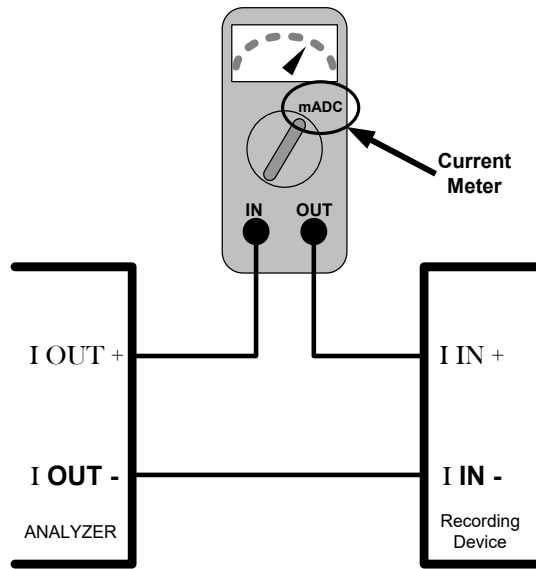


Figure 2-54. Setup for Checking / Calibration Current Output Signal Levels

### 2.5.9. SETUP>INSTRUMENT

As presented in Table 2-15, view product and system information and network settings, edit network settings, and perform certain maintenance tasks.

Table 2-15. Setup>Instrument Menu

| MENU               | DESCRIPTION   |
|--------------------|---|
| Product Info       | View Model, Part, and Serial Numbers and Package and Driver Versions, and options information.  |
| System Info        | View Windows and RAM information.   |
| Network Settings   | View the network settings (configurable through the Setup>Comm>Network Settings menu).  |
| Module Info        | Provides part and revision numbers of the modules that are installed  |
| Date/Time Settings | Adjust date, hour, and minutes, select a time zone*, and set the system clock to automatically adjust for Daylight Savings Time or not. (Also see Setup>Vars>Daylight Savings Enable). *Time Zone change requires a special procedure; see Maintenance Section 5.5. |
| NTP Time Settings  | Configure Network Time Protocol settings for clock synchronization.   |
| Language           | Select an available language.   |
| Remote Update      | When an instrument is connected to a network that is connected to the Internet, follow the instructions on this Remote Update page to check for and activate software/firmware updates. (Also refer to Section 5.3).  |

### 2.5.10. SETUP>COMM (COMMUNICATIONS)

This menu is for specifying the various communications configurations.

#### 2.5.10.1. COM

Configure the instrument's COM port to operate in modes listed in Table 2-16.



## N200, N200M, N200H

**Table 2-16. COM Configuration**

| MODE                           | DESCRIPTION   |
|--------------------------------|---|
| <b>Baud Rate</b>               | Set the baud rate for the COM1 or COM2 port being configured.   |
| <b>Command Prompt Display</b>  | Enable/disable a command prompt to be displayed when in terminal mode.  |
| <b>Data Bits</b>               | Set the data bits to 7 or 8 (typically set in conjunction with Parity and Stop bits).   |
| <b>Echo and Line Editing</b>   | Enable/disable character echoing and line editing.  |
| <b>Handshaking Mode</b>        | Choose SOFTWARE handshaking for data flow control (do NOT use SOFTWARE handshaking mode when using MODBUS RTU for Protocol mode; select only HARDWARE or OFF for MODBUS RTU), or HARDWARE for CTS/RTS style hardwired transmission handshaking. (This style of data transmission handshaking is commonly used with modems or terminal emulation protocols).<br>Or choose to turn OFF handshaking. |
| <b>Hardware Error Checking</b> | Enable/disable hardware error checking.   |
| <b>Hardware FIFO</b>           | Enable/disable the hardware First In – First Out (FIFO) for improving data transfer rate for that COM port.   |
| <b>Modem Connection</b>        | Select either a modem connection or a direct cable connection.  |
| <b>Modem Init String</b>       | Input an initialization string to enable the modem to communicate.  |
| <b>Parity</b>                  | Select odd, or even, or no parity (typically set in conjunction with Data Bits and Stop Bits).  |
| <b>Protocol</b>                | If selecting a MODBUS protocol, see Handshaking Mode, this table; MODBUS Registers are presented in Appendix A, this manual. Also see <a href="http://www.modbus.org">www.modbus.org</a> .  |
| <b>Quiet Mode</b>              | Enable/disable Quiet mode, which suppresses any feedback from the analyzer (such as warning messages) to the remote device and is typically used when the port is communicating with a computer program where such intermittent messages might cause communication problems.<br>Such feedback is still available, but a command must be issued to receive them.                                   |
| <b>Security</b>                | Enable/disable the requirement for a password for this serial port to respond. The only command that is active is the request-for-help command (? CR).  |
| <b>Stop bits</b>               | Select either 0 or 1 stop bit (typically set in conjunction with Parity and Data bits).   |

### 2.5.10.2. TCP PORT1

This menu is configured with the port number for MODBUS.

### 2.5.10.3. NETWORK SETTINGS

The Setup>Comm>Network Settings menu is for Ethernet configuration. The address settings default to automatic configuration by Dynamic Host Configuration Protocol (DHCP). Most users will want to configure the instrument with a static IP address: click the Static radio button to manually assign a static IP address (consult your network administrator, and see Table 2-17 for information).



# N200, N200M, N200H



Figure 2-55. Communications Configuration, Network Settings

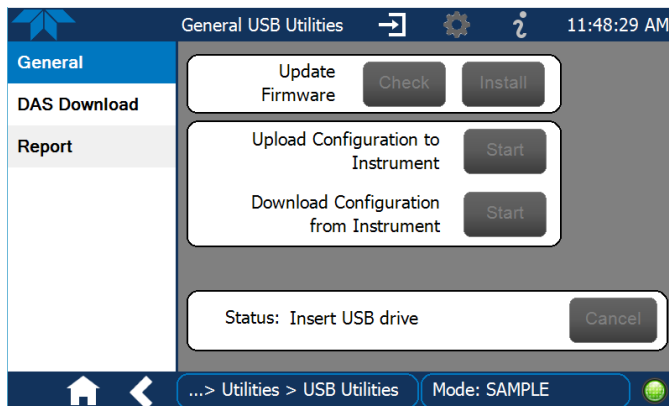
Table 2-17. LAN/Ethernet Configuration Properties

| PROPERTY               | DESCRIPTION   |
|------------------------|---|
| <b>IP address</b>      | A string of four packets of 1 to 3 numbers each (e.g. 192.168.76.55.) is the internet protocol address of the instrument itself.  |
| <b>Subnet Mask</b>     | A string of four packets of 1 to 3 numbers each (e.g. 255.255.252.0) number that masks an IP address, and divides the IP address into network address and host address and identifies the LAN to which the device is connected. All addressable devices and computers on a LAN must have the same subnet mask. Any transmissions sent to devices with different subnets are assumed to be outside of the LAN and are routed through the gateway computer onto the Internet. |
| <b>Default Gateway</b> | A string of numbers very similar to the Instrument IP address (e.g. 192.168.76.1.) that is the address of the computer used by your LAN and serves as a router to access the Internet or another network.   |



## 2.6. TRANSFERRING CONFIGURATION TO OTHER INSTRUMENTS

Once an instrument is configured, the same configuration can be copied to other instruments of the same Model. This encompasses essentially anything the user can configure and does not apply to instrument-specific settings such as those that are configured at the factory for calibration.



**Figure 2-56. Configuration Transfer**

1. In the source instrument, go to the Home>Utilities>USB Utilities>General page.
2. Insert a flash drive into either of the two front panel USB ports.
3. When the Status field indicates that the USB drive has been detected, press the “Download Configuration from Instrument” Start button.
4. When the Status field indicates that the download is complete, remove the flash drive.
5. In the target instrument, go to the Home>Utilities>USB Utilities>General page.
6. Insert a flash drive into either of the two front panel USB ports.
7. When the Status field indicates that the USB drive has been detected, press the “Upload Configuration to Instrument” Start button.
8. When the Status field indicates that the upload is complete, remove the flash drive.



### 3. COMMUNICATIONS AND REMOTE OPERATION

This instrument's rear panel connections include an Ethernet port and a serial communications port. Connection instructions were provided in Section 2.3.1.4. Configuration information was provided in Section 2.5.10.

Data acquisition is set up through the Datalogger (Section 2.5.1).

#### 3.1. SERIAL COMMUNICATION

The rear panel COM port operates on the RS-232 protocol (default configuration is DCE RS-232), or it can be configured for DTE RS-232 operation (more common for PLCs) (Section 2.3.1.4).

Referring to Table 2-16, use the SETUP>COMM menu to view/edit the communications settings for the COM port.

#### 3.2. ETHERNET

When using the Ethernet interface, the analyzer can be connected to any Ethernet network via low-cost network hubs, switches or routers. The interface operates as a standard TCP/IP device on port 3000. This allows a remote computer to connect through the network to the analyzer using NumaView™ Remote, terminal emulators or other programs.

The Ethernet connector has two LEDs that are on the connector itself, indicating its current operating status.

**Table 3-1. Ethernet Status Indicators**

| LED              | FUNCTION                                 |
|------------------|--|
| green (link)     | On when connection to the LAN is valid.  |
| amber (activity) | Flickers during any activity on the LAN. |

The analyzer is shipped with DHCP enabled by default. This allows the instrument to be connected to a network or router with a DHCP server; however, it should be configured with a Static IP address as soon as practical. See Section 2.5.10.3 for configuration details.

#### 3.3. NUMAVIEW™ REMOTE

For remote operation and data capture through an Ethernet connection, please refer to the NumaView™ Remote Software User Guide, PN 08492, available on our website.



## 4. CALIBRATION

This section is organized into subsections as follows:

### **SECTION 4.1 – Important Precalibration Information**

: contains important information you should know before calibrating the instrument.

**SECTION 4.2 – Calibration Procedures:** describes the procedure for manually checking calibration and performing actual calibration of the instrument.

**SECTION 4.3 – Automatic Zero/Span Cal/Check (Auto Cal):** describes the procedure for using the AutoCal feature to check calibration or to calibrate the instrument. (The AutoCal feature requires that either the zero/span valve option or the internal span gas generator option be installed and operating).

**SECTION 4.4 – Calibration Quality Analysis:** describes how to evaluate quality of each calibration.

**SECTION 4.5 – Conversion Efficiency (CE) Check:** provides information on monitoring and calibrating the efficiency of the converter.

**SECTION 4.6 – EPA Protocol Calibration:** provides comments regarding calibration with EPA protocols.

### 4.1. IMPORTANT PRECALIBRATION INFORMATION

**Note**

**A start-up period of 4-5 hours is recommended prior to calibrating the analyzer.**

#### 4.1.1. CALIBRATION REQUIREMENTS

The following equipment, supplies, and expendables are required for calibration:

- Zero-air source
- Span gas source
- Gas lines - all gas line materials should be stainless steel or Teflon-type (PTFE or FEP).
- High-concentration NO gas transported over long distances may require stainless steel lines to avoid oxidation of NO due to the possibility of O<sub>2</sub> diffusing into the tubing.

Optional equipment: A recording device such as a strip-chart recorder and/or data logger.

For electronic documentation, the internal data acquisition system (DAS) can be used by configuring the Datalogger through the Setup>Data Logging menu; Section 2.5.1).

The method for performing an initial calibration for the analyzer differs between the standard instrument and those with options.

- See Section 4.2.1 for instructions for initial calibration of the analyzer in its base configuration.





## N200, N200M, N200H

- See Section 4.2.2 for information regarding setup and calibration of the analyzer with Z/S Valve options.

### Note

**Zero air and span gases must be supplied at twice the instrument's specified gas flow rate. Therefore, the zero and span gases should be supplied to their respective inlets in excess of 1000 cc/min (500 cc/min x 2).**

### 4.1.2. ZERO AIR

Zero air or zero calibration gas is similar in chemical composition to the measured medium but without the gas to be measured by the analyzer. For the N200's, this means zero air should be devoid of NO, NO<sub>2</sub>, CO<sub>2</sub>, NH<sub>3</sub> or H<sub>2</sub>O vapor.

### Note

**Moderate amounts of NH<sub>3</sub> and H<sub>2</sub>O can be removed from the sample gas stream by installing the optional sample gas dryer/scrubber (call Sales).**

- If your application is not a measurement in ambient air, the zero calibration gas should be matched to the composition of the gas being measured.
- Pure nitrogen (N<sub>2</sub>) could be used as a zero gas for applications where NO<sub>x</sub> is measured in nitrogen.
- If your analyzer is equipped with an external zero air scrubber option, it is capable of creating zero air from ambient air.
- For analyzers without the external zero air scrubber, a zero air generator such as the Teledyne API's Model T701 can be used. Please visit the company website for more information.

### 4.1.3. CALIBRATION (SPAN) GAS

Calibration gas is specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired reporting range. To measure NO<sub>x</sub> with the analyzer, it is recommended that you use a span gas with an NO concentration equal to 80% of the measurement range for your application.

EXAMPLE:

- If the application is to measure NO<sub>x</sub> in ambient air between 0 ppb and 500 ppb, an appropriate span gas would be 400 ppb.
- If the application is to measure NO<sub>x</sub> in ambient air between 0 ppb and 1000 ppb, an appropriate span gas would be 800 ppb.

### 4.1.4. SPAN GAS FOR MULTIPOINT CALIBRATION

Some applications, such as EPA monitoring, require a multipoint calibration where span gases of different concentrations are needed. We recommend using an NO gas of higher concentration combined with a gas dilution calibrator such as the Teledyne API T700/T700U Models. Calibrators mix high concentration gas with zero air to accurately produce span gas of the desired concentration. Linearity profiles can be automated with these models and run unattended overnight.

If a dynamic dilution system is used to dilute high concentration gas standards to low, ambient concentrations, ensure that the NO concentration of the reference gas matches the



## N200, N200M, N200H

dilution range of the calibrator. (Section 2.5.5 contains information about the dilution option).

Choose the NO gas concentration so that the dynamic dilution system operates in its mid-range and not at the extremes of its dilution capabilities.

### EXAMPLE:

- A dilution calibrator with 10-10000 dilution ratio will not be able to accurately dilute a 5000 ppm NO gas to a final concentration of 500 ppb, as this would operate at the very extreme dilution setting.
- A 100 ppm NO gas in nitrogen is much more suitable to calibrate the analyzer (dilution ratio of 222, in the mid-range of the system's capabilities).

### 4.1.5. PHYSICAL RANGE MEASUREMENTS

The maximum concentration range the analyzers can actually measure is listed in the specifications table per model. Internally the analyzer has the ability to maximize the measurement resolution by adjusting between two physical gain settings on the PMT board. This occurs when the user selects LOW or HIGH Range as part of the instrument setup (Setup>Vars>PMT Range).

Electronically the analyzer converts the full scale analog signal output from the PMT to a digital signal with 4096 counts of resolution. Since the N200's maximum measurement range is 0 ppb to 20,000 ppb, this only allows about 3 ppb per count. While this might be acceptable for high concentration measurements made in parts per million units (ppm), it is not useful enough for lower level NO<sub>x</sub> measurements. To overcome this limitation the analyzer is designed with two fixed physical measurement ranges:

- LOW range to measure concentrations from 0 ppb to 2000 ppb for N200.
  - 0 to 20 PPM for N200M
  - 0 to 200 PPM for N200H
- HIGH range to measure the full 20,000 ppb range of the analyzer.

The analyzer's CPU chooses the appropriate physical range, based on the configuration of the PMT Range variable (also described in Table 2-13).

### 4.1.6. INTERFERENTS

The chemiluminescence method for detecting NO<sub>x</sub> is subject to interference from a number of sources including water vapor (H<sub>2</sub>O), sulfur dioxide (SO<sub>2</sub>), and carbon dioxide (CO<sub>2</sub>); however, the analyzer has been designed to reject most of these interferents.

- Ammonia is the most common interferent, which is converted to NO and creates a NO<sub>x</sub> signal artifact.
  - If the analyzer is installed in an environment with high ammonia, steps should be taken to remove it from the sample gas before it enters the reaction cell.
  - Teledyne API offers a sample gas conditioning option (call Sales) to remove ammonia and water vapor.
- Carbon dioxide (CO<sub>2</sub>) diminishes the NO<sub>x</sub> signal when present in high concentrations.
  - If the analyzer is used in an application with excess CO<sub>2</sub>, contact Teledyne API's Technical Support Department (see Section 5.9) for possible solutions.



## N200, N200M, N200H

- Excess water vapor can be removed with one of the dryer options described in Section 2.3.2.6. In ambient air applications, SO<sub>2</sub> interference is usually negligible.

For more detailed information regarding interferences for NO<sub>x</sub>, NO and NO<sub>2</sub> measurement, see Section 6.1.5.

### 4.1.7. NO<sub>2</sub> PERMEATION TUBES (FOR IZS OPTION IN THE N200)

Teledyne API offers an optional internal span gas generator that utilizes an NO<sub>2</sub> permeation tube as a span gas source (see Section 2.3.2.5). The accuracy of these devices is only about ±5%. Whereas this may be sufficient for quick, daily calibration checks, we recommend using certified NO gases for accurate calibration.

#### CAUTION!



**Insufficient gas flow allows gas to build up to levels that will contaminate the instrument or present a safety hazard to personnel.**

**In units with a permeation tube installed, either the tube must be removed and stored in a sealed container (use original container that tube was shipped in) during periods of non-operation, or vacuum pump must be connected and powered on to maintain constant gas flow through the analyzer at all times.**

(See Section 5.6.6 for removal instructions).

### 4.1.8. DATA RECORDING DEVICES

A strip chart recorder, data acquisition system or digital data acquisition system should be used to record data from either the Ethernet, serial or analog outputs.

- If analog readings are used, the response of the recording system should be checked against a NIST traceable voltage source or meter.
- Data recording devices should be capable of bi-polar operation so that negative readings can be recorded.

For electronic data recording, the analyzers provide an internal data logger, which is configured through the Setup>Data Logger menu (Section 2.5.1).

NumaView™ Remote is a remote control program, which is also available as a convenient and powerful tool for data viewing and handling, download, storage, quick check and plotting.

### 4.1.9. NO<sub>2</sub> CONVERSION EFFICIENCY (CE)

The efficiency at which the (Moly or HiCon) NO<sub>2</sub>-to-NO converter changes NO<sub>2</sub> into NO directly affects the accuracy of the instrument's NO<sub>x</sub>, NO and NO<sub>2</sub> measurements. The firmware includes a Converter Efficiency (CE) gain factor that is multiplied by the NO<sub>2</sub> and NO<sub>x</sub> measurements to calculate the final concentrations for each. This gain factor is stored in the analyzer's memory.



## N200, N200M, N200H

The default setting for the NO<sub>2</sub> converter efficiency is 1.0000. Over time, the molybdenum in the converter oxidizes and it becomes less efficient at converting NO<sub>2</sub> into NO.

To ensure accurate performance of the analyzer, it is important to check the NO<sub>2</sub> conversion efficiency (CE) periodically as presented in Section 4.5.

### 4.2. CALIBRATION PROCEDURES

Check that the pneumatic connections for the specific instrument configuration are as instructed in Section 2.3.2. Calibration procedures include setting the expected span gas concentration (see Note below).

Verify/change (if needed) the settings in the Setup>Vars menu as follows:

- User Units (unit of Measure): PPB
- PMT Range (Low for Min Range measurement; High for Max Range measurement)
- Range Mode: SINGLE

Then perform the calibration:

- Perform a Zero calibration using zero air.
- Perform a span calibration on both the NO & NO<sub>x</sub> channels using a known concentration of NO span gas.
- Perform the Converter Efficiency (Conc Eff A) calibration using a known concentration of NO<sub>2</sub> span gas.

#### Note

##### Tips for Setting the Expected Span Gas Concentration:

- **The expected concentrations for both NO and NO<sub>x</sub> are usually set to the same value.**
- **When setting expected concentration values, consider impurities in your span gas source (e.g. NO often contains 1-3% NO<sub>2</sub> and vice versa).**
- **The NO and NO<sub>x</sub> span gas concentrations should be 80% to 90% of range of concentration values likely to be encountered in your application.**

To calibrate or to perform a calibration check for basic configuration instruments, see Section 4.2.1.

To calibrate or to perform a calibration check for instruments with valve options, see Section 4.2.2.

To perform a calibration check for instruments with the internal span gas generator, see Section 4.3.

To calibrate Conversion Efficiency, see Section 4.5.



## N200, N200M, N200H

### 4.2.1. CALIBRATION AND CHECK PROCEDURES FOR BASIC CONFIGURATION

Although this section uses the Calibration menu for both check and actual calibration, a check does not require the Calibration menu. Instead, while in Home page, simply flow the zero air or the NO span gas through the Sample port, and check the reading after the Stability falls below 1.0 PPB (either in the gas graph or in the Dashboard).

Otherwise, follow the steps presented in Sections 4.2.1.1 and 4.2.1.2.

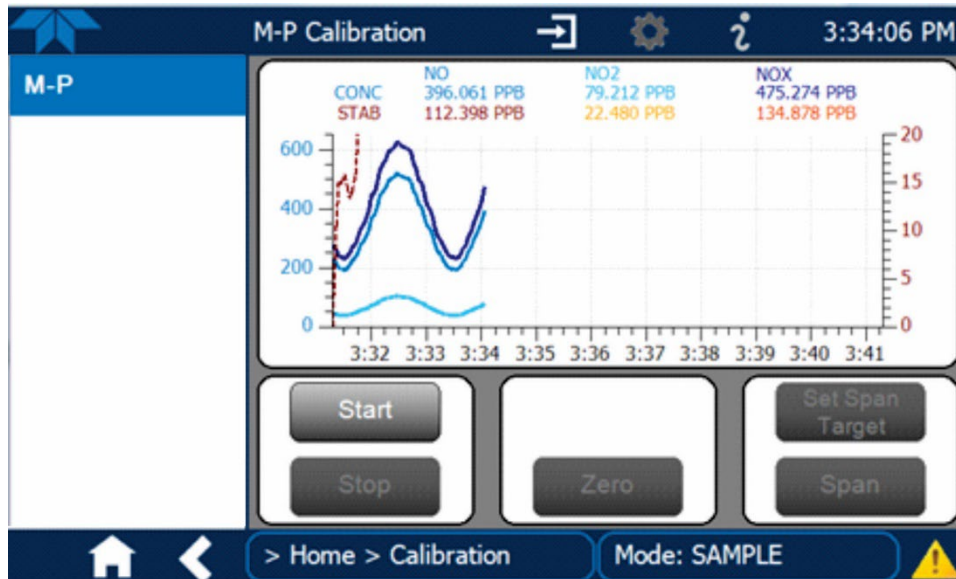


Figure 4-1. Multi-Point Calibration Page

#### 4.2.1.1. ZERO CALIBRATION CHECK AND ACTUAL CALIBRATION

1. Navigate to the Calibration>M-P menu.
2. Input Zero air through the Sample port and press the Start button.
3. Either check or calibrate as follows:

##### CHECK ONLY:

- a. Wait for reading to stabilize.
- b. Press Stop and check the reading.

##### ACTUAL CALIBRATION:

- a. Press the Zero button.
- b. Press Stop and check the reading.



## N200, N200M, N200H

### 4.2.1.2. SPAN CALIBRATION CHECK AND ACTUAL CALIBRATION

1. While still in the Calibration>M-P menu, input NO Span gas through the Sample port and press the Start button.
2. Either check or calibrate as follows:
  - CHECK ONLY:**
    - a. Wait to reach stability, then press Stop.
    - b. Record the reading(s).
  - ACTUAL CALIBRATION:**
    - a. Press the Set Span Target button and enter the NO and NO<sub>x</sub> concentrations.
    - b. Verify the concentration reading is the same as the NO concentration being supplied.
    - c. If correct, wait to reach stability, then press the Span button.
    - d. In the Cal Result window, press OK.
3. Press the Stop button and return to Home screen.
4. In the Dashboard, check and record the Slope(s) and the Offset(s). (See Table 4-4 in Section 4.4, Calibration Quality Analysis, for expected/acceptable values).



### 4.2.2. CALIBRATION AND CHECK PROCEDURES WITH VALVE OPTIONS INSTALLED

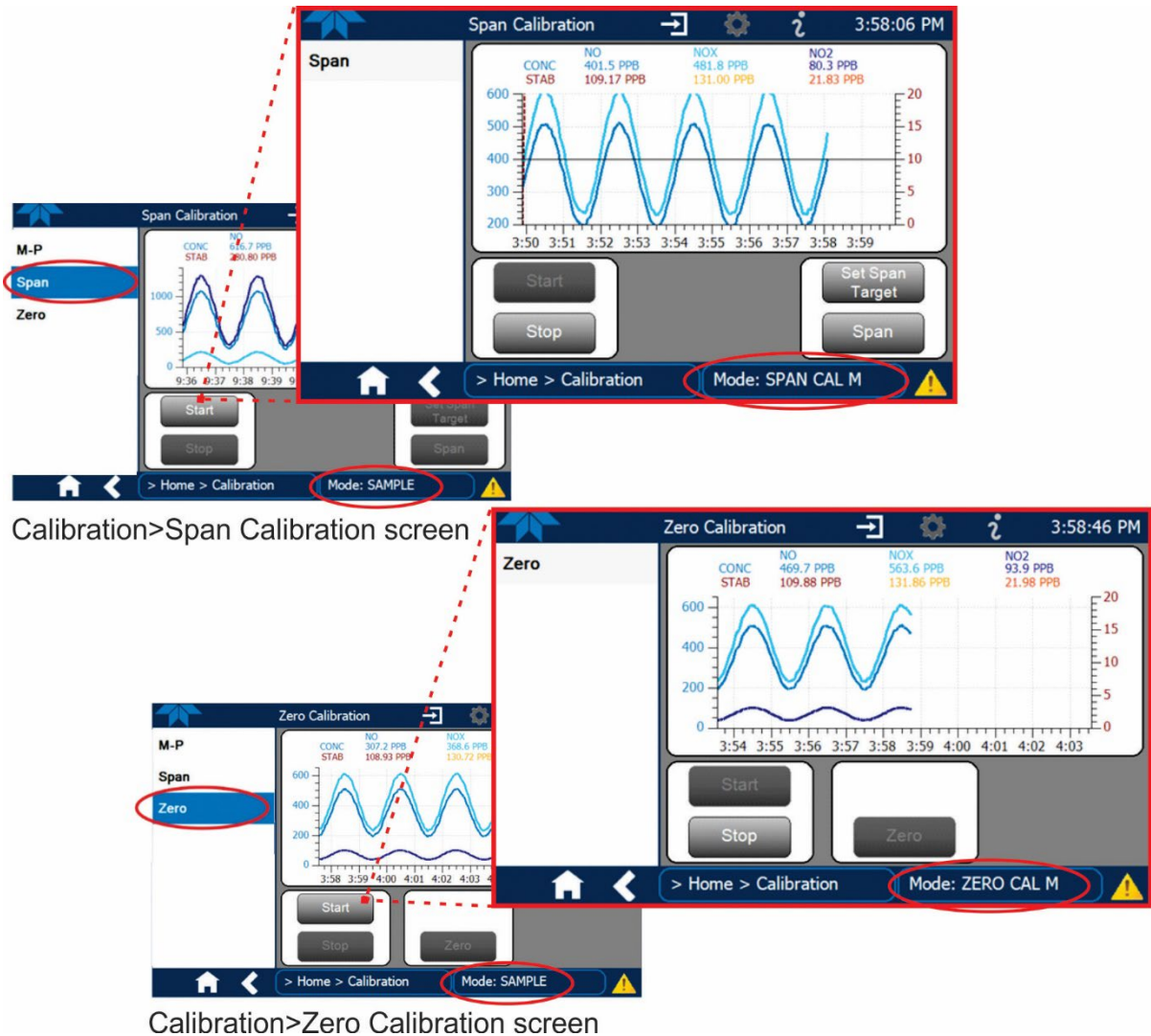


Figure 4-2. Zero and Span Calibration Screens

Follow the instructions in Section 4.2.1, except instead of the M-P menu, go to the Calibration>Zero menu for Zero cal and to the Calibration>Span menu for NO Span cal.

#### 4.2.2.1. USE OF ZERO/SPAN VALVE WITH DIGITAL EXPANSION BOARD OPTION

Digital inputs are available for controlling calibration and calibration checks when the Digital I/O Board option is installed. Instructions for setup and use of this option are outlined in Section 2.3.1.3.





## N200, N200M, N200H

When the Digital Inputs are activated for at least 5 seconds, the instrument switches into zero, low span or high span mode and the internal zero/span valves will be automatically switched to the appropriate configuration.

- The remote calibration Digital Inputs may be activated in any order.
- It is recommended that the Digital Inputs remain closed for at least 10 minutes to establish a reliable reading.
- The instrument will stay in the selected mode for as long as the Input remains closed.

If Digital Inputs are being used in conjunction with the analyzer's AutoCal (see Section 4.3) feature and the AutoCal attribute "Calibrate" is enabled (selection box is checked), the analyzer will not recalibrate the analyzer UNTIL the contact is opened. At this point, the new calibration values will be recorded before the instrument returns to SAMPLE mode.

If the AutoCal attribute "Calibrate" is disabled (selection box is unchecked), the instrument will return to SAMPLE mode, leaving the instrument's internal calibration variables unchanged.

### 4.3. AUTOMATIC ZERO/SPAN CAL/CHECK (AUTO CAL)

The Auto Cal feature allows unattended periodic operation of the ZERO/SPAN valve options by using the instrument's internal time of day clock. Auto Cal operates by executing preprogrammed calibrations or calibration checks set up by the user to initiate the various calibration states of the analyzer and to open and close valves appropriately. It is possible to set up and run up to three separate preprogrammed calibrations or calibration checks (labeled # 1, 2 and 3). Each calibration or check can operate in one of three modes (Zero, Low or High), or be disabled.

Table 4-1 and Table 4-2 show how to set up the operating states of each calibration or check, and Table 4-3 shows how to program the execution of each.

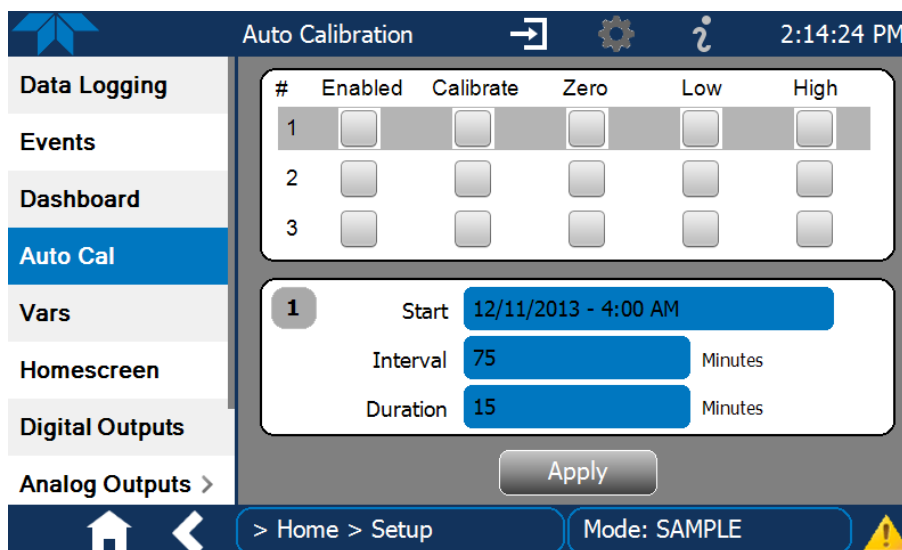


Figure 4-3. Auto Cal Page





## N200, N200M, N200H

**Table 4-1. AUTO CAL States**

| MODE NAME        | ACTION   |
|------------------|--|
| <b>Enabled</b>   | <input checked="" type="checkbox"/> enables the sequence;<br><input type="checkbox"/> disables the sequence.   |
| <b>Calibrate</b> | <input checked="" type="checkbox"/> enables an actual calibration when the Enabled box is also <input checked="" type="checkbox"/><br><input type="checkbox"/> allows a calibration check when the Enabled box is also <input checked="" type="checkbox"/> .   |
| <b>Zero</b>      | <input checked="" type="checkbox"/> causes the sequence to perform a Zero calibration when both the Calibrate and Enabled boxes are also <input checked="" type="checkbox"/><br><input checked="" type="checkbox"/> causes a Zero check when the Enabled box is also <input checked="" type="checkbox"/> and the Calibrate box is unchecked ( <input type="checkbox"/> )<br><input type="checkbox"/> disables Zero calibration and check                                   |
| <b>Low</b>       | <input checked="" type="checkbox"/> causes the sequence to perform a Low Span calibration when both the Calibrate and Enabled boxes are also <input checked="" type="checkbox"/><br><input checked="" type="checkbox"/> causes a Low Span check when the Enabled box is also <input checked="" type="checkbox"/> and the Calibrate box is unchecked ( <input type="checkbox"/> )<br><input type="checkbox"/> disables Low Span calibration and check                       |
| <b>High</b>      | <input checked="" type="checkbox"/> causes the sequence to perform a High Span concentration calibration when both the Calibrate and Enabled boxes are also <input checked="" type="checkbox"/><br><input checked="" type="checkbox"/> causes a High Span check when the Enabled box is also <input checked="" type="checkbox"/> and the Calibrate box is unchecked ( <input type="checkbox"/> )<br><input type="checkbox"/> disables the High Span calibration and check. |

Table 4-2 shows how the selection boxes would be enabled/disabled for calibration checks and calibrations.

**Table 4-2. Auto Cal Setup Combinations**

| MODE          | ACTION    | STATE                               |                                     |                                     |                                     |                                     |
|---------------|-----------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
|               |           | Enabled                             | Calibrate                           | Zero                                | Low                                 | High                                |
| Zero          | Check     | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
|               | Calibrate | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| Low           | Check     | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|               | Calibrate | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
| High          | Check     | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> |
|               | Calibrate | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> |
| Zero Low High | Check     | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|               | Calibrate | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

For each sequence, there are four parameters that control operational details: Date, Time (both in the Start field), Interval, and Duration, as presented in Table 4-3.



**Table 4-3. Auto Cal Programming Sequence Execution**

| ATTRIBUTE       | ACTION   |
|-----------------|--|
| <b>Start</b>    | When the Enabled box is “on” <input checked="" type="checkbox"/> , the Sequence (identified by its number) begins on the date and time shown in the configurable Start field. (Click the field for the pop-up window and toggle between the Time (Hour/Minutes) and the Date (Year/Month/Day) attributes to edit as needed). |
| <b>Interval</b> | Number of minutes to skip between each Sequence execution. (Click the field to input the number of minutes in the pop-up window).  |
| <b>Duration</b> | Number of minutes that each Sequence execution is to run. (Click the field to input the number of minutes in the pop-up window).   |

### Important

#### IMPACT ON READINGS OR DATA

- **The programmed STARTING\_TIME must be a minimum of 5 minutes later than the real time clock for setting real time clock (Setup>Instrument, Section 2.5.9).**
- **Avoid setting two or more sequences at the same time of the day.**
- **Any new sequence that is initiated whether from a timer, the COM port or the contact closure inputs will override any sequence that is in progress.**
- **It is recommended that calibrations be performed using external sources of Zero Air and Span Gas whose accuracy is traceable to EPA standards.**

## 4.4. CALIBRATION QUALITY ANALYSIS

It is important to evaluate the analyzer’s calibration **SLOPE** and **OFFSET** parameters. These values describe the linear response curve of the analyzer, separately for NO and NO<sub>x</sub>. The values for these terms, both individually and relative to each other, indicate the quality of the calibration.

Set up the Data Logger with a Periodic trigger to record the values of the following parameters (see Section 2.5.1).

NO Offset

NO Slope

NO<sub>x</sub> Offset

NO<sub>x</sub> Slope

Ensure that these parameters are within the limits listed in Table 4-4 and frequently compare them to those values on the *Final Test and Validation Data Sheet* that came with your instrument, which should not be significantly different. Otherwise, refer to the troubleshooting Section 5.7.7.



## N200, N200M, N200H

**Table 4-4. Calibration Data Quality Evaluation**

| FUNCTION               | MINIMUM VALUE | OPTIMUM VALUE | MAXIMUM VALUE |
|------------------------|---------------|---------------|---------------|
| NO SLOPE               | 0.700         | 1.000         | 1.300         |
| NO <sub>x</sub> SLOPE  | 0.700         | 1.000         | 1.300         |
| NO Offset              | -20.0 mV      | 0.0 mV        | 150.0 mV      |
| NO <sub>x</sub> Offset | -20.0 mV      | 0.0 mV        | 150.0 mV      |

### 4.5. CONVERSION EFFICIENCY (CE) CHECK

This section describes how to determine the NO<sub>2</sub> → NO converter's efficiency using a GPT method where the actual concentration of ozone is not a factor in the accuracy of the calculation.

- This procedure is based on the Code of Federal Regulations, Title 40, Chapter I, subchapter C, Part 50, Appendix F.
- In the following example a reference point of 450 ppb NO gas will be used. *This is only an example.* Any other reference points within measurement range of the instrument may be used.
- For this procedure use a calibrated O<sub>3</sub> generator, such as a Teledyne API's T700.

**Note**

**There must be a minimum of 10% more NO than O<sub>3</sub> produced. Example, if the O<sub>3</sub> concentration used is 400 ppb, then the NO concentration used must be 440 ppb or more.**

#### PART 1: PREPARATION

1. Leak check machine to ensure that there are no leaks in the analyzer.
2. Calibrate the instrument at the same NO span gas value as being used in this method.
  - For this example we use 450 ppb NO span gas



## N200, N200M, N200H

### **PART 2: DETERMINE THE AMOUNT OF NO OUTGASSED BY THE NO<sub>2</sub> → NO CONVERTER.**

3. Bypass the NO<sub>2</sub> → NO converter by placing a short piece of tubing in the gas stream in place of the converter.
4. Perform a straight dilution with 450 ppb NO gas & air as a diluent gas.
5. Input the NO gas into the analyzer.
6. Allow the machine to stabilize & write down the NO<sub>x</sub> value on line 2 of GPT data sheet (Section 4.5.1.1).
7. Remove the converter bypass so that the NO gas is flowing through the NO<sub>2</sub> → NO converter
8. Allow the machine to stabilize.
9. Write down your NO<sub>x</sub> value on your data sheet on lines 3 AND line 5 of the GPT data sheet.
10. Subtract line 2 from line 3 & write that number down on line 4. Also write the NO value on line 8 of the data sheet.
  - The specification shown on the data sheet is the value that is used by Teledyne API when performing the procedure on new NO<sub>2</sub> → NO converters.
  - Older NO<sub>2</sub> → NO converters might outgas a bit more NO, therefore a slightly wider specification might be in order.
  - If this value is a constant or changes only slightly over time, this is not a problem the machine will calibrate this out.

### **PART 3: PERFORM THE SIMPLIFIED GPT CALCULATION.**

11. Generate the same 450 ppb NO gas & input 400 ppb of O<sub>3</sub> (or generate 450 ppb NO & 400 ppb NO<sub>2</sub>, if that's what your calibrator says).
12. Allow the instrument to stabilize for 10 minutes.
13. Write down the NO<sub>x</sub> value on line 6 & the NO value on line 9.
14. Subtract line 6 from line 5 & put that onto line 7.
15. Subtract line 8 from line 7 & put that onto line 10.
16. Write the number from line 7 into the blank next to letter A on line 11 & put the number from line 10 into the blank next to letter B on line 11.
17. Divide A by B & multiply it by 100.
18. Write this value it into the blank next to letter C on lines 11 and 12.
19. Subtract that value from 100 & write it in the blank next to the letter D on line 12.
20. This is the converter efficiency.
  - This value should be >96%.



# N200, N200M, N200H

## 4.5.1.1. SIMPLIFIED GPT DATA SHEET

| Line # | TEST   | RESULT   |
|--------|--|--|
| 1      | <b>LEAK-CHECK</b> (WHEN HOT)   | YES / NO   |
| 2      | NO <sub>x</sub> RESPONSE (MOLY BYPASSED)   | _____  |
| 3      | NO <sub>x</sub> RESPONSE (MOLY IN-LINE)  | _____  |
| 4      | <b>OUT-GASSING</b> (NO – NOX)  | _____ (>-5 ppb, <5 ppb)  |
| 5      | (NO <sub>x</sub> ORIG) (NO <sub>x</sub> mode, O <sub>3</sub> off)  | _____ ppb  |
| 6      | (NO <sub>x</sub> REM) (NO <sub>x</sub> mode, O <sub>3</sub> on)  | _____ ppb  |
| 7      | NO <sub>x</sub> <b>LOSS</b>  | _____ <b>(A)</b><br>(<4% of NO <sub>x</sub> ORIG:for 450PP 4% is 18 ppb) |
| 8      | (NO ORIG) (NO mode, O <sub>3</sub> off)  | _____ ppb  |
| 9      | (NO REM) (NO mode, O <sub>3</sub> on)  | _____ ppb  |
| 10     | NO <sub>2</sub> _____ <b>(B)</b> (>300ppb)   |  |
| 11     | Efficiency LOSS [ ( <b>A</b> / <b>B</b> ) x 100 ] = [ ( _____ <b>A</b> / _____ <b>B</b> ) x 100 ] = _____ <b>C</b> % |  |
| 12     | Total Conv Eff [ 100% – <b>C</b> ] = 100% - _____ <b>C</b> = _____ <b>D</b> % (>96%)                                 |  |



### 4.6. EPA PROTOCOL CALIBRATION

When running this instrument for U.S. EPA compliance, always calibrate prior to use, adhering to the EPA designation requirements for this instrument. (The official List of Designated Reference and Equivalent Methods is published in the U.S. Federal Register; this List specifies the settings and configurations for EPA calibration protocol). Pay strict attention to the built-in warning features, periodic inspection, regular zero/span checks, regular test parameter evaluation for predictive diagnostics and data analysis, and routine maintenance. Any instrument(s) supplying the zero air and span calibration gasses used must themselves be calibrated, and that calibration must be traceable to an EPA/NIST primary standard.

Comply with Code of Federal Regulations, Title 40 (downloadable from the U.S. Government Publishing Office at <http://www.gpo.gov/fdsys/>) and with Quality Assurance Guidance documents (available on the EPA website). Give special attention to specific regulations regarding the use and operation of ambient NO<sub>x</sub> analyzers (chemiluminescence).



## 5. MAINTENANCE AND SERVICE

Follow the maintenance schedule set forth in Section 5.1. Service and troubleshooting are covered in Section 5.7. To support your understanding of the technical details of maintenance and service, the principles of operation in Section 6 provides information about how the instrument works.



### WARNING – ELECTRICAL SHOCK HAZARD

Disconnect power before performing any of the following operations that require entry into the interior of the analyzer.



### CAUTION – QUALIFIED PERSONNEL

These maintenance procedures must be performed by qualified technicians only.

### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Always power off the instrument before disconnecting or reconnecting any wiring. Failure to do so will damage certain PCAs.

Also, when cleaning (or any time), avoid spraying anything directly onto any part of the analyzer.

## 5.1. MAINTENANCE SCHEDULE

Table 5-1 shows a typical maintenance schedule. The actual frequency of performing the maintenance procedures can vary depending on the operating environment. Additionally, in some cases, there are local regulations or standards that also need to be considered.

In certain environments (e.g., dusty, very high ambient pollutant levels) some maintenance procedures may need to be performed more often than shown.

### Important

#### IMPACT ON READINGS OR DATA

A span and zero calibration check (see CAL CHECK REQ'D Column of Table 5-1) must be performed following some of the maintenance procedures listed herein. To perform a CHECK of the instrument's Zero or Span Calibration, refer to Sections 4.2.1.1 and 4.2.1.2, respectively.

**DO NOT** press the Zero or Span buttons at the end of each operation (actual calibration), as this will reset the stored values for OFFSET and SLOPE and alter the instrument's calibration.

Alternatively, use the Auto Cal feature described in Section 4.3 with the CALIBRATE attribute set to OFF (not enabled).



## N200, N200M, N200H

**Table 5-1. Maintenance Schedule**

| ITEM   | ACTION                               | FREQ  | CAL CHECK REQ'D           | DATE PERFORMED |  |  |  |  |  |  |  |  |  |  |  |  |  |
|--|--------------------------------------|---|---------------------------|----------------|--|--|--|--|--|--|--|--|--|--|--|--|--|
|  |                                      |   |                           |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dashboard functions                                  | Review and evaluate                  | Weekly  | No                        |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sample particulate filter                            | Change                               | Monthly or as necessary                                   | Yes                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Zero/span check                                      | Evaluate offset and slope            | Weekly  | No                        |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Zero/span calibration                                | Zero and span calibration            | Every 3 months  | Yes                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| External zero air scrubber option                    | Exchange chemical                    | Every 3 months  | No                        |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| External dryer option                                | Replace chemical                     | When indicator color changes                              | No                        |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Software/ Firmware                                   | Check for updates                    | Every 6 months or whenever serviced                       | Yes                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ozone cleanser (N200, N200H)                         | Change chemical                      | Annually  | Yes                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Reaction cell window                                 | Clean optics, change o-rings         | Annually or as necessary                                  | Yes                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DFU filters  | Change                               | Annually (or as needed for highly polluted sample air)    | No                        |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pneumatic sub-system                                 | Check for leaks in gas flow paths    | Annually or after repairs involving pneumatics            | Yes if a leak is repaired |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| All critical flow orifice O-rings & sintered filters | Replace                              | Annually  | Yes                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| PMT Sensor Hardware Calibration                      | Low-level hardware calibration       | When PMT changes or if slope is outside of 1.0±0.3        | Yes                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pump (External)                                      | Rebuild head                         | when Rx Cell pressure exceeds 10 in-Hg-A (at sea level)   | Yes                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Inline Exhaust Scrubber                              | Replace                              | Annually  | No                        |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| NO <sub>2</sub> converter                            | Replace converter & check efficiency | Every 3 years or if conversion efficiency drops below 96% | Yes                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Desiccant bags                                       | Replace                              | Any time PMT housing is opened for maintenance            | n/a                       |                |  |  |  |  |  |  |  |  |  |  |  |  |  |





## 5.2. PREDICTIVE DIAGNOSTICS

Predictive diagnostic functions, including failure warnings and alarms built into the analyzer’s firmware, aid in determining whether and when repairs are necessary.

Dashboard Functions can also be used to predict failures by looking at how their values change over time, compared to the values recorded on the printed record of the *Final Test and Validation Data Sheet*. The internal data logger is a convenient way to record and track these changes (set up through the Data Logger, Section 2.5.1). Use NumaView™ Remote to download and review this data from a remote location.

The following table, checked weekly, can be used as a basis for taking action as these values change with time.

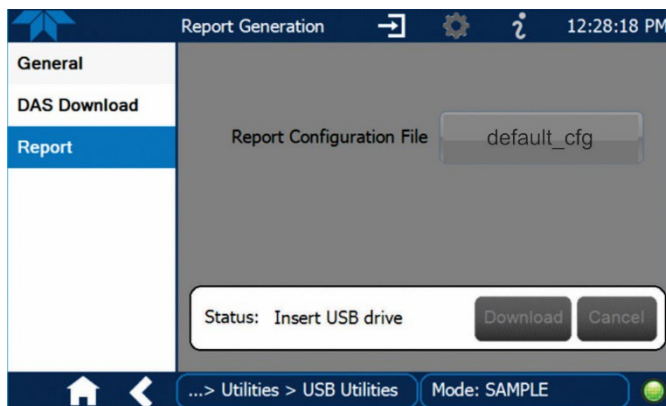
**Table 5-2. Predictive Uses for Dashboard Functions**

| FUNCTION  | EXPECTED                                    | ACTUAL  | INTERPRETATION & ACTION   |
|---|---|---|---|
| <b>Rx Cell Press</b><br>(pressure)                              | Constant to within $\pm 0.5$ in-Hg-A        | Fluctuating                                     | Developing leak in pneumatic system. Check for leaks.   |
|   |   | Slowly increasing                               | Pump performance is degrading. Rebuild pump when pressure is above 10 in-Hg-A.  |
| <b>Sample Press</b><br>(pressure)                               | Constant within atmospheric changes         | Fluctuating                                     | Developing leak in pneumatic system. Check for leaks.   |
|   |   | Slowly increasing                               | Flow path is clogging up. Replace orifice filters.  |
|   |   | Slowly decreasing                               | Developing leak in pneumatic system to vacuum (developing valve failure). Check for leaks.  |
| <b>O3 Flow</b>  | Constant to within $\pm 15$                 | Slowly decreasing                               | Flow path is clogging up. Replace orifice filters.  |
| <b>Auto Ref</b>   | Constant within $\pm 20$ of check-out value | Significantly increasing                        | Developing AUTO REFERENCE valve failure. Replace valve.   |
|   |   |   | PMT cooler failure. Check cooler, circuit, and power supplies.  |
|   |   |   | Developing light leak.  |
|   |   |   | O <sub>3</sub> air filter cartridge is exhausted. Change chemical.  |
| <b>NO2 Conc</b><br>(Concentration)                              | Constant for constant concentrations        | Slowly decreasing signal for same concentration | Converter efficiency may be degrading. Clean or replace converter components.   |
| <b>NO2 Conc</b><br>with IZS Option installed<br>(Concentration) | Constant response from day to day           | Decreasing over time                            | Change in instrument response. Low level (hardware): calibrate the sensor.<br>Degradation of IZS permeation tube. Change permeation tube. |
|   |   | Heavily fluctuating day to day                  | Ambient changes in moisture are affecting the performance. Add a dryer to the zero air inlet..  |
| <b>NO Conc</b><br>(Concentration)                               | Constant for constant concentration         | Decreasing over time                            | Drift of instrument response; clean RCEL window. Check for flow leaks or irregularities.  |



## 5.3. OPERATIONAL HEALTH CHECKS

Navigate to the Utilities>USB Utilities>Report menu (Figure 5-1) to download a report on the basic operations of the instrument. To download the report for your own viewing on a computer or to send to others, insert a flash drive into a front panel USB port and press the Download button, which is enabled when the instrument detects the flash drive.



**Figure 5-1: Report Generation Page**

The report can also be set to generate periodically and sent to a Web services “cloud” where it is available for viewing by Teledyne API technical support personnel. Set this function with two Vars:

Setup>Vars>Upload Report to Cloud: set to True.

Setup>Vars>Report Upload>Interval: edit the number of hours between report uploads.

## 5.4. SOFTWARE/FIRMWARE UPDATES

There are two ways to check for and acquire updates: either remotely or manually.

### 5.4.1. REMOTE UPDATES

The instrument must be connected to a network that is connected to the Internet. In the Setup>Instrument menu, select the Remote Update menu and press the Check for Updates button. If an update is available, it can be downloaded through this page.



## N200, N200M, N200H

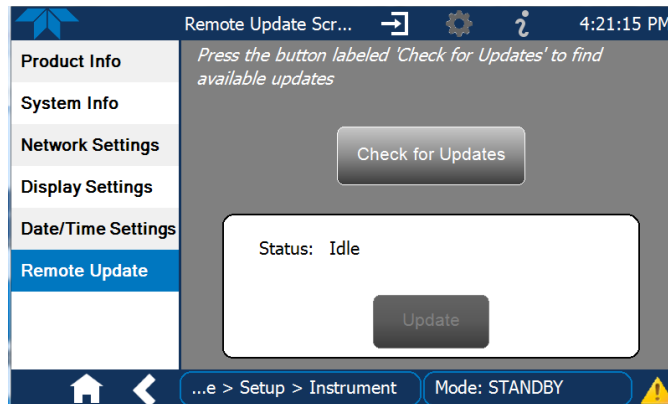


Figure 5-2. Remote Update Page

### 5.4.2. MANUAL RELOAD/UPDATE PROCEDURES

To reload or update firmware, first contact Technical Support to obtain the applicable file(s): [api-techsupport@teledyne.com](mailto:api-techsupport@teledyne.com) /+1 800-324-5190.

1. Follow Technical Support's instructions for copying the firmware files to a flash drive.
2. Go to the Utilities>USB Utilities>General menu.

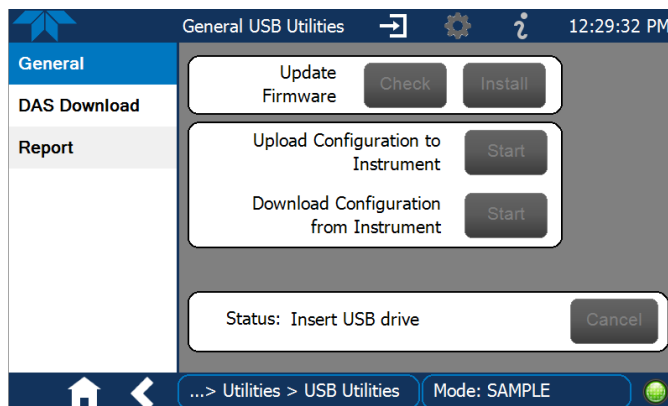


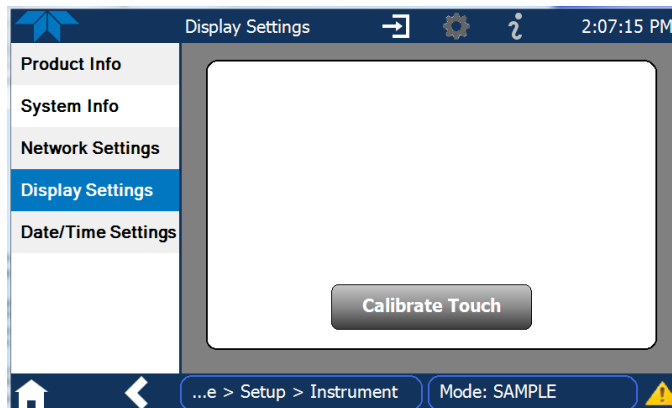
Figure 5-3. Manual Update Page (and other utilities)

3. Insert a flash drive into a front panel USB port and wait for the Status field to indicate that the drive has been detected.
4. In the Update Firmware field, press the Check button for the instrument to determine whether the firmware on the flash drive is more recent than what is currently installed. Once it's been determined that the firmware is new, the Install button will be enabled; if the firmware version on the flash drive is the same as or older than the current firmware of the instrument, the Install button will not be enabled.
5. Press the Install button, and note the messages in the Status field at the bottom of the page. Use the Cancel button if necessary.
6. When complete, as indicated in the Status field, press the Done button, which replaces the Cancel button, and remove the flash drive.
7. Power off and restart the instrument to complete the new firmware installation.



## 5.4.3. INSTRUMENT DISPLAY CALIBRATION (FOR EARLIER INSTRUMENTS)

This section applies to instruments shipped before January 2017. Although unlikely, if ever the touchscreen appears unresponsive or responds incorrectly, the screen can be calibrated via the Setup>Instrument>Display Settings menu.



**Figure 5-4. Touchscreen Calibration Page**

1. Connect a mouse to either of the front panel USB ports.
2. Navigate with the pointer to Setup>Instrument>Display Settings.
3. Click on “Calibrate Touch” and a crosshair appears in the center of the display screen.
4. Note that a timer function is enabled, allowing only 15 seconds to start the calibration process. If the timer expires, the instrument will exit the calibration screen and return to normal operation.
5. Click the very center of the crosshair.
6. When a new crosshair appears in the upper left corner of the screen, carefully and accurately click and hold the very center of that crosshair until it finishes shrinking, then release.
7. Repeat Step 6 for each of the corners.
8. Once the process is completed, a CANCEL and an ACCEPT button appear in the lower left corner: Test the accuracy of the calibration by touching parts of the screen and see that the mouse pointer follows your touches.
9. If you press the CANCEL button, the calibration won't be altered. Otherwise, press the ACCEPT button.

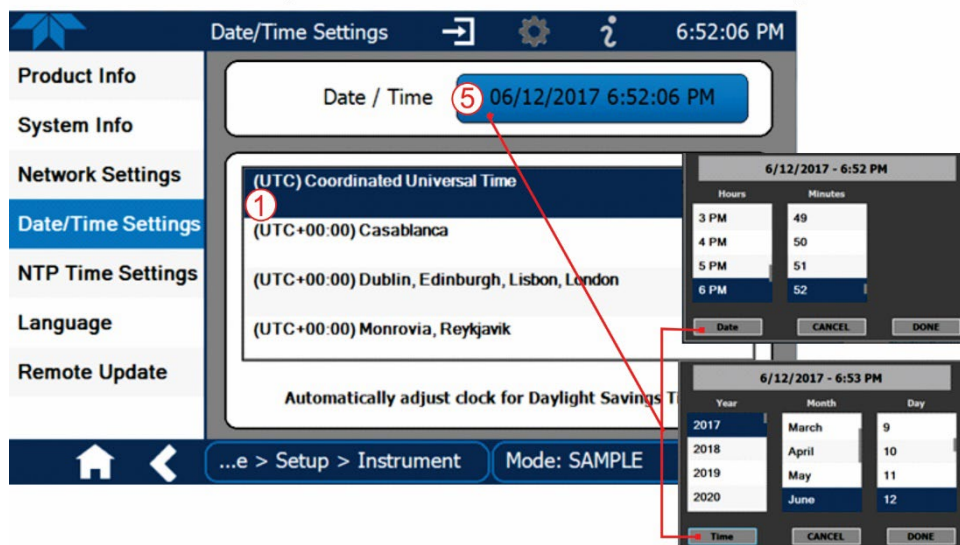


## 5.5. TIME ZONE CHANGES

There is an option to change between 12-hour and 24-hour format in the Setup>Vars menu (System Time Format). Effectively changing the Time Zone requires a specific procedure as follows:

1. In Setup>Instrument>Date/Time Settings select the applicable Time Zone.
2. Allow adequate time for the selected Time Zone to be properly accepted.
3. Verify: return to Home page then back to the Date/Time Settings page, and check that the selected Time Zone is now highlighted.
4. Without making any other changes, power OFF the instrument and power ON again.
5. Once restarted, return to the Date/Time Settings page where the newly selected Time Zone should be highlighted. (If not, it means that not enough time had passed for the instrument to accept the change before the power was cycled OFF).
6. After the Time Zone is implemented first (Steps 1 through 5), then other changes to the date and/or time can be made, and recycling the power is not necessary.

- ① **Time zone** change must be set **first**.
- ② **Wait**. Allow sufficient time to accept new Time Zone.
- ③ **Verify**. Return to Home page, then return to Date/Time Settings page.
- ④ After correct Time Zone is displayed, **power recycle** the instrument.
- ⑤ Only after Time Zone is selected and instrument rebooted, can other changes to date and/or time be made effectively.



Changes to date and/or time do **not** require a reboot.

**Figure 5-5. Time Zone Change Requirements**



## 5.6. HARDWARE MAINTENANCE PROCEDURES

Perform the following procedures as standard maintenance per Table 5-1.

### 5.6.1. REPLACING THE SAMPLE PARTICULATE FILTER OPTION

Inspect the particulate filter often for signs of plugging or contamination. To avoid contamination of the sample filter assembly use only gloves or PTFE-coated tweezers (or similar protective items) to handle any part of the housing, filter element, PTFE retaining ring, glass cover and the o-ring – do not use bare hands.

To change the filter:

1. Turn OFF the analyzer to prevent drawing debris into the instrument.
2. Open the hinged front panel and unscrew the retaining ring on the filter assembly.

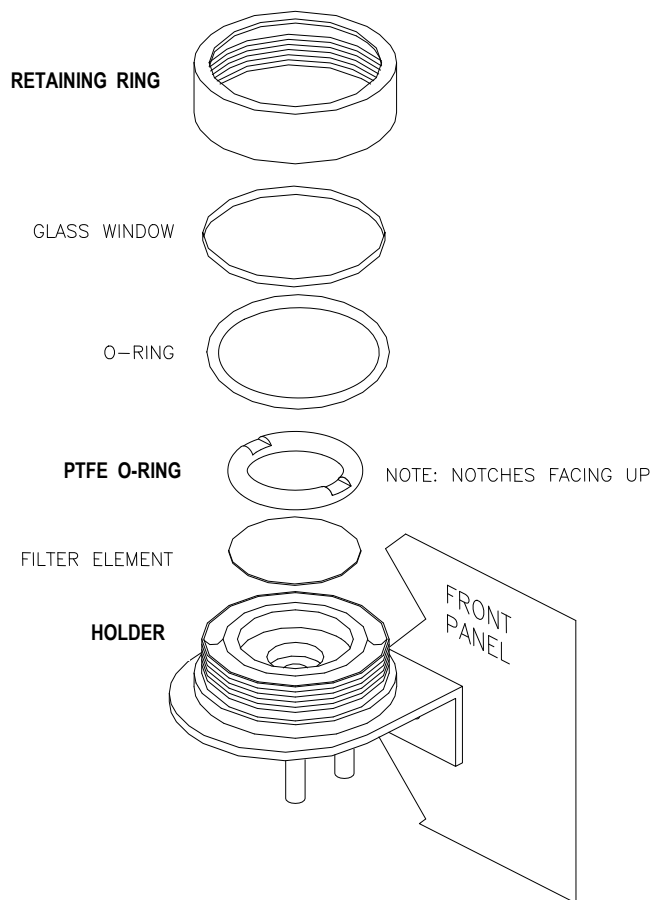


Figure 5-6. Replacing the Particulate Filter

3. Carefully remove the retaining ring, PTFE o-ring, glass window and filter element.
4. Replace the filter, being careful that the element is fully seated and centered in the bottom of the holder.



## N200, N200M, N200H

5. Reinstall the PTFE o-ring with the notches up; the glass window, then screw on the retaining ring and hand tighten. Inspect the seal between the edge of filter and the o-ring to assure a proper seal.
6. Close the panel and restart the analyzer.

### 5.6.2. CHANGING THE DFU SAMPLE FILTER OPTION

For analyzers equipped with the long-life DFU filter, if and when it needs to be replaced, the DFU is easily accessible for removal and replacement.

To replace:

1. Power OFF the analyzer to prevent drawing debris into the instrument.
2. Access the old filter by lowering the hinged portion of the rear panel.
3. Noting the orientation of the filter, remove filter's tie-down and disconnect its fittings. Dispose of according to code.
4. Install the replacement filter in the same orientation.
5. Secure with tie-down.
6. Close and secure hinged rear panel, power up instrument, and allow time for conditioning.
7. Conduct zero and span calibrations and allow time to stabilize.

### 5.6.3. CHANGING THE O<sub>3</sub> DRYER PARTICULATE FILTER

The air for the O<sub>3</sub> generator passes through a dryer equipped with a small particulate filter at its inlet, which prevents dust from entering the ozone dryer and degrading the dryer's performance over time. Change the filter as follows:

1. Before starting the procedure, check and record the average Rx Cell Press and the O<sub>3</sub> Flow values in the Dashboard. (If not visible, see Section 2.5.3 to configure).
2. Turn off the analyzer, unplug the power cord and remove the cover.
3. Unscrew the nut around the port of the filter using two 5/8" wrenches.

#### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

**Ensure to use proper wrenches.**

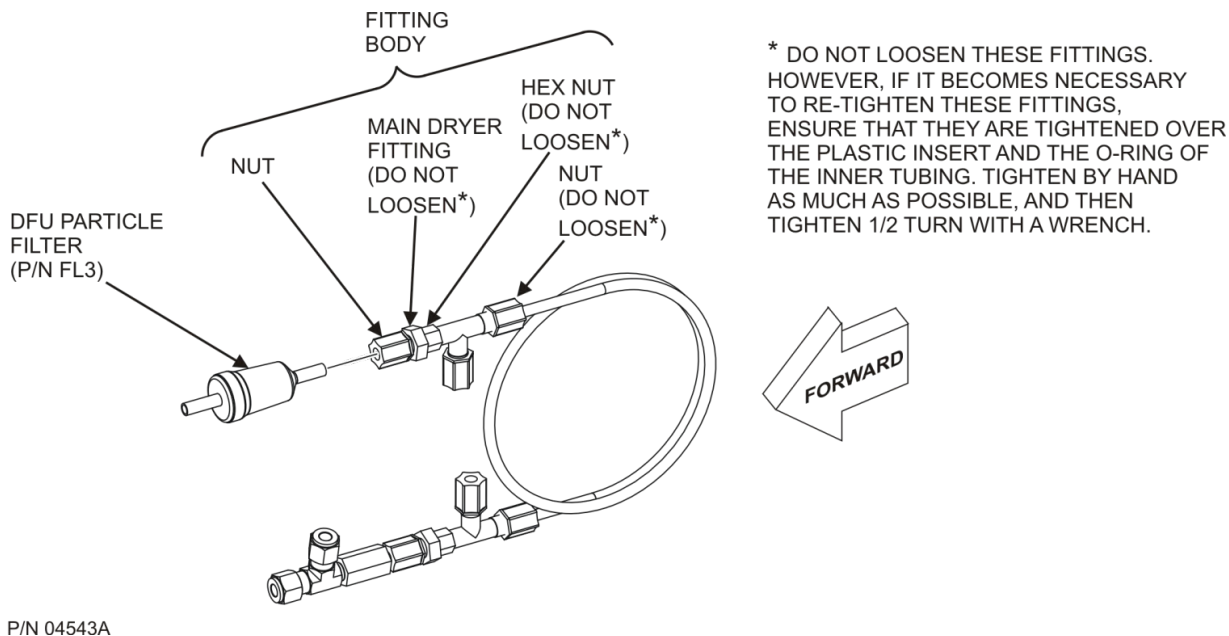
**Hold the main dryer fitting with a 5/8" wrench to ensure that it does not turn against the dryer.**

**Performing this procedure improperly or with incorrect tools creates the risk of causing a significant leak.**

4. Take off the old filter element and replace it with a suitable equivalent (Teledyne API P/N FL-3).



## N200, N200M, N200H



**Figure 5-7. Particle Filter on O<sub>3</sub> Supply Air Dryer**

5. Hold the main dryer fitting steady with a 5/8" wrench and tighten the nut with your hands.
6. If necessary use a second wrench but do not over-tighten the nut.
7. Replace the cover, plug in the power cord and restart the analyzer.
8. Check the O<sub>3</sub> flow (O<sub>3</sub> Flow) rate; it should be around 80 cc/min ± 15.
9. Check the Rx Cell Press; it should be the same value as before.
10. Refer to Section 5.6.12 to perform a leak check after installing the new DFU particle filter.

### 5.6.4. CHANGING THE OZONE CLEANSER CHEMICAL (N200)

The ozone (O<sub>3</sub>) cleanser (Figure 5-8) is located next to the O<sub>3</sub> generator (see Figure 2-3 for location) and cleans the O<sub>3</sub> stream from solid and liquid contaminants that are created inside the O<sub>3</sub> generator. The content of the ozone cleanser needs periodical exchange according to Table 5-1. A rebuild kit is available from the factory (see Appendix B of this manual lists the part numbers). Note the following steps apply to the N200 only:

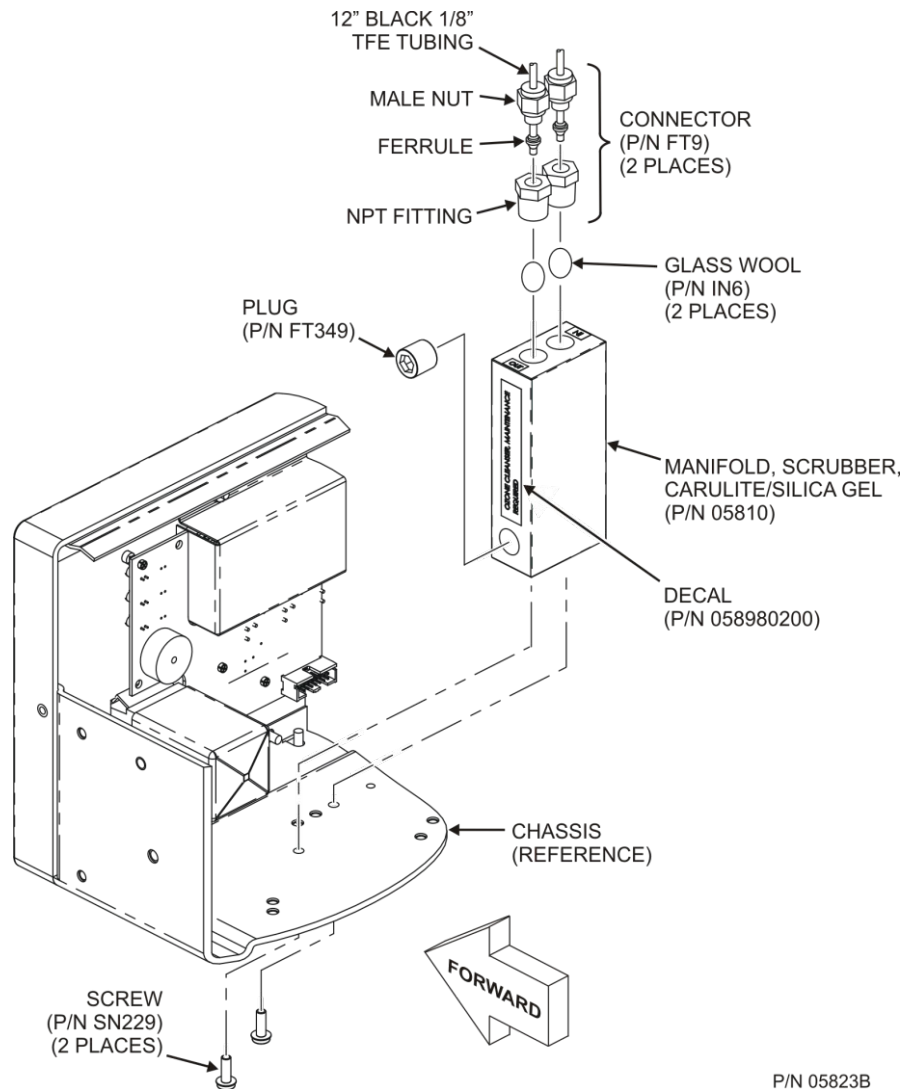
To change the ozone cleanser chemical, follow these steps:

1. Turn off power to the analyzer and pump.
2. Remove the analyzer cover and locate the O<sub>3</sub> filter in the front of the analyzer next to the O<sub>3</sub> generator.
3. Use a 7/16" wrench to remove both pieces of 1/8" male nut with tubing from the NPT fittings.





## N200, N200M, N200H



P/N 05823B

**Figure 5-8. Ozone Cleanser Assembly**

4. Remove the integrated screws with a Phillips screw driver and remove the scrubber manifold from the chassis.
5. Using a 9/16" wrench, remove both fittings from the cartridge.
6. Discard the glass wool.
7. Pour the contents of the scrubber manifold onto a sheet of white paper. If necessary, remove the plug to ensure that all the contents are poured out.
  - Notice any discoloration of the contents, which is usually white and slightly transparent.
  - The amount of discolored chemical (usually with yellow tint) may give you an indication of the lifetime of the chemical in your application.
  - The maintenance cycle of this item is dependent on ambient moisture, sub-micron particle load and other factors and may differ from that shown in Table 5-1.



## N200, N200M, N200H

8. Discard the used silica gel desiccant without touching it. It may contain nitric acid, which is a corrosive and highly irritating substance.



### CAUTION – GENERAL SAFETY HAZARD

**Immediately wash your hands after contact with the silica gel desiccant.**

9. Using a small powder funnel, fill the cartridge with about 10g new silica gel desiccant (Teledyne API P/N CH43) so that it is level on both legs of the cartridge.
  - Slight vibration is required to settle the chemical into the cartridge and achieve tightest packing, which increases performance and lifetime of the filter.
  - Ensure that the level of the chemical does not protrude farther than the first two threads of the NPT fitting.

### Important

#### IMPACT ON READINGS OR DATA

**Use only genuine, pre-conditioned Teledyne API's refill kits for this procedure. Teledyne API's refill kits have been properly conditioned to prevent a significant increase of the Auto Reference value which can cause large negative offsets, which may take 2-3 weeks to disappear.**

**Do not leave this material uncovered for more than a few seconds, as it will absorb contaminants from ambient air. Always store unused, well-covered refill material in a cool dry place.**

10. Seal the silica gel desiccant with 1 cm<sup>3</sup> of glass wool on each well.
  - Ensure that the plug is large enough and compressed into the cartridge so that the chemical is securely held in place.
11. Add new Teflon tape (P/N HN000036) to the NPT fittings.
12. Screw the NPT fittings back into the scrubber manifold.
13. Screw the cartridge back onto the chassis; orientation is not important.
14. Evaluate the ferrules on the tubing.
  - If the ferrules are too old, we recommend replacing them with new ferrules.
15. Reconnect the tubing using 7/16" and 9/16" wrenches.
  - Do not over-tighten the fittings.
16. If the service interval for this item has been exceeded, it may also be necessary to clean the reaction cell as described in Section 5.6.9.
17. Leak check the system using the pressurized approach described in Section 5.6.12.2.
  - If necessary, tighten the fittings some more but do not over-tighten.
18. Restart the analyzer and pump and continue operation.
19. Recalibrate the analyzer after one hour (Section 4).
  - If Auto Reference is high or is changing/not constant, you may have to wait a day until the silica gel is conditioned before recalibrating the instrument.



### 5.6.5. MAINTAINING THE EXTERNAL SAMPLE PUMP (PUMP PACK)

#### 5.6.5.1. REBUILDING THE PUMP

The sample pump head periodically wears out and must be replaced when the reaction cell pressure (Rx Cell Press) exceeds 10 in-Hg-A (at sea level; adjust this value accordingly for elevated locations).

- A pump rebuild kit is available from the factory. Refer to the label on the pump for the part number. Instructions and diagrams are included in the kit.
- A flow and leak check after rebuilding the sample pump is recommended.
- A span check and re-calibration after this procedure is necessary as the response of the analyzer changes with the Rx Cell Press.

#### 5.6.5.2. REPLACING THE SCRUBBER



#### CAUTION!

**Do NOT attempt to change the contents of the inline exhaust scrubber cartridge; change the entire cartridge.**

1. Through the Utilities>Diagnostics menu turn OFF the O3 Gen Override. Wait 10 minutes to allow pump to pull room air through scrubber before proceeding to the next step.
2. Disconnect exhaust line from analyzer.
3. Turn off (unplug) analyzer sample pump.
4. Disconnect tubing from (NO<sub>x</sub> or charcoal) scrubber cartridge.
5. Remove scrubber from system.
6. Dispose of according to local laws.
7. Install new scrubber into system.
8. Reconnect tubing to scrubber and analyzer.
9. Turn on pump.
10. Through the Utilities>Diagnostics menu (per Step 1 above) turn ON the O3 Gen Override.

### 5.6.6. CHANGING THE INTERNAL SPAN GAS GENERATOR PERMEATION TUBE (WITH IZS OPTION IN N200)

1. Turn off the analyzer, unplug the power cord and remove the cover.
2. Locate the permeation tube (Sample Gas Conditioner, Figure 2-3).
3. Remove the top layer of insulation if necessary.
4. Unscrew the black aluminum cover of the oven (3 screws) using a medium Phillips-head screw driver.
  - Leave the fittings and tubing connected to the cover.



## N200, N200M, N200H

5. Remove the old permeation tube and replace it with the new tube (or store the permeation tube in its original container if the instrument will not be operated for several or more hours).
  - Ensure that the tube is placed into the larger of two holes and that the open permeation end of the tube (plastic) is facing up.
6. Re-attach the cover with three screws.
  - Ensure that the three screws are tightened evenly.
7. Replace the analyzer cover, plug the power cord back in and turn on the analyzer.
8. Carry out a span check to see if the new permeation device works properly (see Section 4).
9. The permeation rate may need several days to stabilize.

### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

**Do not leave instrument turned off for more than 8 hours without removing the permeation tube. Do not ship the instrument without removing the permeation tube. The tube continues to emit NO<sub>2</sub>, even at room temperature and will contaminate the entire instrument.**

### 5.6.7. CHANGING THE EXTERNAL ZERO AIR SCRUBBER OPTION

The external zero air scrubber that is included with several of the analyzer's optional calibration valve packages contains two chemicals:

- Pink Purafil® (P/N CH 9) that converts NO in the ambient air to NO<sub>2</sub>, and;
- Black, charcoal (P/N CH 1) that absorbs the NO<sub>2</sub> thereby creating zero air.

These chemicals need to be replaced periodically (see Table 5-1) or as needed.



#### CAUTION!

**The following procedures apply only to the External Zero Air Scrubber and NOT to the inline exhaust scrubber cartridge that is part of the pump pack assembly.**



## N200, N200M, N200H

### Important

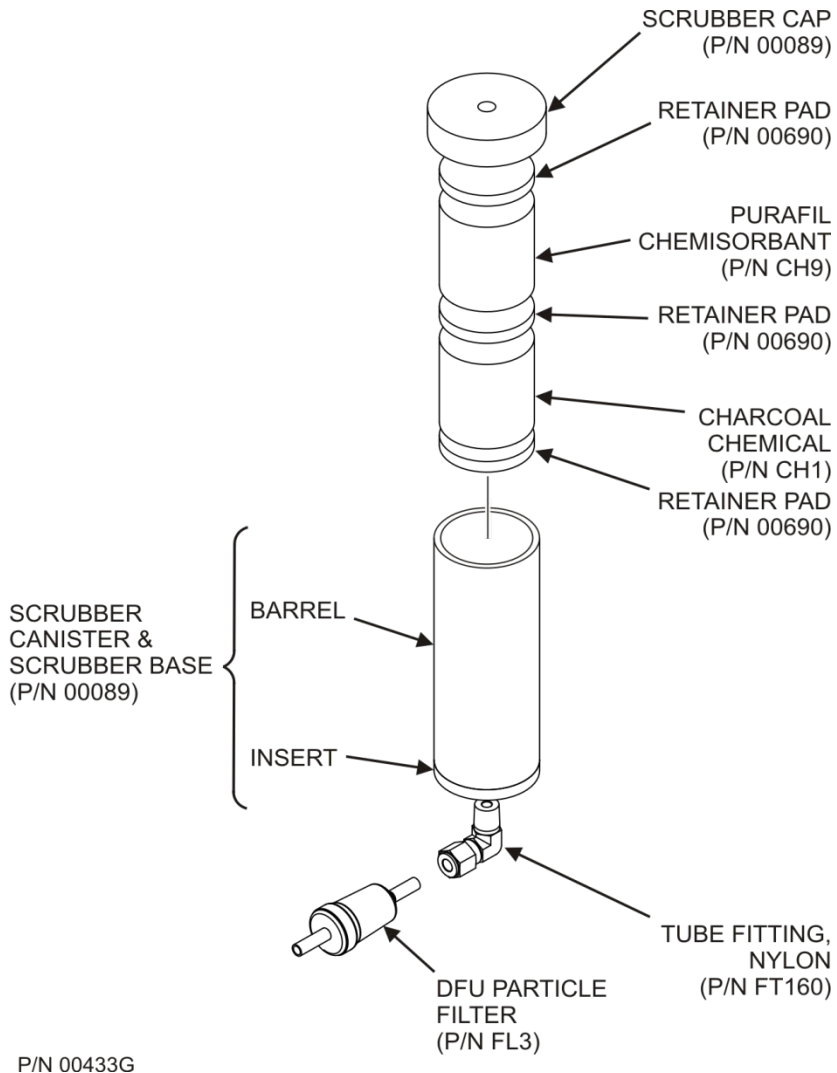
#### IMPACT ON READINGS OR DATA

**This procedure can be carried out while the instrument is running, however ensure that the analyzer is not in ZERO calibration mode.**

1. Locate the scrubber on the outside rear panel; Figure 5-9 shows the exploded assembly.
2. Remove the old scrubber by disconnecting the 1/4" plastic tubing from the DFU particle filter using 9/16" and 1/2" wrenches.
3. Remove the DFU particle filter from the cartridge using 9/16" wrenches.
4. Unscrew the top of the scrubber canister and discard the Purafil® and charcoal contents.
  - Ensure to abide by local laws about discarding these chemicals.
  - The rebuild kit comes with a Material and Safety Data Sheet, which contains more information on these chemicals.
5. It is not necessary to remove the insert from the barrel, but if removed, perform the following procedure:
  - Coat the threads of the insert with epoxy (Teledyne API P/N CH32).
  - Hand tighten the insert to the barrel.
6. It is not necessary to remove the nylon tube fitting from the insert, but if removed, apply Teflon tape (Teledyne API P/N HW36) to the threads of the nylon tube fitting before installing on the insert.
7. Refill the scrubber with charcoal at the bottom and the Purafil® chemical at the top.
  - Use three, white retainer pads to separate the chemicals as shown in Figure 5-9.
8. Replace the screw-top cap and tighten the cap; hand-tighten only.
9. If necessary, replace the filter (DFU, Figure 5-9) with a new unit and discard the old. (The bottom retainer pad should catch most of the dust; the filter should not be visibly dirty on the inside).
  - Disconnect the tube and fitting from one end and remove the filter from the scrubber canister.
  - Insert a new filter, ensuring that the small arrow embedded on the filter points in flow direction, i.e., to analyzer.
10. Replace the scrubber assembly into its clips on the rear panel.
11. Reconnect the plastic tubing to the fitting of the DFU particle filter.
12. Adjust the scrubber cartridge such that it does not protrude above or below the analyzer in case the instrument is mounted in a rack.
  - If necessary, squeeze the clips for a tighter grip on the cartridge.



# N200, N200M, N200H



**Figure 5-9. Zero Air Scrubber Assembly**



## 5.6.8. CHANGING OR CLEANING THE NO<sub>2</sub> CONVERTER

The NO<sub>2</sub> converter is located in the center of the instrument, see Figure 2-3 for the location and Figure 5-10 for the assembly.

The converter is designed for replacement of the cartridge only; the heater with built-in thermocouple is to be reused.



### CAUTION! PERSONAL SAFETY HAZARD

**Wear gloves prior to changing the NO<sub>2</sub> Converter to ensure that the fiberglass insulation does not come into contact with your skin.**

1. Power OFF the instrument.
2. Remove the instrument cover and allow the converter to cool.
3. Remove the converter assembly cover as well as the Moly insulation (top layer and corner cut out layers) until the Moly converter assembly can be seen.



### CAUTION! HOT SURFACE HAZARD

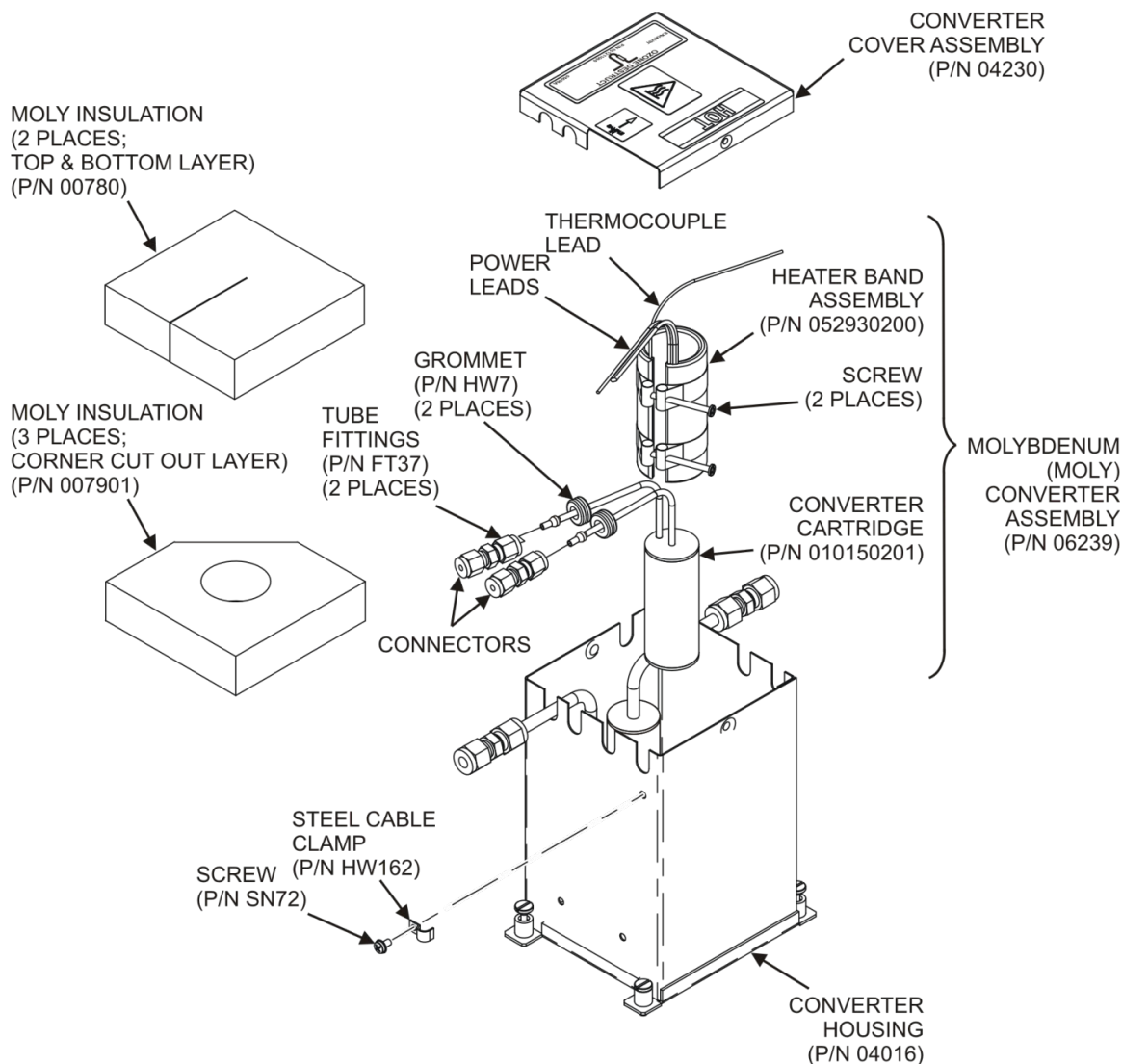
**The converter operates at 315° C. Severe burns can result if the assembly is not allowed to cool.**

**Do not handle the assembly until it is at room temperature. This may take several hours.**

4. Remove the tube fittings from the Moly converter assembly.
5. Disconnect the power and the thermocouple from the Moly converter assembly.
6. Unscrew the steel cable clamp (for the power leads) from the converter housing with a Phillips-head screw driver.
7. Remove the Moly converter assembly (converter cartridge and band heater) from the converter housing.
  - Make a note of the orientation of the tubes relative to the heater cartridge.
8. Unscrew the band heater and loosen it.
9. Remove the old converter cartridge.



## N200, N200M, N200H



P/N 0187202G

**Figure 5-10. NO<sub>2</sub> Converter Assembly (Moly Shown)**

10. Wrap the band heater around the new replacement converter cartridge and tighten the screws using a high-temperature anti-seize agent (Teledyne API P/N CH42) such as copper paste.
  - Ensure to use proper alignment of the heater with respect to the converter tubes.
11. Replace the Moly converter assembly by routing the cables through the holes in the converter housing and reconnecting them properly.
12. Reconnect the steel cable clamp around the power leads for safe operation.
13. Reattach the tube fittings to the converter and replace the Moly insulation (top layer and corner cut out layers).
14. Reinstall the converter assembly cover.
15. Reinstall the instrument cover and power up the analyzer.
16. Allow the converter to burn-in for 24 hours, and then recalibrate the instrument.





### 5.6.9. CLEANING THE REACTION CELL

A dirty reaction cell will cause excessive noise, drifting zero or span values, low response or a combination of all.

To clean the reaction cell, it is necessary to remove it from the sensor housing. Refer to Figure 5-11 for the following procedure.

1. Turn off the instrument power and vacuum pump.
2. Disconnect the black 1/4" exhaust tube and the 1/8" sample and ozone air tubes from the reaction cell. Disconnect the heater/thermistor cable.
3. Remove two screws (Teledyne API P/N SN144) and two washers holding the reaction cell to the PMT housing and lift the cell and manifold out.

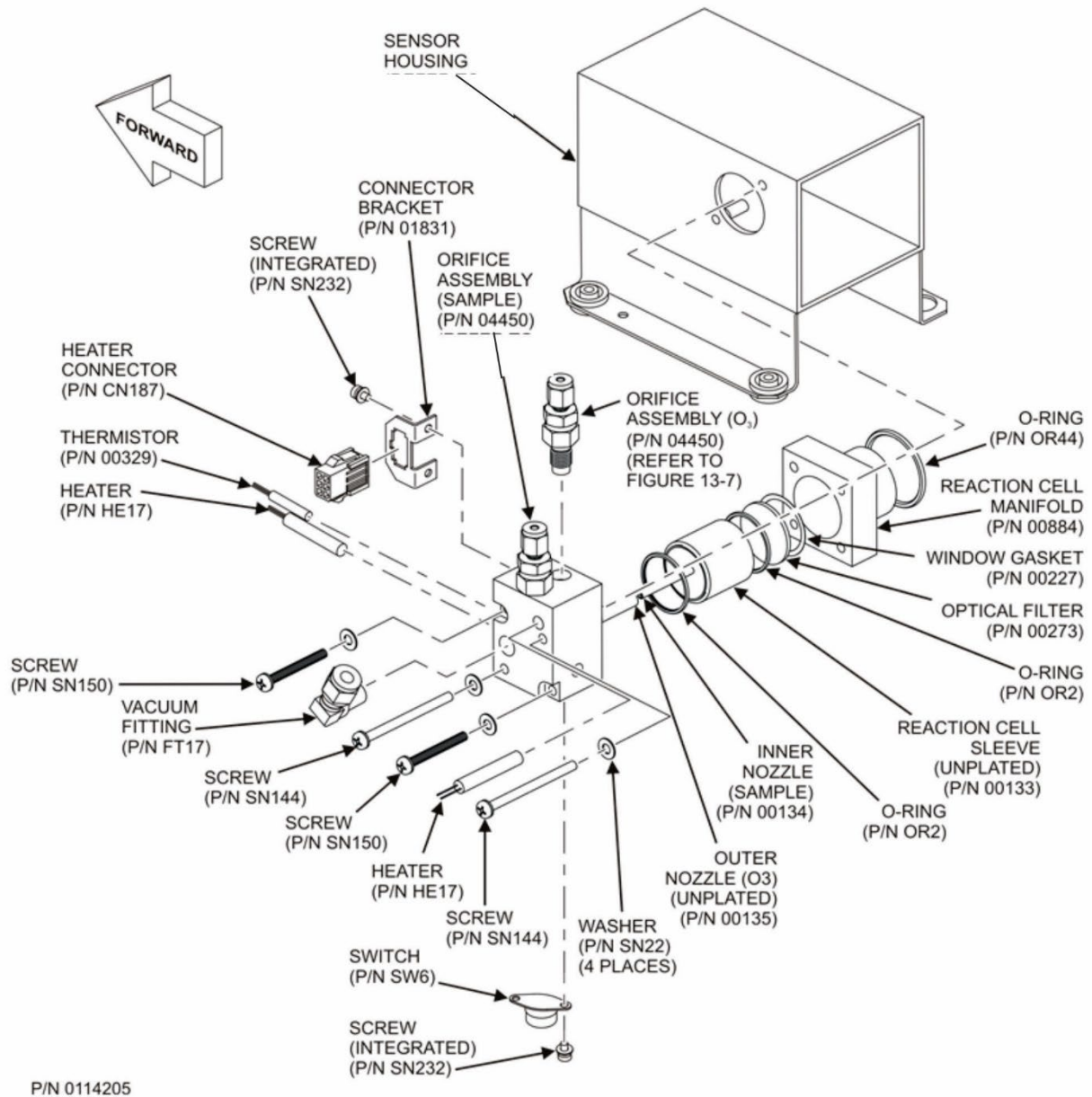


Figure 5-11. Reaction Cell Assembly



## N200, N200M, N200H

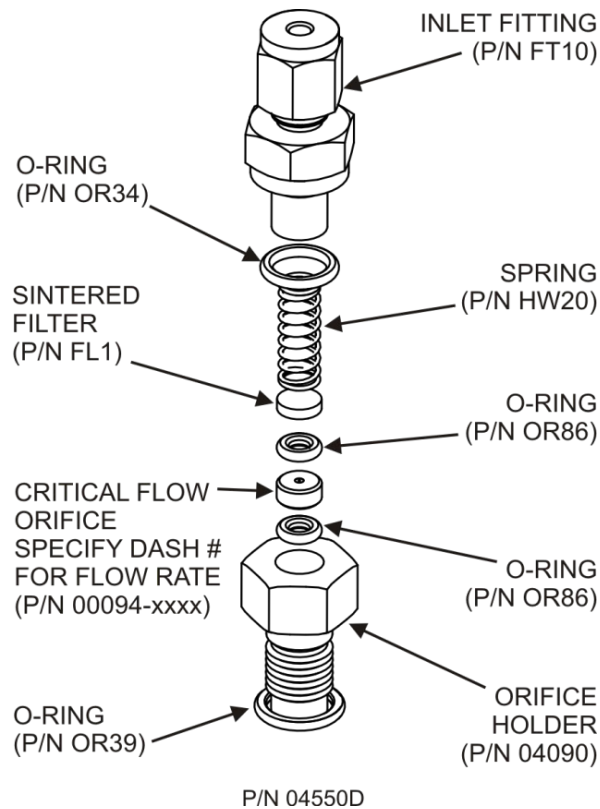
4. Remove two screws (Teledyne API P/N SN150) and two washers.
5. The reaction cell will separate into two halves, the stainless steel manifold assembly and the black plastic reaction cell with window gasket, stainless steel reaction cell sleeve, optical filter and O-rings.
6. The reaction cell (both plastic part and stainless steel sleeve) and optical filter should be cleaned with Distilled Water (DI - Water) and an appropriate optical wipe and then dried.
7. Usually it is not necessary to clean the sample and ozone flow orifices since they are protected by sintered filters.
  - If tests show that cleaning is necessary, refer to Section 5.6.10 on how to clean the critical flow orifice.
8. Do not remove the sample and ozone nozzles. They are Teflon threaded and require a special tool for reassembly. If necessary, the manifold with nozzles attached can be cleaned in an ultrasonic bath.
9. Reassemble in proper order and re-attach the reaction cell to the sensor housing. Reconnect pneumatics and heater connections, then re-attach the pneumatic sensor assembly and the cleaning procedure is complete.
10. After cleaning the reaction cell, it is also recommended to exchange the ozone supply air filter chemical as described in Section 5.6.4.
11. After cleaning, the analyzer span response may drop 10 - 15% in the first 10 days as the reaction cell window conditions. This is normal and does not require another cleaning.

### 5.6.10. SERVICING CRITICAL FLOW ORIFICES

There are several critical flow orifices installed in the analyzer (see Figure 6-7 for a pneumatic location of each orifice). Despite the fact that these flow restrictors are protected by sintered stainless steel filters, they can, on occasion, clog up, particularly if the instrument is operated without sample filter or in an environment with very fine, sub-micron particle-size dust.



## N200, N200M, N200H



**Figure 5-12. Critical Flow Orifice Assembly**

To clean or replace a critical flow orifice:

1. Turn off power to the instrument and vacuum pump.
2. Remove the analyzer cover and locate the reaction cell assembly (refer to Figure 2-3 and Figure 5-11).
3. Unscrew the 1/8" sample and ozone air tubes from the reaction cell.

For orifices on the reaction cell:

4. Unscrew the orifice holder with a 9/16" wrench.
  - This part holds all components of the critical flow assembly as shown in Figure 5-12.

For orifices in the vacuum manifold: the assembly is similar to the one shown in Figure 5-12, except:

- Without the orifice holder, P/N 04090, and bottom O-ring, P/N OR34 and;
  - With an NPT fitting in place of the FT 10 fitting.
5. After taking off the connecting tube, unscrew the NPT fitting.



## N200, N200M, N200H

6. Take out the components of the assembly:

- spring
- sintered filter
- two O-rings
- the orifice

### Note

**For the vacuum manifold only, you may need to use a scribe or pressure from the vacuum port to get the parts out of the manifold.**

7. Discard the two O-rings and the sintered filter and install new ones.
8. Reassemble the parts as shown in Figure 5-12.
9. Reinstall the critical flow orifice assembly into the reaction cell manifold or the vacuum manifold.
10. Reconnect all tubing, power up the analyzer and pump. After a warm-up period of 30 minutes, carry out a leak test as described in Section 5.6.12.

### 5.6.11. CHECKING FOR LIGHT LEAKS

When re-assembled or operated improperly, the PMT assembly can develop small gaps, which let stray light from the analyzer surrounding into the PMT housing. To find such light leaks, follow the procedures below.



#### CAUTION – QUALIFIED PERSONNEL ONLY

**This procedure is carried out with the analyzer running and its cover removed.**

1. In the Dashboard view the **PMT Signal** (if not visible, configure the Dashboard to add; see Section 2.5.3).
2. Supply zero gas to the analyzer.
3. With the instrument still running, carefully remove the analyzer cover.



#### WARNING – ELECTRICAL SHOCK HAZARD

**Do NOT touch any of the inside wiring with the metal cover or with your body.**

**Do NOT drop screws or tools into a running analyzer.**

4. Shine a powerful flashlight or portable incandescent light at the inlet and outlet fitting and at all of the joints of the reaction cell as well as around the PMT housing.
  - The PMT value should not respond to the light, the PMT signal should remain steady within its usual noise floor.
5. If there is a PMT response to the external light, symmetrically tighten the reaction cell mounting screws or replace the 1/4" vacuum tubing with new, black PTFE tubing (this tubing will fade with time and become transparent).



## N200, N200M, N200H

### Note

Often, light leaks are also caused by O-rings being left out of the assembly.

6. If, during this procedure, the black PMT housing end plate for the Sensor Assembly is removed, ensure to replace the 5 desiccant bags inside the housing.
7. Carefully replace the analyzer cover. If tubing was changed, carry out a pneumatic leak check (Section 5.6.12).

### 5.6.12. CHECKING FOR PNEUMATIC LEAKS

This section covers a simple leak check and a detailed leak check.



#### CAUTION - TECHNICAL INFORMATION

**Do not exceed 15 psi when pressurizing the system during either Simple or Detailed checks.**

#### 5.6.12.1. SIMPLE VACUUM LEAK AND PUMP CHECK

Leaks are the most common cause of analyzer malfunction. This section presents a simple leak check, whereas the next section details a more thorough procedure. The method described here is easy, fast and detects, but does not locate, most leaks. It also verifies the sample pump condition.

1. Turn the analyzer ON, and allow at least 30 minutes for flows to stabilize.
2. Cap the sample inlet port (cap must be wrench-tight).
3. After several minutes, when the pressures have stabilized, note the Sample Press (sample pressure) and the Rx Cell Press (vacuum pressure) readings.
  - If both readings are equal to within 10% and less than 10 in-Hg-A, the instrument is free of large leaks.
  - It is still possible that the instrument has minor leaks.
  - If both readings are < 10 in-Hg-A, the pump is in good condition.
  - A new pump will create a pressure reading of about 4 in-Hg-A (at sea level).
4. When done switch off the pump and open the cap to the sample inlet port slowly to minimize inrush flow.

#### 5.6.12.2. DETAILED PRESSURE LEAK CHECK

If a leak cannot be located by the above procedure, obtain a leak checker that contains a small pump, shut-off valve, and pressure gauge to create both over-pressure and vacuum. Alternatively, a tank of pressurized gas, with the two-stage regulator adjusted to  $\leq 15$  psi, a shutoff valve and a pressure gauge may be used.

### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

**Once tube fittings have been wetted with soap solution under a pressurized system, do not apply or reapply vacuum as this will cause soap solution to be sucked into the instrument, contaminating inside surfaces.**

1. Turn OFF power to the instrument and remove the instrument cover.



## N200, N200M, N200H

2. Install a leak checker or a tank of gas (compressed, oil-free air or nitrogen) as described above on the sample inlet at the rear panel.
3. Disconnect the pump tubing on the outside rear panel and cap the pump port.
  - If IZS or zero/span valves are installed, disconnect the tubing from the zero and span gas ports and plug the ports.
  - Cap the DFU particle filter on the dryer.
4. Pressurize the instrument with the leak checker or tank gas, allowing enough time to fully pressurize the instrument through the critical flow orifice.
  - Check each tube connection (fittings, hose clamps) with soap bubble solution, looking for fine bubbles.
  - Once the fittings have been wetted with soap solution, do not reapply vacuum as it will draw soap solution into the instrument and contaminate it.
  - Do not exceed 15 psi pressure.
5. If the instrument has the zero and span valve option, the normally closed ports on each valve should also be separately checked.
  - Connect the leak checker to the normally closed ports and check with soap bubble solution.
6. If the analyzer is equipped with an IZS Option, connect the leak checker to the Dry Air inlet and check with soap bubble solution.
7. Once the leak has been located and repaired, the leak-down rate of the indicated pressure should be less than 1 in-Hg-A (0.4 psi) in 5 minutes after the pressure is turned off.
8. Clean surfaces from soap solution, reconnect the sample and pump lines and replace the instrument cover.
9. Restart the analyzer.

### 5.6.12.3. PERFORMING FLOW CHECKS/CALIBRATIONS

#### Important

#### IMPACT ON READINGS OR DATA

**Use a separate, calibrated flow meter capable of measuring the flow specifications for the instrument being checked/calibrated in order to get accurate measurements. Do not use the built in flow measurement viewable in the Dashboard. This value is only calculated, not measured.**

The rates of sample gas flow and O<sub>3</sub> flow through the analyzer are a key part of the NO<sub>x</sub>, NO and NO<sub>2</sub> concentration readings, but the readings are only calculated values derived by the CPU. The Flow Cal and Ozone Flow Cal features under the Utilities>Diagnostics menu are used to check and to calibrate/adjust these calculations.

Such checks are useful for monitoring the actual flow of the instrument, using an external flow meter. A decreasing, actual sample flow may point to slowly clogging pneumatic paths, most likely critical flow orifices or sintered filters (Section 5.6.10).



## N200, N200M, N200H

### FLOW CHECK

Low flows indicate blockage somewhere in the pneumatic pathway.

To check the Sample flow with the external flow meter:

1. Disconnect the sample inlet tubing from the rear panel SAMPLE port.
2. Attach the outlet port of a suitable flow meter to the rear panel SAMPLE port.
  - Ensure that the inlet to the flow meter is at atmospheric pressure.
3. The sample flow measured with the external flow meter should be within  $\pm 10\%$  of the analyzer's Flow specification (Table 1-1).
  - If a combined sample/ozone air dryer is installed (optional equipment), the flow will be an additional 80 cc/min for the ozone generator supply air and 60 cc/min for the purge flow).

To check the Ozone flow with the external flow meter:

1. Open the analyzer to gain access to the reaction cell.
2. Disconnect the tube going to the reaction cell's 4 mil fitting.
3. Connect the flow meter to the reaction cell's 4 mil fitting.
4. The ozone flow measured with the external flow meter should be 80 cc/min.

### FLOW CALIBRATION

To calibrate the Sample flow (Flow Cal) or the O<sub>3</sub> flow (Ozone Flow Cal):

1. In the Utilities>Diagnostics>Flow Cal or Ozone Flow Cal menu (Figure 5-13), as applicable, edit the Actual Flow value by inputting the reading from the external flow meter obtained in the corresponding check of the flow to be calibrated.
2. Press the Calibrate button.

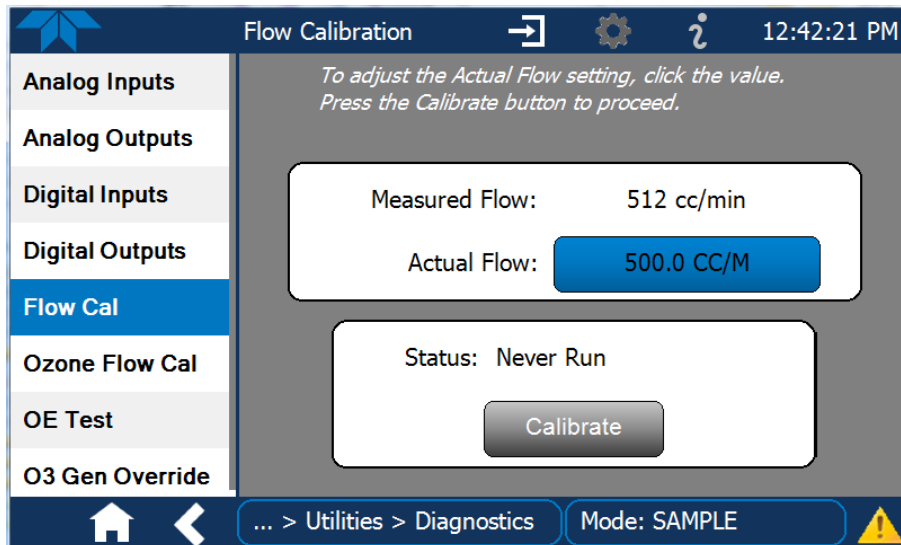


Figure 5-13. Flow Calibration Menu





### 5.7. SERVICE AND TROUBLESHOOTING

This section contains methods to identify the source of performance problems with the analyzer and procedures to service the instrument.

#### Note

**Section 6, Principles of Operation, provides information about how the instrument works, to support your understanding of the technical details of maintenance.**



#### CAUTION

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



#### WARNING – RISK OF ELECTRICAL SHOCK

**Some operations need to be carried out with the analyzer open and running.**

**Exercise caution to avoid electrical shocks and electrostatic or mechanical damage to the analyzer.**

**Do not drop tools into the analyzer or leave them after your procedures.**

**Do not short or touch electric connections with metallic tools while operating inside the analyzer.**

**Use common sense when operating inside a running analyzer.**

The analyzer has been designed so that problems can be rapidly detected, evaluated and repaired. During operation, it continuously performs diagnostic tests and provides the ability to evaluate its key operating parameters without disturbing monitoring operations.

A systematic approach to troubleshooting will generally consist of the following five steps:

1. Note any Alerts and take corrective action as necessary (see Table 5-3).
2. Examine the values of all basic functions in the Dashboard and compare them to factory values. Note any major deviations from the factory values and take corrective action.
3. Use the internal electronic status LEDs to determine whether the electronic communication channels are operating properly.
  - Verify that the DC power supplies are operating properly by checking the voltage test points on the relay PCA.
  - Note that the analyzer's DC power wiring is color-coded and these colors match the color of the corresponding test points on the relay PCA.
4. Suspect a leak first!
  - Customer service data indicate that the majority of all problems are eventually traced to leaks in the internal pneumatics of the analyzer or the diluent gas and source gases delivery systems.





## N200, N200M, N200H

- Check for gas flow problems such as clogged or blocked internal/external gas lines, damaged seals, punctured gas lines, damaged / malfunctioning pumps, etc.
5. Follow the procedures defined in Section 2.3.4.3 to confirm that the analyzer's vital functions are working (power supplies, CPU, relay PCA, touchscreen, PMT cooler, etc.).

### 5.7.1. FAULT DIAGNOSIS WITH ALERTS

Table 5-3 lists brief descriptions of warning Alerts that may occur during start up and describes their possible causes for diagnosis and troubleshooting.

It should be noted that if more than two or three warning Alerts occur at the same time, it is often an indication that some fundamental sub-system has failed rather than an indication of the specific failures referenced by the warnings.

**Table 5-3. Warning Alerts, Fault Conditions and Possible Causes**

| WARNING                                 | FAULT CONDITION  | POSSIBLE CAUSES  |
|---|--|--|
| <b>AUTO REFERENCE WARN<br/>XXX.X MV</b> | Auto-Reference reading too high. (Auto-Reference reading above 200 mV).<br>Value shown in message indicates Auto-Reference reading at time warning was displayed.              | Auto Reference valve not working<br>Valve control driver failed<br>Bad Relay PCA<br>Failed +12 VDC power supply<br>Gas leak across Auto Reference valve ports<br>Dirty Reaction Cell<br>O <sub>3</sub> flow problem to RCELL |
| <b>BOX TEMP WARNING</b>                 | Temperature of chassis is outside specified limits. (typically < 7°C or >48°C)   | Box Temperature typically runs ~7°C warmer than ambient temperature<br>Poor/blocked ventilation to the analyzer<br>Stopped Exhaust-Fan<br>Ambient Temperature outside of specified range                                     |
| <b>CANNOT DYN SPAN<sup>2</sup></b>      | Dynamic Span operation failed. (Contact closure span calibration failed while <i>DYN_SPAN</i> was set to <i>ON</i> ).  | Measured concentration value is too high or low<br>Concentration Slope value to high or too low  |
| <b>CANNOT DYN ZERO<sup>3</sup></b>      | Dynamic Zero operation failed. (Contact closure zero calibration failed while <i>DYN_ZERO</i> was set to <i>ON</i> ).  | Measured concentration value is too high<br>Concentration Offset value to high   |
| <b>CONFIG INITIALIZED</b>               | Configuration and Calibration data reset to original Factory state or erased.  | User erased data   |
| <b>CONV TEMP WARNING</b>                | NO <sub>2</sub> to NO converter temperature too high or too low to efficiently convert NO <sub>2</sub> to NO. (NO <sub>2</sub> to NO converter temperature < 305°C or >325°C). | Heater configured for wrong voltage type<br>Failed converter Temperature Sensor<br>Relay controlling the Heater is not working   |
| <b>DATA INITIALIZED</b>                 | Data Storage in DAS was erased before the last power up occurred.  | User cleared data.   |



## N200, N200M, N200H

| WARNING                              | FAULT CONDITION   | POSSIBLE CAUSES  |
|--------------------------------------|---|--|
| <b>HVPS WARNING</b>                  | High voltage power supply output is too high or too low for proper operation of the PMT. (Outside of warning limits).   | No +15 VDC power supply to PMT PCA<br>Drive voltage not adjusted properly<br>Failed PMT PCA<br>Dirty reaction cell<br>Bad pneumatic flow   |
| <b>OZONE FLOW WARNING</b>            | Ozone gas flow is too high or too low for accurate NO <sub>x</sub> , NO and NO <sub>2</sub> readings. (O <sub>3</sub> flow rate < 50 cc/min or >150 cc/min).  | Failed Sample Pump<br>Blocked O <sub>3</sub> dryer<br>Blocked inlet/outlet to O <sub>3</sub> purifier<br>Dirty O <sub>3</sub> dryer DFU<br>Leak downstream of RCELL<br>Failed O <sub>3</sub> Flow Sensor   |
| <b>OZONE GEN OFF <sup>4</sup></b>    | Ozone generator is off. This is the only warning message that automatically clears itself. It clears itself when the ozone generator is turned on. Upon power up the Ozone generator will remain off for 30 minutes, which allows the ozone dryer to reach its working dew point. | O <sub>3</sub> generator override is turned ON.<br>Electrical connection loose or faulty.<br>Bad power supply  |
| <b>IZS TEMP WARNING <sup>5</sup></b> | Permeation tube oven temperature is out of range (< 45°C or >55°C) for efficient O <sub>3</sub> production.   | Heater configured for wrong voltage type<br>Failed permeation tube Temperature Sensor<br>Relay controlling the Heater is not working   |
| <b>PMT TEMP WARNING</b>              | PMT temperature outside of warning limits. (Sample temperature is < 5°C or >12°C).  | PMT fan not operating<br>Failed PMT Temperature Sensor<br>TEC not functioning  |
| <b>RCELL PRESS WARN</b>              | Reaction cell pressure is out of range (< 0.5 in-Hg or >15 in-Hg) for accurate readings.<br>Nominal range 4-7 in-Hg.  | Pump may not be functioning properly, Or if Reaction Cell Pressure is < 0.5 in-Hg:<br><ul style="list-style-type: none"> <li>•Blocked Particulate Filter</li> <li>•Blocked Sample Inlet/Gas Line</li> <li>•Failed Pressure Sensor/circuitry</li> </ul> If Sample Pressure is >15 in-Hg:<br><ul style="list-style-type: none"> <li>•Blocked vacuum manifold</li> <li>•Broken Ozone Dryer</li> </ul> |
| <b>RCELL TEMP WARN</b>               | Reaction cell temp tout of range (< 45°C or >55°C). for accurate readings.  | Heater configured for wrong voltage type<br>Failed RCELL Temperature Sensor<br>Relay controlling the heater is not working   |
| <b>SAMPLE FLOW WARN</b>              | The flow rate of the sample gas is outside the specified limits. (Sample flow rate is < 350 cc/min or >600 cc/min).   | Failed Sample Pump<br>Blocked Sample Inlet/Gas Line<br>Dirty Particulate Filter<br>Leak downstream of RCELL Critical Flow Orifice<br>Failed Sample Pressure Sensor<br>Failed Vacuum Pressure Sensor  |
| <b>SAMPLE PRESS WARN</b>             | Sample pressure is too high or too low for accurate NO <sub>x</sub> , NO, NO <sub>2</sub> readings. (Sample Pressure is <15 in-Hg or >35 in-Hg).<br>Normally 29.92 in-Hg at sea level decreasing at 1 in-Hg per 1000 ft of altitude (with no flow – pump disconnected).           | If Sample Pressure is < 15 in-Hg:<br><ul style="list-style-type: none"> <li>•Blocked Particulate Filter</li> <li>•Blocked Sample Inlet/Gas Line</li> <li>•Failed Pressure Sensor/circuitry</li> </ul> If Sample Pressure is >35 in-Hg:<br><ul style="list-style-type: none"> <li>•Bad Pressure Sensor/circuitry</li> <li>•Pressure too high at Sample Inlet.</li> </ul>                            |



## N200, N200M, N200H

| WARNING             | FAULT CONDITION            | POSSIBLE CAUSES  |
|---------------------|----------------------------|--|
| <b>SYSTEM RESET</b> | The computer has rebooted. | This message occurs at power on.<br>If it is confirmed that power has not been interrupted:<br>Failed +5 VDC power<br>Fatal Error caused software to restart<br>Loose connector/wiring |

- <sup>1</sup> Clears 45 minutes after power up.
- <sup>2</sup> Clears the next time successful zero calibration is performed.
- <sup>3</sup> Clears the next time successful span calibration is performed.
- <sup>4</sup> Clears 30 minutes after power up.
- <sup>5</sup> Only appears if the IZS option is installed.

### 5.7.2. FAULT DIAGNOSIS WITH DASHBOARD FUNCTIONS

In addition to being useful as predictive diagnostic tools, the functions viewable in the Dashboard can be used to isolate and identify many operational problems when combined with a thorough understanding of the analyzer’s principles of operation (see Section 6).

The acceptable ranges for these functions are listed in the “Nominal Range” column of the analyzer *Final Test and Validation Data Sheet* shipped with the instrument. Values outside these acceptable ranges indicate a failure of one or more of the analyzer’s subsystems. Functions whose values are still within acceptable ranges but have significantly changed from the measurement recorded on the factory data sheet may also indicate a failure.

Make note of these values for reference in troubleshooting.

**Note** If no value displays for any of these Dashboard functions, it indicates an OUT OF RANGE reading.

**Note** Sample Pressure measurements are represented in terms of “Absolute Atmospheric Pressure” because this is the least ambiguous method for reporting gas pressure. Absolute atmospheric pressure is about 29.92 in-Hg-A at sea level. It decreases about 1 in-Hg per 1000 ft gain in altitude. A variety of factors such as air conditioning systems, passing storms, and air temperature, can also cause changes in the absolute atmospheric pressure.



## N200, N200M, N200H

**Table 5-4. Dashboard Functions - Indicated Failures**

| DASHBOARD FUNCTION     | INDICATED FAILURE(S)  |
|------------------------|---|
| Stability              | Unstable concentrations; leaks  |
| Sample Flow            | Leaks; clogged critical flow orifice  |
| O3 Flow                | Leaks; clogged critical flow orifice  |
| PMT                    | Calibration off; HVPS problem; no flow (leaks)  |
| Auto Reference         | Leaks; malfunctioning NO, NO <sub>x</sub> or Auto Reference valve; O <sub>3</sub> air filter cartridge exhausted  |
| HVPS                   | Calibration off; PMT board circuit problems   |
| Rx Cell Temp           | Malfunctioning heater; relay board communication (I <sup>2</sup> C bus); relay burnt out  |
| Box Temp               | Environment out of temperature operating range; broken thermistor   |
| PMT Temp               | TEC cooling circuit broken; relay board communication (I <sup>2</sup> C bus); 12 V power supply   |
| IZS Temp (option)      | Malfunctioning heater; relay board communication (I <sup>2</sup> C bus); relay burnt out  |
| Moly Temp              | Malfunctioning heater; disconnected or broken thermocouple; relay board communication (I <sup>2</sup> C bus); relay burnt out; incorrect AC voltage configuration |
| Rx Cell Press          | Leak; malfunctioning valve; malfunctioning pump; clogged flow orifices  |
| Sample Pressure        | Leak; malfunctioning valve; malfunctioning pump; clogged flow orifices; sample inlet overpressure   |
| NO <sub>x</sub> Slope  | HVPS out of range; low-level (hardware) calibration needs adjustment; span gas concentration incorrect; leaks   |
| NO <sub>x</sub> Offset | Incorrect span gas concentration; low-level calibration off   |
| NO Slope               | HVPS out of range; low-level calibration off; span gas concentration incorrect; leaks   |
| NO Offset              | Incorrect span gas concentration; low-level calibration off   |

### 5.7.3. USING THE DIAGNOSTIC SIGNAL I/O FUNCTIONS

The signal I/O functions in the Utilities>Diagnostics menu allows access to the digital and analog I/O in the analyzer. Some of the digital signals can be controlled through the Setup menu. These signals, combined with a thorough understanding of the instrument's principles of operation (Section 6), are useful for troubleshooting in three ways:

- The technician can view the raw, unprocessed signal level of the analyzer's critical inputs and outputs.
- Many of the components and functions that are normally under algorithmic control of the CPU can be manually exercised.
- The technician can directly control the signal level Analog and Digital Output signals.

This allows the technician to observe systematically the effect of directly controlling these signals on the operation of the analyzer. Use the Utilities>Diagnostics menu to view the raw voltage of an input signal or the Setup menu to control the state of an output voltage or control signal.

### 5.7.4. USING THE ANALOG OUTPUT CHANNELS

Signals available for output over the analyzer's analog output channel (configured in the Setup>Analog Outputs menu; see Section 2.5.8) can also be used as diagnostic tools through the Utilities>Diagnostics menu. Some of the outputs and their descriptions and causes are presented in Table 5-5.



## N200, N200M, N200H

**Table 5-5. Analog Outputs as Diagnostic Tools**

| TEST CHANNEL                  | DESCRIPTION  | ZERO                   | FULL SCALE                | CAUSES OF EXTREMELY HIGH / LOW READINGS  |
|-------------------------------|--|------------------------|---------------------------|--|
| PMT                           | The output of the PMT detector converted to a 0 to 5 VDC scale.                                    | 0 mV                   | 5000 mV                   | Failed PMT<br>PMT Temperature too High/Low<br>Bad PMT PCA<br>Failed HVPS<br>Misadjusted HVPS drive Voltage<br>Light Leak in reaction cell  |
| O3 Flow                       | The flow rate of O <sub>3</sub> through the analyzer as measured by the O <sub>3</sub> flow sensor | 0 cm <sup>3</sup> /min | 1000 cm <sup>3</sup> /min | Check for Gas Flow problems in the O <sub>3</sub> gas lines.   |
| Sample Flow                   | The calculated flow rate for sample gas through the analyzer.                                      | 0 cm <sup>3</sup> /min | 1000 cm <sup>3</sup> /min | Check for Gas Flow problems in the sample gas lines.   |
| Sample Press                  | The pressure of the sample gas measured upstream of the Auto Reference Valve                       | 0 In-Hg-A              | 40 In-Hg-A                | Check for Gas Flow problems in the sample gas lines.   |
| Rx Cell Press                 | The pressure of gas inside the reaction cell of the sensor module                                  | 0 In-Hg-A              | 40 In-Hg-A                | Check for Gas Flow problems in all gas lines.  |
| Rx Cell Temp                  | The temperature of gas inside the reaction cell of the sensor module                               | 0 °C                   | 70 °C                     | Heater configured for wrong voltage type<br>Failed RCELL Temperature Sensor<br>Relay controlling the heater is not working<br>Failed Relay Board<br>I <sup>2</sup> C Bus                 |
| IZS Temp<br>(with IZS option) | The temperature of the permeation tube oven of the optional internal span gas generator.           | 0 °C                   | 70 °C                     | Heater configured for wrong voltage type<br>Failed permeation tube Temperature Sensor<br>Relay controlling the Heater is not working<br>Failed Relay Board                               |
| PMT Temp                      | The temperature inside PMT   | 0 °C                   | 50 °C                     | PMT fan not operating<br>Failed PMT Temperature Sensor<br>TEC not functioning<br>Failed PMT PCA  |
| Box Temp                      | The temperature inside the analyzer's chassis  | 0 °C                   | 70 °C                     | Box Temperature typically runs ~7°C warmer than ambient temperature<br>Poor/blocked ventilation to the analyzer<br>Stopped Exhaust-Fan<br>Ambient Temperature outside of specified range |

### 5.7.5. FAULT DIAGNOSIS WITH BOARD LEDs

The following illustrations show connectors and LEDs on boards that can indicate where issues may lie. Figure 5-14 shows the layout for the Mainboard, and Figure 5-15 and Figure 5-16 show the board layouts for the PMT Bench Module and the Ozone Brick Board, respectively.





# N200, N200M, N200H

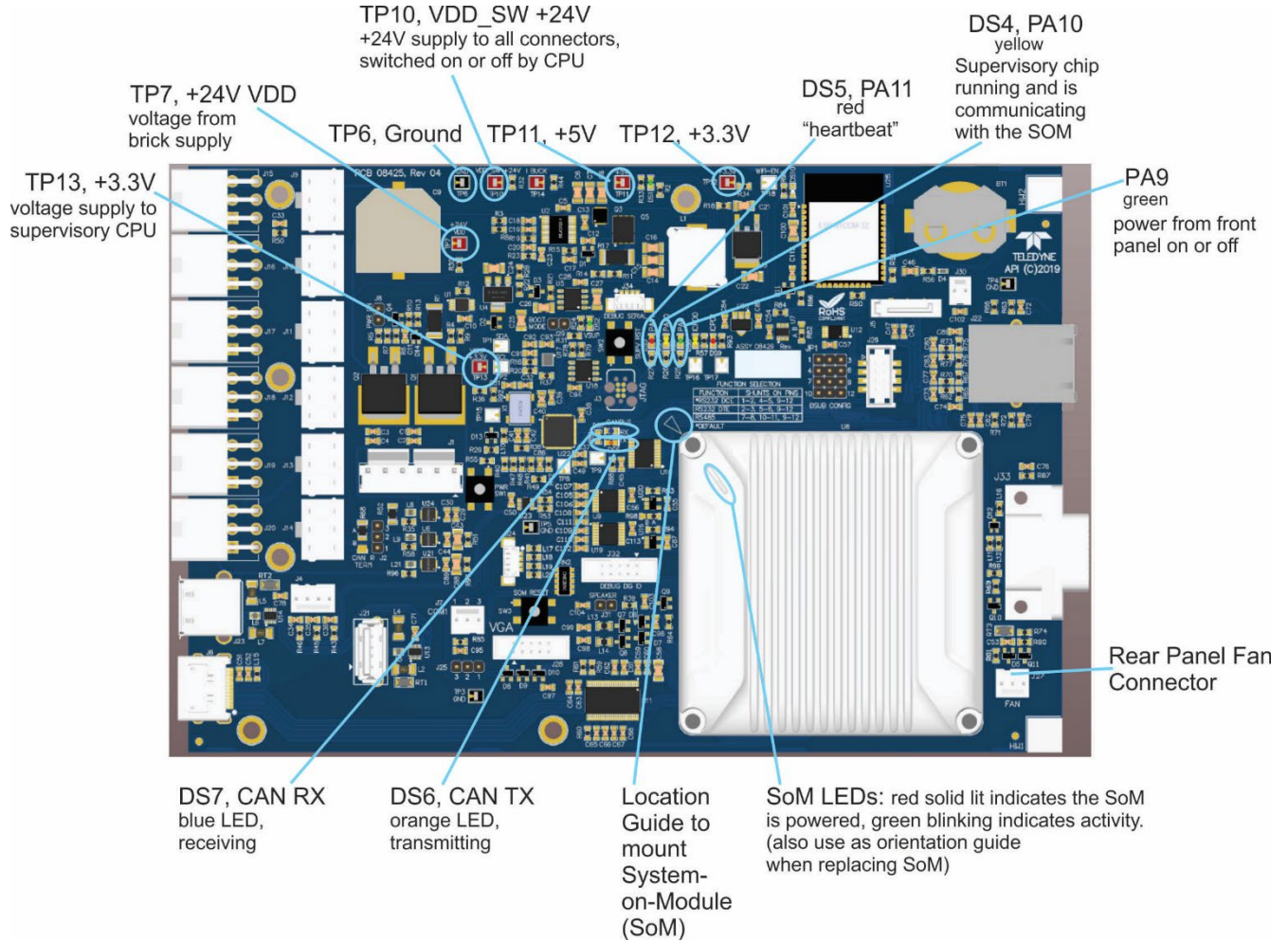


Figure 5-14. Mainboard

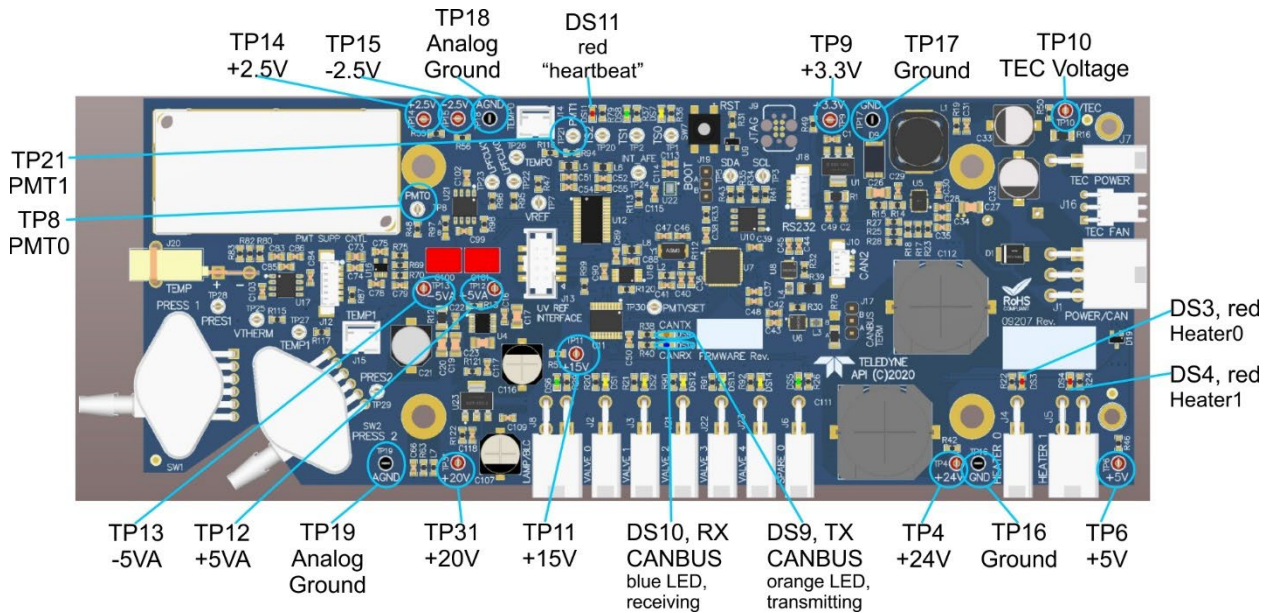
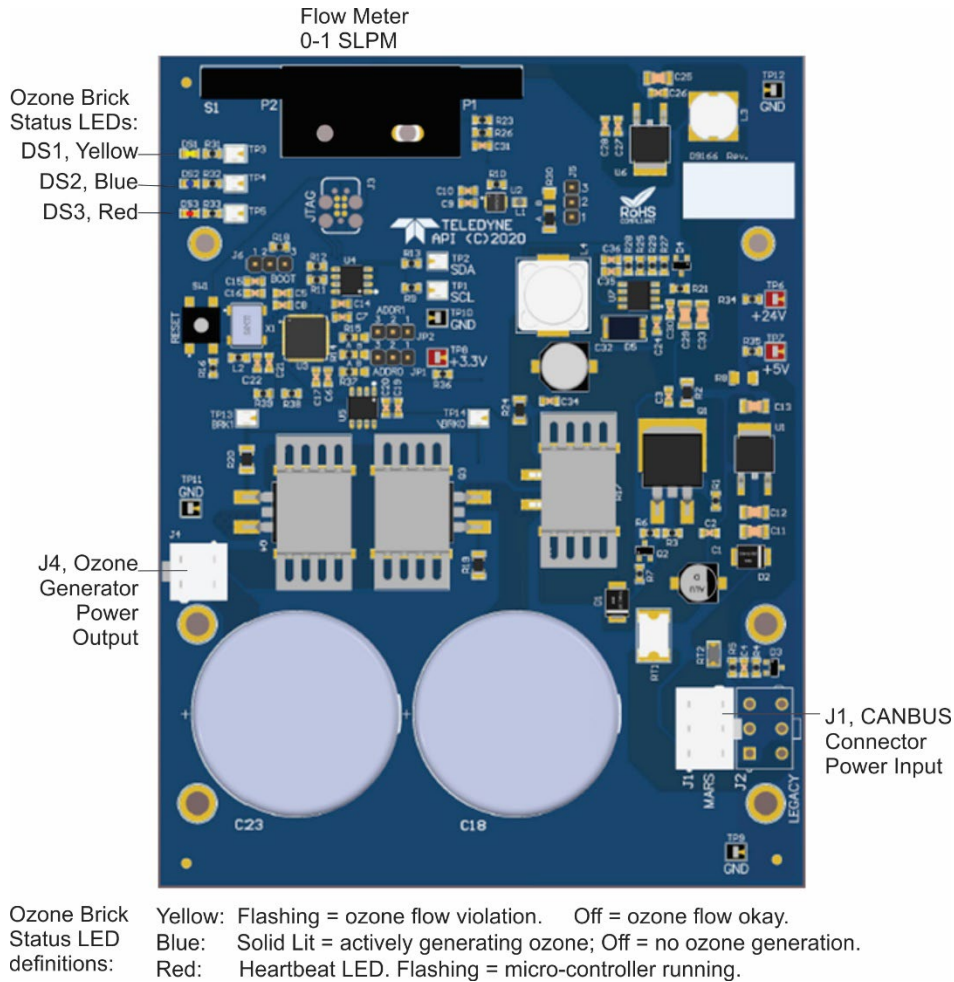


Figure 5-15. PMT Bench Module Board – Test Points and Indicator LEDs



## N200, N200M, N200H



**Figure 5-16. Ozone Brick Board**

### 5.7.6. FLOW PROBLEMS

The analyzer has two main flow paths, the sample flow and the flow of the ozone supply air. With IZS or zero/span valve option installed, there is a third (zero air) and a fourth (span gas) flow path, but either one of those is only controlled by critical flow orifices and not displayed on the front panel or stored to the DAS.

In the two main flow paths, flow problems occur in the following three ways:

- Flow is zero or low
- Flow is too high
- Flow is greater than zero, but is too low, and/or unstable

When troubleshooting flow problems, it is essential to confirm the actual flow rate without relying on the analyzer's flow display. The use of an independent, external flow meter to perform a flow check as described in Section 5.6.12.3 is essential. Refer to the pneumatic flow diagrams as needed for reference.



### 5.7.6.1. SAMPLE FLOW IS ZERO OR LOW

The analyzer does not actually measure the sample flow but rather calculates it from a differential pressure between sample and vacuum manifold. On flow failure, the unit will display a SAMPLE FLOW WARNING in the Active Alerts page and the respective function reports nothing instead of a numerical value. This message applies to both a flow rate of zero as well as a flow that is outside the standard range (350-600 cc/min).

If the analyzer displays nothing for the sample flow, confirm that the external sample pump is operating and configured for the proper AC voltage.

- Check to confirm the external pump power requirements match the correct external power. The pump can come in three different power regimes (100 V / 50 Hz, 115 V / 60 Hz and 230 V / 50 Hz).
- If the pump is not running, use an AC Voltmeter to ensure that the pump is supplied with the proper AC power. If AC power is supplied properly, but the pump is not running, replace the pump.

#### Note

**Sample and vacuum pressures mentioned in this chapter refer to operation of the analyzer at sea level. Pressure values need to be adjusted for elevated locations, as the ambient pressure decreases by about 1 in-Hg per 300 m / 1000 ft.**

If the pump is operating but the unit is not reporting gas flow value, take the following three steps:

1. Check for actual sample flow.
  - To check the actual sample flow, disconnect the sample tube from the sample inlet on the rear panel of the instrument.
  - Ensure that the unit is in basic SAMPLE mode.
  - Place a finger over the inlet and feel for suction by the vacuum or, more properly, use a flow meter to measure the actual flow.
  - If there is proper flow of around 450-550 cc/min, contact Technical Support.
  - If there is no flow or low flow, continue with the next step.
2. Check pressures.
  - Check that the sample pressure is at or around 28 in-Hg-A at sea level (adjust as necessary when in elevated location, the pressure should be about 1" below ambient atmospheric pressure) and that the Rx Cell pressure is below 10 in-Hg-A.
  - The analyzer will calculate a sample flow up to about 14 in-Hg-A RCEL pressure but a good pump should always provide less than 10 in-Hg-A.
  - If both pressures are the same and around atmospheric pressure, the pump does not operate properly or is not connected properly. The instrument does not get any vacuum.
  - If both pressures are about the same and low (probably under 10 in-Hg-A, or ~20" on sample and 15" on vacuum), there is a cross-leak between sample flow path and vacuum, most likely through the dryer flow paths. Check for leaks (Section 5.6.12).





## N200, N200M, N200H

- If the sample and vacuum pressures are around their nominal values (28 and <10 in-Hg-A, respectively) and the flow still displays no numerical value, carry out a leak check as described in Section 5.6.12.
  - If gas flows through the instrument during the above tests but goes to zero or is low when it is connected to zero air or span gas, the flow problem is not internal to the analyzer but likely caused by the gas source such as calibrators/generators, empty gas tanks, clogged valves, regulators and gas lines.
  - If an IZS or Zero/Span valve option is installed in the instrument, press Start in the Calibration>Zero and Span menus. If the sample flow increases, suspect a bad Sample/Cal valve.
3. If none of these suggestions help, carry out a detailed leak check of the analyzer as described in Section 5.6.12.2.

### 5.7.6.2. OZONE FLOW IS ZERO OR LOW

If there is zero or a low (<50 cc/min) ozone flow, the unit displays an OZONE FLOW WARNING message in the Alerts page and a value between 0.0 and 50 cc/min for the actual ozone flow as measured by the internal mass flow meter. In this case, carry out the following steps:

- Check the actual flow rate through the ozone dryer by using an external flow meter to the inlet port of the dryer.
  - This inlet port is inside the analyzer at the end of the plastic particle filter (Section 5.6.3 for illustration).
  - If there is nominal flow (about 160 cc/min from 80 cc/min O<sub>3</sub> flow and 80 cc/min purge flow), consult customer service as there is a problem with the firmware or electronics.
  - If the actual flow is low or zero, check if the pump operates properly. The RCEL pressure should be below 10 in-Hg-A at sea level.
  - If it is above 10 in-Hg-A, rebuild the pump (Section 5.6.5.1). Check the spare parts list in Appendix B on how to order pump rebuild kits.
- Check if the particle filter is clogged.
  - Briefly remove the particle filter to see if this improves the flow.
  - Be very cautious when handling the dryer fittings (see Section 5.6.3 on proper handling instructions).
  - If the filter is clogged, replace it with a new unit.
  - If taking off this filter does not solve the problem, continue to the next step.
  - Do not leave the dryer without filter for more than a few seconds, as you may draw in dust, which will reduce the performance of the dryer.
- A leak between the flow meter and the reaction cell (where the flow-determining critical orifice is located) may cause a low flow (the system draws in ambient air through a leak after the flow meter).
  - Check for leaks as described in Section 5.6.12.
  - Repair the leaking fitting, line or valve and re-check.



## N200, N200M, N200H

- The most likely cause for zero or low ozone flow is a clogged critical flow orifice or sintered filter within the orifice assembly.
  - The orifice that sets the ozone flow is located on the reaction cell.
  - Check the actual ozone flow by disconnecting the tube from the reaction cell and measuring the flow going into the cell.
    - If this flow is correct (~80 cc/min), the orifice works properly.
    - If this flow is low, replace the sintered filter.
  - The orifice holder assembly allows a quick and easy replacement of the filter (Section 5.6.10).

### 5.7.6.3. HIGH FLOW

Flow readings that are significantly higher than the allowed operating range (typically  $\pm 10$ - $11\%$  of the nominal flow) should not occur in the analyzer unless a pressurized sample, zero or span gas is supplied to the inlet ports.

- Ensure to vent excess pressure and flow just before the analyzer inlet ports.
- When supplying sample, zero or span gas at ambient pressure, a high flow could indicate a broken critical flow orifice (very unlikely case), allowing more than nominal flow, or were replaced with an orifice of wrong specifications.
- If the flows are within 15% above normal, we recommend measuring and recalibrating the flow electronically (Section 5.6.12.3), followed by a regular review of these flows over time to see if the new setting is retained properly.
- Also, check the flow assembly o-rings and replace as needed.

### 5.7.6.4. SAMPLE FLOW IS ZERO OR LOW BUT ANALYZER REPORTS CORRECT FLOW

The analyzer can report a correct flow rate even if there is no or a low actual sample flow through the reaction cell.

- The sample flow is only calculated from the sample pressure and critical flow condition is verified from the difference between sample pressure and vacuum pressure.
- If the critical flow orifice assembly is partially or completely clogged, both the sample and vacuum pressures are still within their nominal ranges (the pump keeps pumping, the sample port is open to the atmosphere), but there is no flow possible through the reaction cell.

Although measuring the actual flow is the best method, in most cases, this fault can also be diagnosed by evaluating the two pressure values.

- Since there is no longer any flow, the sample pressure should be equal to ambient pressure, which is about 1 in-Hg-A higher than the sample pressure under normal operation.
- The reaction cell pressure, on the other hand, is significantly lower than under normal operation, because the pump no longer has to remove 500 cc/min of sample gas and evacuates the reaction cell much better.
- Those two indicators, taken together with a zero or low actual flow, indicate a clogged sample orifice.

The analyzer features a new orifice holder, which makes switching sample and ozone flow orifices very easy; refer to Section 5.6.10 on how to change the sample orifices.



## N200, N200M, N200H

Again, monitoring the pressures and flows regularly will reveal such problems, because the pressures would slowly or suddenly change from their nominal, mean values. Teledyne API recommends reviewing all test data once per week and to do an exhaustive data analysis for test and concentration values once per month, paying particular attention to sudden or gradual changes in all parameters that are supposed to remain constant, such as the flow rates.

### 5.7.7. CALIBRATION PROBLEMS

This section describes possible causes of calibration problems.

#### 5.7.7.1. NEGATIVE CONCENTRATIONS

Negative concentration values can be caused for several reasons:

- A slight, negative signal is normal when the analyzer is operating under zero gas and the signal is drifting around the zero calibration point.
  - This is caused by the analyzer's zero noise and may cause reported concentrations to be negative for a few seconds at a time down to -20 ppb, but should randomly alternate with similarly high, positive values.
  - The analyzer has a built-in Auto Reference function, which should take care of most of these deviations from zero, but may yield a small, residual, negative value.
  - If larger, negative values persist continuously, check if the Auto Reference feature is functioning.
  - In this case, the sensitivity of the analyzer may be drifting negative.
- A corruption of the Auto Reference filter may also cause negative concentrations.
  - If a short, high noise value was detected during the Auto Reference cycle, that higher reading will alter the Auto Reference filter value.
  - As the value of the Auto Reference filter is subtracted from the current PMT response, it will produce a negative concentration reading.
  - High Auto Reference readings can be caused by:
    - a leaking or stuck Auto Reference valve (replace the valve),
    - an electronic fault in the PMT PCA causing it to have a voltage on the PMT output pin during the Auto Reference cycle,
    - a reaction cell contamination causing high background (>40 mV) PMT readings (clean the reaction cell),
    - a broken PMT temperature control circuit, allowing high zero offset (repair the faulty PMT cooler). After fixing the cause of a high Auto Reference filter reading, allow 15 minutes for the filter to clear itself, or
    - an exhausted chemical in the ozone cleanser (see Section 5.6.4).
  - Calibration error is the most likely explanation for negative concentration values.
- If the zero air contained some NO or NO<sub>2</sub> gas (contaminated zero air or a worn-out zero air scrubber) and the analyzer was calibrated to that concentration as "zero", the analyzer may report negative values when measuring air that contains little or no NO<sub>x</sub>.
- The same problem occurs, if the analyzer was zero-calibrated using zero gas that is contaminated with ambient air or span gas (cross-port leaks or leaks in supply tubing or user not waiting long enough to flush pneumatic systems).



## N200, N200M, N200H

- If the response offset test functions for NO (NO OFFS) or NO<sub>x</sub> (NOX OFFS) are greater than 150 mV, a reaction cell contamination is indicated.
- Clean the reaction cell as described in Section 5.6.9.

### 5.7.7.2. ABSENCE OF ANALYZER RESPONSE TO SAMPLE GAS

If the instrument shows no response (display value is near zero) even though sample gas is supplied properly and the instrument seems to perform correctly:

1. Carry out an optical test, located in the Utilities>Diagnostics>Digital Outputs menu. See Optic Test (OTest) in Section 5.7.9.5.
  - If this test results in a concentration signal, then the PMT sensor and the electronic signal path are operating properly.
  - If the analyzer passes the OTest, it is capable of detecting light and processing the signal to produce a reading.
  - Therefore, the problem must be in the pneumatics or the ozone generator.
2. Check if the ozone generator is turned on.
  - Usually, the analyzer issues a warning whenever the ozone generator is turned off.
  - Go to Utilities>Diagnostics>O3 Gen Override and see if it shows ON.
    - If it shows OFF, turn it ON and check the O3 Flow reading in the Dashboard menu.
    - If this is done and the ozone flow is correct, the analyzer should be properly supplied with ozone unless the generator itself is broken.
3. Confirm the lack of response by supplying NO or NO<sub>2</sub> span gas of about 80% of the range value to the analyzer.
4. Check the sample flow and ozone flow rates for proper values.
5. Check for disconnected cables to the sensor module.
6. If the NO<sub>2</sub> signal is zero while NO signal is correct, check the NO/NO<sub>x</sub> valve and the NO<sub>2</sub> converter for proper operation.

### 5.7.7.3. UNSTABLE ZERO AND SPAN

Leaks in the external gas supply and vacuum systems are the most common source of unstable and non-repeatable concentration readings.

1. Check for leaks in the pneumatic systems as described in Section 5.6.12.
2. Consider pneumatic components in the gas delivery system outside the analyzer such as a change in zero air source (ambient air leaking into zero air line or a worn-out zero air scrubber) or a change in the span gas concentration due to zero air or ambient air leaking into the span gas line.
3. Once the instrument passes a leak check, do a flow check (this chapter) to ensure that the instrument is supplied with adequate sample and ozone air.
4. Confirm the sample pressure, sample temperature, and sample flow readings are correct and steady.
5. Verify that the sample filter element is clean and does not need to be replaced.



### 5.7.7.4. INABILITY TO SPAN - DEACTIVATED SPAN BUTTON

In general, the analyzer will deactivate certain buttons whenever the actual value of a parameter is outside of the expected range for that parameter. If the Span is grayed out, the actual concentration must be outside of the range of the expected span gas concentration, which can have several causes.

1. Verify that the expected concentration is set properly to the actual span gas concentration in the CONC sub-menu.
2. Confirm that the NO<sub>x</sub> span gas source is accurate.
  - This can be done by comparing the source with another calibrated analyzer, or by having the NO<sub>x</sub> source verified by an independent traceable photometer.
3. Check for leaks in the pneumatic systems as described in Section 5.6.12.
  - Leaks can dilute the span gas and, hence, the concentration that the analyzer measures may fall short of the expected concentration defined in the CONC sub-menu.
4. If the low-level, hardware calibration has drifted (changed PMT response) or was accidentally altered by the user, a low-level calibration may be necessary to get the analyzer back into its proper range of expected values.
  - One possible indicator of this scenario is a slope or offset value that is outside of its allowed range (0.7-1.3 for slope, -20 to 150 for offsets). See Section 5.7.10.3 on how to carry out a low-level hardware calibration.

### 5.7.7.5. INABILITY TO ZERO - DEACTIVATED ZERO BUTTON

In general, the analyzer will deactivate certain buttons whenever the actual value of a parameter is outside of the expected range for that parameter. If the Zero button is grayed out, the actual gas concentration must be significantly different from the actual zero point (as per last calibration), which may be for any of several reasons.

1. Confirm that there is a good source of zero air. If the IZS option is installed, compare the zero reading from the IZS zero air source to a zero air source using NO<sub>x</sub>-free air. Check any zero air scrubber for performance. It may need to be replaced (Section 5.6.5.2).
2. Check to ensure that there is no ambient air leaking into zero air line. Check for leaks in the pneumatic systems as described in Section 5.6.12.

### 5.7.7.6. NON-LINEAR RESPONSE

The analyzer 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 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 Section 5.6.12.
- The calibration device is in error:



## N200, N200M, N200H

- 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 dryer for leaks.
  - This mostly affects linearity at the low end.
- Ozone stream may be contaminated with impurities.
  - An exhausted ozone cleanser 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 cleanser and replace as necessary (Section 5.6.4).
  - 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.
  - Ensure to create and properly vent excess span gas.
- Diffusion of oxygen into Teflon-type tubing 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 (> 1 m) between high concentration span gases and the dilution system, oxygen from ambient air can diffuse into the line and react with NO to form NO<sub>2</sub>.
    - This reaction is dependent on NO concentration and accelerates with increasing NO concentration, hence, affects linearity only at high NO levels.
    - Using stainless steel for long span gas supply lines avoids this problem.

### 5.7.7.7. DISCREPANCY BETWEEN ANALOG OUTPUT AND DISPLAY

If the concentration reported through the analog outputs does not agree with the value reported on the front panel, you may need to recalibrate the analog outputs.

- This becomes more likely when using a low concentration or low analog output range.
- See Section 2.5.8.1 for a detailed description of this procedure.



### 5.7.7.8. DISCREPANCY BETWEEN NO AND NO<sub>x</sub> SLOPES

If the slopes for NO and NO<sub>x</sub> are significantly different after software calibration (more than 1%), consider the following three problems:

- NO<sub>2</sub> impurities in the NO calibration gas. NO gases often exhibit NO<sub>2</sub> on the order of 1-2% of the NO value.
  - This will cause differences in the calibration slopes. If the NO<sub>2</sub> impurity in NO is known, it can easily be accounted for by setting the expected values for NO and NO<sub>2</sub> accordingly to different values, e.g., 448 ppb NO and 450 ppb NO<sub>x</sub>.
  - This problem is worse if NO gas is stored in a cylinder with balance air instead of balance gas nitrogen or large amounts of nitrous oxide (N<sub>2</sub>O), because the oxygen in the air slowly reacts with NO to yield NO<sub>2</sub>, increasing over time.
- The expected concentrations for NO and NO<sub>x</sub> in the calibration menu are set to different values.
  - If a gas with 100% pure NO is used, this would cause a bias.
  - See Section 4.2 on how to set expected concentration values.

An instrument calibration with the IZS option (and expected concentrations set to the same amount) will always yield identical slopes for NO and NO<sub>x</sub>, as the instrument measures only NO<sub>x</sub> and assumes NO to be the same (with NO<sub>2</sub> being zero).

### 5.7.8. OTHER PERFORMANCE PROBLEMS

Dynamic problems (i.e., problems that only manifest themselves when the analyzer is monitoring sample gas) can be the most difficult and time consuming to isolate and resolve. The following section provides an itemized list of the most common dynamic problems with recommended troubleshooting checks and corrective actions.

#### 5.7.8.1. EXCESSIVE NOISE

Excessive noise levels under normal operation usually indicate leaks in the sample supply or the analyzer itself.

- Ensure that the sample or span gas supply is leak-free and carry out a detailed leak check as described earlier in this chapter.

Another possibility of excessive signal noise may be the PMT board, the high voltage power supply and/or the PMT detector itself.

- Contact the factory on troubleshooting these components.

#### 5.7.8.2. SLOW RESPONSE

If the analyzer starts responding too slow to any changes in sample, zero or span gas, check for the following:

- Dirty or plugged sample filter or sample lines.
- Sample inlet line is too long.
- Leaking NO/NO<sub>x</sub> valve. Carry out a leak check.
- Dirty or plugged critical flow orifices. Check flows, pressures and, if necessary, change orifices (Section 5.6.10).





## N200, N200M, N200H

- Wrong materials in contact with sample - use glass, stainless steel or Teflon materials only. Porous materials, in particular, will cause memory effects and slow changes in response.
- Dirty reaction cell. Clean the reaction cell.
- Insufficient time allowed for purging of lines upstream of the analyzer. Wait until stability is low.
- Insufficient time allowed for NO or NO<sub>2</sub> calibration gas source to become stable. Wait until stability is low.
- Moly temperature is too low. Check for proper temperature.

### 5.7.8.3. AUTO REFERENCE ALERTS

Auto Reference Alerts occur if the signal measured during an Auto Reference cycle is higher than 200 mV.

#### Note

**The Auto-Reference Alert displays the value of the Auto Reference reading that occurred at the time of the Alert.**

- If this value is higher than 150 mV, check that the Auto Reference valve is operating properly.
  - To do so, use the Utilities>Diagnostics>Digital Outputs menu to toggle the valve on and off.
  - Listen if the valve is switching, see if the respective LED on the relay board is indicating functionality.
- Alternatively, navigate to the Dashboard and observe the PMT value change between the two valve states.
  - If the valve is operating properly, you should be able to hear it switch (once a minute under normal operation or when manually activated from the Utilities>Diagnostics>Digital Outputs menu):
    - the PMT value should drop from span gas reading (e.g., 800-900 mV at 400 ppb NO) to less than 150 mV and;
    - the LED on the relay board should light up when the valve is activated.
  - If the PMT value drops significantly but not to less than 150 mV, the valve is probably leaking across its ports.
    - In this case, replace the valve.
- If the PMT value does not change at all, the valve is probably not switching at all.
  - Check the power supply to the valve (12 V to the valve should turn on and off when measured with a voltmeter).

#### Note

**It takes only a small leak across the ports of the valve to show excessive Auto Reference values when supplying high concentrations of span gas.**





## N200, N200M, N200H

Another reason for high (although not necessarily out-of-range) values for Auto Reference could be the ozone air filter cartridge, if its contents have been exhausted and must be replaced.

- This filter cartridge chemicals that can cause chemiluminescence and, if saturated, these chemicals can break through to the reaction cell, causing an erroneously high Auto Reference value (background noise).

A dirty reaction cell can cause high Auto Reference values.

- Clean the reaction cell according to Section 5.6.9.

Finally, a high HVPS voltage value may cause excess background noise and a high Auto Reference value.

- The HVPS value changes from analyzer to analyzer and could show nominal values between 450 and 800 V.
- Check the low-level hardware calibration of the PMT board and, if necessary, recalibrate exactly as described in Section 5.7.10.3 in order to minimize the HVPS.

### 5.7.9. SUBSYSTEM CHECK FOR TROUBLESHOOTING

The preceding sections of this manual discussed a variety of methods for identifying possible sources of failures or performance problems within the analyzer. In most cases this included a list of possible causes and, in some cases, quick solutions or at least a pointer to the appropriate sections describing them. This section describes how to determine if a certain component or subsystem is actually the cause of the problem being investigated.

#### 5.7.9.1. AC MAIN POWER



#### **WARNING – ELECTRICAL SHOCK HAZARD**

**Should the AC power circuit breaker trip, investigate and correct the condition causing this situation before turning the analyzer back on.**



## N200, N200M, N200H

The instrument's electronic systems will operate with any of the specified power within the 100 VAC to 240 VAC, at 47 Hz to 63 Hz. Using the properly rated power cord, it will power on when the rear panel Hard Power switch is placed in the ON position. (If the power source is disrupted, the instrument will turn on once the power is restored). If the instrument doesn't start, check the following possible causes and possible solutions:

- Check the power cord for damage, such as whether it's cut or burned.
- Check that the power cord is adequately rated for the instrument's specified power rating.
- Check that the power source is of the proper voltage for the instrument's specified power rating.
- If there are no findings in the preceding steps, then note whether the instrument had been opened for maintenance; if so, place the rear panel Hard Power switch in the OFF position, and disconnect the power cord; then reopen the instrument and check that no wiring had been dislodged, and no tools were left inside.
- If no other reason can be found for the instrument not powering on, then check the fuse with an ohmmeter to determine its viability: carefully follow the instructions in Section 5.7.10.5 to remove the fuse for testing.
  - If the fuse is blown, replace it with a fuse of the correct specifications as instructed in Section 5.7.10.5.
  - If the fuse is not blown, or if the replacement fuse blows, then call Technical Support (Section 5.9).

### 5.7.9.2. LCD/DISPLAY MODULE

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 process.

### 5.7.9.3. RS-232 COMMUNICATIONS

Teledyne API's analyzers use the RS-232 communications protocol to allow the instrument to be connected to a variety of computer-based equipment. Problems with RS-232 connections usually center around such things as incorrect connector configuration, incorrect software settings, improper/incomplete seating of the internal cable. Do not do anything inside the instrument without first contacting Technical Support (Section 5.9). For additional information, see Section 2.3.1.4 under "Serial Connection."

### 5.7.9.4. NO<sub>2</sub> > NO CONVERTER

Provided that oxygen was present in the Sample stream during operation for the NO<sub>2</sub> converter to function properly, the NO<sub>2</sub> converter assembly can fail in two ways:

- An electrical failure of the band heater and/or the thermocouple control circuit and;
- A performance failure of the converter itself.



## N200, N200M, N200H

### NO<sub>2</sub> > NO CONVERTER ELECTRICAL FAILURE

NO<sub>2</sub> converter heater failures can be divided into two possible categories:

- Temperature is reported properly but heater does not heat to full temperature.
  - In this case, the heater is either disconnected or broken or the power relay is broken.
    - Disconnect the heater cable coming from the PMT PCA and measure the resistance between the two heater leads with a multi-meter.
    - The resistance should be about 11.5 Ω.
    - If the resistance is near zero or there is no continuity, the heater is broken.
- Temperature reports zero or overload (near 500° C).
  - This indicates a disconnected or failing thermocouple or a failure of the thermocouple circuit.
    - Check that the thermocouple is connected properly and the wire does not show signs of a broken or kinked pathway.
    - If it appears to be properly connected, disconnect the yellow thermocouple plug (marked K) from the relay board and measure the voltage (not resistance) between the two leads with a multi-meter capable of measuring in the low mV range.
    - The voltage should be about 12 mV (ignore the sign) at 315° C and about 0 mV at room temperature.
  - Measure the continuity with an Ohm-meter.
    - It should read close to zero Ω. If the thermo-couple does not have continuity, it is broken.
    - If it reads zero voltage at elevated temperatures, it is broken.
  - To test the thermocouple at room temperature, heat up the converter can (e.g., with a heat gun) and see if the voltage across the thermocouple leads changes.
    - If the thermocouple is working properly, the electronic circuit is broken.

#### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

**If the thermocouple is broken, do NOT replace the thermocouple without first consulting the factory; using the wrong Type could cause permanent damage to the instrument. The Type K thermocouple has a red and a yellow wire. If in doubt, consult the factory.**

### NO<sub>2</sub> > NO CONVERTER EFFICIENCY ISSUE

The efficiency at which the NO<sub>2</sub> → NO converter changes NO<sub>2</sub> into NO directly affects the accuracy of the NO<sub>x</sub>, NO and NO<sub>2</sub> measurements. The analyzer's firmware includes a Converter Efficiency (CE) gain factor that is multiplied by the NO<sub>2</sub> and NO<sub>x</sub> measurements to calculate the final concentrations for each. This gain factor is stored in the analyzer's memory.



## N200, N200M, N200H

The default setting for the NO<sub>2</sub> converter efficiency is 1.0000. Over time, the molybdenum in the NO<sub>2</sub> → NO converter oxidizes and it becomes less efficient at converting NO<sub>2</sub> into NO.

To ensure accurate operation of the analyzer, it is important to check the NO<sub>2</sub> conversion efficiency (CE) periodically. See Section 4.5 for checking and calculating the CE.

- For the analyzer to function correctly, the converter efficiency must be greater than 0.9600 (96% conversion efficiency) as per US-EPA requirements.
- If the converter's efficiency is below this limit, the NO<sub>2</sub> converter should be replaced.
- The current converter efficiency level is also recorded along with the calibration data in the DAS for documentation and performance analysis (Section 2.5.1).

### 5.7.9.5. PHOTOMULTIPLIER TUBE (PMT) SENSOR MODULE

The PMT detects the light emitted by the reaction of NO with ozone. It has a gain of about 500,000 to 1,000,000. It is not possible to test the detector outside of the instrument in the field. The basic method to diagnose a PMT fault is to eliminate the other components using the Optic Test and specific tests for other sub-assemblies.

#### OPTIC TEST (OTEST)

The optic test function tests the response of the PMT sensor by turning on an LED located in the cooling block of the PMT (see Figure 5-18). The analyzer uses the light emitted from the LED to test its photo-electronic subsystem, including the PMT and the current to voltage converter on the pre-amplifier board.

- To ensure that the analyzer measures only the light coming from the LED, the analyzer should be supplied with zero air.
- The Optic Test should produce a PMT response.

Activate the optics test under the Utilities>Diagnostics>Digital Outputs menu.

#### Note

**This is a coarse test for functionality and not an accurate calibration tool. The resulting PMT signal can vary significantly over time and also changes with low-level calibration.**

### 5.7.9.6. HIGH VOLTAGE POWER SUPPLY (HVPS)

The HVPS is located in the interior of the sensor module and is plugged into the PMT tube. It requires two voltage inputs.

- The first is +15 V, which powers the supply.
- The second is the programming voltage which is generated on the PMT board.
- Adjustment of the HVPS is covered in the factory calibration procedure in Section 5.7.10.3.

This power supply has 10 independent power supply steps, one to each pin of the PMT. The following test procedure below allows you to test each step.

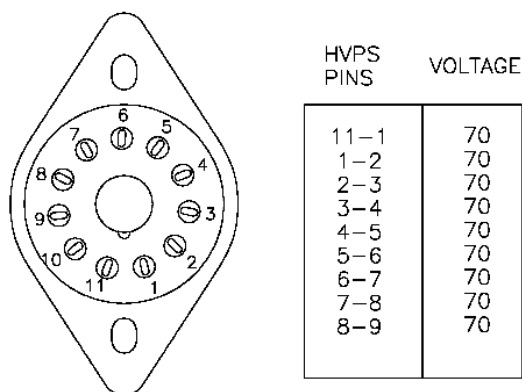
1. Turn off the instrument.



## N200, N200M, N200H

2. Remove the cover and disconnect the two connectors at the front of the NO<sub>x</sub> sensor module.
3. Remove the end cap from the sensor (four screws).
4. Remove the HVPS/PMT assembly from the cold block inside the sensor (two plastic screws).
5. Disconnect the PMT from the HVPS.
6. Re-connect the 7-pin connector to the sensor end cap, and power-up the instrument.
7. Navigate to the HVPS parameter in the Dashboard (if not shown, configure the Dashboard to display HVPS, Section 2.5.3).
8. Divide the displayed HVPS voltage by 10 and test the pairs of connector points as shown in the example below.
9. Check the overall voltage (should be equal to the HVPS value displayed in the Dashboard and the voltages between each pair of pins of the supply).

EXAMPLE: if the HVPS signal is 700 V the pin-to-pin voltages should be 70 V.



10. Turn off the instrument power, and reconnect the PMT, and then reassemble the sensor.
  - If any faults are found in the test, you must obtain a new HVPS as there are no user serviceable parts inside the supply.

### 5.7.9.7. O<sub>3</sub> GENERATOR

The ozone generator can fail in two ways, electronically (printed circuit board) and functionally (internal generator components). Assuming that air is supplied properly to the generator, the generator should automatically turn on 30 minutes after the instrument is powered up or if the instrument is still warm. See Section 6.2.3 for ozone generator functionality. Accurate performance of the generator can only be determined with an ozone analyzer connected to the outlet of the generator. However, if the generator appears to be working properly but the sensitivity or calibration of the instrument is reduced, suspect a leak in the ozone generator supply air.

A leak in the dryer or between the dryer and the generator can reduce sensitivity and cause performance drift. Carry out a leak check (Section 5.6.12).



### O<sub>3</sub> GENERATOR OVERRIDE

This feature in the Utilities>Diagnostics menu is used to manually turn the ozone generator off and on. This should be done before disconnecting the generator, to prevent ozone from leaking out, or after a system restart if the user does not want to wait for 30 minutes during warm-up time.

#### Note

**The ozone generator does not turn on if the ozone flow conditions are out of specification, e.g., if there is no flow through the system or the pump is broken.**

### 5.7.9.8. INTERNAL SPAN GAS GENERATOR AND VALVE OPTIONS

The zero/span valves and internal span gas generator options need to be enabled in the software (contact the factory on how to do this).

The semi-permeable PTFE membrane of the permeation tube is severely affected by humidity. Variations in humidity between day and night are usually enough to yield very variable output results. If the instrument is installed in an air-conditioned shelter, the air is usually dry enough to produce good results. If the instrument is installed in an environment with variable or high humidity, variations in the permeation tube output will be significant. In this case, a dryer for the supply air is recommended (dewpoint should be  $-20^{\circ}\text{C}$  or less).

The permeation tube of the internal span gas generator option is heated with a proportional heater circuit and the temperature is maintained at  $50^{\circ}\text{C} \pm 1^{\circ}\text{C}$ . Check the IZS Temp in the Dashboard or the IZS Temp Raw signal in the Utilities>Diagnostics>Analog Inputs menu. At  $50^{\circ}\text{C}$ , the temperature signal from the IZS thermistor should be around 2500 mV.

### 5.7.9.9. TEMPERATURE SENSORS

#### BOX TEMPERATURE SENSOR

The box temperature sensor is located on the mainboard and its reading can be viewed on the Dashboard (configure at Setup>Dashboard if needed). The temperature reading is typically higher than ambient temperature by about 5 degrees Celsius, and is useful for monitor absolute changes in ambient temperature.

#### PMT TEMPERATURE SENSOR CONTROL

The temperature of the PMT should be low and constant. It is more important that this temperature is maintained at a constant level than it is to be a specific temperature.

The PMT cooler uses a Peltier, thermo-electric cooler element to cool the PMT cold block. The temperature is controlled by the PMT Sensor module PCA.

- The programmed temperature set point may vary by  $\pm 2^{\circ}\text{C}$ .
- The actual temperature will be maintained to within  $0.1^{\circ}\text{C}$ .

### 5.7.10. SERVICE PROCEDURES

This section contains some procedures that may need to be performed when a major component of the analyzer requires repair or replacement.



## N200, N200M, N200H

### Note

Regular maintenance procedures are discussed in Section 5.5 and are not listed here). Also, there may be more detailed service notes for some of the below procedures. Contact Teledyne API's Technical Support Department.



### WARNING – ELECTRICAL SHOCK HAZARD

Unless the procedure being performed requires the instrument to be operating, turn it off and disconnect power before opening the analyzer and removing, adjusting or repairing any of its components or subsystems.



### CAUTION – QUALIFIED TECHNICIAN

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

#### 5.7.10.1. O<sub>3</sub> GENERATOR REPLACEMENT

The ozone generator is a black, brick-shaped device with a printed circuit board attached to its rear and two tubes extending out the right side in the front of the analyzer (see Figure 2-3). The board has a red LED that, when lit, indicates ozone is being generated. To replace the ozone generator:

1. Turn off the analyzer power; remove the power cord and the analyzer cover.
2. Disconnect the 1/8" black tube from the ozone cleanser and the 1/4" clear tube from the plastic extension tube at the brass fitting nearest to the ozone generator.
3. Unplug the electrical connection on the rear side of the brick.
4. Unscrew the two mounting screws that attach the ozone generator to the chassis and take out the entire assembly.
5. If you received a complete replacement generator with circuit board and mounting bracket attached, simply reverse the above steps to replace the current generator.

### Note

Ensure to carry out a leak check (Section 5.6.12) and a recalibration after the analyzer has warmed up for about 60 minutes.

#### 5.7.10.2. SAMPLE AND OZONE DRYER REPLACEMENT

The analyzer's standard configuration is equipped with a dryer for the ozone supply air. An optional dryer is available for the sample stream, and a combined dryer for both gas streams can also be purchased. To change one or both of these dryers:

1. Turn off power to the analyzer and pump, and remove the power cord and the analyzer cover.



## N200, N200M, N200H

2. Locate the dryer(s), and *gently* disconnect all tubing that extends out of the dryer assembly.

### Note

**Do not twist any of the white plastic fittings on the dryer: they connect the inner drying tube to the outer purge tube and are delicate. See Section 5.6.3.**

3. Make note of the dryer's orientation on the bracket in order to correctly position the replacement dryer.
4. Cut the tie wraps that hold the dryer to the mounting bracket and take out the old dryer.
  - If necessary, unscrew the two mounting screws on the bracket and take out the entire assembly.
5. Attach the replacement dryer to the mounting bracket in the same orientation as the old dryer.
6. Fix the dryer to the bracket using new tie wraps.
7. Cut off excess length of the wraps.
8. Put the assembly back into the chassis and tighten the mounting screws.
9. Use at least two wrenches to carefully re-attach the tubes to vacuum manifold, flow meter and/or NO/NO<sub>x</sub> valve using at least two wrenches.

### Note

**Avoid twisting the dryer's white plastic fittings, as this will result in large leaks, which are difficult to trouble-shoot or fix.**

10. Carry out a detailed leak check (see Section 5.6.12.2),
11. Close the analyzer and reconnect the power cord.
12. Power up pump and analyzer and re-calibrate the instrument after it stabilizes.

### 5.7.10.3. PMT SENSOR HARDWARE ADJUSTMENT

The sensor module HVPS adjustment feature changes the gain of the PMT output. This is performed when the instrument's slope and offset values are outside the acceptable values and all other more obvious causes have been eliminated.

To adjust the PMT gain:

1. Deliver a known concentration of Span Gas, preferably at 90% of the desired range, e.g., 450ppb in a 500ppb range.
2. Also in the Setup>Vars menu, if needed, use the HVPS SetPoint Var to edit the setpoint value if the concentration is grossly off.
3. Return to Homescreen and navigate to Utilities>Diagnostics>HVPS Adjust (Figure 5-17).





## N200, N200M, N200H

4. In the lower left field of the HVPS screen click the slider button to change Maintenance Mode to ON. (The Up and Down adjustment buttons become active and an Alert indicates that the instrument is in this mode).
5. Use the Up/Down buttons to make adjustments, allowing time for values to respond and for the concentration to stabilize. (Typically, the value for the PMT Reading should be about 10% higher than the target concentration value; for example, a target concentration for NO is 500 ppb, then the PMT Reading should be about 550 mV).
6. Before exiting, click the slider button to turn OFF Maintenance Mode.
7. Allow time to stabilize.
8. Perform a calibration if necessary.

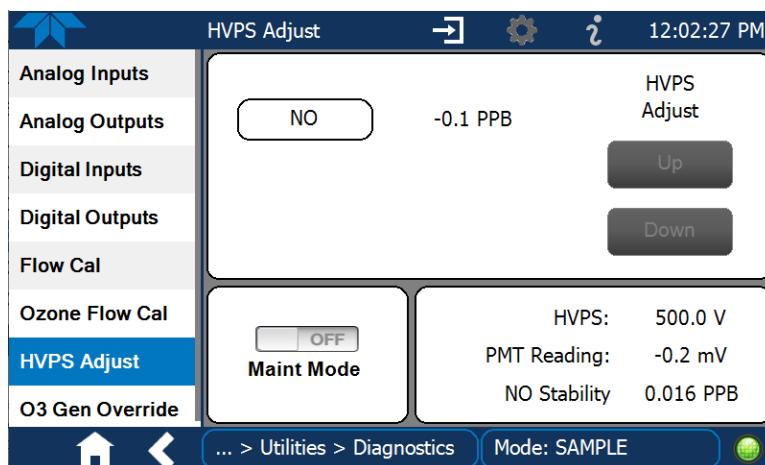


Figure 5-17. HVPS Adjust Menu

### 5.7.10.4. REPLACING THE PMT, HVPS OR TEC

Replacing any of these components requires opening the sensor module. This is a delicate assembly and it is recommended that you ensure the PMT, HVPS or TEC modules are, indeed, faulty before unnecessarily opening of the module.

#### CAUTION – QUALIFIED PERSONNEL



Power off the analyzer, open its top cover to remove the entire sensor assembly and carry out the procedures at an anti-ESD workstation.

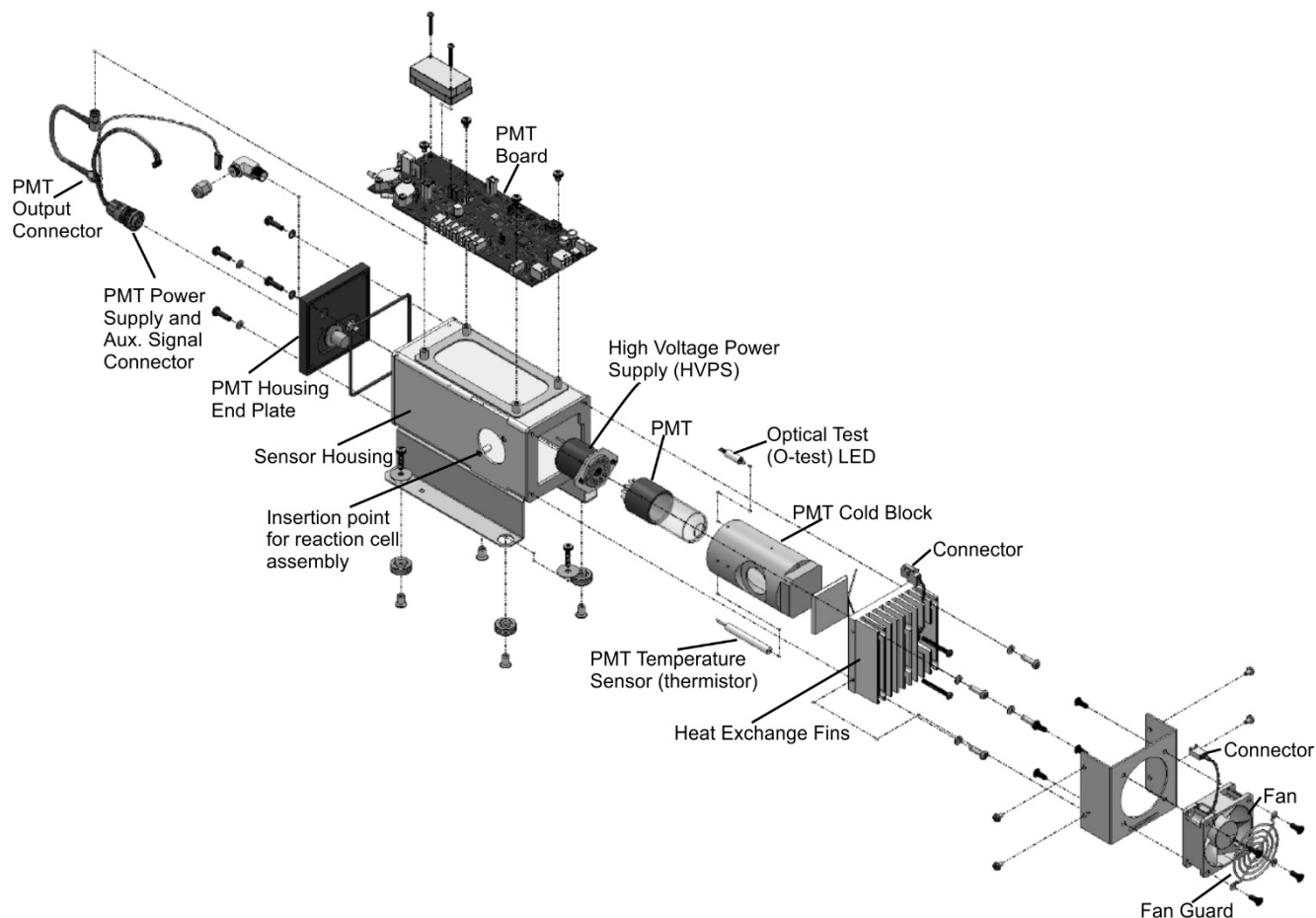
Follow the guidelines for preventing electrostatic damage to electronic components, defined in the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at <http://www.teledyne-api.com> under Help Center >Product Manuals in the Special Manuals section..

1. Turn OFF the analyzer and disconnect the power cord.
2. Remove the cover.
3. Disconnect all pneumatic and electrical connections from the sensor assembly.



## N200, N200M, N200H

4. Remove the sensor assembly.
5. If the TEC is to be replaced, remove the reaction cell assembly at this point by unscrewing two holding screws.
  - This is necessary only if the repair being performed involves removing the PMT cold block.



**Figure 5-18. Sensor Assembly**

6. Remove the two connectors on the PMT housing end plate facing towards the front panel.
7. Remove the end plate itself (4 screws with plastic washers).

**Note**

**Any time the black PMT housing end plate for the Sensor Assembly is removed, replace the five desiccant bags inside the housing.**

8. Remove the desiccant bags from the PMT housing.
9. Unscrew the PMT assembly, which is held to the cold block by two plastic screws.
10. Discard the plastic screws and replace with new screws at the end of this procedure (the threads get stripped easily and it is recommended to use new screws).



## N200, N200M, N200H

11. Along with the plate, slide out the optic test (O-Test) LED and the thermistor that measures the PMT temperature.
  - Thermistor will be coated with a white, thermal conducting paste.
  - Do not contaminate the inside of the housing with this grease, as it may contaminate the PMT glass tube on re-assembly.
12. Carefully take out the assembly consisting of the HVPS, the insulation gasket and the PMT.
13. Change the PMT or the HVPS or both, clean the PMT glass tube with a clean, anti-static wipe and do not touch it after cleaning.
14. If the cold block or TEC is to be changed:
  - Disconnect the TEC connector from the PMT PCA, remove the cooler fan duct (4 screws on its side) including the driver board.
15. Remove the end plate with the cooling fins (4 screws) and slide out the PMT cold block assembly, which contains the TEC.
16. Unscrew the TEC from the cooling fins and the cold block and replace it with a new unit.
17. Reassemble this TEC subassembly in reverse order.
  - Ensure to use thermal grease between TEC and cooling fins as well as between TEC and cold block and that the side opening in the cold block will face the reaction cell when assembled.
  - Evenly tighten the long mounting screws to maintain good thermal conductivity.

### CAUTION – QUALIFIED PERSONNEL



**The thermo-electric cooler needs to be mounted flat to the heat sink.**

**If there is any significant gap, the TEC might burn out. Ensure to apply heat sink paste before mounting it and tighten the screws evenly and cross-wise.**

18. Reinsert the TEC subassembly in reverse order.
  - Ensure that the O-ring is seated properly and the assembly is tightened evenly.
19. Insert the O-Test LED and thermistor into the cold block, insert new desiccant bags and carefully replace the end plate by making sure that the O-ring is properly in place.
  - Improperly placed O-rings will cause leaks, which – in turn – cause moisture to condense on the inside of the cooler and likely cause a short in the HVPS.
20. Reinsert the PMT/HVPS subassembly in reverse order.
  - Don't forget the insulation gasket between HVPS and PMT.
  - Use new plastic screws to mount the PMT assembly on the PMT cold block.



## N200, N200M, N200H

21. Install new silica gel packets (desiccant bags).
22. Reconnect the cables and the reaction cell (evenly tighten these screws).
23. Replace the sensor assembly into the chassis and fasten with four screws and washers.
24. Reconnect all electrical and pneumatic connections.
25. Leak check the system (see Section 5.6.12).
26. Turn ON the analyzer.
27. Verify the basic operation of the analyzer using the OTEST feature (Section 5.7.9.5) or zero and span gases, then carry out a hardware calibration of the analyzer followed by a zero/span point calibration (Section 4.2.1).

### 5.7.10.5. FUSE REPLACEMENT PROCEDURE

#### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Fuses do not typically fail without definite cause. Do not attempt to replace until after all measures to detect the cause of a power failure, per Section 5.7.9.1, have been carried out, including Soft Power switch LED not lit (neither solid nor blinking), but Hard Power switch is in ON position and instrument's power cord properly connected at both ends. If an ohmmeter shows that the fuse is good, or if a new fuse blows, call Technical Support (Section 5.9).



#### WARNING – ELECTRICAL SHOCK HAZARD

Never pull out fuse drawer without ensuring that the Hard Power switch is in OFF position and power cord disconnected, to ensure there is no power to the instrument before checking/changing fuse.



## N200, N200M, N200H

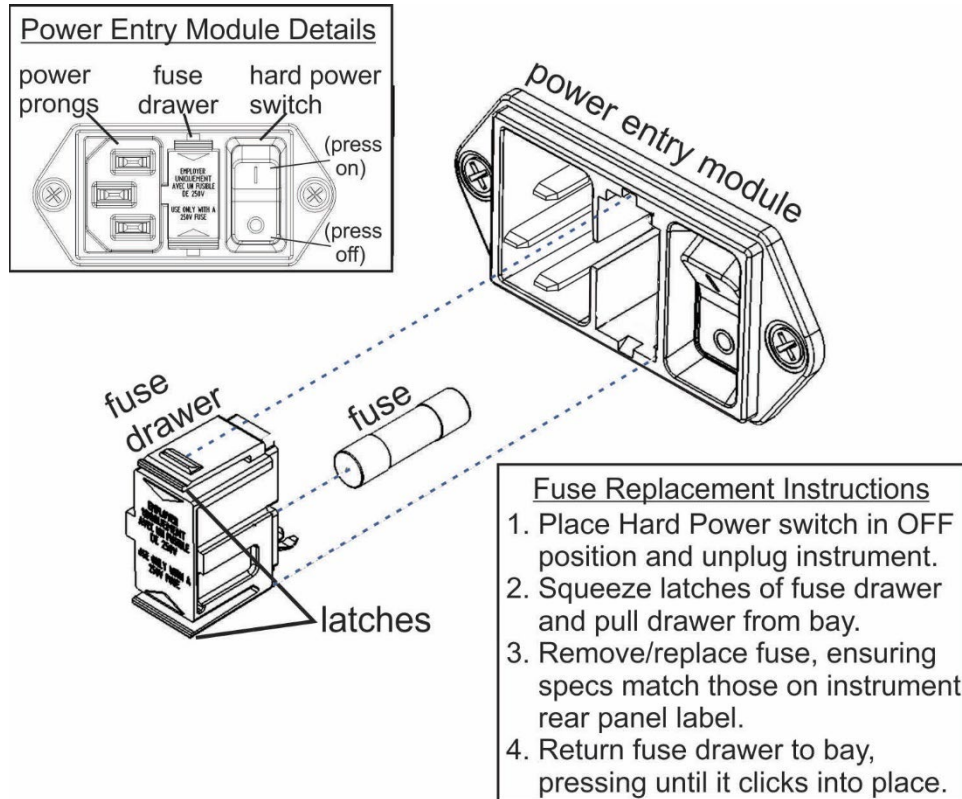


Figure 5-19. Fuse Access

### 5.7.10.6. MODULE REPLACEMENT

Each smart module has its own printed circuit board mounted to it so that the entire assembly can be quickly and efficiently swapped out.

#### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

**Always power off the instrument before disconnecting or reconnecting any wiring when uninstalling/installing modules. Failure to do so will damage certain PCAs.**

1. Turn off the analyzer power (noting that the front panel switch LED should either be blinking or solid off before powering down via the rear panel switch).
2. Remove the power cord and the analyzer cover.
3. Disconnect tubing connected to the module.
4. Unplug the electrical connection to the module.
5. Unscrew the mounting screws that attach the module to the chassis and lift out the entire assembly.
6. If you received a complete replacement module with circuit board and mounting bracket attached, simply reverse the above steps to install.



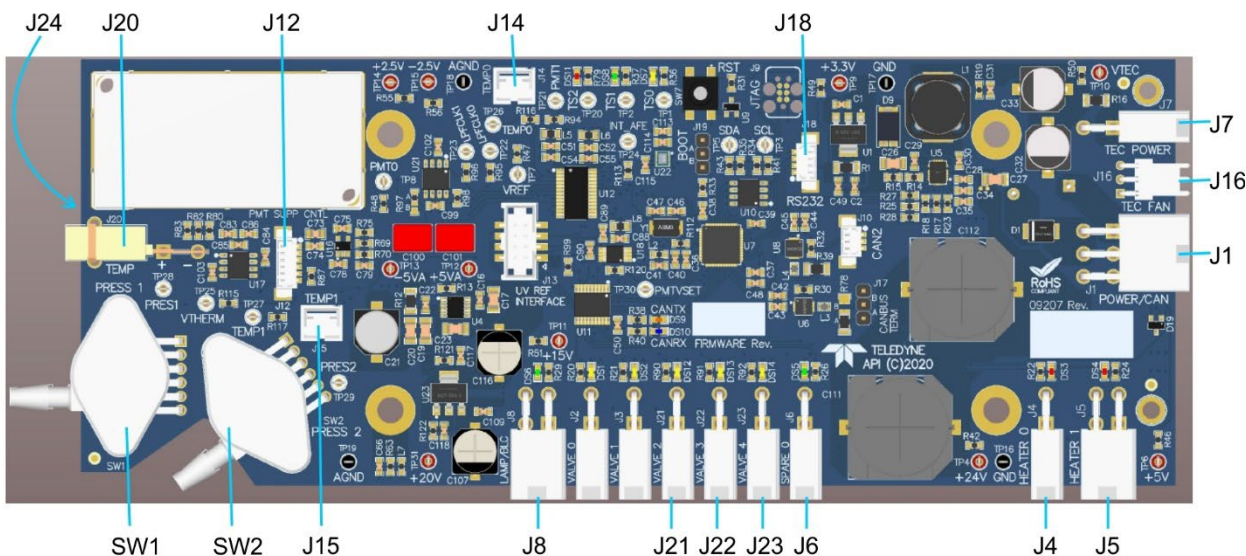
# N200, N200M, N200H

## Note

Ensure to carry out a leak check (Section 5.6.12) and a recalibration after the analyzer has warmed up for about 60 minutes.

In the event of replacement, the following illustrations provide connector information:

- J24: PMT Signal (back side of PCA)
- J20: Moly/Hicon/O3 Destruct
- J12: PMT HVPS Drive Control
- J14: PMT Temp
- J18: RS232 Comm
- J7: TEC Cooler Power
- J16: TEC Cooler Fan
- J1: Power and CAN Bus



- SW1: Sample Pressure
- SW2: RCell Pressure
- J15: RCell Temp
- J8: Power for Lamp PCA
- J21: Sample/Cal Valve (Not used for IZS option which uses external CAN Bus PCA)
- J22: Span Valve (Not used for IZS option which uses external CAN Bus PCA)
- J23: Spare
- J6: Spare
- J4: RCell Heater Power

Figure 5-20. PMT Board Connectors





## N200, N200M, N200H

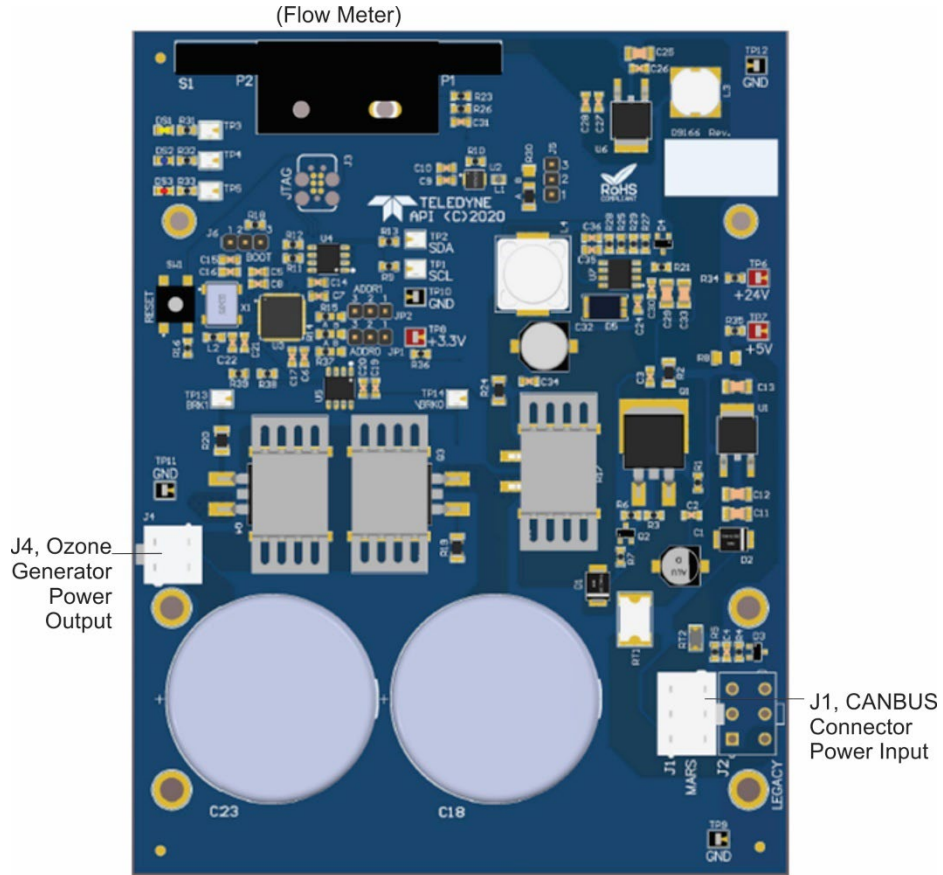


Figure 5-21. Ozone Brick Board Connectors

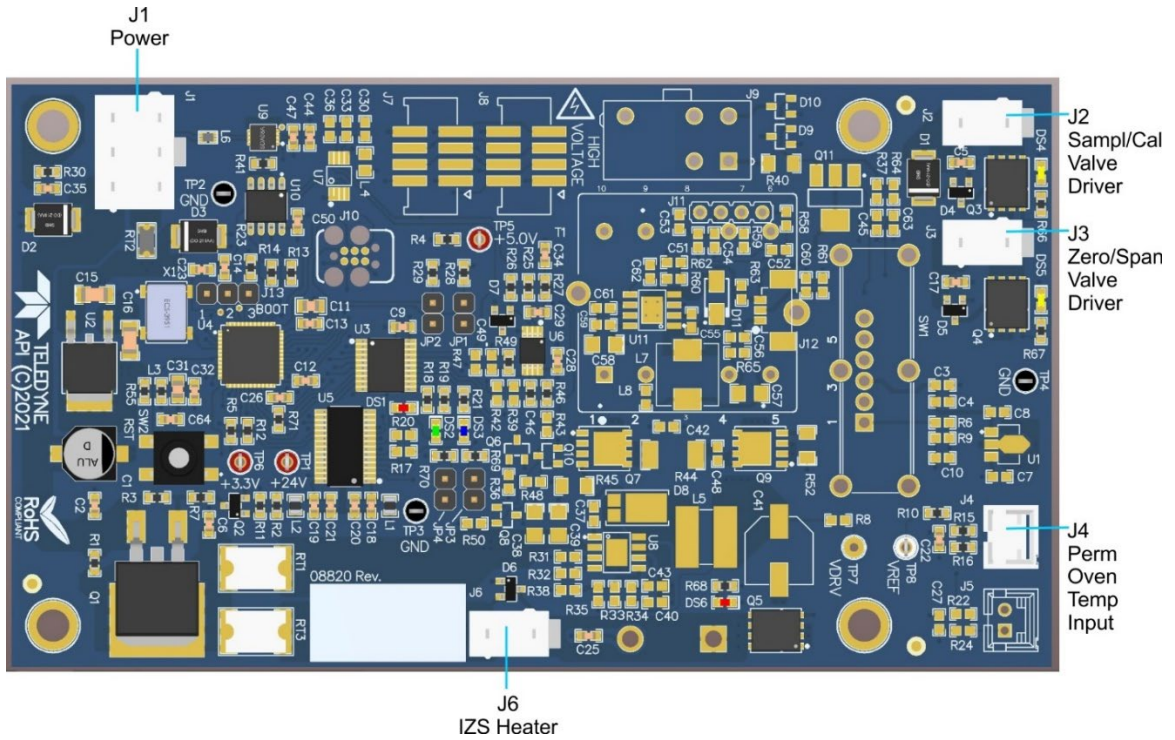


Figure 5-22. IZS Option Board Connectors



# N200, N200M, N200H

Other connectors on the Mainboard are shown next in Figure 5-23.

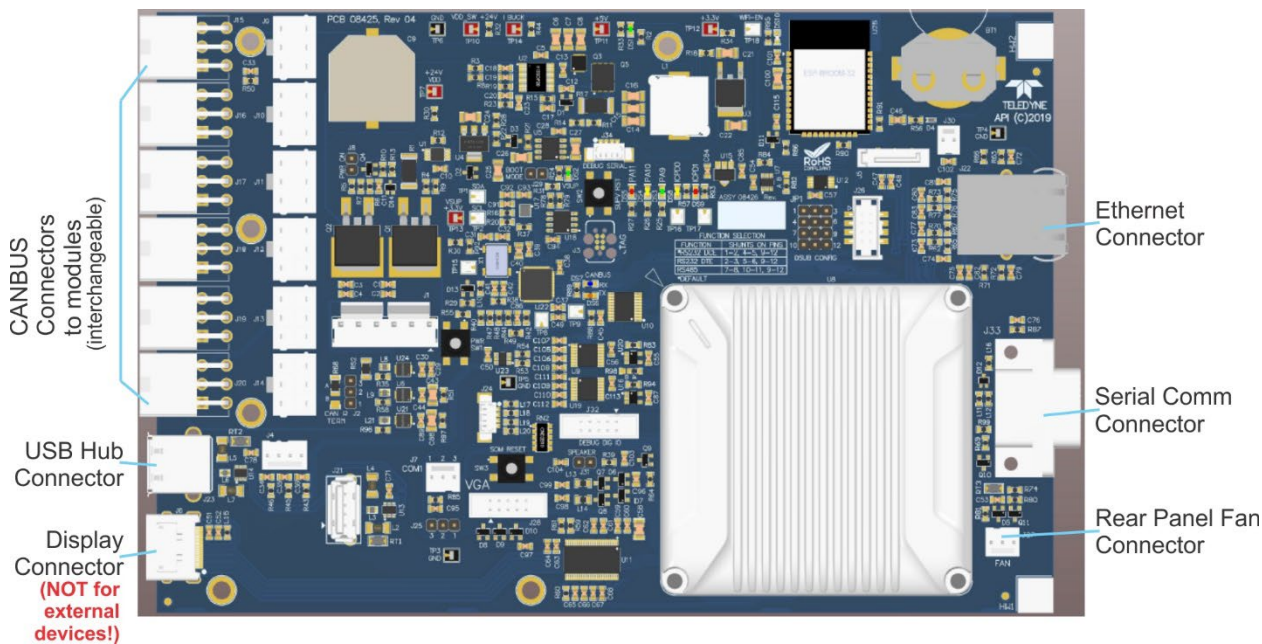


Figure 5-23. Mainboard Connectors

## 5.8. FREQUENTLY ASKED QUESTIONS

The following list was compiled from the Teledyne API's Technical Support Department's ten most commonly asked questions relating to the analyzer.

| QUESTION   | ANSWER   |
|--|--|
| Why does the ENTR button sometimes disappear on the front panel display? | Sometimes the ENTR button will disappear if you select a setting that is invalid or out of the allowable range for that parameter, such as trying to set the 24-hour clock to 25:00:00 or a range to less than 1 or more than 20000 ppb. Once you adjust the setting to an allowable value, the ENTR button will re-appear.        |
| Why is the ZERO or SPAN button deactivated during calibration?           | This happens when the measured gas concentration differs significantly from the span or zero gas concentration value entered by the user. This prevents accidental recalibration of the analyzer to an out-of-range response curve.<br>EXAMPLE: The span set point is 400 ppb but gas concentration being measured is only 50 ppb. |
| How do I enter or change the value of my Span Gas?                       | See Section 4.2.1.2.   |
| Can I automate the calibration of my analyzer?                           | Any analyzer with zero/span valve or IZS option can be automatically calibrated using the instrument's AutoCal feature (Section 4.3).  |





## N200, N200M, N200H

| QUESTION  | ANSWER  |
|---|---|
| Can I use the IZS option to calibrate the analyzer?                       | Yes. However, the accuracy of the IZS option's permeation tube is only $\pm 5\%$ . To achieve highest accuracy, it is recommended to use cylinders of calibrated span gases in combination with a zero air source.  |
| How do I measure the sample flow?   | For accurate measurement, attach a calibrated flow meter to the sample inlet port, and get a reading while the instrument is operating. The sample flow should be as specified in Table 1-1. (To calibrate, use the Utilities>Diagnostics menu; refer to Section 5.6.12.3).   |
| How often do I need to change the particulate filter?                     | Refer to the Maintenance Schedule in Table 5-1. Keep in mind that highly polluted sample air may require more frequent changes.   |
| How long does the sample pump last?                                       | The sample pump should last one to two years and the pump head should be replaced when necessary.<br>If the reaction cell pressure value goes above 10 in-Hg-A, on average, the pump head needs to be rebuilt.  |
| Why does my RS-232 serial connection not work?                            | There are several possible reasons: <ul style="list-style-type: none"> <li>• The wrong cable: please use the provided or a generic "straight-through" cable (do not use a "null-modem" type cable) and ensure the pin assignments are correct (Section 2.3.1.4 under Serial Connection).</li> <li>• The baud rate of the analyzer's COM port does not match that of the serial port of your computer/data logger (Table 2-16).</li> </ul> |
| How do I make the instrument's display and my data logger agree?          | This most commonly occurs when an independent metering device is used besides the data logger/recorder to determine gas concentration levels while calibrating the analyzer. These disagreements result from the analyzer, the metering device and the data logger having slightly different ground levels.<br>Use the data logger itself as the metering device during calibration procedures.   |
| Do the critical flow orifices of my analyzer require regular replacement? | No. The o-rings and the sintered filter associated with them require replacement once a year, but the critical flow orifices do not.<br>See Section 5.6.10 for instructions.  |

## 5.9. TECHNICAL ASSISTANCE

If this manual and its troubleshooting & service section do not solve your problems, technical assistance may be obtained from:

**Teledyne API Technical Support**  
**9970 Carroll Canyon Road**  
**San Diego, California 92131-1106 USA**

**Toll-free Phone:** +1 800-324-5190

**Phone:** +1 858-657-9800

**Fax:** +1 858-657-9816

**Email:** [api-techsupport@teledyne.com](mailto:api-techsupport@teledyne.com)

**Website:** <http://www.teledyne-api.com/>



### 6. PRINCIPLES OF OPERATION

The N200 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 (hv).
- The instrument measures the amount of chemiluminescence to determine the amount of NO in the sample gas.
- A catalytic-reactive converter converts NO<sub>2</sub> in the sample gas to NO which, along with the NO present in the sample is reported as NO<sub>x</sub>. NO<sub>2</sub> is calculated as the difference between NO<sub>x</sub> and NO.

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 or NO<sub>2</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 are reported to the user through a vacuum fluorescence display or several output ports.

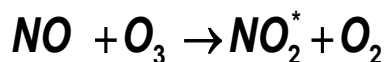
#### 6.1. MEASUREMENT PRINCIPLE

##### 6.1.1. CHEMILUMINESCENCE CREATION IN THE REACTION CELL

The analyzer measures the amount of NO present in a gas by detecting the chemiluminescence which occurs when nitrogen oxide (NO) is exposed to 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> molecules created by this reaction retain excess energy from the collision and exist in an excited state, where one of the electrons of the NO<sub>2</sub> molecule resides in a higher energy state than normal (denoted by an asterisk in the following equation).

Equation 6-1

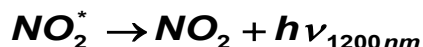




## N200, N200M, N200H

- The second step occurs because the laws of thermodynamics require that systems seek the lowest stable energy state available, therefore the excited NO<sub>2</sub> molecule quickly returns to its ground state, releasing the excess energy. This release takes the form of a quantum of light ( $h\nu$ ). The distribution of wavelengths for these quanta range between 600 and 3000 nm, with a peak at about 1200 nm.

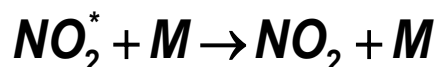
### Equation 6-2



- All things being constant (temperature, pressure, amount of ozone present, etc.), the relationship between the amount of NO present in the reaction cell and the amount of light emitted from the reaction is very linear. If more NO is present, more IR light is produced. By measuring the amount of IR light produced with a sensor sensitive in the near-infrared spectrum (see Figure 6-2) the amount of NO present can be determined.

In addition, sometimes the excited NO<sub>2</sub> collides with other gaseous molecules in the reaction cell chamber or even the molecules of the reaction cell walls and transfers its excess energy to this collision partner (represented by  $M$  in Equation 6-3 below) without emitting any light at all. In fact, by far the largest portion of the excited NO<sub>2</sub> returns to the ground state this way, leaving only a few percent yield of usable chemiluminescence.

### Equation 6-3



The probability of a collision between the NO<sub>2</sub>\* molecule and a collision partner  $M$  increases proportionally with the reaction cell pressure. This non-radiating collision with the NO<sub>2</sub>\* molecules is usually referred to as *third body quenching*, an unwanted process further described in Section 6.1.5.2.

Even under the best conditions only about 20% of the NO<sub>2</sub> that is formed by the reaction described in equation 12-1 is in the excited state. In order to maximize chemiluminescence, the reaction cell is maintained at reduced pressure (thereby reducing the amount of available collision partners) and is supplied with a large, constant excess of ozone (about 3000-5000 ppm) from the internal ozone generator.



## 6.1.2. CHEMILUMINESCENCE DETECTION IN THE REACTION CELL

### 6.1.2.1. THE PHOTO MULTIPLIER TUBE (PMT)

The analyzer uses a special kind of vacuum tube, called 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.

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 multiplied through a sequence of similar acceleration steps (dynodes) until a useable current signal is generated (see Section 6.3.3 for a more detailed description). The more light present (in this case photons given off by the chemiluminescent reaction described above), the more current is produced. Therefore the more NO present in the reaction cell the more current is produced by the PMT.

The current produced by the PMT is converted to a voltage and communicated to the analyzer's CPU.

### 6.1.2.2. OPTICAL FILTER

A high pass optical filter, only transparent to wavelengths of light above 645nm, placed between the reaction cell and the PMT (see Figure 6-1) in conjunction with the response characteristics of the PMT creates a very narrow window of wavelengths of light to which the analyzer will respond.

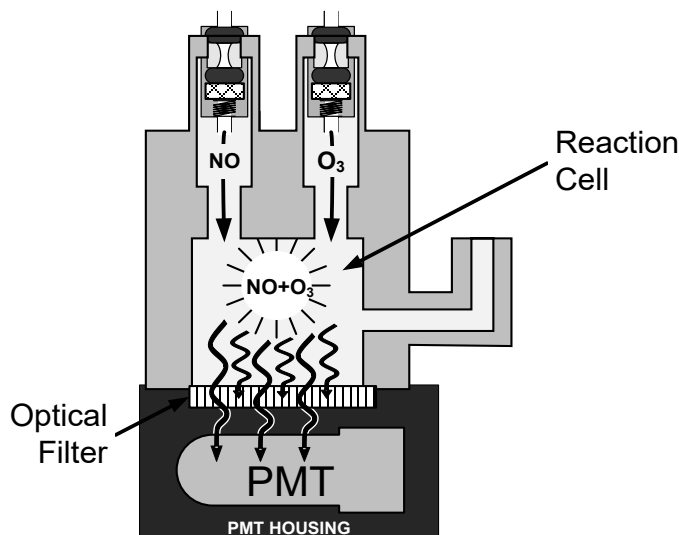


Figure 6-1. Reaction Cell with PMT Tube and Optical Filter

The narrowness of this band of sensitivity allows the analyzer to ignore extraneous light and radiation that might interfere with the analyzer's measurement (more on interferences in Section 6.1.5). For instance, some oxides of sulfur can also be chemiluminescent emitters when in contact with O<sub>3</sub> but give off light at much shorter wavelengths (usually around 260nm to 480nm).



## N200, N200M, N200H

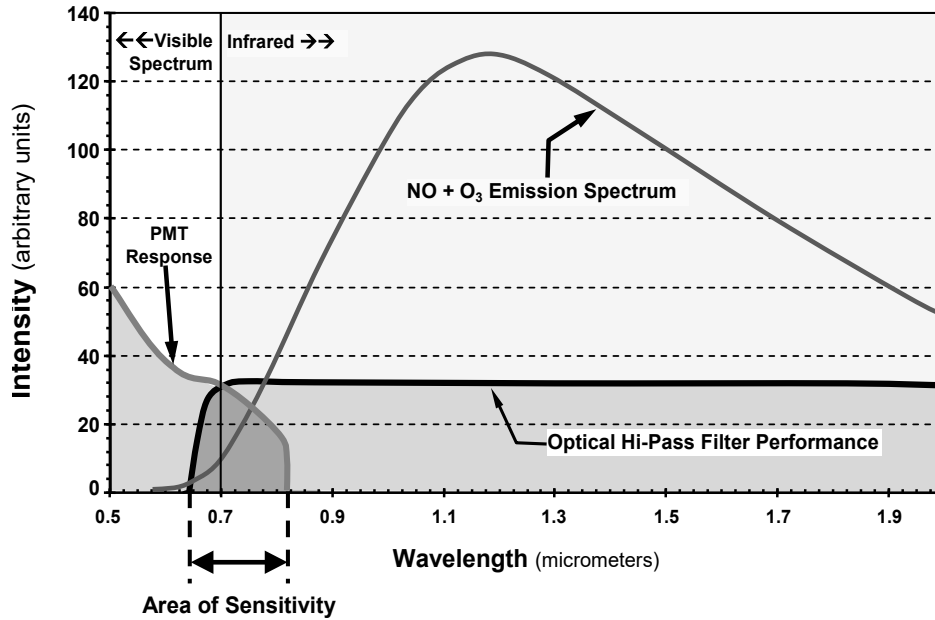


Figure 6-2. Sensitivity Spectrum

### 6.1.3. NO<sub>x</sub> AND NO<sub>2</sub> DETERMINATION

The only gas that is actually measured by the N200 is NO. NO<sub>2</sub>, and therefore NO<sub>x</sub> (which is defined here as the sum of NO and NO<sub>2</sub> in the sample gas), contained in the gas is not detected because NO<sub>2</sub> does not react with O<sub>3</sub> to create chemiluminescence.

In order to measure the concentration of NO<sub>2</sub>, and therefore the concentration of NO<sub>x</sub>, the N200 periodically switches the sample gas stream so that the pump pulls it through a special converter cartridge filled with molybdenum (Mo, “moly”) chips that are heated to a temperature of 315°C.

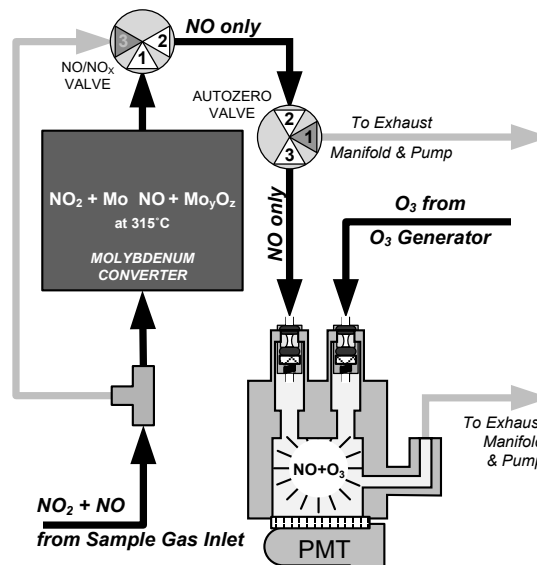


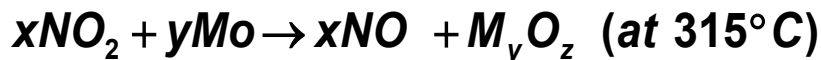
Figure 6-3. NO<sub>2</sub> → NO Conversion



## N200, N200M, N200H

The heated molybdenum reacts with NO<sub>2</sub> in the sample gas and produces a NO gas and a variety of molybdenum.

### Equation 6-4



Once the NO<sub>2</sub> in the sample gas has been converted to NO, it is routed to the reaction cell where it undergoes the chemiluminescence reaction described in Equation 6-1 and Equation 6-2.

By converting the NO<sub>2</sub> in the sample gas into NO, the analyzer can measure the total NO<sub>x</sub> content of the sample gas (i.e. the NO present + the converted NO<sub>2</sub> present). By switching the sample gas stream in and out of the “moly” converter every 6 - 10 seconds, the analyzer is able to quasi-continuously measure both the NO and the total NO<sub>x</sub> content.

Finally, the NO<sub>2</sub> concentration is not directly measured but calculated by subtracting the known NO content of the sample gas from the known NO<sub>x</sub> content.

### 6.1.4. AUTO REFERENCE

Inherent in the operation of any PMT is a certain amount of noise. This is due to a variety of factors such as black body infrared radiation given off by the metal components of the reaction cell, unit to unit variations in the PMT units and even the constant universal background radiation that surrounds us at all times. In order to reduce this amount of noise and offset, the PMT is kept at a constant 7° C (45° F) by a Thermo-Electric Cooler (TEC).

While this intrinsic noise and offset is significantly reduced by cooling the PMT, it is not eradicated. To determine how much noise remains, once every minute for a short period the analyzer diverts the sample gas flow directly to the vacuum manifold, bypassing the reaction cell. During this period, only O<sub>3</sub> is present in the reaction cell, effectively turning off the chemiluminescence reaction. Once the cell is completely dark (“zero” light), the analyzer records the output of the PMT and keeps a running average of these Auto Reference (Aref) values. This average offset value is subtracted from the raw PMT readings while the instrument is measuring NO and NO<sub>x</sub> to arrive at an Auto Reference corrected reading.



# N200, N200M, N200H

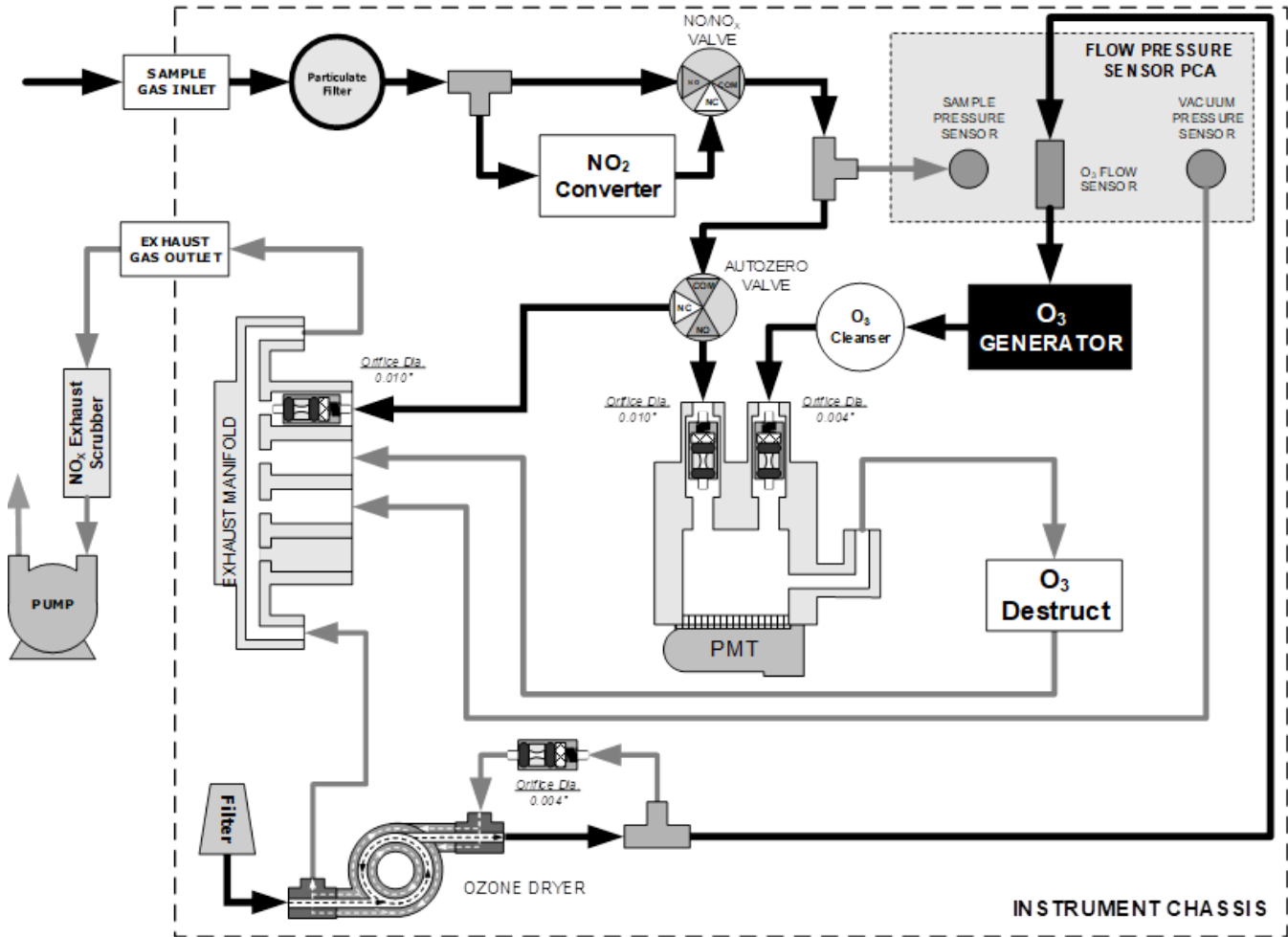


Figure 6-4. Pneumatic Flow during the Auto Reference Cycle

## 6.1.5. MEASUREMENT INTERFERENCES

Interferences in the chemiluminescence method come from a number of sources. The analyzer has been successfully tested for its ability to reject interference from most of these sources. Table 6-1 lists the most common types of interferents that could affect the analyzer's performance.

Table 6-1. List of Interferents

| GAS             | INTERFERENCE TYPE  | REJECTION METHOD   |
|-----------------|--|--|
| CO <sub>2</sub> | Dilution: Viscosity of CO <sub>2</sub> molecules causes them to collect in aperture of Critical Flow Orifice altering flow rate of NO.                                     | If high concentrations of CO <sub>2</sub> are suspected, special calibration methods must be performed to account for the effects of the CO <sub>2</sub> .<br>Contact Teledyne API's Technical Support Department (Section 5.9) for details. |
|                 | 3 <sup>rd</sup> Body Quenching: CO <sub>2</sub> molecules collide with NO <sub>2</sub> * molecules absorbing excess energy kinetically and preventing emission of photons. |  |





## N200, N200M, N200H

| GAS              | INTERFERENCE TYPE  | REJECTION METHOD   |
|------------------|--|--|
| SO <sub>x</sub>  | Some SO <sub>x</sub> variants can also initiate a chemiluminescence reaction upon exposure to O <sub>3</sub> producing excess light.   | Wavelengths of light produced by chemiluminescence of SO <sub>x</sub> are screened out by the Optical Filter.  |
|                  | Chemically reacts with NH <sub>3</sub> , O <sub>2</sub> and H <sub>2</sub> O in O <sub>3</sub> generator to create (NH <sub>3</sub> ) <sub>2</sub> SO <sub>4</sub> (ammonium sulfate) and NH <sub>3</sub> NO <sub>2</sub> (ammonium nitrate) which form opaque white deposits on optical filter window. Also forms highly corrosive HNO <sub>3</sub> (Nitric Acid)               | Most of the ammonium sulfate and ammonium nitrate produced is removed from the sample gas by the Ozone cleanser located between the O <sub>3</sub> Generator and the reaction cell.  |
|                  | 3 <sup>rd</sup> Body quenching: SO <sub>x</sub> molecules collide with NO <sub>2</sub> * molecules absorbing excess energy kinetically and preventing emission of photons.   | If high concentrations of SO <sub>x</sub> are suspected, special calibration methods must be performed to account for the effects of the SO <sub>2</sub> .<br>Contact Teledyne API's Technical Support Department (Section 5.9) for details. |
| H <sub>2</sub> O | 3 <sup>rd</sup> Body quenching: H <sub>2</sub> O molecules collide with NO <sub>2</sub> * molecules absorbing excess energy kinetically and preventing emission of light.  | Analyzer's operating in high humidity areas must have some drying applied to the sample gas (see Section 2.3.2.6 for more details).  |
|                  | Water also reacts with NH <sub>3</sub> and SO <sub>x</sub> in the O <sub>3</sub> generator to create (NH <sub>3</sub> ) <sub>2</sub> SO <sub>4</sub> (ammonium sulfate) and NH <sub>3</sub> NO <sub>2</sub> (ammonium nitrate) which form opaque white deposits on the optical filter window. This also forms highly corrosive HNO <sub>3</sub> (nitric acid)                    | Water is effectively removed from the O <sub>3</sub> gas stream by the Nafion Dryer (Section 6.2.3.2 for more details). We offer several Sample dryers for the sample stream (see Section 2.3.2.6 for more details).                         |
| NH <sub>3</sub>  | NH <sub>3</sub> also reacts with H <sub>2</sub> O, O <sub>2</sub> and SO <sub>x</sub> in the O <sub>3</sub> generator to create (NH <sub>3</sub> ) <sub>2</sub> SO <sub>4</sub> (ammonium sulfate) and NH <sub>3</sub> NO <sub>2</sub> (ammonium nitrate) which form opaque white deposits on optical filter window. Also forms highly corrosive HNO <sub>3</sub> (nitric acid). | The Sample dryer option is sufficient for removing typical ambient concentration levels of NH <sub>3</sub> .   |

### 6.1.5.1. DIRECT INTERFERENCE

Some gases can directly alter the amount of light detected by the PMT due to chemiluminescence in the reaction cell. This can either be a gas that undergoes chemiluminescence by reacting with O<sub>3</sub> in the reaction cell or a gas that reacts with other compounds and produces excess NO upstream of the reaction cell.



### 6.1.5.2. THIRD BODY QUENCHING

As described by Equation 6-3, other molecules in the reaction cell can collide with the excited  $\text{NO}_2^*$ , causing the excited  $\text{NO}_2^*$  to return to its ground state without releasing a photon of light. This is known as third party quenching.

Quenching is an unwanted phenomenon and the extent to which it occurs depends on the properties of the collision partner.

- Larger, more polarized molecules such as  $\text{H}_2\text{O}$  and  $\text{CO}_2$  are the most significant quenching interferents of NO chemiluminescence.
- The influence of water vapor on the analyzer's measurement can be eliminated with an optional, internal sample gas dryer (see Section 2.3.2.6).
- The interference of varying  $\text{CO}_2$  amounts at low concentrations (less than 0.5%) is negligible.
- In cases with excessively high  $\text{CO}_2$  concentrations (larger than 0.5%), the effect can be calibrated out by using calibration gases with a  $\text{CO}_2$  content equal to the measured air.
- Only very high and highly variable  $\text{CO}_2$  concentrations will then cause a measurable interference. For those applications, it is recommended to use other analyzer models. Please consult Teledyne API's Sales Department or our website (front cover, this manual).
- Smaller less polar and electronically "harder" molecules such as  $\text{N}_2$  and  $\text{O}_2$  can cause interference of this type as well, however, the concentrations of  $\text{N}_2$  and  $\text{O}_2$  are virtually constant in ambient air measurements, hence provide a constant amount of quenching that is accounted for in the calibration of the instrument .

### 6.1.5.3. LIGHT LEAKS

The sensitivity curve includes a small portion of the visible light spectrum (see Figure 6-2), therefore it is important to ensure that the reaction cell is completely sealed with respect to light. To ensure this:

- All pneumatic tubing leading into the reaction cell is opaque in order to prevent light from entering the cell.
- Light penetration is prevented by stainless steel filters and orifices.

### 6.1.5.4. REACTION CELL TEMPERATURE CONTROL

The stability of the chemiluminescence reaction between NO and  $\text{O}_3$  can be affected by changes in the temperature and pressure of the  $\text{O}_3$  and sample gases in the reaction cell. In order to reduce temperature effects, the reaction cell is maintained at a constant  $50^\circ\text{C}$ , just above the high end of the instrument's operation temperature range. A thermistor detects the temperature which is detected and evaluated via the CANBUS system.



## 6.2. PNEUMATIC OPERATION

### Important

#### IMPACT ON READINGS OR DATA

**The sample gas is the most critical flow path in the analyzer. At any point before and in the reaction cell, the integrity of the sample gas must not be compromised. Therefore, it is important that the sample airflow system is both leak tight and not pressurized over ambient pressure.**

Regular leak checks should be performed on the analyzer as presented in the maintenance schedule, Table 5-1. Procedures for correctly performing leak checks can be found in Section 5.6.12.

### 6.2.1. SAMPLE GAS FLOW

#### Note

**In this section of the manual vacuum readings are given in inches of mercury absolute (In-Hg-A). This pressure value is referenced against zero (a perfect vacuum).**

The sample gas flow is created by an external vacuum pump that is located pneumatically downstream from the rest of the instrument's components.

- The pump creates a vacuum of approximately 5 in-Hg-A which is distributed to various pneumatic components by a vacuum manifold, located just in front of the rear panel (see Figure 2-3).

Gas flow is created by keeping the analyzer's sample gas inlet near ambient pressure, usually by means of a small vent installed in the sample line at the inlet, in effect pulling the gas through the instrument's pneumatic systems.

By placing the pump downstream from the analyzer's reaction cell, several problems are avoided.

- First, the pumping process heats and compresses the sample air complicating the measurement process.
- Additionally, certain physical parts of the pump itself are made of materials that might chemically react with the sample gas.
- Finally, in certain applications where the concentration of the target gas might be high enough to be hazardous, maintaining a negative gas pressure relative to ambient means that should a minor leak occur, no sample gas would be pumped into the atmosphere surrounding the analyzer.



### 6.2.1.1. VACUUM MANIFOLD

The vacuum created by the analyzer's pump is supplied to all of the gas streams for the analyzer through the vacuum manifold (also called the exhaust manifold).

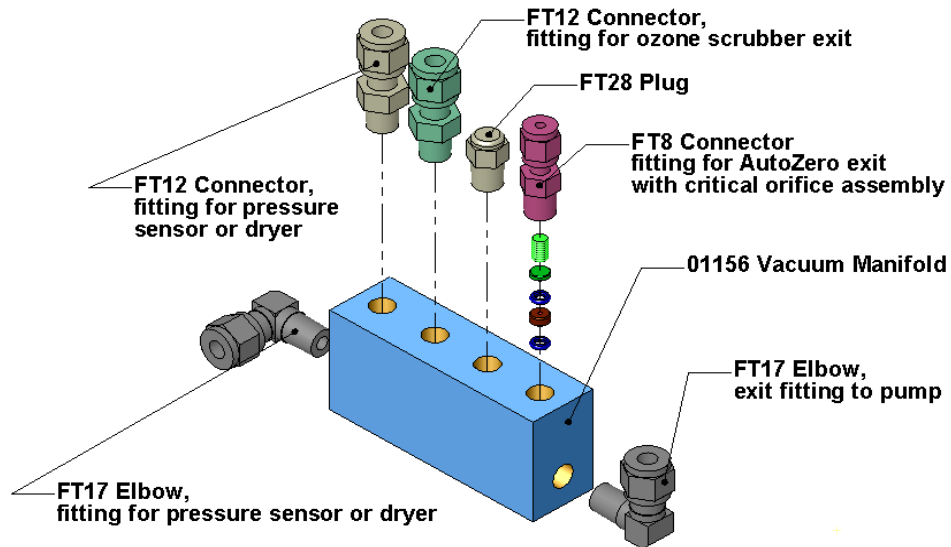


Figure 6-5. Vacuum Manifold, Standard Configuration

Configurations will vary depending on the optional equipment that is installed. For example:

- An optional internal span gas generator installed will add another FT8 connector and orifice assembly to the manifold where the FT28 fitting is as shown in the above drawing.
- An optional sample gas dryer will add a Tee-fitting so that two 1/4" tubes can be connected to the same port.



### 6.2.1.2. SAMPLE GAS FLOW VALVES AND ROUTING

As discussed in Section 6.1, the measurement of NO<sub>x</sub>, NO and NO<sub>2</sub> requires that the sample gas flow cycles through different routes that include and exclude various scrubbers and converters. There are several valves that perform this function:

- The NO/NO<sub>x</sub> valve directs the sample gas either directly to the reaction cell or through the unit's NO<sub>2</sub> converter, alternating every ~8 sec.
- The Auto Reference valve directs the sample gas stream to completely bypass the reaction cell for dark noise measurement once every minute, which is then subtracted as a measurement offset from the raw concentration signal.

**Table 6-2. Valve Cycle Phases**

| PHASE                          | NO/ NOX VALVE STATUS              | AUTO REFEREN CE VALVE STATUS | TIME INDEX | ACTIVITY   | FIGURE     |
|--------------------------------|-----------------------------------|------------------------------|------------|--|------------|
| NO Measure                     | Open to Auto Reference valve      | Open to reaction cell        | 0 - 2 s    | Wait period (NO dwell time). Ensures reaction cell has been flushed of previous gas.   | Figure 6-3 |
|                                |                                   |                              | 2 - 4 s    | Analyzer measures chemiluminescence in reaction cell.  |            |
| NO <sub>x</sub> Measure        | Open to NO <sub>2</sub> converter | Open to reaction cell        | 4 – 6 s    | Wait period (NO <sub>x</sub> dwell time). Ensures reaction cell has been flushed of previous gas.                              | Figure 6-3 |
|                                |                                   |                              | 6 – 8 s    | Analyzer measures NO + O <sub>3</sub> chemiluminescence in reaction cell.  |            |
| Cycle repeats every ~8 seconds |                                   |                              |            |  |            |
| Auto Reference                 | Open to Auto Reference valve      | Open to vacuum manifold      | 0 – 4 s    | Wait period (AREF dwell time). Ensures reaction cell has been flushed of sample gas and chemiluminescence reaction is stopped. | Figure 6-4 |
|                                |                                   |                              | 4 - 6 s    | Analyzer measures background noise without sample gas  |            |
| Cycle repeats every minute     |                                   |                              |            |  |            |

### 6.2.2. FLOW RATE CONTROL - CRITICAL FLOW ORIFICES

Sample gas flow in the analyzer is created via the use of several flow control assemblies (see Figure 6-6 for an example) located in various places in the gas streams of the instrument. These assemblies consist of:

- a critical flow orifice
- two o-rings, Located just before and after the critical flow orifice, the o-rings seal the gap between the walls of assembly housing and the critical flow orifice
- a sintered filter
- a spring (applies mechanical force needed to form the seal between the o-rings, the critical flow orifice and the assembly housing)

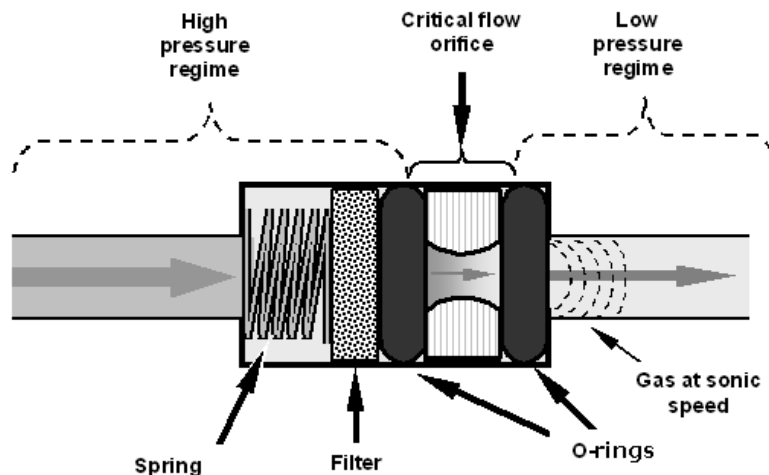


Figure 6-6. Flow Control Assembly & Critical Flow Orifice

### 6.2.2.1. CRITICAL FLOW ORIFICE

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 that the gas flows 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. As long as that ratio stays at least 2:1, the gas flow rate is unaffected by any fluctuations, surges, or changes in downstream pressure because such variations only travel at the speed of sound themselves and are therefore cancelled out by the sonic shockwave at the downstream exit of the critical flow orifice.

The actual flow rate of gas through the orifice (volume of gas per unit of time), depends on the size and shape of the aperture in the orifice. The larger the holes, the more gas molecules (moving at the speed of sound) pass through the orifice.

In addition to controlling the gas flow rates into the reaction cell, the two critical flow orifices at the inlets of the reaction cell also maintain an under-pressure inside it, effectively reducing the number of molecules in the chamber and the corresponding incidence of third body quenching (see Section 6.1.5.2), and thereby increasing the chemiluminescence yield.

- The analyzer reaches its peak sensitivity at about 2 in-Hg-A, below which the sensitivity drops due to there being too few molecules present and a corresponding decrease in chemiluminescence.

### 6.2.2.2. LOCATIONS AND DESCRIPTIONS OF CRITICAL FLOW ORIFICES

Several critical flow orifices (Figure 6-7) are used to create and maintain the proper flow rate of gas through its various components. (Please note that Figure 6-7 represents the standard configuration and is provided for reference).



## N200, N200M, N200H

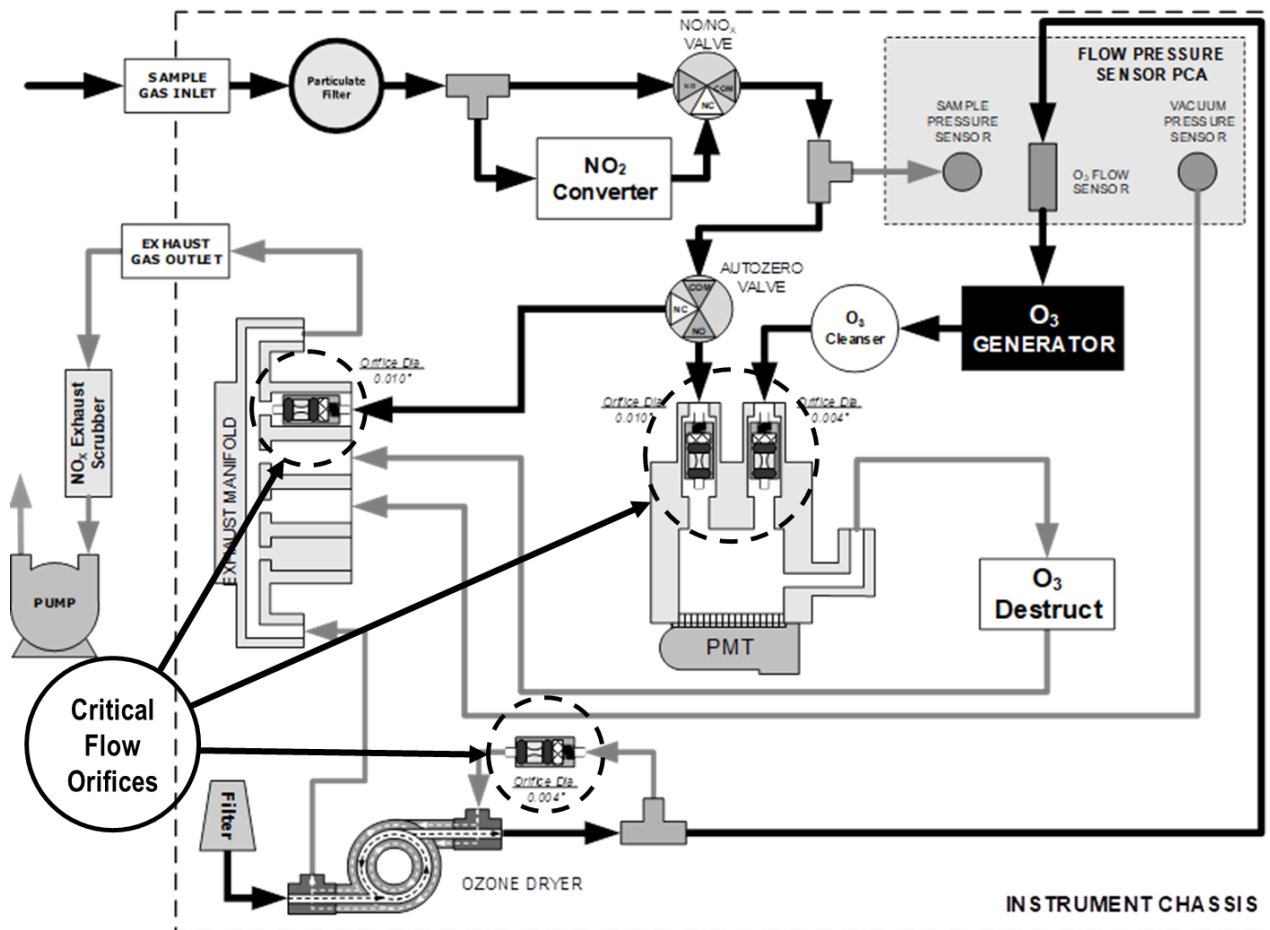


Figure 6-7. Location of Flow Control Assemblies & Critical Flow Orifices

Table 6-3. Gas Flow Controls

| LOCATION   | PURPOSE  | ORIFICE DIAMETER | FLOW RATE (NOMINAL) |
|--|--|------------------|---------------------|
| Sample gas inlet of reaction cell  | Controls rate of flow of sample gas into the reaction cell.  | 0.010" (0.25 mm) | 500 cc/min          |
| O <sub>3</sub> supply inlet of reaction cell   | Controls rate of flow of ozone gas into the reaction cell.   | 0.004" (0.10 mm) | 80 cc/min           |
| Dry air return of ozone dryer  | Controls flow rate of dry air return / purge air of the dryer.   | 0.004" (0.10 mm) | 80 cc/min           |
| Vacuum manifold, Auto Reference connection.  | Controls rate of sample gas flow when bypassing the reaction cell during the Auto Reference cycle.             | 0.010" (0.25 mm) | 500 cc/min          |
| Vacuum manifold, Internal span gas generator exhaust port (when optional IZS generator installed). | Controls rate of flow of zero purge gas through the optional Internal span gas generator when it is installed. | 0.003" (0.08 mm) | 60 cc/min           |
| Dry air return of ozone dryer  | Controls flow rate of dry air return / purge air of the dryer.   | 0.004" (0.10 mm) | 80 cc/min           |



## N200, N200M, N200H

The necessary 2:1 ratios across the critical flow orifices is largely exceeded by the pumps supplied with the analyzer which are designed to accommodate a wide range of possible variability in atmospheric pressure and age related degradation of the pump itself. Once the pump does degrade the ratio between sample and vacuum pressures may fall to less than 2:1. At this point, the instrument will display an invalid sample flow rate measurement.

### Note

The diameter of a critical flow orifice may change with temperature because of expansion of the orifice material and, hence, the most crucial critical flow orifices (those controlling the sample gas and O<sub>3</sub> flow into the cell itself) are located in the reaction cell where they can be maintained at a constant temperature.

### 6.2.3. OZONE GAS GENERATION AND 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.

#### CAUTION – GENERAL SAFETY HAZARD



Ozone (O<sub>3</sub>) is a toxic gas.

Obtain a Safety Data Sheet (SDS) for this gas. Read and rigorously follow the safety guidelines described there.

Always ensure that the plumbing of the O<sub>3</sub> generation and supply system is maintained and leak-free.





## 6.2.3.1. THE O<sub>3</sub> GENERATOR

The analyzer uses a dual-dielectric, Corona Discharge (CD) tube for creating its O<sub>3</sub>, which is capable of producing high concentrations of ozone efficiently and with low excess heat (see Figure 6-8). The primary component of the generator is a glass tube with hollow walls of which the outermost and innermost surfaces are coated with electrically conductive material.

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 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 cells. 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.

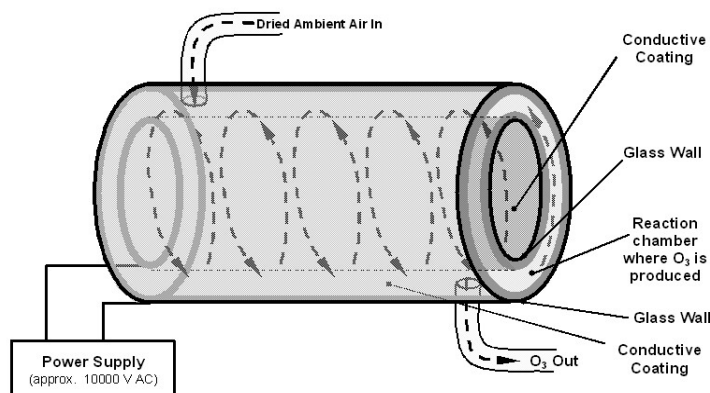


Figure 6-8. Ozone Generator Principle

## 6.2.3.2. OZONE GENERATOR DRY AIR SUPPLY

Ambient air usually contains enough water vapor to greatly diminish the yield of ozone produced by the ozone generator. Water also reacts with chemicals inside the O<sub>3</sub> Generator to produce caustic substances such as ammonium sulfate or highly corrosive nitric acid that will damage the optical filter located between the reaction cell and the PMT.

To prevent this, the air supply for the O<sub>3</sub> generator is dried using a special single tube permeation dryer. The dryer consists of a single tube of Nafion<sup>®</sup> that is mounted within an outer, flexible plastic tube. Nafion<sup>®</sup> is a co-polymer that absorbs water very well but not most other chemicals. 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 evaporated into the dry purge gas flowing through the outer tube, countercurrent to the gas in the inner tube.

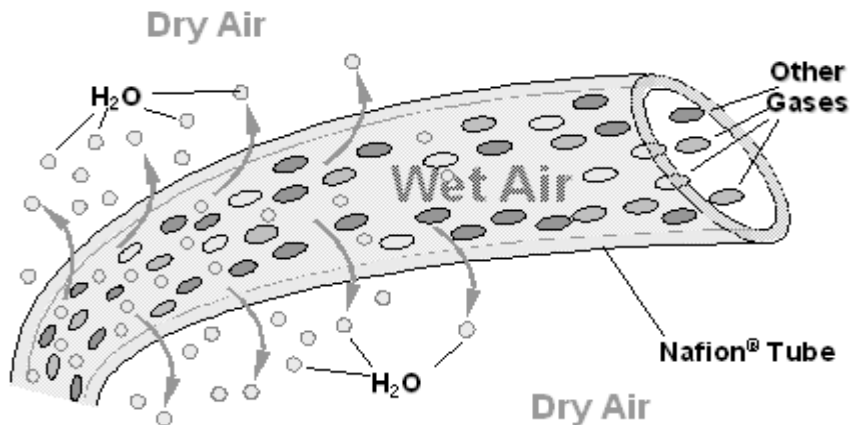


Figure 6-9. Semi-Permeable Membrane Drying Process

The process by which the water vapor molecules are collected and transported through Nafion<sup>®</sup> material 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.

Because this chemical reaction is based on hydrogen bonds between the water molecule and the Nafion<sup>®</sup> material most other chemical components of the gas to be dried are usually unaffected. Specifically, the gases of interest, NO and NO<sub>2</sub>, do not get absorbed and pass the dryer unaltered.

On the other hand, other small polar gases that are capable of hydrogen bonds such as ammonia (NH<sub>3</sub>) can be absorbed this way, too. This is an advantage since gases such as NH<sub>3</sub> can cause interference for the measurement of NO<sub>x</sub>, NO and NO<sub>2</sub> (see Table 6-1).

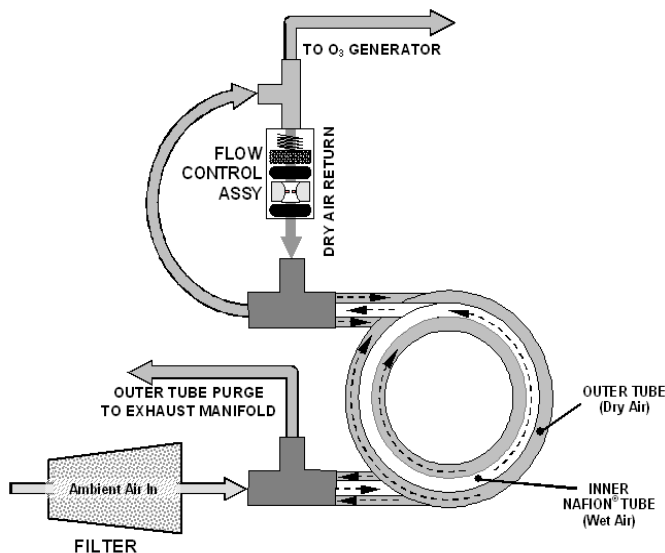


Figure 6-10. Sample Dryer

To provide a dry purge gas for the outer side of the Nafion<sup>®</sup> tube, the analyzer returns some of the dried air from the inner tube to the outer tube. This means that any time the analyzer



## N200, N200M, N200H

is turned on after having been OFF for 30 minutes or more, the humidity gradient between the inner and outer tubes is not very large and the dryer's efficiency is low. It takes a certain amount of time for the humidity gradient to become large enough for the Sample Dryer operate efficiently, in such cold start cases the O<sub>3</sub> Generator is not turned on until 30 minutes has passed in order to ensure that it is not operating until its air supply is properly dry.

### Note

**When rebooting the instrument within less than 30 minutes of power-down, the generator is turned on immediately.**

The Sample Dryer is capable of adequately drying ambient air to a dewpoint of  $\leq -5^{\circ}\text{C}$  ( $\sim 4000$  ppm residual H<sub>2</sub>O) at a flow rate of 1 standard liter per minute (slpm) or down to  $\leq -15^{\circ}\text{C}$  ( $\sim 1600$  ppm residual H<sub>2</sub>O) at 0.5 slpm. The Sample Dryer is also capable of removing ammonia from the sample gas up to concentrations of approximately 1 ppm.

### 6.2.3.3. OZONE SUPPLY AIR FILTER

The analyzer uses ambient air as the supply gas for the O<sub>3</sub> generator and may produce a variety of byproducts. Small amounts of water, ammonia and various sulfur oxides can combine to create ammonium sulfate, ammonium nitrate, nitric acid and other compounds. Whereas sulfates and nitrates can create powdery residues inside the reaction cell causing sensitivity drift, nitric acid is a very aggressive compound, which can deteriorate the analyzer's components. In order to remove these chemical byproducts from the O<sub>3</sub> gas stream, the output of the O<sub>3</sub> generator flows through a special filter between the generator and the reaction cell.

The small amount of NO<sub>x</sub> produced in the generator (from the reaction of O<sub>2</sub> or O<sub>3</sub> and N<sub>2</sub> in the air) will not affect the analyzer's ability to measure NO<sub>x</sub>, NO and NO<sub>2</sub> as it is accounted for and removed from the concentration calculations by the analyzer's Auto Reference feature (Section 6.1.4).

### 6.2.3.4. OZONE DESTRUCT

Even though ozone is unstable and typically reacts to form O<sub>2</sub>, the break-down is not quite fast enough to ensure that it is completely removed from the exhaust gas stream by the time the gas exits the analyzer. Due to the high toxicity and reactivity of O<sub>3</sub>, a highly efficient catalytic converter scrubs or converts all of the O<sub>3</sub> from the gas exiting the reaction cell. The conversion process is very safe. It only converts ozone to oxygen and does not produce any toxic or hazardous gases.

The O<sub>3</sub> destruct is located just inside the NO<sub>2</sub> converter. As this is a true catalytic converter, there are no maintenance requirements as would be required for charcoal-based ozone destructs.

A certain amount of fine, black dust may exit the catalyst, particularly if the analyzer is subjected to sudden pressure drops (for example, when disconnecting the running pump without letting the analyzer properly and slowly equilibrate to ambient pressure). To prevent the dust from entering the reaction cell or the pump, the ozone destruct is equipped with a quartz wool filter material.



## 6.2.4. PNEUMATIC SENSORS

### Note

The analyzer displays all pressures in inches of mercury absolute (in-Hg-A), i.e. absolute pressure referenced against zero (a perfect vacuum).

Three pneumatic sensors verify the flow and pressure levels of the gas streams. They are located on a printed circuit assembly, called the pneumatic pressure/flow sensor board, located just behind the sensor assembly. The measurements made by these sensors are used for a variety of important calculations and diagnostics.

### 6.2.4.1. SAMPLE PRESSURE SENSOR

An absolute pressure transducer connected to the input of the NO/NO<sub>x</sub> valve is used to measure the pressure of the sample gas before it enters the analyzer's reaction cell.

- In conjunction with the measurement made by the vacuum pressure sensor, this "upstream" measurement is used to compute the sample gas sample flow rate and to validate the critical flow condition (2:1 pressure ratio) through the sample gas critical flow orifice (Section 6.2.2).
- If the Temperature/Pressure Compensation (TPC) feature is turned on (Section 6.4.2), the output of this sensor is also used to supply pressure data for that calculation.

### 6.2.4.2. VACUUM PRESSURE SENSOR

An absolute pressure transducer connected to the exhaust manifold is used to measure the pressure downstream from and inside the instrument's reaction cell.

- The output of the sensor is used by the CPU to calculate the pressure differential between the gas upstream of the reaction cell and the gas downstream from it and is also used as the main diagnostic for proper pump operation.
- If the ratio between the upstream pressure and the downstream pressure falls below 2:1, an Alert is triggered, and the sample flow rate will not display an actual value.
- If this pressure exceeds 10 in-Hg-A, an Rx Press Alert is issued, even though the analyzer will continue to calculate a sample flow up to ~14 in Hg.
- If the Temperature/Pressure Compensation (TPC) feature is turned on (see Section 6.4.2), the output of this sensor is also used to supply pressure data for that calculation.

### 6.2.4.3. SAMPLE GAS FLOW CALCULATION

Sample gas flow in the analyzer is not a directly measured value, but is rather calculated based on the measured pressure differential across the sample gas critical flow orifice. Specifically, the upstream reading of the sample pressure sensor is compared to the downstream pressure reading of the vacuum pressure sensor, and this differential is used by the analyzer's CPU to derive the gas flow rate through the reaction cell.

- The results of this calculation are viewable in the Dashboard and/or in the Home page meter if configured to display Sample Flow. (To configure, see Section 2.5.3 for Dashboard, and Section 2.5.6 for Home page meter).



### 6.2.4.4. O<sub>3</sub> SUPPLY AIR FLOW SENSOR

In contrast to the sample gas flow, the ozone flow is measured with a mass flow sensor, which is mounted on the flow/pressure sensor PCA just behind the PMT sensor assembly. Pneumatically, it lies between the sample dryer and the O<sub>3</sub> generator. This mass flow sensor has a full scale range of 0-1000 cc/min and can be calibrated through software to its span point (Section 4.5).

Since the displayed flow value is an actual measurement (and not a calculated value), short term variability in the measurement may be higher than that of the sample flow, which is based on a calculation from (more stable) differential pressures. On the other hand, any sustained drift, i.e. long-term change, in the ozone flow rate may usually indicate a flow problem.

This information is used to validate the O<sub>3</sub> gas flow rate.

- If the flow rate exceeds  $\pm 15\%$  of the nominal flow rate (80 cc/min), an O3 FLOW message appears in the Alerts page, and the O<sub>3</sub> generator is turned off, triggering a corresponding message in the Alerts page.
- The O3 FLOW parameter shows the value for this flow .

As with all other parameters, we recommend to monitor the ozone flow over time for predictive diagnostics and maintenance evaluation.

## 6.3. ELECTRONIC OPERATION

The electronic platform is based on a Controller Area Network (CAN) bus modular system. CAN is the central networking system that enables communication among all the parts and facilitates centralized diagnoses of errors, as well as configuration of all the parts. CAN bus technology allows for a uniform cable architecture with interchangeable 6-pin connectors configured for power (5 V and 24 V) and communications (CAN high and CAN low serial lines).

The Mainboard is the main hub, which not only contains the Central Processing Unit (CPU) that communicates with other modules, but also directs power and communication distribution. The Mainboard includes an altitude sensor, a temperature sensor, and the Supervisory Chip.

The Supervisory Chip monitors power and the sensors, and when the front panel Soft Power switch is pressed (see Power Switches, Section 6.3.2), the Supervisory Chip directs the soft power down of the internal components, to safely shut down processes and close connections to prevent damage.

### 6.3.1. MODULES

Each module consists of its own board controlled by a microprocessor that receives messages from and sends information to the Mainboard on the CAN network. Depending on the signal line, CAN Low or CAN High, the modules can determine whether a message is intended for them and what the priority is, and then act on the applicable messages. These are called “Smart Modules,” which conduct local operations, such as activating the zero/span valves, toggling the NO<sub>x</sub>/NO<sub>2</sub> valve, or controlling manifold temperature. There is also the Sensor Module; it is comprised of the Optical Bench Unit which has the gas



sensor inside the main oven and the data acquisition (DAQ) board with logic device, microcontroller and LED driver mounted on the outside. The Sensor Module calculates gas concentrations and may command the Smart Modules.

## 6.3.2. POWER SWITCHES

The front panel Soft Power switch should always be used by the operator to power the instrument On and Off. When the instrument is initially powered on, the Supervisory Chip spins up the internal computer components and places them in operational mode (indicated by LED's solid-lit state). However, before powering off the instrument, pressing and momentarily holding the solid-lit Soft Power switch tells the Supervisory Chip to put the internal computer components through a soft-shutdown process and into deep sleep mode (indicated by LED's blinking state).

The rear panel Hard Power switch is used to remove power from the instrument; however, before turning off the instrument, the Soft Power switch must be used first as described above. If there is an unexpected loss of source power while the instrument is running, it will power up in the ON state when source power is restored.

## 6.3.3. PHOTO MULTIPLIER TUBE (PMT)

The analyzers use a photo multiplier tube (Figure 5-18) to detect the amount of chemiluminescence created in the Reaction Cell.

A typical PMT is a vacuum tube containing a variety of specially designed electrodes. Photons from the reaction are filtered by an optical high-pass filter, enter the PMT and strike a negatively charged photo cathode causing it to emit electrons. A high voltage potential across these focusing electrodes directs the electrons toward an array of high voltage dynodes.

The dynodes in this electron multiplier array are designed so that each stage multiplies the number of emitted electrons by emitting multiple, new electrons. The greatly increased numbers of electrons emitted from one end of the electron multiplier are collected by a positively charged anode at the other end, which creates a useable current signal.

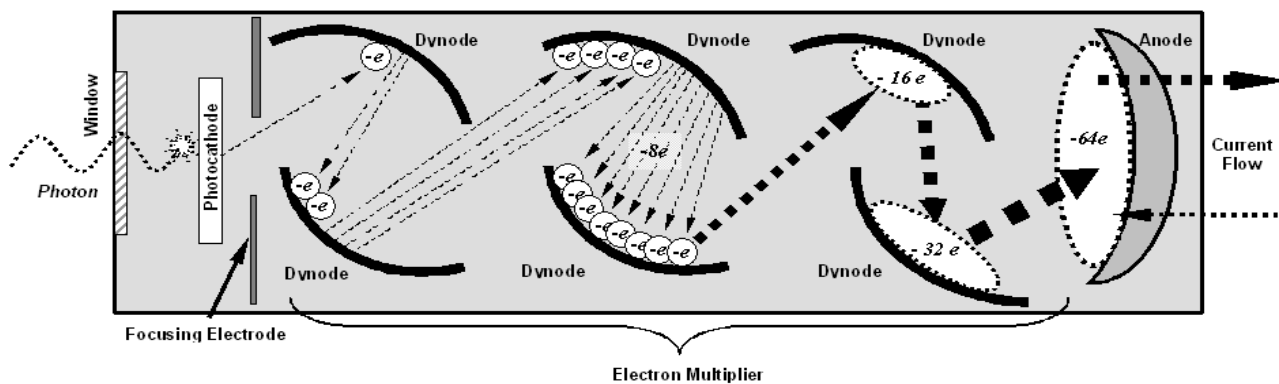


Figure 6-11. Basic PMT Design





## N200, N200M, N200H

A significant performance characteristic of the PMT is the voltage potential across the electron multiplier. The higher the voltage, the greater the number of electrons emitted from each dynode of the electron multiplier, in effect, making the PMT more sensitive and responsive to smaller variations in light intensity, but also more noisy (this is referred to as “dark noise”).

- The gain voltage of the PMT is usually set between 400 V and 800 V.
- This parameter is viewable in the Dashboard as HVPS.
- For information on when and how to set this voltage, see Section 5.7.10.3.

The PMT is housed inside the PMT smart module assembly (see Figure 5-18), which also includes an LED used by the instrument’s optical test function (Section 5.7.9.5), a thermistor that measures the temperature of the PMT and various components of the PMT cooling system including the TEC.

### 6.3.3.1. PMT COOLING SYSTEM

The performance of the analyzer’s PMT is significantly affected by temperature. Variations in PMT temperature are directly reflected in the signal output of the PMT. Also the signal to noise ratio of the PMT output is radically influenced by temperature as well. The warmer the PMT is, the noisier its signal becomes until the noise renders the concentration signal useless.

To alleviate this problem, the instrument uses a special cooling system called a thermo-electric cooler (TEC), which is a solid-state active heat pump that transfers heat from a heat absorbing “cool” side to a heat releasing “hot” side via a series of DC powered semiconductor junctions. The effectiveness of the pump at moving heat away from the cold side is reliant on the amount of current flowing through the semiconductor junctions and how well the heat from the hot side can be removed.

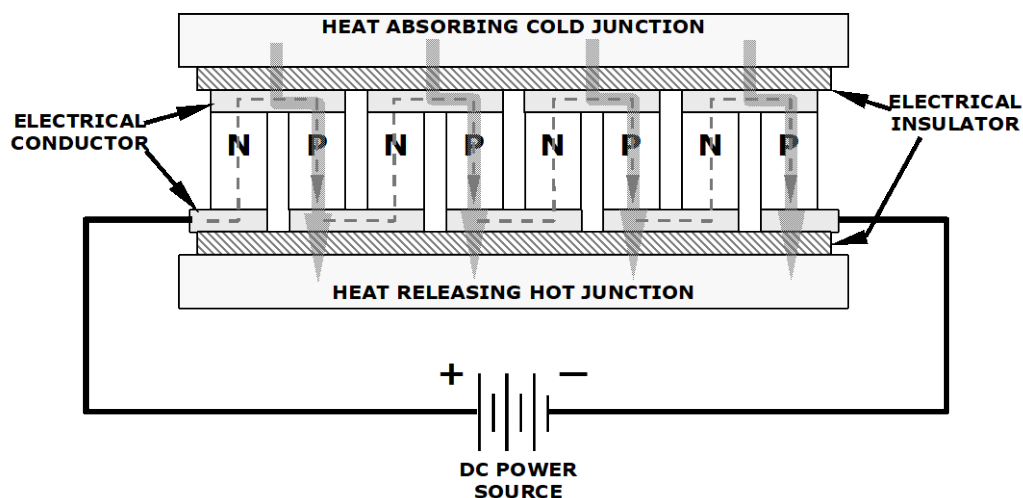


Figure 6-12. Typical Thermo-Electric Cooler

In this case, the current flow is controlled by the PMT PCA which adjusts the amount of current applied to the TEC based on the temperature sensed by a thermistor embedded in



## N200, N200M, N200H

the PMT's cold block. The higher the temperature of the PMT, the more current is pumped through the TEC. The "hot" side of the TEC is cooled by a constant flow of ambient air that is directed across a set of heat sinks by a fan.

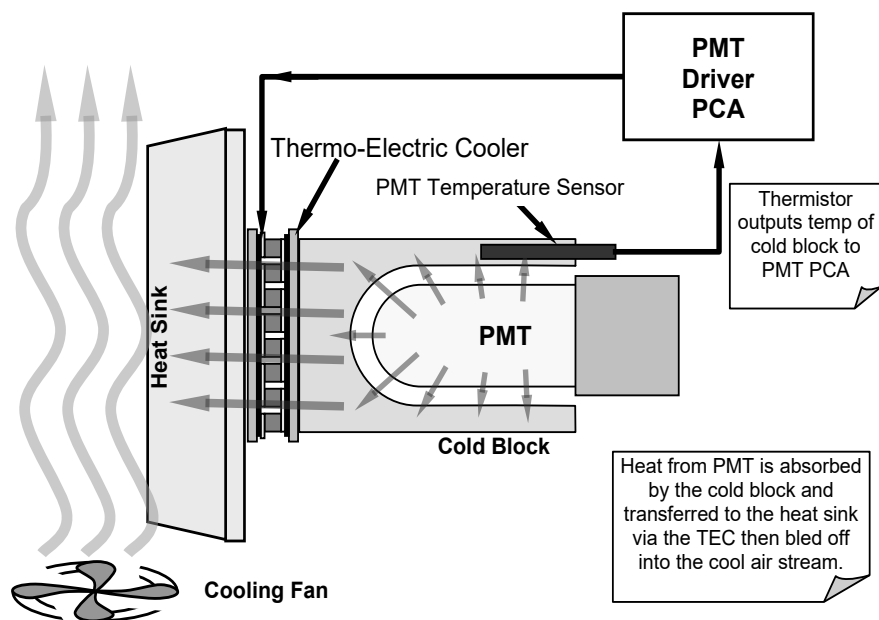


Figure 6-13. PMT Cooling System Block Diagram

The target temperature at which the TEC system keeps the PMT is approximately 8.0°C. Arriving at this temperature may take up to 30 minutes after the instrument is turned on.

The actual temperature of the PMT can be viewed in the Dashboard.

## 6.4. SOFTWARE OPERATION

The NumaView™ software developed by Teledyne API provides the ability to operate the instrument locally and/or remotely and provides diagnostics, real-time graphing, data acquisition with customizable periodic and conditional triggers, and instrument health status reports among other features.

### 6.4.1. ADAPTIVE FILTER

The analyzer software processes sample gas concentration data through a built-in adaptive filter. Unlike other analyzers that average the output signal over a fixed time period, these analyzers average over a defined number of samples. This technique is known as boxcar filtering. During operation, the software may automatically switch between two different filter lengths based on the conditions at hand.

During constant or nearly constant concentrations, the software, by default, computes an average sample value using the long filter. This provides smooth and stable readings and





averages out a considerable amount of random noise for an overall less noisy concentration reading.

If the filter detects rapid changes in concentration, the filter reduces its size thus allowing the analyzer to respond more quickly. Two conditions must be simultaneously met to switch to the short filter. First, the instantaneous concentration must differ from the average in the long filter by an absolute amount. Second, the instantaneous concentration must differ from the average in the long filter by at least a set percentage of the average in the long filter.

### 6.4.2. TEMPERATURE/PRESSURE COMPENSATION (TPC)

The software includes a feature that compensates for some temperature and pressure changes that might affect measurement of NO and NO<sub>x</sub> concentrations.

When the TPC feature is enabled (default setting), the analyzer divides the value of the PMT output signal (PMT Signal) by a value called TP\_FACTOR, which is calculated using the following four parameters:

- Box Temp: The temperature inside the analyzer's case measured in K. This is typically about 5 K higher than room temperature.
- Rx Cell Temp: The temperature of the reaction cell, measured in K.
- Rx Cell Press: The pressure of the gas in the vacuum manifold, measured in in-Hg-A.
- Sample Press: The pressure of the sample gas before it reaches the reaction cell, measured in in-Hg-A. This measurement is ~1 in-Hg-A lower than atmospheric pressure.

As Rx Cell Temp, Box Temp, Rx Cell Press and Sample Press increase, the value of TP\_FACTOR increases and, hence, the PMT Signal value decreases. These adjustments are meant to counteract changes in the concentrations caused by these parameters.

- The current value of each of these measurements is viewable in the editable Dashboard (see Sections 2.4.2 and 2.5.3).
- The preset gain parameters are set at the factory and may vary from analyzer to analyzer. The TPC feature is enabled or disabled by setting the value of the variable TPC Enable in the Setup>Vars menu. (see Section 2.5.5).

### 6.4.3. CALIBRATION - SLOPE AND OFFSET

Calibration of the analyzer is performed exclusively in the software. During instrument calibration, (see Section 4) the user enters expected values for zero and span via the front panel touchscreen control and commands the instrument to make readings of calibrated sample gases for both levels.

- The readings taken are adjusted, linearized and compared to the expected values.
- With this information, the software computes values for instrument slope and offset and stores these values in memory for use in calculating the NO<sub>x</sub>, NO and NO<sub>2</sub> concentrations of the sample gas.

The instrument slope and offset values recorded during the last calibration can be viewed in the Dashboard.



## GLOSSARY

| TERM   | DESCRIPTION/DEFINITION   |
|--|--|
| 10BaseT  | an Ethernet standard that uses twisted ("T") pairs of copper wires to transmit at 10 megabits per second (Mbps)  |
| 100BaseT   | same as 10BaseT except ten times faster (100 Mbps)   |
| APICOM   | name of a remote control program offered by Teledyne-API to its customers  |
| ASSY   | <i>Assembly</i>  |
| CAS  | <i>Code-Activated Switch</i>   |
| CD   | <i>Corona Discharge</i> , a frequently luminous discharge, at the surface of a conductor or between two conductors of the same transmission line, accompanied by ionization of the surrounding atmosphere and often by a power loss          |
| CE   | <i>Converter Efficiency</i> , the percentage of the total amount that is actually converted (e.g., light energy into electricity; NO <sub>2</sub> into NO, etc.)   |
| CEM  | <i>Continuous Emission Monitoring</i>  |
| Chemical elements that may be included in this document: |  |
| CO <sub>2</sub>  | carbon dioxide   |
| C <sub>3</sub> H <sub>8</sub>                            | propane  |
| CH <sub>4</sub>  | methane  |
| H <sub>2</sub> O   | water vapor  |
| HC   | general abbreviation for hydrocarbon   |
| HNO <sub>3</sub>   | nitric acid  |
| H <sub>2</sub> S   | hydrogen sulfide   |
| NO   | nitric oxide   |
| NO <sub>2</sub>  | nitrogen dioxide   |
| NO <sub>x</sub>  | nitrogen oxides, here defined as the sum of NO and NO <sub>2</sub>   |
| NO <sub>y</sub>  | nitrogen oxides, often called odd nitrogen: the sum of NO <sub>x</sub> plus other compounds such as HNO <sub>3</sub> (definitions vary widely and may include nitrate (NO <sub>3</sub> ), PAN, N <sub>2</sub> O and other compounds as well) |
| NH <sub>3</sub>  | ammonia  |
| O <sub>2</sub>   | molecular oxygen   |
| O <sub>3</sub>   | ozone  |
| SO <sub>2</sub>  | sulfur dioxide   |
| cm <sup>3</sup>  | metric abbreviation for <i>cubic centimeter</i> (replaces the obsolete abbreviation "cc")  |
| CPU  | <i>Central Processing Unit</i>   |
| DAC  | <i>Digital-to-Analog Converter</i>   |
| DAS  | <i>Data Acquisition System</i>   |
| DCE  | <i>Data Communication Equipment</i>  |
| DFU  | <i>Disposable Filter Unit</i>  |
| DHCP   | <i>Dynamic Host Configuration Protocol</i> . A protocol used by LAN or Internet servers to automatically set up the interface protocols between themselves and any other addressable device connected to the network                         |
| DOM  | <i>Disk On Module</i> , a 44-pin IDE flash drive with up to 128MB storage capacity for instrument's firmware, configuration settings and data  |
| DOS  | <i>Disk Operating System</i>   |
| DRAM   | <i>Dynamic Random Access Memory</i>  |
| DR-DOS   | <i>Digital Research DOS</i>  |



## N200, N200M, N200H

| TERM                 | DESCRIPTION/DEFINITION  |
|----------------------|---|
| DTE                  | <i>Data Terminal Equipment</i>  |
| EEPROM               | <i>Electrically Erasable Programmable Read-Only Memory</i> also referred to as a FLASH chip or drive  |
| ESD                  | <i>Electro-Static Discharge</i>   |
| ETEST                | <i>Electrical Test</i>  |
| Ethernet             | a standardized (IEEE 802.3) computer networking technology for local area networks (LANs), facilitating communication and sharing resources   |
| FEP                  | <i>Fluorinated Ethylene Propylene</i> polymer, one of the polymers that Du Pont markets as <i>Teflon</i> <sup>®</sup>   |
| Flash                | non-volatile, solid-state memory  |
| FPI                  | <i>Fabry-Perot Interface</i> : a special light filter typically made of a transparent plate with two reflecting surfaces or two parallel, highly reflective mirrors   |
| GFC                  | <i>Gas Filter Correlation</i>   |
| I <sup>2</sup> C bus | a clocked, bi-directional, serial bus for communication between individual analyzer components  |
| IC                   | <i>Integrated Circuit</i> , a modern, semi-conductor circuit that can contain many basic components such as resistors, transistors, capacitors, etc., in a miniaturized package used in electronic assemblies   |
| IP                   | <i>Internet Protocol</i>  |
| IZS                  | <i>Internal Zero Span</i>   |
| LAN                  | <i>Local Area Network</i>   |
| LCD                  | <i>Liquid Crystal Display</i>   |
| LED                  | <i>Light Emitting Diode</i>   |
| LPM                  | <i>Liters Per Minute</i>  |
| MFC                  | <i>Mass Flow Controller</i>   |
| M/R                  | <i>Measure/Reference</i>  |
| NDIR                 | <i>Non-Dispersive Infrared</i>  |
| MOLAR MASS           | <p>the mass, expressed in grams, of 1 mole of a specific substance. Conversely, one mole is the amount of the substance needed for the molar mass to be the same number in grams as the atomic mass of that substance.</p> <p>EXAMPLE: The atomic weight of Carbon is 12 therefore the molar mass of Carbon is 12 grams. Conversely, one mole of carbon equals the amount of carbon atoms that weighs 12 grams.</p> <p>Atomic weights can be found on any Periodic Table of Elements.</p> |
| NDIR                 | <i>Non-Dispersive Infrared</i>  |
| NIST-SRM             | <i>National Institute of Standards and Technology - Standard Reference Material</i>   |
| PC                   | <i>Personal Computer</i>  |
| PCA                  | <i>Printed Circuit Assembly</i> , the PCB with electronic components, ready to use  |
| PC/AT                | <i>Personal Computer / Advanced Technology</i>  |
| PCB                  | <i>Printed Circuit Board</i> , the bare board without electronic component  |
| PFA                  | <i>Per-Fluoro-Alkoxy</i> , an inert polymer; one of the polymers that <i>Du Pont</i> markets as <i>Teflon</i> <sup>®</sup>  |
| PLC                  | <i>Programmable Logic Controller</i> , a device that is used to control instruments based on a logic level signal coming from the analyzer  |
| PLD                  | <i>Programmable Logic Device</i>  |
| PLL                  | <i>Phase Lock Loop</i>  |



## N200, N200M, N200H

| TERM        | DESCRIPTION/DEFINITION  |
|-------------|---|
| PMT         | <i>Photo Multiplier Tube</i> , a vacuum tube of electrodes that multiply electrons collected and charged to create a detectable current signal  |
| P/N (or PN) | <i>Part Number</i>  |
| PSD         | <i>Prevention of Significant Deterioration</i>  |
| PTFE        | <i>Poly-Tetra-Fluoro-Ethylene</i> , a very inert polymer material used to handle gases that may react on other surfaces; one of the polymers that <i>Du Pont</i> markets as <i>Teflon</i> <sup>®</sup>    |
| PVC         | <i>Poly Vinyl Chloride</i> , a polymer used for downstream tubing   |
| Rdg         | Reading   |
| RS-232      | specification and standard describing a serial communication method between DTE (Data Terminal Equipment) and DCE (Data Circuit-terminating Equipment) devices, using a maximum cable-length of 50 feet   |
| RS-485      | specification and standard describing a binary serial communication method among multiple devices at a data rate faster than RS-232 with a much longer distance between the host and the furthest device  |
| SAROAD      | <i>Storage and Retrieval of Aerometric Data</i>   |
| SLAMS       | <i>State and Local Air Monitoring Network Plan</i>  |
| SLPM        | <i>Standard Liters Per Minute</i> of a gas at standard temperature and pressure   |
| STP         | <i>Standard Temperature and Pressure</i>  |
| TCP/IP      | <i>Transfer Control Protocol / Internet Protocol</i> , the standard communications protocol for Ethernet devices  |
| TEC         | <i>Thermal Electric Cooler</i>  |
| TPC         | <i>Temperature/Pressure Compensation</i>  |
| USB         | <i>Universal Serial Bus</i> : a standard connection method to establish communication between peripheral devices and a host controller, such as a mouse and/or keyboard and a personal computer or laptop |
| VARS        | <i>Variables</i> , the variable settings of the instrument  |
| V-F         | <i>Voltage-to-Frequency</i>   |
| Z/S         | <i>Zero / Span</i>  |



## APPENDIX A – MODBUS REGISTERS

| ADDRESS                | TAG                               | DESCRIPTION   |
|------------------------|-----------------------------------|---|
| <b>Discrete Inputs</b> |                                   |   |
| 0                      | MANIFOLD_TEMP_WARN                | Indicates status of Manifold temperature warning      |
| 1                      | CONVERTER_TEMP_WARN               | Indicates status of Converter temperature warning     |
| 2                      | AUTO_ZERO_WARN                    | Indicates status of Auto zero                         |
| 3                      | BOX_TEMP_WARN                     | Indicates status of box temperature warning           |
| 4                      | PMT_TEMP_WARN                     | Indicates status of PMT_TEMP_WARNING                  |
| 5                      | RCELL_TEMP_WARN                   | Indicates status of RCELL_TEMP_WARNING                |
| 6                      | SAMPLE_FLOW_WARN                  | Indicates status of sample flow warning               |
| 7                      | O3_FLOW_WARN                      | Indicates status of Ozone flow warning                |
| 8                      | RCELL_PRESS_WARN                  | Indicates status of reaction cell pressure warning    |
| 9                      | HVPS_WARN                         | Indicates status of HVPS warning                      |
| 10                     | SYS_WARN_RESET                    | Indicates status of system reset warning              |
| 11                     | SYS_WARN__REARBOARD               | Indicates status of rear board communication warning  |
| 12                     | SYS_WARN_RELAYBOARD               | Indicates status of relay board communication warning |
| 13                     | SYS_WARN_FRONT_PANEL              | Indicates status of front panel communication warning |
| 14                     | SYS_WARN_ANALOG_CAL               | Indicates status of analog calibration warning        |
| 15                     | DYN_ZERO_WARN                     | Indicates status of dynamic zero warning              |
| 16                     | DYN_SPAN_WARN                     | Indicates status of dynamic span warning              |
| 17                     | ASF_INVALID_CONCENTRATION_WARNING | Indicates concentration invalid                       |
| 18                     | ASF_CAL_ZERO_ACTIVE               | Indicates zero calibration active                     |
| 19                     | ASF_CAL_SPAN_ACTIVE               | Indicates span calibration active                     |
| 20                     | ASF_CALIBRATION_MULTIPOINT        | Indicates multi-point calibration active              |
| 21                     | SYS_OK_WARN                       | Indicates system is OK                                |
| 22                     | O3_GEN_WARN                       | Indicates status of Ozone generator warning           |
| 23                     | IZS_BLOCK_TEMP_WARN               | Indicates status of IZS temperature warning           |
| 24                     | ASF_CAL_LOW_SPAN_ACTIVE           | Indicates low span calibration active                 |
| 25                     | ASF_CONC_ALARM_1                  | Indicates NO concentration alarm limit 1 exceeded     |
| 26                     | ASF_CONC_ALARM_2                  | Indicates NO concentration alarm limit 2 exceeded     |
| 27                     | ASF_NO2_CONC_ALARM_1              | Indicates NO2 concentration alarm limit 1 exceeded    |
| 28                     | ASF_NO2_CONC_ALARM_2              | Indicates NO2 concentration alarm limit 2 exceeded    |
| 29                     | ASF_NOX_CONC_ALARM_1              | Indicates NOX concentration alarm limit 1 exceeded    |
| 30                     | ASF_NOX_CONC_ALARM_2              | Indicates NOX concentration alarm limit 2 exceeded    |
| 31                     | SYS_WARN_ACAL1_CAL_FAIL           | Indicates Auto-Cal Seq 1 failed                       |
| 32                     | SYS_WARN_ACAL2_CAL_FAIL           | Indicates Auto-Cal Seq 2 failed                       |
| 33                     | SYS_WARN_ACAL3_CAL_FAIL           | Indicates Auto-Cal Seq 3 failed                       |
| <b>Coils</b>           |                                   |   |
| 20                     | MB_ZERO_CAL_RANGE1                | Trigger zero calibration of NOx range 1               |
| 21                     | MB_SPAN_CAL_RANGE1                | Trigger span calibration of NOx range 1               |
| 22                     | MB_ZERO_CAL_RANGE2                | Trigger zero calibration of NOx range 2               |
| 23                     | MB_SPAN_CAL_RANGE2                | Trigger span calibration of NOx range 2               |



## N200, N200M, N200H

### Input Registers

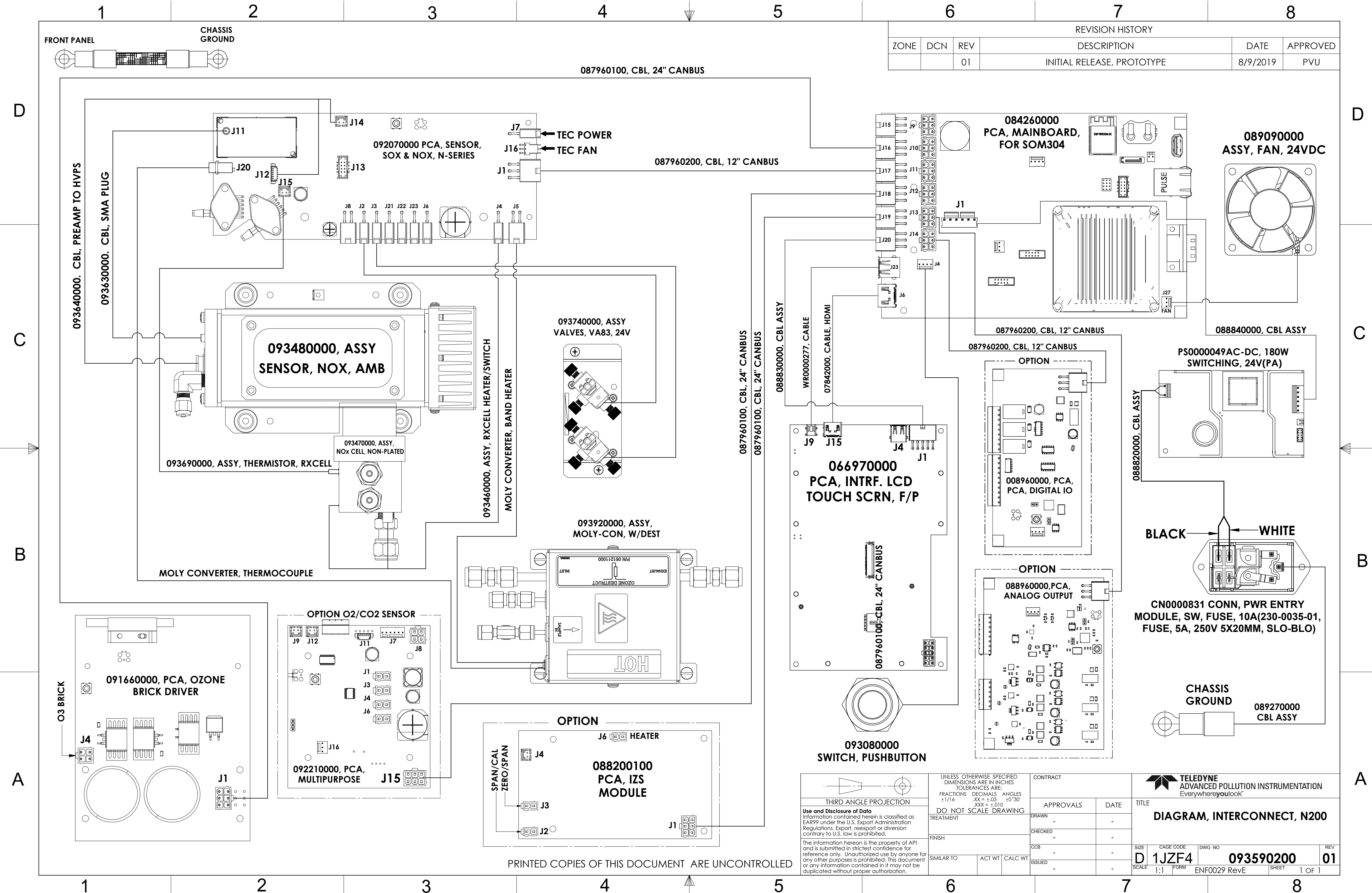
|     |                    |  |
|-----|--------------------|--|
| 0   | AI_PMT_NO          | PMT Detector Reading for NO in mV                          |
| 2   | NOX_SLOPE1         | NOX slope for range 1                                      |
| 4   | NOX_SLOPE2         | NOX slope for range 2                                      |
| 6   | NO_SLOPE1          | NO slope for range 1                                       |
| 8   | NO_SLOPE2          | NO slope for range 2                                       |
| 18  | NOX_PRE_CAL_CONC_1 | NOX concentration for range 1 during zero/span calibration |
| 20  | NOX_PRE_CAL_CONC_2 | NOX concentration for range 2 during zero/span calibration |
| 22  | NO_PRE_CAL_CONC_1  | NO concentration for range 1 during zero/span calibration  |
| 24  | NO_PRE_CAL_CONC_2  | NO concentration for range 2 during zero/span calibration  |
| 26  | NO2_PRE_CAL_CONC_1 | NO2 concentration for range 1 during zero/span calibration |
| 28  | NO2_PRE_CAL_CONC_2 | NO2 concentration for range 2 during zero/span calibration |
| 30  | NOX_CONC           | NOX concentration for range 1                              |
| 32  | NOX_CONC_2         | NOX concentration for range 2                              |
| 34  | NO_CONC            | NO concentration for range 1                               |
| 36  | NO_CONC_2          | NO concentration for range 2                               |
| 38  | NO2_CONC           | NO2 concentration for range 1                              |
| 40  | NO2_CONC_2         | NO2 concentration for range 2                              |
| 42  | NOX_STABILITY      | Concentration stability                                    |
| 44  | AUTO_ZERO_OFFSET   | Auto zero offset   |
| 46  | AI_O3_FLOW         | Ozone flow rate in CCM                                     |
| 48  | AI_RCELL_PRESSURE  | Reaction cell pressure in In.Hg                            |
| 50  | AI_RCELL_TEMP      | Reaction cell temperature in degrees C                     |
| 54  | SV_CONV_EFF_1A     | Converter efficiency factor for range 1                    |
| 56  | SV_CONV_EFF_2A     | Converter efficiency factor for range 2                    |
| 58  | AI_CONVERTER_TEMP  | Converter temperature in mV                                |
| 60  | AI_PMT_TEMP        | PMT temperature in mV                                      |
| 62  | AI_SAMPLE_FLOW     | Sample flow in CCM   |
| 64  | AI_SAMPLE_PRESSURE | Sample pressure in In.Hg                                   |
| 66  | AI_BOX_TEMP        | Box temp in degrees C                                      |
| 78  | AI_IZS_BLOCK_TEMP  | IZS temperature  |
| 84  | AI_PMT_NOX         | PMT Detector Reading for NOX                               |
| 86  | AI_PMT_NO          | PMT Detector Reading for NO                                |
| 200 | O2_CONC            | O2 concentration for range 1                               |
| 204 | O2_SLOPE1          | O2 slope for range 1                                       |
| 206 | O2_OFFSET1         | O2 Offset for range 1                                      |

### Holding Registers

|     |                        |   |
|-----|------------------------|---|
| 0   | NOX_TARGET_SPAN_CONC_1 | NOX span target concentration for range 1 |
| 2   | NO_TARGET_SPAN_CONC_1  | NO span target concentration for range 1  |
| 4   | NOX_TARGET_SPAN_CONC_2 | NOX span target concentration for range 2 |
| 6   | NO_TARGET_SPAN_CONC_2  | NO span target concentration for range 2  |
| 200 | O2_TARGET_SPAN_CONC_1  | O2 span target concentration              |



APPENDIX B - N200 Interconnects

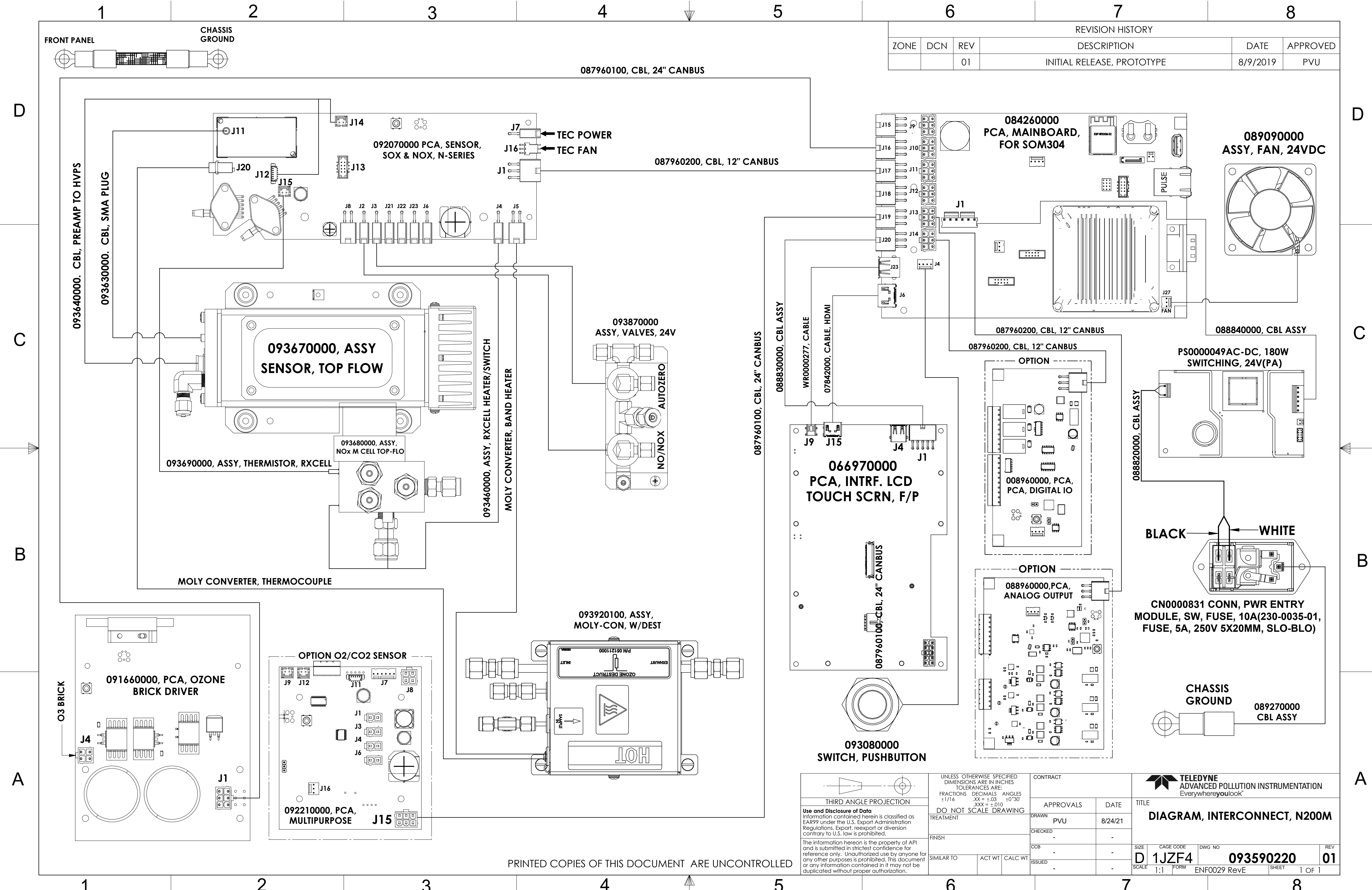


| REVISION HISTORY |     |     |                            |          |          |
|------------------|-----|-----|----------------------------|----------|----------|
| ZONE             | DCN | REV | DESCRIPTION                | DATE     | APPROVED |
|                  |     | 01  | INITIAL RELEASE, PROTOTYPE | 8/9/2019 | PVU      |

|  |  |           |              |
|--|--|-----------|--------------|
| <p>THIRD ANGLE PROJECTION</p>  | <p>UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ±1/16 ±.03 ±0°30' ±.010</p> <p>DO NOT SCALE DRAWING</p> | CONTRACT  |              |
|  |  | APPROVALS | DATE         |
| <p>Use and Disclosure of Data</p> <p>Information contained herein is classified as EAR99 under the U.S. Export Administration Regulations. Export, reexport or diversion contrary to U.S. law is prohibited.</p> <p>The information hereon is the property of API and is submitted in strictest confidence for reference only. Unauthorized use by anyone for any other purposes is prohibited. This document or any information contained in it may not be duplicated without proper authorization.</p> | TREATMENT  | DRAWN     |              |
|  | FINISH   | CHECKED   |              |
| SIMILAR TO   | ACT WT   | CALC WT   | ISSUED       |
| <p>TELEDYNE<br/>ADVANCED POLLUTION INSTRUMENTATION<br/>Everywhere you look</p>   |  | TITLE     |              |
| <p>DIAGRAM, INTERCONNECT, N200</p>   |  | SIZE      | REV          |
| D  | 1JZF4  | DWG NO    | 093590200    |
| SCALE  | 1:1  | FORM      | ENF0029 RevE |
| SHEET  |  | 1 OF 1    |              |

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APPENDIX B - N200M Interconnects

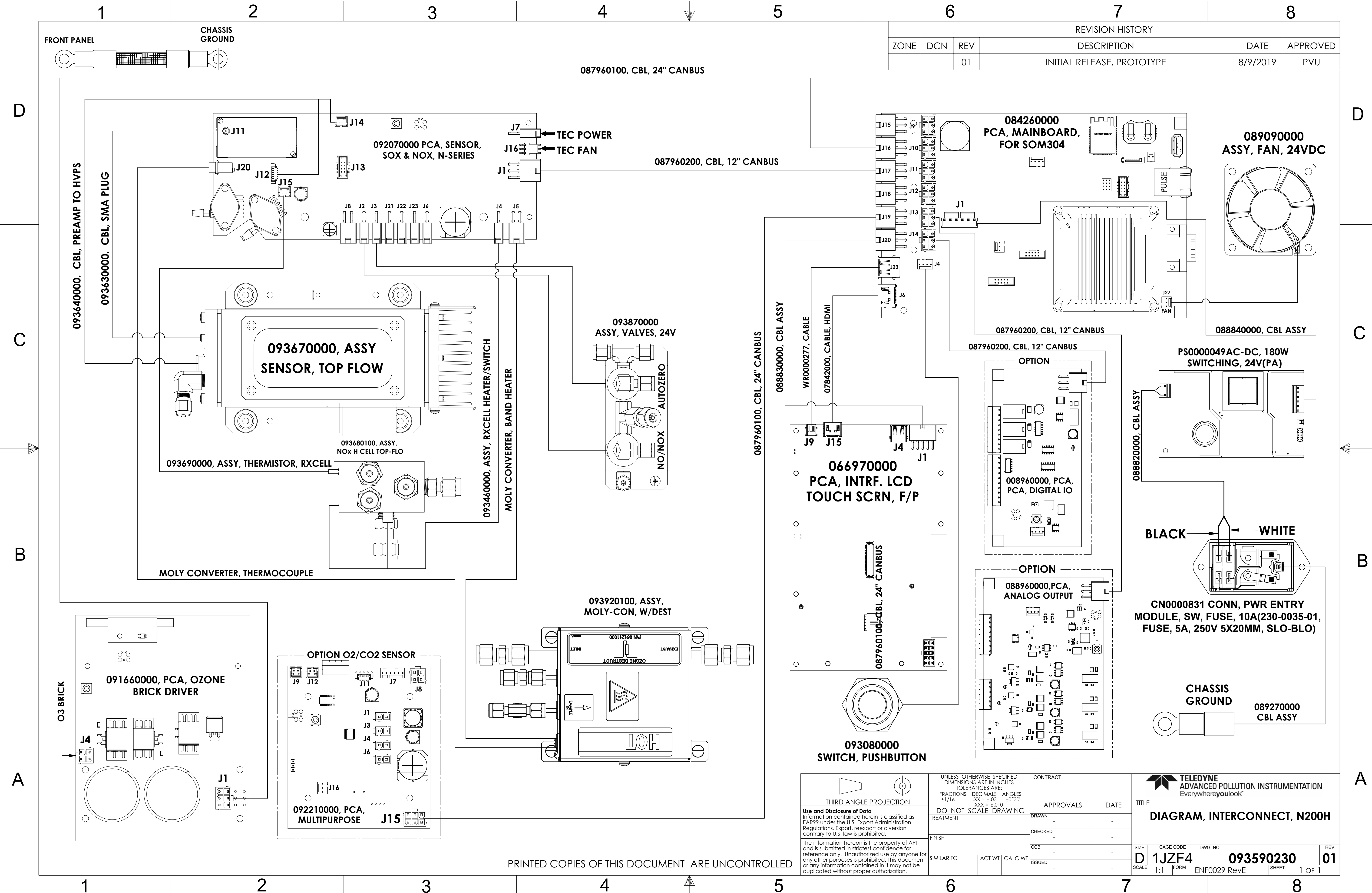


| REVISION HISTORY |     |     |                            |          |          |
|------------------|-----|-----|----------------------------|----------|----------|
| ZONE             | DCN | REV | DESCRIPTION                | DATE     | APPROVED |
|                  |     | 01  | INITIAL RELEASE, PROTOTYPE | 8/9/2019 | PVU      |

|   |   |  |  |                        |   |           |
|---|---|--|--|------------------------|---|-----------|
| <p>THIRD ANGLE PROJECTION</p>   | UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN INCHES<br>TOLERANCES ARE:<br>FRACTIONS DECIMALS ANGLES<br>±1/16 ±.03 ±0°30'<br>.XXX ±.010 |  | CONTRACT<br>APPROVALS<br>DATE<br>8/24/21 |                        | <p>TELEDYNE<br/>ADVANCED POLLUTION INSTRUMENTATION<br/>Everywhereyoulook®</p> |           |
|   | DO NOT SCALE DRAWING  |  | TITLE<br>DIAGRAM, INTERCONNECT, N200M    |                        |   |           |
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APPENDIX B - N200H Interconnects



| REVISION HISTORY |     |     |                            |          |          |
|------------------|-----|-----|----------------------------|----------|----------|
| ZONE             | DCN | REV | DESCRIPTION                | DATE     | APPROVED |
|                  |     | 01  | INITIAL RELEASE, PROTOTYPE | 8/9/2019 | PVU      |

|                        |   |          |           |      |
|------------------------|---|----------|-----------|------|
| THIRD ANGLE PROJECTION | UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ±1/16 .03 ±0°30' .010 ±0.10 | CONTRACT | APPROVALS | DATE |
| DO NOT SCALE DRAWING   | TREATMENT   | DRAWN    | CHECKED   |      |
| FINISH                 | ISSUED  | CCB      |           |      |
| SIMILAR TO             | ACT WT  | CALC WT  |           |      |

|  |              |  |              |
|--|--------------|--|--------------|
| <br>ADVANCED POLLUTION INSTRUMENTATION<br>Everywhereyoulook® |              | TITLE<br><b>DIAGRAM, INTERCONNECT, N200H</b> |              |
| SIZE   | CAGE CODE    | DWG NO                                       | REV          |
| <b>D</b>   | <b>1JZF4</b> | <b>093590230</b>                             | <b>01</b>    |
| SCALE  | FORM         | ENF0029 RevE                                 | SHEET 1 OF 1 |

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