



TELEDYNE API
Everywhere you look™



User Manual

Models N100, N100H
UV Fluorescence SO₂ Analyzers



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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.



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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: 800-324-5190
Email: 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.



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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).

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.



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ABOUT THIS MANUAL

Support manuals, such as Fundamentals of Electro-Static Discharge (ESD), PN 04786, and NumaView™ Remote, PN 04892, 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.



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1. INTRODUCTION, SPECIFICATIONS, APPROVALS, & COMPLIANCE

The Teledyne API Models N100 and N100H (high range) UV Fluorescence SO₂ Analyzers are microprocessor controlled analyzers that determine the concentration of sulfur dioxide (SO₂), in a sample gas drawn through the instrument's sample chamber where it is exposed to ultraviolet light, which causes any SO₂ present to fluoresce. The instrument measures the amount of fluorescence to determine the amount of SO₂ present in the sample gas. The N100 model is typically used in monitoring ambient air quality, while the N100H model has applications in continuous emission monitoring systems in industrial settings.

These models' exceptional stability is achieved with the use of a continuously pulsing UV lamp whose intensity fluctuations are automatically managed in real-time with reference readings captured during the light and dark cycles. Additionally, an advanced optical design combined with a special scrubber, called a "kicker" (option in the N100H) that removes hydrocarbons (which fluoresce similarly to SO₂), to prevent inaccuracies caused by interferences.

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.



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1.1. SPECIFICATIONS

Table 1-1. Specifications

| PARAMETER | SPECIFICATION | |
|---|--|---|
| | N100 | N100H |
| Measurement Units | ppb, ppm, $\mu\text{g}/\text{m}^3$, mg/m^3 (selectable) | ppm, mg/m^3 (selectable) |
| Response Time | < 120 seconds to 95% | < 40 seconds to 95% |
| Min/Max Range (Physical Analog Output) | Min: 0-50 ppb Full Scale Max: 0-20,000 ppb Full Scale (selectable, dual range supported) | Min: 0-10 ppm Full Scale Max: 0-5,000 ppm Full Scale |
| Sample Flow Rate | 650 cc/min \pm 10% | 700 cc/min \pm 10% |
| Zero Noise | < 0.2 ppb (RMS) | < 0.1 ppm (RMS) |
| Span Noise | < 0.5% of reading (RMS) above 50 ppb | < 1% of reading (RMS) above 10 ppm |
| Lower Detectable Limit | < 0.4 ppb | < 0.2 ppm |
| Precision | 0.5% of reading above 50 ppb | 0.5% of reading above 10 ppm |
| Linearity | 1% of full scale | 1% of full scale |
| Zero Drift | < 0.5 ppb/24 hours | < 1 ppm/24 hours |
| Span Drift | < 0.5% of Full Scale/24 hours | < 0.5% of Full Scale/24 hours |
| AC Power | Rating / Typical Power Consumption 100-240 V, 50/60 Hz, 3.0 A / 55 W 100-240 V, 50/60 Hz, 3.0 A / 145 W | |
| External Pump | Refer to External Pump Pack Manual PN 079000000 for external pump specifications | |
| Recorder Offset | \pm 10% | |
| Standard I/O | 1 Ethernet: TCP/IP 1 RS-232 2 front panel USB device ports | |
| Optional I/O | Universal Analog Output Board (all user-definable): 4 x isolated voltage outputs (5 V, 10 V) 3 x individually isolated current outputs (4-20 mA) Digital I/O Expansion Board includes: 3 x isolated digital input controls (fixed) 5 x isolated digital output controls (user-definable) 3 x form C relay alarm outputs (user-definable) | |
| Dimensions H x W x D | 7" x 17" x 24.3" (178mm x 432 mm x 617 mm) | |
| Weight | 31 lbs (14 kg) | 28 lbs (12.7 kg); ext. pump 21 lbs (9.5 kg) |
| Operating Temperature Range | 0 - 45 °C (with US EPA Approval) | |
| Humidity Range | 0-95% RH non-condensing | |
| Environmental Conditions | Installation Category (Over voltage Category) II Pollution Degree 2 Intended for Indoor Use Only at Altitudes \leq 2000m | |

All specifications are based on constant conditions.

Table 1-2. O₂ Sensor Option Specifications

| PARAMETER | DESCRIPTION |
|-------------------------------------|---|
| Ranges | 0-1% to 0-100% user selectable. Dual ranges and auto-ranging supported. |
| Zero Noise ¹ | <0.02% O ₂ |
| Lower Detectable Limit ² | <0.04% O ₂ |
| Zero Drift (24 hours) ³ | <± 0.02% O ₂ |
| Zero Drift (7 days) | <± 0.05% O ₂ |
| Span Noise ¹ | <± 0.05% O ₂ |
| Span Drift (7 days) | <± 0.1% O ₂ |
| Accuracy | (intrinsic error) <± 0.1% O ₂ |
| Linearity | <± 0.1 % O ₂ |
| Temp Coefficient | <± 0.05% O ₂ /°C, |
| Rise and Fall Time | <60 seconds to 95% |

¹ As defined by the USEPA

² Defined as twice the zero noise level by the USEPA

³ Note: zero drift is typically <± 0.1% O₂ during the first 24 hrs of operation

Table 1-3. CO₂ Sensor Option Specifications

| PARAMETER | DESCRIPTION |
|-------------------------------------|--|
| Ranges | 0-1% to 0-20% user selectable. Dual ranges and auto-ranging supported. |
| Zero Noise ¹ | <0.02% CO ₂ |
| Zero Drift (24 hours) | <± 0.02% CO ₂ |
| Zero Drift (7 days) | <± 0.05% CO ₂ |
| Span Noise ¹ | <± 0.1% CO ₂ |
| Span Drift (7 days) | <± 0.1% CO ₂ |
| Lower Detectable Limit ² | <0.04% CO ₂ |
| Accuracy | <± (0.02% CO ₂ + 2% of reading) |
| Linearity | <± 0.1% CO ₂ |
| Temperature Coefficient | <± 0.01% CO ₂ /°C |
| Rise and Fall Time | <60 seconds to 95% |

¹ As defined by the USEPA

² Defined as twice the zero noise level by the USEPA

1.2. EPA DESIGNATION

Teledyne API's Model N100 Fluorescent SO₂ Analyzer is officially designated as US EPA Federal Equivalent Method Number EQSA-0495-100 for sulfur dioxide measurement. The official List of Designated Reference and Equivalent Methods is published in the U.S. Federal Register, which specifies the instrument's settings and configurations.



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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.



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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 side-panel screws that hold the cover in place.
 - 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

This Section illustrates the front and rear panels 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).

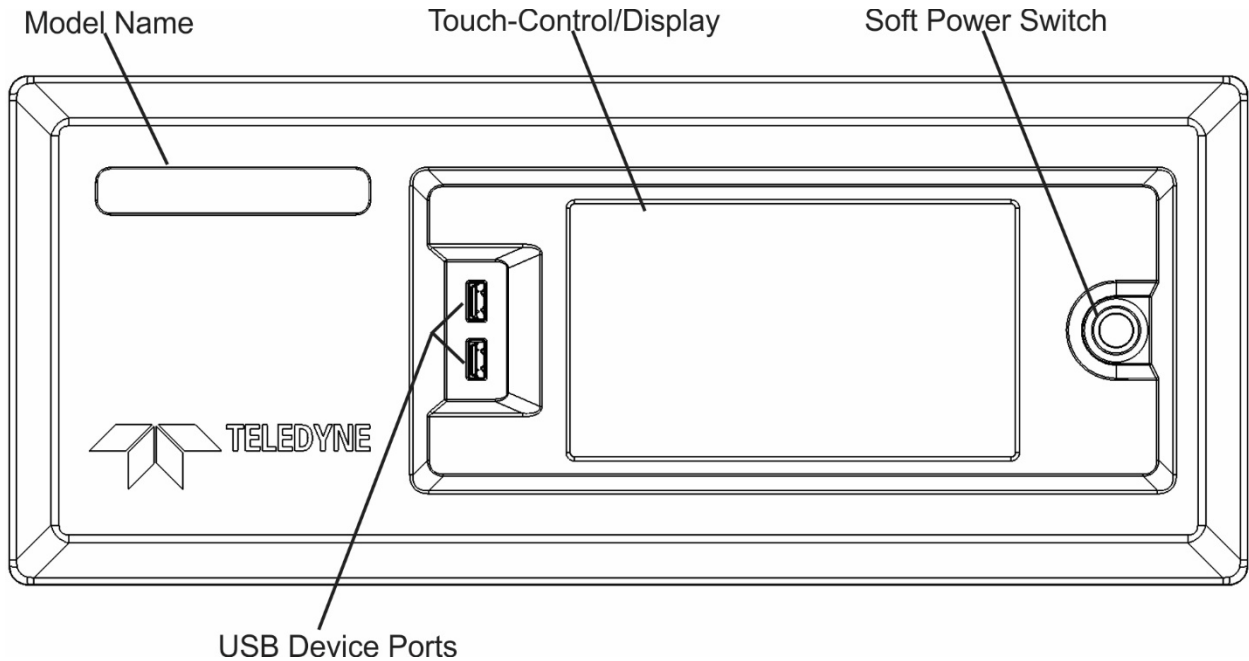


Figure 2-1. Front Panel Layout

2.2.1. REAR PANEL

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

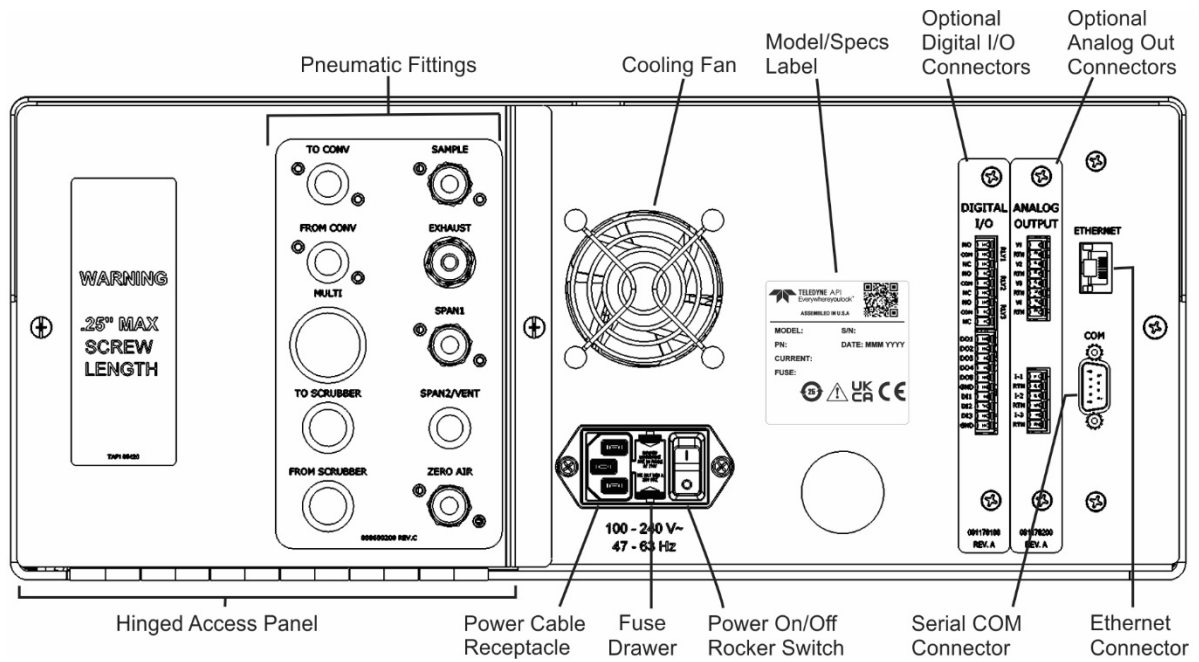



Figure 2-2. Rear Panel Layout, Base Unit (options include additional pneumatic port fixtures)



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Table 2-2. Rear Panel Description

| COMPONENT | FUNCTION |
|---|--|
| TO CONV | (not used in this model) |
| FROM CONV | (not used in this model) |
| SAMPLE | Connect a gas line from the source of sample gas here. Calibration gases can also enter here on units without valve options installed. |
| EXHAUST | T100: 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. T100H: Connect ¼" PTFE tubing from here to external pump's inlet port, and not more than 10 meters long from pump's outlet port to outside the shelter or immediate area surrounding the instrument. |
| SPAN1 (option) | On units with zero/span valve option installed, connect a gas line to the source of calibrated span gas here. |
| SPAN2/VENT (option) | Used as a second cal gas input line when instrument is configured with zero/span valves and a dual gas option, or as a cal gas vent line when instrument is configured with a pressurized span option (<i>Call factory for details</i>). |
| ZERO AIR (with valve option) | On units with zero/span valve option installed, attach a gas line to the source of zero air here. In the N100 only, if a permeation oven, also known as internal zero/span valve (IZS), option is installed attach the zero air scrubber here. |
| Cooling fan | Pulls ambient air into chassis through side vents and exhausts through rear (software-controlled to Box Temp setpoint). |
| Model/specs label | Identifies the analyzer model number and provides power specs. |
|  | Power cable connector Connector for three-prong cord to apply AC power to the analyzer CAUTION! The cord's power specifications (specs) MUST comply with the power specs on the analyzer's rear panel label |
| | Power On/Off Switch Rocker switch to power unit on or off. CAUTION! Prior to powering OFF, use front panel button for preliminary internal "soft" power-down to protect against data loss. |
| Fuse drawer | For circuit protection |
| DIGITAL I/O (option) | For remotely activating the zero and span calibration modes. |
| ANALOG OUT (option) | For voltage or current loop outputs to a strip chart recorder and/or a data logger. |
| ETHERNET | Connector for network or Internet remote communication, using Ethernet cable. |
| COM | Serial communications port for RS-232 |



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2.2.2. INTERNAL CHASSIS

This Section shows the internal chassis configuration for each model including options.

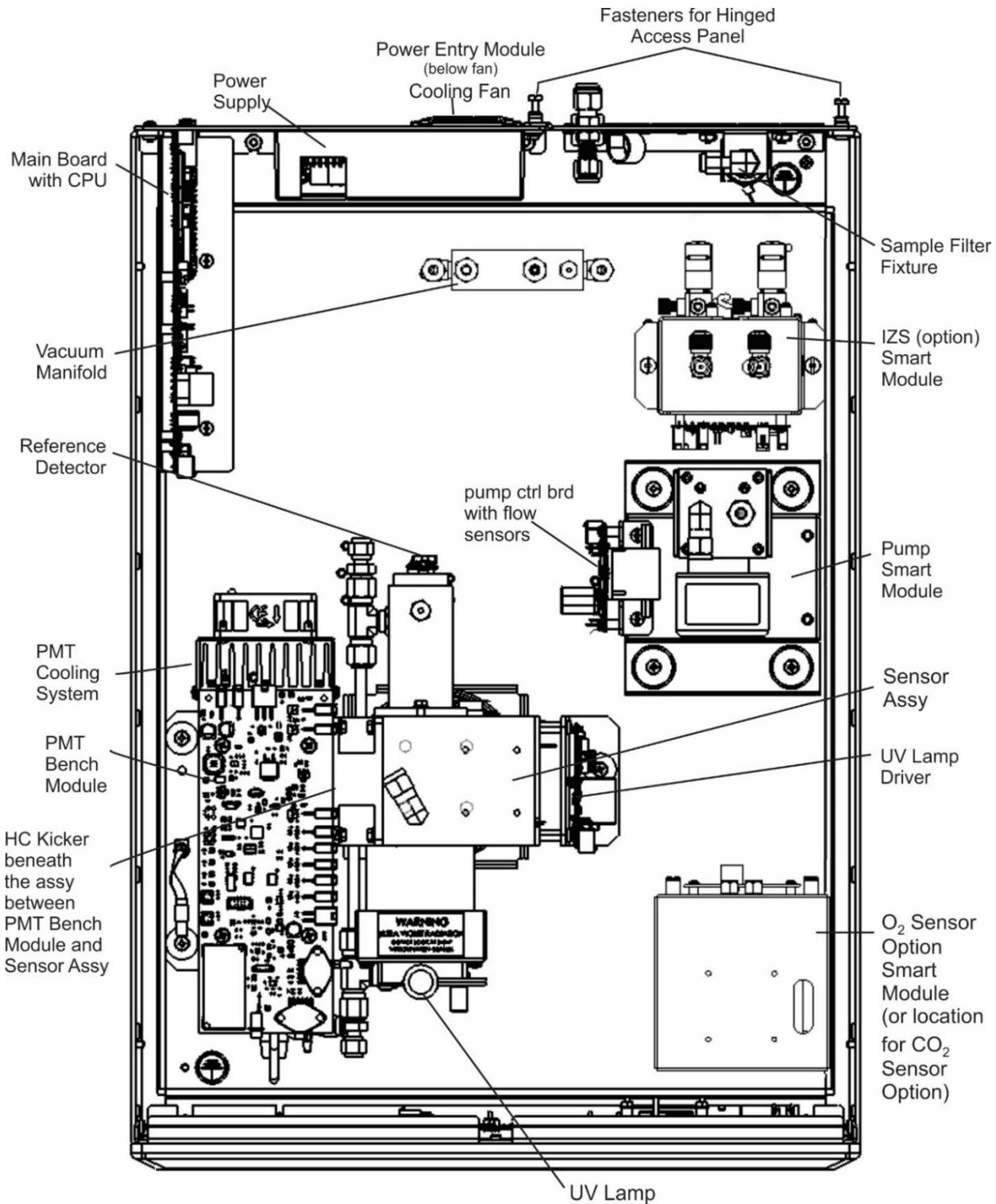


Figure 2-3. N100 Internal Chassis Layout



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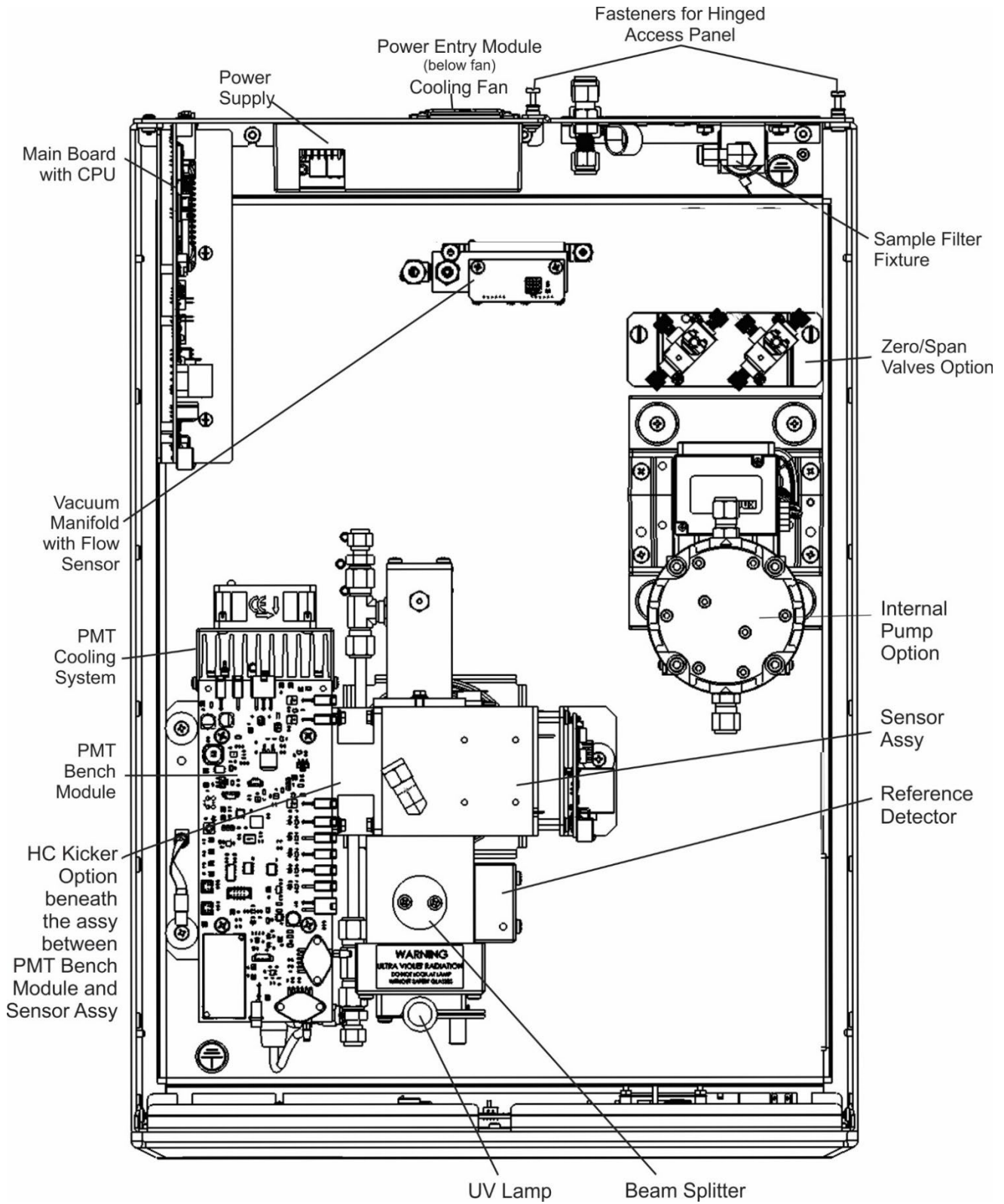


Figure 2-4. N100H Internal Chassis Layout



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.

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.



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.



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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 shut down the internal computerized components and preserve data. 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.



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2.3.1.2. CONNECTION 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.

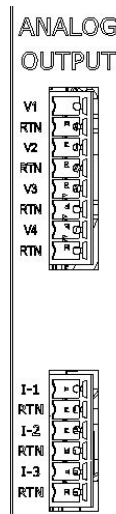


Figure 2-5. Analog Outputs Connectors Panel Option

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 - | |



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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.

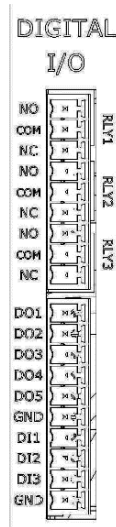


Figure 2-6. Digital I/O Connector Panel Option



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Table 2-4. Digital Input/Output Pin Assignments

| PIN | DESCRIPTION | |
|----------------------------|--|---|
| Relays | | |
| NO | RLY1 | Relay Alarms, user-configurable through the Setup>Digital Outputs menu. |
| COM | | |
| NC | | |
| NO | RLY 2 | |
| COM | | |
| NC | | |
| NO | RLY 3 | |
| COM | | |
| NC | | |
| 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) | |
| DI3 | 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 can be manually configured with a static IP address (recommended).



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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 2-15).



WARNING – ELECTRICAL SHOCK HAZARD

Disconnect 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 communications connector.

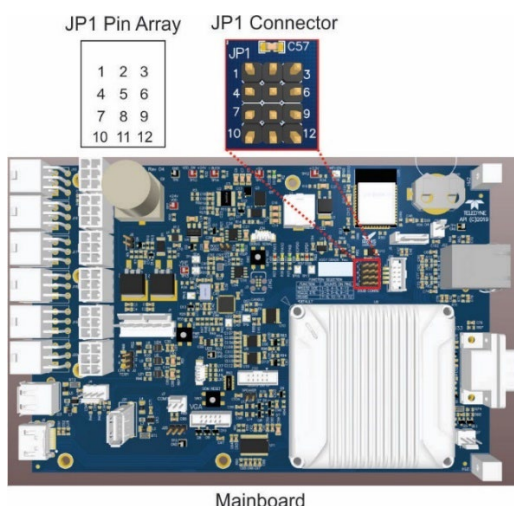


Figure 2-7. Mainboard JP1 Location and Pin Arrangements

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>COM 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 optional configurations. Pneumatic flow diagrams are shown in Section 2.3.3. Calibration instructions are provided in Section 4.



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

CAUTION – General Safety Hazard

Sulfur Dioxide (SO₂) is a toxic gas. Obtain a Safety Data Sheet (SDS) for this material, and rigorously follow the safety guidelines described there.



Vent the exhaust from the analyzer's internal pump (in N100) to outside the immediate area or shelter surrounding the instrument.

Do not vent calibration gas or sample gas into enclosed areas. Sample and calibration gases should only come into contact with PTFE (Teflon) or glass tubes and fixtures.

Do not allow sample and calibration gases to come into contact with brass or stainless steel fittings prior to the reaction cell.

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 Section 5.6.3 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.



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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.

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. BASIC CONNECTIONS FROM CALIBRATOR

Figure 2-8, through Figure 2-10 illustrate pneumatic connections for basic configurations.

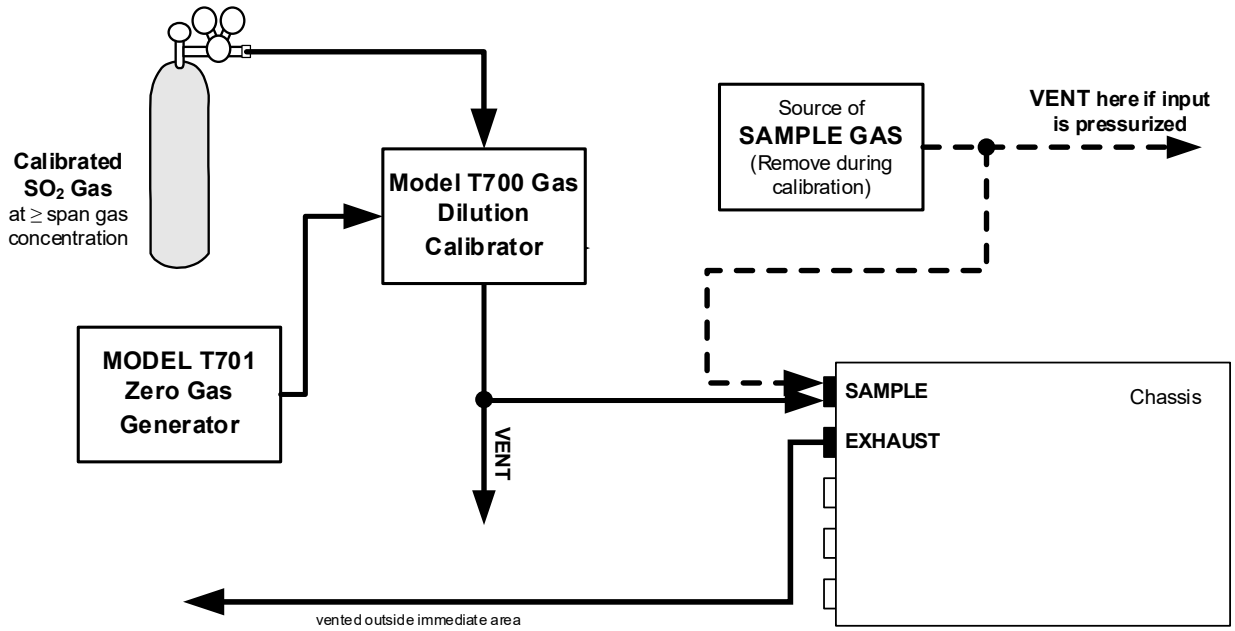


Figure 2-8. N100 Basic Connections from Gas Dilution Calibrator

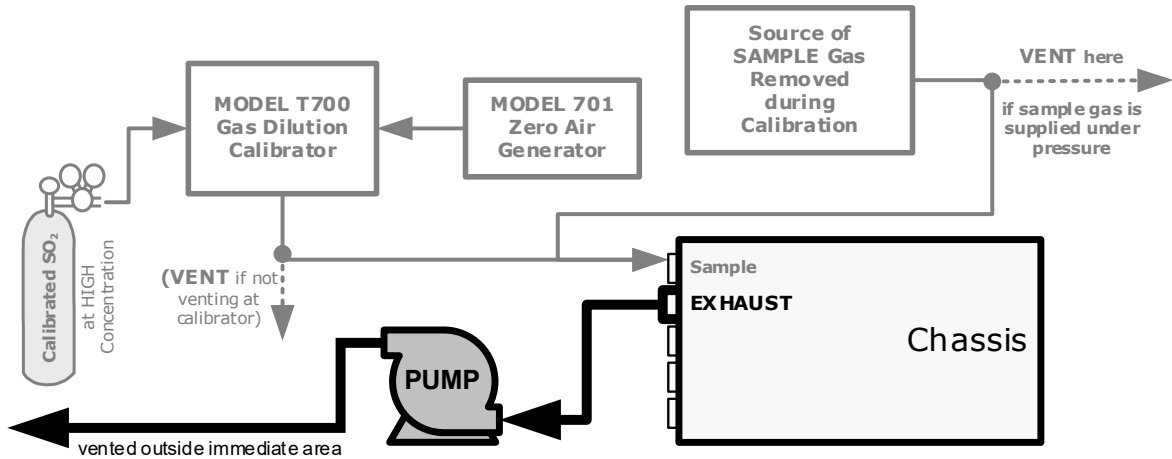


Figure 2-9. N100H Basic Connections from Gas Dilution Calibrator

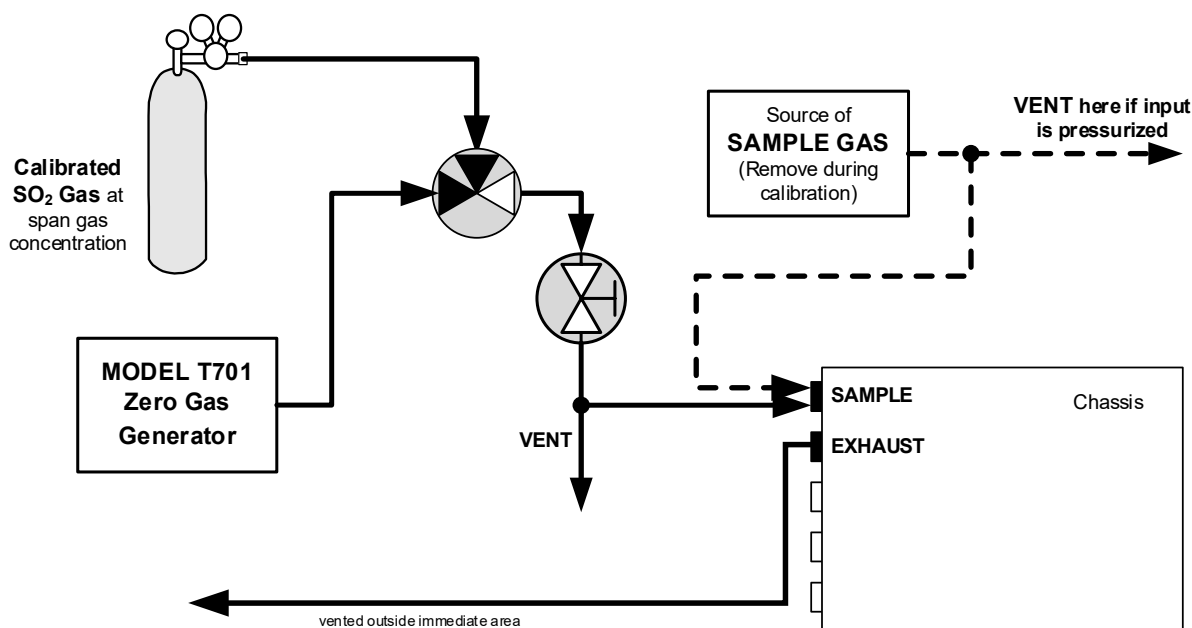


Figure 2-10. N100 Basic Connections from Bottled Span Gas (N100H: add external pump to Exhaust)

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

SAMPLE INLET

Connect ¼" gas line not more than 2 m long, from sample gas source to this inlet.

When no zero/span/shutoff valve options, also connect line from calibration gas source to this inlet, but only when a calibration operation is actually being performed.

EXHAUST OUTLET

N100: Connect exhaust line made of PTEF tubing; minimum O.D ¼", to this fitting. The exhaust line should be no longer than 10 meters, and should lead outside the shelter or immediate area surrounding the instrument.

N100H: Connect PTFE tubing, minimum O.D ¼", from this fitting to the inlet port of the external pump, and connect same from outlet port of pump, no longer than 10 meters, leading outside the shelter or immediate area surrounding the instrument.

CALIBRATOR VENTING

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

2.3.2.3. N100 CONNECTIONS W/AMBIENT ZERO/AMBIENT SPAN (Z/S) VALVES OPTION

This valve package includes:

- two solenoid valves located inside the analyzer that allow the user to switch zero, span or sample gas to the instrument's sensor

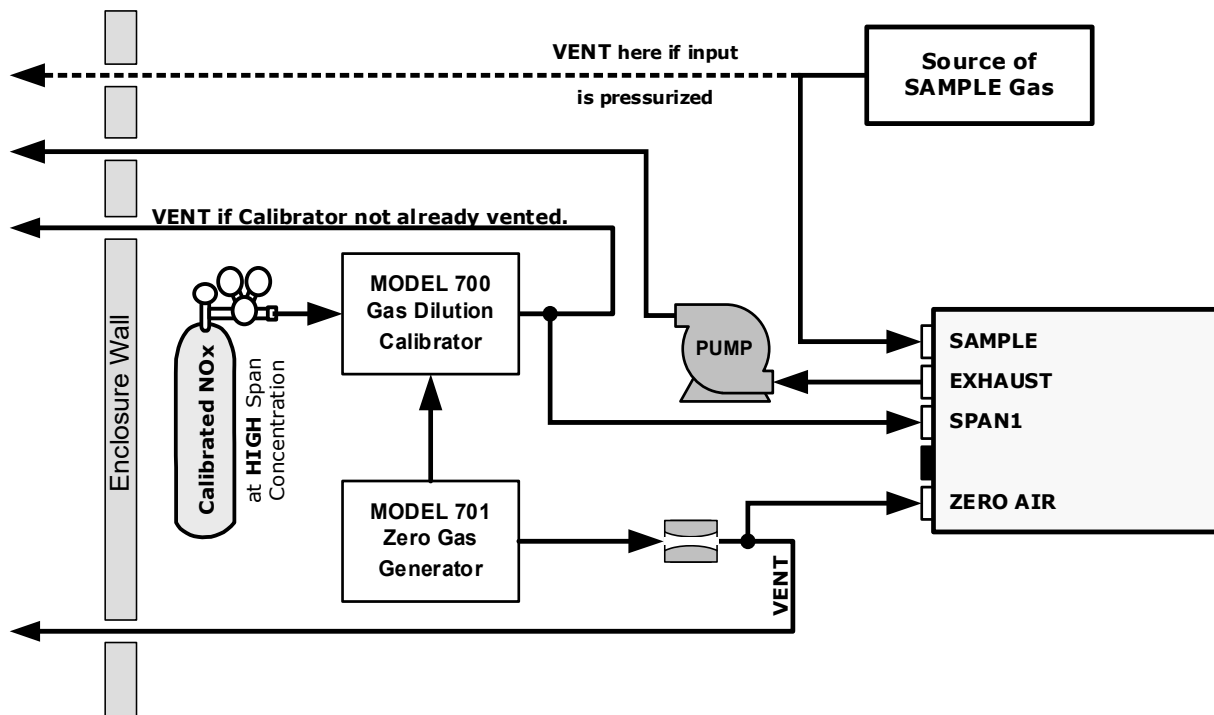


Figure 2-11. Gas Line Connections with Z/S Valves Option

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 SPAN1 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.



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2.3.2.4. N100 CONNECTIONS W/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

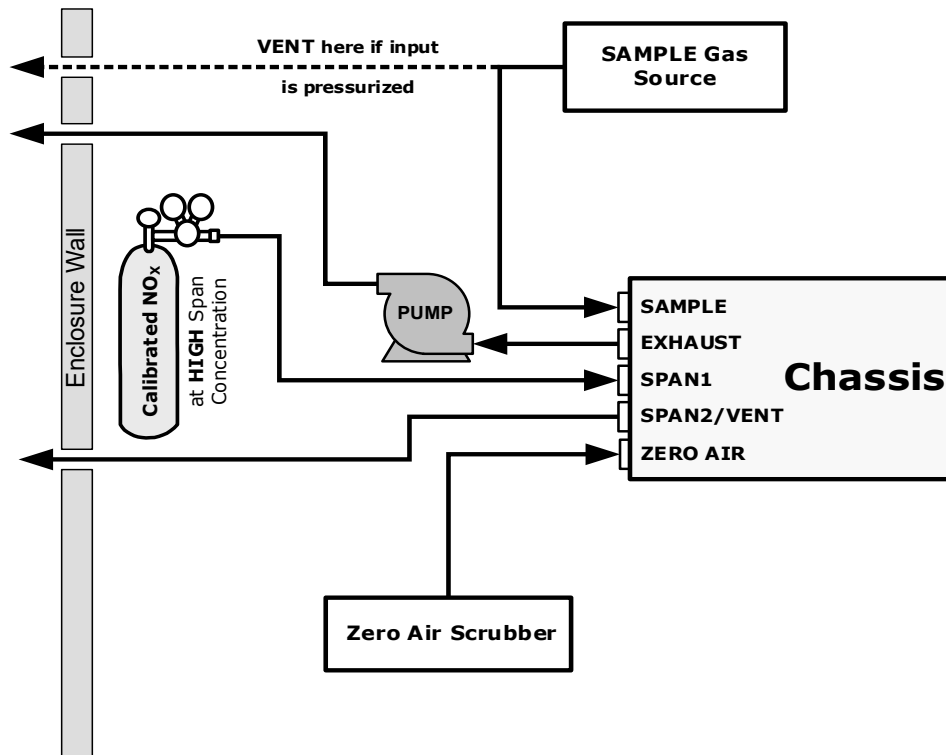


Figure 2-12. N100 Gas Line Connection w/Ambient Zero/Pressurized Span Valves Option

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.

CALIBRATION GAS SOURCES

SPAN GAS Attach a gas line from the pressurized source of calibration gas (e.g. a bottle of NIST SRM gas) to the SPAN1 inlet. Use PTFE tubing, minimum O.D 1/4".

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

VENTING

Vent the SPAN2/VENT outlet.

2.3.2.5. N100 CONNECTIONS W/ZERO SCRUBBER & INTERNAL ZERO SPAN (IZS) OPTION

The internal 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”).

This valve package includes:

- an external scrubber filled with activated charcoal that removes SO₂ in order to produce zero air
- a heated enclosure for a 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).
- two internal valves for switching between the sample gas inlet and the output of the zero/span subsystem

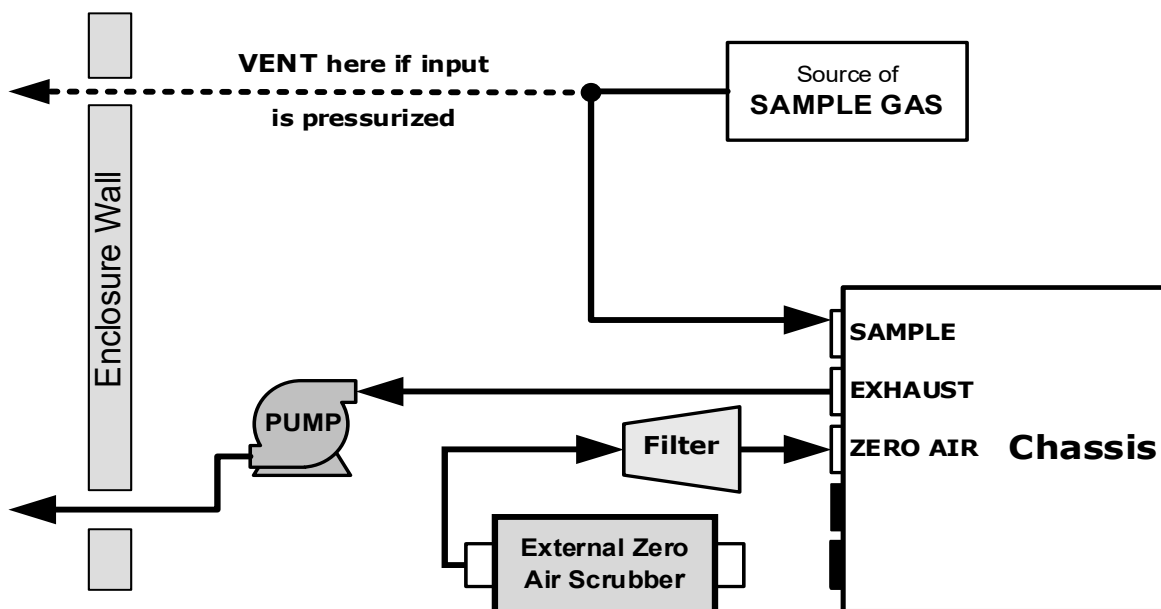


Figure 2-13. N100 Gas Line Connection w/Zero Scrubber and IZS Option

The internal span gas generator utilizes an SO₂ permeation tube as a span gas source (see the “Internal Span Gas Generation” at the end of this section). The accuracy of these devices is only about $\pm 5\%$. Whereas this may be sufficient for frequent automated calibration checks (Figure 2-13), we recommend using certified gases for precise calibration (Figure 2-14).

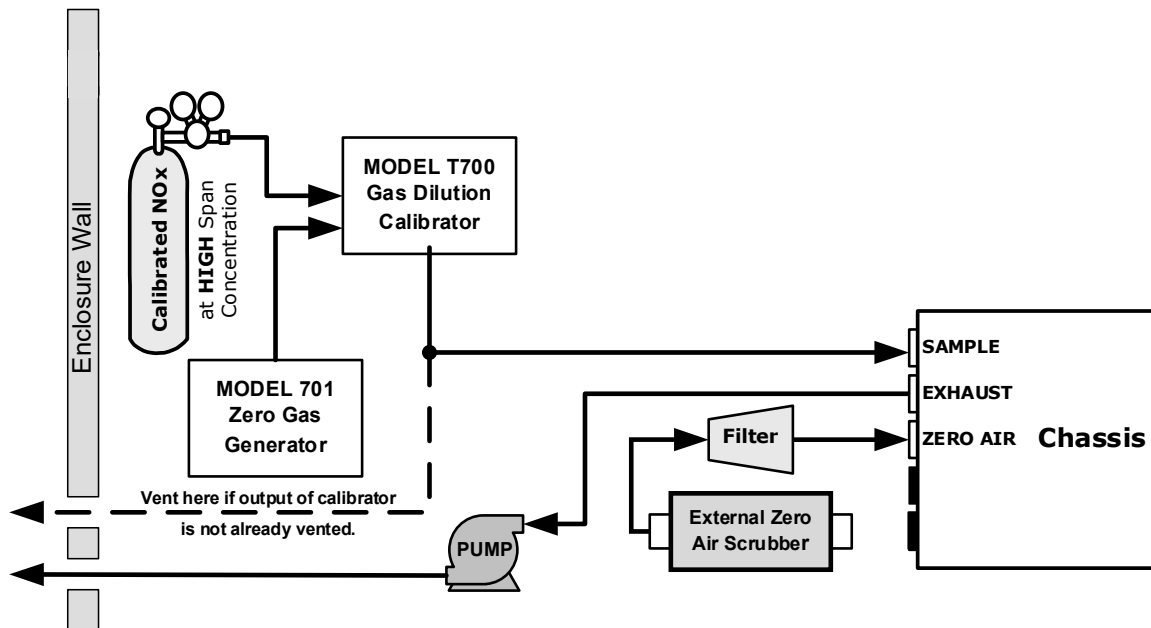


Figure 2-14. N100 Pneumatic Connections for Precision Calibration when IZS Generator Present

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 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

The primary component of the internal span option is a permeation tube containing liquid SO₂. As zero air is passed over a permeable membrane on the end of the tube, molecules of SO₂ slowly pass through the membrane mixing with the zero air. The speed at which the SO₂ permeates the membrane is called the effusion rate.

The resulting concentration of the span gas is determined by three factors:



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- size of the membrane (the larger the area of the membrane, the more permeation occurs)
- temperature of the SO₂ (increasing the temperature of the permeation tube increases the pressure inside the tube, thereby increasing the effusion).
- flow rate of the zero air (if the previous two variables are constant, the permeation rate of air into the zero air stream will be constant; therefore, a lower flow rate of zero air produces higher concentrations of SO₂).

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. The IZS heater is controlled by a precise PID (Proportional/Integral/Derivative) temperature control loop. A thermistor measures the actual temperature and reports it to the CPU 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.

Although the factors that influence the resulting span gas concentration can be kept at a constant, they also can be manipulated, thereby impacting the concentration.

2.3.3. PNEUMATIC FLOW DIAGRAMS

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

2.3.3.1. PNEUMATIC FLOW FOR BASIC CONFIGURATION

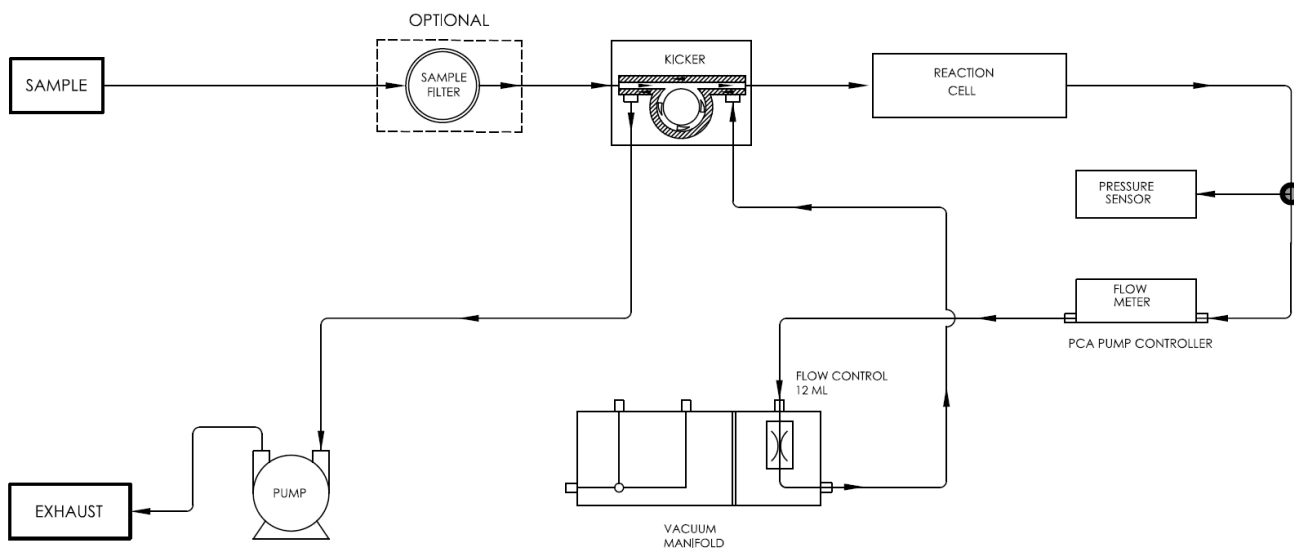


Figure 2-15. N100 Pneumatic Flow Path, Basic Configuration



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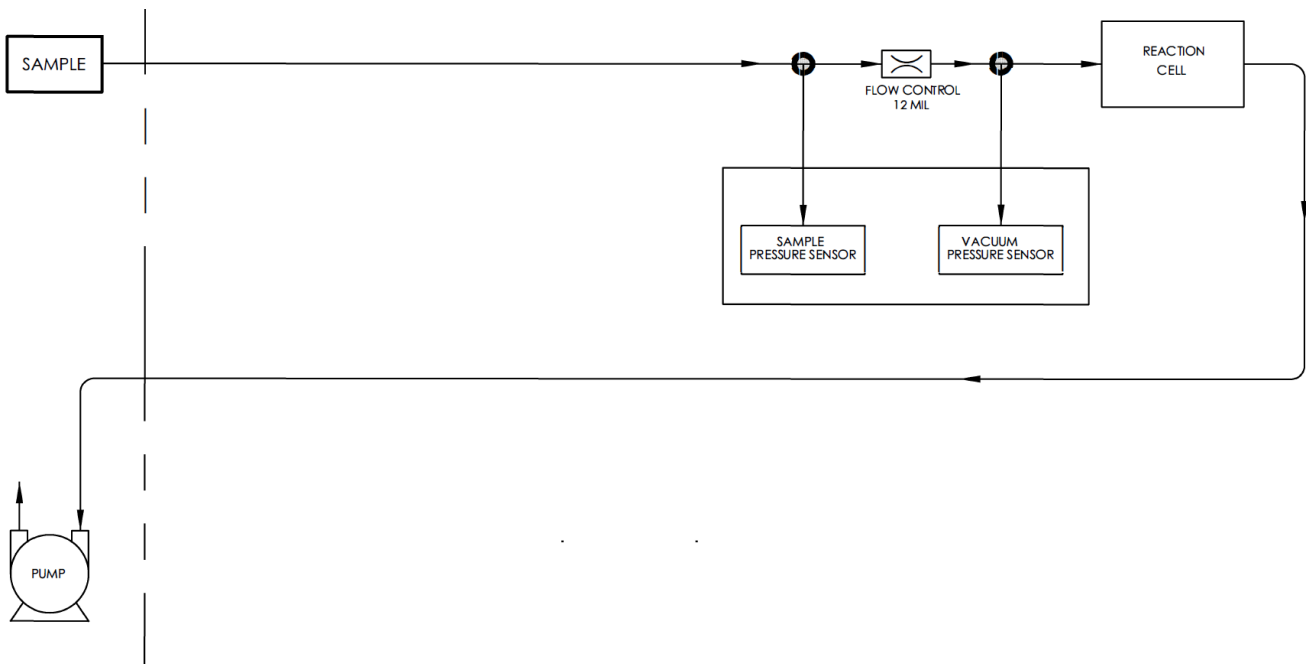


Figure 2-16. N100H Pneumatic Flow Path, Basic Configuration

2.3.3.2. PNEUMATIC FLOW FOR N100 ZERO/SPAN VALVES OPTION

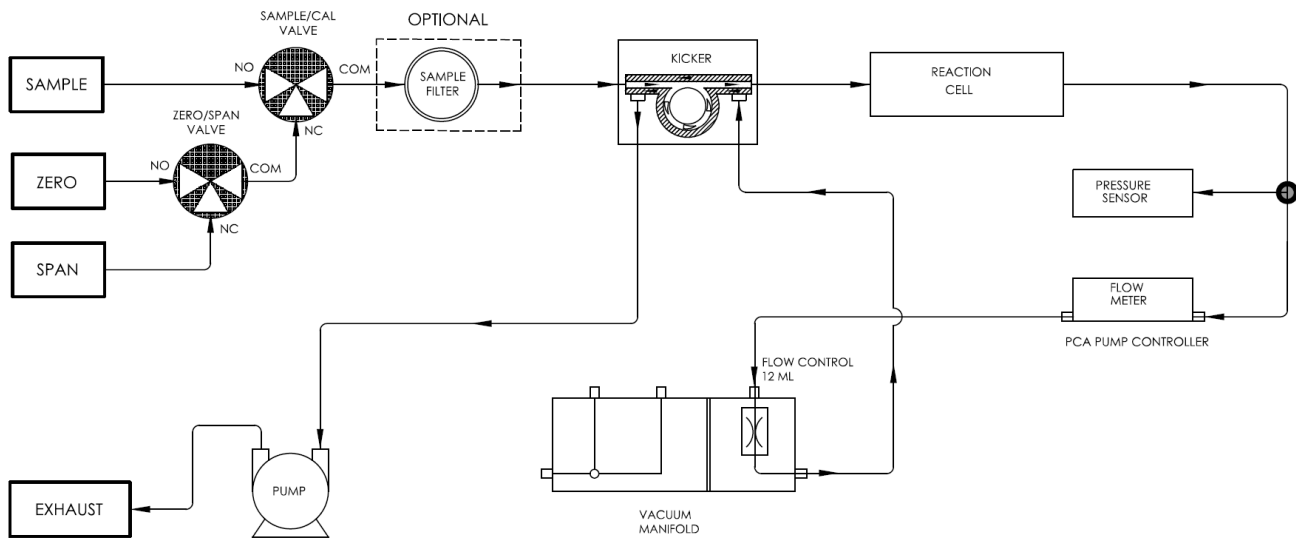


Figure 2-17. N100 Pneumatic Flow with Zero/Span Valves Option



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Table 2-6. N100 Zero/Span and Sample/Cal Valve Operating States

| MODE | VALVE | STATE | 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 GAS inlet | NC → COM |

2.3.3.3. N100 PNEUMATIC FLOW FOR AMBIENT ZERO/PRESSURIZED SPAN OPTION

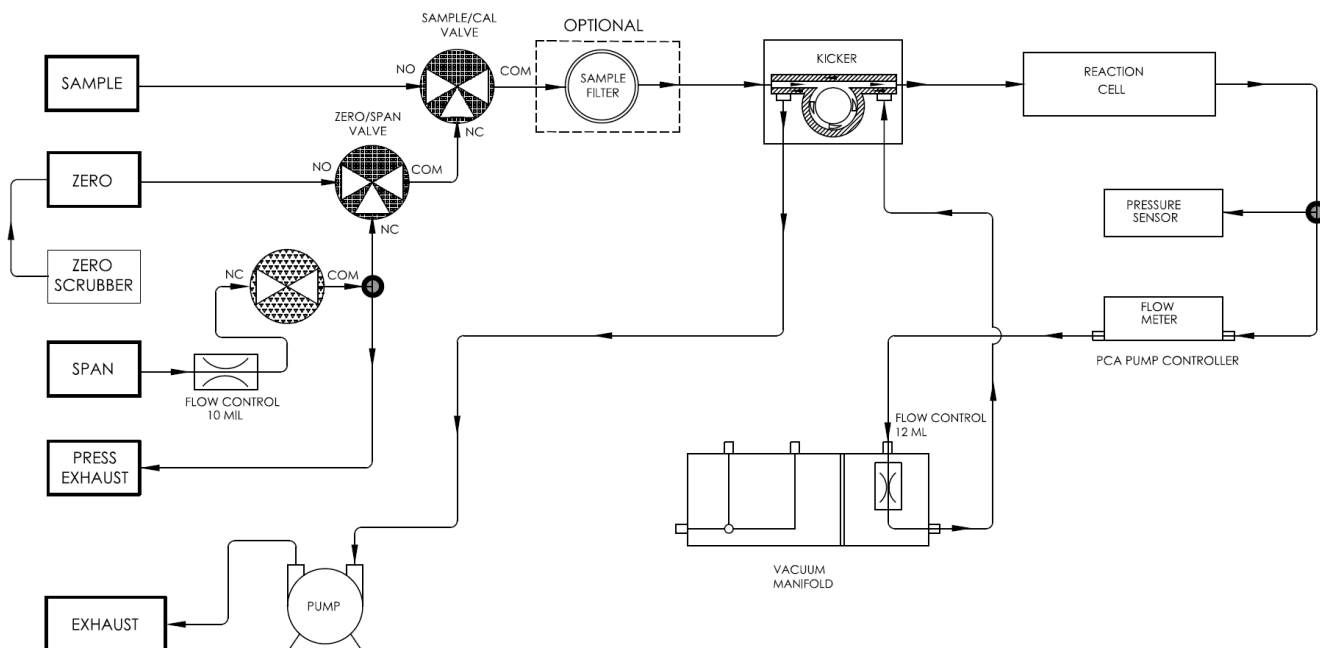


Figure 2-18. N100 Pneumatics with Ambient Zero/Pressurized Span Valves Option



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Table 2-7. Valve Operating States for Ambient Zero/Pressurized Span Option

| MODE | VALVE | STATE | 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 | 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 | |

2.3.3.4. PNEUMATIC FLOW FOR N100 INTERNAL ZERO/SPAN (IZS) GAS GENERATOR OPTION

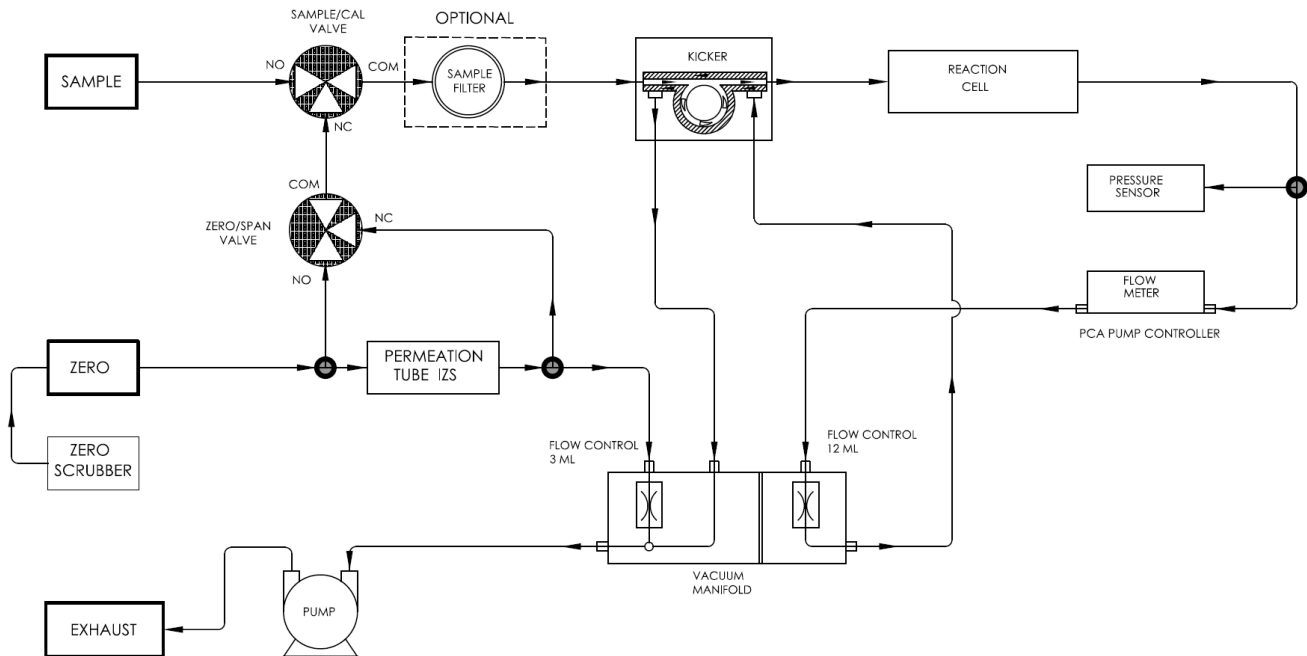


Figure 2-19. N100 Pneumatics with IZS Option

Table 2-8. IZS Valve Option Operating States

| MODE | VALVE | STATE | 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 GAS inlet | NC → COM |

Note

The permeation tube is not included in the IZS Option and must be ordered separately.

2.3.3.5. N100H PNEUMATIC FLOW WITH HYDROCARBON KICKER OPTION

Since hydrocarbons are not in the sample stream of the typical N100H application, the hydrocarbon scrubber is not included in the basic configuration. For applications that include hydrocarbons, the scrubber (Figure 2-20) is offered as an option. Figure 2-21 shows the pneumatic flow for the N100H with the hydrocarbon scrubber option installed.

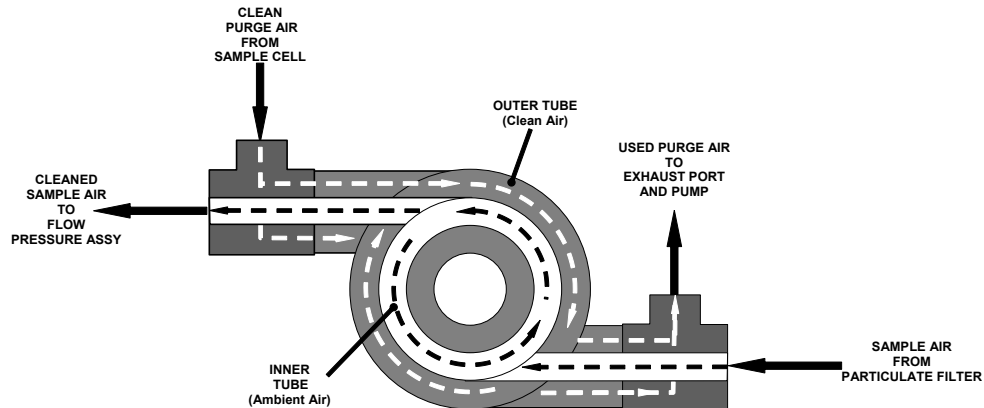


Figure 2-20. N100H Hydrocarbon Scrubber (Kicker) Option

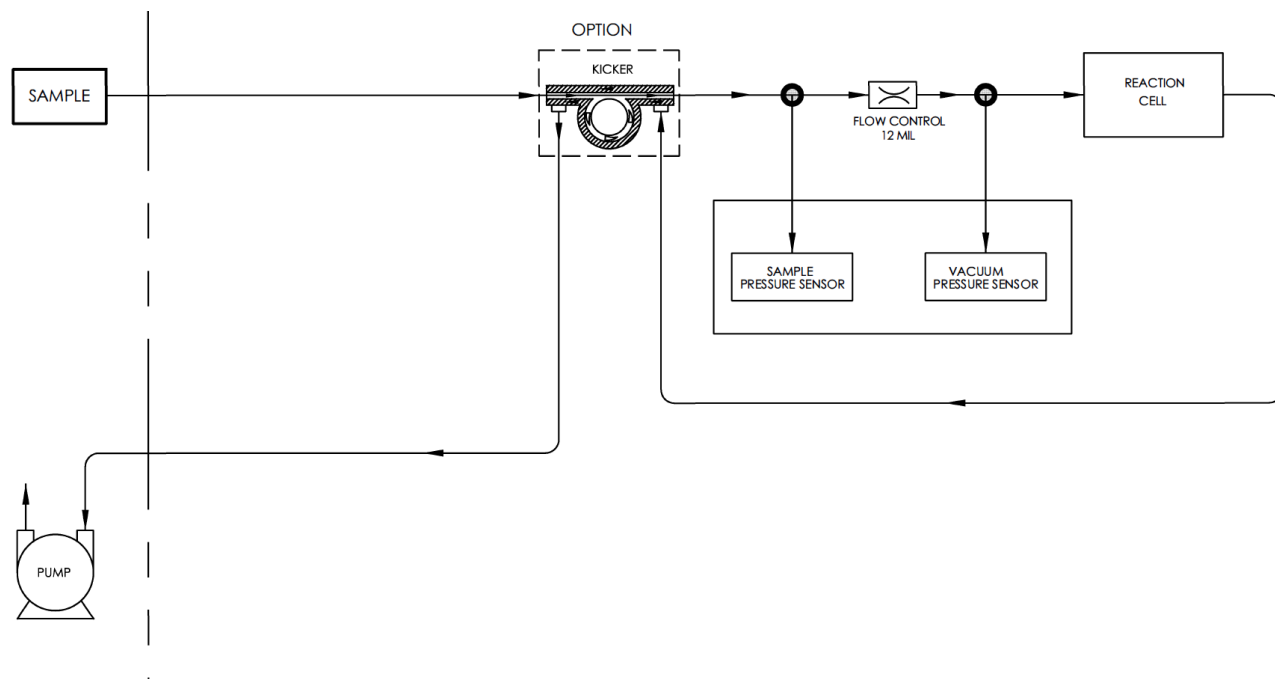


Figure 2-21. N100H Pneumatic Flow with Hydrocarbon Kicker Option

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.

2.3.4.1. STARTUP

Upon initial startup, a sequence of status screens (Figure 2-22) appear prior to the Home page (Figure 2-23).

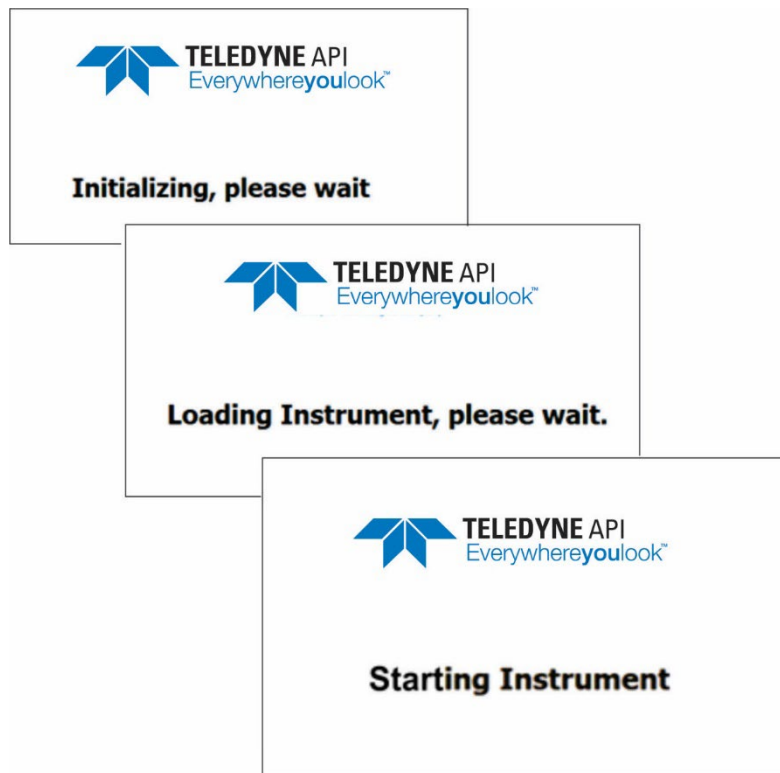


Figure 2-22. Status Screens at Startup

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

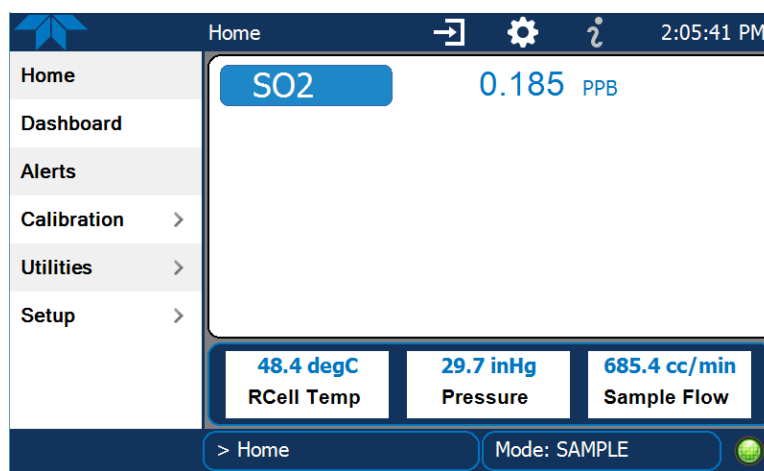


Figure 2-23. Home Page Example



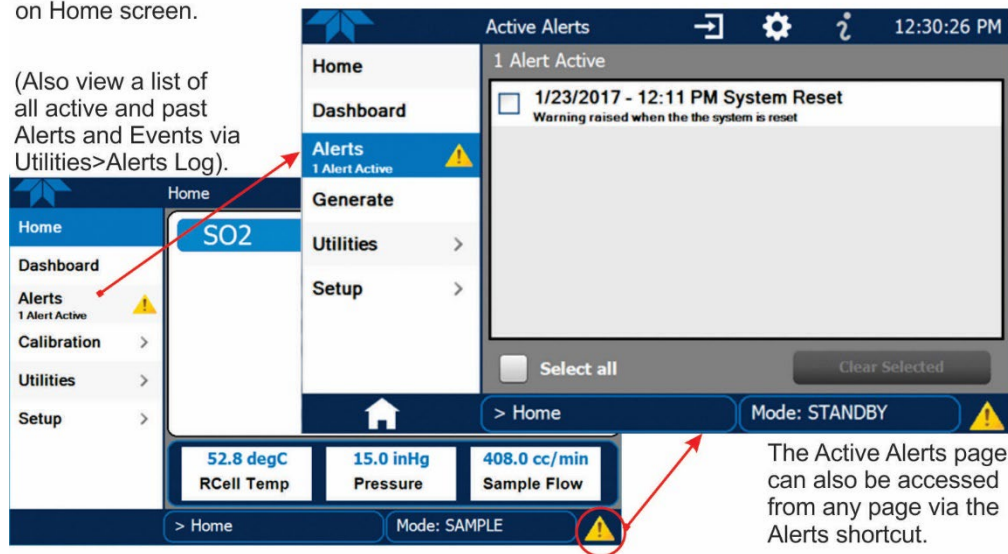
2.3.4.2. ALERTS: WARNINGS AND OTHER MESSAGES

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 2-24) 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.

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 2-24. Viewing Active Alerts Page

If alerts of 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).

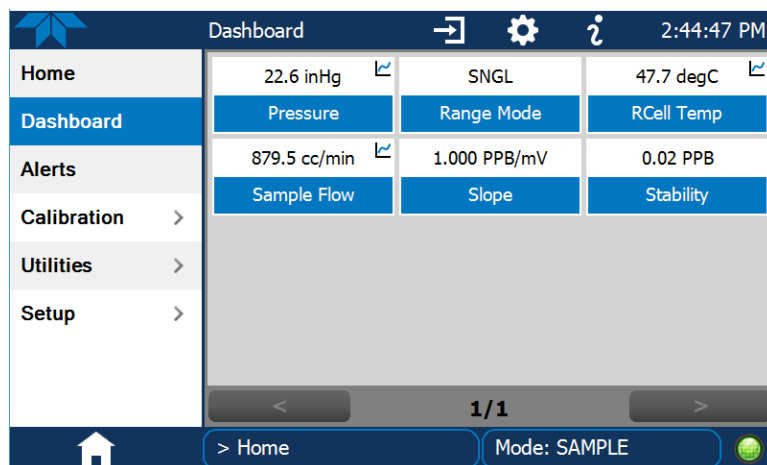


Figure 2-25. Sample Dashboard Page

2.3.4.4. CALIBRATION

Before operation begins, the analyzer requires zero and span calibrations, and possibly HVPS adjustment. Also, any time an analyzer is moved or its configuration changed, it must be calibrated. The method for performing a calibration 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 2-9 describes the main menus and provides cross-references to the respective sections with configuration details.

Table 2-9. Menu Overview

| MENU | DESCRIPTION | LOCATION |
|----------------------------------|---|----------------------|
| Home | View and plot concentration readings and other selectable parameter values (Figure 2-27). | Section 2.4.1 |
| Dashboard | View user-selected parameters and their values, some of which can be displayed in a live-plot graph (Figure 2-28). | 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 or calibration checks on the SO ₂ channel (and second gas sensor if installed). | 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). 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 2-25) via selectable parameters. | Section 2.5.3 |
| Auto Cal (with valve options) | When zero/span valve options installed, configure sequences for automatic calibration checks. | Section 4.2.2.2 |
| 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 2-26). | Section 2.5.6 |
| Digital Outputs (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 Outputs (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. *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 |



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2.4.1. HOME PAGE

Figure 2-26 presents an orientation to the main display screen; Figure 2-27 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 2-26. User Interface Orientation



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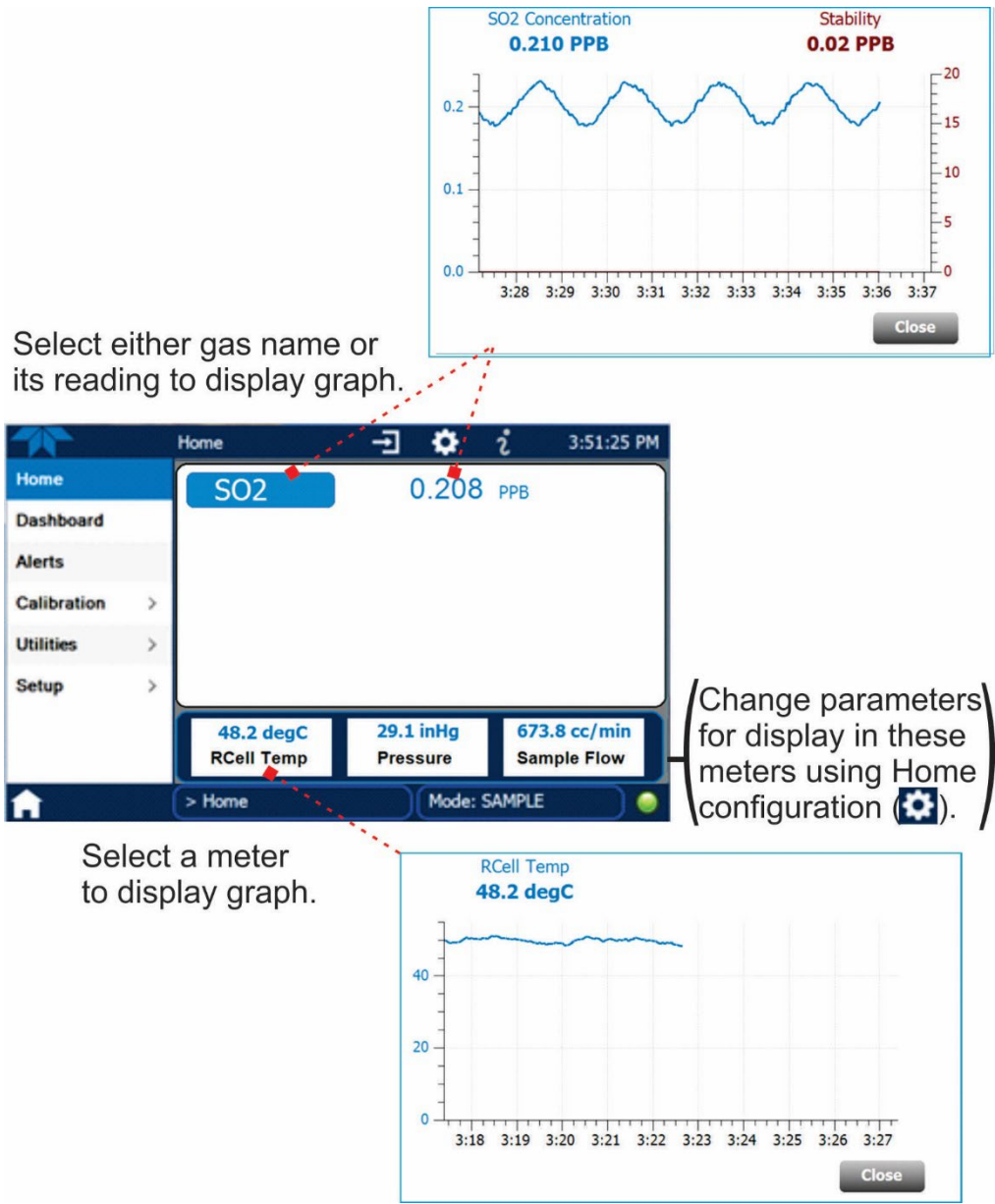


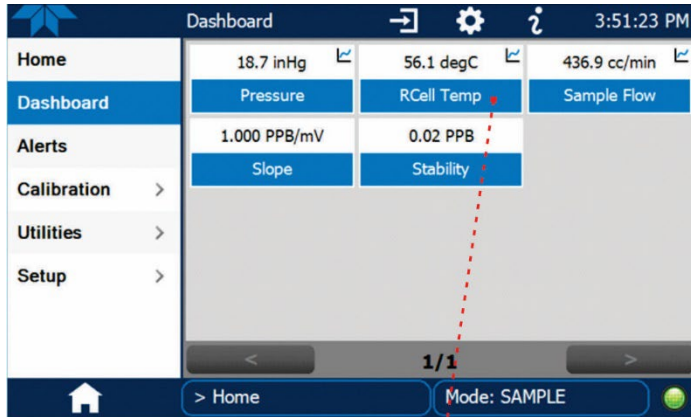
Figure 2-27. Concentration and Stability Graph (top) and Meter Graph (bottom)



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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 2-28.



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

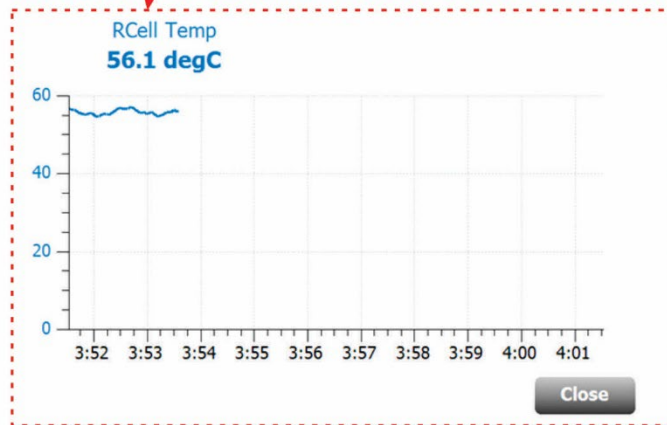


Figure 2-28. Dashboard Page



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Common parameters and their descriptions are presented in Table 2-10.

Table 2-10. Common Dashboard Parameters

| PARAMETER | UNITS | DESCRIPTION |
|---------------------------|---------|---|
| Box Temp | °C | The ambient temperature of the inside of the analyzer case. |
| HVPS | V | The PMT high voltage power supply. |
| PMT | mV | The raw output voltage of the PMT. |
| PMT Dark | mV | The PMT output reading recorded the last time the UV source lamp shutter was closed. |
| PMT Temp | °C | The current temperature of the PMT. |
| Sample Press | in-Hg-A | The current pressure of the sample gas as it enters the sample chamber, measured between the SO ₂ and Auto-Zero valves. |
| RCell Temp | °C | The current temperature of the sample chamber. |
| Pump Flow | cc/m | The flow rate of the sample gas through the sample chamber. This value is not measured but calculated from the sample pressure. |
| SO ₂ Offset | mV | The overall offset of the instrument as calculated during the last calibration activity. The offset parameter is used to set the zero point of the analyzer response. |
| SO ₂ Slope | - | The sensitivity of the instrument as calculated during the last calibration activity. The slope parameter is used to set the span calibration point of the analyzer. |
| SO ₂ Stability | mV | Standard deviation of SO ₂ Concentration readings. Data points are recorded every ten seconds. The calculation uses the last 25 data points. |
| UV Lamp | % | The current output of the UV reference detector divided by the reading stored in the CPU's memory from the last time a UV Lamp calibration was performed. |



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 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 2-29).

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).

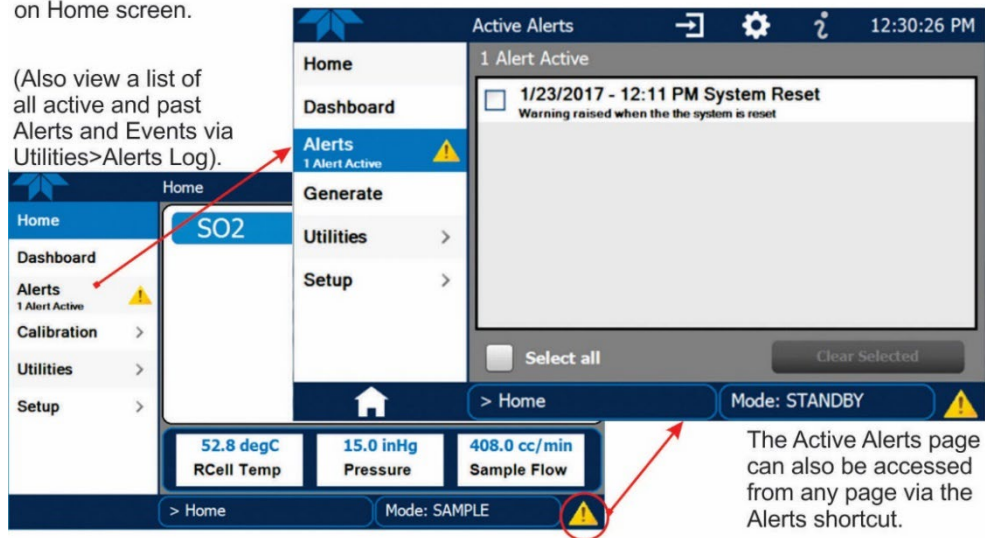


Figure 2-29. Navigating to the Active Alerts Page

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.

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 2-30). However, Alerts can reappear if the conditions causing them are not resolved. For troubleshooting guidance, refer to Section 5.7.

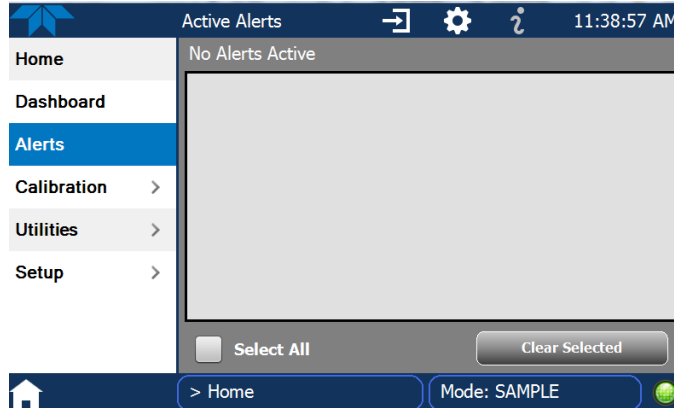


Figure 2-30. Active Alerts Cleared

Alerts and Events remain recorded in the Utilities>Alerts Log (Figure 2-31).

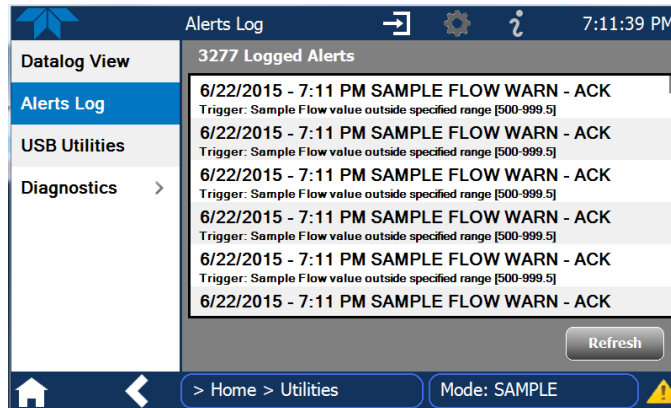


Figure 2-31. Utilities>Alerts Log of Active and Past Alerts and Events

2.4.4. CALIBRATION

The Calibration menu is used for 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 2-11.

Table 2-11. Utilities Submenu Descriptions

| UTILITIES MENU | DESCRIPTION | |
|----------------------|--|---|
| Datalog View | 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). | |
| Alerts Log | 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). | |
| USB Utilities | Serves multiple purposes using a flash drive connected to the instrument's front panel USB port: <ul style="list-style-type: none"> • download data from the instrument's Data Acquisition System (DAS), the Data Logger, to a flash drive (Section 2.5.1.3) • update firmware (Section 5.3) • transfer instrument configuration from/to other same-model instruments (Section 2.6) • download a basic operation functionality report (Section 5.3). | |
| Diagnostics | Provides access to various pages that facilitate troubleshooting and 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 menu. (Section 2.3.1.3 presents the rear panel connections). |
| | Digital Inputs (option) | Show whether digital inputs for specific available features are in ON or OFF state. |
| | Digital Outputs (option) | Show the function of user-specified parameters configured in the Setup>Digital Outputs menu. |
| | Flow Cal | Used to calibrate the sample gas flow reading with actual flow measured by an external device. (See Section 5.6.7.3). |
| | Lamp Cal | Used to calibrate the lamp after adjustment procedure (Section 5.7.9.3 – "Adjusting the UV Lamp (<i>Peaking the Lamp</i>)"). |
| | HVPS Adjust | Used to adjust PMT output gain when no other cause can be found for slope and offset values being out of range. (See Section 5.7.9.4). |

2.4.6. SETUP

The Setup menu is used to configure the instrument's software features, gather information on the instrument's performance, and configure and access data from the Data Logger, the instrument's internal data acquisition system (DAS). 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 such as variables, outputs, display parameters, and the Data Logger, 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 Data Logger 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 for examination and analysis.

Figure 2-32 shows a new log; Figure 2-33 shows a sample existing log, which can be edited or deleted, and Figure 2-34 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.

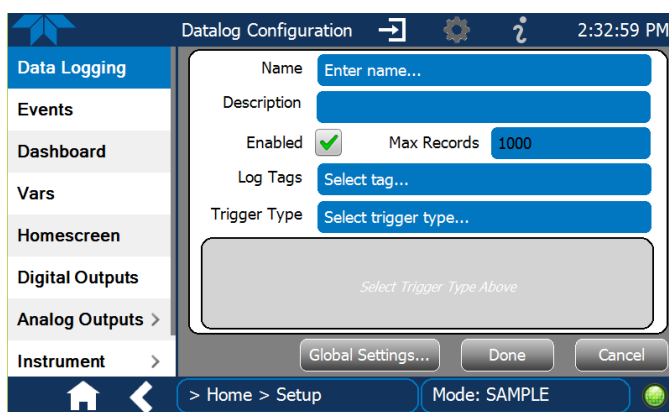


Figure 2-32. Datalog Configuration, New Log Page

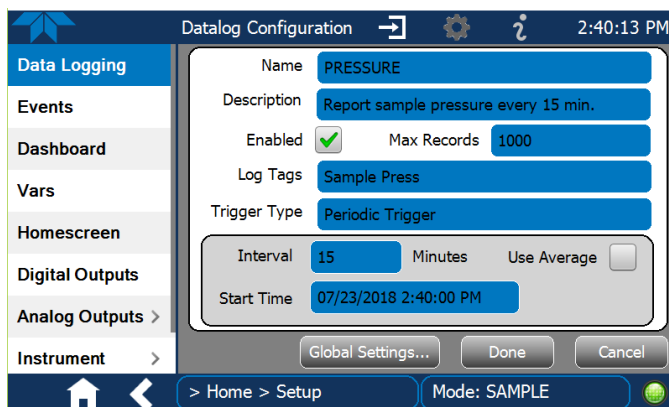
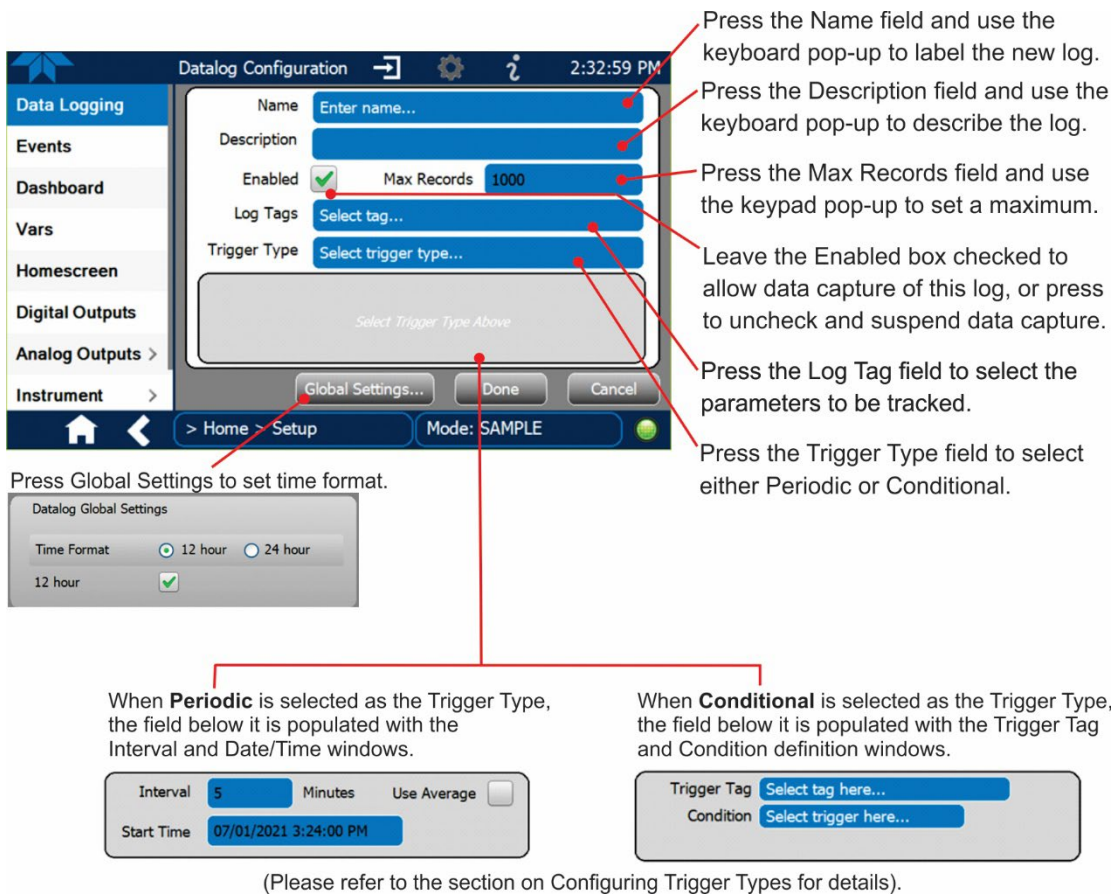


Figure 2-33. Datalog Configuration, Existing Log



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.

Datalog Global Settings

Time Format 12 hour 24 hour

12 hour

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 2-34. 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).



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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 minutes ("Use Average" appears with 2 or more minutes) 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)

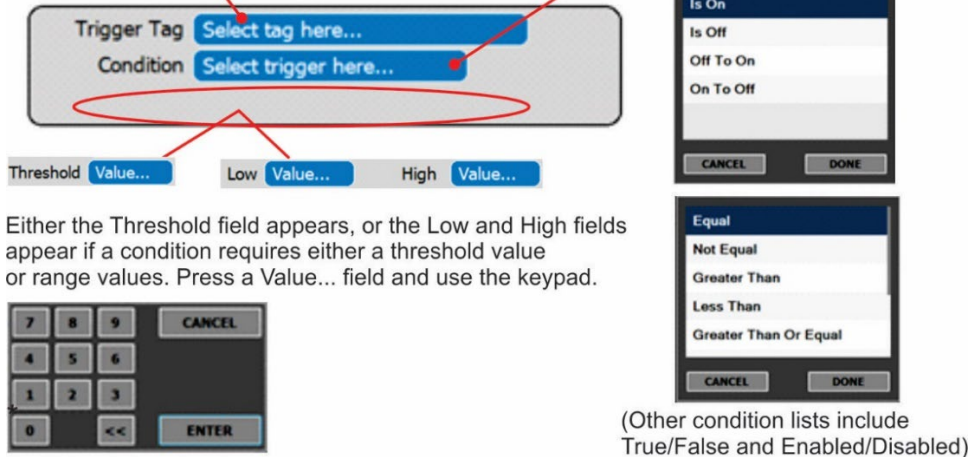
Figure 2-35. Datalog Periodic Trigger Configuration

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 2-36. Datalog - Conditional Trigger Configuration

2.5.1.3. DOWNLOADING DAS (DATA ACQUISITION SYSTEM) DATA

To download DAS data collected by the Data Logger 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.

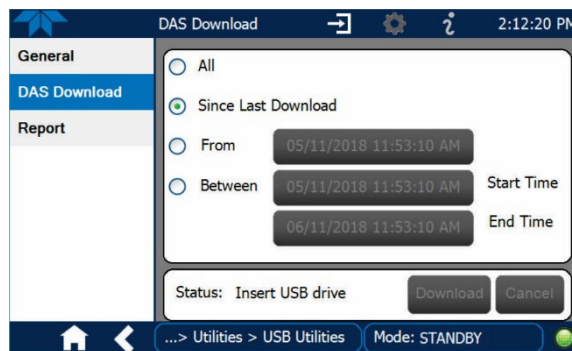


Figure 2-37. DAS Download Page

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 2-38) under the Setup menu.

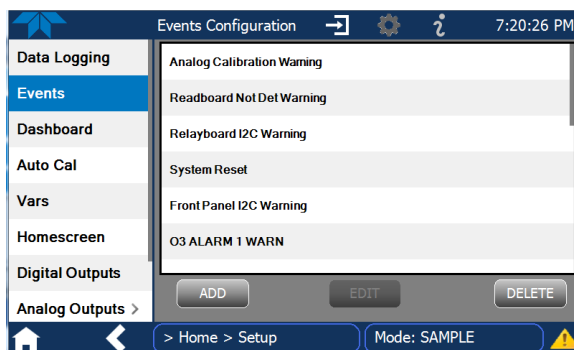


Figure 2-38. Events List

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 2-38). Press ADD to create a new Event (refer to Figure 2-39 for details), or select an existing Event to either Edit or Delete it (Figure 2-41).

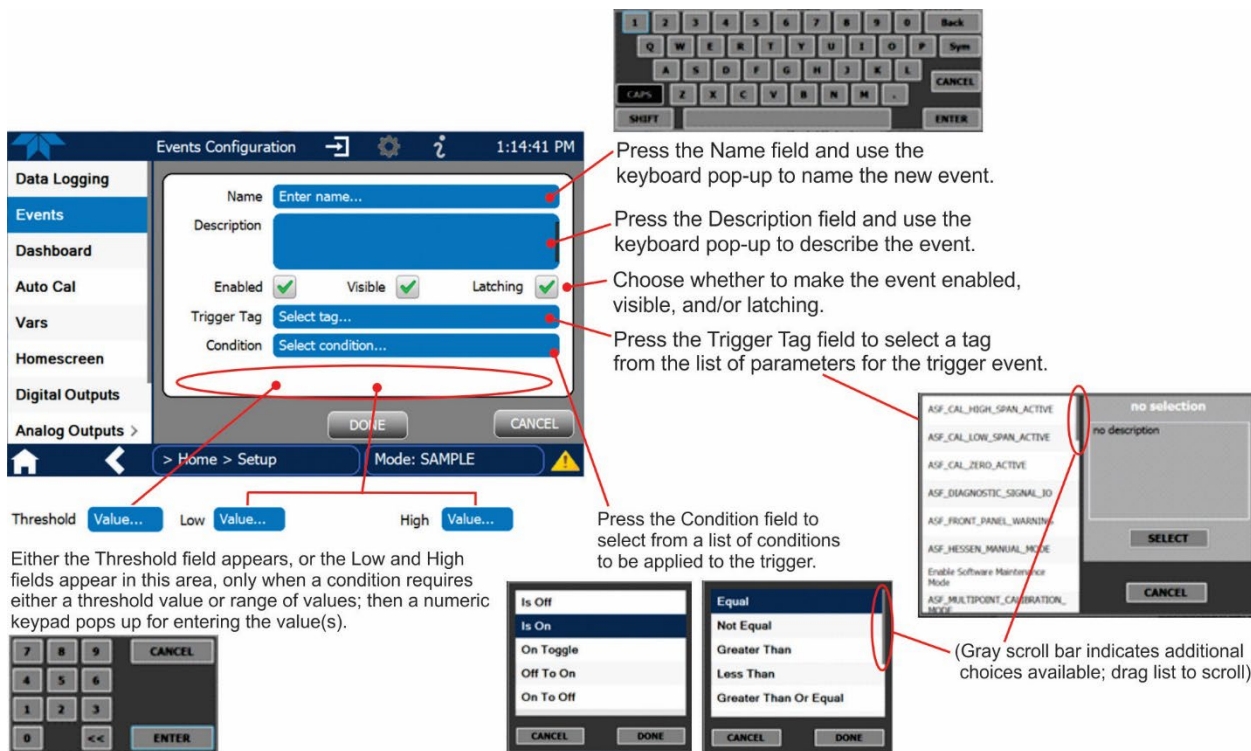


Figure 2-39. Event Configuration



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- 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).

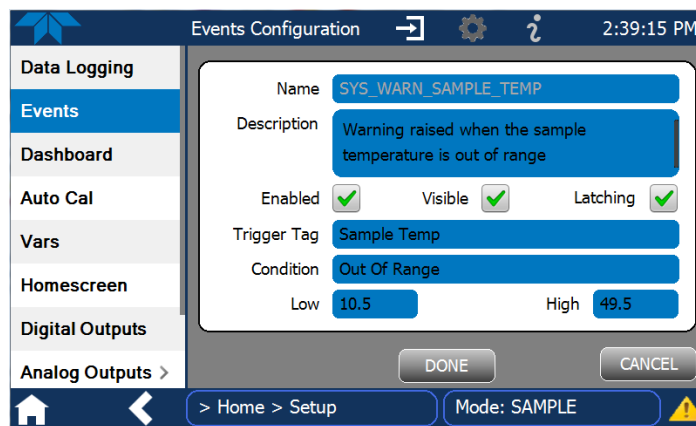


Figure 2-40. Configured Event Sample



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2.5.2.1. EDITING OR DELETING EVENTS

Select an Event from the list (Figure 2-38) and press the Edit button to view or edit the details (Figure 2-40), or press the Delete button to delete the Event.

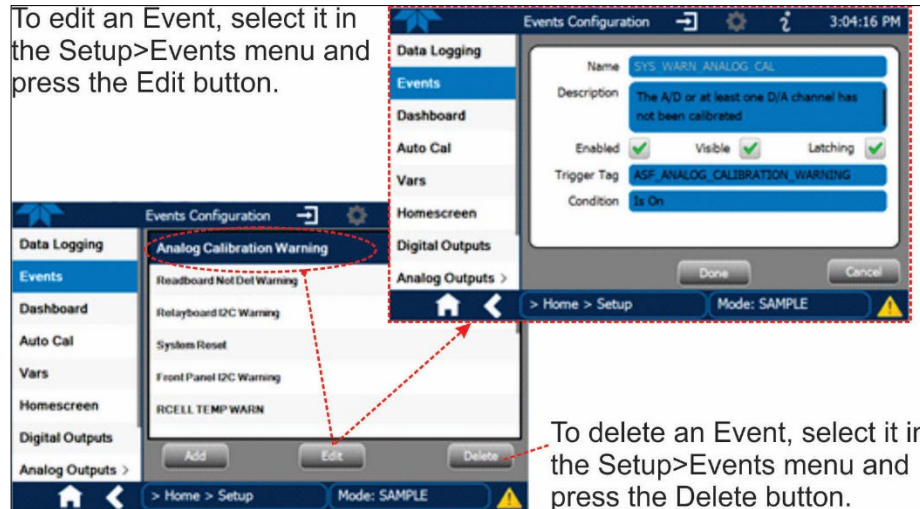


Figure 2-41. Edit or Delete an Event

Note

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

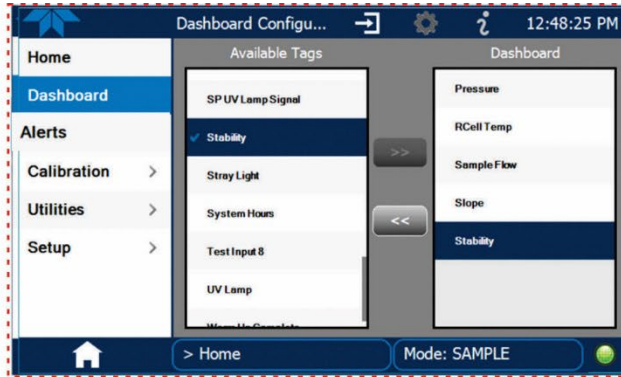
2.5.2.2. USING EVENTS AS TRIGGERS FOR DATA LOGGING

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.

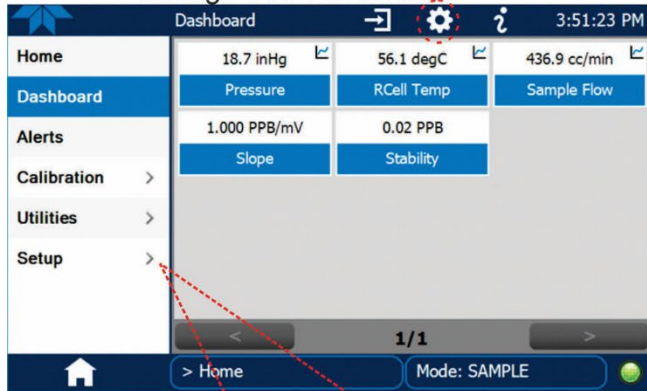


2.5.3. SETUP>DASHBOARD

From Dashboard page, select the configuration shortcut, or navigate to Setup>Dashboard.



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.

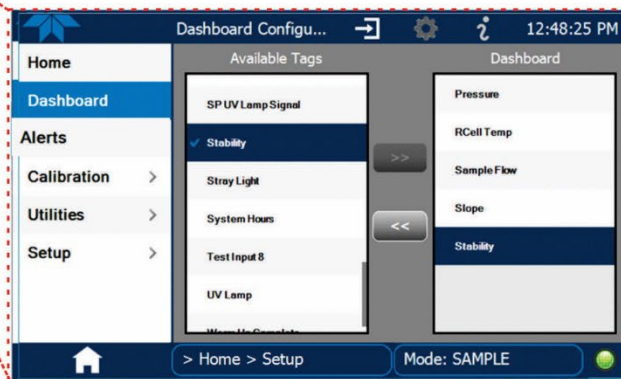


Figure 2-42. Dashboard Display and Configuration

2.5.4. SETUP>AUTOCAL (WITH VALVE OPTION)

AutoCal is available for running automated calibration checks with installed valve options (Section 4.2.2.2).



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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 (Vars); select a Var to view its description; touch the Edit button to change its setting(s). Table 2-12 describes some of the Vars.

Table 2-12. Typical 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. | |
| Background Periodic Report Upload | Allow a periodic report to be automatically uploaded to cloud service at a frequency (in hours) set in the Report Upload Interval var. |
| 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"> 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>Vars>User Units menu). 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). 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). |
| Enable Software Maintenance Mode | Set instrument to continue sampling, while ignoring calibration, diagnostic, and reset instrument commands. This feature is of particular use for instruments connected to Hessen protocol networks. |
| 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 (see Setup>Comm). |
| PMT Range | Set to Low or High according to the level of concentration expected: Low for Min Range or High Max Range specification, as this is used by the CPU to adjust physical ranges. (Section 4.1.5 provides more information). |



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| VARIABLE | DESCRIPTION |
|-------------------------|---|
| 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. 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. |
| PRIGAS Precision | Sets the number of significant digits to the right of the decimal point display of primary gas concentration and stability values. (SECGAS Precision for secondary gas) |
| 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 6.4.3). |
| User Conc 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 2-43).

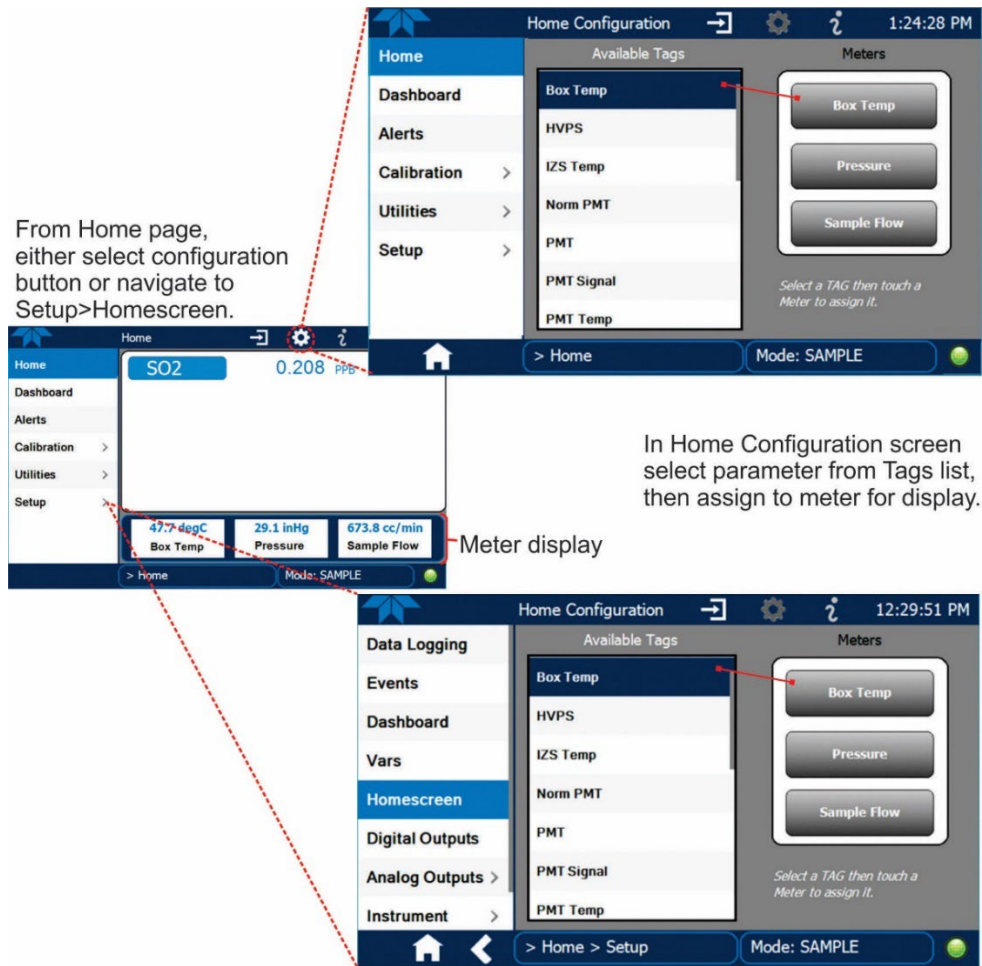


Figure 2-43. Homescreen Configuration

An orientation to the Homescreen was presented in Section 2.4.1, including Figure 2-26 and Figure 2-27.



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).

To map Digital Outputs to Signals, select a pin in the Outputs list, 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).

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

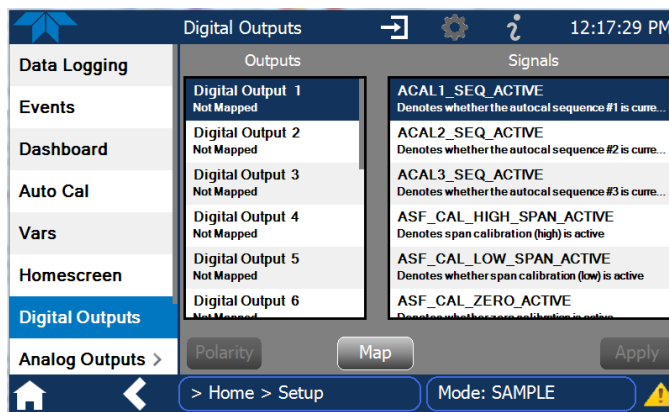


Figure 2-44. Digital Outputs Setup

2.5.8. SETUP>ANALOG OUTPUTS (OPTION)

Map the 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.

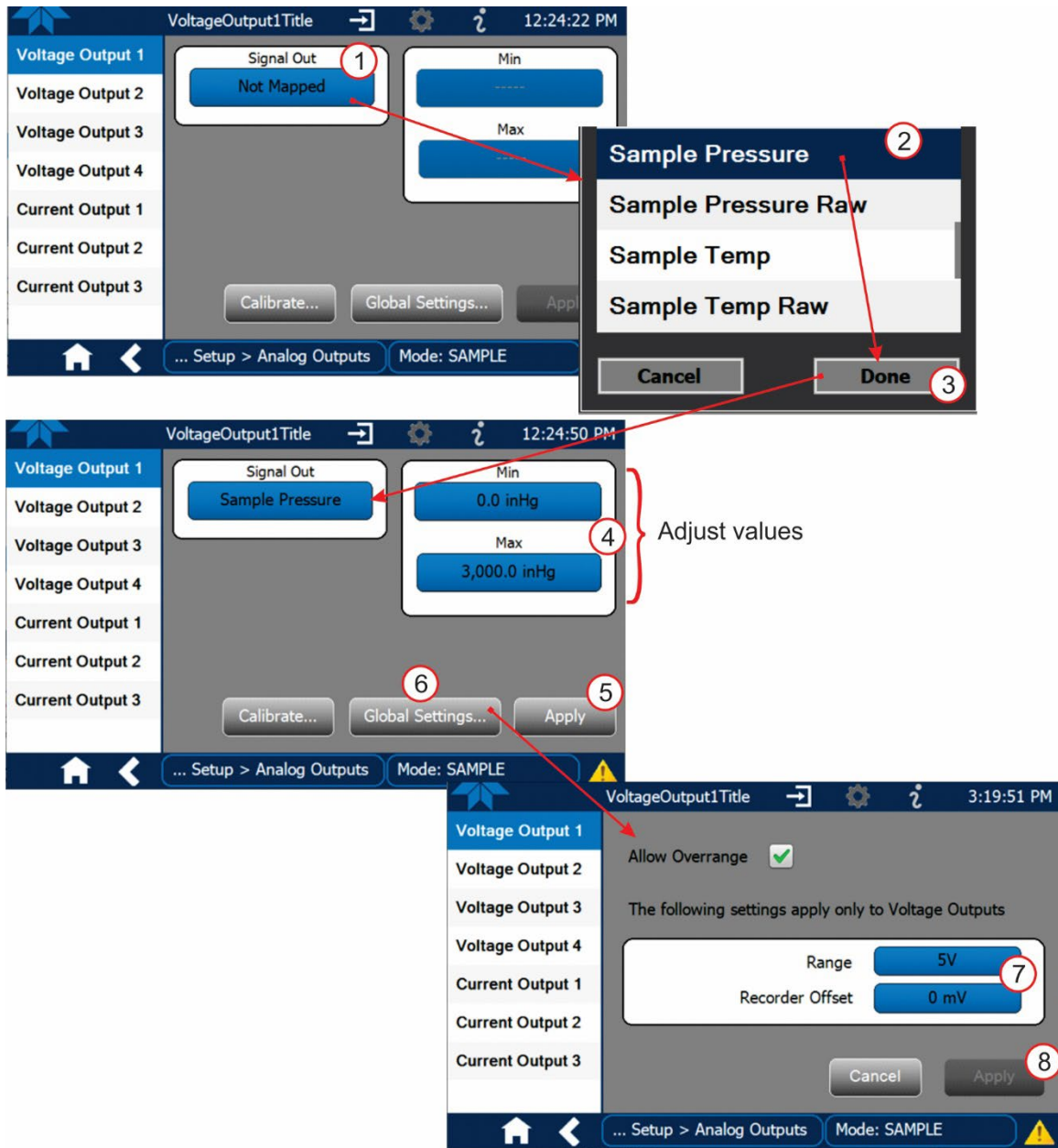


Figure 2-45. Analog Output Configuration for Voltage Output, Example

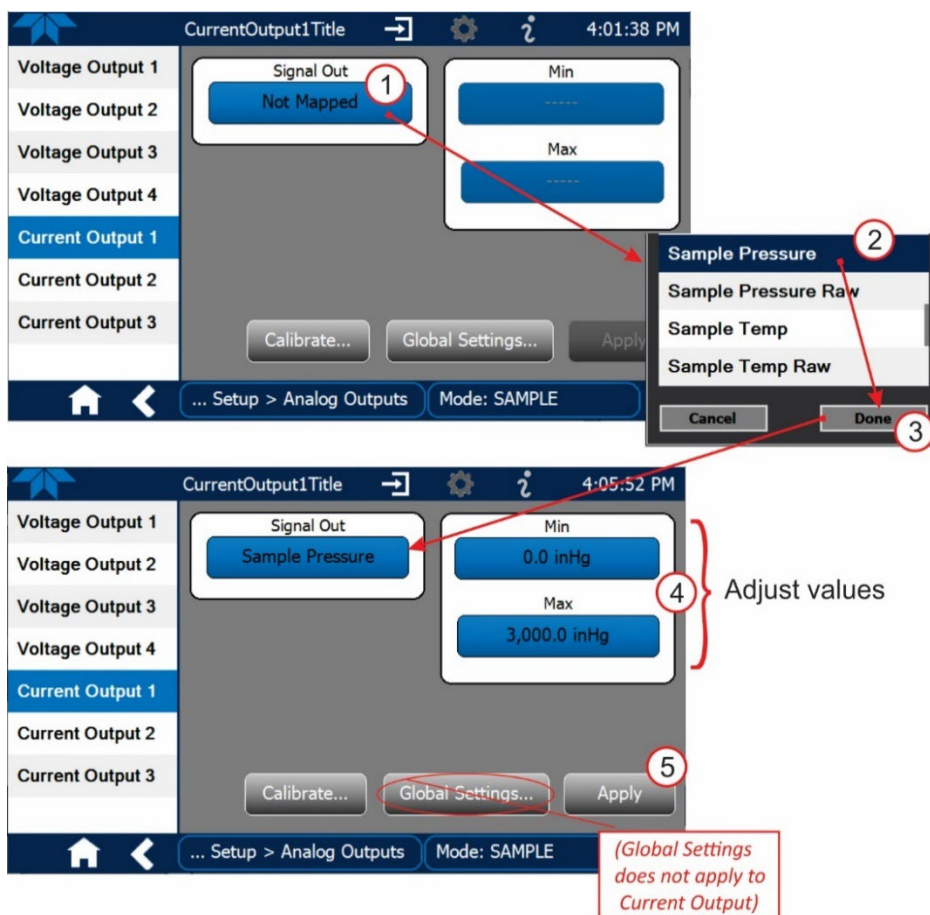


Figure 2-46. Analog Output Configuration for Current Output, Example

Refer to Figure 2-45 (Voltage output) or to Figure 2-46 (Current output), and to Table 2-13 for the following:

1. Signal Out: select a Signal for the output (typically the gas concentration).
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 Overage” to allow a $\pm 5\%$ over-range, or uncheck to disable over-range if the recording device is sensitive to excess voltage and assign a maximum voltage.
 - For Current output, Global Settings does not apply.
4. After completing the configurations, press the (Apply or Accept) button.
5. To calibrate, press the Start button to see the reading, and use the buttons in the Manual Adjust field to make incremental adjustments as needed, noting the range and the minimum/maximum outputs shown in (Table 2-13).
 - For Current output, press the +100 button several times to get the setting close to 4mA.
6. Press the Accept button when adjustment reached.

Table 2-13. Analog Output Voltage/Current Range

| RANGE ¹ | RANGE SPAN | MINIMUM OUTPUT | MAXIMUM OUTPUT |
|----------------------------|------------|----------------|----------------|
| 5V | 0-5 VDC | -1 VDC | 6 VDC |
| 10V | 0-10 VDC | - 2 VDC | 12 VDC |
| Current² | 4-20 mA | 3 mA | 21 mA |

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

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

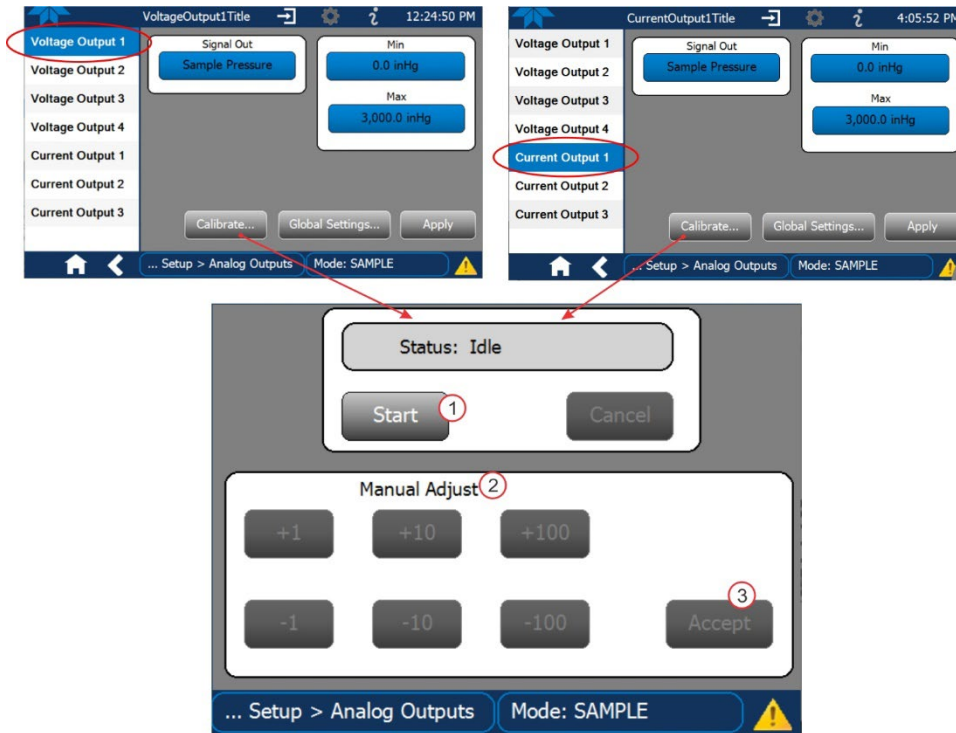


Figure 2-47. Analog Output Calibration, Voltage or Current



2.5.8.1. MANUAL CALIBRATION OF VOLTAGE RANGE ANALOG OUTPUTS

It is possible to manually calibrate the voltages by using a voltmeter connected across the output terminals (Figure 2-48) and changing the output signal level in the Setup>Analog Outputs>Calibrate screen's Manual Adjust field (Figure 2-47).

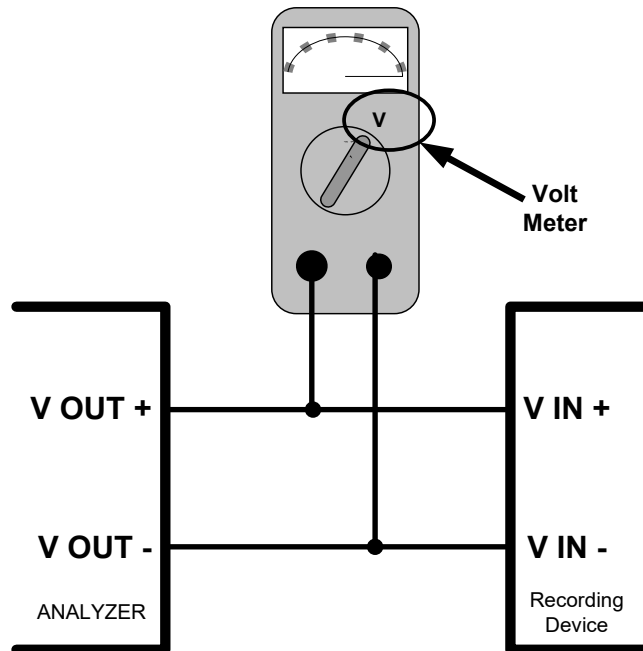


Figure 2-48. Setup for Checking / Calibrating DCV Analog Output Signal Levels

2.5.8.2. MANUAL ADJUSTMENT OF CURRENT RANGE ANALOG OUTPUTS

To manually calibrate the current signals, use an amp meter (Figure 2-49) 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.

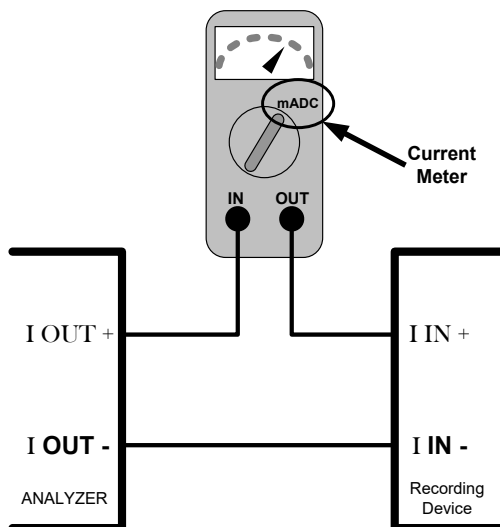


Figure 2-49. Setup for Checking / Calibration Current Output Signal Levels

2.5.9. SETUP>INSTRUMENT

As presented in Table 2-14, view product and system information and network settings, edit network settings, and perform certain maintenance tasks.

Table 2-14. 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.



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2.5.10.1. COM2

Configure the instrument's rear panel COM port to operate in modes listed in Table 2-15.

Table 2-15. COM Port Configuration

| MODE | DESCRIPTION |
|--------------------------------|---|
| Baud Rate | Set the baud rate. |
| Command Prompt Display | Enable/disable a command prompt to be displayed when in terminal mode. |
| Data Bits | Set the data bits to 7 or 8 (typically set in conjunction with Parity and Stop bits). |
| Echo and Line Editing | Enable/disable character echoing and line editing. |
| Handshaking Mode | 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). Or choose to turn OFF handshaking. |
| Hardware Error Checking | Enable/disable hardware error checking. |
| Hardware FIFO | Enable/disable the hardware First In – First Out (FIFO) for improving data transfer rate for that COM port. |
| Modem Connection | Select either a modem connection or a direct cable connection. |
| Modem Init String | Input an initialization string to enable the modem to communicate. |
| Parity | Select odd, or even, or no parity (typically set in conjunction with Data Bits and Stop Bits). |
| Protocol | Select among the communications protocols: MODBUS RTU, MODBUS ASCII (Section 3.1.1), Hessen (Section 3.1.2), or REST (Section 3.1.3). If selecting a MODBUS protocol, see Handshaking Mode, this table; MODBUS Registers are presented in Appendix A, this manual. Also see www.modbus.org . |
| Quiet Mode | Enable/disable Quiet mode, which suppresses any feedback from the analyzer (such as Alerts) 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. Such feedback is still available, but a command must be issued to receive them. |
| Security | 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. |
| Stop bits | Select either 0 or 1 stop bit (typically set in conjunction with Parity and Data bits). |

2.5.10.2. TCP PORT2

This menu is configured with the port number for MODBUS (Section 3.1.1).

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 2-16 for information).

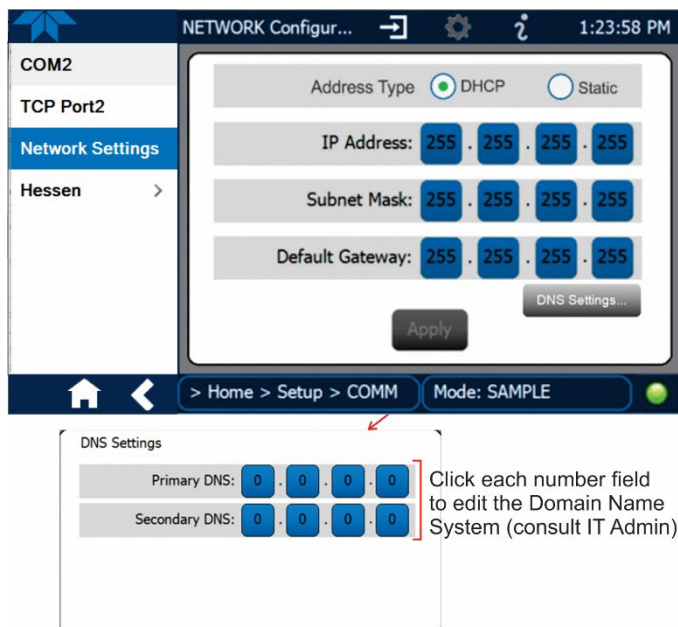


Figure 2-50. Communications Configuration, Network Settings

Table 2-16. LAN/Ethernet Configuration Properties

| PROPERTY | DESCRIPTION |
|------------------------|---|
| IP address | 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. |
| Subnet Mask | 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. |
| Default Gateway | 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. |

2.5.10.4. HESSEN

Configure Hessen Settings and Gas List (see Section 3.1.2).



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.

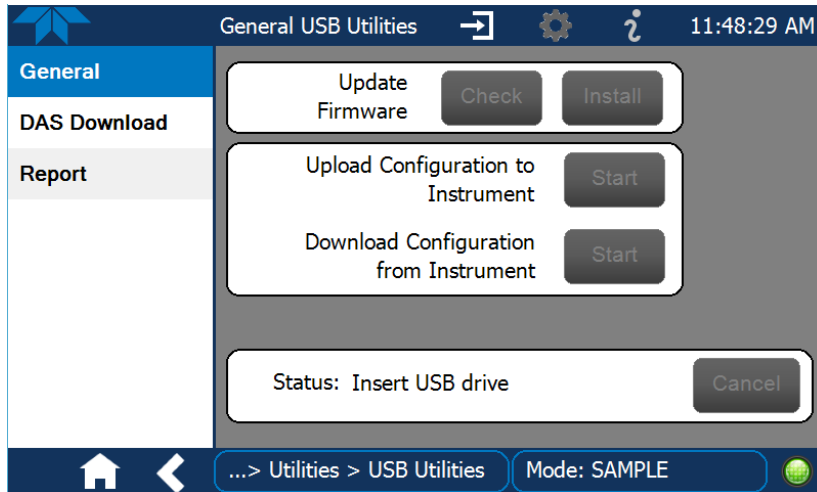


Figure 2-51. Configuration Transfer

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 standard 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 Data Logger (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 2-15, use the SETUP>COMM menu to view/edit the communications settings for the COM2 port.

3.1.1. MODBUS

MODBUS communications can be configured through the Setup>Comm>COM2 menu for transmission over Ethernet (Section 3.1.3) or serial communications.

1. Make the appropriate cable connections between the instrument and a PC.
2. Check the instrument's Modbus Units selection in the Setup>Vars menu and edit if needed.
3. Select the communication protocol for either MODBUS RTU or MODBUS ASCII transmission mode.

Important

When using MODBUS RTU, ensure that the Handshaking Mode is set to either Hardware or OFF. Do NOT set it to Software.

4. Set other parameters as needed (see descriptions in Table 2-15).
5. Press the Accept button to apply the settings.

The Setup>Comm>TCP Port2 is set to 502 for MODBUS by default.

See Appendix A for MODBUS Registers.

3.1.2. HESSEN

Hessen protocol is supported through serial communications. The Hessen protocol is not strictly defined; therefore, while Teledyne API's application is completely compatible with the protocol itself, it may be different from implementations by other companies. Configure the COM2 port for Hessen protocol through the Setup>Comm>COM2 menu: select COM2 Protocol and press Edit to select HESSEN, then press Accept.



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Hessen configuration includes settings for alarms, version, response mode, status flags and gas list. Locate the alarms in the Hessen Settings list (Setup>Comm>Hessen>Hessen Settings) and edit as desired.

HESSEN PROTOCOL RESPONSE MODE

Set the response mode, referring to Table 3-1 for descriptions.

Table 3-1. Teledyne API's Hessen Protocol Response Modes

| MODE ID | MODE DESCRIPTION |
|-------------|---|
| CMD | This is the default setting. Responses from the instrument are encoded as the traditional command format. Style and format of responses depend on exact coding of the initiating command. |
| BCC | Responses from the instrument are always delimited with <STX> (at the beginning of the response, <ETX> (at the end of the response followed by a 2 digit Block Check Code (checksum), regardless of the command encoding. |
| TEXT | Responses from the instrument are always delimited with <CR> at the beginning and the end of the string, regardless of the command encoding. |

HESSEN VARIATION

For the Hessen Variation setting, there are two versions.

- TYPE 1 is the original implementation.
- TYPE 2 has more flexibility when operating with instruments that can measure more than one type of gas. For more specific information about the difference between the two versions, download the *Manual Addendum for Hessen Protocol* from the Teledyne API's web site.

HESSEN STATUS FLAGS

Locate the various status flags in the Hessen Settings list and edit as needed. They are listed by status flag name with their default bit assignments. (Those with unassigned flags are listed as "0x0000").

- The status bits are included in the instrument's responses to inform the host computer of its condition. Each bit can be assigned to one operational and warning message flag.
- It is possible to assign more than one flag to the same Hessen status bit. This allows the grouping of similar flags, such as all temperature warnings, under the same status bit.
- Assigning conflicting flags to the same bit will cause each status bit to be triggered if any of the assigned flags is active.



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HESSEN GAS LIST

Table 3-2 describes the Hessen List (Setup>Comm>Hessen menu).

Table 3-2. Hessen List Configuration Summary

| ITEM | DEFINITION |
|-----------|---|
| Parameter | gas or non-gas parameter: either Add new or Edit existing. |
| Range | concentration range to be reported (when Reported box is checked) |
| 0 | currently active range |
| 1 | only when range 1 or low range is active |
| 2 | only when range 2 or high range is active |
| 3 | not applicable |
| Id | unique identification for parameter being added or edited |
| 110 | typically designated for SO ₂ |
| Reported | check to report when polled by the Hessen network |

3.1.3. REST

The REST protocol can be used to collect data, change parameters, extract data logs, poll groups of parameter values, and trigger calibration functions.

The user needs to be familiar with REST principles and underlying network technologies. The REST API service is on port 8180, using HTTP verbs (GET, PUT) and REST Resources in JSON format. Tag names and command strings are case sensitive. The Resources are defined in Table 3-3.

The Teledyne API REST guide is a tutorial in the form of Service Note 22-002, accessible on our website under this product page's Downloads tab.

Important

EXTERNAL DATALOGGER BEST FOR REST PROTOCOL
Frequent polling of the instrument's datalogger with REST can slow not only its software routines and tasks, but also the response to the external datalogger polling request.
We recommend polling the live Tag values directly for external datalogger use with REST protocol.



Table 3-3. REST Resource Descriptions

| RESOURCE | DESCRIPTION | OPERATION |
|----------------|--|----------------------|
| Tag | Maps to an instrument tag, allowing direct access to parameter properties/attributes | Read/Write (GET/PUT) |
| Tag.value | Maps to an instrument tag value separately from its properties for direct/fast access due to dynamic characteristics | Read/Write (GET/PUT) |
| Tag-list | Queries for instrument's available tags and their properties; query can be filtered for specific tag group | Read only (GET) |
| Tag-list.value | Retrieves specified group of tag values as a batch; groups include: PRIGAS, LOG, TRIG, AOUTMAP, HIST, TRACK_ALL_UPDATES | Read/Write (GET/PUT) |
| Datalog-list | Retrieves list of the instrument's available data logs | Read only (GET) |
| Datalog | Retrieves specified data log, based on a defined page number and number of records per page, or on a defined time range that includes start & end date, hour (24-hr format), minute, and seconds (where blank = default, no seconds) | Read only (GET) |

3.2. ETHERNET

When using the Ethernet interface, the analyzer can be connected to any standard 10BaseT or 100BaseT 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 3-4. 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.

For MODBUS communications configuration, see 3.1.1.

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 provides important pre-calibration information as well as calibration and check procedures, and how to evaluate the quality of each calibration.

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 (see Note below, regarding flow)
- Span gas source (see Note below, regarding flow)
- Gas lines - all gas line materials should be Teflon-type or glass.
- Traceability Standards

Optional equipment: A recording device such as a strip-chart recorder and/or data logger should be used to record data from the serial or analog option 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 device should be capable of bi-polar operation so that negative readings can be recorded. For electronic documentation, the internal data acquisition system (DAS) can be used by configuring the Data Logger through the Setup>Data Logging menu; Section 2.5.1).



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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.
- 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 1.5 to 2 times 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.

4.1.2. ZERO AIR

Zero air is similar in chemical composition to the Earth's atmosphere but scrubbed of all components that might affect the analyzer's readings. For SO₂ measuring devices, zero air should be similar in composition to the sample gas but devoid of SO₂ and large amounts of hydrocarbons, nitrogen oxide (NO) and with a water vapor dew point $\leq -15^{\circ}\text{C}$.

Devices such as the API Model 701 zero air generator that condition ambient air by drying and removal of pollutants are available. We recommend this type of device for generating zero air.

4.1.3. CALIBRATION (SPAN) GAS

Span gas is specifically mixed to match the chemical composition of the gas being measured at near full scale of the desired reporting range. For example, if the measurement range is 500 ppb (50 ppm, N100H), the span gas should have an SO₂ concentration of about 400 ppb (40 ppm, N100H).

Span gases should be certified to a specific accuracy to ensure accurate calibration of the analyzer. Typical gas accuracy for SO₂ gases is 1 or 2 %.

- If using a secondary dilution source with zero air through a calibrator, then use a bottle of SO₂ balanced nitrogen.
- If calibrator and zero air source are not available, then use a bottle of SO₂ balanced air.

Teledyne API offers an IZS option (N100 only) operating with permeation devices. The accuracy of these devices is about $\pm 5\%$. Whereas this may be sufficient for quick, daily calibration checks, we strongly recommend using certified SO₂ span gases for accurate calibration.



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4.1.4. SPAN GAS FOR MULTIPOINT CALIBRATION

Some applications may require a multipoint calibration procedure where span gases of different concentrations are needed. We recommend using a bottle of calibrated SO₂ gas of higher concentration in conjunction with a gas dilution calibrator such as a Teledyne API Model T700. This type of calibrator precisely mixes a high concentration gas with zero air (both supplied externally) to accurately produce span gas of the correct concentration. Linearity profiles can be automated with this model and run unattended over night.

If a dynamic dilution system is used to dilute high concentration gas standards to low, ambient concentrations, ensure that the SO₂ concentration of the reference gas matches the dilution range of the calibrator.

Choose the SO₂ 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 SO₂ gas to a final concentration of 500 ppb, as this would operate at the very extreme dilution setting.
- A 100 ppm SO₂ 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 entire measurement range of the N100 is 0 – 20,000 ppb and the N100H is 0 – 5,000 ppm, but many applications use only a small part of the analyzer's full measurement range, which then becomes a data resolution challenge where the reported measurement may be barely perceptible. The software rectifies this challenge when the user defines the portion of the physical range relevant to the specific application, which the software then uses to scale the reporting range and accurately display the concentration(s).

The analyzer's CPU chooses the appropriate physical range, based on the configuration of the PMT Range variable in the Setup>Vars>PMT Range menu (see Table 2-12).



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4.1.6. INTERFERENTS

The fluorescence method for detecting SO₂ is subject to interference from a number of sources including hydrocarbons, which fluoresce similarly to SO₂. However, the analyzer has been designed to reject most of these interferences.

Nitrogen oxide (NO) also fluoresces in a spectral range near to SO₂. For critical applications where high levels of NO are expected, an optional optical filter is available in the N100 that improves the rejection of NO (contact Technical Support for more information).

4.1.7. PERMEATION TUBE OPTIONS

Teledyne API offers an optional internal span gas generator that utilizes a permeation tube as a span gas source. The accuracy of these devices is only about $\pm 5\%$. Whereas this may be sufficient for quick, daily calibration checks, we recommend using certified SO₂ span 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 a vacuum pump must be connected and powered on to maintain constant gas flow through the analyzer at all times.

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 handling, download, storage, quick check and plotting.



4.2. CALIBRATION PROCEDURES

First verify and if needed, change (if needed) the settings in the Setup>Vars menu as follows:

- User Units (unit of Measure)
- PMT Range (Low for Min Range spec; High for Max Range spec)
- Range Mode: SNGL

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 span gas through the Sample port, and check the reading after the Stability falls below 1.0 PPB (N100) or 1.0 PPM (N100H) per user selection (viewable 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. after connecting the sources of zero air and span gas in either of the following two ways:

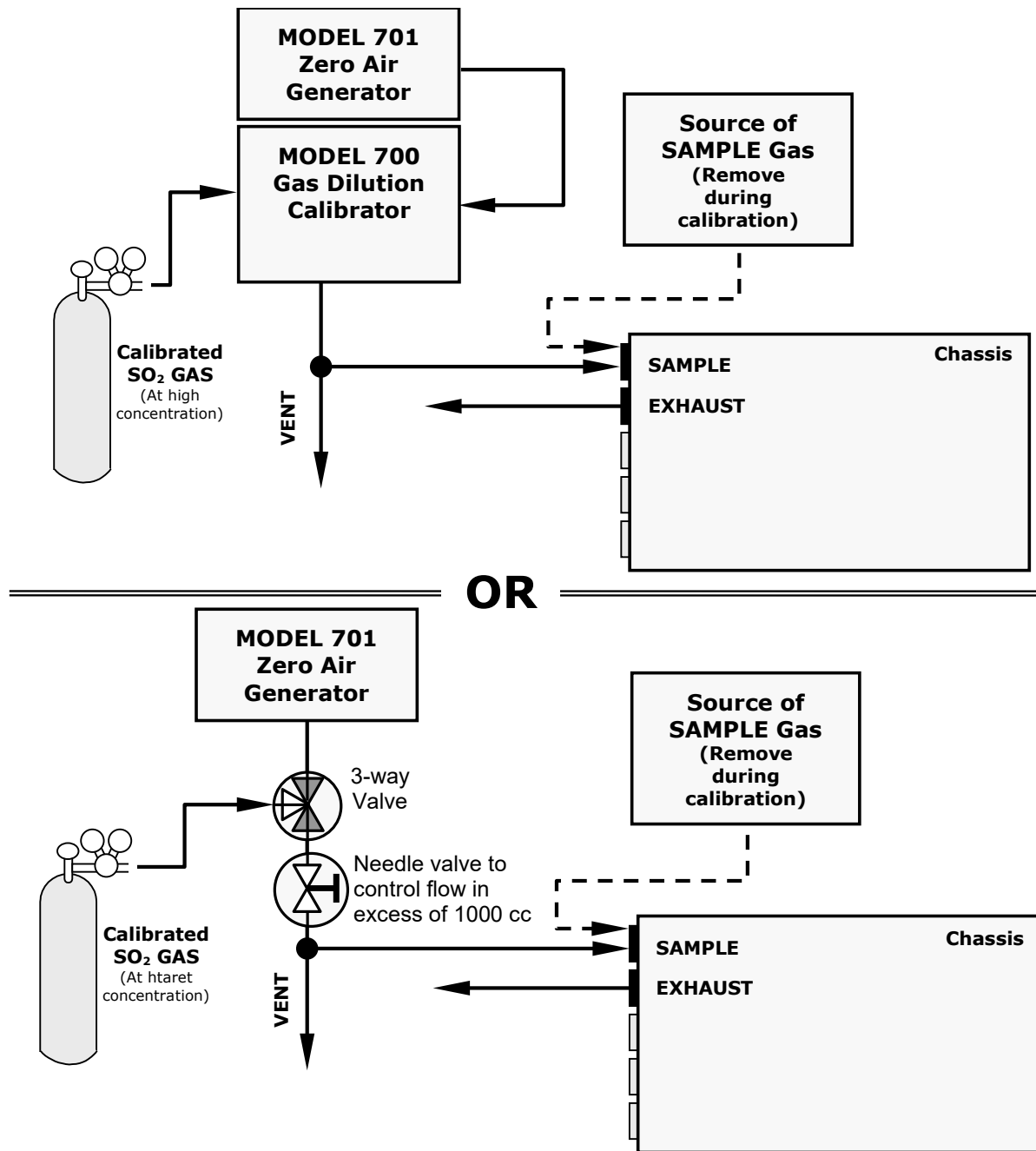


Figure 4-1. Setup for Manual Calibration without Z/S Valve Option



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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 to reach stability.
- b. Press Stop and check the reading.

ACTUAL CALIBRATION:

- a. Wait to reach stability, then press the Zero button.
- b. Press Stop and check the reading.

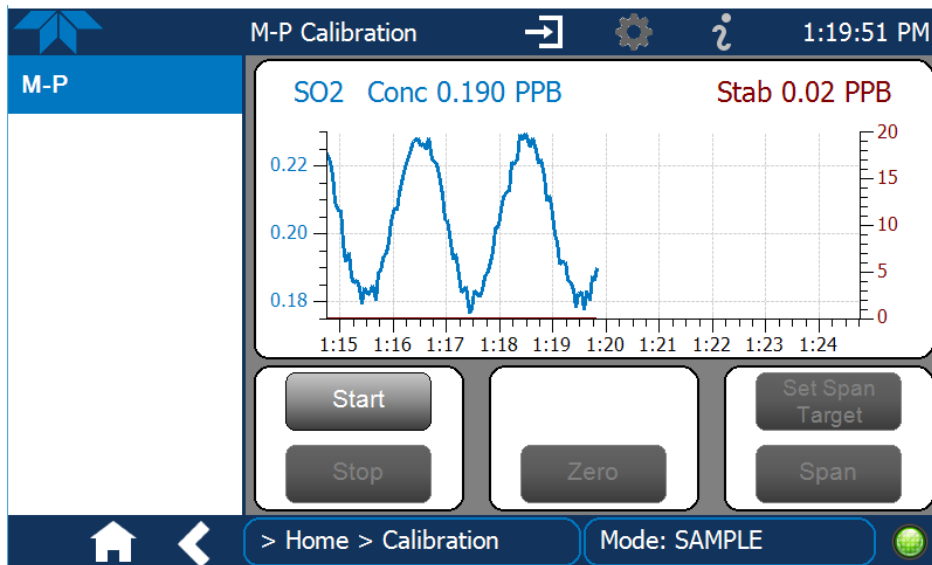


Figure 4-2. Multi-Point Calibration Page

4.2.1.2. SPAN CALIBRATION CHECK AND ACTUAL CALIBRATION

1. While still in the Calibration>M-P menu, input 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. Check the reading(s).

ACTUAL CALIBRATION:

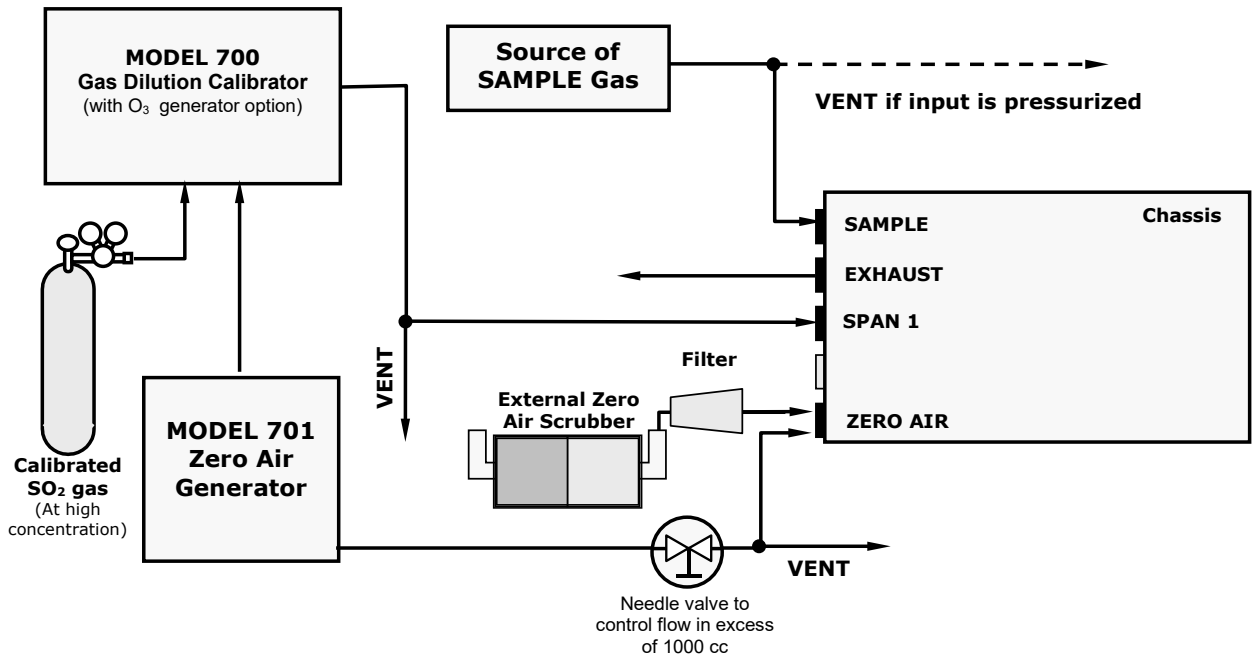
- a. Press the Set Span Target button and enter the gas concentration.
 - b. Verify the concentration reading is the same as the concentration being supplied.
 - c. If incorrect, wait to reach stability, then press the Span button.
 - d. In the Cal Result window, press OK.
3. Press the Stop button and return to Home screen.
 4. In the Dashboard, check and record the Slope(s) and the Offset(s). (See Table 4-2 in Section 0,
 5. Calibration Quality Analysis, for expected/acceptable values).



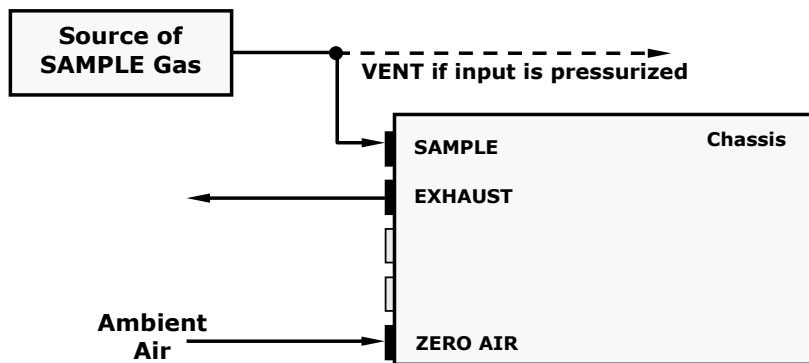
4.2.2. CALIBRATION AND CHECK PROCEDURES WITH VALVE OPTION INSTALLED

On units with an IZS option installed, zero air and span gas are supplied to the analyzer through the zero gas inlet and from ambient air.

On units with a zero/span valve option installed, zero air and span gas are supplied to the analyzer through the zero gas and span gas inlets from two different sources.



Connections with Zero Span Valves Option



Connections with IZS Valves Option

Figure 4-3. Setup for Manual Calibration Check with Valve Options

Navigate to the Calibration>Zero menu for Zero cal and to the Calibration>Span menu for Span cal (see Figure 4-4) and follow the instructions in Sections 4.2.1.1 and 4.2.1.2



Figure 4-4. Zero and Span Calibration Screens

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

Digital Inputs are available for controlling 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.

4.2.2.2. AUTOMATIC CALIBRATION CHECK (AUTO CAL) WITH ZERO/SPAN VALVE OPTION

The Auto Cal feature allows unattended periodic calibration checks with the ZERO/SPAN valve option by executing up to three separate preprogrammed sequences (labeled # 1, 2 and 3). Each calibration check can operate in either Zero mode or Span mode. The Auto Cal feature requires that the instrument remain in Calibration mode after the values reset to ambient, in order to continue flagging the data until purging is complete. This is accomplished with the Auto Cal Purge VAR.

To continue calibration until the system is purged, navigate to Setup>Vars>AutoCal Purge and use the Edit button to select the number of minutes for the purge duration.

To program the calibration checks for future execution (Figure 4-5), in the numbered sequence row (#1, #2, #3), click the Zero box or the Span box to select the valve to be switched open, then input the Start, Interval, and Duration parameters (refer to Table 4-3) in the active field for that sequence (identified by the matching number in its upper left corner). Checking the Enabled box for that sequence allows the program to execute once the Apply button is clicked.

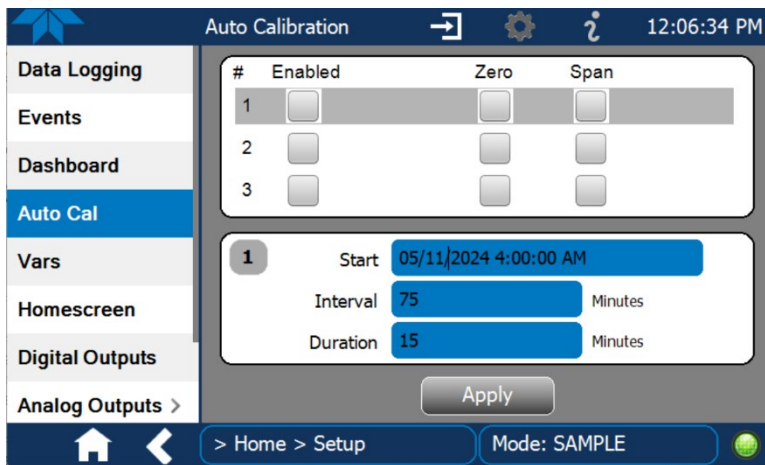


Figure 4-5. Auto Cal Page

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 4-1.

Table 4-1. Auto Cal Calibration Check Programming Sequence Execution

| ATTRIBUTE | ACTION |
|-----------|--|
| Start | 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). |
| Interval | Number of minutes to skip between each Sequence execution. (Click the field to input the number of minutes in the pop-up window). |
| Duration | 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 (Setup>Instrument>Date/Time Settings, Section 2.5.9).
- Avoid setting two or more sequences at the same time of the day.
- Any user-initiated calibration or calibration check that overlaps or coincides with a preprogrammed AutoCal check will override the AutoCal check.
- It is recommended that calibration checks be performed using external sources of Zero Air and Span Gas whose accuracy is traceable to EPA standards.

4.3. CALIBRATION QUALITY ANALYSIS

After completing a calibration procedure, it is important to evaluate the analyzer’s calibration **SLOPE** and **OFFSET** parameters. These values describe the linear response curve of the analyzer. 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 (see Section 2.5.1) to record the values of the SO₂ Offset and SO₂ Slope parameters.

Ensure that these parameters are within the limits listed in Table 4-2 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 5.7.6.

Table 4-2. Calibration Data Quality Evaluation

| FUNCTION | MINIMUM VALUE | OPTIMUM VALUE | MAXIMUM VALUE |
|------------------------|---------------|---------------|---------------|
| SO ₂ Slope | 0.700 | 1.000 | 1.300 |
| SO ₂ Offset | 0.0 mV | n/a | 250.0 mV |



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 internal electrical assemblies. Failure to do so can cause damage to instrument.

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 these 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.



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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.

When running a “check” only, 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 (see Section 4.2.2.2).

Table 5-1. Maintenance Schedule

| ITEM | ACTION | FREQ | CAL CHECK REQ'D | DATE PERFORMED | | | | | | | | | | | | |
|--|---------------------------|--|-----------------|----------------|--|--|--|--|--|--|--|--|--|--|--|--|
| | | | | | | | | | | | | | | | | |
| Dashboard functions | Review and evaluate | Weekly | No | | | | | | | | | | | | | |
| ¹ Sample particulate filter option | Change membrane element | Weekly or as necessary | No | | | | | | | | | | | | | |
| Zero/span check | Evaluate offset and slope | Weekly | No | | | | | | | | | | | | | |
| ¹ Zero/span calibration | Calibrate Zero and span | Every 3 months | Yes | | | | | | | | | | | | | |
| ¹ External zero air scrubber option | Exchange chemical | Annually or as necessary | No | | | | | | | | | | | | | |
| ¹ Flow | Check Flow | Every 6 months | No | | | | | | | | | | | | | |
| Software/Firmware | Check for updates | Every 6 months or whenever serviced | Yes | | | | | | | | | | | | | |
| IZS Permeation Tube (N100 option) | Replace | Annually | Yes | | | | | | | | | | | | | |
| Calibrate Lamp Output | Perform Lamp Cal | Prior to zero/span calibration or PMT hardware calibration | N/A | | | | | | | | | | | | | |
| DFU filters | Change | Annually (or as needed for highly polluted sample air) | No | | | | | | | | | | | | | |



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| ITEM | ACTION | FREQ | CAL CHECK REQ'D | DATE PERFORMED | | | | | | | | | | | | | |
|---|-----------------------------------|---|---------------------------|----------------|--|--|--|--|--|--|--|--|--|--|--|--|--|
| | | | | | | | | | | | | | | | | | |
| Pneumatic sub-system | Check for leaks in gas flow paths | Annually or after repairs involving pneumatics | Yes if a leak is repaired | | | | | | | | | | | | | | |
| ¹ Sample chamber optics | Clean chamber, windows & filters | As necessary | Yes | | | | | | | | | | | | | | |
| ¹ PMT Sensor Hardware Calibration | Low-level hardware calibration | After changing PMT/preamp or if slope is outside of 0.7 – 1.3 | Yes | | | | | | | | | | | | | | |
| Pump (N100H) | Rebuild head | when Rx Cell pressure exceeds 10 in-Hg-A (at sea level) | Yes | | | | | | | | | | | | | | |
| ¹ Pump Diaphragm (N100) | Replace | Annually | Yes | | | | | | | | | | | | | | |
| ¹ Critical flow orifice & sintered filters | Replace | As necessary | Yes | | | | | | | | | | | | | | |
| Desiccant bags | Replace | Any time PMT housing is opened for maintenance | n/a | | | | | | | | | | | | | | |

¹ These Items are required to maintain full warranty; all other items are strongly recommended.

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 |
|------------|--|----------------------------------|---|
| Dark PMT | Constant to within ± 20 of check-out value | Significantly increasing | <ul style="list-style-type: none"> • PMT cooler failure • Lamp Failure |
| Lamp Ratio | Stable and near 100% | Fluctuating or Slowly increasing | <ul style="list-style-type: none"> • UV detector wearing out • UV source Filter developing pin holes |
| | | Slowly decreasing | <ul style="list-style-type: none"> • UV detector wearing out • Opaque oxides building up on UV source Filter • UV lamp aging |



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| FUNCTION | EXPECTED | ACTUAL | INTERPRETATION |
|--------------------------------------|---|----------------------|--|
| Pressure | Constant within atmospheric changes | Fluctuating | Developing leak in pneumatic system. Check for leaks. |
| | | Slowly increasing | Flow path is clogging up. Check and/or replace orifice filters. Replace particulate filter |
| | | Slowly decreasing | Developing leak in pneumatic system to vacuum (developing valve failure). Check for leaks. |
| Sample Flow | Stable | Slowly decreasing | Flow path is clogging up. Check and/or replace orifice filters. Replace particulate filter |
| | | Fluctuating | Leak in gas flow path. |
| SO ₂ Conc (Concentration) | (At span with IZS option installed): Constant response from day to day. | Decreasing over time | Change in instrument response Degradation of IZS permeation tube |
| | (Standard configuration at span): Stable for constant concentration | Decreasing over time | Drift of instrument response; UV Lamp output is excessively low. |

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. The report is generated every 24 hours to a Web services “cloud” where it is available for viewing by Teledyne API technical support personnel. 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.

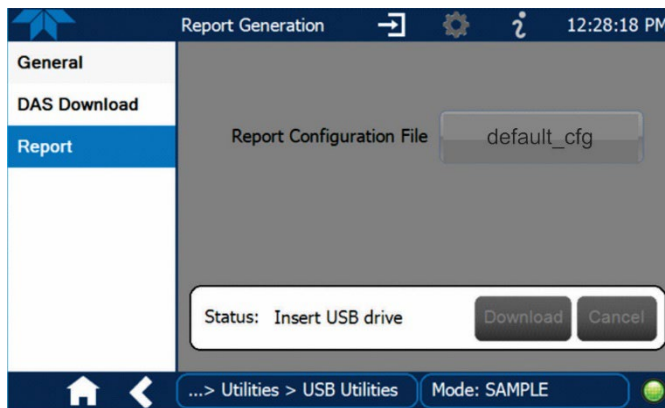


Figure 5-1. Report Generation Page



5.4. SOFTWARE/FIRMWARE UPDATES

An automatic weekly check for updates can be enabled in the Setup>Vars>Periodically Check for Updates menu, and/or a check for updates can be prompted at any time in the Setup>Instrument>Remote Update page. Downloading updates can be performed either remotely (5.4.1) or manually (5.4.2).

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 (Figure 5-2). If an update is available, the Update button will be enabled.

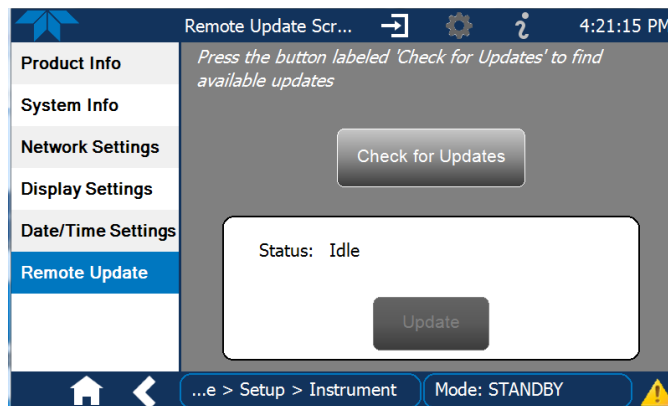


Figure 5-2. Remote Update Page

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 (email), +1 800-324-5190 (toll free), +1 858-657-9800 (phone).

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

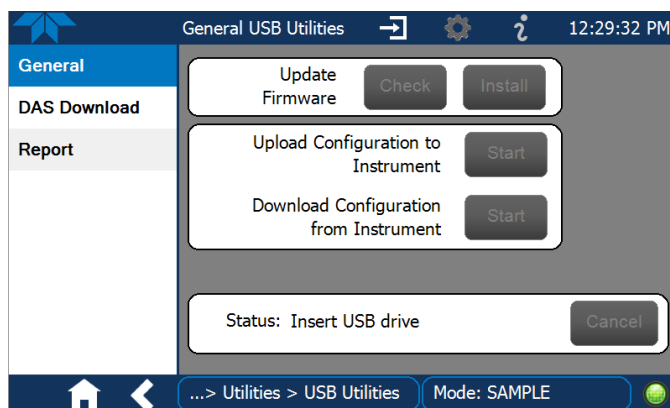


Figure 5-3. Manual Update Page (and other utilities)

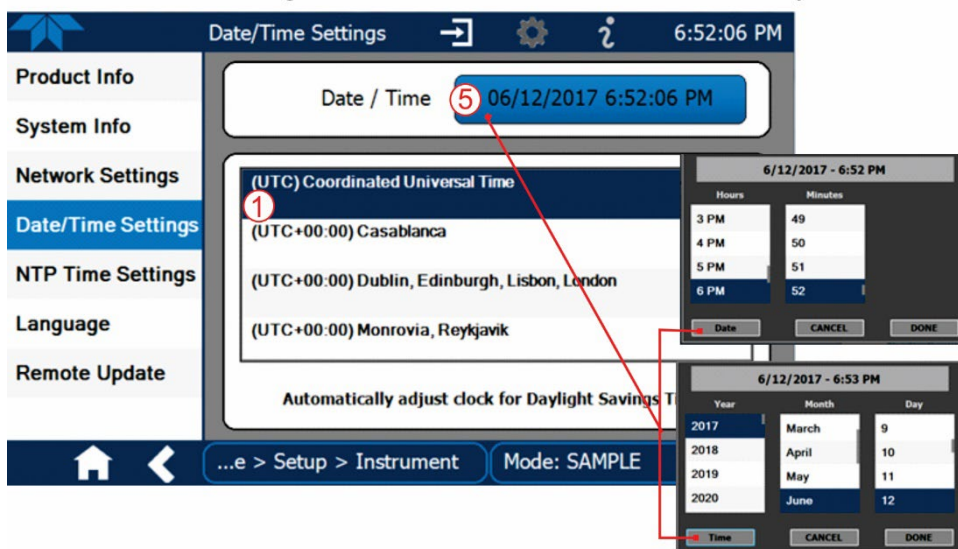
3. Insert the flash drive into a front panel USB port and wait for the Status field to indicate that the drive has been detected.
4. In the Update Firmware field, press the Check button for the instrument to determine whether the firmware on the flash drive is more recent than what is currently installed. 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.

5.5. 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 5-4. 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 DFU SAMPLE FILTER

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.

5.6.2. REPLACING THE 47 MM SAMPLE PARTICULATE FILTER ELEMENT

For analyzers equipped with the 47mm filter, inspect the particulate filter often for signs of plugging or contamination. It should be replaced according to the service interval schedule even without obvious signs of dirt, as filters with 1 and 5 μm pore size can clog up while retaining a clean look.

Important

IMPACT ON READINGS OR DATA

Use gloves or PTFE coated tweezers or similar handling to avoid contamination of the sample filter assembly. Do not touch any part of the housing, filter element, PTFE retaining ring, glass cover and the o-ring with bare hands, as contamination can negatively impact accuracy of readings.

To change the filter:

1. Turn OFF the analyzer to prevent drawing debris into the instrument.
2. Open the hinged rear panel and unscrew the Retaining Ring on the filter assembly (Figure 5-5).



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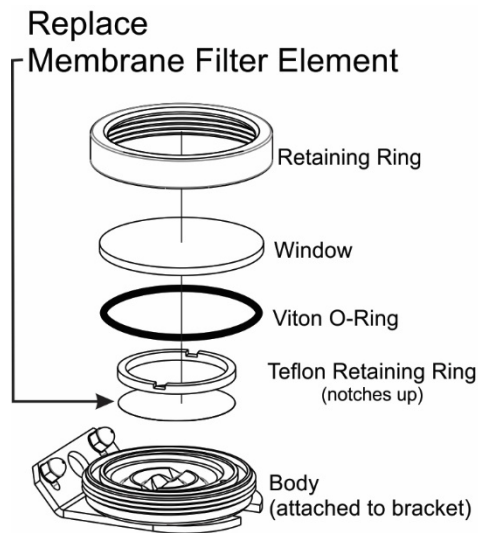


Figure 5-5. Replacing the Particulate Filter Element

3. Carefully remove the Retaining Ring, the glass Window, the notched Teflon Retaining Ring, and the used Membrane Filter Element. (the Viton O-Ring may come up with the Window or it may remain nested in the Body)
4. Insert the new Membrane Filter Element, being careful that it is fully seated and centered in the bottom of the Body.
5. Ensuring that the Viton O-Ring is nested in the Body, reinsert the Teflon Retaining Ring with the notches up, then the glass Window, and gently screw on the Retaining Ring and hand tighten.
6. Inspect and ensure that the Viton O-ring is creating a proper seal all around.
7. Close the panel and restart the analyzer.

5.6.3. CHANGING/REMOVING THE IZS PERMEATION TUBE (N100 OPTION)

1. Turn off the analyzer, unplug the power cord and remove the cover.
2. Locate the IZS oven inside the analyzer.
3. Remove the top layer of insulation.
4. Unscrew the black aluminum cover of the IZS oven (3 screws) using a medium Phillips-head screwdriver.
 - Leave the fittings and tubing connected to the cover.
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 (Teflon) is facing up.
6. With the sealing O-ring properly in place, re-attach the cover with three screws.
 - Ensure that the three screws are tightened evenly.



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7. Return the top layer of insulation back into place.
8. Replace the analyzer cover, plug the power cord back in and turn on the analyzer.
9. Carry out an IZS span check to verify that the new permeation device works properly (see Section 4.2.2.2).
 - 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 gas, even at room temperature and will contaminate the entire instrument.

5.6.4. CHANGING THE EXTERNAL ZERO AIR SCRUBBER OPTION

The chemicals in the external scrubber need to be replaced periodically according to the maintenance schedule or more frequently as needed. This procedure can be carried out while the instrument is running, but ensure that the analyzer is not in either the ZERO or SPAN calibration modes.

1. Locate the scrubber on the outside rear panel.
2. Remove the old scrubber by disconnecting the 1/4" plastic tubing from the particle filter using 9/16" and 1/2" wrenches.
3. Remove the particle filter from the cartridge using 9/16" wrenches.
4. Unscrew the top of the scrubber canister and discard charcoal contents. Ensure to abide by local laws for discarding these chemicals. The rebuild kit comes with a Material and Safety Data Sheet, which contains more information on these chemicals.
5. Refill the scrubber with charcoal.
6. Tighten the cap on the scrubber - hand-tight only.
7. Replace the DFU filter, if required, with a new unit and discard the old.
8. Replace the scrubber assembly into its clips on the rear panel.
9. Reconnect the plastic tubing to the fitting of the particle filter.
10. 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.



5.6.5. SERVICING CRITICAL FLOW ORIFICES

A critical flow orifice, located on the exhaust manifold maintains the proper flow rate of gas through the analyzer. 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 a sample filter or in an environment with very fine, sub-micron particle-size dust.

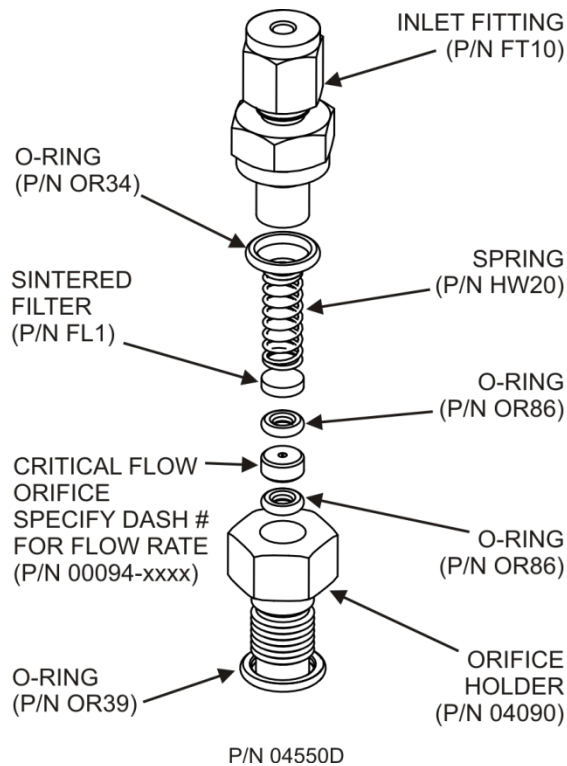


Figure 5-6. Critical Flow Orifice Assembly

To clean or replace a critical flow orifice:

1. Turn off power to the instrument and vacuum pump.
2. Locate the critical flow orifice on the exhaust manifold.
3. Disconnect the pneumatic line.
4. Unscrew the NPT fitting.

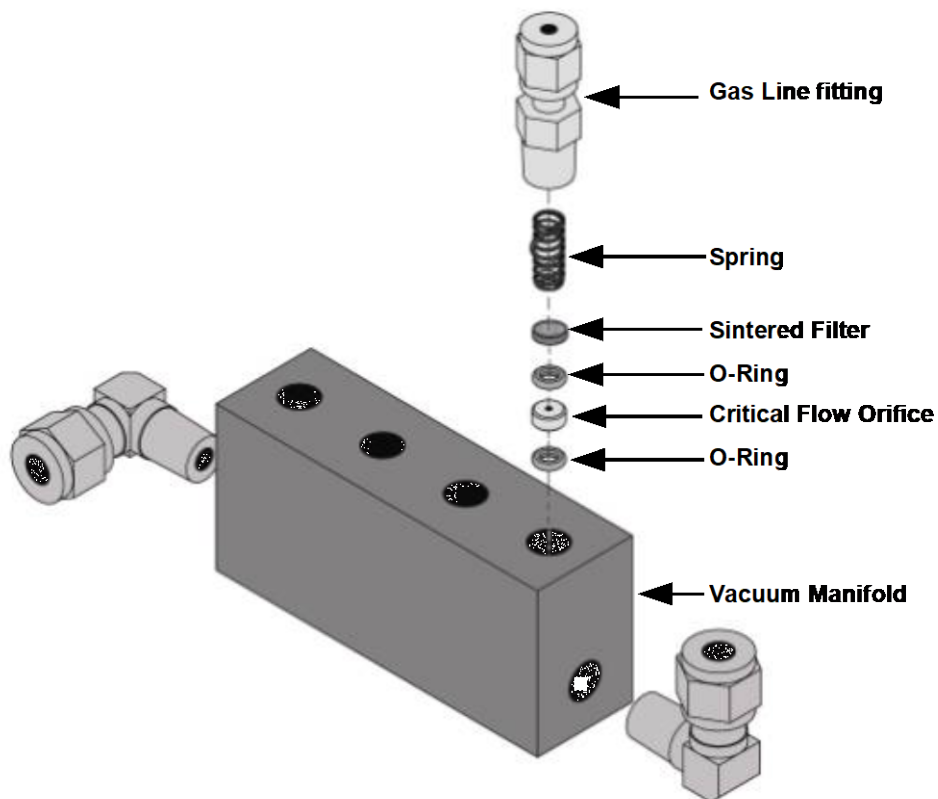


Figure 5-7. Critical Flow Orifice and Vacuum Manifold Assembly

5. Take out the components of the assembly: a spring, a sintered filter, two O-rings and the critical flow orifice.

Note You may need to use a scribe or pressure from the vacuum port to get the parts out of the manifold.

6. Discard the two O-rings and the sintered filter.
7. Replace the critical flow orifice.
8. Using a new filter and o-rings, reassemble the parts as shown in Figure 5-6.
9. Reinstall the NPT fitting with fresh Teflon tape and connect all tubing
10. Power up the analyzer and allow it to warm up for 60 minutes.
11. Perform a leak check.



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5.6.6. CHECKING FOR LIGHT LEAKS AFTER MAINTENANCE OR REPAIR

When re-assembled after maintenance or repair, or if operated improperly, the PMT assembly can develop small gaps, allowing stray light from the analyzer surroundings 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, especially the power supply, 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 fittings 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 performance.
5. If there is a PMT response to the external light, symmetrically tighten the sample chamber mounting screws or replace the 1/4" vacuum tubing with new, black PTFE tubing (this tubing will fade with time and become transparent).

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 5.6.7).



5.6.7. 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.

5.6.7.1. 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. Cap the sample inlet port (cap must be wrench-tight).
2. After several minutes, when the pressures have stabilized, note the Sample Pressure reading.
 - If between .9 and 10 in-Hg-A, the instrument is free of large leaks.
 - It is still possible that the instrument has minor leaks.
 - If the reading less than 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).
3. When finished, switch off the pump and open the cap to the sample inlet port slowly to minimize in-rush flow.

5.6.7.2. DETAILED PRESSURE LEAK CHECK

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 ≤ 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.

Also, do not exceed 15 psi when pressurizing the system.

1. Turn OFF power to the instrument and remove the instrument cover.
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. Pressurize the instrument with the leak checker or tank gas, allowing enough time to fully pressurize the instrument through the critical flow orifice.
4. 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.



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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.

5.6.7.3. PERFORMING FLOW CHECKS/CALIBRATIONS

Important

IMPACT ON READINGS OR DATA

For accurate measurements use a separate, calibrated, volumetric flow meter capable of measuring the instrument's flow specifications. Do not use the built in flow measurement viewable in the Dashboard as this value is only calculated, not measured.

The sample gas flow rate through the analyzer is a key part of the gas concentration reading, but the reading is only a calculated value derived by the CPU. The Flow Cal feature under the Utilities>Diagnostics menu is used to check and to calibrate/adjust the calculations.

Sample flow checks, using an external flow meter, are useful for monitoring the actual flow of the instrument to detect drift of the internal flow measurement. A decreasing, actual sample flow may point to slowly clogging sample filter, sample/cal valve, or to pneumatic paths, most likely critical flow orifices or sintered filters (Section 5.6.5).

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).

FLOW CALIBRATION

To calibrate the Sample flow (Flow Cal):

1. In the Utilities>Diagnostics>Flow Cal menu (Figure 5-8), 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.

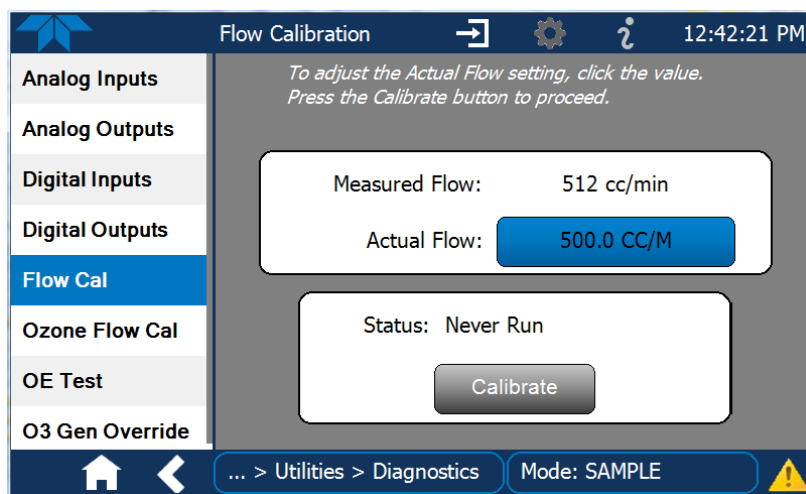


Figure 5-8. Flow Calibration Menu

5.6.8. CHECKING THE HYDROCARBON SCRUBBER/KICKER (OPTION IN N100H)

There are two possible types of problems that can occur with the scrubber: pneumatic leaks and contamination that ruins the inner tube's ability to absorb hydrocarbons.

5.6.8.1. CHECKING THE SCRUBBER FOR LEAKS

Leaks in the outer tubing of the scrubber can be found using the procedure described in Section 5.6.7.2. Use the following method to determine if a leak exists in the inner tubing of the scrubber.

This procedure requires a pressurized source of air (chemical composition is unimportant) capable of supplying up to 15 psia and a leak checking fixture such as the one illustrated in Figure 5-9.



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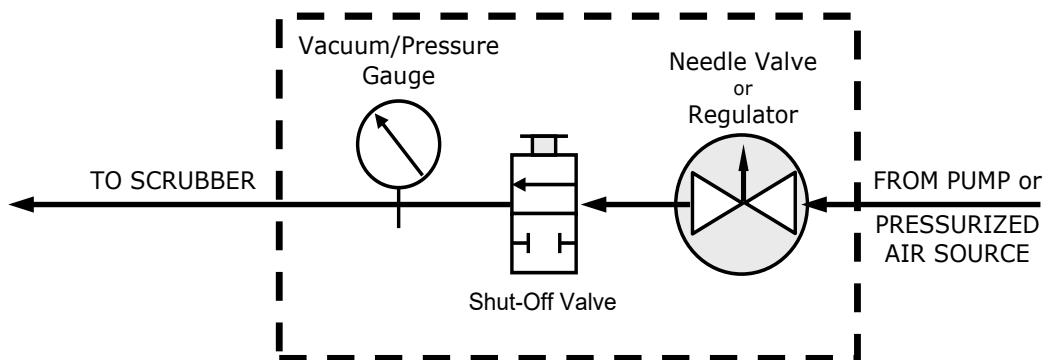


Figure 5-9. Simple Leak Check Fixture

1. Turn off the analyzer.
2. Disconnect the pneumatic tubing attached to both ends of the scrubber's inner tubing.
3. One end is connected to the sample particulate filter assembly and the other end is connected to the reaction cell assembly.
4. Both ends are made of the 1/8" black Teflon tubing.
5. Cap one end of the hydrocarbon scrubber.
6. Attach the pressurized air source to the other end of the scrubber inner tubing with the leak check fixture in line.

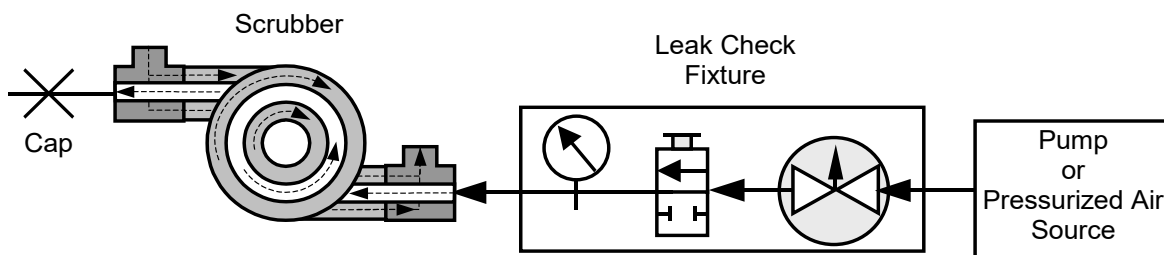


Figure 5-10. Hydrocarbon Scrubber Leak Check Setup

7. Use the needle valve or regulator to adjust the air input until the gauge reads 10-15 psiA.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY
Ensure the pressure does not exceed 15 psiA.
Do not pull vacuum through the scrubber.

8. Close the shut-off valve.
9. Wait 5 minutes.

If the gauge pressure drops >1 psi within 5 minutes, then the hydrocarbon scrubber has an internal leak and must be replaced. Contact Teledyne API's Technical Support.



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 (Section 5.7.4).
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.
 - 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.



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.

Note 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 |
|---------------------------------------|---|---|
| ANALOG CAL WARNING | One of the analog outputs is not calibrated | <ul style="list-style-type: none"> • A parameter for one of the analog outputs, even one not currently being used, has been changed without the output being recalibrated |
| BOX TEMP WARNING | Temperature of chassis is outside specified limits. (typically < 7°C or > 48°C) | <ul style="list-style-type: none"> • Box Temperature typically runs ~7°C warmer than ambient temperature • Poor/blocked ventilation to the analyzer • Stopped Exhaust Fan • Ambient temperature outside of specified range |
| CONFIG INITIALIZED | Configuration and Calibration data reset to original Factory state or erased. | <ul style="list-style-type: none"> • User erased data |
| DARK PMT WARNING | Dark PMT signal is too high Dark offset above limit specified | <ul style="list-style-type: none"> • Light leak in reaction cell • Loose connector/wiring • PMT bench module board not functioning properly |
| DATA INITIALIZED | Data Storage in DAS was erased before the last power up occurred. | <ul style="list-style-type: none"> • User cleared data. |
| HVPS WARNING | High voltage power supply output is too high or too low for proper operation of the PMT. (Outside of allowable limits). | <ul style="list-style-type: none"> • High voltage power supply is bad • High voltage power supply is out of cal |
| IZS TEMP WARNING (N100 option) | Permeation tube temperature is outside specified limits. | <ul style="list-style-type: none"> • Bad IZS heater • Bad IZS temperature sensor |
| PMT TEMP WARNING | PMT temperature outside of set limits. | <ul style="list-style-type: none"> • PMT fan not operating • Failed PMT Temperature Sensor • Failed PMT TEC • Failed PMT TEC driver circuit • Failed PMT bench module board • Loose connection to/from PMT temperature sensor |
| PMT DET WARNING | PMT detector output is outside of operational limits. | <ul style="list-style-type: none"> • Failed PMT • Malfunctioning PMT bench module board |
| RCELL TEMP WARN | Sample chamber temperature is out of range. | <ul style="list-style-type: none"> • Failed reaction cell heater • Failed reaction cell temperature sensor |



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| WARNING | FAULT CONDITION | POSSIBLE CAUSES |
|-------------------------------------|---|--|
| SAMPLE FLOW WARN | The flow rate of the sample gas is outside the specified limits. | <ul style="list-style-type: none">• Failed Sample Pump• Blocked Sample Inlet/Gas Line• Dirty Particulate Filter• Leak downstream of Critical Flow Orifice• Failed flow sensor circuitry |
| SAMPLE PRES WARN | Sample Pressure is <10 in-Hg or > 35 in-H Note: 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 < 10 in-hg: <ul style="list-style-type: none">• Blocked particulate filter• Blocked sample inlet/gas line• Failed pressure sensor/circuitry If sample pressure is > 35 in-hg: <ul style="list-style-type: none">• Blocked vent line on pressurized sample/zero/span gas supply• Bad pressure sensor/circuitry |
| SYSTEM RESET | The instrument has rebooted. | This message occurs at power on. If confirmed that power has not been interrupted: <ul style="list-style-type: none">• Fatal Error caused software to restart• Loose connector/wiring |
| UV LAMP WARNING | The UV lamp intensity measured by the reference is outside of specified limits. | <ul style="list-style-type: none">• UV lamp is bad• Reference detector is bad or out of adjustment.• Fogged or damaged lenses/filters in UV light path• Light leak in reaction cell |
| VACUUM PRESS WARNING (N100H) | Gas pressure inside the reaction cell outside of warning limits. | If sample pressure is > 10 in-Hg: <ul style="list-style-type: none">• Pneumatic Leak• Bad Pump: Rebuild Pump• Failed pressure sensor/circuitry |



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

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.



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Table 5-4. Dashboard Functions - Possible Causes for Out-of-Range Values

| DASHBOARD FUNCTION | NOMINAL VALUES | POSSIBLE OUT-OF-RANGE CAUSE(S) |
|-------------------------------|---|---|
| Stability | ≤1 ppb, N100; ≤1 ppm, N100H with Zero Air | Faults that cause high stability values are: pneumatic leak; low or very unstable UV lamp output; light leak; faulty HVPS; defective preamp board; aging detectors; PMT recently exposed to room light; dirty/contaminated reaction cell. |
| Sample Flow | 650 cc, N100; 700 cc, N100H, ± 10% | Faults are caused due to: clogged critical flow orifice; pneumatic leak; faulty flow sensor; sample line flow restriction. |
| PMT | Range is 0-2300mV | High or noisy readings could be due to: calibration error; pneumatic leak; excessive background light; aging UV filter; low UV lamp output; PMT recently exposed to room light; light leak in reaction cell; reaction cell contaminated HVPS problem. <i>It takes 24-48 hours for the PMT exposed to ambient light levels to adapt to dim light.</i> |
| UV Lamp | 200 - 1000 mV | This is the instantaneous reading of the UV lamp intensity. Low UV lamp intensity could be due to: aging UV lamp; UV lamp position out of alignment; faulty lamp transformer; aging or faulty UV detector; UV detector needs adjusting; dirty optical components. Intensity lower than 200 mV will cause UV LAMP warning. Most likely cause is a UV lamp in need of replacement. |
| Dark PMT | -150 to +150 mV | High dark UV detector could be due to: light leak or high electronic offset. |
| HVPS | ≈ 400 V to 900 V | Incorrect HVPS reading could be due to: HVPS broken; preamp board circuit problems. |
| RCell Temp | 50°C ± 1°C | Incorrect temperature reading could be due to: malfunctioning heater. |
| Box Temp | Ambient + ≈ 5°C | Incorrect temperature reading could be due to: Environment out of temperature operating range; broken thermistor; runaway heater |
| PMT Temp | 7°C ± 2°C Constant | Incorrect temperature reading could be due to: TEC cooling circuit broken; High chassis temperature. |
| IZS (N100 option) Temp | 50°C ± 1°C | Malfunctioning heater |
| Pressure | Ambient ± 2 IN-HG-A | Incorrect sample gas pressure could be due to: pneumatic leak; malfunctioning valve; malfunctioning pump; clogged flow orifices; sample inlet overpressure; faulty pressure sensor |
| Slope | 1.0 ± 0.3 | Slope out of range could be due to: poor calibration quality; incorrect span gas; leaks; UV Lamp output decay. |
| Offset | < 250 mV | High offset could be due to: incorrect span gas concentration/contaminated zero air/leak; low-level calibration off; light leak; aging UV filter; contaminated reaction cell; pneumatic leak. |

5.7.3. USING THE DIAGNOSTIC SIGNAL I/O FUNCTIONS

The Utilities>Diagnostics menu can be used to help determine whether any faults lie within the signal I/O functions. 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.



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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 use the Setup menu to control the state of an output voltage or control signal.

5.7.4. FAULT DIAGNOSIS WITH LEDs

The following illustrations show connectors and LEDs that can indicate where issues may lie. Figure 5-11 shows the layout for the mainboard, and Figure 5-12 through Figure 5-14 show the board layouts for the PMT Bench Module, the Lamp Driver, and the Pump Control, respectively.

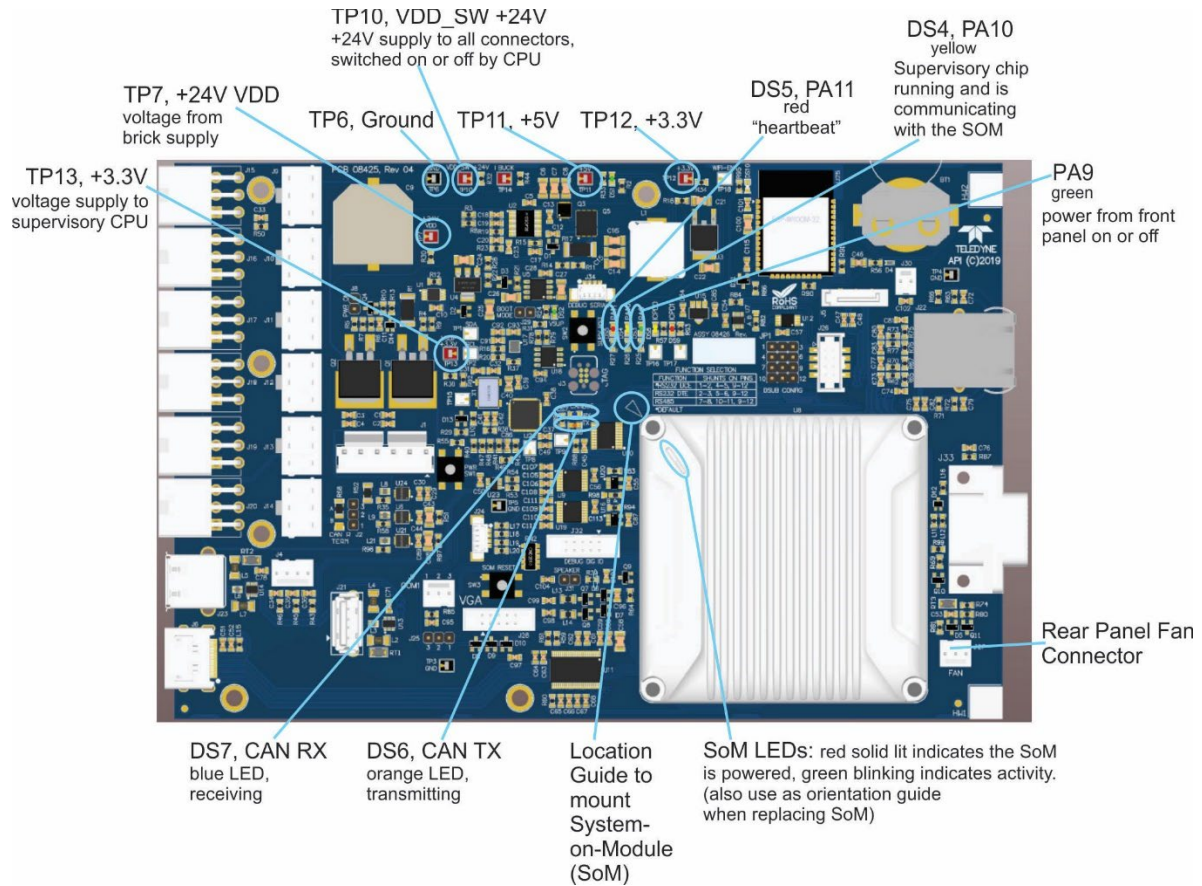


Figure 5-11. Mainboard



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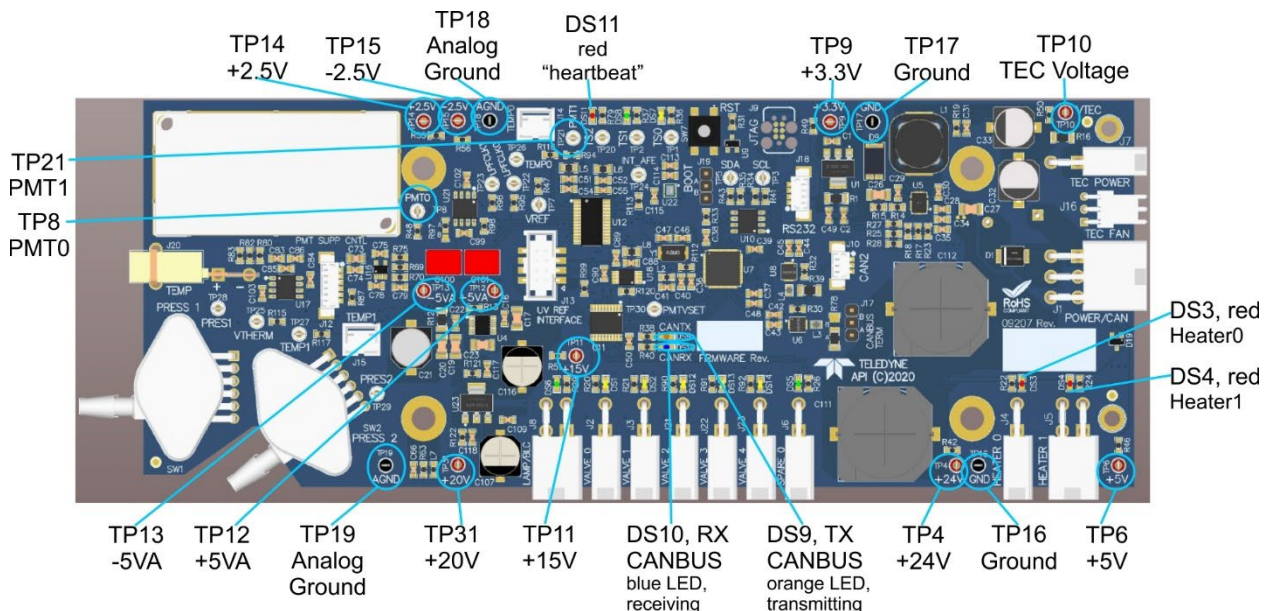


Figure 5-12. PMT Bench Module Board – Test Points and Indicator LEDs

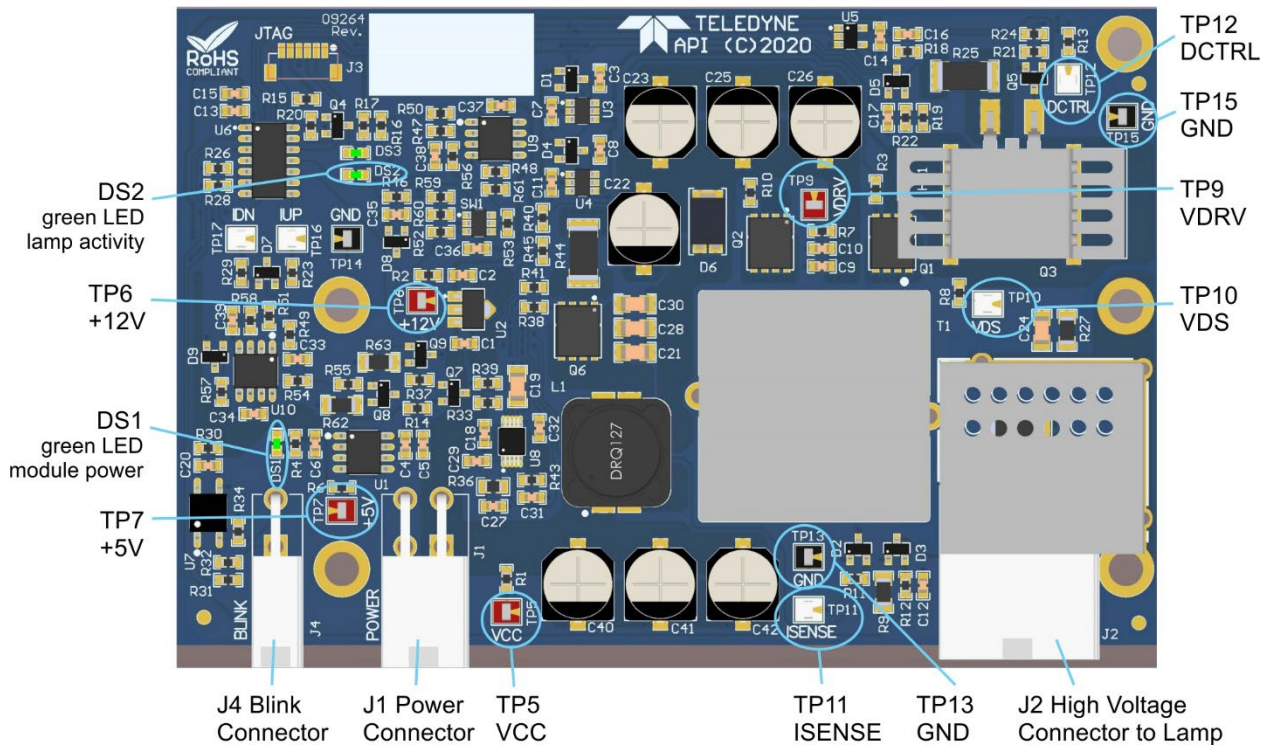


Figure 5-13. Lamp Driver Board – Test Points and Indicator LEDs



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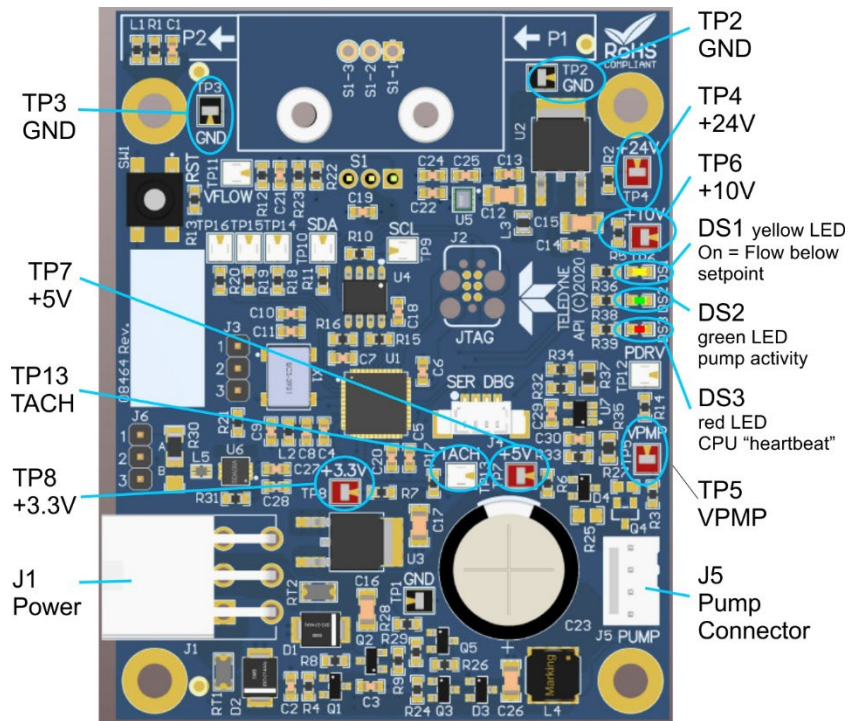


Figure 5-14. DC Pump Control Board – Test Points and Indicator LEDs

5.7.5. FLOW PROBLEMS

Refer to the flow diagrams (Section 2.3.3) for help in troubleshooting flow problems. In general, flow problems can be divided into three categories:

- Flow is too high
- Flow is greater than zero, but is too low, and/or unstable
- Flow is zero (no flow)

When troubleshooting flow problems, it is essential to confirm the actual flow rate without relying on the analyzer's flow display to ensure that the error is not with the analyzer's flow sensor and software. Use an independent, external, volumetric flow meter to perform a flow check as described in Section 5.6.7.3. Refer to the pneumatic flow diagrams in Section 2.3.3 as needed for reference.



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5.7.5.1. SAMPLE FLOW IS ZERO OR LOW

On flow failure, the unit will display a SAMPLE FLOW WARNING in the Active Alerts page, and the respective function (Dashboard or Home Meter, if configured to display) reports a zero or very low flow rate. The instrument has an HD pump running at 100% with a critical flow orifice.

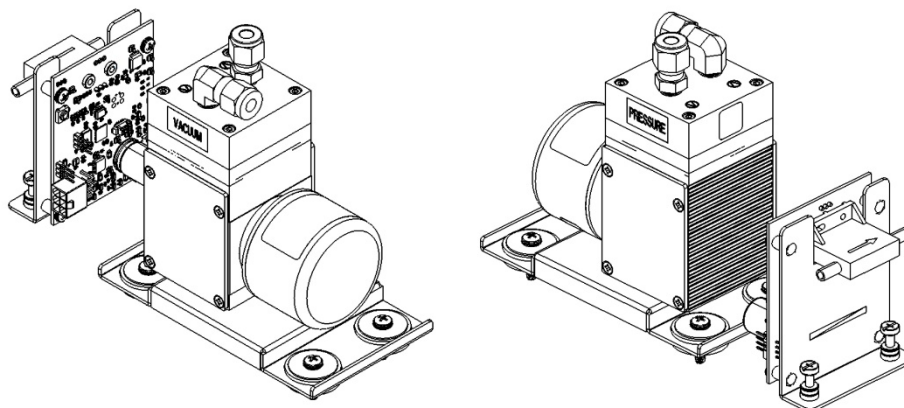


Figure 5-15. HD Pump

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 not running, use a DC voltmeter to ensure that power is being supplied to the pump. If power is supplied properly but the pump is not running, replace the pump.

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:
 - 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 the flow meter to measure the actual flow.
 - If there is proper flow (within spec), 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.



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- 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. See troubleshooting the dryer later in this chapter.
 - 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 5.6.7.
 - 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 5.6.7.2.

5.7.5.2. HIGH FLOW

Flow readings that are significantly higher than the allowed operating range (typically ± 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 5.6.7.3), 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.

5.7.5.3. 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.



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

- 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.
- Taken together with a zero or low actual flow, this could indicate a clogged sample orifice.

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.

5.7.6. CALIBRATION PROBLEMS

This Section describes possible causes of calibration problems.

5.7.6.1. 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 but should alternate with similarly high, positive values.
- Miscalibration is the most likely explanation for negative concentration values. If the zero air contained some SO₂ 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 SO₂. The same problem occurs, if the analyzer was zero-calibrated using ambient air or span gas.
- If the response Offset function for SO₂ is greater than 150 mV, a failed PMT or high voltage supply, or sample chamber contamination, could be the cause.

5.7.6.2. NO RESPONSE

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. Run an optical test, located in the Utilities>Diagnostics>Digital Outputs menu. See Optic Test (OTest) in Section 5.7.8.2.
 - 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, optics, or the UV lamp/lamp driver.



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2. Confirm the lack of response by supplying SO₂ span gas of about 80% of the range value to the analyzer.
3. Check the sample flow for proper value.
4. Check for disconnected cables to the sensor module.

5.7.6.3. 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 5.6.7.
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 (Section 5.6.7.3) to ensure that the instrument is supplied with adequate sample gas
4. Confirm the sample pressure, sample temperature, and UV lamp readings are correct and steady.
5. Verify that the sample filter element is clean and does not need to be replaced.

5.7.6.4. 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 button is grayed out, the actual concentration must be outside of the range of the expected span gas concentration, which can have several reasons.

1. Verify that the expected concentration is set properly to the actual span gas concentration.
2. Confirm that the SO₂ span gas source is accurate.
 - This can be done by comparing the source with another calibrated analyzer, or by having the SO₂ source verified by an independent traceable photometer.
3. Check for leaks in the pneumatic systems as described in Section 5.6.7.
 - Leaks can dilute the span gas and, hence, the concentration that the analyzer measures may fall short of the expected concentration.
4. If the physical, 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 5.7.9.4 on how to carry out a low-level hardware calibration.



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5.7.6.5. 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 SO₂-free air. Check any zero air scrubber for performance. It may need to be replaced (Section 5.6.3).
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 5.6.7.

5.7.6.6. NON-LINEAR RESPONSE

The analyzer was factory calibrated and should be linear to within 1% of full scale. Common causes for non-linearity are:

- Leaks in the pneumatic system. Leaks can add a constant of ambient air, zero air or span gas to the current sample gas stream, which may be changing in concentrations as the linearity test is performed. Check for leaks as described in Section 5.6.7.
- The calibration device is in error. Check flow rates and concentrations, particularly when using low concentrations. If a mass flow calibrator is used and the flow is less than 10% of the full scale flow on either flow controller, you may need to purchase lower concentration standards.
- The standard gases may be mislabeled as to type or concentration. Labeled concentrations may be outside the certified tolerance.
- The sample delivery system may be contaminated. Check for dirt in the sample lines or sample chamber.
- Calibration gas source may be contaminated.
- Dilution air contains sample or span gas.
- Sample inlet may be contaminated with SO₂ exhaust from this or other analyzers. Verify proper venting of the analyzer's 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.
- If the instrument is equipped with an internal IZS valve option and the SO₂ span value is continuously trending downward, the IZS permeation tube may require replacement.

5.7.6.7. 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 re-calibrate the analog outputs. This becomes more likely when using a low concentration or low analog output range. Analog outputs running at 0.1 V full scale should always be calibrated manually. See Section 2.5.8.1 for a detailed description of this procedure.



5.7.7. 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.

5.7.7.1. 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 under Section 5.6.7.

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

- Contact the factory on troubleshooting these components.

5.7.7.2. 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.
- Dirty or plugged critical flow orifices. Check flows, pressures and, if necessary, change orifices (Section 5.6.5).
- Wrong materials in contact with sample - use glass or Teflon materials only. Porous materials, in particular, will cause memory effects and slow changes in response.
- Sample vent line is located too far from the instrument sample inlet causing a long mixing and purge time. Locate sample inlet (overflow) vent as close as possible to the analyzer's sample inlet port.
- Dirty sample cell.
- Insufficient time allowed for purging of lines upstream of the analyzer. Wait until stability is low.
- Insufficient time allowed for SO₂ calibration gas source to become stable. Wait until stability is low.

5.7.8. SUBSYSTEM CHECK FOR TROUBLESHOOTING

The preceding sections discussed a variety of methods for identifying possible sources of failures or performance problems, with possible causes and, in some cases, quick solutions or cross-references to the subsections that may help. This Section describes how to determine if a certain component or subsystem is actually the cause of the problem being investigated.



5.7.8.1. AC MAIN POWER

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Plugging the analyzer into a power supply that is too high a voltage or frequency can damage the pump and the AC Heaters.

Plugging the analyzer into a power supply that is too low a voltage or frequency will cause these components to not operate properly.

The analyzer's electronic systems will operate with any of the specified power regimes. As long as system is connected to 100-120 VAC or 220-240 VAC at either 50 or 60 Hz it will turn on and after about 30 seconds show a front panel display. Internally, the status LEDs located Mainboard (Figure 5-11) should turn on as soon as the power is supplied. If not, look into 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 5.7.9.1 to remove the fuse for testing.
 - If the fuse is blown, replace it with a fuse of the correct specifications as instructed in Section 5.7.9.1.
- If the fuse is not blown, or if the replacement fuse blows, then call Technical Support (Section 5.9).



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5.7.8.2. PHOTOMULTIPLIER TUBE (PMT) SENSOR MODULE

The PMT detects the light emitted by the UV-excited fluorescence of SO₂ (see Principles of Operation, Section 6). 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 5-33). 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.

HIGH VOLTAGE POWER SUPPLY (HVPS)

The HVPS is located in the interior of the sensor module and is plugged into the PMT tube (refer to Figure 5-33). 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 preamplifier board.
- Adjustment of the HVPS is covered in the factory calibration procedure in Section 5.7.9.4.

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.

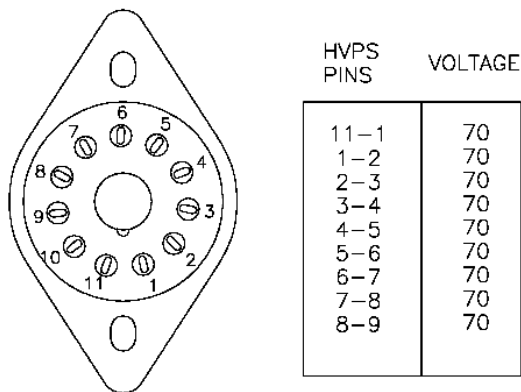
1. Turn off the instrument.
2. Remove the cover and disconnect the 2 connectors at the front of the PMT housing.
3. Remove the end plate from the sensor (4 screws).
4. Remove the HVPS/PMT assembly from the cold block inside the sensor (2 plastic screws).
5. Unplug the PMT from the HVPS.
6. Re-connect 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).



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8. Divide the displayed HVPS voltage by 10 and test the pairs of connector points as shown in the figure below, which uses 700 V as an example.
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 tube, and then reassemble the sensor, including desiccant bag replacement per the Maintenance Schedule requirements (Section 5.1).
 - If any faults are found in the test, you must obtain a new HVPS as there are no user serviceable parts inside the supply.

5.7.8.3. INTERNAL SPAN GAS (IZS) GENERATOR AND VALVE OPTIONS

If purchased, the zero/span valves and internal span gas generator options should be enabled. Check if the option is listed in the Setup>Instrument>Product Info page, and also check if the Span and Zero are in the Calibration menu. (Otherwise, contact the factory).

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°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°C , the temperature signal from the IZS thermistor should be around 2500 mV.



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5.7.9. SERVICE PROCEDURES

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

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.

5.7.9.1. 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 5.7.8.1 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.



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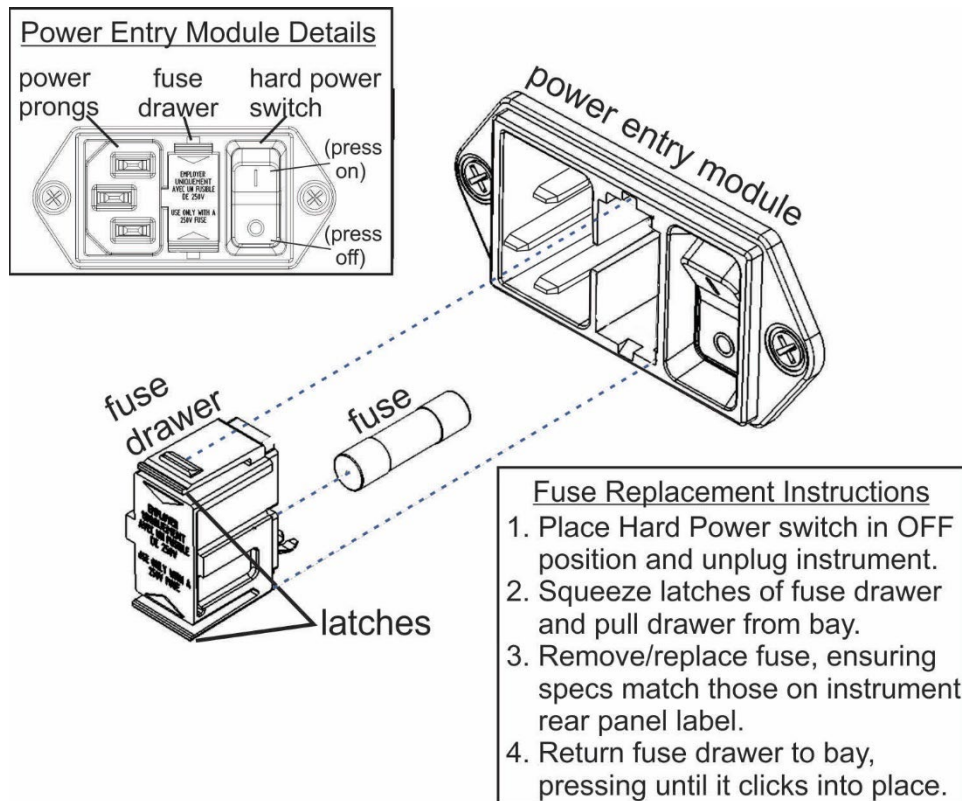


Figure 5-16. Fuse Access



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5.7.9.2. 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.

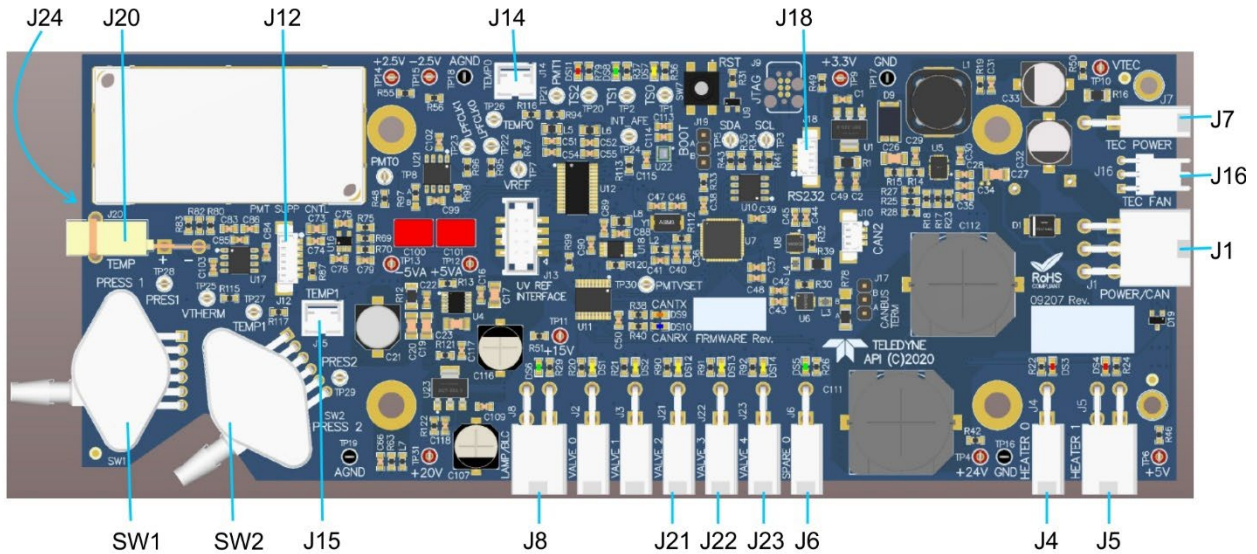
1. Turn off the analyzer power (noting that the front panel switch LED should either be blinking or solid off before powering down via the rear panel switch).
2. Remove the power cord and the analyzer cover.
3. Disconnect tubing connected to the module.
4. Unplug the electrical connection(s) to the module.
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. For connector information, refer to the illustrations that follow.

Note

Ensure to carry out a leak check (Section 5.6.7) and a recalibration after the analyzer has warmed up for about 60 minutes.

The following illustrations provide connector information for module boards:

- 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 5-17. PMT Bench Module Board Connectors

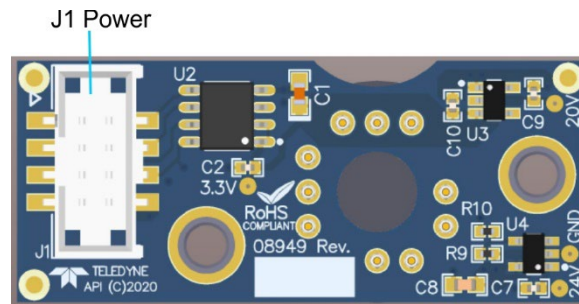


Figure 5-18. UV Detector Board Connector



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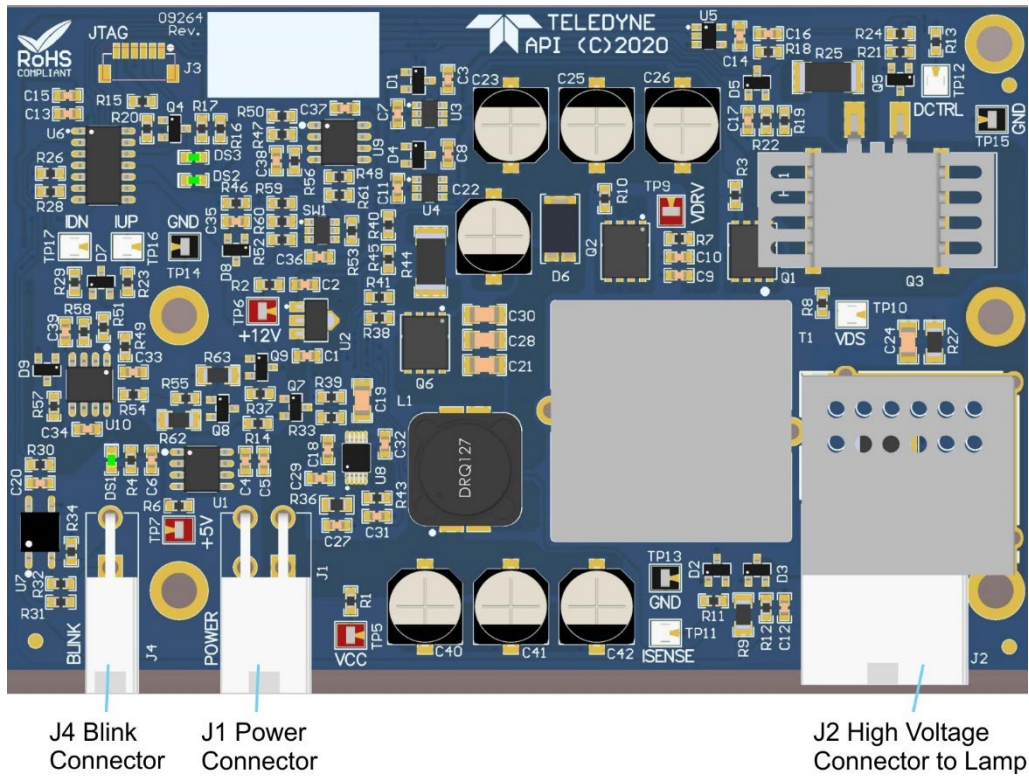


Figure 5-19. Lamp Driver Board Connectors

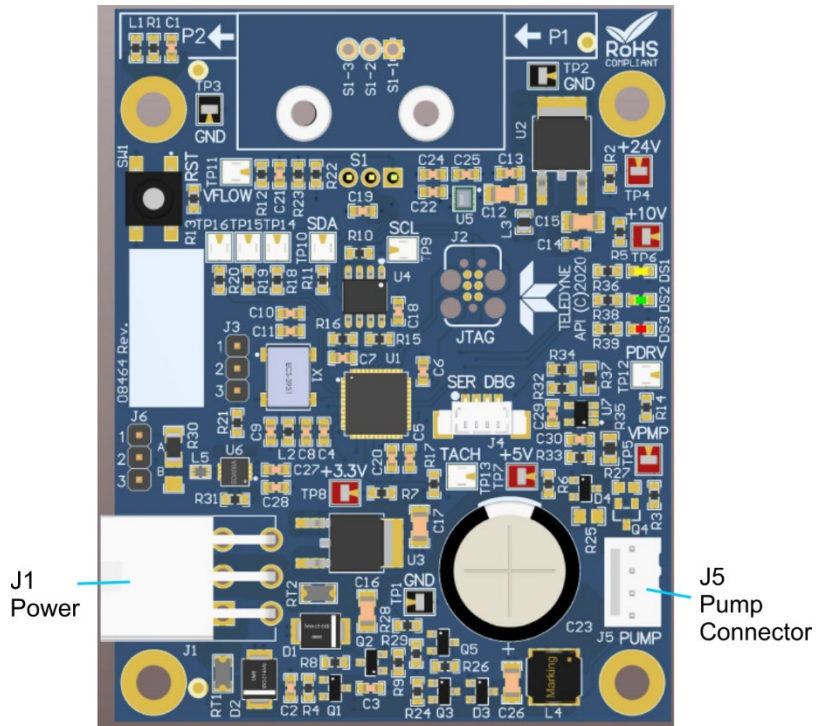


Figure 5-20. DC Pump Control Board Connectors



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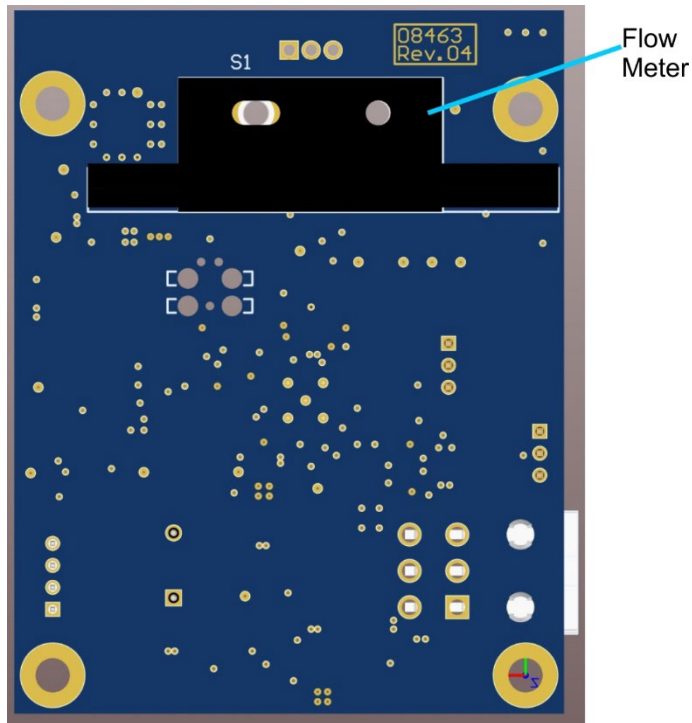


Figure 5-21. DC Pump Flow Meter (DC Pump Control Board Bottom)

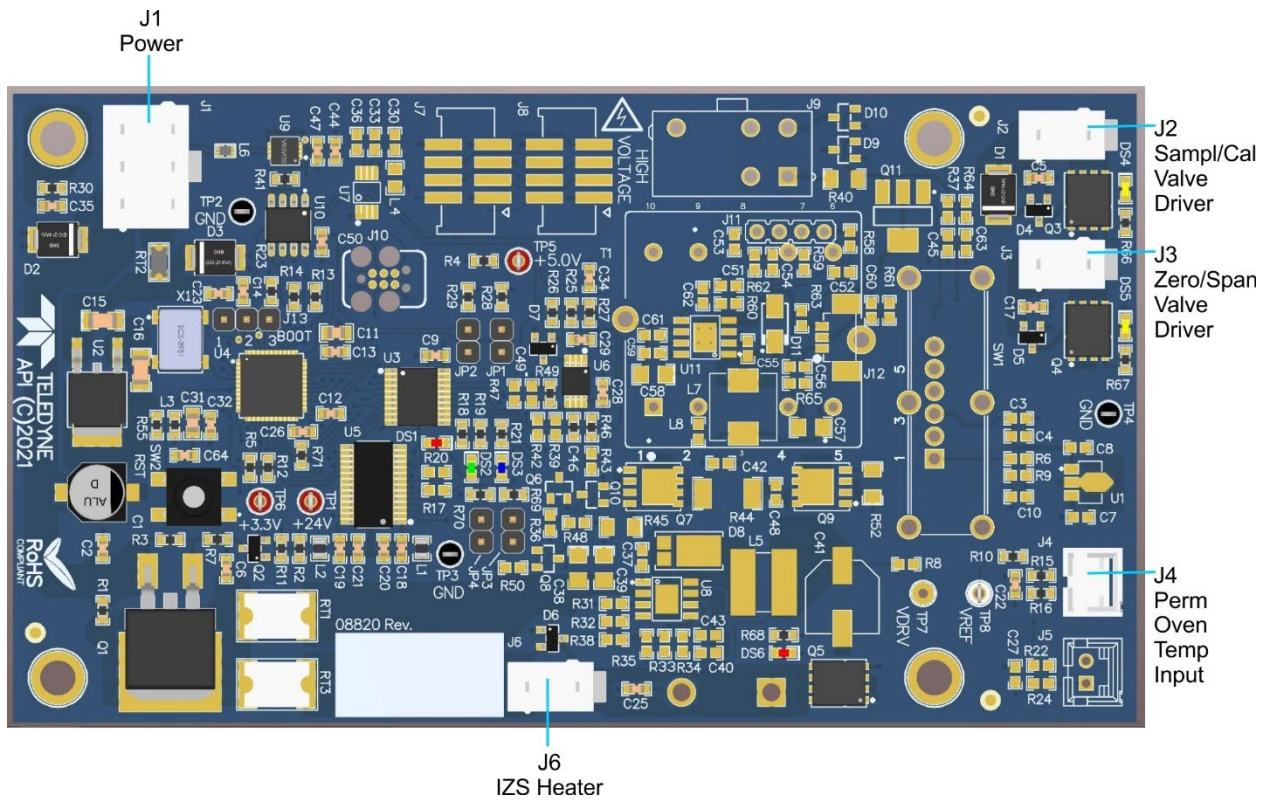


Figure 5-22. IZS Option Board Connectors



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

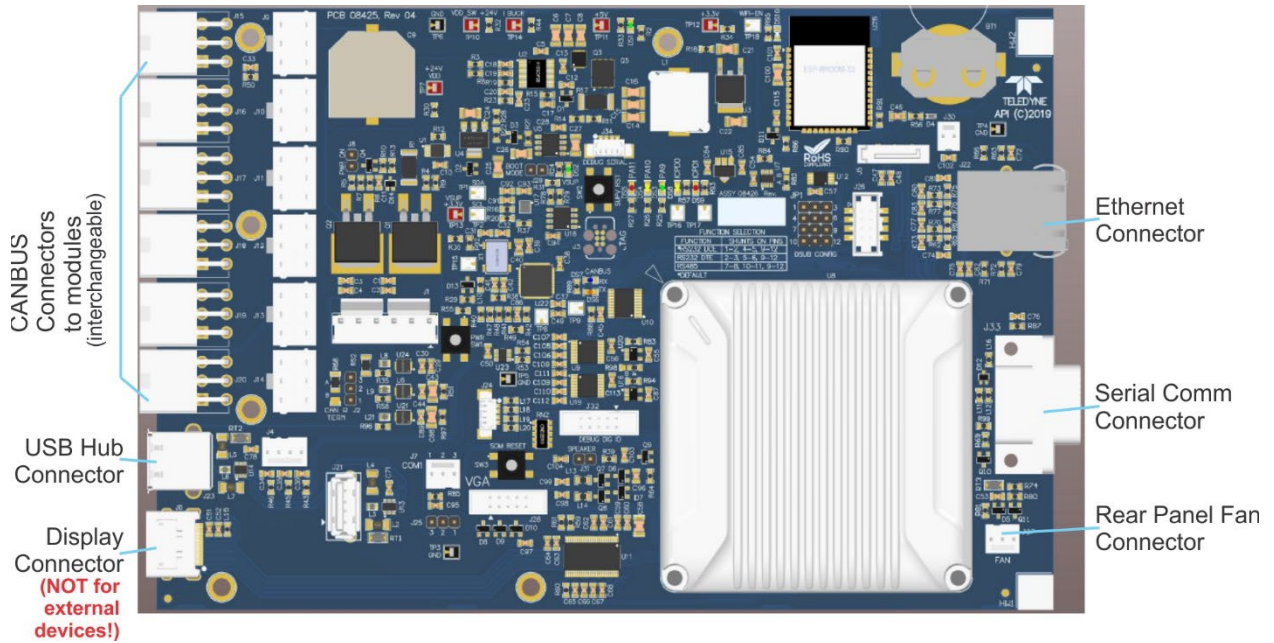


Figure 5-23. Mainboard Connectors

5.7.9.3. SENSOR MODULE REPAIR AND CLEANING

This Section presents steps for properly removing and reinstalling the sensor module prior to performing cleaning and repair procedures.

CAUTION – QUALIFIED PERSONNEL



To replace either the PMT or HVPS, power off the analyzer, open its top cover to remove the entire 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.

CAUTION – GENERAL SAFETY HAZARD



Do not look at the UV lamp while the unit is operating. UV light can cause eye damage. Always use safety glasses made from UV blocking material when working with the UV Lamp Assembly. (Generic plastic glasses are not adequate).



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Important

IMPACT ON READINGS OR DATA

- The sample chamber should only be opened or cleaned on instructions from the Teledyne API Technical Support Department.
- Be careful not to leave thumbprints on the interior of the sample chamber. The various oils that make up fingerprints fluoresce brightly under UV light and will significantly affect the accuracy of the analyzer's SO₂ measurement.
- After any repair or service has been performed on the sensor module, the instrument should be allowed to warm up for 60 minutes.
- Always perform a leak check and calibrate the analyzer before placing it back into service.

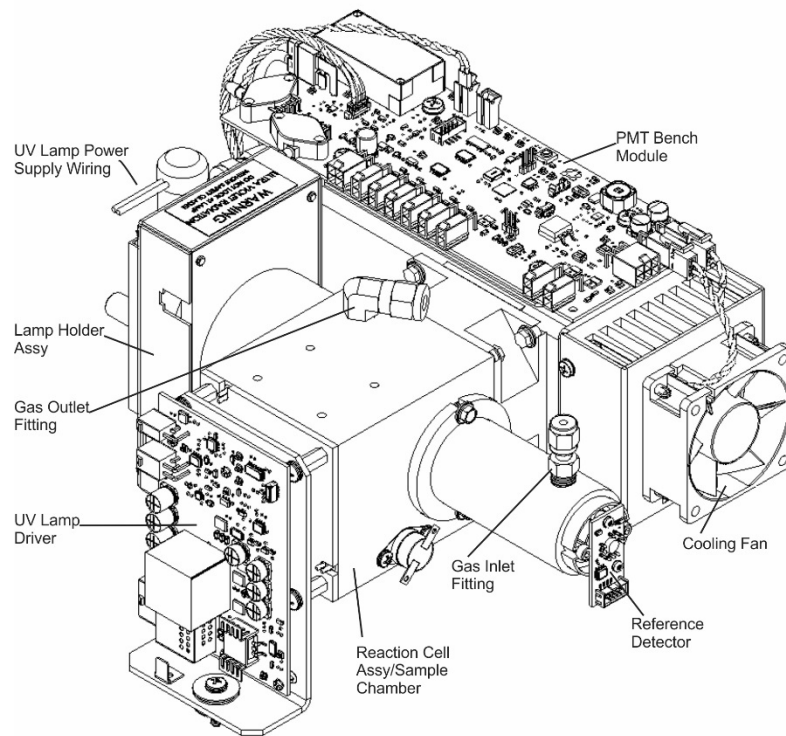


Figure 5-24. N100 Sensor Module



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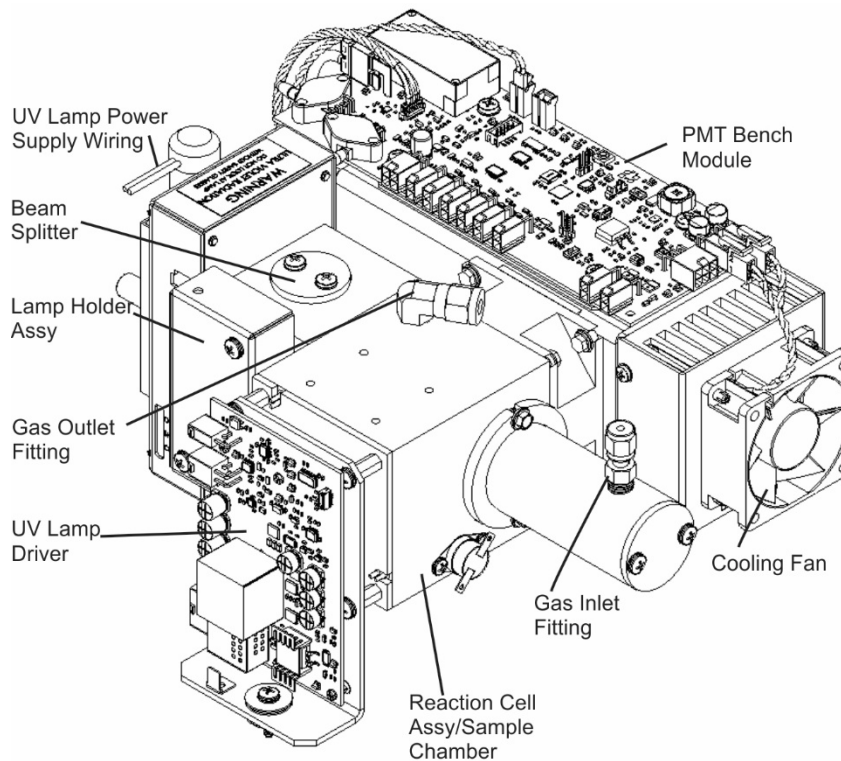


Figure 5-25. N100H Sensor Module

To remove the Sensor Module:

1. Turn off the instrument power.
2. Open the top cover of the instrument:
 - Remove the set screw located in the top, center of the rear panel.
 - Remove the screws fastening the top cover to the unit (four per side).
 - Lift the cover straight up.
3. Disconnect the sensor module pneumatic lines (refer to Figure 5-24)
 - Gas inlet line: 1/8" black Teflon[®] line with stainless steel fitting.
 - Gas outlet line: 1/4" black Teflon[®] line with brass fitting.
4. Disconnect all electrical wiring to the Sensor Module:
 - UV lamp power supply wiring
 - Reaction cell thermistor wiring (yellow)
 - Reaction cell heater wiring (red)
 - UV detector wiring
 - PMT wiring



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5. Remove the three sensor module mounting screws to lift the module straight up.

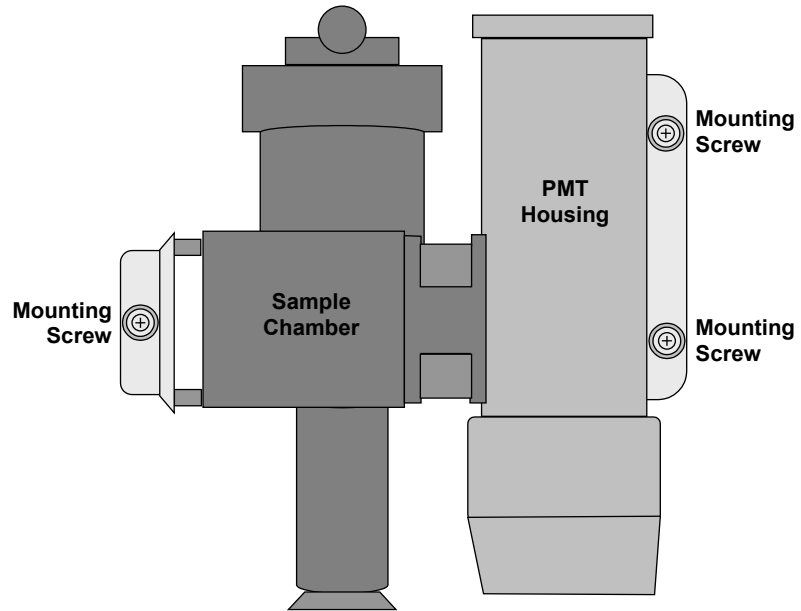


Figure 5-26. Sensor Module Mounting Screws

Follow the above steps in reverse order to reinstall the sensor module.



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CLEANING THE PMT LENS AND PMT FILTER

To clean the PMT Lens and filter:

1. Remove the sensor module as described above.

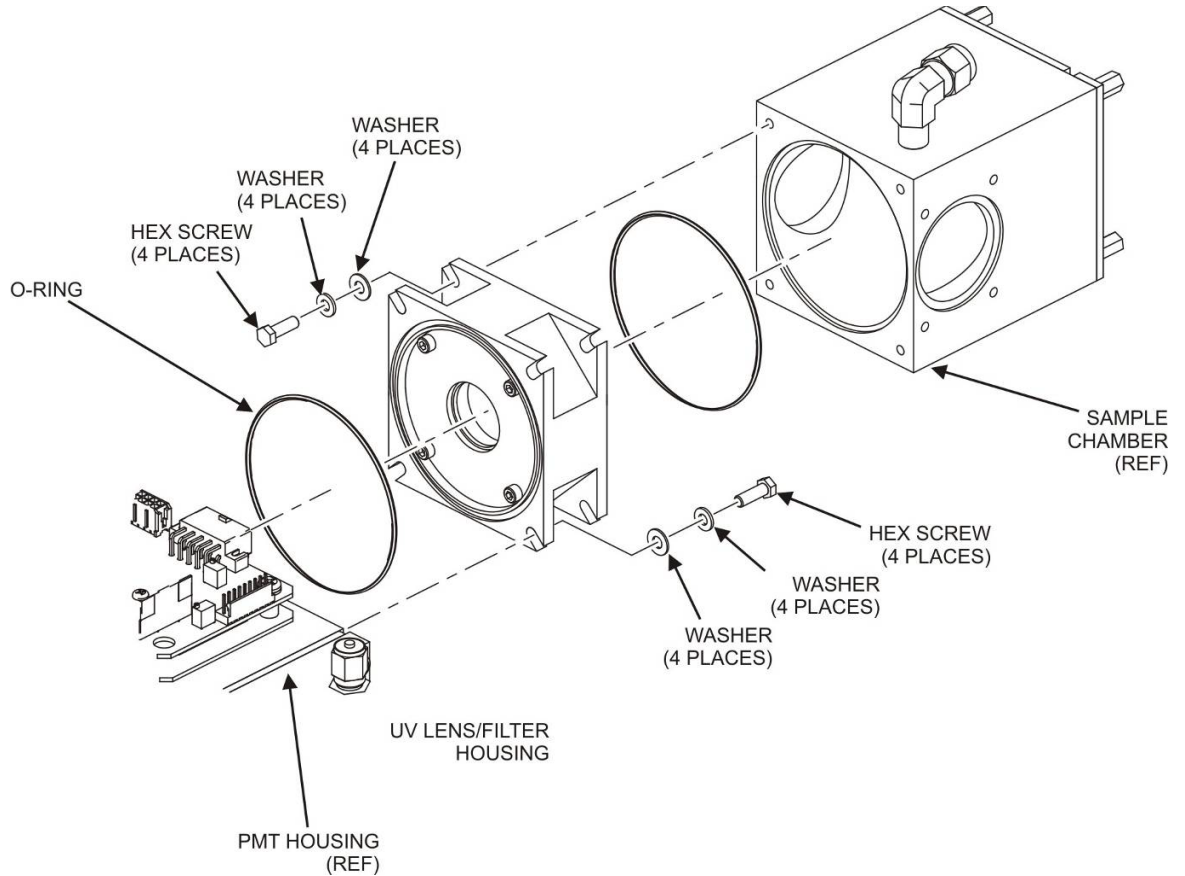


Figure 5-27. Hex Screw Between Lens Housing and Sample Chamber

2. Remove the sample chamber from the PMT lens and filter housing by unscrewing the 4 hex screws that fasten the chamber to the housing.
3. Remove the four lens cover screws.

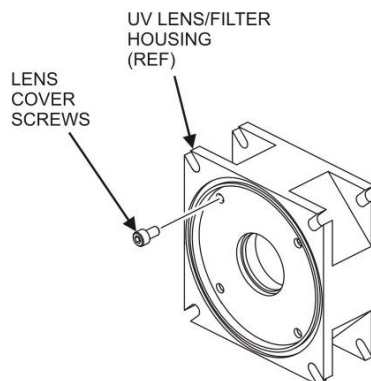


Figure 5-28. UV Lens Housing / Filter Housing



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4. Remove the lens/filter cover.
5. Carefully remove the PMT lens and set it aside on soft, lint-free cloth.
6. Remove the 3-piece, lens/filter spacer.
7. Carefully remove the PMT filter and set it aside on soft, lint-free cloth.

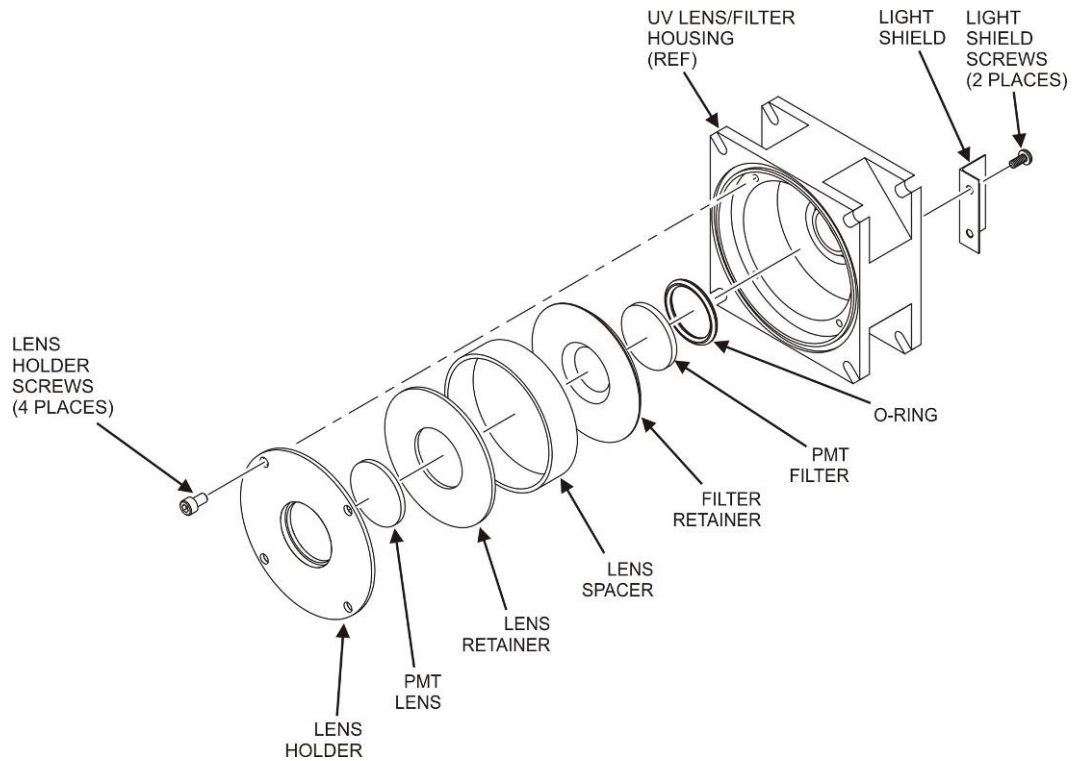


Figure 5-29. PMT UV Filter Housing Disassembled

8. Using a lint-free cloth dampened with distilled water, clean the lens, the filter and all of the housing assembly mechanical parts.
9. Dry everything with a 2nd lint-free cloth.
10. Referring to the illustrations presented, reassemble the lens/filter housing, ensuring to apply Loctite to the four lens holder screws and the two light shield screws.

Important

IMPACT ON READINGS OR DATA

Use gloves and a clean plastic covered surface during assembly. Cleanliness of the inside of the light shield, the UV lens filter housing and the PMT lens is especially important.



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REPLACING THE UV FILTER/LENS

To replace the UV filter/lens:

1. Turn off the instrument's power and remove the power cord from the instrument.
2. Alternatively, remove the sensor module as described above.
3. Remove 4 screws from the shutter cover (refer to the preceding figures that apply) and remove the cover.
4. Remove 4 screws from the UV filter retainer.

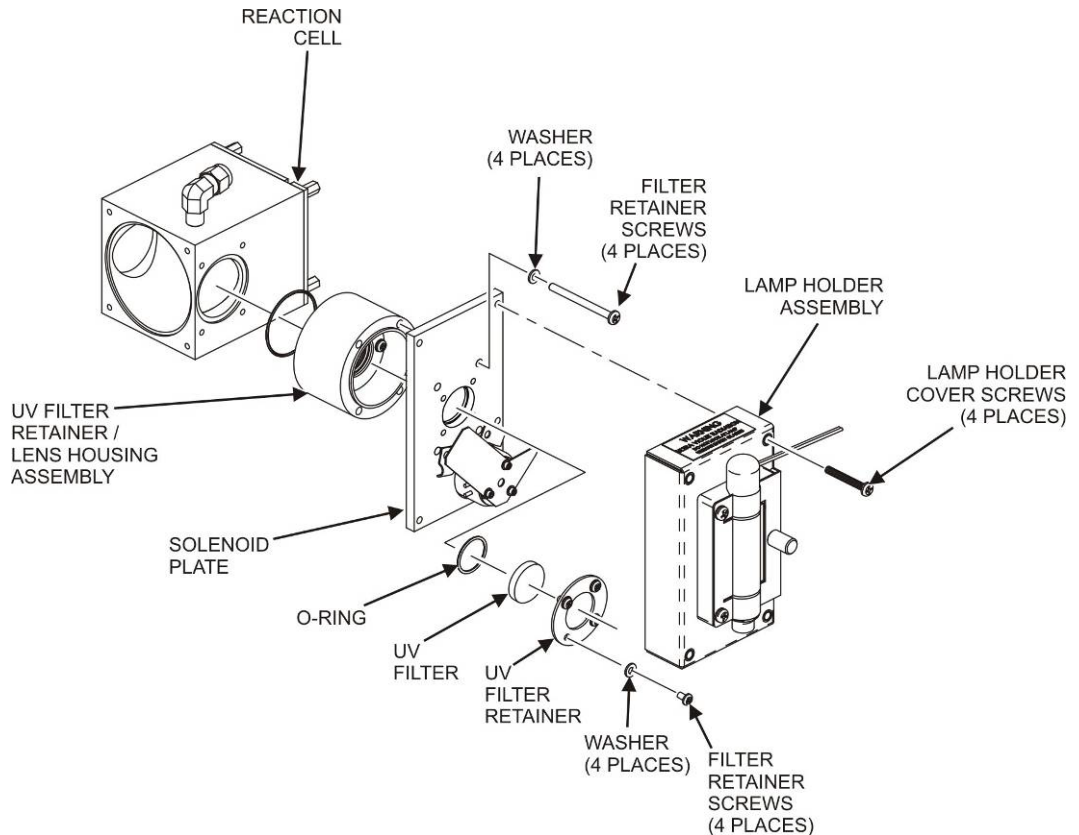


Figure 5-30. Disassembling the UV Filter/Lens Assembly

5. Carefully remove the UV filter.
6. Install the UV filter with the arrow pointing toward the reaction cell.
7. Handle carefully and never touch the filter's surface.
8. UV filter's wider ring side should be facing out.
9. Install UV filter retainer and tighten screws.
10. Install the lamp holder cover and mini-fit connector. Tighten 4 lamp holder screws.
11. Reinstall the sensor module.



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ADJUSTING THE UV LAMP (*PEAKING THE LAMP*)

Lamp aging and lamp positioning can affect the UV Lamp output and therefore the accuracy of the SO₂ concentration measurement, described as follows:

- **Lamp Aging:** Over a period of months, the UV energy will show a downward trend and can be up to 50% in the first 90 days, and then a slower rate, until the end of useful life of the lamp. Periodically running the UV lamp calibration routine (Utilities>Diagnostics menu) will compensate for this until the lamp output becomes too low to function at all.

Note that as the lamp degrades over time, the software for the CPU compensates for the loss of UV output.

- **Lamp Positioning:** The UV output level of the lamp is not even across the entire length of the lamp. Some portions of the lamp shine slightly more brightly than others. At the factory the position of the UV lamp is adjusted to optimize the amount of UV light shining through the UV filter/lens and into the reaction cell. Changes to the physical alignment of the lamp can affect the analyzer's ability to accurately measure SO₂.



CAUTION – GENERAL SAFETY HAZARD

Do not look at the UV lamp while the unit is operating. UV light can cause eye damage. Always use safety glasses made from UV blocking material when working with the UV Lamp Assembly. (Generic plastic glasses are not adequate).



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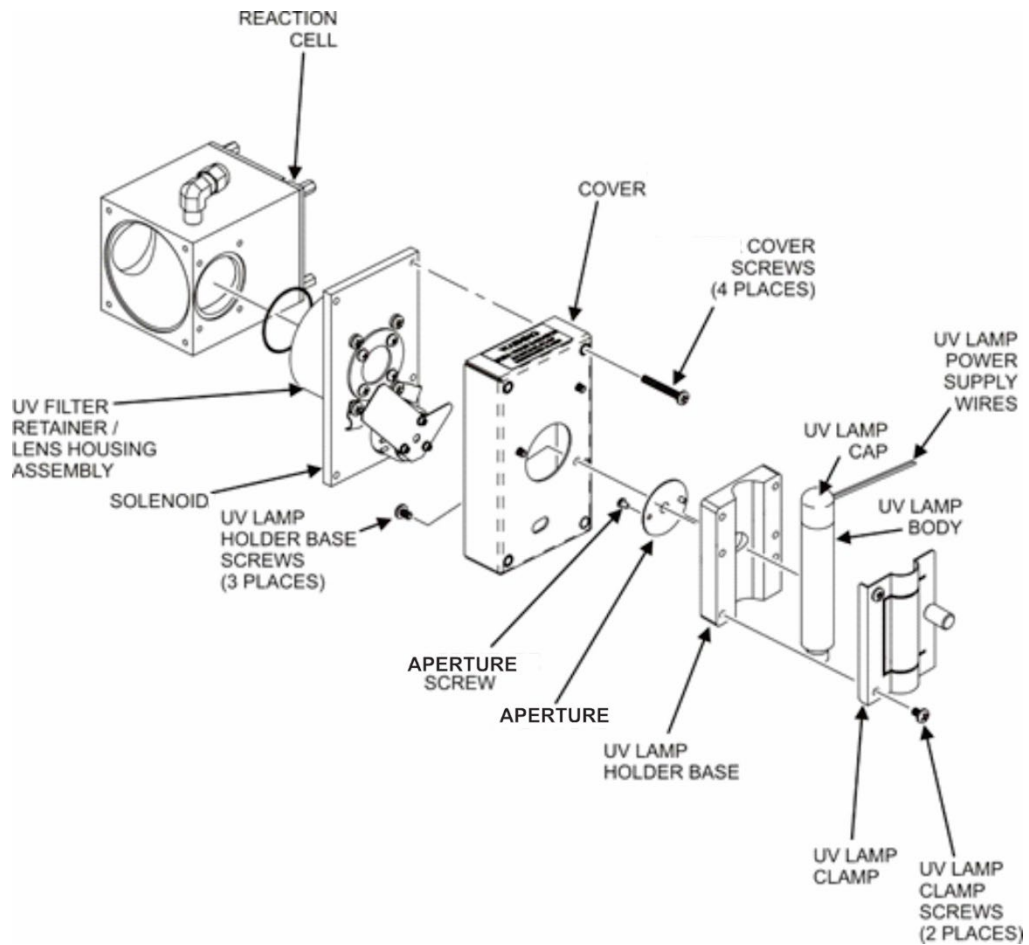


Figure 5-31. Lamp Assembly



CAUTION – GENERAL SAFETY HAZARD

Do not look at the UV lamp while the unit is operating. UV light can cause eye damage. Always use safety glasses made from UV blocking material when working with the UV Lamp Assembly. (Generic plastic glasses are not adequate).



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1. Navigate to the Utilities>Diagnostics>Lamp Cal menu to observe the Lamp Cal Value.
2. Slightly loosen the large brass thumbscrew located on the lamp housing (refer to Figure 5-32) so that the lamp can be moved.

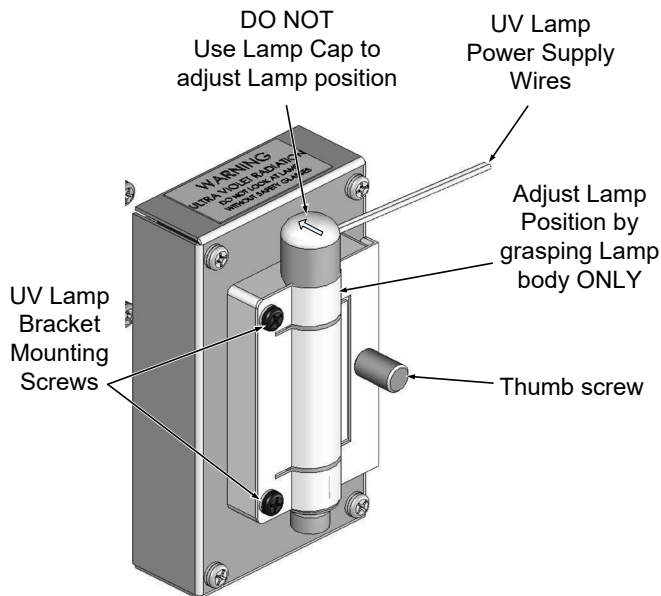


Figure 5-32. UV Lamp Adjustment

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

DO NOT grasp the UV lamp by its cap when changing its position - always grasp the main body of the lamp (refer to Figure 5-31). Inattention to this detail could twist and potentially disconnect the lamp's power supply wires.

3. While watching the Lamp Cal Value reading, slowly rotate the lamp or move it back and forth vertically until the reading is at its maximum, which can be as high as 1000 mV and should not fall lower than 200 mV (replace lamp if highest possible reading falls below 200 mV).
4. Finger-tighten the thumbscrew.
5. In the Utilities>Diagnostics>Lamp Cal menu press the Calibrate button to set this new value as the benchmark for use in calculating the concentration.



CAUTION – GENERAL SAFETY HAZARD

DO NOT over tighten the thumbscrew, as over-tightening can cause breakage to the lamp and consequently release mercury into the area.



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REPLACING THE UV LAMP

To replace the UV Lamp (call Tech Support for part number):

1. Turn off the analyzer.
2. Disconnect the UV lamp from its power supply.
3. You can find the power supply connector by following the two, white UV Lamp power supply wires from the lamp to the power supply.
4. Loosen, but do not remove the two UV lamp bracket screws and the large brass thumbscrew located (refer to Figure 5-31 and Figure 5-32) on the housing so that the lamp can be moved.

ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

DO NOT grasp the UV lamp by its cap when changing its position - always grasp the main body of the lamp (refer to Figure 5-31) Inattention to this detail could twist and potentially disconnect the lamp's power supply wires.

5. Remove the UV Lamp by pulling it straight up.
6. Insert the new UV lamp into the bracket.
7. Tighten the two UV lamp bracket screws, but leave the brass thumb screw un-tightened.
8. Connect the new UV lamp to the power supply.
9. Turn the instrument on and perform the UV adjustment procedure as defined in the preceding section.
10. Finger tighten the thumbscrew.



CAUTION – GENERAL SAFETY HAZARD

DO NOT over tighten the thumbscrew, as over-tightening can cause breakage to the lamp and consequently release mercury into the area.

11. Calibrate the lamp (Utilities>Diagnostics menu).



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REPLACING THE PMT, HVPS OR TEC

The photo multiplier tube (PMT) should last for the lifetime of the analyzer, however, the high voltage power supply (HVPS) or the thermo-electric cooler (TEC) components may fail. 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.

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.
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.

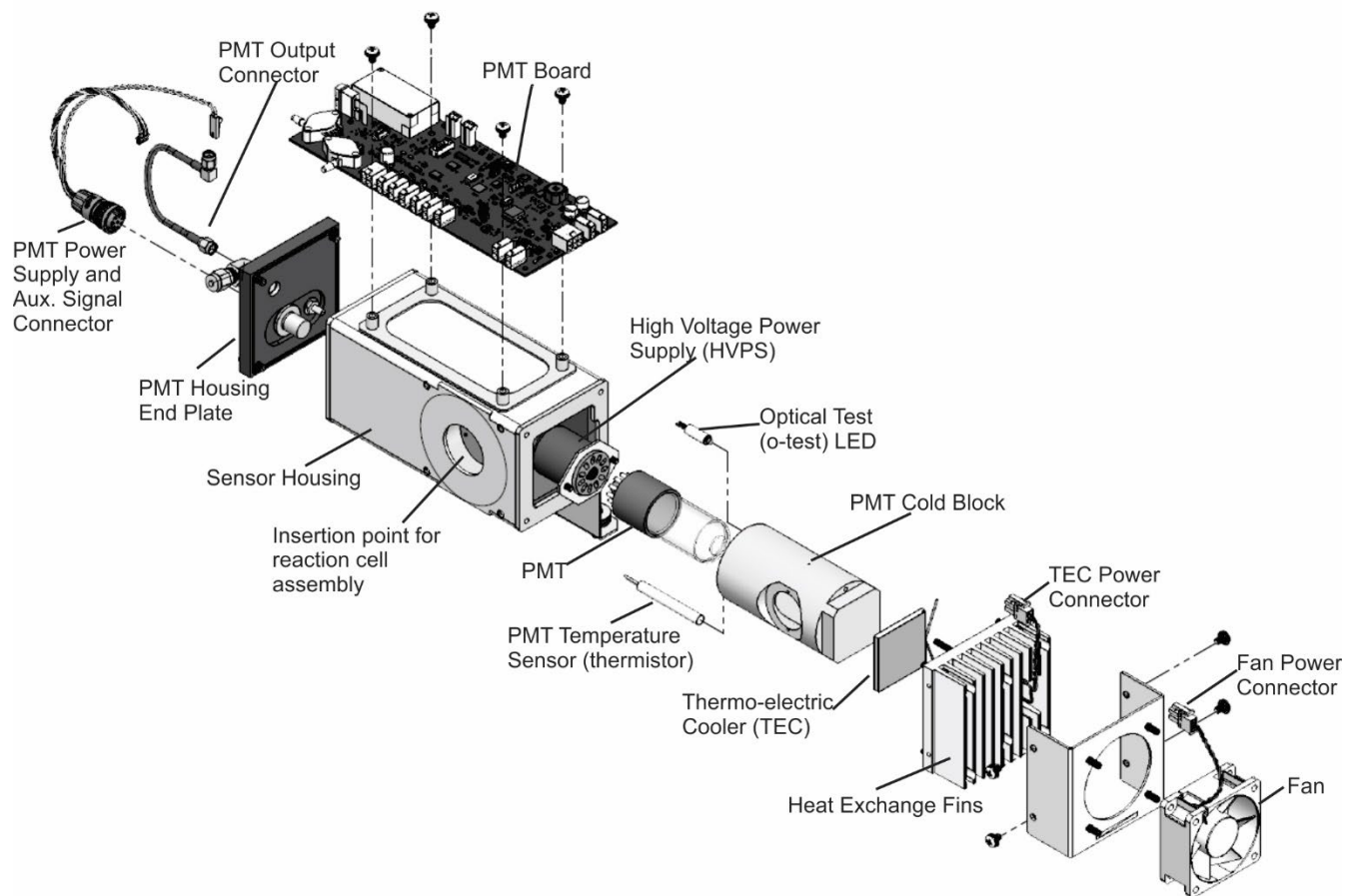


Figure 5-33. Sensor Assembly



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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 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).
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 driver board from the TEC and set the sub-assembly aside.
15. Remove cooling fan.
16. Remove the end plate with the cooling fins (4 screws) and slide out the PMT cold block assembly, which contains the TEC.
17. Unscrew the TEC from the cooling fins and the cold block and replace it with a new unit.
18. 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 for 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.



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19. Reinsert the TEC subassembly in reverse order.
 - Ensure that the O-ring is seated properly and the assembly is tightened evenly.
20. 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.
21. 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.
22. Install new silica gel packets (desiccant bags).
23. Reconnect the cables and the reaction cell (evenly tighten these screws).
24. Replace the sensor assembly into the chassis and fasten with four screws and washers.
25. Reconnect all electrical and pneumatic connections.
26. Leak check the system (see Section 5.6.7).
27. Turn ON the analyzer.
28. Verify the basic operation of the analyzer using the OTEST feature (Section 5.7.8.2) 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).

5.7.9.4. PMT SENSOR HARDWARE CALIBRATION (“FACTORY CAL”)

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

To calibrate the PMT PCA:

1. Deliver a known concentration of Span Gas, preferably at 90% of the desired range (e.g., 450 ppb in a 500 ppb range).
2. Also in the Setup>Vars menu, if needed, use the HVPS SetPoint Var to edit the setpoint value if grossly out of range.
3. Return to Homescreen and navigate to Utilities>Diagnostics>HVPS Adjust (Figure 5-34).
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 in the N100 model should be about the same as the target concentration; for example, 100 ppb sampled gas should give 100 mV PMT response).
6. Before exiting, click the slider button to turn OFF Maintenance Mode.

7. Allow time to stabilize.
8. Perform a calibration if necessary.

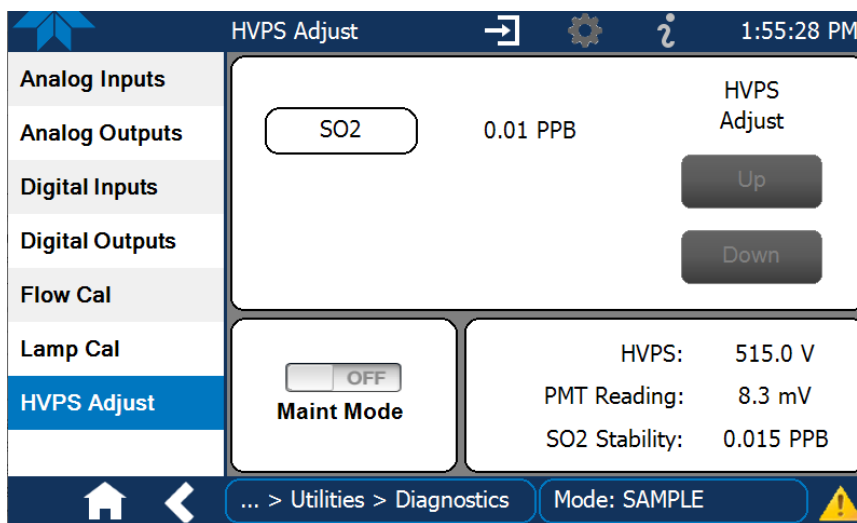


Figure 5-34. HVPS Adjust Menu

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 that includes a value less than or more than the min/max range. 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. |
| How do I enter or change the value of my Span Gas? | See Section 4.2.1.2. |
| Can I automate calibration checks of my analyzer? | Any analyzer with zero/span valve or IZS option can be automatically calibration checked using the instrument's AutoCal feature (Section 4.2.2.2). |
| How do I measure the sample flow? | For accurate measurement, attach a calibrated volumetric 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 5.6.7.3). |
| 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. |



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| QUESTION | ANSWER |
|---|--|
| 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. 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">• The wrong cable: please use the provided or a generic “straight-through” cable (do not use a “null-modem” type cable).• The DCE/DTE switch on the back of the analyzer is not set properly; ensure that both green and red lights are on (Figure 2-2).• The baud rate of the analyzer’s COM port does not match that of the serial port of your computer/data logger (Table 2-15). |
| 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. 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. See Section 5.6.5 for instructions. |
| How do I set up and use the Digital Inputs on the rear panel of the analyzer? | See Section 2.3.1.3. |

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: 800-324-5190

Phone: +1 858-657-9800

Fax: +1 858-657-9816

Email: api-techsupport@teledyne.com

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



6. PRINCIPLES OF OPERATION

This Section describes the principles of operation for the sensor as well as for electronic and software operation.

6.1. SULFUR DIOXIDE (SO₂) SENSOR PRINCIPLES OF OPERATION

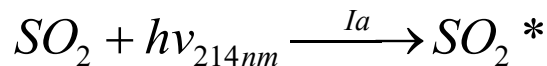
This UV Fluorescence SO₂ Analyzer is a microprocessor-controlled analyzer that determines the concentration of sulfur dioxide (SO₂), in a sample gas drawn through the instrument. It requires that sample and calibration gases be supplied at ambient atmospheric pressure in order to establish a constant gas flow through the sample chamber where the sample gas is exposed to ultraviolet light; this exposure causes the SO₂ molecules to change to an excited state (SO₂*). As these SO₂* molecules decay into SO₂ they fluoresce. The instrument measures the amount of fluorescence to determine the amount of SO₂ present in the sample gas.

Calibration of the instrument is performed in software and usually does not require physical adjustments to the instrument. During calibration, the microprocessor measures the sensor output signal when gases with known amounts of SO₂ at various concentrations are supplied and stores these measurements in memory. The microprocessor uses these calibration values along with other performance parameters such as the PMT dark offset and UV lamp ratio, along with sample gas temperature and pressure measurements to compute the final SO₂ concentration.

6.1.1. SO₂ ULTRAVIOLET FLUORESCENCE MEASUREMENT PRINCIPLE

The physical principle upon which the measurement method is based is the fluorescence that occurs when sulfur dioxide (SO₂) is changed to excited state (SO₂*) by ultraviolet light with wavelengths in the range of 190 nm-230 nm. This reaction is a two-step process.

The first stage (Equation 6-1) occurs when SO₂ molecules are struck by photons of the appropriate ultraviolet wavelength. In this analyzer, a band pass filter between the source of the UV light and the affected gas limits the wavelength of the light to approximately 214 nm. The SO₂ absorbs some of energy from the UV light causing one of the electrons of the SO₂ molecule to move to a higher energy orbital state.



(Equation 6-1)

The amount SO₂ converted to SO₂* in the sample chamber is dependent on the average intensity of the UV light (***Ia***) and not its peak intensity because the intensity of UV light is not constant in every part of the sample chamber. Some of the photons are absorbed by the SO₂ as the light travels through the sample gas.

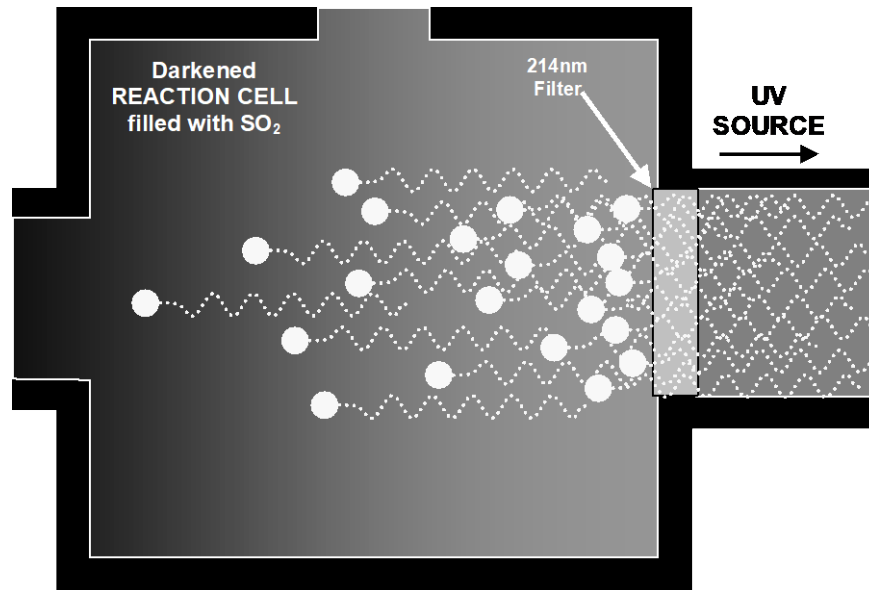


Figure 6-1. UV Absorption

The equation for defining the average intensity of the UV light (I_a) is:

$$I_a = I_0 [1 - \exp(-ax(SO_2))]$$

(Equation 6-2)

Where:

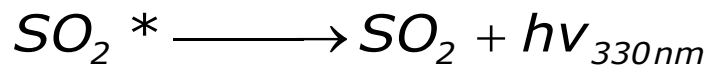
I_0 = Intensity of the excitation UV light.

a = The absorption coefficient of SO_2 (a constant).

SO_2 = Concentration of SO_2 in the sample chamber.

x = The distance between the UV source and the SO_2 molecule(s) being affected (path length).

The second stage of this reaction occurs after the SO_2 reaches its excited state (SO_2^*). Because the system will seek the lowest available stable energy state, the SO_2^* molecule quickly returns to its ground state (Equation 6-3) by giving off the excess energy in the form of a photon ($h\nu$). The wavelength of this fluoresced light is also in the ultraviolet band but at a longer (lower energy) wavelength centered at 330nm.



(Equation 6-3)



The amount of detectable UV given off by the decay of the SO₂* is affected by the rate at which this reaction occurs (*k*).

$$F = k(SO_2^*)$$

(Equation 6-4)

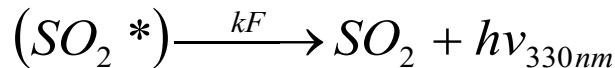
Where:

F = the amount of fluorescent light given off.

k = the rate at which the SO₂* (excited state) decays into SO₂.

SO₂* = Amount of excited-state SO₂ in the sample chamber.

Therefore:



(Equation 6-5)

Finally, the function (*k*) is affected by the temperature of the gas. The warmer the gas, the faster the individual molecules decay back into their ground state and the more photons of UV light are given off per unit of time.

Given that the absorption rate of SO₂ (*a*) is constant, the amount of fluorescence (**F**) is a result of:

- The amount of SO₂* created which is affected by the variable factors from (Equation 6-2) above: concentration of SO₂; intensity of UV light (*I₀*); path length of the UV light(*x*) and;
- The amount of fluorescent light created which is affected by the variable factors from (Equation 6-5): the amount of SO₂* present and the rate of decay (*k*) which changes based on the temperature of the gas.

When and the intensity of the light (*I₀*) is known; path length of excited light is short (*x*); the temperature of the gas is known and compensated for so that the rate of SO₂*decay is constant (*k*). and; no interfering conditions are present (such as interfering gases); the amount of fluorescent light emitted (**F**) is directly related to the concentration of the SO₂ in the Sample Chamber. This analyzer is specifically designed to create these circumstances.

- The light path is very short (*x*).
- A reference detector measures the intensity of the available excitation UV light and is used to remove effects of lamp drift (*I₀*).
- The temperature of the sample gas is measured and controlled via heaters attached to the sample chamber so that the rate of decay (*k*) is constant.
- A special hydrocarbon scrubber removes the most common interfering gases from the sample gas.



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- And finally, the design of the sample chamber reduces the effects of stray light via its optical geometry and spectral filtering.

The net result is that any variation in UV fluorescence can be directly attributed to changes in the concentration of SO_2 in the sample gas.

6.1.2. THE UV LIGHT PATH

The optical design of the sample chamber optimizes the fluorescent reaction between SO_2 and UV Light (refer to Figure 6-2) and assure that only UV light resulting from the decay of SO_2^* into SO_2 is sensed by the instruments fluorescence detector.

UV radiation is generated by a lamp specifically designed to produce a maximum amount of light of the wavelength needed to excite SO_2 into SO_2^* (214 nm) and a special reference detector circuit constantly measures lamp intensity (refer to (Equation 6-2)). A Photo Multiplier Tube (PMT) detects the UV given off by the SO_2^* decay (330 nm) and outputs an analog signal. Several focusing lenses and optical filters ensure that both detectors are exposed to an optimum amount of only the right wavelengths of UV. To further assure that the PMT only detects light given off by decaying SO_2^* the pathway of the excitation UV and field of view of the PMT are perpendicular to each other and the inside surfaces of the sample chamber are coated with a layer of black Teflon[®] that absorbs stray light.

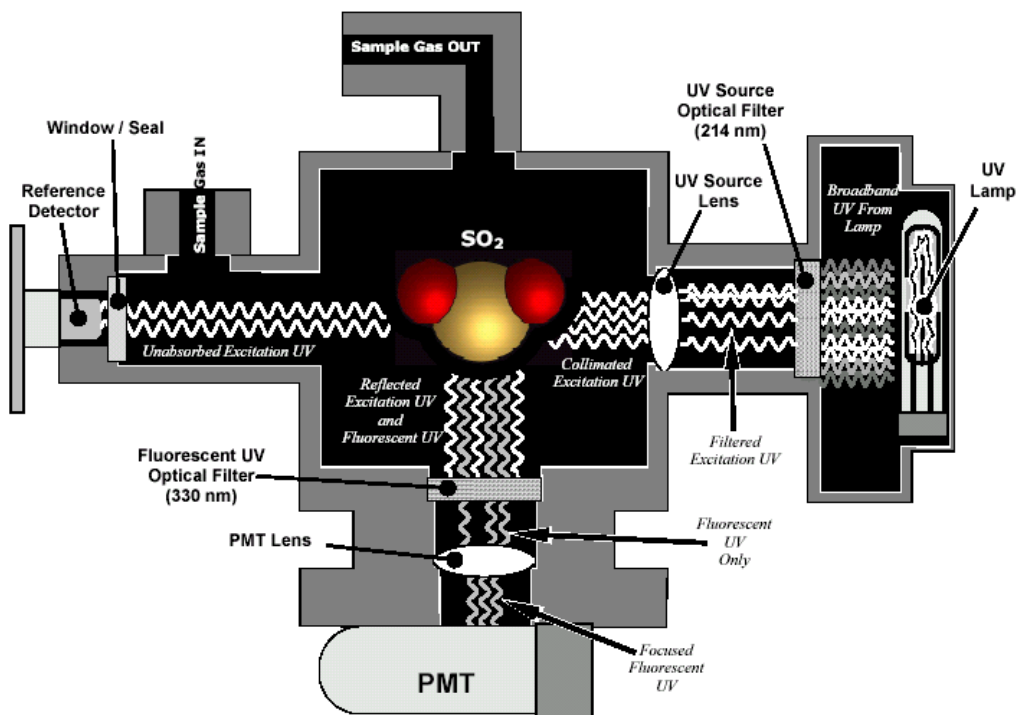


Figure 6-2. N100 UV Light Path



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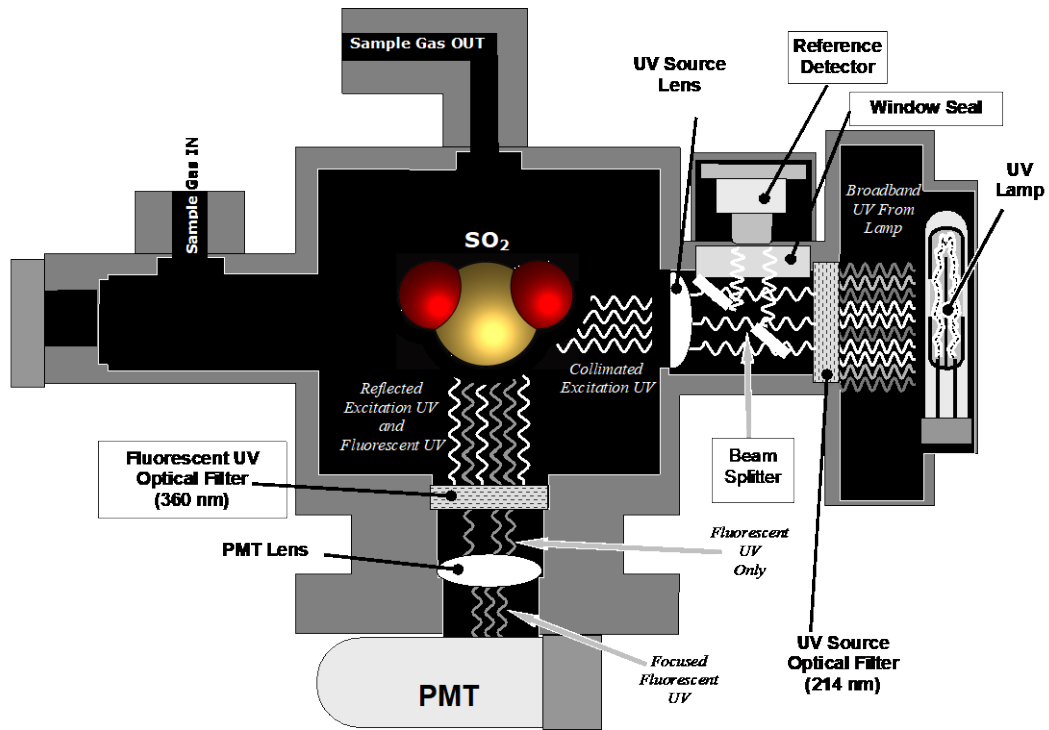


Figure 6-3. N100H UV Light Path

6.1.3. UV SOURCE LAMP

The source of excitation UV light is a low pressure zinc-vapor lamp. A DC voltage heats up and vaporizes zinc contained in the lamp element creating a light-producing plasma arc. Zinc-vapor lamps are preferred over the more common mercury-vapor lamps for this application because they produce very strong emission levels at the wavelength required to convert SO_2 to SO_2^* , 213.9 nm (refer to Figure 6-5).

The lamp is constructed with a vacuum jacket surrounding a double-bore lamp element (refer to Figure 6-4). The vacuum jacket isolates the plasma arc from most external temperature fluctuations. The jacket also contains thermal energy created by the lamp's operation therefore helping the lamp to heat up and maintain proper vaporization temperature. Light is emitted through a 20 mm x 5 mm portal.

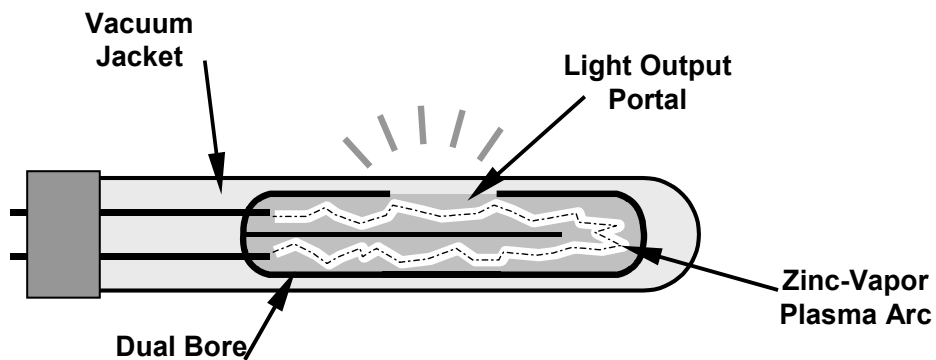


Figure 6-4. Source UV Lamp Construction



6.1.4. THE REFERENCE DETECTOR

A vacuum diode, UV detector that converts UV light to a DC current is used to measure the intensity of the excitation UV source lamp. It is located directly across from the source lamp at the back of a narrow tube-shaped light trap, which places it directly in the path of the excitation UV light. A window transparent to UV light provides an air-proof seal that prevents ambient gas from contaminating the sample chamber. The shape of the light trap and the fact that the detector is blind to wavelengths other than UV no extra optical filtering is needed.

6.1.5. THE PMT

The amount of fluoresced UV produced in the sample chamber is much less than the intensity of excitation UV source lamp (refer to Figure 6-5). Therefore a much more sensitive device is needed to detect this light with enough resolution to be meaningful: a Photo Multiplier Tube (PMT), a vacuum tube containing a variety of specially designed electrodes called dynodes. Photons enter the PMT and strike a negatively charged photo cathode causing it to emit electrons. These electrons are accelerated by a high voltage applied across a series of dynodes that multiply the amount of electrons until a useable current signal is generated, which increases or decreases with the amount of detected light.

6.1.6. UV LAMP & PMT OFFSET

Inherent in the operation of the PMT are minor electronic offsets, the degree of which can differ among PMTs, and with age. To account for these offsets the UV lamp shuts off, causing a brief dark period in the sample chamber during which the analyzer records the PMT output and factors them into the SO₂ concentration calculation. The PMT offset is stored as **Dark PMT** and can be viewed in the Dashboard.

6.1.7. OPTICAL FILTERS

The analyzer uses two stages of optical filters to enhance performance. The first stage conditions the UV light used to excite the SO₂ by removing frequencies of light that are not needed to produce SO₂*. The second stage protects the PMT detector from reacting to light not produced by the SO₂* returning to its ground state.

6.1.7.1. UV SOURCE OPTICAL FILTER

Zinc-vapor lamps output light at other wavelengths beside the 214nm required for the SO₂ → SO₂* transformation including a relatively bright light of the same wavelength at which SO₂* fluoresces as it returns to its SO₂ ground state (330 nm). In fact, the intensity of light emitted by the UV lamp at 330nm is so bright, nearly five orders of magnitude brighter than that resulting from the SO₂* decay, it would drown out the SO₂* fluorescence.

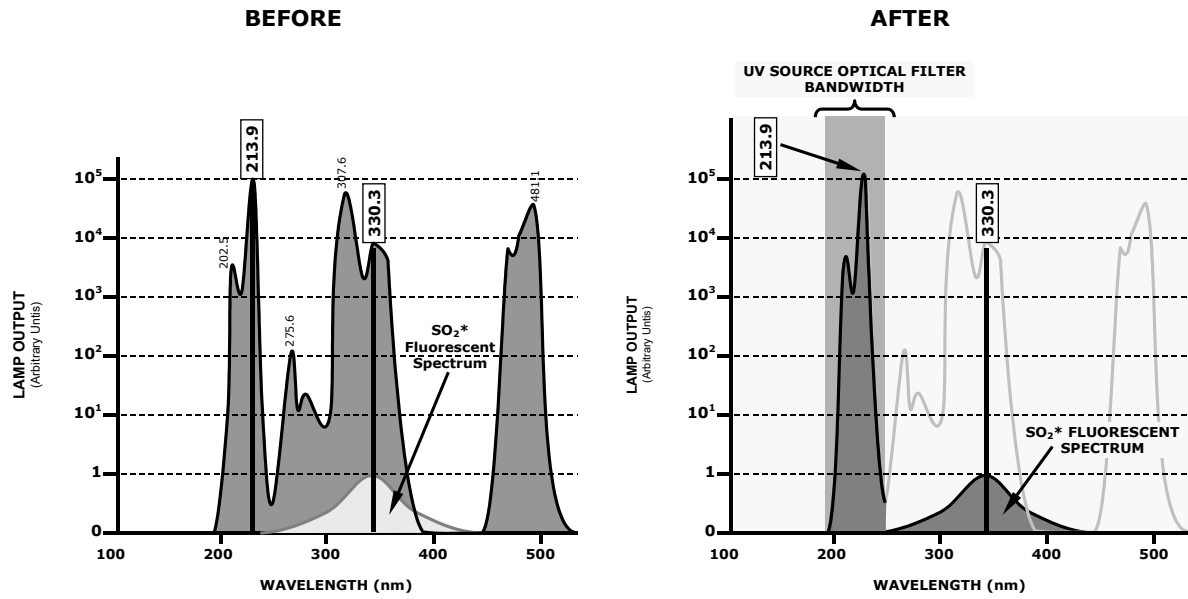


Figure 6-5. Excitation Lamp UV Spectrum Before/After Filtration

To solve this problem, the light emitted by the excitation UV lamp passes through a band pass filter that screens out photons with wavelengths outside the spectrum required to excite SO₂ into SO₂* (refer to Figure 6-5).



6.1.7.2. PMT OPTICAL FILTER

The PMT reacts to a wide spectrum of light which includes much of the visible spectrum and most of the UV spectrum. Even though the 214 nm light used to excite the SO₂ is focused away from the PMT, some of it scatters in the direction of the PMT as it interacts with the sample gas. A second optical band pass filter placed between the sample chamber (refer to Figure 6-2) and the PMT strips away light outside of the fluorescence spectrum of decaying SO₂* (refer to Figure 6-6) including reflected UV from the source lamp and other stray light.

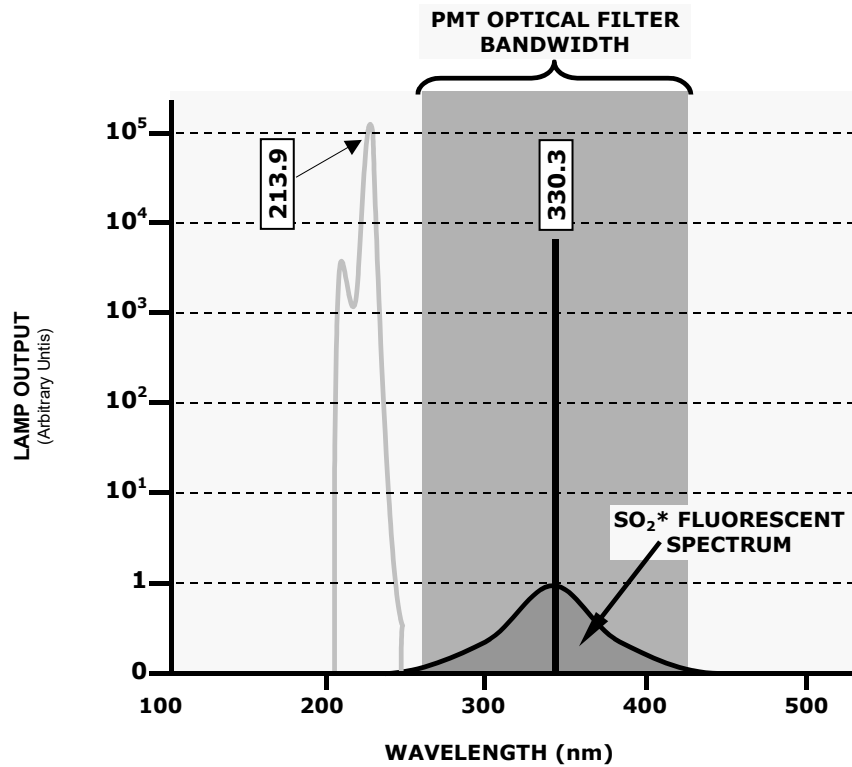


Figure 6-6. PMT Optical Filter Bandwidth

6.1.8. OPTICAL LENSES

Two optical lenses are used to focus and optimize the path of light through the sample chamber.

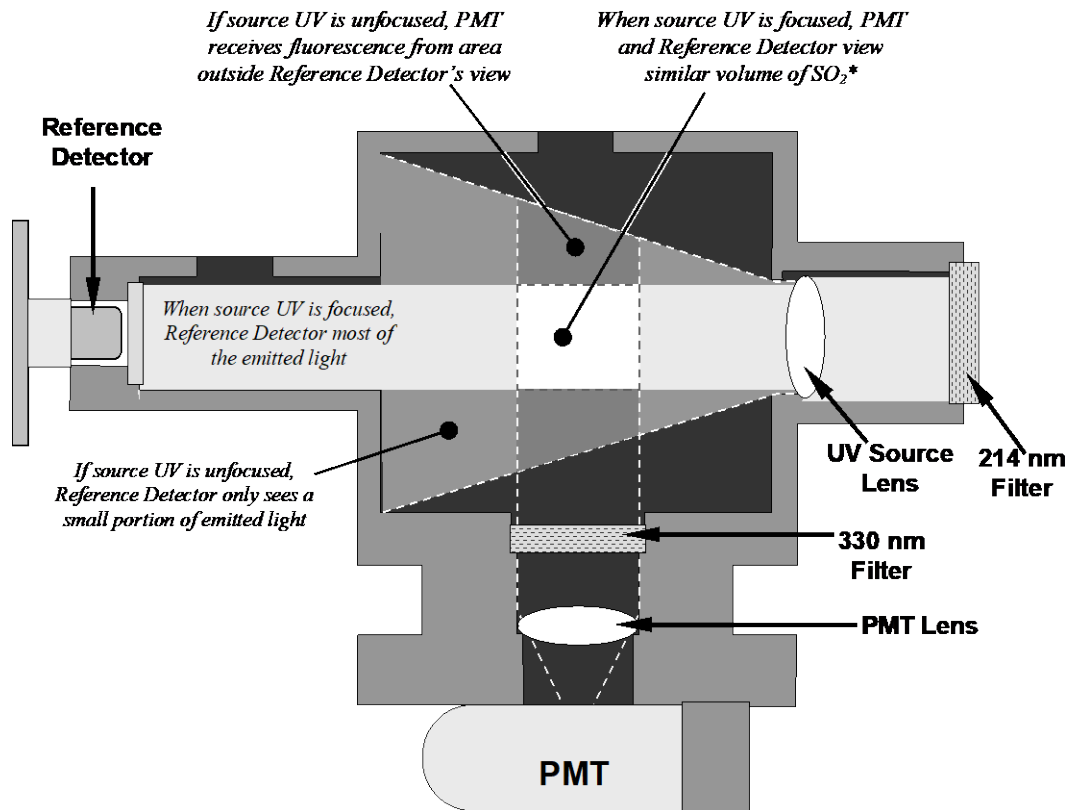


Figure 6-7. Effects of Focusing Source UV in Sample Chamber

A lens located between PMT and the sample chamber collects as much of the fluoresced UV created there as possible and focuses it on the most sensitive part of the PMT's photo cathode.

Another lens located between the excitation UV source lamp and the sample chamber collimates the light emitted by the lamp into a steady, circular beam and focuses that beam directly onto the reference detector. This allows the reference detector to accurately measure the effective intensity of the excitation UV by eliminating the effect of flickering inherent in the plasma arc that generates the light.

Ensure that all of the light emitted by the source lamp, passes through the 214 nm filter and not absorbed by the SO₂ reaches the reference detector. Conversely, this also makes sure that the volume of sample gas affected by the excitation beam is similar to the volume of fluorescing SO₂* being measured by the PMT, eliminating a possible source of measurement offset.



6.1.9. MEASUREMENT INTERFERENCES

It should be noted that the fluorescence method for detecting SO₂ is subject to interference from a number of sources. The analyzer has been successfully tested for its ability to reject interference from most of these sources.

6.1.9.1. DIRECT INTERFERENCE

The most common source of interference is from other gases that fluoresce in a similar fashion to SO₂ when exposed to UV Light. The most significant of these is a class of hydrocarbons called poly-nuclear aromatics (PNA) of which xylene and naphthalene are two prominent examples. Nitrogen oxide fluoresces in a spectral range near to SO₂. For critical applications where high levels of NO are expected an optional optical filter is available in the that improves the rejection of NO (contact Technical Support for more information). The analyzer has several methods for rejecting these gas interferences:

- A special scrubber (kicker) mechanism (option in the N100H) removes any PNA chemicals present in the sample gas before it the reach the sample chamber.
- The exact wavelength of light needed to excite a specific non-SO₂ fluorescing gas is removed by the source UV optical filter.
- The light given off by Nitrogen Oxide and many of the other fluorescing gases is outside of the bandwidth passed by the PMT optical filter.

6.1.9.2. UV ABSORPTION BY OZONE

Because ozone absorbs UV Light over a relatively broad spectrum it could cause a measurement offset by absorbing some of the UV given off by the decaying SO₂* in the sample chamber. This is prevented by having a very short light path between the area where the SO₂* fluorescence occurs and the PMT detector. Because the light path is so short, the amount of O₃ needed to cause a noticeable effect would be much higher than could be reasonably expected in any application for which this instrument is intended.

6.1.9.3. DILUTION

Certain gases with higher viscosities can lower the flow rate, thereby reducing the amount of sample gas in the sample chamber and thus the amount of SO₂ available to react with the to the UV light. While this can be a significant problem for some analyzers, the design of this analyzer is very tolerant of variations in sample gas flow rate and therefore does not suffer from this type of interference.

6.1.9.4. THIRD BODY QUENCHING

While the decay of SO₂* to SO₂ happens quickly, it is not instantaneous. Because it is not instantaneous it is possible for the extra energy possessed by the excited electron of the SO₂* molecule to be given off as kinetic energy during a collision with another molecule. This in effect heats the other molecule slightly and allows the excited electron to move into a lower energy orbit without emitting a photon.



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The most significant interferents in this regard are nitrogen oxide (NO), carbon dioxide (CO₂), water vapor (H₂O) and molecular oxygen (O₂). In ambient applications the quenching effect of these gases is negligible. For stack applications where the concentrations of some or all of these may be very high, specific steps **MUST** be taken to remove them from the sample gas before it enters the analyzer.

6.1.9.5. LIGHT POLLUTION

Because the analyzer measures light as a means of calculating the amount of SO₂ present, obviously stray light can be a significant interfering factor, which is removed in several ways.

- The sample chamber is designed to be completely light tight to light from sources other than the excitation UV source lamp.
- All pneumatic tubing leading into the sample chamber is completely opaque in order to prevent light from being piped into the chamber by the tubing walls.
- The optical filters discussed in Section 6.1.7; remove UV with wavelengths extraneous to the excitation and decay of SO₂/SO₂*.
- Most importantly, during instrument calibration the difference between the value of the most recently recorded PMT offset (refer to Section 6.1.6) and the PMT output while measuring zero gas (calibration gas devoid of SO₂) is recorded as **OFFSET**. This **OFFSET** value is used during the calculation of the SO₂ concentration.



6.2. PNEUMATIC OPERATION

Important

IMPACT ON READINGS OR DATA

It is important that the sample airflow system is leak-tight and not pressurized over ambient pressure. Regular leak checks should be performed on the analyzer as stated in the Maintenance Schedule.

Note

Relative Pressure vs Absolute Pressure: In this manual vacuum readings are given in inches of mercury absolute pressure (in-Hg-A), i.e. indicate an absolute pressure referenced against zero (a perfect vacuum).

6.2.1. SAMPLE GAS FLOW

Gas flows through the analyzer by way of an internal pump that pulls air in through the Sample inlet, along the pneumatic flow path through the instrument (refer to pneumatic diagrams in Section 2.3.3) and pushes it out at the Exhaust outlet.

6.2.2. FLOW RATE CONTROL

The analyzer uses special flow control assembly/assemblies (see “FLOW CONTROL” component(s) in pneumatic diagrams in Section 2.3.3) to maintain a constant flow rate of the sample gas through the instrument. Each assembly (Figure 6-8) consists of:

- A critical flow orifice
- Two o-rings, located just before and after the critical flow orifice, to seal the gap between the walls of assembly housing and the critical flow orifice
- A sintered filter
- A spring for mechanical force to maintain the seal between the filter, the o-rings, and the critical flow orifice within the assembly housing

6.2.2.1. CRITICAL FLOW ORIFICE

The most important component of this flow control assembly is the critical flow orifice.

Critical flow orifices are a simple way to regulate stable gas flow rates. They operate without moving parts by taking advantage of the laws of fluid dynamics. Restricting the flow of gas through the orifice creates a pressure differential. This pressure differential combined with the action of the analyzer’s 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.

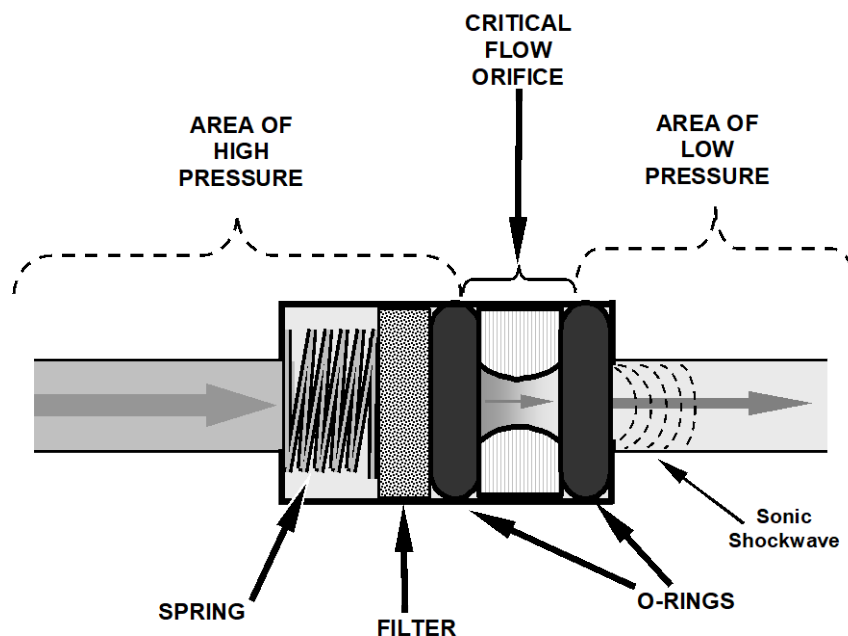


Figure 6-8. Flow Control Assembly & Critical Flow Orifice

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 hole, the more gas molecules, moving at the speed of sound, pass through the orifice. Because the flow rate of gas through the orifice is only related to the minimum 2:1 pressure differential and not absolute pressure the flow rate of the gas is also unaffected by degradations in pump efficiency due to age.

The critical flow orifice is designed to provide a flow rate of 650 cm³/min.

6.2.2.2. SAMPLE PARTICULATE FILTER

To remove particles in the sample gas, the analyzer can be equipped with either of two filter options (also referred to as the sample filter):

- a Teflon membrane filter of 47 mm diameter with a 1 μm or 5 μm pore size
- or a Long Life filter

6.2.3. HYDROCARBON SCRUBBER/KICKER (OPTION IN THE N100H)

It is very important to ensure that the air supplied sample chamber is clear of hydrocarbons. To accomplish this task the analyzer uses a single tube permeation scrubber (refer to Figure 6-9). The scrubber consists of a single tube of a specialized plastic that absorbs hydrocarbons very well. This tube is located within outer flexible plastic tube shell. As gas flows through the inner tube, hydrocarbons are absorbed into the membrane walls and transported through the membrane wall and into the hydrocarbon free, purge gas flowing through the outer tube. This process is driven by the hydrocarbon concentration gradient between the inner and outer of the tubes.

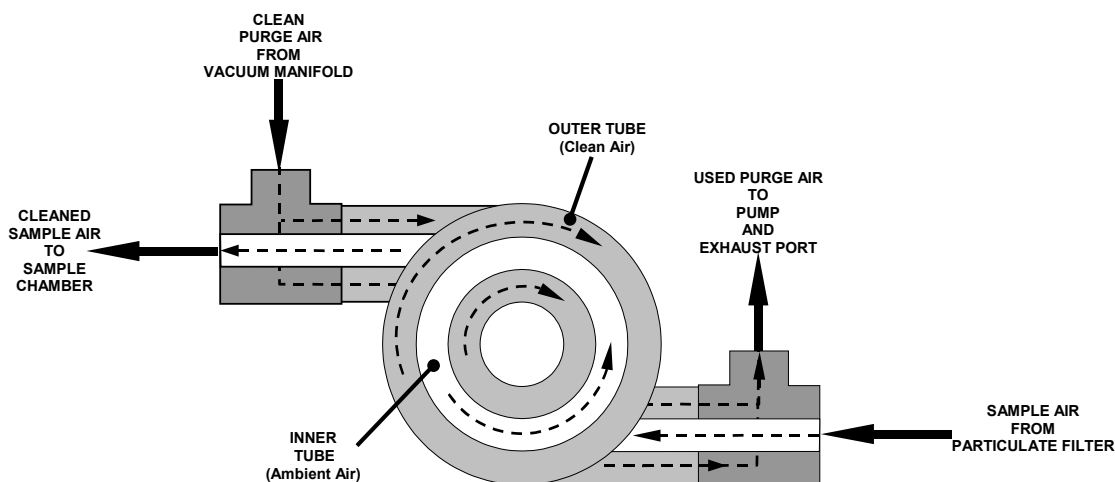


Figure 6-9. Hydrocarbon Scrubber (Kicker)

Some of the cleaned air from the inner tube is returned to be used as the purge gas in the outer tube. This means that when the analyzer is first started, the concentration gradient between the inner and outer tubes is not very large and the scrubber's efficiency is relatively low. When the instrument is turned on after having been off for more than 30 minutes, it takes a certain amount of time for the gradient to become large enough for the scrubber to adequately remove hydrocarbons from the sample air.

6.2.4. PNEUMATIC SENSORS

The analyzer uses two pneumatic sensors to verify gas streams. These sensors are located on a printed circuit assembly: pneumatic pressure sensor is on the PMT Bench Module board, and the flow sensor is on the pump control board. The flow simultaneously enters the sample pressure sensor and the flow sensor from the outlet of the reaction cell.

6.2.4.1. SAMPLE PRESSURE SENSOR

An absolute pressure transducer plumbed to the input of the analyzer's sample chamber is used to measure the pressure of the sample gas before it enters the chamber. This upstream measurement is used to validate the critical flow condition (2:1 pressure ratio) through the instrument's critical flow orifice (refer to Section 6.2.2). Also, if the Temperature/Pressure Compensation (TPC) feature is turned on, the output of this sensor is also used to supply pressure data for that calculation.

The actual pressure measurement is displayed as Pressure.

6.2.4.2. SAMPLE FLOW (N100)

A thermal-mass flow sensor is used in the N100 to measure the sample flow through the analyzer. This sensor is also mounted on the pneumatic pressure/flow sensor board upstream of the sample chamber. The flow rate is monitored by the CRT which issues an Alert if the flow rate is too high or too low. The flow rate of the sample gas is displayed as Sample Flow.



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6.2.4.3. SAMPLE FLOW (N100H)

Unlike the N100, which uses a thermal-mass flow sensor to directly measure the gas flow through the instrument, the N100H calculates the gas as a ratio of the two pressures to validate critical flow. If the pressure ratio is not correct ($< 2:1$) an Alert with SAMPLE FLOW WARN message is activated, but if it is valid ($\geq 2:1$), the instrument calculates the flow based on sample gas pressure level (Pressure) and is displayed as Sample Flow.

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.

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 valves or controlling manifold temperature. There is also the Sensor Module, which is comprised of the gas sensor and its operational components, as well as the data acquisition (DAQ) board with logic device, microcontroller and LED driver mounted on it. The Sensor Module calculates gas concentrations and may command the Smart Modules.



6.3.2. POWER SWITCHES

The front panel Soft Power switch is used to protect against data loss. 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 turn on or off 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.

6.4. SOFTWARE OPERATION

The analyzer's software developed by Teledyne API interprets user commands via the various interfaces, performs procedures and tasks, stores data in the various memory devices and calculates the concentration of the sample gas.

6.4.1. ADAPTIVE FILTER

The analyzer software processes sample gas measurement and reference 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, which allows 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. 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 concentration of the sample gas.

The instrument slope and offset values recorded during the last calibration can be viewed in the Dashboard.

6.4.3. TEMPERATURE/PRESSURE COMPENSATION (TPC)

As explained in the principles of operation, changes in temperature can significantly affect the amount of fluoresced UV light generated in the instrument's sample chamber. To negate this effect the analyzer maintains the sample gas at a stable, raised temperature.

Pressure changes can also have a noticeable, if more subtle, effect on the SO₂ concentration calculation. To account for this, a software feature allows the instrument to compensate changes in ambient pressure during the SO₂ calculations.

When the TPC feature is enabled, the analyzer's SO₂ concentration is divided by a factor called PRESSCO, which is based on the difference between the ambient pressure of the sample gas normalized to standard atmospheric pressure (Equation 6-6). As ambient pressure increases, the compensated SO₂ concentration is decreased.

$$PRESSCO = \frac{SAMPLE_PRESSURE (" HG - A) \times SAMP_PRESS_SLOPE}{29.92 (" HG - A)}$$

(Equation 6-6)

SAMPLE_PRESSURE: The ambient pressure of the sample gas as measured by the instrument's sample pressure sensor in "Hg-A.

SAMP_PRESS_SLOPE: Sample pressure slope correction factor.

The SETUP>VARS menu enables/disables the TPC feature.

6.4.4. INTERNAL DATA ACQUISITION SYSTEM (DAS)

The DAS is designed to implement predictive diagnostics that store trending data for users to anticipate when an instrument will require service. Large amounts of data can be stored and retrieved for analysis. The DAS is configured and managed through the Data Logging menu (Section 2.5.1).



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 ₂ into NO, etc.) |
| CEM | <i>Continuous Emission Monitoring</i> |
| Chemical elements that may be included in this document: | |
| CO ₂ | carbon dioxide |
| C ₃ H ₈ | propane |
| CH ₄ | methane |
| H ₂ O | water vapor |
| HC | general abbreviation for hydrocarbon |
| HNO ₃ | nitric acid |
| H ₂ S | hydrogen sulfide |
| NO | nitric oxide |
| NO ₂ | nitrogen dioxide |
| NO _x | nitrogen oxides, here defined as the sum of NO and NO ₂ |
| NO _y | nitrogen oxides, often called odd nitrogen: the sum of NO _x plus other compounds such as HNO ₃ (definitions vary widely and may include nitrate (NO ₃), PAN, N ₂ O and other compounds as well) |
| NH ₃ | ammonia |
| O ₂ | molecular oxygen |
| O ₃ | ozone |
| SO ₂ | sulfur dioxide |
| cm ³ | 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> |



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| TERM | DESCRIPTION/DEFINITION |
|------------|---|
| DR-DOS | <i>Digital Research DOS</i> |
| 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> |
| 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> [®] |
| 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> |
| 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> [®] |
| 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> |



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| 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> [®] |
| 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> |



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APPENDIX A – MODBUS REGISTERS

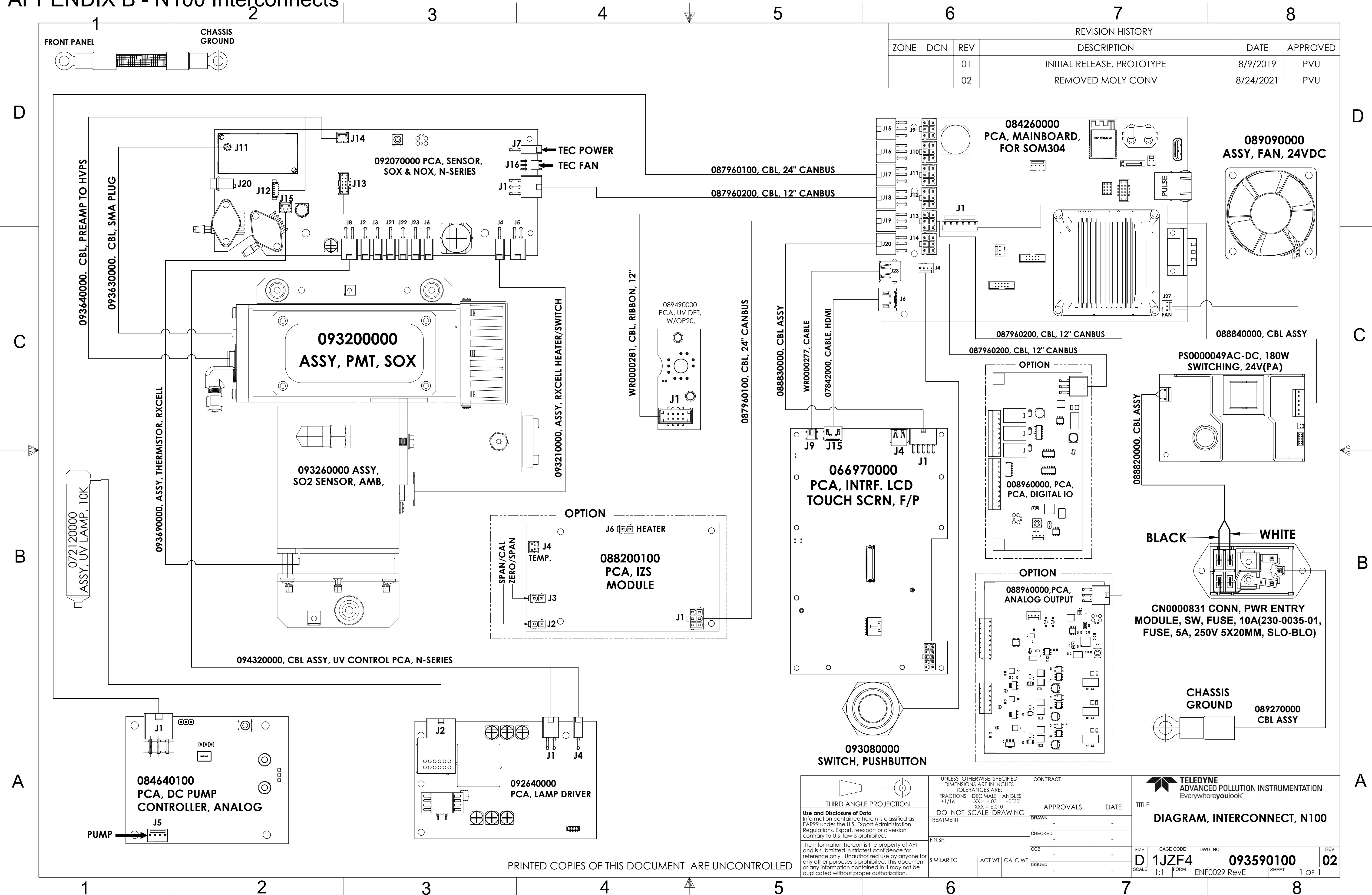
| ADDRESS | NAME | DESCRIPTION |
|------------------------|-----------------------------------|---|
| Discrete Inputs | | |
| 0 | PMT_DET_WARN | PMT detector output outside operational limits |
| 1 | UV_DET_WARN | UV intensity outside set limits |
| 2 | DARK_CAL_WARN | Dark offset outside set limits |
| 3 | BOX_TEMP_WARN | Chassis temperature outside specified limits. |
| 4 | PMT_TEMP_WARN | PMT temperature outside set limits |
| 5 | RCELL_TEMP_WARN | Sample chamber temperature out of range. |
| 6 | SAMP_PRESS_WARN | Sample pressure out of range |
| 7 | HVPS_WARN | High voltage power supply outside allowable limits |
| 8 | SYS_WARN_RESET | CPU has rebooted |
| 9 | N/A | N/A |
| 10 | N/A | N/A |
| 11 | SYS_WARN_FRONT_PANEL | Communication error with front panel |
| 12 | SYS_WARN_ANALOG_CAL | A/D circuitry or output not calibrated |
| 13 | DYN_ZERO_WARN | Error with performing Dynamic Zero |
| 14 | DYN_SPAN_WARN | Error with performing Dynamic Span |
| 15 | ASF_INVALID_CONCENTRATION_WARNING | Concentration reading invalid |
| 16 | ASF_CAL_ZERO_ACTIVE | Zero Cal Valve Active |
| 17 | ASF_CAL_HIGH_SPAN_ACTIVE | Span Cal Valve Active |
| 18 | ASF_MULTIPOINT_CALIBRATION_MODE | Multipoint Calibration Mode Active |
| 19 | SYS_OK_WARN | Fault present in system |
| 20 | SAMP_FLOW_WARN | Sample Flow outside of operating limits |
| 21 | SYS_WARN_IZS_TEMP | IZS temperature outside of operating limits |
| 22 | ASF_CAL_LOW_SPAN_ACTIVE | Low Span Cal Valve Active |
| 23 | VACUUM_PRESS_WARN | Vacuum pressure outside of operating limits |
| 24 | SO2_CONC_ALARM_1 | Concentration Alarm 1 Active |
| 25 | SO2_CONC_ALARM_2 | Concentration Alarm 2 Active |
| 26 | ASF_HESSSEN_MANUAL_MODE | Denotes whether instrument is in HESSEN manual mode |
| 27 | SYS_WARN_ACAL1_CAL_FAIL | Auto-Cal Seq 1 failed |
| 28 | SYS_WARN_ACAL2_CAL_FAIL | Auto-Cal Seq 2 failed |
| 29 | SYS_WARN_ACAL3_CAL_FAIL | Auto-Cal Seq 3 failed |
| Coils | | |
| 20 | MB_ZERO_CAL_RANGE1 | Enable/disable external zero cal |
| 21 | MB_SPAN_CAL_RANGE1 | Enable/disable external low span cal |
| 22 | MB_ZERO_CAL_RANGE2 | Enable/disable external zero cal |
| 23 | MB_SPAN_CAL_RANGE2 | Enable/disable external low span cal |
| Input Registers | | |
| 0 | AI_PMT | PMT Detector Reading in mV |
| 2 | AI_UVLAMP_RAW | UV Lamp Intensity Reading in mV |
| 4 | AI_UVLAMP | UV Lamp ratio in % |
| 6 | AI_PMT_DARK | PMT Dark reading in mV |



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| ADDRESS | NAME | DESCRIPTION |
|--------------------------|------------------------|---|
| 8 | AI_PMT_LIGHT | PMT light reading in mV |
| 10 | SO2_SLOPE1 | SO2 Slope for range 1 |
| 12 | SO2_SLOPE2 | SO2 Slope for range 2 |
| 14 | SO2_OFFSET1 | SO2 Offset for range 1 |
| 16 | SO2_OFFSET2 | SO2 Offset for range 2 |
| 18 | SO2_PRE_CAL_CONC_1 | SO2 concentration for range #1 during zero/span calibration |
| 20 | SO2_PRE_CAL_CONC_2 | SO2 concentration for range #2 during zero/span calibration |
| 22 | SO2_CONC | SO2 concentration for range 1 |
| 24 | SO2_CONC_2 | SO2 concentration for range 2 |
| 26 | SO2_STABILITY | Box temperature in degree C |
| 30 | AI_RCELL_TEMP | Reaction cell temperature in degree C |
| 32 | AI_PMT_TEMP | PMT temperature in degree C |
| 34 | AI_SAMPLE_PRESSURE | Sample pressure in In.Hg-A |
| 36 | AI_BOX_TEMP | Internal box temperature in degree C |
| 38 | AO_HVPS_SETPOINT | High voltage power supply output Volts |
| 40 | AI_PMT_BOARD_TEMP | PMT Board temperature in degree C |
| 46 | AI_MEASURE_VDD | VDD Measured in mV |
| 48 | AI_MEASURE_5V | 5V Measured in mV |
| 50 | AI_PUMP_FLOW | Pump flow in CCM |
| 52 | AI_IZS_BLOCK_TEMP | IZS temperature in degree C |
| 54 | AI_VACUUM_PRESS | Vacuum pressure in In.Hg-A |
| 56 | AI_UVLAMP_RAW | UV lamp intensity reading in mV |
| Holding Registers | | |
| 0 | SO2_TARGET_SPAN_CONC_1 | Target span concentration for range 1 |
| 2 | SO2_TARGET_SPAN_CONC_2 | Target span concentration for range 2 |

APPENDIX B - N100 Interconnects

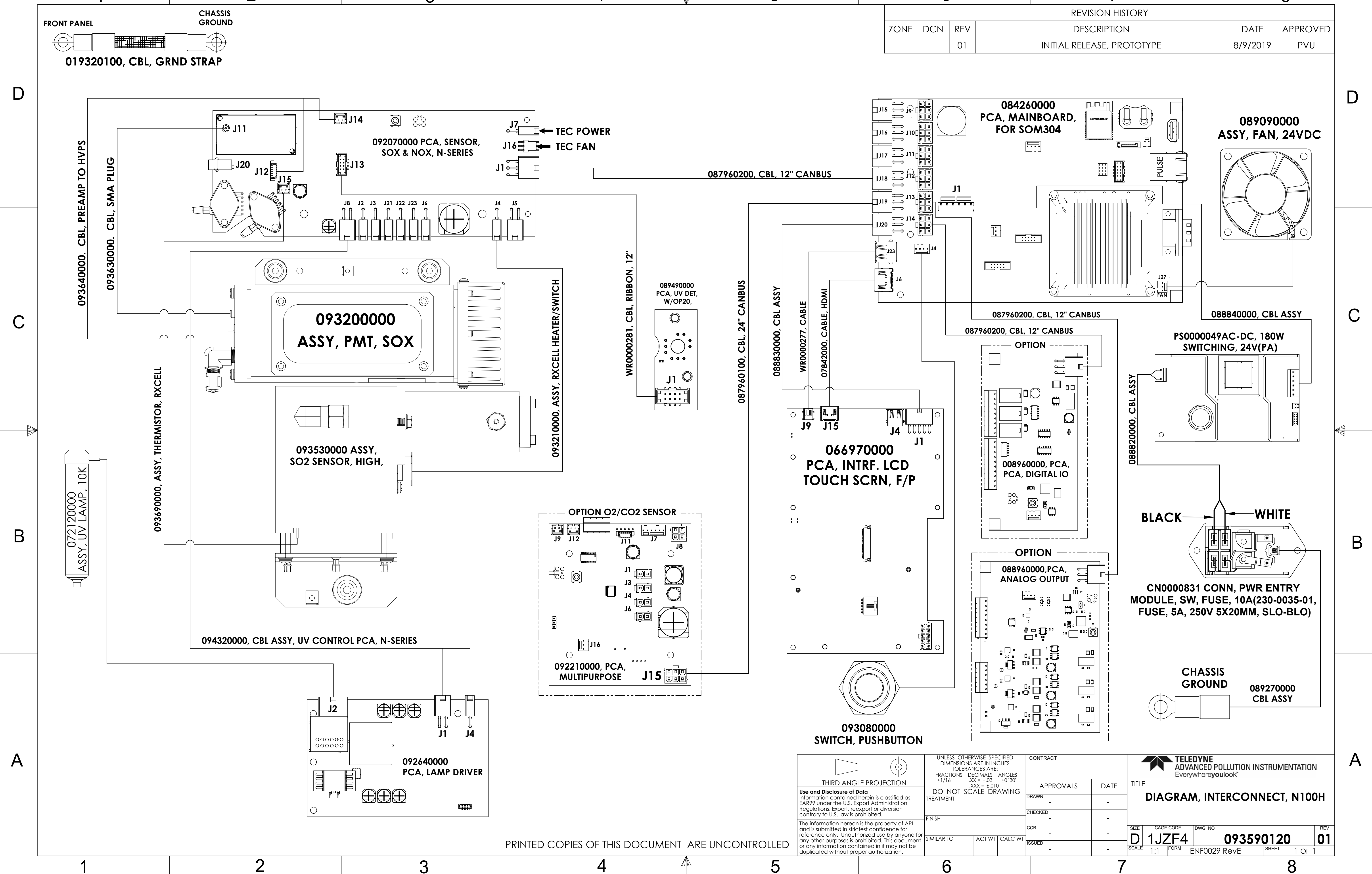


| REVISION HISTORY | | | | | |
|------------------|-----|-----|----------------------------|-----------|----------|
| ZONE | DCN | REV | DESCRIPTION | DATE | APPROVED |
| | | 01 | INITIAL RELEASE, PROTOTYPE | 8/9/2019 | PVU |
| | | 02 | REMOVED MOLY CONV | 8/24/2021 | PVU |

| | | | | |
|--|---|-----------|------|---|
| <p>THIRD ANGLE PROJECTION</p> | <p>UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ±1/16 ±.03 ±0°30' .XXX ±.010</p> <p>DO NOT SCALE DRAWING</p> | CONTRACT | | <p>TELEDYNE ADVANCED POLLUTION INSTRUMENTATION Everywhereyoulook®</p> |
| | | APPROVALS | DATE | |
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| FINISH | CHECKED | | | |
| SIMILAR TO | ISSUED | | | <p>SIZE: D 1JZF4</p> <p>SCALE: 1:1</p> |
| ACT WT | CALC WT | | | <p>CAGE CODE: 093590100</p> <p>FORM: ENF0029 RevE</p> <p>REV: 02</p> <p>SHEET: 1 OF 1</p> |

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APPENDIX B - N100H 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' .XXX ±.010</p> <p>DO NOT SCALE DRAWING</p> | | <p>CONTRACT</p> | |
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| <p>FINISH</p> | | <p>ISSUED</p> | | <p>TITLE</p> | |
| <p>SIMILAR TO</p> | | <p>ACT WT CALC WT</p> | | <p>DIAGRAM, INTERCONNECT, N100H</p> | |
| <p>SCALE 1:1</p> | | <p>FORM ENF0029 RevE</p> | | <p>SIZE CAGE CODE DWG NO REV D 1JZF4 093590120 01</p> | |
| | | | | <p>SHEET 1 OF 1</p> | |

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