



**DRAFT**  
**Petroleum Refinery**  
**Community Air Monitoring Plan**

San Joaquin Valley Air Pollution Control District

June 21, 2024

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## 1. Background

On October 8, 2017, the California State Legislature and Governor Jerry Brown passed Assembly Bill (AB) 1647. As a part of the California Health and Safety Code (CH&SC) §42705.6, this legislation requires the following: (1) the San Joaquin Valley Air Pollution Control District (District) design, develop, install, operate, and maintain a refinery-related community air monitoring system; 2) petroleum refinery owners and operators develop, install, operate, and maintain a fence-line monitoring system, per guidance developed by the District; 3) the District and petroleum refinery owners and operators collect real-time data from the refinery-related community air monitoring system and the fence-line monitoring system and the data be provided to the public as quickly as possible in a publicly accessible format; and 4) petroleum refinery owner and operators be responsible for the costs associated with implementing a refinery-related community air monitoring system. In response to these requirements, District staff have conducted an extensive level of research regarding air monitoring equipment and approaches, and have engaged in a robust outreach process in working with affected Valley petroleum refineries and other public stakeholders.

Through extensive research and a public outreach process, the District developed Rules 4460 (Petroleum Refinery Fence-line Air Monitoring) and 3200 (Petroleum Refinery Community Air Monitoring Fees) requiring publicly-accessible monitoring data to be collected at refinery fence-lines and in nearby communities. In accordance with requirements of AB 1647, Rule 4460 requires that petroleum refinery owners and operators install, operate, and maintain fence-line air monitoring systems and make data collected by these systems publicly available. Rule 3200 requires that owners and operators of petroleum refineries operating in the Valley pay an initial fee to support the implementation of refinery-related community air monitoring by the District, and also requires the payment of an annual operations and maintenance fee to support community air monitoring system maintenance and associated District staff time. The District Governing Board adopted both rules on December 19, 2019. Subsequently, these rules were amended on October 20, 2022 to address court rulings.

This document outlines the District's Community Air Monitoring Plan (CAMP) which provides the District's strategy and approach for conducting air monitoring in communities adjacent to refineries. Community air monitoring will be developed and operated by the District based on the information provided in this CAMP. Refinery fence-line monitoring which is also required will be conducted by the refineries in accordance to the approved fence-line air monitoring plans submitted to the District.

In accordance with the District's Community Air Monitoring Plan, dated January 28, 2021, community air monitoring was implemented for Kern Energy and San Joaquin Refining Co., as they were the only refineries subject to the requirements at that time. However, due to amendments to the rules, Tricor Refining, LLC, is now also subject to the refinery monitoring requirements. As a result, community monitoring for that facility is included in this updated CAMP.

The anticipated timeline for the implementation of community air monitoring for Tricor Refining LLC is as follows:

**Table 1. Anticipated Implementation Timeline**

Action	Date
Petroleum Refinery Community Air Monitoring Workshop	August 2023
Public Comments Received on Community Air Monitoring	September 2023
Complete development of community air monitoring systems	3rd Quarter 2024
Secure community air monitoring sites	3rd Quarter 2024
Install, calibrate, and test equipment	3rd Quarter 2024
Begin operating community air monitoring systems and displaying data to the public	3rd Quarter 2024

## 2. Community Air Monitoring Site Selection

This CAMP includes three (3) fixed long-term community air monitoring systems, one for each refinery community, in accordance with the CH&SC section 42705.6(b). This section of the CH&SC requires that a refinery-related community air monitoring system be installed near each refinery that is consistent with the requirements and guidance applicable to the siting of air quality monitors as established by the federal Environmental Protection Agency and that meets all of the following requirements:

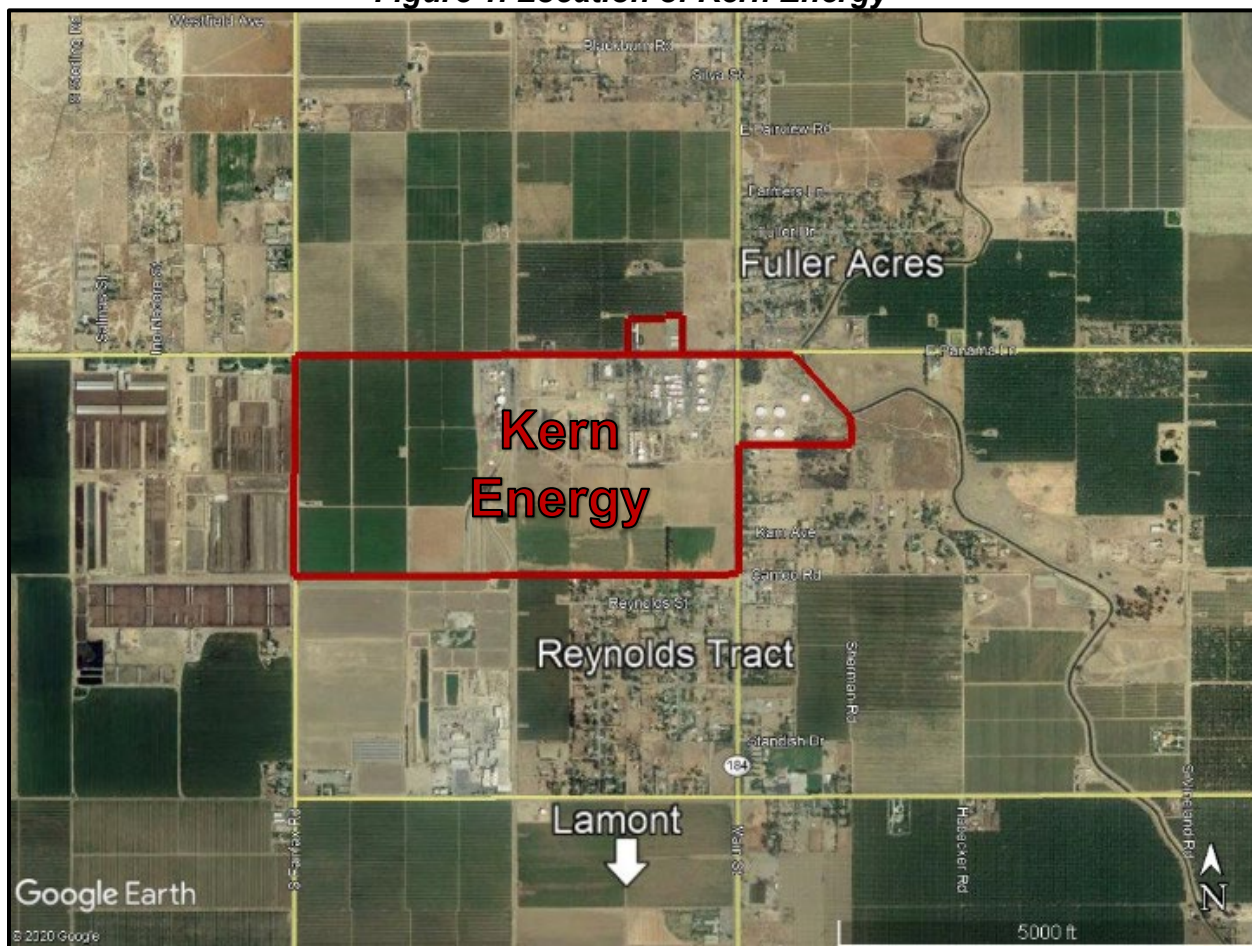
- (1) A district shall design, develop, install, operate, and maintain the refinery-related community air monitoring system, which shall be operated and maintained in accordance with guidance from the appropriate district. A district may contract with a third party to implement this paragraph.
- (2) The refinery-related community air monitoring system shall include equipment capable of measuring compounds emitted to the atmosphere from refinery processes, as determined by the appropriate district.

EPA siting guidance, established in *40 CFR Appendix D to Part 58 - Network Design Criteria for Ambient Air Quality Monitoring*, recommends that the location be based on the air monitoring objective. In this case, the objective is to monitor the potential impact of petroleum refineries on nearby neighborhoods. Therefore, the siting of refinery community monitors will be located downwind of the refineries and/or nearby sensitive receptors, as described below.

### **Kern Energy:**

Kern Energy is an oil refinery located at 7724 E. Panama Lane, Bakersfield, CA 93307. The facility is located closest to the intersection of Weedpatch Highway and East Panama Lane. The nearest communities to Kern Energy are Fuller Acres, Reynolds Tract, and Lamont as shown below.

**Figure 1. Location of Kern Energy**

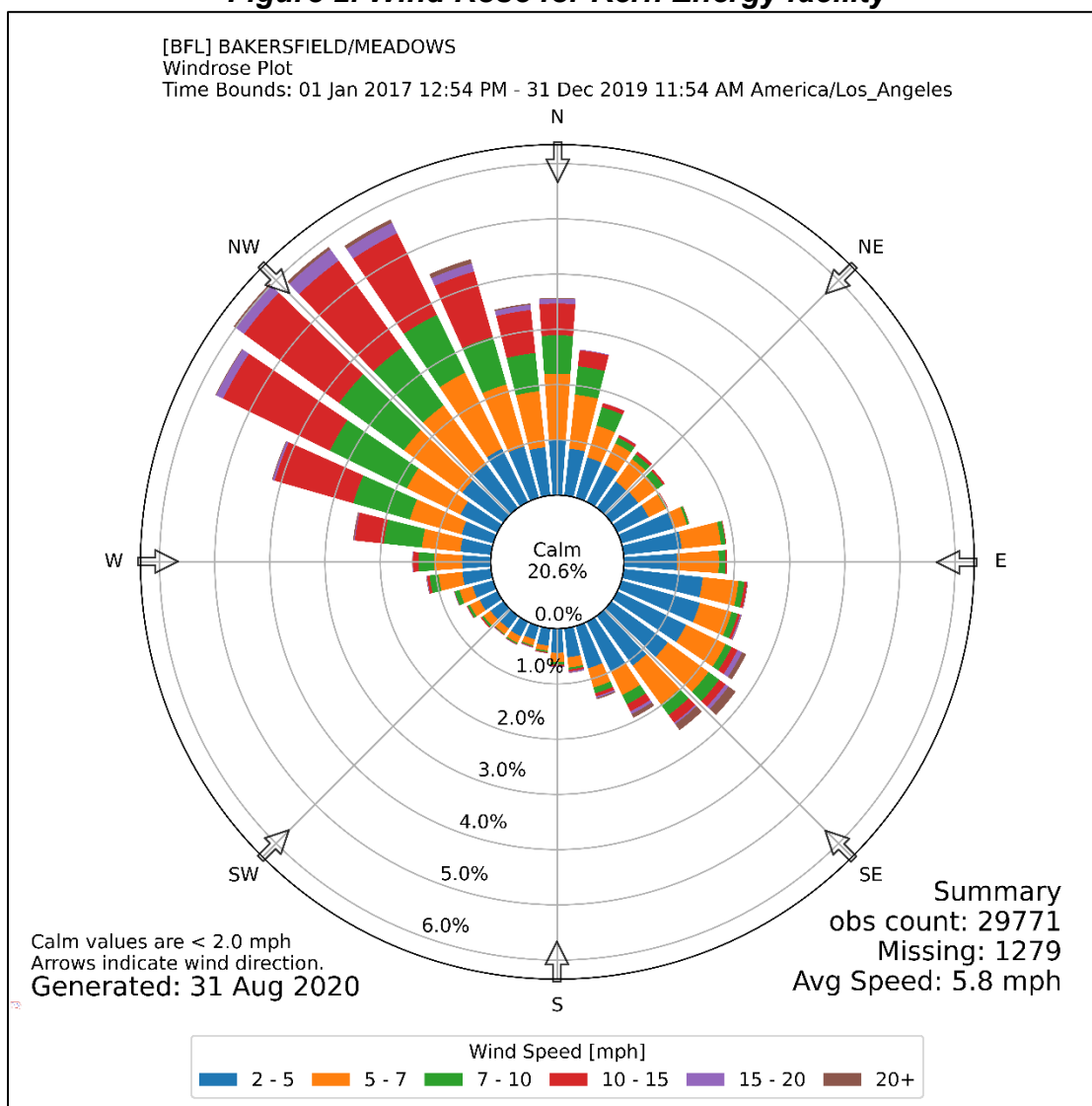


The Kern Energy facility is located in the southern end of the San Joaquin Valley with mountain ranges 10 miles to the east and 30 miles to the west. With the facility located in the San Joaquin Valley air basin, the surrounding topography can influence wind flow and direction. Outside of stagnant conditions, the predominant wind flow through the area is from the northwest to the southeast.

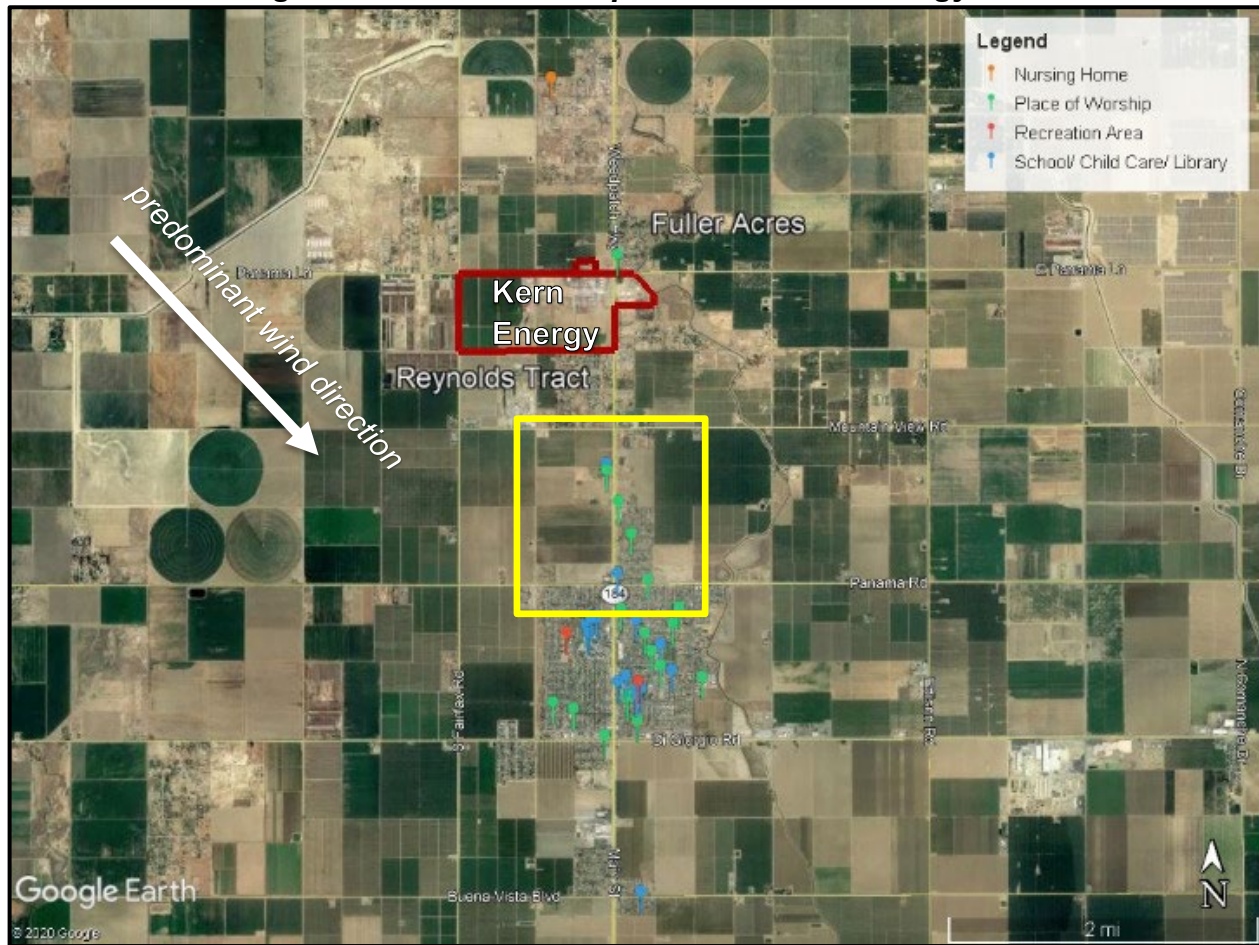
The District used wind data from the Bakersfield Municipal Airport, including wind speeds and directions, to generate the wind rose in the following Figure 2. Wind data from the Bakersfield Municipal Airport was selected due to its relative close proximity to the source and having recent 3-year data from January 1, 2017 to December 31, 2019. The wind rose, a diagram showing the relative frequency of wind directions at a place,

in Figure 2 was generated using the Iowa Environmental Mesonet tool. As shown by the wind rose, the predominant wind direction is from northwest to southeast.

**Figure 2. Wind Rose for Kern Energy facility**



In addition to wind direction, the District also considered impacted communities and sensitive receptors such as schools, medical facilities, senior communities, places of worship, and outdoor public event venues. The nearby-populated areas of Fuller Acres, Reynolds Tract, and Lamont represent air quality “receptor” communities that may at times be downwind from the Kern Energy facility. In addition to these areas, sensitive receptors, such as nursing homes, places of worship, recreation areas, schools, child care centers, and libraries in the area were identified. Figure 3 below shows the location of nearby population centers, as well as sensitive receptors with respect to the refinery. As noted in Figure 3, the sensitive receptors within a mile of the facility are located in Fuller Acres and Lamont. There are no nearby sensitive receptors located to the west of the facility within about 4 miles.

**Figure 3. Sensitive Receptors Near Kern Energy**

Consistent with the CH&SC section 42705.6(b) and based on the predominant wind direction in the area, the large number of sensitive receptors, and due to it being the most highly populated community in the area, the District proposed to install the community air monitoring system within the northern Lamont area (see yellow box in above map). The final location was established at the following:

**Figure 4. Final Location of Community Monitor for Kern Energy**



This final location was determined based on the following:

- Downwind of applicable refinery and near populated area
- Input from community members and other stakeholders
- Proper monitoring siting (no obstructions, mindful of influence from other local sources of pollution)
- Security of the location to protect equipment
- Access to power source to operate equipment
- Permission of land owner to place equipment on property

- Establishment of lease agreements with property owner

The community air monitor was installed and began operating on June 2, 2022 at Mountain View Elementary School in Lamont, CA. Community air monitoring data is available online at: <https://ww2.valleyair.org/air-quality-information/air-monitoring/petroleum-refinery-air-monitoring/>.

### **San Joaquin Refining Co.:**

San Joaquin Refining Co. (SJR) is an oil refinery located at 3542 Shell St, Bakersfield, CA 93308. The facility is located west of Golden State Highway and north of Rosedale Highway. It is surrounded by residential areas within a one-mile radius in the northwest, northeast, and southeast, as shown below.

**Figure 5. Location of San Joaquin Refining Co.**

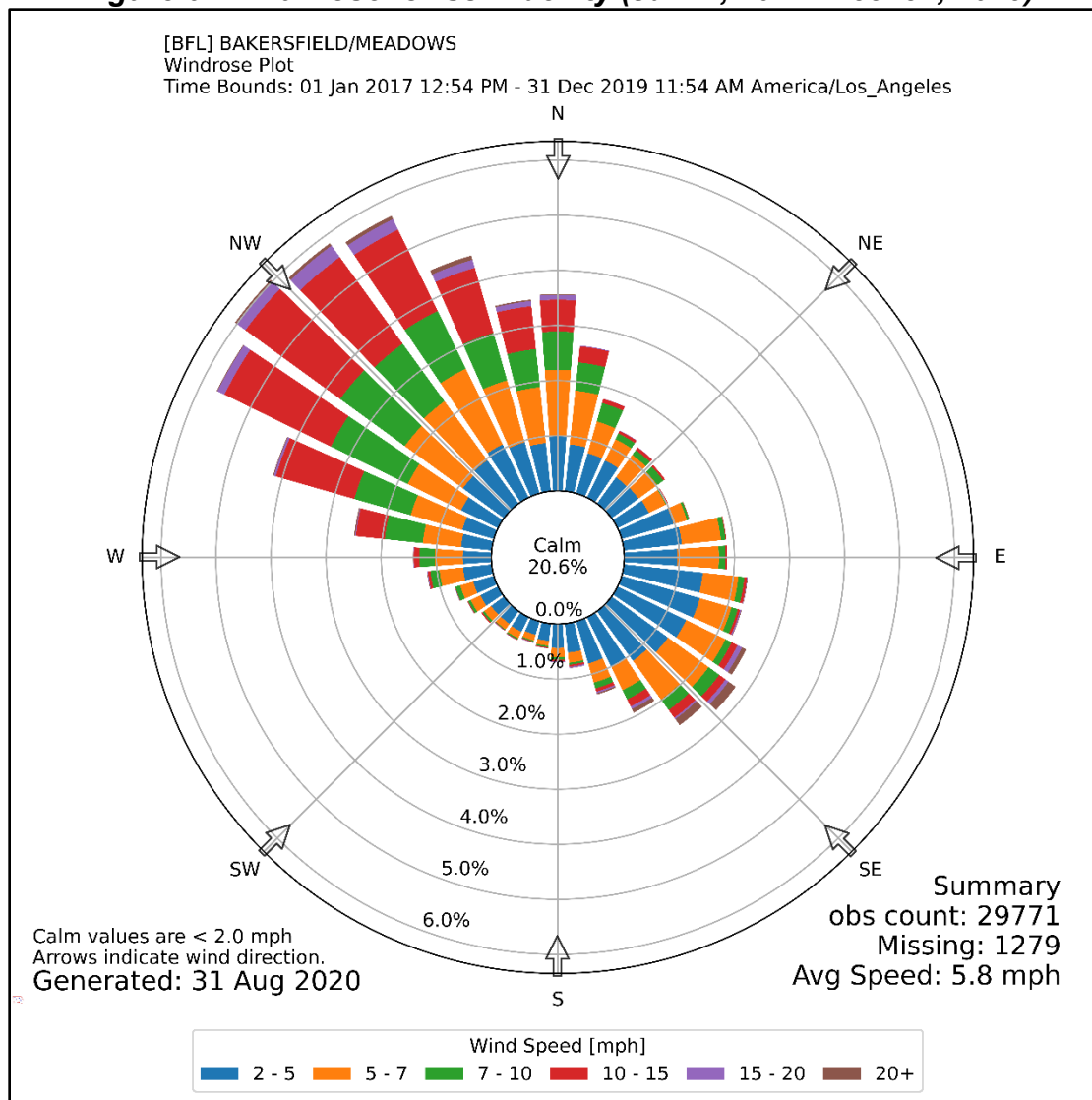


The SJR facility is located in the southern end of the San Joaquin Valley with mountain ranges 10 miles to the east and 30 miles to the west. With the facility located in the San Joaquin Valley air basin the surrounding topography can influence wind flow and direction. Outside of stagnant conditions, the predominant wind flow through the area is from the northwest to the southeast.

To determine the wind speeds and directions, wind data from the Bakersfield Municipal Airport is used to generate the wind rose, a diagram showing the relative frequency of wind directions at a place, in the following Figure 6. Wind data from the Bakersfield Municipal Airport was selected since it is the closest source with the most recent 3-year

data from January 1, 2017 to December 31, 2019. The wind rose in Figure 6 was generated using the Iowa Environmental Mesonet tool. As shown by the wind rose, the predominant wind direction is from northwest to southeast.

**Figure 6. Wind Rose for SJR facility (Jan. 1, 2017- Dec. 31, 2019)**



In addition to wind direction, the District also considered impacted communities and sensitive receptors. In particular, sensitive receptors, such as places of worship, health care facilities, recreation areas, residential areas, schools, and daycare centers in the area were identified. Figure 7 shows the location of the nearby sensitive receptors with respect to the refinery. Most of the sensitive receptors are located downwind and southeast of the facility.

**Figure 7. Sensitive Receptors Near SJR**



Consistent with the California Health and Safety Code section 42705.6(b) and based on the predominant wind direction in the area, the large number of sensitive receptors, and due to it being near a highly populated community in the area, the District proposed to install the community air monitoring system within the commercial area southeast of the refinery (see yellow shape in above map), which is also just upwind of a highly populated area. The final location was established at the following:

**Figure 8. Final Location of Community Monitor for SJR**

The community air monitor was installed and began operating on October 19, 2022 at N. Sillect Avenue Bakersfield, CA. Community air monitoring data is available online at: <https://ww2.valleyair.org/air-quality-information/air-monitoring/petroleum-refinery-air-monitoring/>.

The final location was determined by the following site selection criteria:

- Downwind of applicable refinery and near populated area
- Input from community members and other stakeholders
- Proper monitoring siting (no obstructions, mindful of influence from other local sources of pollution)
- Security of the location to protect equipment
- Access to power source to operate equipment
- Permission of land owner to place equipment on property
- Establishment of lease agreements with property owner

### **Tricor Refining, LLC:**

Tricor Refining, LLC (Tricor) is a petroleum refinery specializing in the production of asphalt and pavement emulsions. It is located at 1134 Manor St, Bakersfield, CA 93308. The facility is located east of Manor Street and south of China Grade Loop. It is surrounded by residential areas within a one-mile radius in the north, west and south as shown below.

**Figure 9. Location of Tricor**

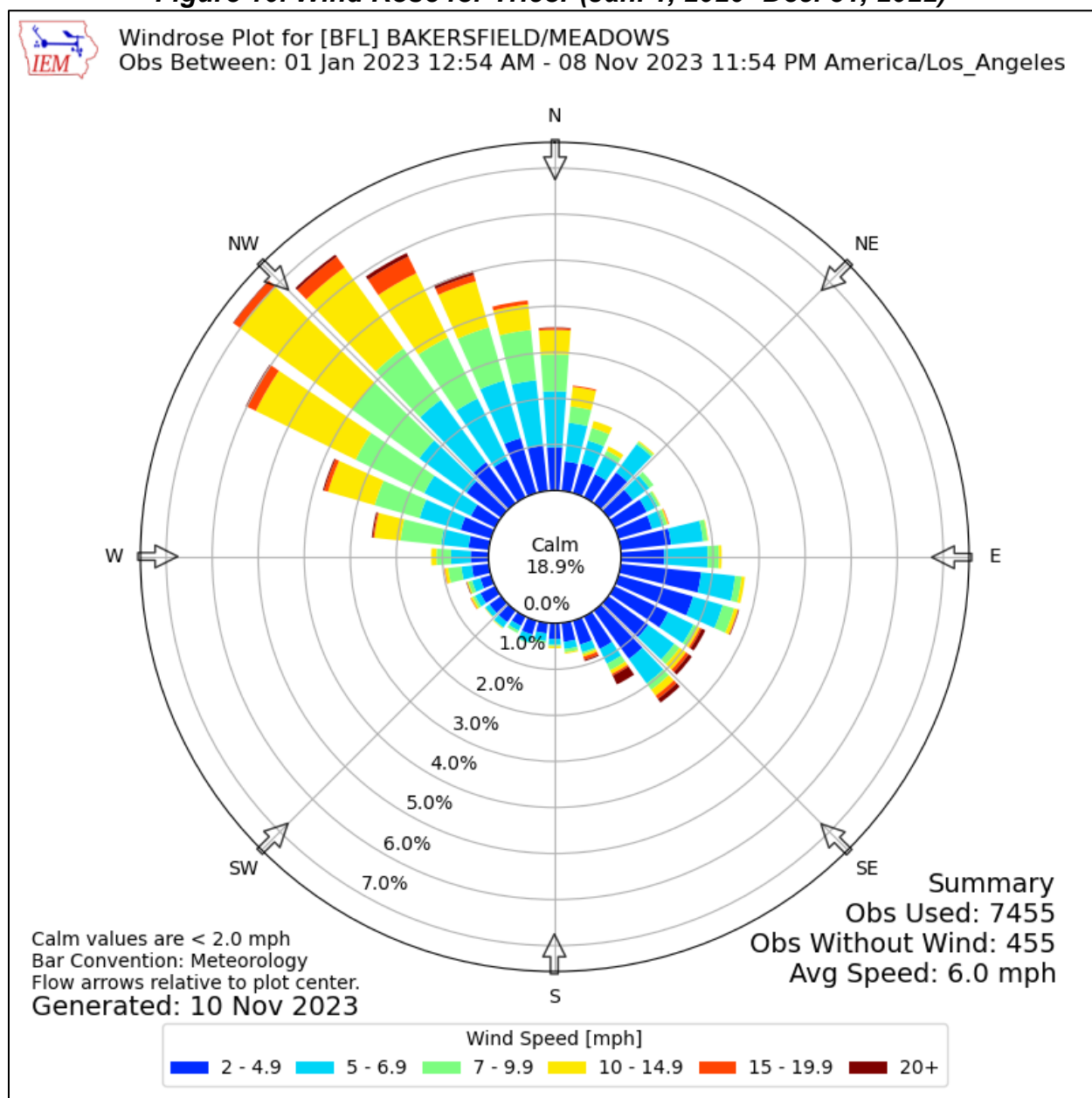


The Tricor facility is located in the southern end of the San Joaquin Valley. With the facility located in the San Joaquin Valley air basin the surrounding topography can influence wind flow and direction. Outside of stagnant conditions, the predominant wind flow through the area is from the northwest to the southeast.

To determine the wind speeds and directions, wind data from the Bakersfield Municipal Airport is used to generate the wind rose, diagram showing the relative frequency of wind directions at a place, in the following Figure 10. Wind data from the Bakersfield Municipal Airport was selected since it is the closest source with the most recent 3-year data from January 1, 2020 to December 31, 2022. The wind rose in Figure 10 was

generated using the Iowa Environmental Mesonet tool. As shown by the wind rose, the predominant wind direction is from northwest to southeast.

**Figure 10. Wind Rose for Tricor (Jan. 1, 2020- Dec. 31, 2022)**



In addition to wind direction, the District also considered impacted communities and sensitive receptors. In particular, sensitive receptors, such as places of worship, health care facilities, recreation areas, residential areas, schools, and daycare centers in the area were identified. Figure 11 shows the location of the nearby sensitive receptors with respect to the refinery. The closest sensitive receptors are located west of the facility.

**Figure 11. Sensitive Receptors Near Tricor**

Consistent with the CH&SC section 42705.6(b) and based on the proximity of the sensitive receptors west of the refinery, the District is proposing to install the community air monitoring system within the school or park area west of the refinery (see yellow shape in above map), as this area includes a number of sensitive receptors and since the area directly downwind does not include nearby sensitive receptors.

The final location will be determined by the following site selection criteria:

- Downwind of applicable refinery and near populated area
- Input from community members and other stakeholders
- Proper monitoring siting (no obstructions, mindful of influence from other local sources of pollution)
- Security of the location to protect equipment
- Access to power source to operate equipment
- Permission of land owner to place equipment on property
- Establishment of lease agreements with property owner

### 3. Pollutants to be Monitored in Communities

Petroleum refineries typically have the potential to emit a wide range of air contaminants. The petroleum refineries in the Valley are significantly smaller than other petroleum refineries throughout the state and focus much of their efforts in refining, blending, or storing a variety of specialized products such as biofuels, asphalt products, drilling fluids, fuel additives, hydraulic fluids, and lubricants that produce significantly less criteria and toxic emissions than the larger and more complex crude oil refining facilities in other parts of the state. The Office of Environmental Health Hazard Assessment (OEHHA) Report<sup>1</sup> of March 2019, "Analysis of Refinery Chemical Emissions and Health Effects," was prepared for the purpose of assisting CARB and local air districts when making decisions regarding air monitoring of communities near refineries.

The report identifies sulfur dioxide, hydrogen sulfide, and hydrocarbons as the most commonly reported pollutants emitted during refinery incidents:

*Based on this research, sulfur dioxide, hydrogen sulfide, and hydrocarbons were the most commonly reported chemicals emitted during refinery incidents. In many instances, adverse health effects were reported following the release of sulfur compounds. Symptoms were consistent with those associated with acute sulfur dioxide and/or hydrogen sulfide exposure: nausea; dizziness; irritation of the eyes, nose, throat, and skin; and unconsciousness.*

The report also identifies sulfur dioxide as the highest routine pollutant emitted by California refineries. Consistent with the report, sulfur dioxide is one of the top three pollutants emitted at Valley petroleum refineries Kern Energy, San Joaquin Refining, and Tricor Refining.

The report further emphasizes that among hydrocarbons, benzene stands out as having the highest toxicity-weighted impact. This means that, considering both its emission levels and inherent toxicity, benzene represents the most significant health risk in this category of compounds. An increase in benzene levels may indicate a corresponding rise in other hydrocarbons and pollutants, possibly originating from nearby petroleum refineries. To gauge the levels of these additional pollutants, one can refer to the data from the fence-line monitoring systems installed around these refineries. Therefore, benzene should be monitored. Furthermore, some instruments used for measuring benzene can also detect toluene, ethylbenzene, and xylene hydrocarbons (commonly referred to as BTEX).

Considering this, the District is proposing to continue monitoring for BTEX, H<sub>2</sub>S, and SO<sub>2</sub> at Kern Energy and San Joaquin Refining community air monitoring sites. In addition, the District is proposing to monitor BTEX, H<sub>2</sub>S, and SO<sub>2</sub> at the forthcoming

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<sup>1</sup> <https://oehha.ca.gov/media/downloads/faqs/refinerychemicalsreport032019.pdf>

Tricor Refining community air monitoring site. Each pollutant is described in further detail below.

- BTEX Compounds (Benzene, Toluene, Ethylbenzene, and Xylenes).** BTEX is a specified subset of aromatic hydrocarbons compounds containing benzene, toluene, ethylbenzene and xylene. These chemicals appear naturally in crude oil and can be associated with emissions from refineries as they are released partly due to incomplete combustion of natural gas as well as emissions from petroleum and storage and transfer. In addition, other combustion sources such as wood burning and fossil fuel combustion also contribute to BTEX emissions. The negative health effects associated with BTEX exposure include neurological impairment and cancer.
- Hydrogen Sulfide.** Hydrogen sulfide (H<sub>2</sub>S) is a colorless gas characterized by its foul odor of rotten eggs and can be smelled at low concentrations. It is poisonous, corrosive, and flammable, and exposure at high concentrations can cause irritation, unconsciousness, and death. Hydrogen sulfide is often produced from the breakdown of organic matter in the absence of oxygen gas, such as in swamps, sewers, and in the crude oil extraction / refining process.
- Sulfur Dioxide.** Sulfur Dioxide (SO<sub>2</sub>) is a colorless gas, with a pungent odor akin to a struck match. Inhalation of SO<sub>2</sub> can produce adverse health effects, and difficulty breathing. Sulfur dioxide is produced largely by fossil fuel combustion.

Monitoring for the remaining OEHHA recommended pollutants is not proposed due to the very low emissions and/or being below defined health exposure thresholds within the boundaries of each refinery. The dispersion of these pollutants after their release from the facility further reduces their concentration levels at nearby community monitors, resulting in levels that are below health thresholds and/or below minimum detection levels of available air monitoring equipment. Additionally, the pollutants being measured above for the community air monitoring systems (BTEX, H<sub>2</sub>S, and SO<sub>2</sub>) will serve as valuable surrogates for the other OEHHA recommended pollutants not being monitored, as identified below.

**Table 2. Basis for Pollutants Not Monitored**

Pollutant	San Joaquin Refining	Tricor Refining, LLC	Kern Energy
	<b><i>Based on highest annual emissions inventory among above refineries</i></b>		
Acetaldehyde	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>OEHHA reference exposure level</li> <li>Monitoring equipment detection levels</li> </ul>		
Ammonia	Not emitted at facilities		

Pollutant	San Joaquin Refining	Tricor Refining, LLC	Kern Energy
	<i>Based on highest annual emissions inventory among above refineries</i>		
1,3-Butadiene	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>• OEHHA reference exposure level</li> <li>• Monitoring equipment detection levels</li> </ul>		
Cadmium	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>• OEHHA reference exposure level</li> <li>• Monitoring equipment detection levels</li> </ul>		
Diethanolamine	Not emitted at facilities		
Formaldehyde	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>• OEHHA reference exposure level</li> <li>• Monitoring equipment detection levels</li> </ul>		
Hydrogen Fluoride	Not emitted at facilities		
Manganese	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>• OEHHA reference exposure level</li> <li>• Monitoring equipment detection levels</li> </ul>		
Naphthalene	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>• OEHHA reference exposure level</li> <li>• Monitoring equipment detection levels</li> </ul>		
Nickel	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>• OEHHA reference exposure level</li> <li>• Monitoring equipment detection levels</li> </ul>		
Nitrogen Oxides	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>• OEHHA reference exposure level for NO<sub>2</sub></li> <li>• California Department of Industrial Relations Permissible Exposure Limits for NO</li> </ul>		
Polycyclic Aromatic Hydrocarbons (PAH)	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>• OEHHA reference exposure level</li> <li>• Monitoring equipment detection levels</li> </ul> <p>Real-time monitoring method not available</p>		
Particulate Matter	Emissions concentration at community monitor below: <ul style="list-style-type: none"> <li>• Federal health-based standards</li> <li>• Monitoring equipment detection levels</li> </ul>		
Sulfuric Acid	Not emitted at facilities		

## 4. Selection of Air Monitoring Equipment and Methods

The refinery-related community air monitoring network includes one fully equipped fixed-site air monitoring system being deployed for each refinery in the community. The data provided by each system will help the District assess emissions trends, better detect potential air quality impacts from refinery emissions resulting from fugitive emissions (e.g. leaks) and other releases through real-time data reporting.

The selection of the instrumentation for the air monitoring systems was driven by the requirement to provide real-time air pollution data, notification systems, as well as detection limits for characterization of pollutants. Real-time monitoring is necessary to evaluate the immediate impact of fugitive emissions (e.g. leaks) and other releases in the surrounding communities. Therefore, the instrumentation proposed will have sufficient time resolution to characterize pollution levels changing on short time scales (e.g. minutes). The community air monitoring data gathered will allow for the characterization of the levels of pollutants on longer time scales (diurnal, seasonal, annual) in various locations that likely would represent local background levels. Such long-term monitoring is important when assessing potential air quality impacts of refinery emissions over time. Thus, the sensitivity of the instrumentation will need to be capable of measuring the typical background concentrations of air pollutants.

In order to satisfy these objectives, the District is and will be using a combination of advanced air monitoring technology, using the most appropriate instruments and methods for the given monitoring objectives. The following factors were considered in the community air monitoring instrument selection process:

- Instrument performance (e.g. minimum detection limits, accuracy, and precision);
- Measurement time resolution;
- Experience and reliability of the manufacturer;
- Possible interferences from other local pollutants or environmental conditions (e.g. can instrument performance be affected by environmental conditions such as high relative humidity or high PM loadings);
- Availability of spare parts;
- Software integration capabilities and software compatibility; and
- Data output capability including format and processing

The system for all these locations is a compact multi-pollutant system (see Figure 12) that will provide the most flexibility to be placed in various locations. This system will be equipped with advanced air monitoring analyzers measuring various pollutants, with the ability to communicate the community-level air quality in real time.

**Figure 12. Example of Compact Multi-Pollutant Air Monitoring System**



The following technologies will be used as a part of the air monitoring systems.

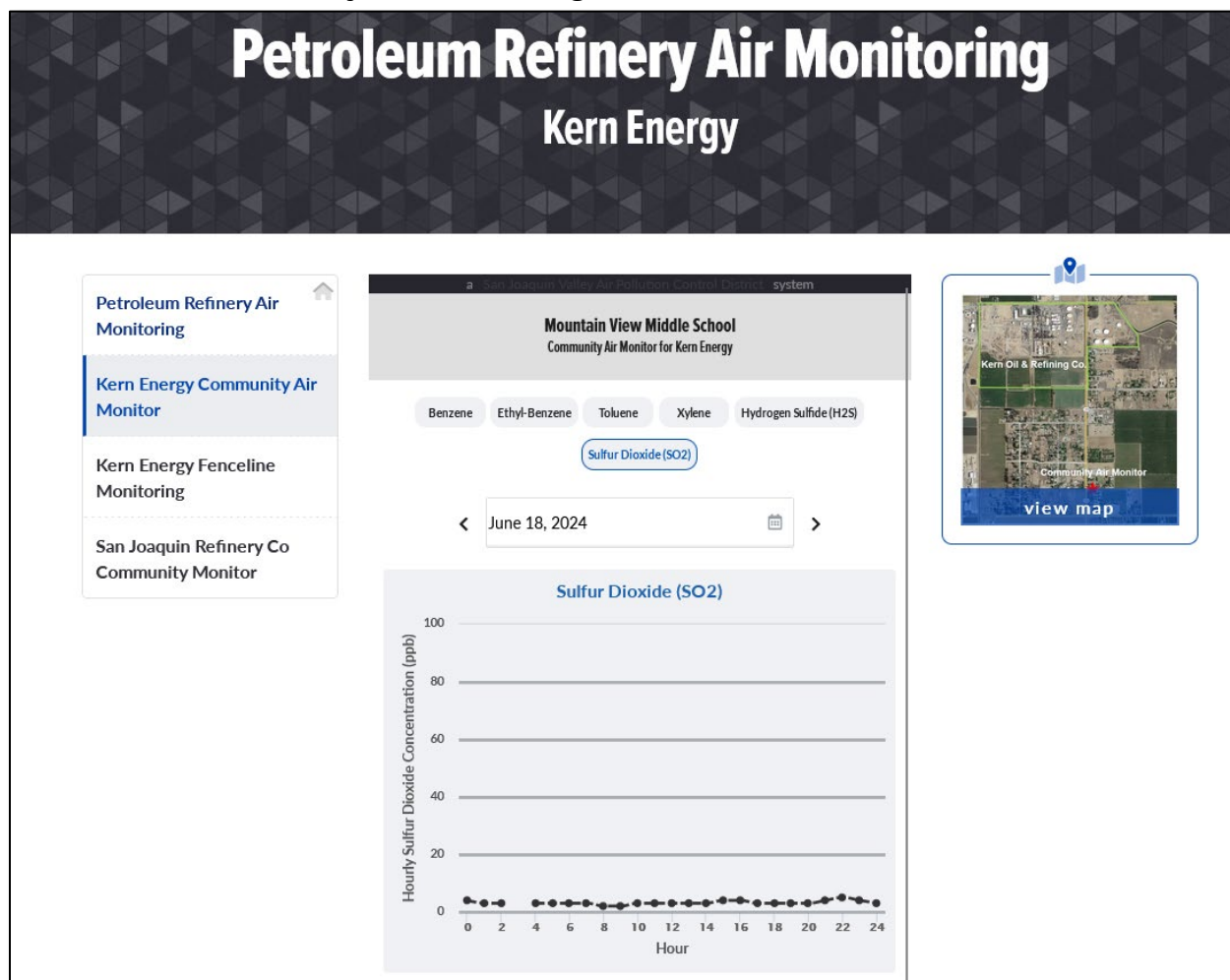
**Table 2. Technologies Selected for Community Air Monitoring**

Measurement	Instrument	Method	Data Acquisition Frequency	Detection Limit
Benzene, Toluene, Ethylbenzene, and Xylene	Mlu-recordum or Pyxis: BTEX GC	Gas Chromatography-Photoionization Detection	15 minutes	0.2 ppb – 100 ppb
Hydrogen Sulfide (H <sub>2</sub> S) and Sulfur Dioxide (SO <sub>2</sub> )	Teledyne T101	Ultraviolet Fluorescence	90 seconds	0.5 ppb – 10 ppm
Meteorology (wind speed, wind direction, temperature, pressure, and relative humidity)	Vaisala WXT530	Sonic Anemometer	1 second	0-134 mph 0-100 RH -60 +140 °F

## 5. Data Visualization, Analysis, and Reporting

The primary goal of this data platform is to share the monitoring data with the community to the extent feasible and as quickly as possible, so that the public can better evaluate and assess potential impacts of refinery emissions in the community. It is essential that the collected data be available and displayed online in real-time, and in a user-friendly manner. The air monitoring data is provided to the public through a dedicated website (<https://ww2.valleyair.org/air-quality-information/air-monitoring/petroleum-refinery-air-monitoring/>). The website for displaying the data includes the current real-time measurements, historical data, and other relevant information and is available in multiple languages (see Figure 13 below). The air monitoring data is provided in a manner that the public can readily access and understand. The District will provide alternative methods of accessing reports as needed for those members of the community who may not have internet access, including hard copies of reports.

**Figure 12. Example of Display of Real-Time Community Air Monitoring Data Measured at Community Air Monitoring Site**



## 6. Maintenance and Quality Assurance

The District has extensive experience and expertise in designing, operating, and maintaining the regulatory and community air monitoring networks throughout the San Joaquin Valley. Building upon this, the District takes a similar approach to the community monitoring for refineries to ensure quality assurance and quality control, including training of personnel, development and maintenance of proper documentation (i.e., instrument manuals, Standard Operating Procedures (SOP), routine maintenance and calibration checks, technical audits, data verification and validation, and data quality assessment (see Appendix A)).

The real-time and near-real-time disseminated measurement data will not be considered final, but it is important that the preliminary real-time measurement data distributed to the public be of an acceptable quality. Therefore, District staff ensure that any instrument failures are detected quickly, with automated screening where feasible, to prevent grossly invalid data from being presented to the public. This is accomplished

by utilizing built-in status flags on the instrument operational parameters and by providing real-time data screening for outliers, impossible values, stuck values, negative values, rates of change, excessive short-term noise, etc.

All monitoring data are collected and archived in a standard electronic format after necessary data validation. Data validation involves collecting the data, assuring its quality, storing it in a standardized format, and presenting the data to the public. The most critical steps in this process include:

- Automatically retrieving data from the fence-line monitors containing the measured levels of each air pollutant along with meteorological parameters;
- Validating data file completeness and integrity;
- Transferring file contents to a database;
- Flagging data that do not meet pre-defined quality control limits;
- Copying quality assured data and indices into a database which will be used for data display and dissemination;
- Generating and recording logs to monitor system operation; and
- Automated notifications, as appropriate, when measured concentrations are above pre-defined concentrations limits.

To ensure that the collected data meets the highest quality possible, each piece of monitoring equipment is operated in accordance with an in-depth operating procedure. To achieve the appropriate level of detail and standardization, and to consequently ensure that the monitoring equipment provides high quality data, SOPs are prepared for each specific measurement method. The SOPs are informed by general operating instructions that are typically provided by the manufacturers of equipment, by operational experience, and by general operational guidelines and performance specifications that are available for EPA and State approved methods. The SOPs address specific topics such as calibration and quality control procedures (indicating standards and checks, acceptance criteria and schedule), as well as data reduction (indicating validation procedures, reporting and schedule).

The District utilizes highly trained and experienced staff to maintain its air monitoring network throughout the Valley, who continually ensure that the air monitoring system is maintained in accordance with manufacturer specifications and that any breakdowns and malfunctions are addressed in a timely manner. The District utilizes enhanced integration of the air monitoring system to a central data server that will immediately notify District staff of any equipment offline or apparent data errors in the community air monitoring systems.

## 7. Community Engagement

Community and stakeholder engagement is essential for providing ideas and feedback for the successful implementation of this CAMP. Members of each community have unique knowledge of and relationship with the area they live in. Therefore, the

information provided through public participation will offer valuable insights to the development and implementation of this CAMP.

Towards that end, the District held a public workshop regarding the development of the refinery community air monitoring plan on August 22, 2023 to gain initial comment and feedback as this program continued to be developed. In order to provide the public with an additional opportunity to meaningfully participate in the development of this community air monitoring plan, the District has released this proposed draft for review on June 21, 2024. Members of the public will be invited to provide feedback within a 30-day comment period.

Furthermore, the District has provided additional resources to the public, including the following:

- A web page to provide updates, presentations, documents and other information related to petroleum refinery air monitoring: <http://valleyair.org/aqinfo/Petroleum-Refinery-Air-Monitoring.htm>
- A public mailing list, so members of the public can sign up to receive email notifications about activities related to this and other petroleum refinery related updates: [http://lists.valleyair.org/mailman/listinfo/petroleum\\_refineries](http://lists.valleyair.org/mailman/listinfo/petroleum_refineries)

## 8. Appendix A: Documentation for Operation and Maintenance of Refinery Community Air Monitoring Equipment



Version 2.11 A



Ambilabs

100 Elm Street, Factory D, Warren, RI 02885

[www.ambilabs.com](http://www.ambilabs.com)

SO<sub>2</sub>

## 10.4. The SO<sub>2</sub> Module

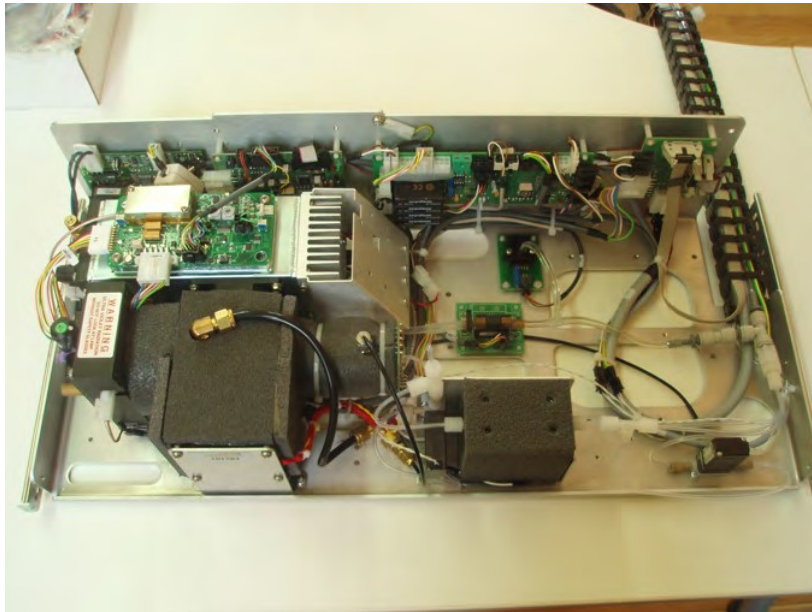
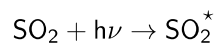


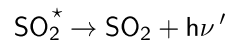
Figure 10.15.: Complete SO<sub>2</sub> Module

### 10.4.1. SO<sub>2</sub> Ultraviolet Fluorescence

The SO<sub>2</sub> module of the airpointer<sup>®</sup> measures the amount of sulphur dioxide in a sample. This is done by exciting the SO<sub>2</sub> molecules by ultraviolet light with a wavelength of 214nm and then measuring their fluorescence.



The use of UV light causes the particles to absorb energy which is emitted as a light pulse (photon) shortly afterwards. The photons have a wavelength of 330nm and can be recorded with a detector.



### 10.4.2. The UV Light Path

The optical design of the component's sample chamber optimizes the fluorescent reaction between SO<sub>2</sub> and UV light (see Figure 10.16). Furthermore, it assures that only UV light resulting from the decay of SO<sub>2</sub><sup>\*</sup> into SO<sub>2</sub> is sensed by the instrument's 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<sub>2</sub> to SO<sub>2</sub><sup>\*</sup> (214nm). A special reference detector circuit constantly measures the lamp intensity. A Photomultiplier Tube (PMT) (see Section 10-35) detects the UV emitted by the SO<sub>2</sub><sup>\*</sup> decay and outputs an analog signal. Several focusing lenses and optical filters make sure that both detectors are exposed to

an optimum amount of only the desired wavelengths of UV. To assure further that the PMT only detects light emitted by the decaying SO<sub>2</sub><sup>\*</sup>, the pathway of the excitation UV and field of view of the PMT are perpendicular to each other. The inner surfaces of the sample chamber are coated with a layer of black Teflon<sup>®</sup> to absorb stray light.

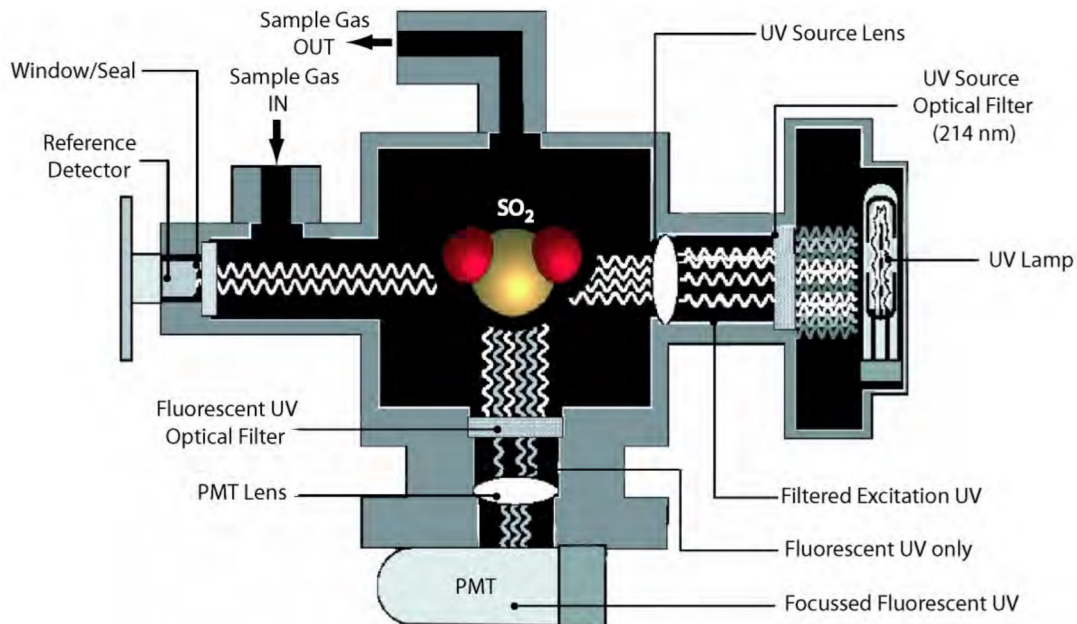


Figure 10.16.: UV Light Path

### 10.4.3. UV Source Lamp

The source of excitation UV light is a low pressure zinc-vapor lamp. An AC voltage heats up and vaporizes zinc contained in the lamp element creating a light-producing plasma arc. Zinc-vapor lamps are preferred to the more common mercury-vapor lamps for this application because they produce very strong emission levels at the wavelength required to convert  $\text{SO}_2$  to  $\text{SO}_2^*$ , i.e., 213.9 nm. The intensity of the lamp is controlled by the UV lamp control on the side of the sensor. It ensures that the intensity of the lamp is constant and increases the current from time to time until the maximum value is reached. At this point one can consider changing the lamp. You can check the value using the Service Interface (see Figure 7.7.2.2). Open the folder 'SO2' and control the 'Power Lamp' value. If it is about to reach 100% , you should change the lamp (see page 11-33). However, the brightness distribution along the active area of the lamp surface may change with operation time, thereby also producing a drop of detected intensity. A slight change of the lamp window orientation may again increase the detected intensity. Therefore, first try changing the orientation of this window, only if this does not improve the intensity, replace the lamp with a new one (see Section 11.7.1 on how to perform these steps).

**NOTE**

**Check the intensity of the lamp regularly!**

The lamp used in the  $\text{SO}_2$  module is constructed of a vacuum jacket surrounding a double-bore lamp element (see Figures 10.18 and 10.17). The vacuum jacket isolates the plasma arc from most of the external temperature fluctuations. The jacket also keeps the thermal energy created by the operating lamp. This helps the lamp to heat up and maintains a proper vaporization temperature. Light is emitted through a 20mm x 5mm portal.

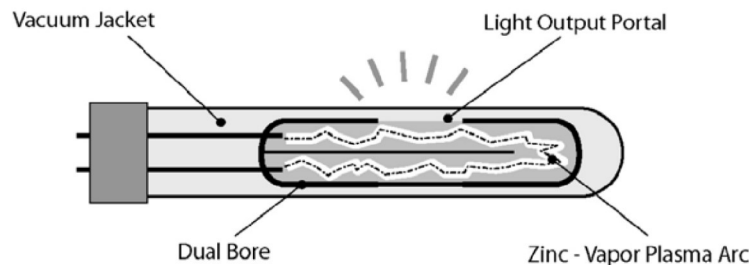


Figure 10.17.: UV Source Lamp Schematic



Figure 10.18.: UV Source Lamp

#### 10.4.4. The Reference Detector

A vacuum diode acts as a UV detector that converts UV light to a DC current. It is used to measure the intensity of the excitation UV source lamp. Its location, directly across from the source lamp at the back of a narrow tube-shaped light trap, 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. Due to 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.

#### 10.4.5. UV Lamp Shutter and PMT Offset

Inherent to the operation of both the reference detector and the PMT are electronic offsets. The degree of offset differs for each detector and PMT and can vary during the time of use. To account for these offsets the device includes a shutter, located between the UV Lamp and the source filter that cuts off periodically the UV light from the sample chamber (every 5 minutes). The analyzer records the outputs of both the reference detector and the PMT during this dark period and includes them into the SO<sub>2</sub> concentration calculation.

- The reference detector offset is stored and viewable via the Service Interface as the test function RefDetSO2Dark.
- The PMT offset is stored as and viewable via the Service Interface as the test function PMTSigSO2Dark.

### 10.4.6. Optical Filters

The analyzer uses two stages of optical filters to enhance performance. The first stage conditions the UV light used to excite the SO<sub>2</sub> by removing frequencies of light that are not needed to produce SO<sub>2</sub><sup>\*</sup>. The second stage protects the PMT detector from reacting to light not produced by the SO<sub>2</sub><sup>\*</sup> returning to its ground state.

#### 10.4.6.1. UV Source Optical Filter

Zinc-vapor lamps output light at other wavelengths than the 214nm required for the SO<sub>2</sub> → SO<sub>2</sub><sup>\*</sup> transformation including a relatively bright light of the same wavelength at which SO<sub>2</sub><sup>\*</sup> fluoresces as it returns to its SO<sub>2</sub> ground state (330nm). In fact, the intensity of the light emitted by the UV lamp at 330nm is so bright, nearly five orders of magnitude brighter than that resulting from the SO<sub>2</sub><sup>\*</sup> decay, it would drown out the SO<sub>2</sub><sup>\*</sup> fluorescence. To solve this problem, the light emitted by the excitation UV lamp passes through a bandpass filter that screens out photons with wavelengths outside the spectrum required to excite SO<sub>2</sub> into SO<sub>2</sub><sup>\*</sup> (see Figure 10.19).

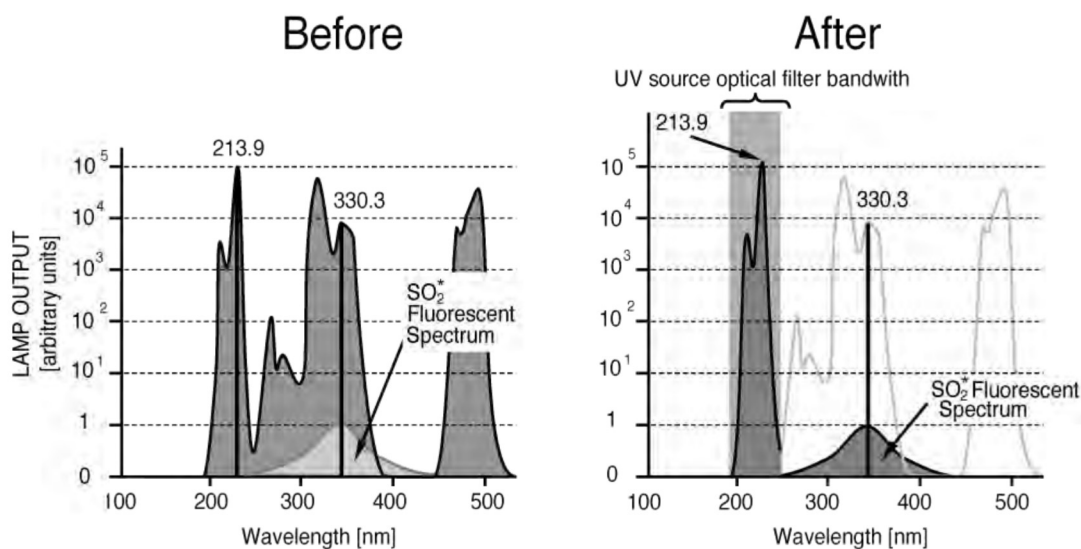


Figure 10.19.: Excitation Lamp UV Spectrum Before/After Filtration

#### 10.4.6.2. 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 214nm light used to excite the SO<sub>2</sub> 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 bandpass filter placed between the sample chamber (Figure 10.16) and the PMT strips away light outside of the fluorescence spectrum of decaying SO<sub>2</sub><sup>\*</sup> (Figure 10.20) including reflected UV from the source lamp and other stray light.

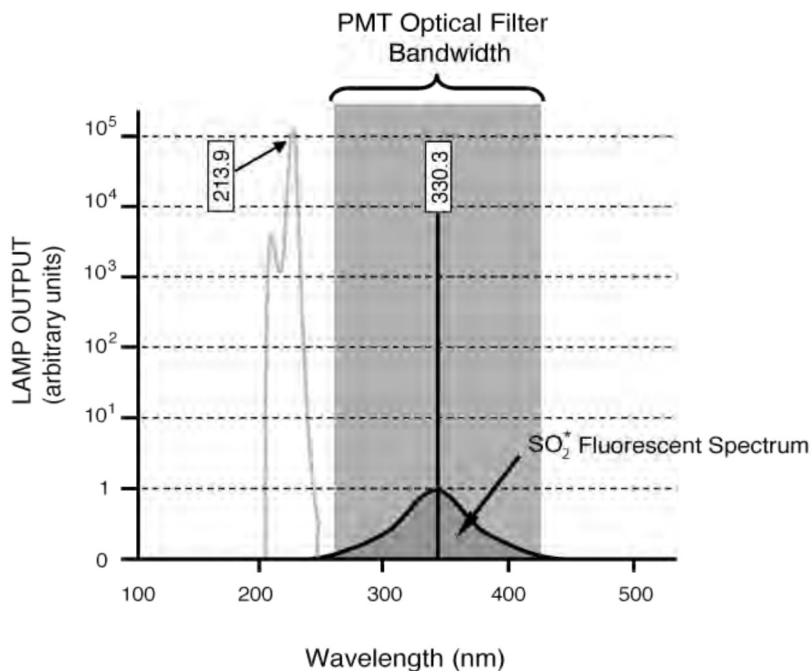


Figure 10.20.: PMT Optical Filter Bandwidth

#### 10.4.7. Optical Lenses

Two optical lenses are used to focus and optimize the path of light through the 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. This also makes sure that all light emitted by the UV source lamp that is not absorbed by the SO<sub>2</sub> is passed through the 214nm filter and reaches the reference detector. Furthermore, this technique eliminates the effect of flickering, inherent in the plasma arc that generates the light. Conversely, this also makes sure that the volume of sample gas affected by the excitation beam is similar to the volume of fluorescing SO<sub>2</sub>\* being measured by the PMT, eliminating a possible source of measurement offset.

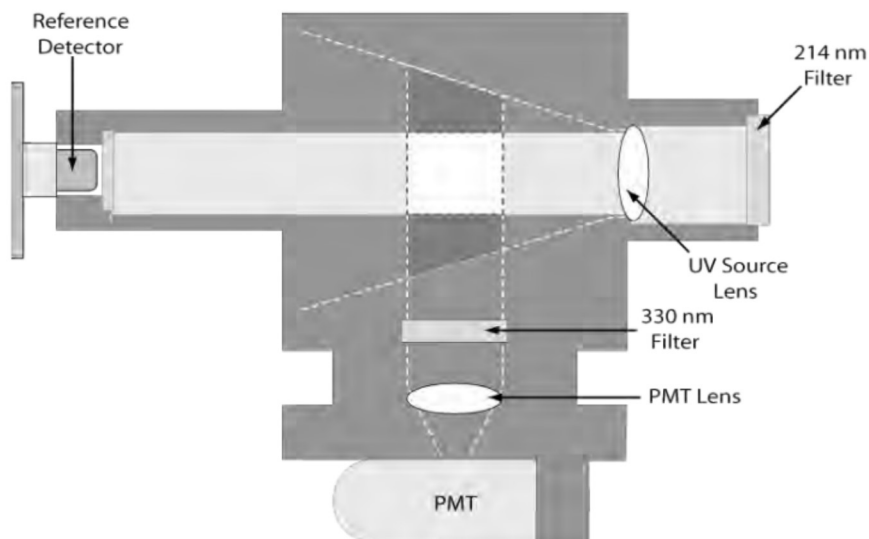


Figure 10.21.: Effects of Focusing Source UV in Sample Chamber

### 10.4.8. Measurement Interferences

It should be noted that the fluorescence method for detecting SO<sub>2</sub> is subject to interference from a number of sources. The airpointer<sup>®</sup> has been successfully tested for its ability to reject interference from most of these sources.

#### 10.4.8.1. Direct Interference

The most common source of interference is from other gases that fluoresce in a similar fashion to SO<sub>2</sub> 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 SO<sub>2</sub>. For critical applications where high levels of NO are expected, an optional optical filter is available that improves the rejection of NO (contact distributor for more information). The airpointer<sup>®</sup> utilizes several methods for rejecting interference from these gases. A special scrubber (kicker) mechanism removes any PNA chemicals present in the sample gas before it can reach the sample chamber. The exact wavelength of light needed to excite a specific non-SO<sub>2</sub> 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.

#### 10.4.8.2. 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 emitted by the decaying SO<sub>2</sub><sup>\*</sup> in the sample chamber. airpointer<sup>®</sup> prevents this from occurring by having a very short light path between the area where the SO<sub>2</sub><sup>\*</sup> fluorescence occurs and the PMT detector. Because the light path is so short, the amount of O<sub>3</sub> needed to cause a noticeable effect would be much higher than could be reasonably expected in any application for which this instrument is intended.

### 10.4.8.3. Dilution

Certain gases with higher viscosities can lower the flow rate through the critical flow orifice that controls the movement of sample gas through the analyzer, reducing the amount of sample gas in the sample chamber and thus the amount of SO<sub>2</sub> available to react with the UV light. While this can be a significant problem for some analyzers, the design of the airpointer<sup>®</sup> is very tolerant of variations in sample gas flow rate and therefore does not suffer from this type of interference.

### 10.4.8.4. Third Body Quenching

While the decay of SO<sub>2</sub><sup>\*</sup> to SO<sub>2</sub> happens quickly, it is not instantaneous. Therefore, it is possible for the extra energy possessed by the excited electron of the SO<sub>2</sub><sup>\*</sup> 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. In this regard the most significant molecules are nitrogen oxide (NO), carbon dioxide (CO<sub>2</sub>), water vapor (H<sub>2</sub>O) and molecular oxygen (O<sub>2</sub>). 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 they enter the analyzer.

### 10.4.8.5. Light Pollution

SO<sub>2</sub>

Because the device measures light as a means of calculating the amount of SO<sub>2</sub> present, obviously stray light can be a significant interfering factor. The airpointer<sup>®</sup> removes this interference source 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 10.4.6 remove UV with wavelengths extraneous to the excitation and decay of SO<sub>2</sub> and SO<sub>2</sub><sup>\*</sup>, respectively.
- Most important, during instrument calibration the difference between the value of the most recently recorded PMT offset (see Section 10.4.5) and the PMT output while measuring zero gas (calibration gas devoid of SO<sub>2</sub>) is recorded as the test function PMTSigSO2Dark. This offset value is used during the calculation of the SO<sub>2</sub> concentration. Since this offset is assumed to be due to stray light present in the sample chamber, it is also multiplied by the SLOPE. PMTSigSO2Dark is viewable via the Service Interface (see Section 7.7.2.2) in folder 'SO2', the SLOPE via the User Interface: menu item 'Configuration'→'SO2 Sensor', variable 'SO2Slope' and in 'Servic Interfac/SO2'.

### 11.3.2. Maintenance door

**Use the following procedure to open the maintenance door:**

---

1. Unlock the lock with your key.
2. Pull the door.



Figure 11.6.: Open and close the maintenance door

---

**Use the following procedure to close the maintenance door:**

---

1. Close the door.
  2. Lock the door with your key.
- 

### 11.3.3. Slide a Module

For most of the maintenance procedures it is sufficient to slide out the module.

**Use the following procedure to slide a module:**

---

1. Hold the Module on the left and right side and slide it out carefully.

**NOTE**  
**Pull and push simultaneously on both sides!**

2. When you slide in a module be careful not to quench any tubing or cable.
  3. The module arrests with a light click
-



Figure 11.7.: Push and pull the module on both sides simultaneously

#### 11.3.4. Lift a Module out or in

For most of the maintenance procedures it is sufficient to slide out the module. If you want to completely lift out a module use the following procedure.

##### NOTE

**Note on which drawer the module was placed and where and how the chain with the tubings and cables is linked with the flow block of the base unit.**

#### Use the following procedure to lift out a module:

1. Slide out the module as far as possible.
2. Loose the 7 connections of the connection chain on the right side. There are 3 tubes (Pump, Zero and Sample, 3 cables and one grounding).
3. The Zero and Pump Connection are fixed by two quick release fasteners which can be released by pushing down the grey ring.(see figure below). The Sample connection has to be screwed.
4. Loose the clamp of the connection chain (quench).
5. Press the levers in both drawers up (left) or down (right) and simultaneously slide completely out the module.

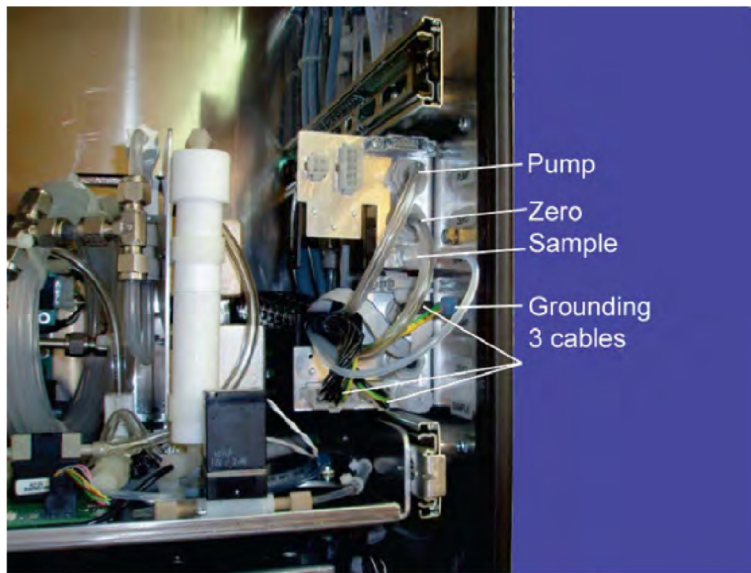


Figure 11.8.: Disconnect the seven connections of the connection chain.



Figure 11.9.: Pushing down the grey ring with a screwdriver



Figure 11.10.: Loose the clamp



Figure 11.11.: Press the small levers in both drawers up (left) or down (right).



**CAUTION:**

Be aware of the weight of the Module! The weight is listed in chapter 4 'Spezification'.

---

**Use the following procedure to lift in a module:**

1. Locate the drawer and the flow block of the module and slide out the drawers a bit.
2. Hold the module with one arm near the drawers and arrange the connection chain. It should lei in the holder.

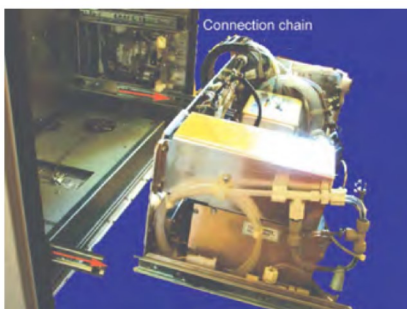


Figure 11.12.: Slide out the drawers a bit



Figure 11.13.: Hold the module with one arm near the drawers

**NOTE**

**Be careful not to squeeze any tubings or cables!**

3. Slide in the module as far as possible. There is a light click at the end.
  4. Connect the 7 connections on the right side. There are 3 tubes (Pump, Zero and Sample), 3 cables and one grounding.
  5. Fix the connection chain into the clamp.
-

## 11.4. Maintenance of Base Unit (System parts)

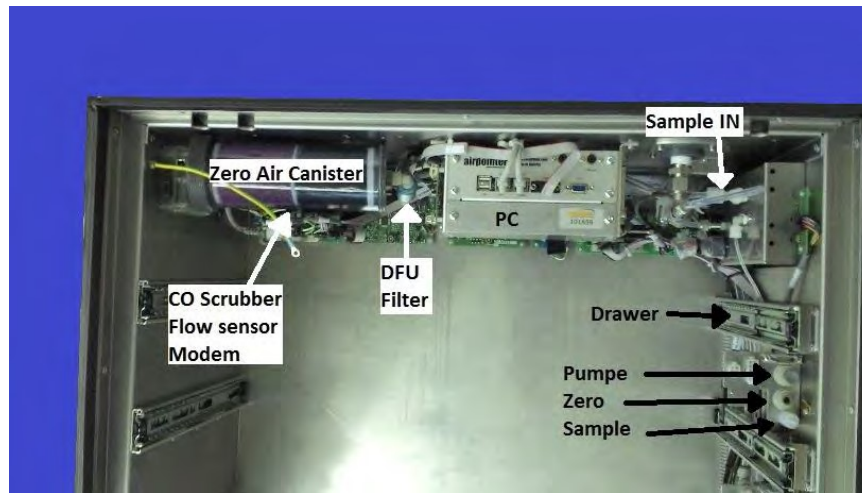


Figure 11.14.: System Components

This subsection includes following maintenance information and replacement procedures:

1. Sample Particulate Filter Inspection and Replacement
2. Visual Inspection and Cleaning
3. DFU Filter Replacement
4. Zero Air Scrubber Maintenance
5. Louvers Inspection and Cleaning
6. Cleaning the Cooling Aggregate
7. Air Condition
8. Pump Maintenance

### 11.4.1. Sample Particulate Filter

The particulate filter should be inspected regularly for signs of plugging or excess dirt. If contaminated, replace the filter following the procedure outlined below. It should be replaced according to the service interval in Table 11.1 even without obvious signs of dirt. This is because filters with a pore size between 1 and 5  $\mu\text{m}$  can clog while retaining a clean look. We recommend handling the filter and the wetted surfaces of the filter housing with gloves and tweezers.

---

**Follow these steps to change the sample particulate filter:**


---

1. Open the maintenance door and locate the sample particulate filter (see Figure 11.4)
2. See Figure 11.15 for an exploded view of the filter assembly.

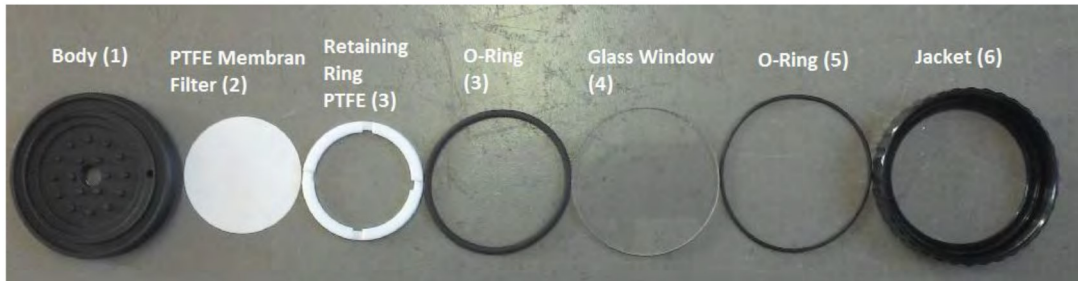


Figure 11.15.: Parts of the Sample Particulate Filter

3. Carefully open the jacket (6) with the glass window (4) which is attached by one O-Ring (5) and remove the retaining ring (3) and the filter element (2). In the side of the retaining ring is an additional O-Ring (3). The Body (1) itself stays in the airpointer®. We recommend cleaning the glass window and O-Rings at least once monthly, weekly in very polluted areas.

**NOTE**

**Clean with a soft cloth and if needed clean water.**

4. If the O-Rings are porous replace them. After cleaning the O-Rings reinstall them.
5. Install a new filter element, carefully centering it in the bottom of the holder.



**CAUTION:**

**Do not touch any part of the housing, filter element, PTFE retaining ring, glass cover and the O-Ring with bare hands.**

6. Reinstall the PTFE O-Ring (Returning Ring) with the notches facing up (important!). Place the glass window, then screw on the nut and hand-tighten the assembly. Inspect the (visible) seal between the edge of the glass window and the O-Ring to assure proper gas tightness.
  7. Perform a Sample Flow Check as described in Section 11.11.
-

### 11.4.1.1. Extended Lifetime Sample Filter

If your airpointer® is equipped with the Extended Lifetime Sample Filter the maintenance procedure does not change. If your airpointer also contains the High Humidity Option you should also regularly check the water level in the water reservoir. Release the water due the tube on a regular basis.

### 11.4.2. Visual Inspection and Cleaning

The instrument should be inspected occasionally for obvious visible defects, such as loose connectors, loose fittings, cracked or clogged Teflon® lines, and excessive dust or dirt accumulation. Dust and dirt can accumulate in the instrument and can cause overheating or component failure. Dirt on the components prevents efficient heat dissipation and may provide conducting paths for electricity. The best way to clean the inside of the instrument is to first carefully vacuum all accessible areas and then blow away the remaining dust with low pressure compressed air. Use a soft paint brush or cloth to remove stubborn dirt.

### 11.4.3. DFU Filter

Right of the Zero Air Scrubber a DFU Filter is located (see Figure 11.16).

**NOTE**

**Make sure that the airpointer® is not in ZERO calibration mode. To do so, do not perform any ZERO calibration using the User Interface.**

**Follow these steps to change the DFU supply particulate filter:**

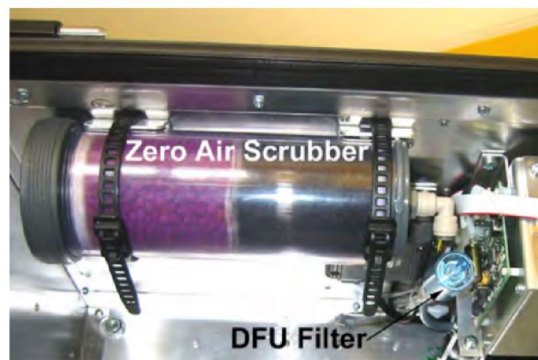


Figure 11.16.: Location of the DFU Filter

1. The DFU Filter is fasten with a quick release fastener at both ends. Press the dark gray ring into the gray holder and unplug the filter on one side. Repeat the same procedure at the other end.

2. Replace the DFU Filter and reconnect it
-

### 11.4.4. Replacing the Zero Air Scrubber

**CAUTION:**

Purafil® contains an aggressive and poisonous chemical compound (potassium permanganate)! Make sure you wear appropriate protection gloves. Take care for sufficient ventilation and do not inhale any dust from it.

The internal zero air scrubber contains two chemicals, pink Purafil® and black charcoal (scrubs O<sub>3</sub>, SO<sub>2</sub>, NO<sub>2</sub> and CO). The Purafil® scrubs NO in the ambient air. The chemicals need to be replaced periodically. This procedure can be carried out while the instrument is running.

**NOTE**

Make sure that the airpointer® is not in ZERO calibration mode. To do so, do not perform any ZERO calibration using the User Interface.

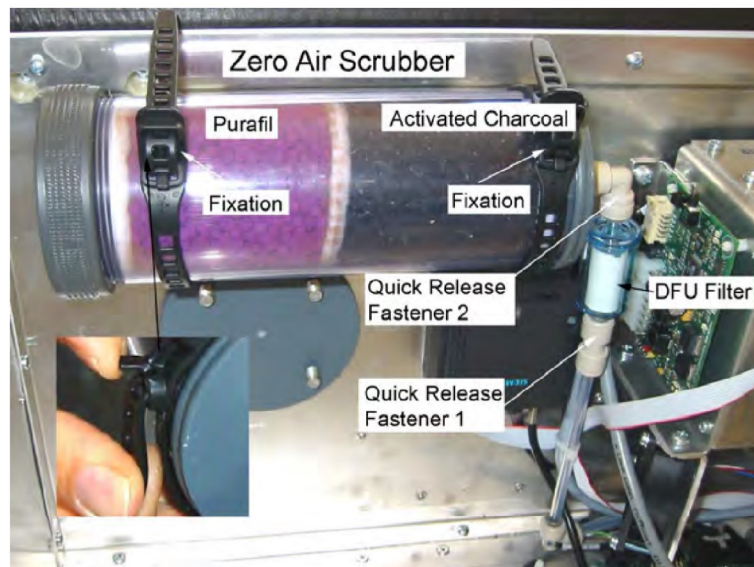
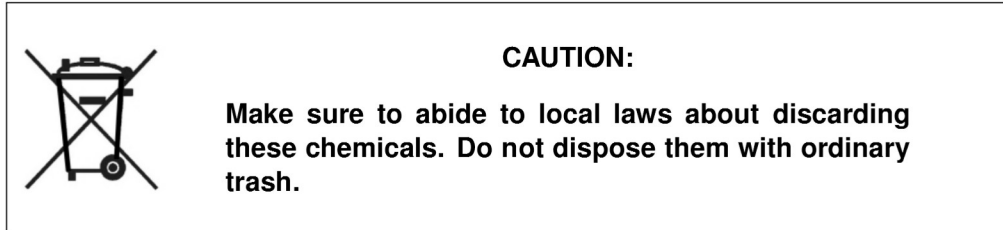


Figure 11.17.: View of the Zero Air Scrubber

**Follow these steps to change the Zero Air Scrubber:**

1. Locate the scrubber at the top left of the airpointer®. Figure 5.12 shows the location, Figures 11.17 and 11.18 the assembly.
2. Remove the old scrubber:
  - Open the quick release fastener 1 (press the dark gray ring into the gray holder and unplug)
  - Loosen the fixation on the left side about 2 holes (see small picture in Figure 11.17).
  - Open the fixation on the right side and pull out the zero air scrubber with the DFU filter
3. Remove the small DFU particle filter from the cartridge (Quick Release Fastener 2).
4. Unscrew the top of the scrubber canister and discard the Purafil® and charcoal contents.



5. Refill the scrubber. Take care to refill the scrubber in the correct order. First fill with charcoal at the bottom, then place the white filter pad and the Purafil® chemical on top.
6. **Put a new filter pad on top of that, then close the cartridge with the screw-top cap.**
7. Tighten the cap on the scrubber—hand-tight only.
8. Connect a new DFU Filter
9. Put the scrubber assembly into the left fixation, fix the right fixation and tighten the left.
10. Reconnect the Quick Release Fastener 1.
11. Perform a Sample Flow Check as described in Section 11.11.

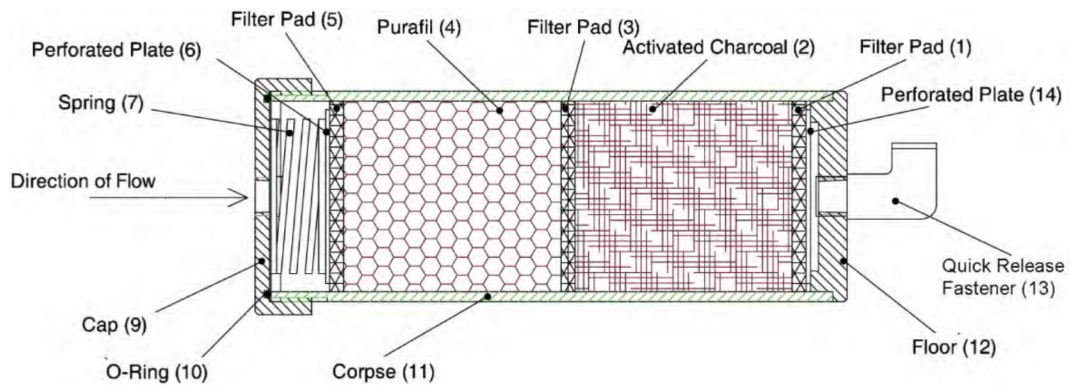


Figure 11.18.: Zero Air Scrubber Assembly

### 11.4.5. Inspection and Cleaning of the ventilation grids

**Follow these steps for inspection and cleaning of the air inlet grilles:**

1. Open the main door and power down the airpointer®
2. Locate the grids at the bottom of the airpointer® (see figure 11.19).
3. Unscrew the holding screws of both grilles (six each).
4. Remove the grilles.
5. Clean the inner grids by blowing dust away with low pressure compressed air. Use a soft paint brush to remove stubborn dirt.
6. Reinstall the grilles and fasten the screws.
7. Power up the airpointer® and close the main door.



Figure 11.19.: Ventilation grids of the airpointer

### 11.4.6. Maintenance of the Air Condition

An experienced worker should need approximately 30 minutes for assembling and another 30 minutes for disassembling the air condition.

**Follow these steps to extract the air condition:**

---

1. 1. Tools you will need:
    - Ratchet with 7mm socket
    - Allen key in sizes: 2,5/3/4
    - Phillips screwdriver: PH2
    - wire cutter
  2. Remove the bottom module (NO<sub>x</sub>) for easier access
  3. Remove the cover by unscrewing the 4 screws and the tape.
  4. Remove the 2 NTCs
  5. Remove the pump:
    - Loosen the holding screws from the bottom.
    - Unplug the grounding
    - Unplug the 3 tubes
    - Unplug the power chord
  6. Remove the Power Supply Unit (PSU):  
Start with untightening the 2 screws in the front. Then gently pull the PSU out. Notice that the unit is still connected, but to change the AC just leave it in the case, as shown in figure (bla).
  7. Disconnect the gray air tube:
    - loosen the 2 screws on the right side
    - cut the cable ties
    - loosen the screw on left side with the ratchet
  8. Remove the panel by unscrewing the 8 screws
  9. Remove the control cables
  10. Remove the control board by disconnecting the narrow gray cable. Then carefully lever out the board.
  11. Unscrew the 5 screws at the bottom of the case.
  12. Remove the AC:  
You can now safely remove the air condition. Note: if the cables in the back of your device are not fixed by a tape this might be the perfect moment to do so. This will save you some trouble during the re-installation of the AC unit.
-

**Follow these steps to reassemble the air condition**

---

1. Put the air condition in the case:  
Start by inserting the air condition device in the airpointer. To make the installation of the top cover easier, do not insert any screws at this point.
  2. Connect the control board:  
  
Reconnect the control board with the narrow grey plug. Make sure the cable stays on the backside of the board, i.e. between the board and the air condition.
  3. Connect the air condition:
    - fasten the 3 screws holding the air tube and install a cable tie to the air tube
    - connect the power chord
  4. Insert the top panel and fasten it with 8 screws.
  5. Carefully insert the Power supply unit into its bay.
  6. Connect the NTCs:  
To connect the NTC insert the cable in the small hole and plug them in on the top of the air condition.
  7. Connect the fan with the corresponding plug in the back
  8. Connect the numbered plugs to the control board. Make sure that the numbers on the plug match the port.
  9. Connect the grounding and power cable with cable tie to fan. This step makes sure that these cables do not touch anything they rather should not.
  10. Insert the pump:
    - Connect the power chord of the pump
    - Connect the pumps tubes
    - Connect the grounding to the pump
    - Fasten the 4 screws holding the pump
  11. Fasten the air condition
  12. To complete the installation, insert the top cover. Fix the top cover with 4 screws.
-

**CAUTION:****Cleaning supplies**

A general industrial detergent or degreaser intended for painted and plastic parts may be used on all surfaces to remove dirt and oil accumulations.

**CAUTION:**

**Disconnect power cable while using any liquid cleaners! Extreme care must be taken when using such cleaners around electrical components and connections.**

**CAUTION:**

**Do not use solvents or cleaners not specifically intended for ABS plastic or painted parts as these may be damaged!**

General inspection and cleaning should be carried out twice annually. When operating the unit in dirty conditions, the unit should be inspected more frequently (monthly) and cleaned as necessary. If continuing operational problems occur, check heat exchanger fins and air channels for obstruction.

### 11.4.7. System Pump

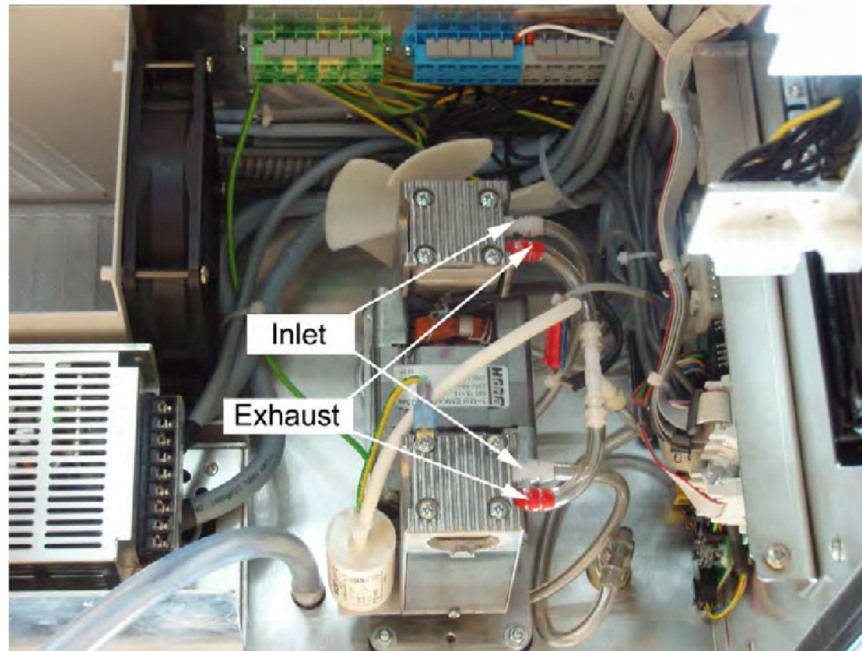


Figure 11.20.: Picture of the double piston pump from the top

#### 11.4.7.1. Extraction of the pump

The sample pump head periodically wears out and must be replaced when the pressure is critically high. This is indicated by a warning message using the Service Interface (value 'Press Pump' in folder 'System Values'). A pump rebuild kit is available from the factory. A flow and leak check after rebuilding the system pump is recommended.

#### 11.4.7.2. Double Piston Pump

The double headed pump is the same model as the single piston pump just with two heads. Note that, the maintenance of the double piston pump is completely analogous to the single piston model. You just need two "Pump Rebuild Kits" and repeat the extraction procedure for each piston. Caution: DO NOT reach inside the ventilation blades of the pump!

## 11.7. Maintenance of the SO<sub>2</sub> module

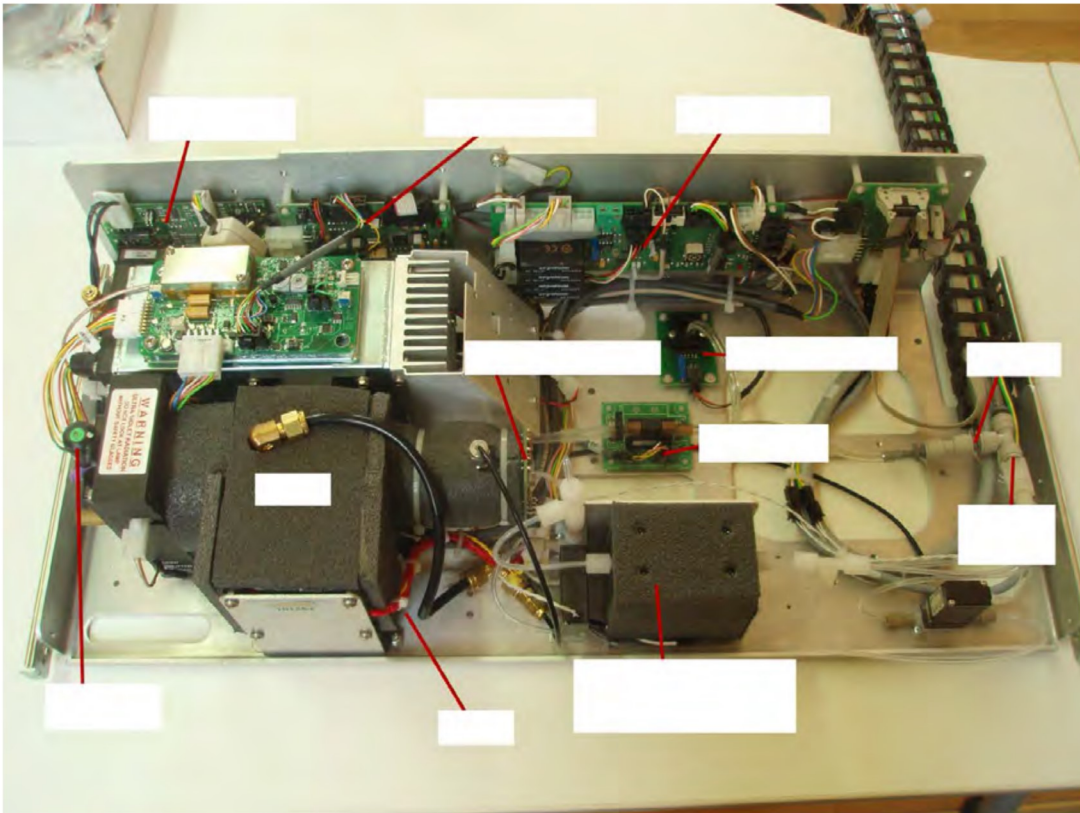


Figure 11.29.: Complete SO<sub>2</sub> Bench

### NOTE

The service procedures in this manual are restricted to qualified service representatives.



### CAUTION:

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

**CAUTION:**

Do not use alcohol or other solvents for cleaning the components conducting gas!

**CAUTION:**

Some internal components can be damaged by small amount of static electricity. A properly grounded antistatic wrist must be worn while handling any internal component.

**CAUTION:**

Take care that screws and tools do not fall into the airpointer<sup>®</sup> !  
Loose screws or tools can damage the airpointer<sup>®</sup> !

This section includes following maintenance information and replacement procedures:

1. Replacing the SO<sub>2</sub> UV Lamp
2. Cleaning the Critical Orifice
3. Maintaining the capillaries is described in section 11.9

### 11.7.1. Replacing the SO<sub>2</sub> UV Lamp

**CAUTION:**

Attention: UV light! May cause injuries.

**Follow these steps to replace the UV lamp :**

1. Power down the airpointer®
2. Locate the SO<sub>2</sub> module (see Figure 11.29) with the UV lamp inside the airpointer® (see Figure 5.12, front part of Section B).
3. Loosen the fixation (see Figure 11.30).

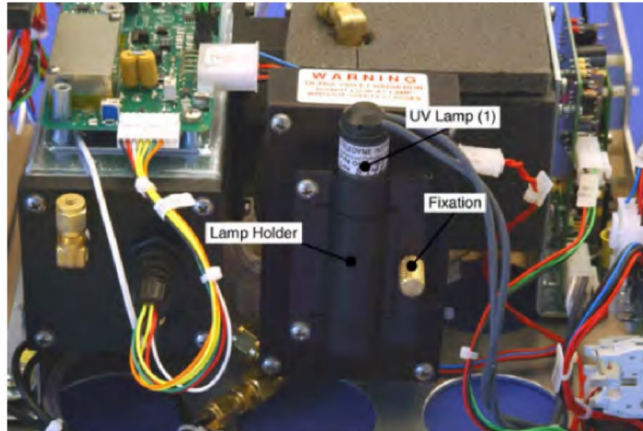


Figure 11.30.: Location of the UV lamp

4. Disconnect the power cable of the UV lamp by removing the Molex MiniFit JR plug from the ST1 port of the UV power supply (see Figure 11.31).



Figure 11.31.: Location of the UV Lamp Power Connector

5. Carefully remove the old lamp from its place. If the lamp does not move out of its place, try loosening the two recessed head screws of the lamp holder also and move the lamp by pulling and turning the lamp left and right until it moves out.

6. Place a new UV lamp into the lamp holder and reconnect the power cable. Do not fasten the Fixation too tight—the lamp is not adjusted yet!
  7. Restart the airpointer®
  8. Let the UV lamp warm up for at least 30 minutes.
  9. Adjust the lamp now. To do so connect a computer to the airpointer® and start the Service Interface as outlined in Section 7.7.2.2
  10. Locate the entries 'RefDetSO2' and 'Power Lamp' in folder 'SO2' in the sensor interface.
  11. Turn the lamp up, down, left and right while observing these entries. The numbers should change as you move the lamp. Move the lamp until the value 'RefDetSO2' reaches a maximum. This number measures the signal strength of the reference detector. It should rise at least above 2000 mV (the exact value is depending on settings, see value 'RefDetSO2Setpoint' in folder 'SO2').
  12. Now continue and try to reach an as small value of the 'Power Lamp'—value as possible keeping the value 'RefDetSO2' nearly constant. This number measures the necessary lamp control—power as a percentage of the maximum value. The lower this value becomes, the longer the lifetime of the lamp and the better the S/N-ratio of the signals will be.
  13. The final orientation of the lamp should now be such that one of the two windows of the UV lamp points toward the reference detector. It may well be that the results are better with the other side of the window pointing toward the reference detector. Therefore, in order to optimize the operation of the lamp you should also try to turn the lamp 180° and repeat the adjustment above. Decide for the orientation with the lower power consumption of the lamp.
  14. Fasten all screws and the fixation of the lamp holder again.
  15. Calibrate the instrument.
-

### 13.1.8. Vaisala Precipitation Sensor

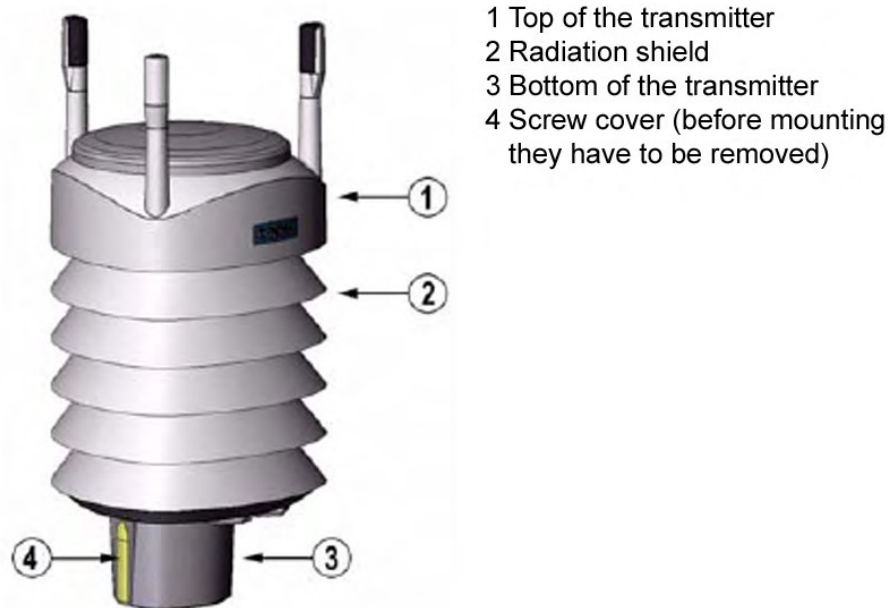


Figure 13.20.: Exterior view of the Vaisala sensor

The weather transmitter is a small and lightweight transmitter that offers six weather parameters in one compact package. It measures wind speed and direction, precipitation (rain and hail), temperature, atmospheric pressure, and relative humidity. The last three are packed together in the PTU module and are located inside the sensor.

#### 13.1.8.1. Wind Speed and Direction - Principle of Operation

The wind sensor has an array of three equally spaced ultrasonic transducers on a horizontal plane. Wind speed and wind directions are determined by measuring the time it takes the ultrasonic to travel from each transducer to the other two.

The wind sensor measures the transit time (in both directions) along the three paths established by the array of transducers. This transit time depends on the wind speed along the ultrasonic path. For zero wind speed, both the forward and the reverse transit times are the same. With wind along the south path, the up-wind direction transit time increases and the down-wind transit time decreases.

The wind speed is calculated from the measured transit times using following formula:

$$v_w = 0.5 \times L \times \left( \frac{1}{t_f} - \frac{1}{t_r} \right) \quad (13.1)$$

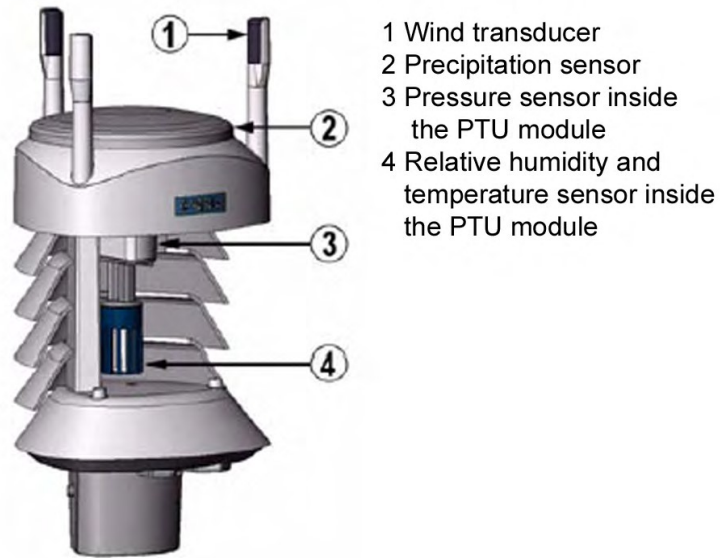


Figure 13.21.: Exterior view of the Vaisala sensor without outer shell

Bottom of the transmitter

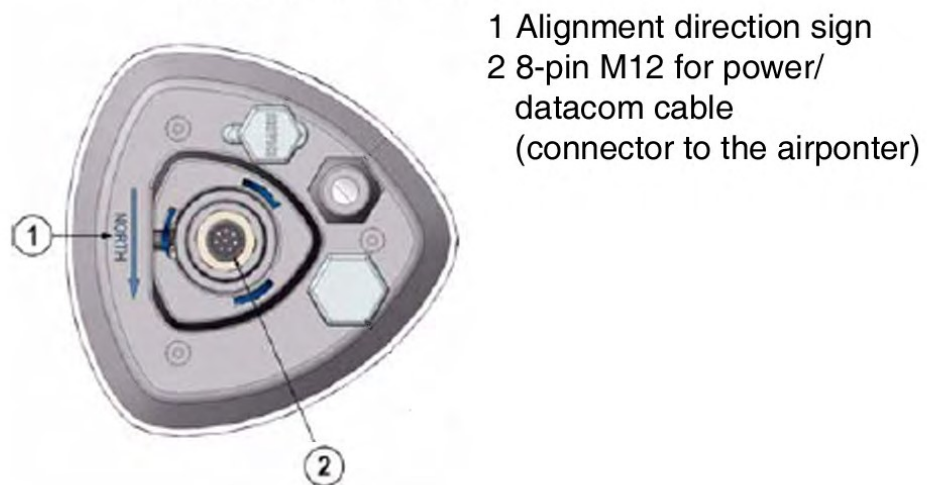


Figure 13.22.: Bottom view of the Vaisala sensor

where:  $v_w$  ... Wind speed in measurement direction  
L ... Distance between the two transducers  
 $t_f$  ... Transit time in forward direction  
 $t_r$  ... Transit time in reverse direction

Measuring the six transit times allows  $v_w$  to be computed for each of the three ultrasonic paths. The computed wind speeds are independent of altitude, temperature, and humidity, which are canceled out when the transit measurement times are measured in both directions, although the individual transit times depend on these parameters.

Using  $v_w$  values of two array paths is enough to compute wind speed and wind direction. A signal processing technique is used so that wind speed and wind direction are calculated from the two array paths of best quality.

**NOTE**  
**Wind speed and wind direction will NOT be calculated if the wind speed is below 0.05m/s.**

#### 13.1.8.2. Precipitation - Principle of Operation

The precipitation sensor comprises of a steel cover and a piezoelectric sensor mounted on the bottom surface to the cover. The precipitation sensor detects the impact of individual raindrops. The impact signal is proportional to the volume of the drops. Hence, the signal of each drop can be converted directly to accumulated rainfall. Advanced noise filtering technique is used to filter out signals originating from other sources than raindrops.

The measured parameters are accumulated rainfall, rain current and peak intensity, and the duration of the rain event. Detection of each individual drop enables computing of rain amount and intensity with high resolution.

The sensor is capable of distinguishing hail from raindrops. The measured hail parameters are cumulative amount of hails, current, and peak hail intensity, and the duration of a hail shower.

**NOTE**  
**Snow can not be measured.**

#### 13.1.8.3. PTU - Principle of Operation

The PTU module contains separate sensors for pressure, temperature, and humidity measurement.

The principle of operation of the pressure, temperature, and humidity sensors is based on an advanced RC oscillator and two reference capacitors against which the capacitance of

the sensors is continuously measured. The microprocessor of the transmitter compensates for the temperature dependency of the pressure and humidity sensors.

The PTU module includes a capacitive silicon BAROCAP<sup>®</sup> sensor for pressure measurement, a capacitive ceramic THERMOCAP<sup>®</sup> sensor for air temperature measurement, and a capacitive thin film polymer HUMICAP<sup>®</sup> 180 sensor for humidity measurement.

#### 13.1.8.4. Calibration

The sensor has to be sent in for calibration.

#### 13.1.8.5. Replacing the PTU Module

1. Turn off the power.

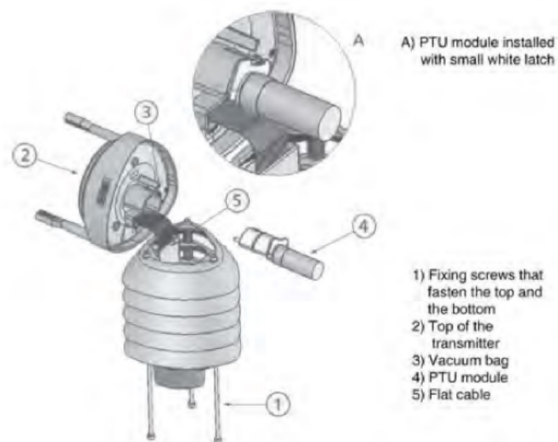


Figure 13.23.: Scheme of the open Vaisala sensor

2. Loosen the three fixing screws at the sensor bottom assembly.
3. Pull off the transmitter top.
4. Release the small white latch (see Figure 13.34) and remove the PTU module. Remove the vacuum bag protecting the PTU module.
5. Connect the new PTU module.

**NOTE**  
**Avoid contacting the white filter cap with your hands while inserting the PTU module.**

6. Replace the top and tighten the three fixing crews that fasten the top to the bottom.

**NOTE**

**When reattaching the top, make sure that the flat cable does not get stuck or squeezed between the top and the funnel for the flat cable.**

**13.1.9. Troubleshooting**

Wind measurement failure	Check the fuse. It is located on the right side of the power supply below the black cap (Figure 13.10).
Wind direction failure	Check if the sensor is aligned to north.
Wind measurement failure	Check if there is a blockage between the wind transducers (trash, leaves, branches..) and remove it.
Pressure, relative humidity and temperature failure	Check if the PTU module (Vaisala) is connected properly and if there is no water in the PTU module.
Error during wind measurement (Lufft)	<ul style="list-style-type: none"> <li>• The device is being operated well above the limit of the ambient conditions</li> <li>• Very strong horizontal wind or snow</li> <li>• The wind meter sensors are very dirty</li> <li>• The wind meter sensors are iced over → check the heating function</li> <li>• There could be foreign objects within the measuring section of the wind meter</li> <li>• One of the wind meter's sensors is faulty</li> </ul>
Measurement temperature appears too high/measured humidity appears too low	Check the operation of the fan on the underside of the device.

Table 13.1.: Troubleshooting

# BTEX GC USER MANUAL

VERSION 2.3



mlu-recordum

Environmental Monitoring Solutions GmbH

Werner Heisenberg-Str. 4, 2700 Wiener Neustadt, Austria



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## Safety message

Please note that all maintenance on this device should be performed by trained personal. Hazards include: heated elements parts, electricity, toxic and carcinogenic compounds (benzene).

## Introduction

The BTEX-GC is a Microsystems-based device for real-time monitoring of ppb and sub-ppb concentrations of aromatic volatiles (Benzene, Toluene, Ethylbenzene, Xylenes, or BTEX) in air. Its reduced size makes it ideal for being included in the airpointer, and the absence of a carrier gas cylinder significantly decreases the need for periodic maintenance.

# 1- Specifications

## General specifications

Measurement principle	Gas Chromatography – Photoionization Detection (GC-PID 10.6 eV), column MEMS packed
Carrier gas	Zero air ~10 ml/min
Compounds monitored	Benzene, Toluene, Ethylbenzene, Xylenes
Weight	4 Kg
Dimensions	Version1: Width: 660 mm, Depth: 300 mm, Height: 100 mm Version2: Width: 300 mm, Depth: 250 mm, Height: 200 mm
Sample flow rates	~300 ml/min (or ~100 ml/min depending on the application)
Operating temperature	-20 to +40°C Optional heater for -40°C available
Cycle time	10/15 minutes
Measurement units	µg/m <sup>3</sup> , ppb
Autocalibration	Permeation tubes
Power	Two versions are available: 115V/60Hz or 230V/50Hz
Power consumption	10W average, 18W peak
Maintenance interval	Twice a year
<b>Performances</b>	
Lower Detectable Limit	0,2 ppb
Range	100 ppb (extended range on request)
Memory effect (carryover)	<1% benzene

## Warranty

Same terms as described in 'Chapter 4.3. Warranty' of the airpointer manual apply.

## 2- Principle

### ThermoDesorption Gas Chromatography (TD-GC)

Thermo-Desorption Gas Chromatography is the USEPA reference method for measuring VOCs including BTEX. The VOCs are pre-concentrated on a solid adsorbent at ambient temperature prior the analysis. The sudden heating of the adsorbent releases the trapped compounds into the column. The chromatographic column, swept by carrier gas, separates the compounds according mainly to their volatility: the most volatile compound is the first to reach the detector.

### Photo-Ionisation Detector (PID)

A 10.6 eV lamp ionizes the molecules that enter the detector. The ions are collected on an electrode, thus creating an electrical signal.

### MicroElectroMechanical Systems (MEMS)

MEMS are miniaturized devices, with components typically smaller than 1 mm in size. This technology allows to reduce dramatically the size, the weight and the electrical consumption of an analyzer. *Figure 1* shows the BTEX-GC column and pre-concentrator next to a 1€ coin.



MEMS Pre-concentrator



MEMS GC column

FIGURE 1: MEMS

## 3- Overview of the BTEX-GC system

The BTEX-GC consists of the following main blocks:

- A. Sampling and pre-concentration unit
- B. Gas-chromatographic (GC) separation unit
- C. PID detector unit
- D. Manifolds for flow distribution and filter
- E. Housing, including cooling fans and electrical connectors

Some of the main blocks include sub-blocks, which are listed below:

- A. Sampling and pre-concentration unit
  - A1 Sampling pump
  - A2 Injection valve
  - A3 MEMS pre-concentration chip
  - A4 Pre-concentrator control electronics and MEMS interface
  - A5 Pre-concentrator fluidic block with block temperature control
- B. GC separation unit
  - B1 Carrier-gas pump
  - B2 Injection valve
  - B3 MEMS packed GC separation chip
  - B4 GC control electronics and MEMS interface
  - B5 GC fluidic block with block temperature control
- C. PID detector unit
  - C1 PID detector containing the PID lamp
  - C2 PID control electronics
  - C3 PID fluidic block

Please refer to *Figure 2* and *Figure 3* for identifying the above blocks and sub-blocks.

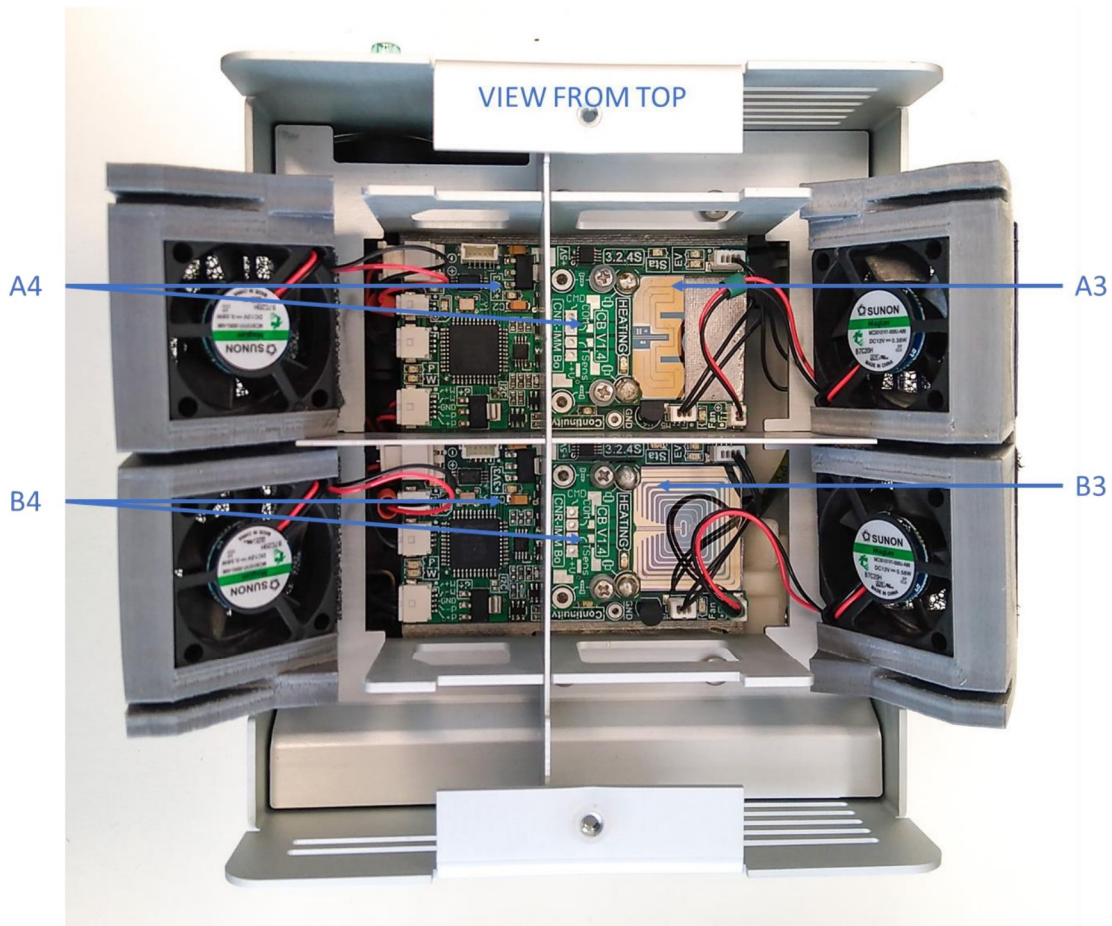


FIGURE 2: OVERVIEW OF THE BTEX-GC SYSTEM CORE HARDWARE (VIEW FROM TOP)

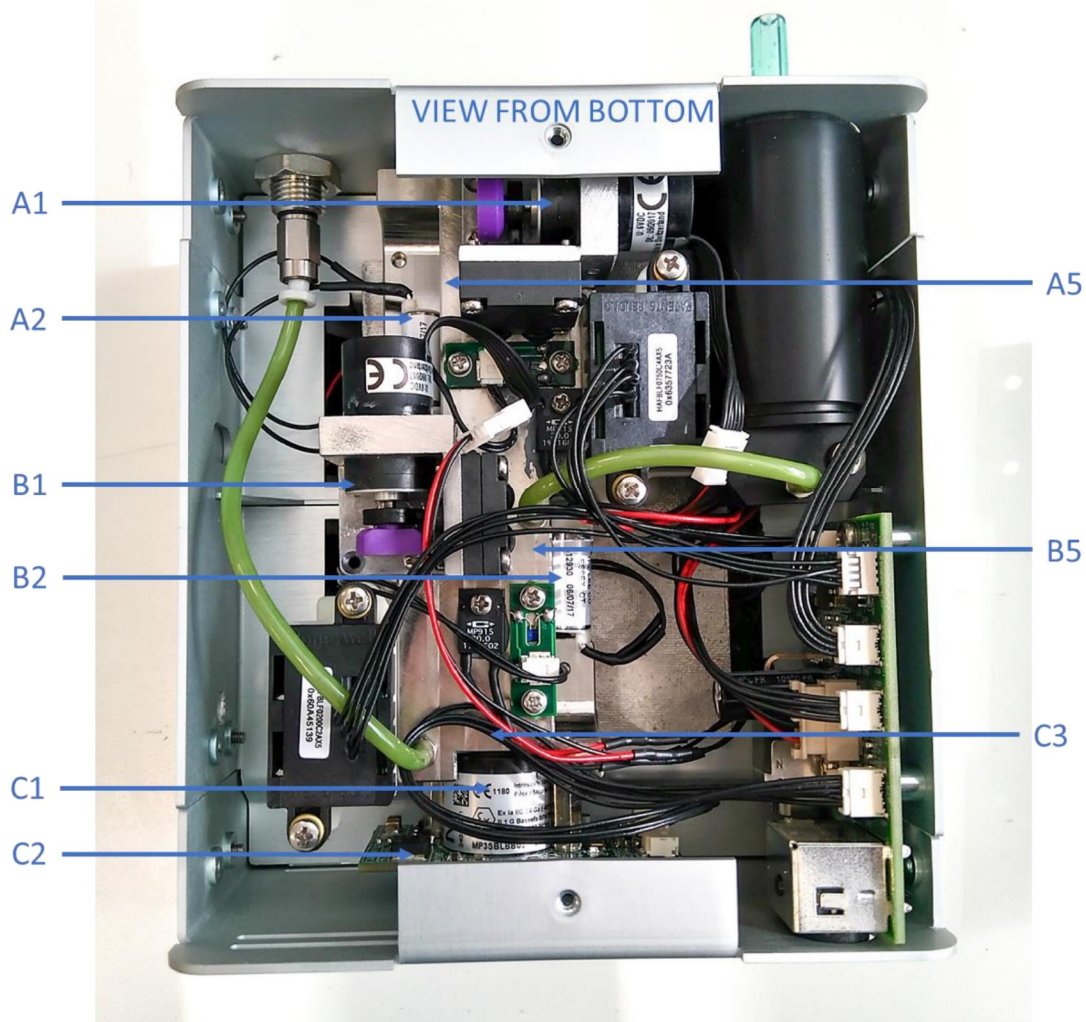


FIGURE 3: OVERVIEW OF THE BTEX-GC SYSTEM CORE HARDWARE (VIEW FROM BOTTOM)

The operating principle of the BTEX-GC is described in the following:

An analytical cycle consists of a complete set of sequential system states which implement a complete measurement. The result of each single measurement cycle is a chromatogram, which is processed to extract the height of the peaks of the compounds, namely benzene, toluene, ethylbenzene and xylene.

The height of each peak is linearly correlated, by means of a calibration factor, to the concentration of each single compound sampled during a sampling cycle.

In the current set-up, the BTEX-GC has a fixed cycle duration of 15 minutes. This means that the height of each of the BTEX peaks is computed 4 times every hour.

The height of each peak is proportional to an average concentration of the compound, as sampled during approximately 10 minutes during a 15 minutes cycle. 4 minutes are needed for the cleaning of the pre-concentrator between successive measurement cycles, and 1 minute is used as a buffer, to allow the device to start the next cycle at the exact time. This is due to the fact that the sampling time varies slightly because the sampling stops when a sampled volume of 2800 ml is reached. This

enhances the repeatability of the measurement. The contents of the pre-concentrator are injected at 60" after the beginning of the following cycle, so the first 60" of each cycle, all units are idle.

The phases during a 15 minutes cycle are described in more details in *Table 1* and *Figure 4*.

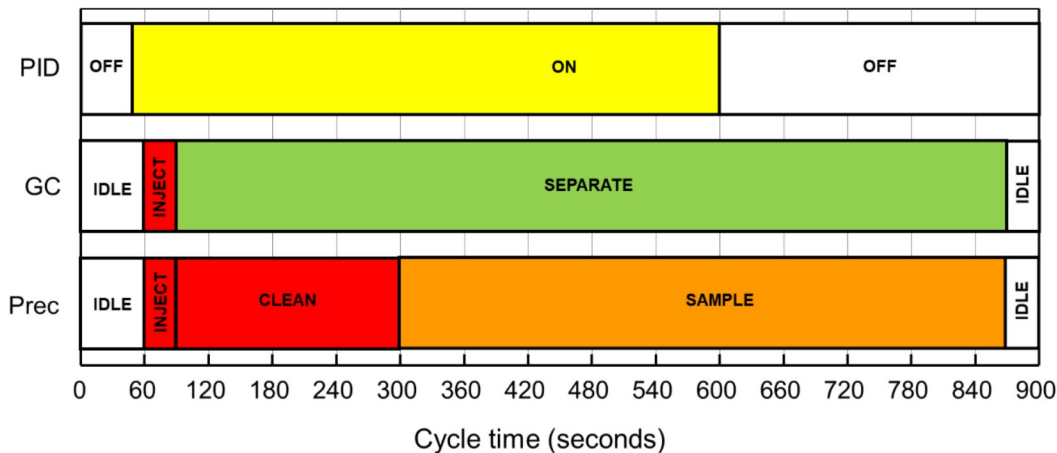


TABLE 1: STATES OF THE SINGLE BTEX-GC UNITS DURING A MEASUREMENT CYCLE

As can be seen from the table above, the pre-concentrator samples the air during the final 600" of the cycle.

This means that the chromatogram peaks acquired by the PID detector refer mostly to the air sampled during the previous cycle!

The preconcentrator flow is written  $F_1$  and the GC column flow  $F_2$ . The temperature of the preconcentrator is noted  $T_{prec}$ .

The first phase is the idle phase, from  $t = 0''$  to  $t = 60''$ , in which  $F_1 = 0$  ml/min;  $F_2 = 30$  ml/min;  $T_{prec} = 40^\circ\text{C}$ .

The second phase is injection phase, from  $t = 60''$  to  $t = 90''$ , in which  $F_1 = 30$  ml/min;  $F_2 = 30$  ml/min;  $T_{prec} = 110^\circ\text{C}$

The third phase is the cleaning phase, from  $t = 90''$  to  $t = 300''$ , in which  $F_1 = 300$  ml/min;  $F_2 = 30$  ml/min;  $T_{prec} = 110^\circ\text{C}$

The fourth phase is the sampling phase, from  $t = 300''$  to  $t = 900''$ , in which  $F_1 = 300$  ml/min;  $F_2 = 30$  ml/min;  $T_{prec} = 40^\circ\text{C}$

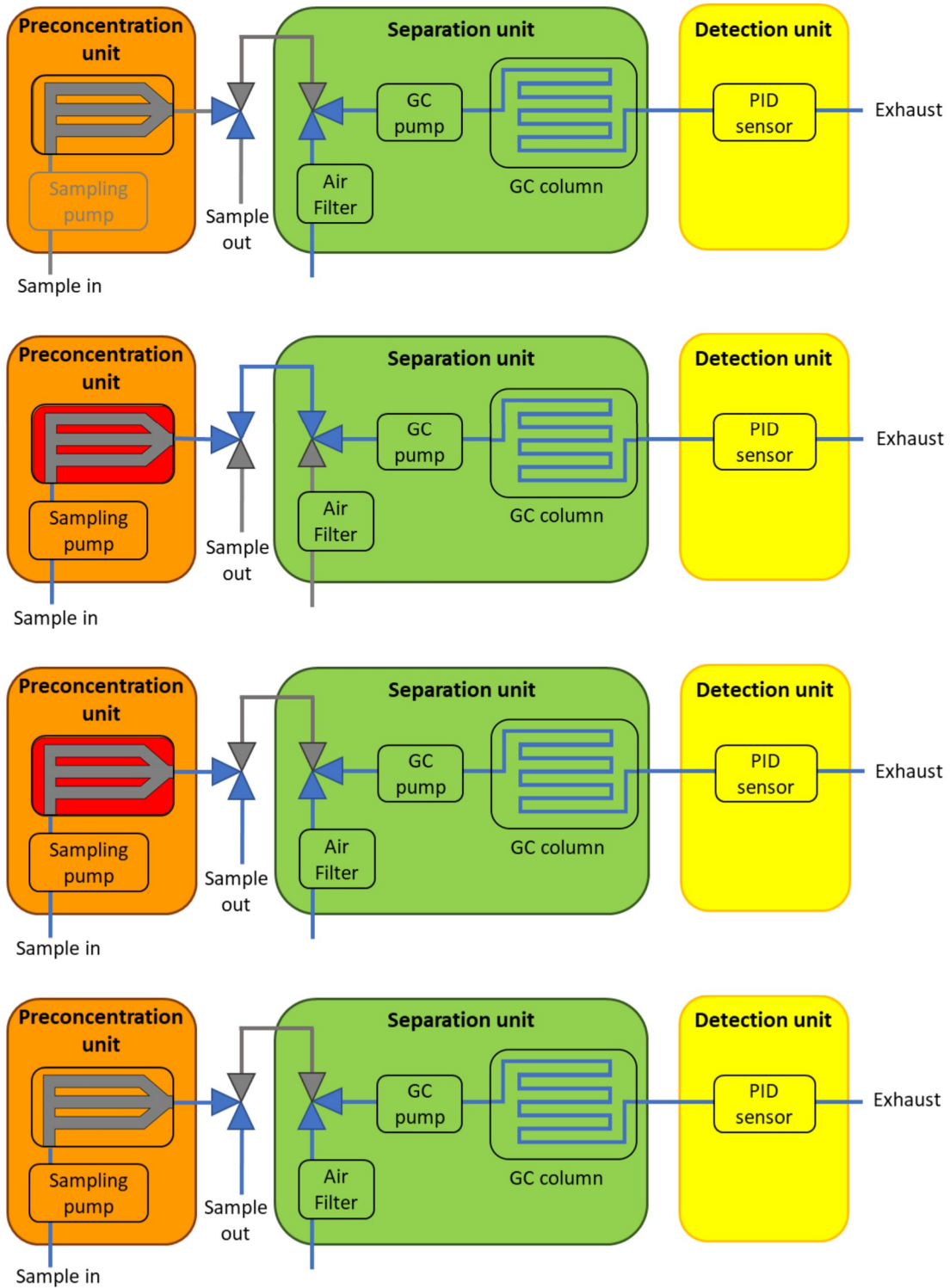


FIGURE 4: THE 4 PHASES OF A CYCLE, FROM TOP TO BOTTOM: IDLE, INJECTION, CLEANING, SAMPLING

A typical example of a chromatogram, as acquired by the PID detector during its 720" acquisition between 60" and 780" of the cycle, is shown below in *Figure 5*. In this example, the benzene peak

elutes with a maximum signal at  $t=125''$  after injection and has a height of 11.173mV. The toluene peak elutes at 377'' and is 49.367mV high, while no ethylbenzene was injected, therefore no clear peak is found.

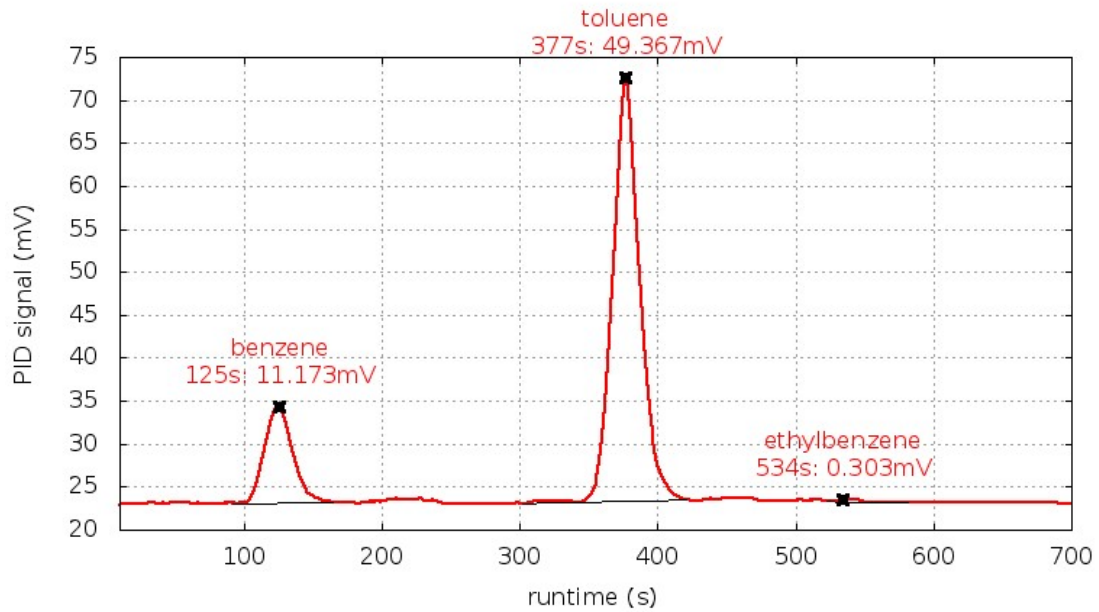


FIGURE 5: EXAMPLE OF CHROMATOGRAPH ACQUIRED BY A BTEX-GC SYSTEM

## 4- Hardware

### Installation

The BTEX module comes in 2 version: the drawer version (*Figure 6*), suitable for all kind of Airpointers, and the compact version (*Figure 7*), available for the HC Airpointers only.

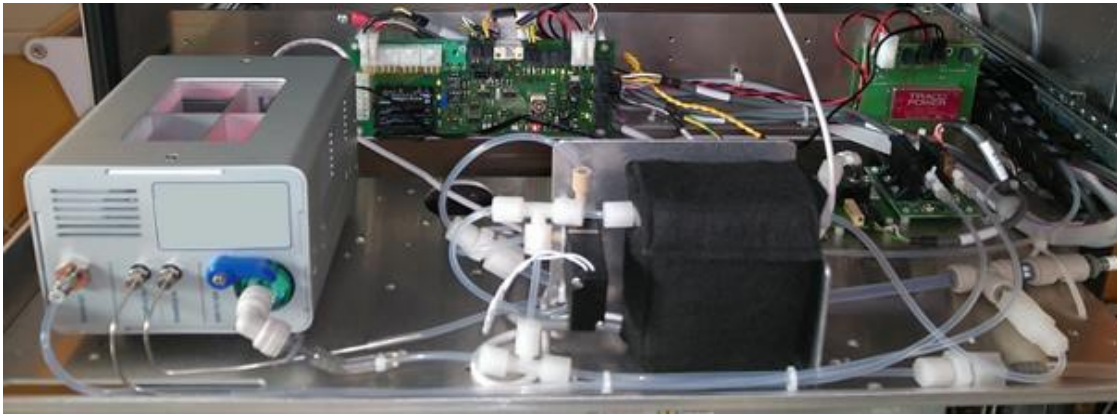


FIGURE 6: AIR POINTER GC BTEX MODULE IN A DRAWER VERSION

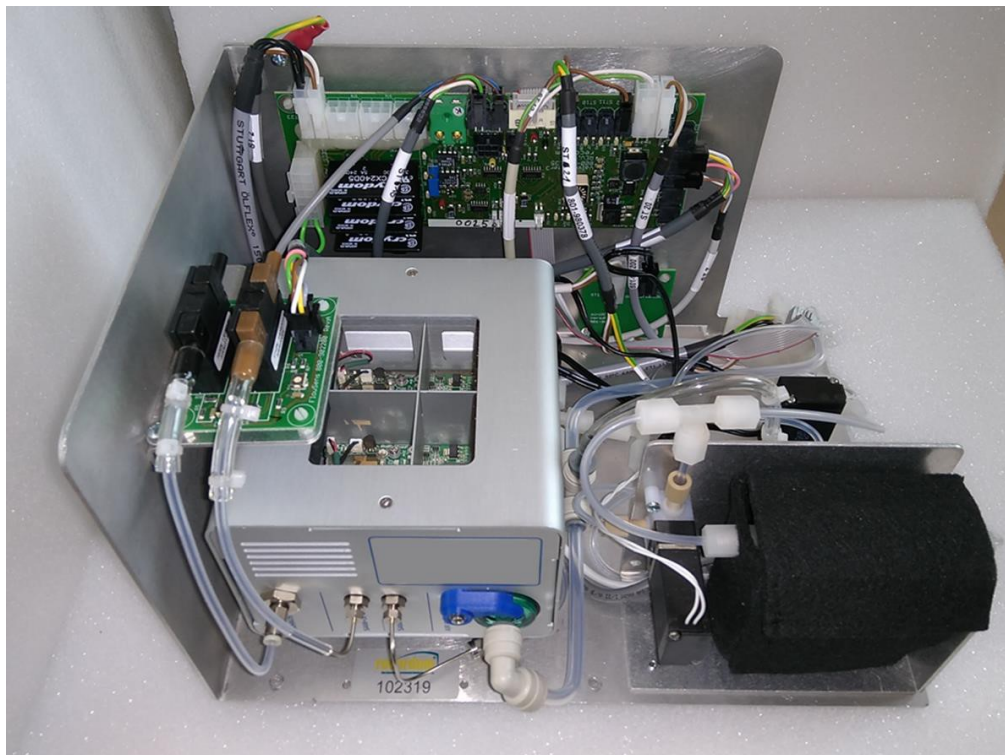


FIGURE 7: AIR POINTER GC BTEX MODULE IN A COMPACT VERSION

The procedure for the mounting/unmounting of the module in the drawer version is identical to the one described in 'Chapter 10.3.4 – Lift a module out or in' of the airpointer manual, except that there is an extra USB cable that needs to be connected to the Airpointer's PC.

The procedure for the mounting of the module in the compact version is similar to this of the drawer version, except that there is no rail to pull the module out.

## Connections



FIGURE 8: FRONT VIEW OF THE BTEX-GC BENCH WITH PNEUMATIC CONNECTIONS

The fluidic connections identified in *Figure 8* are:

**EXHAUST**

This is the PID outlet. The flow eluting from the GC column and flowing through the PID chamber flows OUT OF this connector whenever the GC unit pump is on. In this phase, the flow out of this connector should be in the 10-20mL/min range. This flow increases to >20mL/min when the pre-concentrator unit is injecting into the GC separation unit.

**SAMPLE OUT**

This is the sample outlet. The sample air flows OUT OF this connector while the pre-concentrator is in the sampling phase. In this phase, the flow out of this connector should be around 300 mL/min. During the injection phase, the flow out of this connector must drop to 0 mL/min.

**SAMPLE IN**

This is the sample inlet. The sample air flows INTO this connector all the time the pump of the pre-concentration unit (A1) is on.

**AIRFILTER**

This is the carrier gas inlet. The air flowing through this activated carbon filter is used as GC carrier gas. Ambient air flows INTO this connector whenever the sampling pump of the GC unit (B1) is on and the system is not in the injecting phase.

SAMPLE IN, SAMPLE OUT, and EXHAUST are 1/16" Swagelok® connectors. The filter connection OD is compatible with 1/4" or 6mm Teflon® tube fittings.



FIGURE 9: BACK VIEW OF THE BTEX-GC BENCH WITH ELECTRICAL CONNECTIONS

The electrical connections identified in *Figure 9* are:

**USB**

Mini-USB port for controlling the BTEX-GC

**POWER**

Power supply: DC 12V 3A max rating

**ON/OFF**

Power switch, turns off only the pre-concentrator and GC units

## Gas Flow of the BTEX-GC module

As shown on *Figure 10*, the BTEX-GC includes an internal span module. The drift can therefore be checked and if needed corrected daily. The procedure for the drift correction is described in the 'calibration' section.

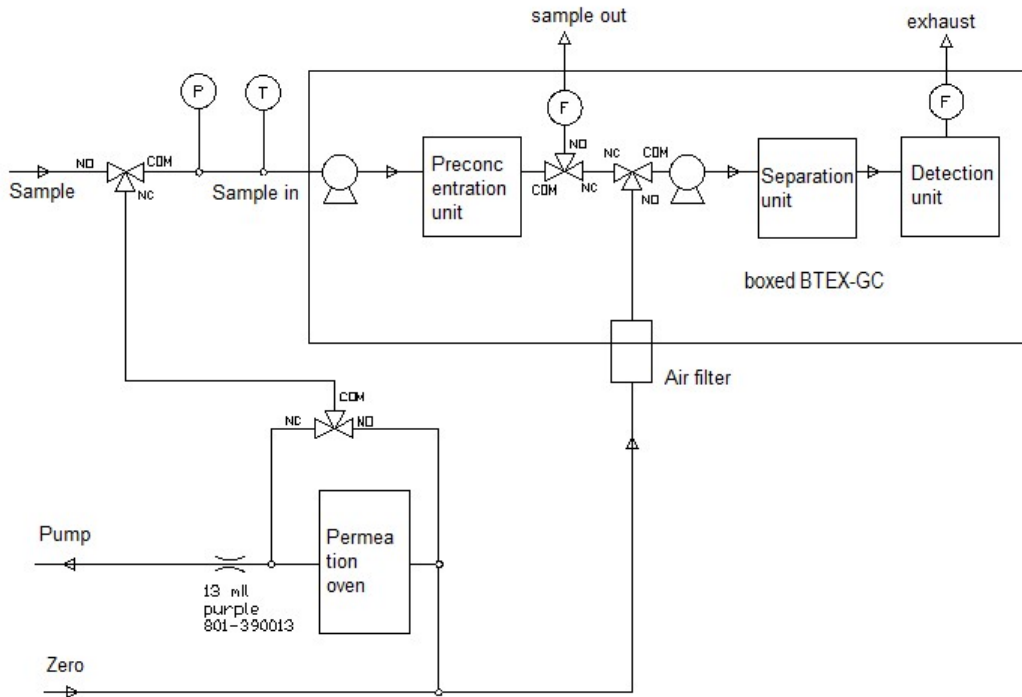


FIGURE 10: FLOW DIAGRAM OF THE BTEX-GC MODULE

## 5- Data Acquisition

In the following, the 6 parameters of the benzene peak are explained, as shown below in *Figure 11*.

- PN** = Peak name
- PBS** = Peak base start time (in seconds)
- PBE** = Peak base end time (in seconds)
- PBW** = Peak base search width (in seconds)
- PMP** = Peak maximum position (in seconds)
- PMW** = Peak maximum search width (in seconds)

### Peak height calculation procedure:

The peak height is calculated as the difference between the PID signal at the peak maximum time and a baseline, which is constructed at the base of the peak by finding two PID signal minima.

The peak minima are searched close to the times **PBS** and **PBE**, at a maximum distance of **PBW** seconds. The baseline is a straight line connecting the two minima found close to **PBS** and **PBE**.

The peak maximum is searched close to the time **PMP**, at a maximum distance of **PMW** seconds.

Once the exact position of the peak is found, it is subtracted by the baseline at the same position, resulting in the peak height.

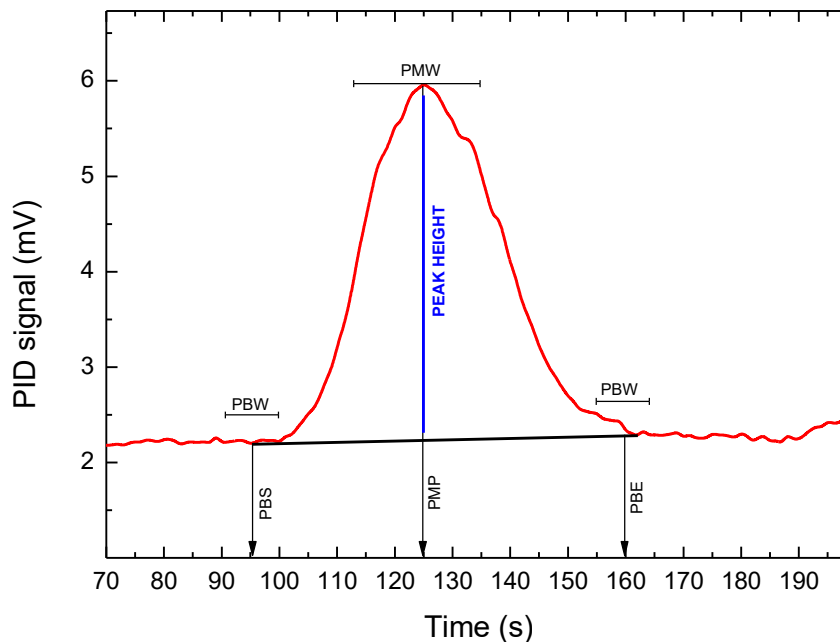


FIGURE 11: VISUAL REPRESENTATION OF THE PEAK INTEGRATION PARAMETERS

## 6- User Interface

### Command Interface

In this section, the BTEX-GC can be reset or turned off as shown in *Figure 12*.



FIGURE 12: COMMAND INTERFACE

### Zero and span checks

As shown in *Figure 13*, the Valve control interface is identical to the one described in 'Chapter 7.6 - Calibration' of the airpointer manual. However, contrary to most airpointer modules, the BTEX module works in 15 minutes cycles, and the sample n-1 is being analysed while the sample n is being sampled. Therefore, the user must wait a for minimum time of 30 minutes before obtaining the first result after switching a valve.

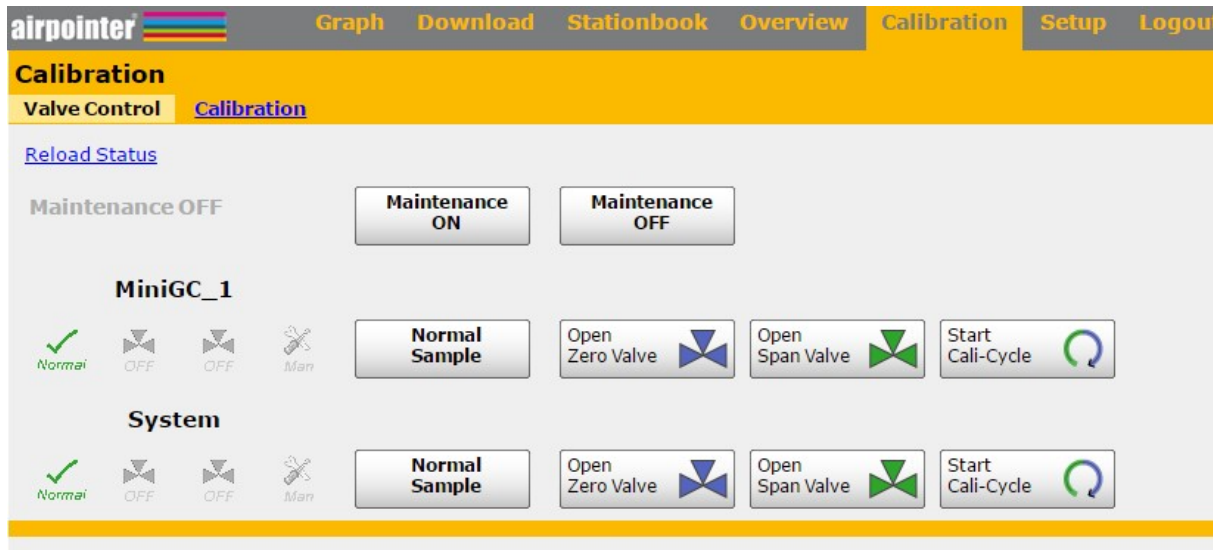


FIGURE 13: VALVE CONTROL OF THE BTEX-GC

### Linsens

In the miniGC tab of the Linsens interface, the current values of the module are shown (see *Figure 14*).

**Actual Values MiniGC 1** [Diagram](#)

no calibration active next automatic calibration cycle starts: 20160615 10:15:00

Parameter	Value	Unit	Status: BS-FS-SS
Benzene	0.13	ppb	0.0.0
Toluene	0.10	ppb	0.0.0
Ethylbenzene	0.04	ppb	0.0.0
Xylene	0.09	ppb	0.0.0
<hr/>			
Benzene_all (25/6)	0.13	ppb	
Toluene_all (25/7)	0.10	ppb	
Ethylbenzene_all (25/8)	0.04	ppb	
Xylene_all (25/9)	0.09	ppb	
Benzene_peak_height (25/12)	0.2	mV	
Toluene_peak_height (25/13)	0.1	mV	
Ethylbenzene_peak_heig (25/14)	0.0	mV	
Xylene_peak_height (25/15)	0.1	mV	
Benzene_baseline (25/18)	4.1	mV	
Toluene_baseline (25/19)	4.0	mV	
Ethylbenzene_baseline (25/20)	4.0	mV	
Xylene_baseline (25/21)	4.1	mV	
<hr/>			
SampleFlow (25/51)	296.8	ml/min	SensorFlow (25/52) 13.5 ml/min
SamplePress (25/53)	968.1	mbar	SampleTemp (25/54) 25.6 °C
PermT (25/49)	49.9	°C	PowerToPerm (25/50) 28.8 %

FIGURE 14: ACTUAL VALUES

The StatList tab shows the current error status (color coded) and value, unit, lower and upper error limit, lower and upper warning limit of each parameter from the system and the installed modules. If limits were set, OK, warning or fail status are shown. OK is written in green, warning in orange and fail in red (see *Figure 15*).

MiniGC\_1

G/P	Status	Parameter	Actual	Average	Unit	lower limit fail	lower limit warn	upper limit warn	upper limit fail	Board Adr
G25P1	OK	Benzene	-	-	ppb	-	-	-	-	-
G25P2	OK	Toluene	-	-	ppb	-	-	-	-	-
G25P3	OK	Ethylbenzene	-	-	ppb	-	-	-	-	-
G25P4	OK	Xylene	-	-	ppb	-	-	-	-	-
G25P6	OK	Benzene_all	-	0.36	ppb	-	-	-	-	-
G25P7	OK	Toluene_all	-	0.14	ppb	-	-	-	-	-
G25P8	OK	Ethylbenzene_all	-	0.04	ppb	-	-	-	-	-
G25P9	OK	Xylene_all	-	0.06	ppb	-	-	-	-	-
G25P12	OK	Benzene_peak_height	-	0.5	mV	-	-	-	-	-
G25P13	OK	Toluene_peak_height	-	0.1	mV	-	-	-	-	-
G25P14	OK	Ethylbenzene_peak_heig	-	0.0	mV	-	-	-	-	-
G25P15	OK	Xylene_peak_height	-	0.1	mV	-	-	-	-	-
G25P18	OK	Benzene_baseline	-	4.5	mV	-	-	-	-	-
G25P19	OK	Toluene_baseline	-	4.1	mV	-	-	-	-	-
G25P20	OK	Ethylbenzene_baseline	-	4.0	mV	-	-	-	-	-
G25P21	OK	Xylene_baseline	4.1	4.1	mV	-	-	-	-	-
G25P49	OK	PermT	50.0	49.9	°C	45.0	47.0	53.0	55.0	042
G25P50	OK	PowerToPerm	29.2	28.9	%	-	-	-	-	042
G25P51	OK	SampleFlow	297.5	72.0	ml/min	40.0	50.0	250.0	300.0	042
G25P52	OK	SensorFlow	13.4	5.0	ml/min	-	-	25.0	30.0	042
G25P53	OK	SamplePress	968.8	970.0	mbar	500.0	550.0	1090.0	1100.0	042
G25P54	OK	SampleTemp	25.4	25.4	°C	0.0	5.0	35.0	60.0	042

FIGURE 15: STATLIST

## Configuration

Figure 16 below shows the parameters you can configure on the BTEX-GC. Contrary to most airpointer modules, the calibration factors are not automatically adjusted after a calibration, but need to be inserted manually in the fields 'slope' and 'offset' of the 'calibration' section.

The interval between calibrations and their durations can be configured in the 'calibration timing' section.

The concentration used for calibration can be configured in the 'calibration setpoint' section.

The name of the species can be configured in the 'typical configuration' section.

The units can be configured in the 'aux configuration' section.

Main Configuration	
<b>miniGC_IP</b> IP Address	<input type="text" value="172.17.2.100"/>
<a href="#">Save</a>	
Calibration	
<b>miniGC_1_1Slope</b> calibration factor (x)	<input type="text" value="0.74"/> [0.01 ≤ value ≤ ]
<b>miniGC_1_1Offset</b> calibration factor (+)	<input type="text" value="0"/>
<b>miniGC_1_2Slope</b> calibration factor (x)	<input type="text" value="1"/> [0.01 ≤ value ≤ ]
<b>miniGC_1_2Offset</b> calibration factor (+)	<input type="text" value="0"/>
<b>miniGC_1_3Slope</b> calibration factor (x)	<input type="text" value="1"/> [0.01 ≤ value ≤ ]
<b>miniGC_1_3Offset</b> calibration factor (+)	<input type="text" value="0"/>
<b>miniGC_1_4Slope</b> calibration factor (x)	<input type="text" value="1"/> [0.01 ≤ value ≤ ]
<b>miniGC_1_4Offset</b> calibration factor (+)	<input type="text" value="0"/>
<b>miniGC_1_5Slope</b> calibration factor (x)	<input type="text" value="1"/> [0.01 ≤ value ≤ ]
<b>miniGC_1_5Offset</b> calibration factor (+)	<input type="text" value="0"/>
<a href="#">Save</a>	
Calibration Setup	
<b>ISM_MiniGC</b> [on/off] Internal span module built in	<input checked="" type="radio"/> On <input type="radio"/> Off
<b>MiniGC_autocorrect4span</b> [on/off] correct following measuring results according to the last span	<input type="radio"/> On <input checked="" type="radio"/> Off
<b>MiniGC_autocorrect4zero</b> [on/off] correct following measuring results according to the last zero	<input type="radio"/> On <input checked="" type="radio"/> Off
<b>MiniGC_wrong_cal_to_status</b> [on/off] status fail on calibration values enabled	<input type="radio"/> On <input checked="" type="radio"/> Off
<b>!CalOnMiniGC</b> [on/off] Zero/Span values are computed, enables automatic calibration cycles	<input checked="" type="radio"/> On <input type="radio"/> Off
<b>!MiniGC_IgnorCalStatus</b> [on/off] Values are averaged even with status wrong calibration on	<input type="radio"/> On <input checked="" type="radio"/> Off
<a href="#">Save</a>	
Calibration Timing	
<b>MiniGC_CaliInterval</b> [hours] 0 disables automatic calibration check	<input type="text" value="2"/>
<b>CalNextAutoStartMiniGC_1</b> [datetime] next calibration cycle starts at:	2016 ▾ - Jun ▾ - 15 ▾ 12 ▾ : 15 ▾ = 2016-06-15 12:15:00
<b>MiniGC_ZeroDuration</b> [sec] duration of active zero valve	<input type="text" value="900"/>
<b>MiniGC_ZeroPurgeIn</b> [sec] purge in time with zero air, data are not sampled	<input type="text" value="600"/>

<b>MiniGC_DurationPurgeOut</b> [sec] purge in time with sample, data are not sampled to averages	<input type="text" value="900"/>
<b>MiniGC_IndependentSpanTiming</b> [on/off] independent timing for span check	<input checked="" type="radio"/> On <input type="radio"/> Off
<b>MiniGC_CallIntervalSpan</b> [hours] 0 disables automatic span calibration check	<input type="text" value="0"/>
<b>CaliNextAutoSpanStartMiniGC_1</b> [datetime] next span calibration cycle starts at:	2015 ▾ - Aug ▾ - 1 ▾ 00 ▾ : 00 ▾ = 2015-08-01 00:00:00
<a href="#">Save...</a>	
<b>Calibration Setpoints</b>	
<b>MiniGC_SetpointSpan_1</b> setpoint for calculation of automatic function check	<input type="text" value="5"/>
<b>MiniGC_SetpointSpan_2</b> setpoint for calculation of automatic function check	<input type="text" value="5"/>
<b>MiniGC_SetpointSpan_3</b> setpoint for calculation of automatic function check	<input type="text" value="5"/>
<b>MiniGC_SetpointSpan_4</b> setpoint for calculation of automatic function check	<input type="text" value="5"/>
<b>MiniGC_SetpointSpan_5</b> setpoint for calculation of automatic function check	<input type="text" value="5"/>
<a href="#">Save...</a>	
<b>Typical Configuration</b>	
<b>miniGC_1_1FileName</b> File Name	<input type="text" value="benzene"/>
<b>miniGC_1_2FileName</b> File Name	<input type="text" value="toluene"/>
<b>miniGC_1_3FileName</b> File Name	<input type="text" value="ethylbenzene"/>
<b>miniGC_1_4FileName</b> File Name	<input type="text" value="xylene"/>
<b>miniGC_1_5FileName</b> File Name	<input type="text"/>
<a href="#">Save...</a>	
<b>Aux Configuration</b>	
<b>miniGC_1_1Name</b> Name	<input type="text" value="Benzene"/>
<b>miniGC_1_1Unit</b> unit	<input type="text" value="ppb"/>
<b>miniGC_1_2Name</b> Name	<input type="text" value="Toluene"/>
<b>miniGC_1_2Unit</b> unit	<input type="text" value="ppb"/>
<b>miniGC_1_3Name</b> Name	<input type="text" value="Ethylbenzene"/>
<b>miniGC_1_3Unit</b> unit	<input type="text" value="ppb"/>
<b>miniGC_1_4Name</b> Name	<input type="text" value="Xylene"/>
<b>miniGC_1_4Unit</b> unit	<input type="text" value="ppb"/>
<b>miniGC_1_5Name</b> Name	<input type="text"/>
<b>miniGC_1_5Unit</b> unit	<input type="text" value="ppb"/>
<a href="#">Save...</a>	
<input type="button" value="Save"/>	

FIGURE 16: CONFIGURATION OF THE BTEX-GC

## 7- Calibration of the device

Like on all other gas modules in the Recordum airpointer, calibration is very important. The user should choose the calibration interval depending on the local regulation, or whenever a drift that exceeds a defined threshold is visible in the automatic zero or span check. Recordum recommends a calibration at least once a year even if the automatic zero and span checks show stable readings. If the BTEX-GC module was purchased with the optional Internal Span Module (ISM), automatic zero and span checks can easily be performed daily. Please be aware that a calibration of the instrument needs to be performed with an external gas source to fulfil the needs of quality assurance. Technically, a calibration can also be done with the built-in ISM when installed. In this case, flow, temperature and permeation rate of the permeation tube need to be checked and taken into account to calculate the concentration.

The signals of the BTEX-GC module are computed with the calibration factors the following way:

Concentration = Conc \* Factory factor \* Slope – Offset

The calibration philosophy is identical to the one described in 'Chapter 7.6 - Calibration' of the airpointer manual, but for the BTEX module, the slope and offset values must be entered manually in the user interface. For this, go to setup/configuration/Pyxis BTEX/, as shown in *Figure 16*.

### Factory Factor

The Factory factor is set during the first calibration with span gas. If the slope factor is more than 25% away from 1.0, a factory factor should be defined and put into the system and should stay the same during the instrument's life. It is calculated the same way as the slope but rounded up to the nearest tenth (e-g: if your result is 2.53 use a factory factor of 2.5).

### Calibration at span and zero level

#### **Span Calibration:**

Supply the span gas to the calibration inlet, making sure there is an excess of gas. The airpointer sampling system will act as a bypass (vent). The typical span concentration for ambient air monitoring should be around 10ppb. Let the instrument run for at least one complete analysis cycle. We recommend running more 4 samples and to discard the first one. Check on the chromatograms that the peaks are clearly separated and unambiguously identified. When this is the case, find the actual value by averaging the concentration values of the last 3 samples and use the following formula to calculate the new slope:

$$\text{New Slope} = \text{Setpoint} / \text{Actual value} * \text{Old slope}$$

Example:

Setpoint: 10 ppb

Actual: 9,5 ppb

Slope: 1,12

$$\text{New Slope} = 10 / 9,5 * 1,12 = 1,179$$

### **Zero Calibration:**

Because of the measuring method, an offset value is not really needed. We added it nonetheless because some customers want to have it. In most situations, the value shown on zero shows the quality of the zero air and less the real zero value. The recommendation is to use an offset factor of 0.

If you need to do a zero calibration, supply zero air to the calibration inlet, making sure there is an excess of gas. We recommend running more 4 samples, discarding the first one, and averaging the last 3. Once you obtained the actual values, you can calculate the new offset value using the following formula:

$$\text{New Offset} = \text{Actual value} + \text{Old Offset}$$

### **Glossary:**

**Function check:** Typically, automatic performed zero and span check with the internal zero and span source. When the results are out of limit, a calibration should be performed.

**Calibration:** Manually performed zero and span check with an external gas source. Slope and offset factors are updated to match the set points.

**Factory factor:** Coarse adjustment to reach a Slope of 1

**Slope:** Multiplicative calibration factor

**Offset:** Additive calibration factor

## **Calibration of the retention times**

The retention times are factory settings, optimized by Recordum before delivery of the device, and under normal conditions, the retention times should be stable. If they aren't, it is most probably due to a flow problem and the BTEX module needs maintenance. Therefore, the user normally doesn't need to modify the retention times.

However, after several years of operation, the retention times may drift slightly. Also, the user's needs may change, and they may want to analyze different compounds.

In these cases, a retention time recalibration is needed. This can be done in Setup/Configuration/Pyxis Timings, as shown in *Figure 17*. The meaning of the different timing parameters is explained in *Figure 11*.

The screenshot shows the 'airpointer' software interface with the 'Setup' tab selected. The main area displays a table of retention time parameters for various compounds. The table is organized by compound, with each compound having its own section. The parameters listed are Base start time, Base end time, Base search width, Maximum position, and Maximum search width. The units for all parameters are 'Seconds'. At the bottom of the table, there is a 'Save' button and a checkbox for 'Generate new shell script that uses the current timings'.

You find each abbreviation below.		Time (s)
PBS	Peak Base Start time	
PBE	Peak Base End time	
PBW	Peak Base search Width	
PMP	Peak Maximum Position	
PMW	Peak Maximum search Width	
<b>Benzene</b>		
Base start time	185	Seconds
Base end time	200	Seconds
Base search width	10	Seconds
Maximum position	190	Seconds
Maximum search width	5	Seconds
<b>Toluene</b>		
Base start time	307	Seconds
Base end time	337	Seconds
Base search width	10	Seconds
Maximum position	317	Seconds
Maximum search width	10	Seconds
<b>Ethylbenzene</b>		
Base start time	367	Seconds
Base end time	397	Seconds
Base search width	10	Seconds
Maximum position	377	Seconds
Maximum search width	10	Seconds
<b>Xylene</b>		
Base start time	534	Seconds
Base end time	569	Seconds
Base search width	15	Seconds
Maximum position	544	Seconds
Maximum search width	15	Seconds

Save      Generate new shell script that uses the current timings

FIGURE 17: SETTING THE RETENTION TIMES

## 8- Troubleshooting

**Sensitivity loss:** perform a leak check, check that the perm tube is not empty or broken, clean the lamp, replace the lamp (see chapter 9 for indications on how to replace the PID lamp).

**Sample flow:** check that the air filter and the sample filter are not polluted, check with an external calibrated flowmeter (with a working range of 0-1000 ml/min) that the flow reading from the “sample” flow sensor is accurate.

**Sensor flow:** check that the air filter and the sample filter are not polluted, check with an external calibrated flowmeter (with a working range of 0-100 ml/min) that the flow reading from the “sensor” flow sensor is accurate.

**Sample press:** check with an external calibrated barometer that the pressure sensor reading is accurate.

**PermT:** check with an external calibrated thermometer that the temperature sensor is working, check that the fans are working and clean.

## 9- Maintenance

### Maintenance schedule

air zero adsorbent	Once to twice a year
air zero filter	Once to twice a year
lamp change	Once to twice a year
Capillary inspection	every year
Perm tube change	every year

### Maintenance procedures

Maintenance procedures can be viewed or downloaded using the links below:

<https://www.airpointer.tech/wp-content/uploads/2019/02/BTEX1-Replacing-the-GC.pdf>

<https://www.airpointer.tech/wp-content/uploads/2019/02/BTEX2-Replacing-the-PID-lamp.pdf>

<https://www.airpointer.tech/wp-content/uploads/2019/02/BTEX3-Replacing-the-carrier-gas-filter.pdf>



**TELEDYNE API**  
Everywhereyoulook™



**User Manual**  
***Models T101 and T102***  
***UV Fluorescence Analyzers***

*with NumaView™ software*

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## **TRADEMARKS**

All trademarks, registered trademarks, brand names or product names appearing in this document are the property of their respective owners and are used herein for identification purposes only.

## 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.

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

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

## CONSIGNES DE SÉCURITÉ

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



AVERTISSEMENT : Risque de choc électrique



DANGER : Oxydant puissant



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



MISE EN GARDE : Surface chaude



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

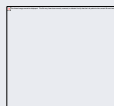


Pictogramme « technicien » : Toutes les opérations portant ce symbole doivent être effectuées uniquement par du personnel de maintenance qualifié.



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

### 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.



## T101, T102

<b>RISQUE</b>	<b>DANGER</b>
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, soulevage et de transport inappropriées	Blessure corporelle

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

# WARRANTY

## WARRANTY POLICY (02024J)

Teledyne API (TAPI), a business unit of Teledyne Instruments, Inc., provides that:

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

## COVERAGE

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

## NON-TAPI MANUFACTURED EQUIPMENT

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

## PRODUCT RETURN

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

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

### CAUTION – Avoid Warranty Invalidation



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



## ABOUT THIS MANUAL

Support manuals, such as 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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**Appendix A – MODBUS Registers**

**Appendix B – Interconnect Wiring Diagrams**



## 1. INTRODUCTION, SPECIFICATIONS, & COMPLIANCE

Teledyne API's Model T101 and T102 UV Fluorescence Analyzers are microprocessor-controlled instruments that use fluorescence technology to measure SO<sub>2</sub> concentrations for ambient air monitoring. User operation is the same in both, but the instruments' processes differ: the T101 converts hydrogen sulfide (H<sub>2</sub>S) gas into SO<sub>2</sub>, using an internal catalytic converter, where the T102 converts total reduced sulfur (TRS) gases into SO<sub>2</sub>, using an external TRS converter.

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.

## 1.1. SPECIFICATIONS

**Table 1-1. Analyzer Specifications**

PARAMETER	SPECIFICATION	
	T101	T102
Min/Max Range (Physical Analog Output)	H <sub>2</sub> S: Min: 0-50 ppb full Scale Max: 0-10,000 ppb full Scale SO <sub>2</sub> : Up to 0-20,000 ppb full scale (selectable, dual range supported)	TRS: Min: 0-50 ppb full Scale Max: 0-10,000 ppb full Scale SO <sub>2</sub> : Up to 0-20,000 ppb full scale (selectable, dual range supported)
Measurement Units	ppb, ppm, µg/m <sup>3</sup> , mg/m <sup>3</sup> (selectable)	ppb, ppm, µg/m <sup>3</sup> , mg/m <sup>3</sup> (selectable)
Zero Noise	< 0.2 ppb (RMS)	< 0.2 ppb (RMS)
Span Noise	< 0.5% of reading (RMS) above 50 ppb	< 0.5% of reading (RMS) above 50 ppb
Lower Detectable Limit	< 0.4 ppb	< 0.4 ppb
Zero Drift	< 0.5 ppb (at constant temperature and voltage) /24 hours	< 0.5 ppb (at constant temperature and voltage) /24 hours
Span Drift	< 0.5% of Full Scale (at constant temperature and voltage) /24 hours	< 0.5% of Full Scale (at constant temperature and voltage) /24 hours
Response Time	< 140 seconds to 95%	< 140 seconds to 95%
Linearity	1% of full scale / 24 hours	1% of full scale / 24 hours
Precision	0.5% of reading above 50 ppb	0.5% of reading above 50 ppb
Sample Flow Rate	650 cc/min ± 10%	650 cc/min ± 10%
AC Power	Rating: 110-120 V~, 60 Hz, 3.0 A, Typical Power Consumption: 165 W 220-240 V~, 50/60 Hz, 3.0 A, Typical Power Consumption: 140 W	
Analog Output Ranges	10V, 5V, 1V, 0.1V (selectable)	
Recorder Offset	± 10%	
Standard I/O	1 Ethernet: 10/100Base-T 2 RS-232 (300 – 115,200 baud) 2 USB device ports 8 opto-isolated digital status outputs (7 defined, 1 spare) 6 opto-isolated digital control inputs (4 defined, 2 spar) 4 analog outputs	
Optional I/O	1 USB com port 1 RS485 8 analog inputs (0-10V, 12-bit) 4 digital alarm outputs Multidrop RS232 3 4-20mA current outputs	
Dimensions H x W x D	7" x 17" x 23.5" (178mm x 432 mm x 597 mm)	
Weight	T101: 41 lbs (18.3 kg); T102: 37 lbs (16.8 kg)	
Operating Temperature Range	5 - 40 °C	
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 ≤ 2000m	

All specifications are based on constant conditions.

**Table 1-2. Model 501 Specifications**

PARAMETER	DESCRIPTION
Minimum Converter Efficiency	H <sub>2</sub> S >95% COS >90% CS <sub>2</sub> >90%
Maximum TS Concentration for specified conversion efficiency	20 ppmv
Sample Flow Rate	650cc/min. ±10% - driven by T102 pneumatic system
Optimum Converter Temperature	850°C (factory setup)
Maximum Converter Temperature	1100°C
Dimensions H x W x D	7" x 17" x 23.5" (178 mm x 432 mm x 597 mm)
Weight	16 lbs (7.3 kg) 26 lbs (11.8 kg) CE version
AC Power Rating	115 V, 50/60 Hz, 4.0A - Typical Power Consumption 400 Watts (non-CE) 230 V, 50/60 Hz, 2.0A - Typical Power Consumption 575 Watts; (CE version)
Internal Alarms	High Alarm Point: 900°C Low Alarm Point: 800°C
Alarm Output Relay	SPST - 1 point: Alarm output is energized should either the temperature controller's high or low internal alarm set points be activated.
Alarm Output Rating	220V AC/30V DC, 1A (resistive load)
Environmental	Installation category (over-voltage category) II; Pollution degree 2 Intended for indoor use at altitudes ≤ 2000m only
Certifications	IEC 1010-1 / 61010-1:93 (includes A1) + A2:95,

## 1.2. EPA DESIGNATION

No EPA equivalency standards exist for TRS measurement, however, the T102 analyzer qualifies for EPA equivalency designation as Equivalent Method Number EQSA-0495-100 per 40 CFR Part 53 when operated under the following conditions:

- Measurement Mode: SO<sub>2</sub> single gas mode
- Range: Any range from 50 parts per billion (ppb) to 10 parts per million (ppm)
- Ambient temperature range of 5 °C to 40 °C
- Line voltage range of 105-125 VAC or 220-240 VAC, at 50 or 60 Hz
- Sample filter: Equipped with PTFE filter element in the internal filter assembly
- Sample flow of 650 +/- 65 cc/min
- Vacuum pump (internal or external) capable of 14"Hg Absolute pressure @ 1 slpm or better
- Software settings:
 

Dynamic span	OFF
Dynamic zero	OFF
Dilution factor	OFF
AutoCal	ON or OFF
Dual range	ON or OFF
Auto-range	ON or OFF
Temp/Pressure compensation	ON



## T101, T102

Under the designation, the analyzer may be operated with or without the following optional equipment:

- Rack mount with chassis slides.
- Rack mount without slides, ears only.
- Zero/span valve options.
- Internal zero/span (IZS) option with either:
  - SO<sub>2</sub> permeation tube - 0.4 ppm at 0.7 liter per minute; certified/uncertified.
  - SO<sub>2</sub> permeation tube - 0.8 ppm at 0.7 liter per minute; certified/uncertified. Under the designation, the IZS option cannot be used as the source of calibration.
- 4-20mA isolated analog outputs
- Status outputs
- Control inputs
- RS-232 output
- Ethernet output
- Zero air scrubber
- 4-20mA, isolated output

### 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/relocated each instrument.

#### 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>.

#### 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.

With no power to the unit, carefully remove the top cover of each 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.



## T101, T102

4. Verify that all (if any) optional hardware ordered with the unit has been installed. These are listed on the paperwork accompanying the instrument.
5. Return cover and refasten with original screws/fasteners.

### 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

**Note**

Failure to provide proper ventilation can result in ambient temperature exceeding the maximum operating temperature specifications.

## 2.2. INSTRUMENT LAYOUT

This section illustrates the front and rear panels and the internal chassis layout.

### 2.2.1. FRONT PANEL

The analyzer 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).

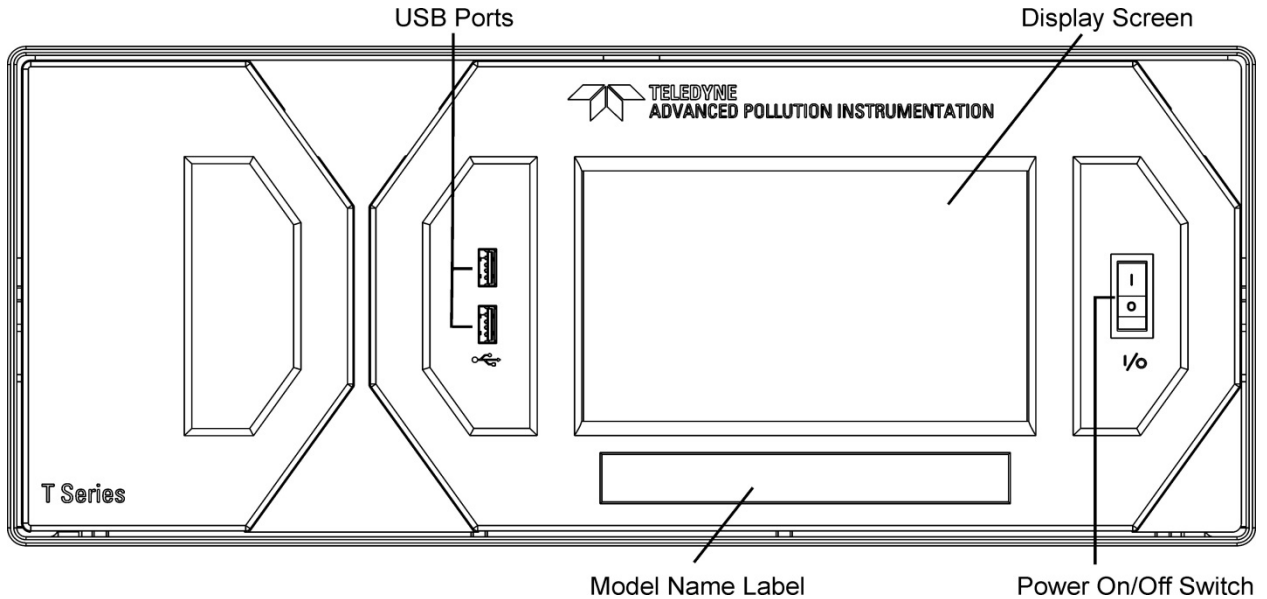


Figure 2-1. Analyzer Front Panel Layout

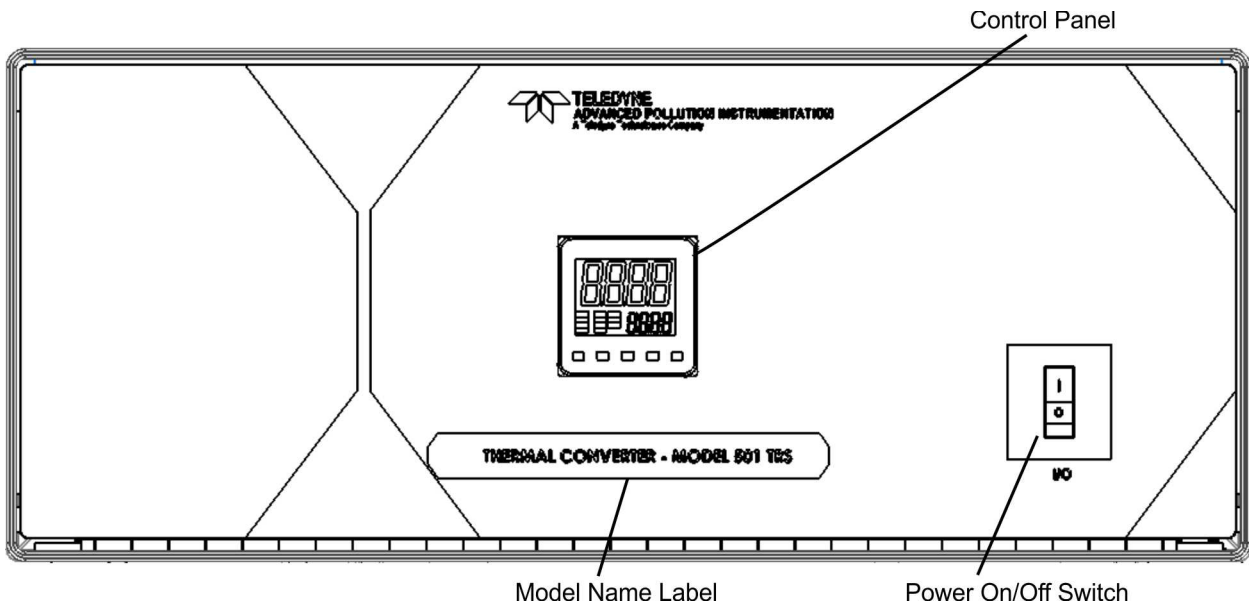
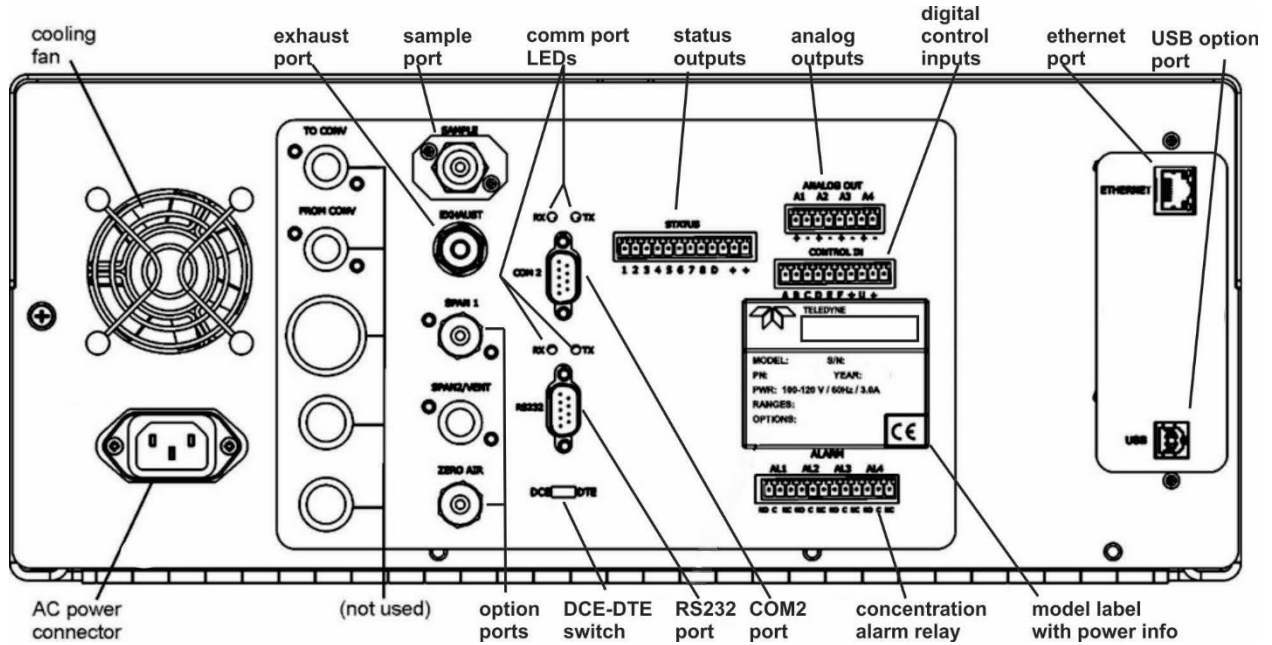


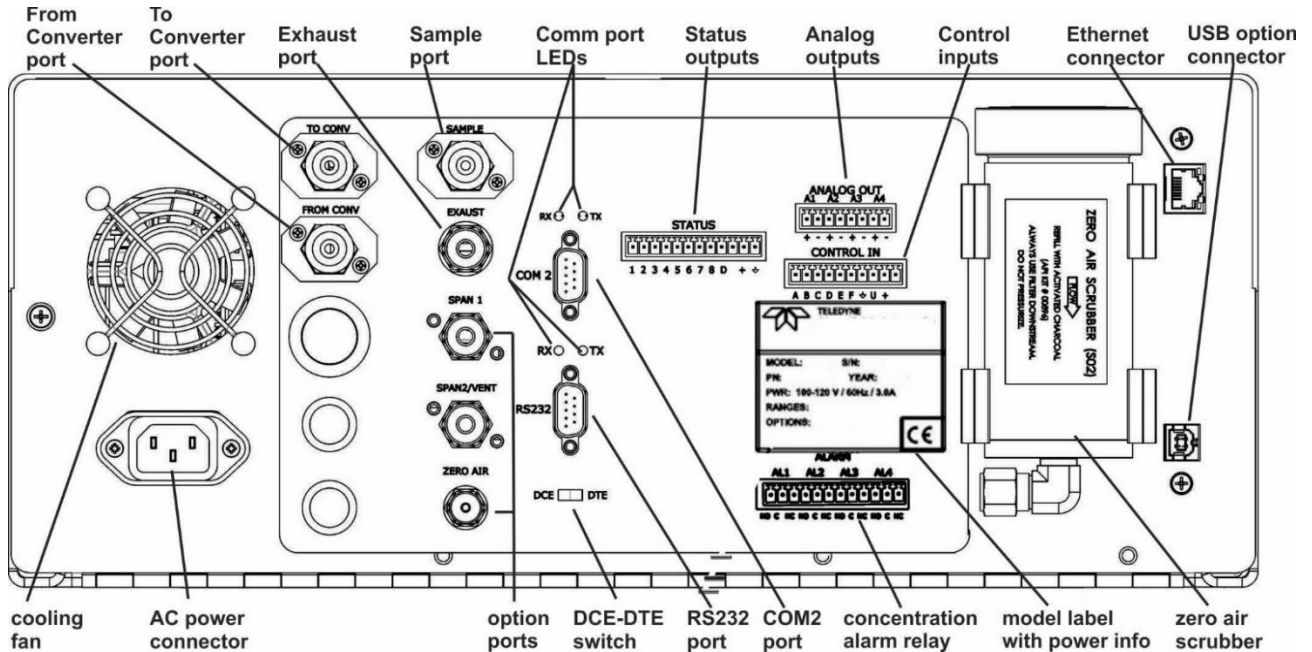
Figure 2-2. Front Panel Layout

## 2.2.2. REAR PANELS

Figure 2-3 shows the rear panel layout of the T101; Figure 2-4 shows the rear panel layout of the T102, and Figure 2-5 shows the rear panel layout of the 501 TRS Converter.




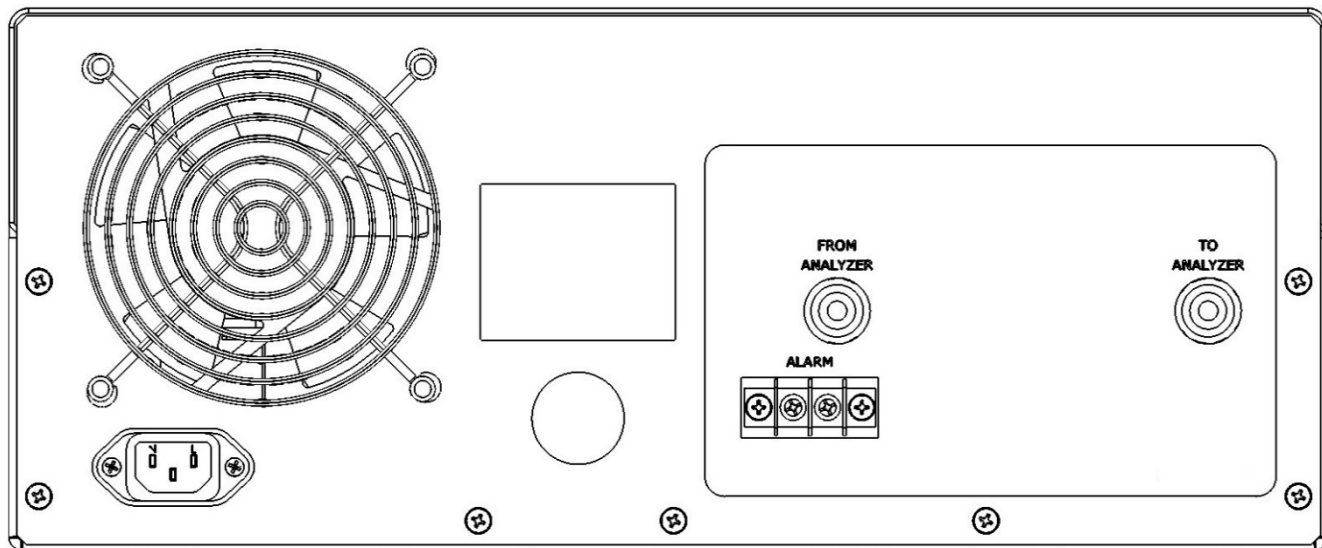
**Figure 2-3. T101 Rear Panel Layout**



**Figure 2-4. T102 Rear Panel Layout**


Table 2-2. Analyzer Rear Panel Description

COMPONENT	FUNCTION
cooling fan	Pulls ambient air into chassis through side vents and exhausts through rear.
 AC power connector	Connector for three-prong cord to apply AC power to the analyzer. <b>CAUTION! The cord's power specifications (specs) MUST comply with the power specs on the analyzer's rear panel Model number label</b>
Model/specs label	Identifies the analyzer model number and provides power specs
(T102) TO CONV	Connect sample gas tubing going from the T102 to the 501 TRS FROM ANALYZER port
(T102) FROM CONV	Connect sample gas returning to the T102 from the 501 TO ANALYZER port
SAMPLE	Connect a gas line from the source of sample gas here. Calibration gases can also enter here on units without zero/span/shutoff valve options installed.
EXHAUST	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.
SPAN 1	On units with zero/span/shutoff valves option installed, connect a gas line to the source of calibrated span gas here.
SPAN2/VENT	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	T101: On units with zero/span/shutoff valves option installed but no internal zero air scrubber, attach a gas line to the source of zero air here. T102: On Units with zero/span valve or IZS option installed, this port connects the zero air gas or the zero air cartridge to the analyzer.
RX TX	LEDs indicate receive (RX) and transmit (TX) activity when blinking.
COM 2	Serial communications port for RS-232 or RS-485.
RS-232	Serial communications port for RS-232 only.
DCE DTE	Switch to select either data terminal equipment or data communication equipment during RS-232 communication.
STATUS	For outputs to devices such as Programmable Logic Controllers (PLCs).
ANALOG OUT	For voltage or current loop outputs to a strip chart recorder and/or a data logger.
CONTROL IN	For remotely activating the zero and span calibration modes.
ALARM	Option for concentration alarms and system warnings.
ETHERNET	Connector for network or Internet remote communication, using Ethernet cable.
USB (option)	Connector for direct connection to laptop computer, using USB cable.
Model label	Includes voltage and frequency specifications.



**Figure 2-5. 501 TRS Rear Panel Layout**

**Table 2-3. 501 TRS Converter Rear Panel Description**

COMPONENT	FUNCTION
cooling fan	Pulls ambient air into chassis through side vents and exhausts through rear.
 AC power connector	Connector for three-prong cord to apply AC power to the analyzer. <b>CAUTION! The cord's power specifications (specs) MUST comply with the power specs on the analyzer's rear panel Model number label</b>
Model/specs label	Identifies the analyzer model number and provides power specs
FROM ANALYZER	Connect sample gas tubing coming from the T102 TO CONV port
TO ANALYZER	Connect sample gas tubing returning to the T102 FROM CONV port
ALARM	Connect input leads of alarm-sensing device



### 2.2.3. INTERNAL CHASSIS

This section shows the internal chassis configuration for the T101 in Figure 2-6, for the T102 in Figure 2-7, and for the 501 in Figure 2-8.

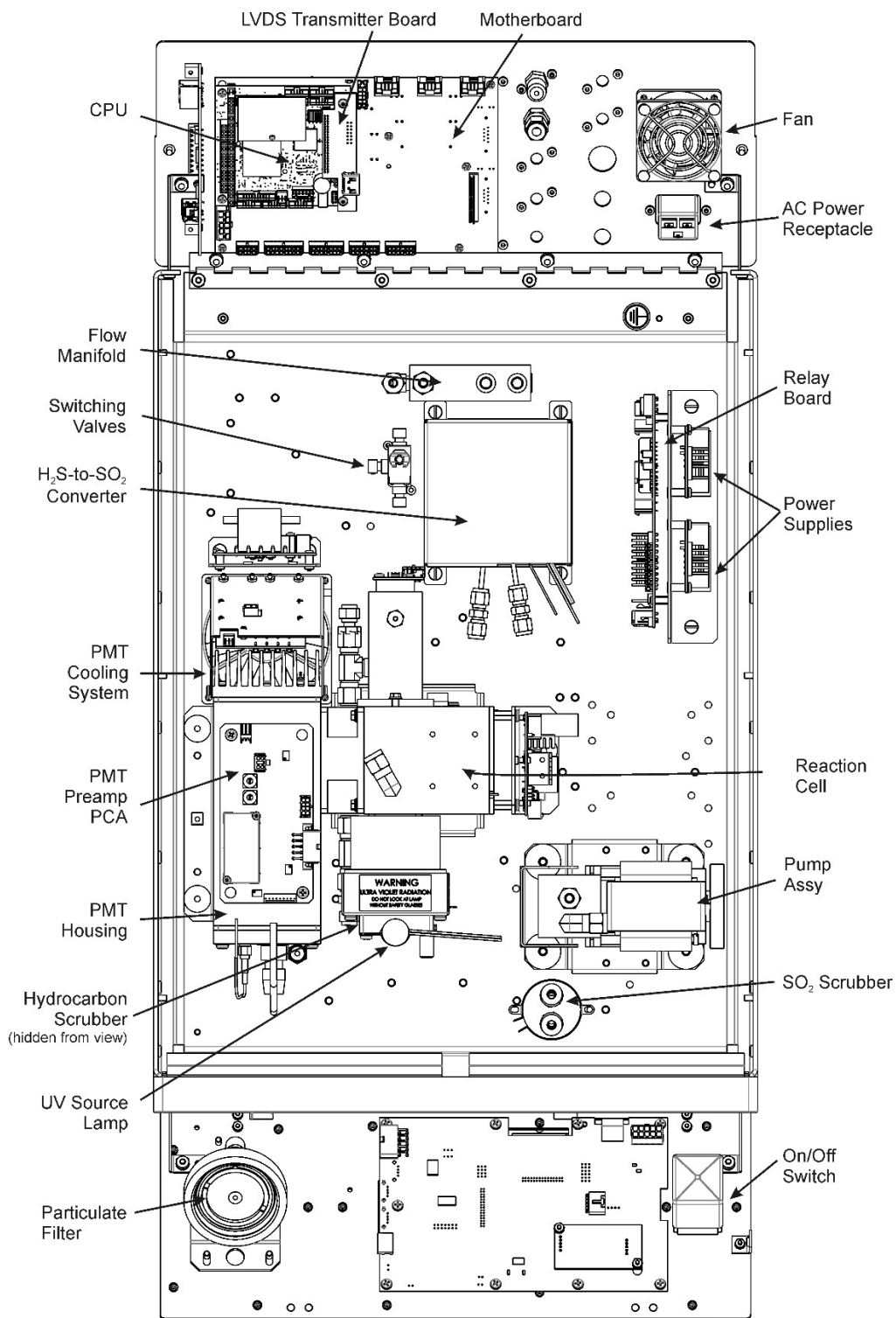


Figure 2-6. T101 Internal Chassis Layout



# T101, T102

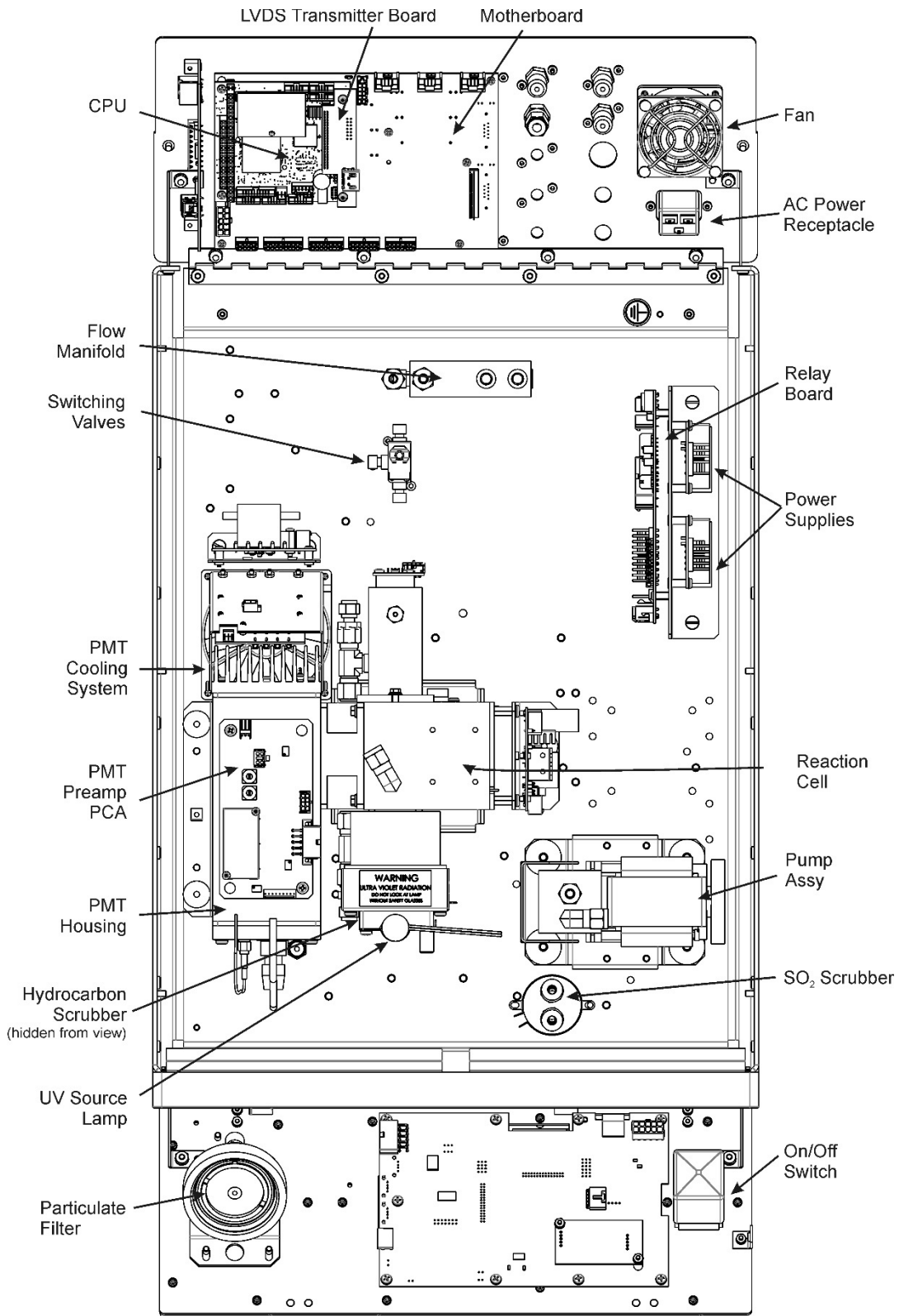


Figure 2-7. T102 Internal Chassis Layout



# T101, T102

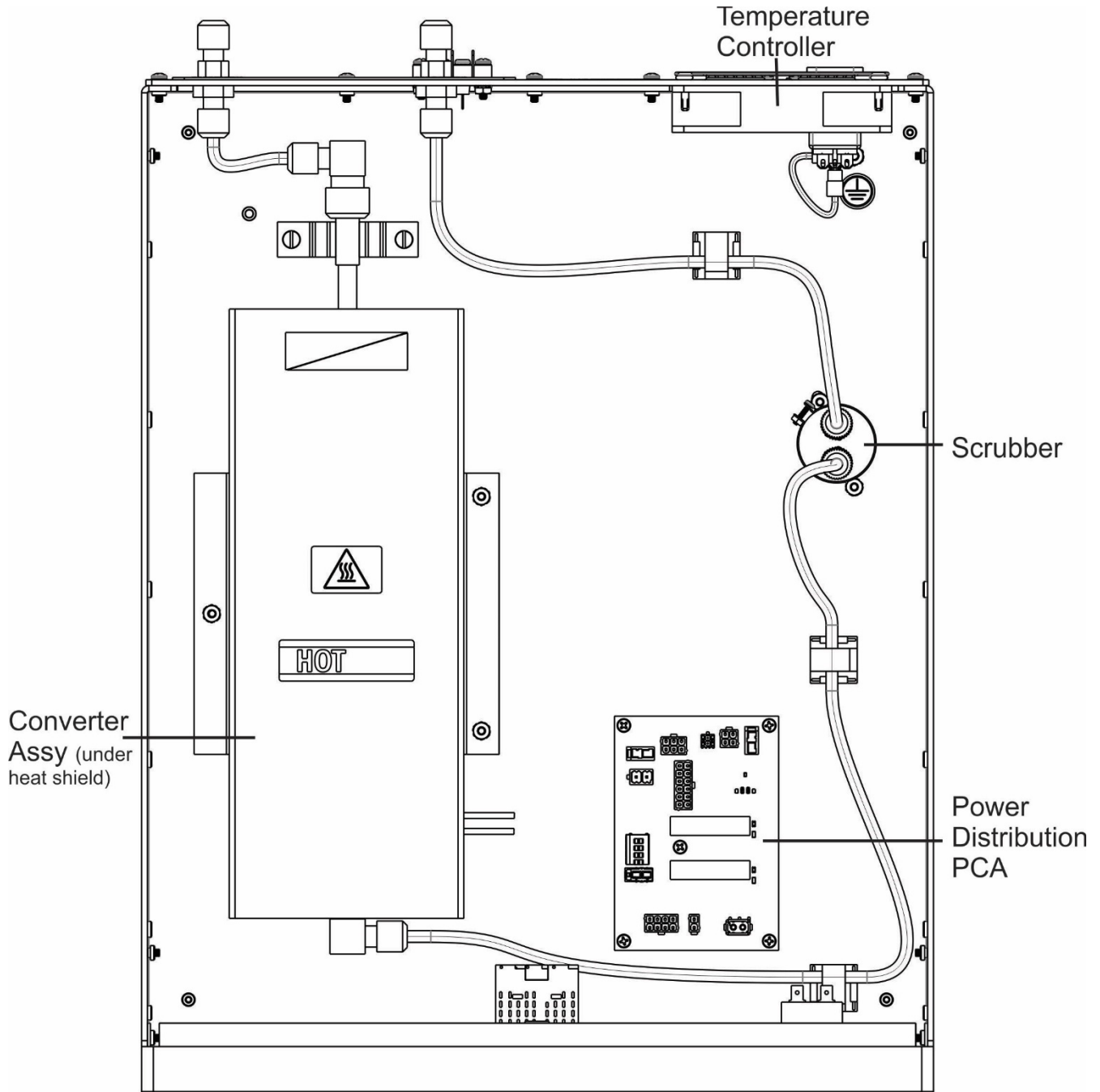


Figure 2-8. 501 Internal Chassis Layout



## 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).

### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Do not operate analyzer without first removing rear panel dust plugs from SAMPLE and EXHAUST port, and do not operate the converter without first properly connecting the ports to the T102 per the instructions for pneumatic connections.

### Note

Do not operate converter without top cover in place: otherwise, the thermal cutout may overheat and shut off the heating element. The air cooling required to stabilize the temperature of the converter tube is dependent on air flow patterns that exist only with the top cover in place.

## 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.

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.
- Never connect or disconnect electronic circuit boards, wiring, harnesses, or electronic subassemblies while unit is powered up.
- Power connection must have functioning ground connection.
- Do not defeat the ground wire on power plug.
- Do not operate with cover off.



#### CAUTION – Avoid Damage to the Instrument

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

### 2.3.1.1. CONNECTING POWER

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. It is important to

adhere to all safety and cautionary messages, and ensure that the outlet is equipped with a functioning earth ground.

### 2.3.1.2. CONNECTING ANALOG OUTPUTS

The rear panel Analog Output channels A1 through A4 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.

An optional Current Loop output (Section 2.3.1.3) is available for A1, A2 and A3 only.

To access these signals attach a strip chart recorder and/or data-logger to the appropriate analog output connections on the rear panel of the analyzer.

Configure through the Setup>Analog Outputs menu (Section 2.5.8)

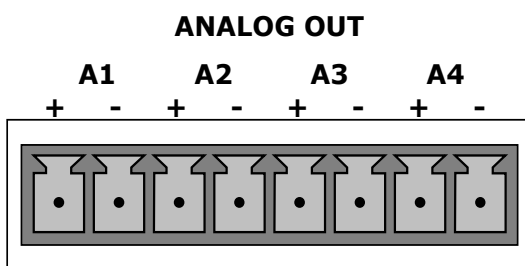


Figure 2-9. Analog Output Connector

Table 2-4. Analog Output Pin Assignments

PIN	ANALOG OUTPUT	SIGNAL OUT	STANDARD VOLTAGE OUTPUT	CURRENT LOOP OPTION
1	A1	User-selected through the Setup>Analog Outputs menu.	V +	I Out +
2			Ground	I Out -
3	A2		V +	I Out +
4			Ground	I Out -
3	A3		V +	I Out +
4			Ground	I Out -
7	A4		V +	Not Available
8			Ground	Not Available



### 2.3.1.3. CURRENT LOOP ANALOG OUTPUTS (OPTION 41) SETUP

If your analyzer had this option installed at the factory, there are no further connections to be made. Otherwise, it can be installed as a retrofit for each of the analog outputs. This option converts the DC voltage analog output to a current signal with 0-20 mA output current, which can be scaled to any set of limits within that 0-20 mA range. However, most current loop applications call for either 2-20 mA or 4-20 mA range. All current loop outputs have a +5% over-range. Ranges with the lower limit set to more than 1 mA (e.g., 2-20 or 4-20 mA) also have a -5% under-range.

Figure 2-10 provides installation instructions and illustrates a sample configuration of one current output combined with two voltage outputs. Next are instructions for converting current loop analog outputs to standard 0-to-5 VDC outputs. To calibrate or adjust these outputs use the Setup>Analog Outputs menu (Section 2.5.8).

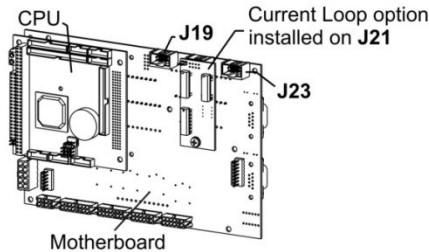
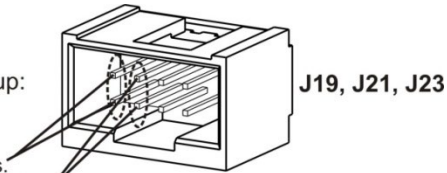


#### CAUTION – Avoid Invalidating Warranty

**Servicing or handling of circuit components requires electrostatic discharge protection, i.e. ESD grounding straps, mats and containers. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. For information on preventing ESD damage, refer to 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..**

J19, J21, J23 Analog Output Setup:

- For **voltage** output of any one, two, or all:
  1. Jumper two leftmost pins.
  2. Jumper next two leftmost pins.
  3. Calibrate per Analog I/O Configuration menu.
- For **current** output of any one, two, or all:
  1. Remove jumper shunts.
  2. Install Current Loop option.
  3. Calibrate per Analog I/O Configuration menu.



Example setup: install jumper shunts for voltage output on J19 and J23; remove jumper shunts and install Current Loop option for current output on J21.

**Figure 2-10. Current Loop Option Installed on the Motherboard**

## CONVERTING CURRENT LOOP ANALOG OUTPUTS TO STANDARD VOLTAGE OUTPUTS

To convert an output configured for current loop operation to the standard 0 to 5 VDC output operation:

1. Turn off power to the analyzer.
2. If a recording device is connected to the output being modified, disconnect it.
3. Remove the top cover.
  - Remove the set screw located in the top, center of the rear panel.
  - Remove the screws fastening the top cover to the unit (one per side).
  - Slide the cover back and lift the cover straight up.
4. Remove the screw holding the current loop option to the motherboard.
5. Disconnect the current loop option PCA from the appropriate connector on the motherboard (see Figure 2-10).
6. Each connector, J19 and J23, requires two shunts. Place one shunt on the two left most pins and the second shunt on the two adjacent pins (see Figure 2-10).
7. Return the top cover to the analyzer and secure.

The analyzer can now have a voltage-sensing recording device attached to that output.

### 2.3.1.4. CONNECTING THE STATUS OUTPUTS (DIGITAL OUTPUTS)

The 12-pin STATUS connector allows the digital status outputs to report analyzer conditions (configured through the Setup>Digital Outputs menu) via optically isolated NPN transistors that sink up to 50 mA of DC current. These outputs can be used to interface with devices that accept logic-level digital inputs, such as Programmable Logic Controllers (PLCs). Each status bit is an open collector output that can withstand up to 40 VDC. All of the emitters of these transistors are tied together and available at pin D (see Figure 2-11).

#### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Most PLC's have internal provisions for limiting the current that the input will draw from an external device. When connecting to a unit that does not have this feature, an external dropping resistor must be used to limit the current through the transistor output to less than 50 mA. At 50 mA, the transistor will drop approximately 1.2V from its collector to emitter.

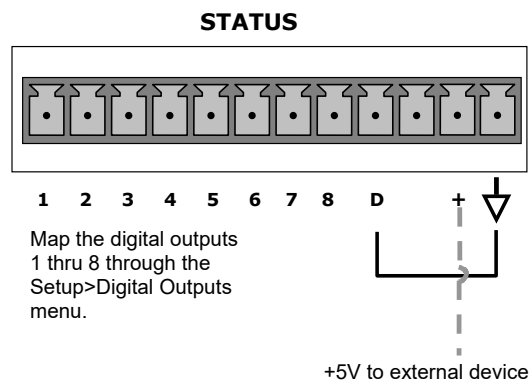


Figure 2-11. Status Output Connector for Digital Outputs

Table 2-5. Status Output Pin Assignments

PIN	STATUS DEFINITION	CONDITION
1-8	Configurable through the Setup>Digital Outputs menu	Collector side of individual status output opto-isolators.
D	Emitter BUS	The emitters of the transistors on pins 1 to 8 are bussed together.
Blank	NO CONNECTION	
+	DC Power	+ 5 VDC, 300 mA source maximum
↓	Digital Ground	The ground level from the analyzer's internal DC power supplies. This connection should be used as the ground return when +5VDC power is used.

### 2.3.1.5. CONNECTING THE CONTROL INPUTS (DIGITAL INPUTS)

With zero and span valves option installed, two digital control inputs in the rear panel CONTROL IN connector, can be used to remotely activate the zero and span calibration modes (see Section 5.2.2.1).

Energize the Control Inputs either by the internal +5V available from the pin labeled “+” (more convenient), or by a separate external 5 VDC power supply (ensures that these inputs are truly isolated). Refer to Figure 2-12.

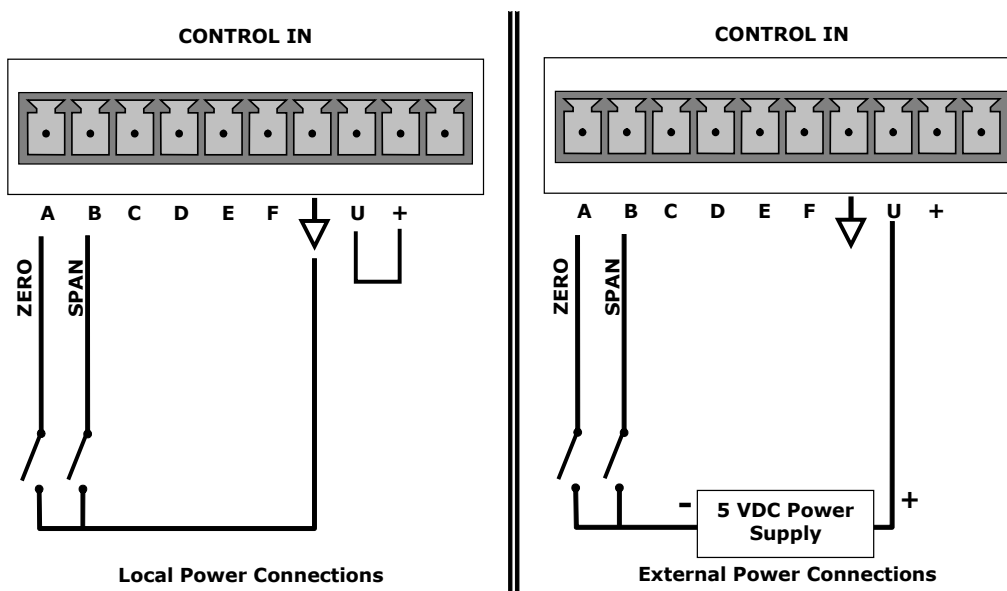



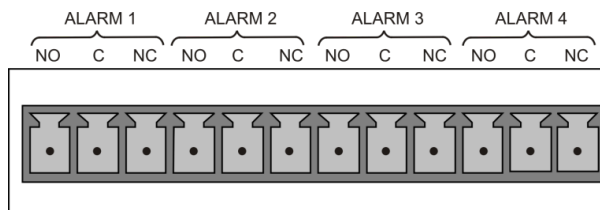
Figure 2-12. Energizing the Control Inputs

**Table 2-6. Control Input Pin Assignments**

INPUT #	STATUS DEFINITION	ON CONDITION
A	Remote Zero Cal	The analyzer is placed in Zero Calibration mode.
B	Remote Span Cal	The analyzer is placed in Span Calibration mode.
C, D, E & F	Spare	
	Digital Ground	The ground level from the analyzer's internal DC Power Supplies (same as chassis ground).
U	External Power input	Input pin for +5 VDC is required to activate pins A – F.
+	5 VDC output	Internally generated 5V DC power. To activate inputs A – F, place a jumper between this pin and the “U” pin. The maximum amperage through this port is 300 mA (combined with the analog output supply, if used).

### 2.3.1.6. ANALYZER CONCENTRATION ALARM RELAY (OPTION 61)

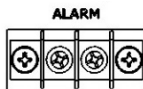
The concentration relay option provides four (4) “dry contact” relays on the rear panel (Figure 2-13), each with 3 pins: Common (C), Normally Open (NO), and Normally Closed (NC). The Relays can be mapped to reflect various internal instrument conditions and states. Configure these outputs through the Setup>Digital Outputs menu (Section 2.5.7) under MB Relay [1 thru 4].



**Figure 2-13. Analyzer Concentration Alarm Relay**

### 2.3.1.7. TRS CONVERTER ALARM

The rear panel of the 501-TRS includes a terminal strip by which connections can be made to the converter's internal temperature alarm.



**Figure 2-14. Converter Alarm Output Connector**

- Connect the input leads of your alarm-sensing device (e.g. datalogger) to the center two pins of the alarm output connector (Figure 2-14).
- Make sure the load does not exceed the rated capacity of the relay.



## 2.3.1.8. CONNECTING COMMUNICATIONS INTERFACES

### ETHERNET CONNECTION

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

**Configuration:** Section 2.5.10.5

### USB (OPTION) CONNECTION

The rear panel USB option is for direct communication between the analyzer and a PC. Connect a USB cable between the analyzer and a computer USB port. Computer and instrument baud rates must match.

**Note**

**If this option is installed, the rear panel RS232 (COM2) port cannot be used for anything other than RS-232 Multidrop communication.**

### RS-232 CONNECTION

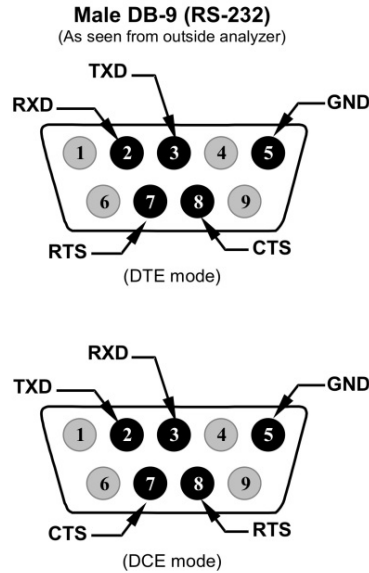
For RS-232 communications with data terminal equipment (DTE) or with data communication equipment (DCE) connect either a DB9-female-to-DB9-female cable (Teledyne API part number WR000077) or a DB9-female-to-DB25-male cable (Option 60A), as applicable, from the analyzer's RS-232 port (see Figure 2-15 for connector pin assignments) to the device. Adjust the rear panel DCE-DTE switch to select DTE or DCE as appropriate (Section 3.1).

**Configuration:** Section 3.2.1 and Section 3.5.2 (for Hessen protocol)

**Important**

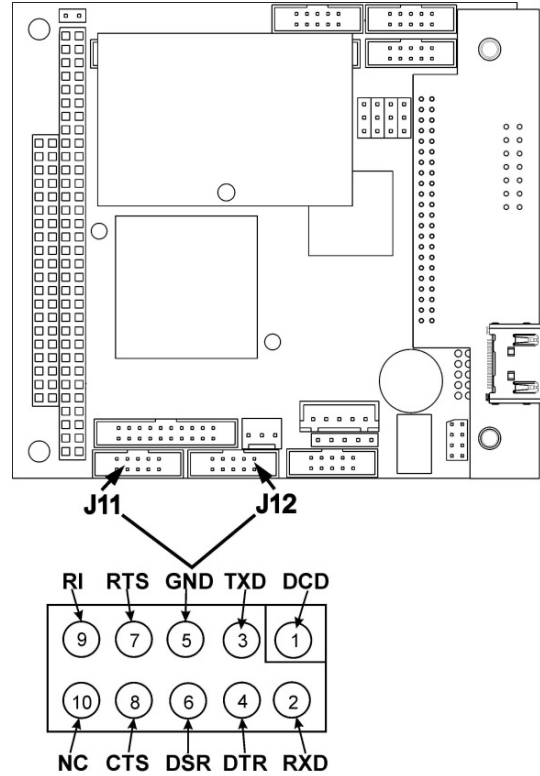
**IMPACT ON READINGS OR DATA**

Cables that appear to be compatible because of matching connectors may incorporate internal wiring that makes the link inoperable. Check cables acquired from sources other than Teledyne API for pin assignments (Figure 2-15) before using.



**Figure 2-15. Rear Panel Connector Pin-Outs for RS-232 Mode**

The signals from these two connectors are routed from the motherboard via a wiring harness to two 10-pin connectors on the CPU card, J11 and J12 (Figure 2-16).



**Figure 2-16. Default Pin Assignments for CPU COM Port Connector (RS-232)**

Teledyne API offers two mating cables, one of which should be applicable for your use.

- P/N WR000077, a DB-9 female to DB-9 female cable, 6 feet long. Allows connection of the serial ports of most personal computers.
- P/N WR000024, a DB-9 female to DB-25 male cable. Allows connection to the most common styles of modems (e.g. Hayes-compatible) and code activated switches.

Both cables are configured with straight-through wiring and should require no additional adapters.

**Note**

**Cables that appear to be compatible because of matching connectors may incorporate internal wiring that makes the link inoperable. Check cables acquired from sources other than Teledyne API for pin assignments before using.**

To assist in properly connecting the serial ports to either a computer or a modem, there are activity indicators just above the RS-232 port. Once a cable is connected between the analyzer and a computer or modem, both the red and green LEDs should be on.

- If the lights are not lit, locate the small switch on the rear panel to switch it between DTE and DCE modes.
- If both LEDs are still not illuminated, ensure that the cable properly constructed.

Received from the factory, the analyzer is set up to emulate an RS-232 DCE device. (View these parameters in the Setup>Comm>COM1[COM2] menu).

**RS-232 (COM1):** RS-232 (fixed) DB-9 male connector

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

**COM2:** RS-232 (configurable to RS 485), DB-9 female connector

- **Baud rate:** 19200 bits per second (baud)
- **Data Bits:** 8 data bits with 1 stop bit
- **Parity:** None

### RS-232 MULTIDROP (OPTION 62) CONNECTION

When the RS-232 Multidrop option is installed, connection adjustments and configuration through the menu system are required. This section provides instructions for the internal connection adjustments, then for external connections, and ends with instructions for menu-driven configuration.

#### Note

**Because the RS-232 Multidrop option uses both the RS232 and COM2 DB9 connectors on the analyzer's rear panel to connect the chain of instruments, COM2 port is no longer available for separate RS-232 or RS-485 operation.**

#### ATTENTION

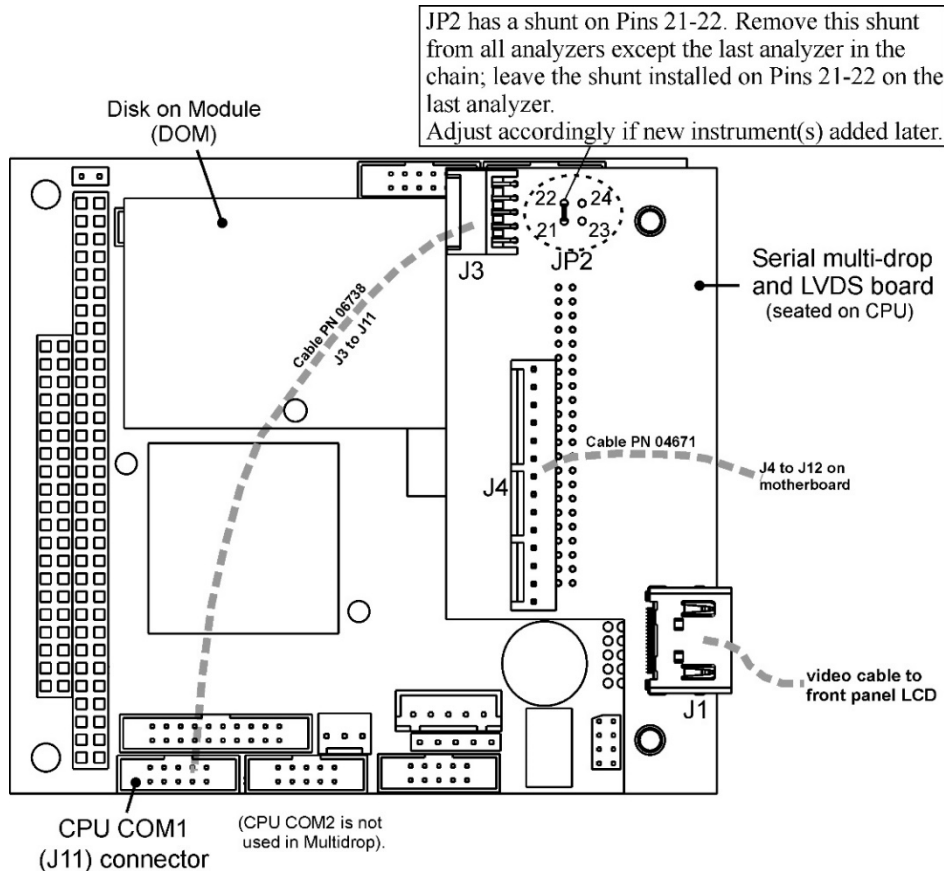
#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

**Printed Circuit Assemblies (PCAs) are sensitive to electro-static discharges too small to be felt by the human nervous system. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. For information on preventing ESD damage, refer to 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.**

In each instrument with the Multidrop option there is a shunt jumpering two pins on the serial Multidrop and LVDS printed circuit assembly (PCA), as shown in Figure 2-17. This shunt must be removed from all instruments except that designated as last in the multidrop chain, which must remain terminated. This requires powering off and opening each instrument and making the following adjustments:

1. With **NO power** to the instrument, remove its top cover and lay the rear panel open for access to the Multidrop/LVDS PCA, which is seated on the CPU.
2. On the Multidrop/LVDS PCA's JP2 connector, remove the shunt that jumpers Pins 21 ↔ 22 as indicated in. (Do this for all but the last instrument in the chain where the shunt should remain at Pins 21 ↔ 22).

3. Check that the following cable connections are made in *all* instruments (again refer to Figure 2-17):
  - J3 on the Multidrop/LVDS PCA to the CPU's COM1 connector (Be aware that the CPU's COM2 connector is not used in Multidrop)
  - J4 on the Multidrop/LVDS PCA to J12 on the motherboard
  - J1 on the Multidrop/LVDS PCS to the front panel LCD

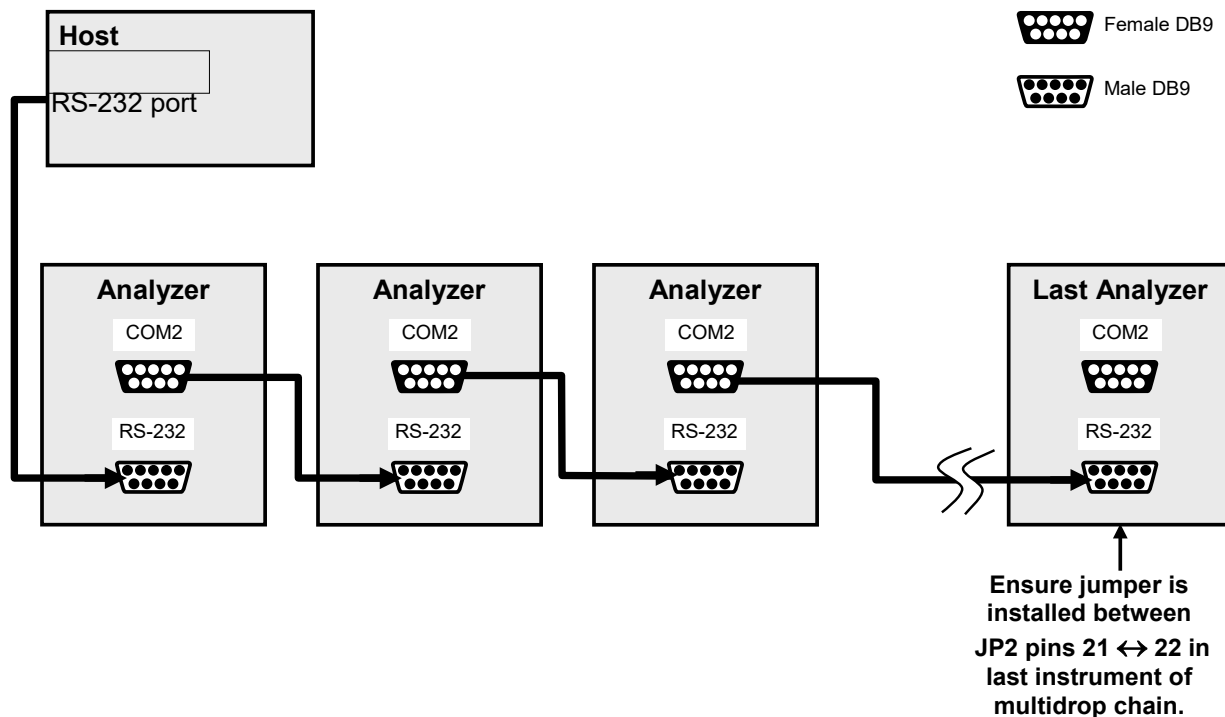


**Figure 2-17. Jumper and Cables for Multidrop Mode**

**Note**

If you are adding an instrument to the end of a previously configured chain, remove the shunt between Pins 21 □ 22 of JP2 on the Multidrop/LVDS PCA in the instrument that was previously the last instrument in the chain.

4. Close the instrument.
5. Referring to Figure 2-18 use straight-through DB9 male → DB9 female cables to interconnect the host RS232 port to the first analyzer's RS232 port; then from the first analyzer's COM2 port to the second analyzer's RS232 port; from the second analyzer's COM2 port to the third analyzer's RS232 port, etc., connecting in this fashion up to eight analyzers, subject to the distance limitations of the RS-232 standard.
6. On the rear panel of each analyzer, adjust the DCE DTE switch so that the green and the red LEDs (RX and TX) of the COM1 connector (labeled RS232) are both lit. (Ensure you are using the correct RS-232 cables internally wired specifically for RS-232 communication; see Figure 2-16).



**Figure 2-18. RS-232 Multidrop PCA Option Host/Analyzer Interconnect Diagram**

7. BEFORE communicating from the host, power on the instruments and check that the user-selectable Instrument ID is unique for each: in the Setup>Vars menu, check Instrument ID in the list of variables. To change, highlight the variable and press the Edit button; once changed, press the Enter button.
8. Next, in the Setup>Comm>COM1 menu (do not use the COM2 menu for multidrop), use the Edit button to set COM1 Quiet Mode and COM1 Multidrop to ENABLED; then press the Accept button.
9. Also check the COM1 Baud Rate to ensure it reads the same for all instruments (edit if needed and press the Accept button).

**Note** The (communication) Host instrument can address only one instrument at a time, each by its unique ID (see step 7 above).

**Note** Teledyne API recommends setting up the first link, between the Host and the first analyzer, and testing it before setting up the rest of the chain.

## 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.

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

**CAUTION – General Safety Hazard**



- Sulfur Dioxide (SO<sub>2</sub>) 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 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.
- 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 6.6.2 for instructions on how to remove the permeation tube when the unit is not in operation).

**ATTENTION**

**COULD DAMAGE INSTRUMENT AND VOID WARRANTY**

**Vent Pressurized Gas:**

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

**Remove Dust Plugs:**

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

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

**Important**

**IMPACT ON READINGS OR DATA**

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

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

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

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

**Tubing:**

- PTFE or glass material (do not use FEP or stainless steel materials)
- 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):

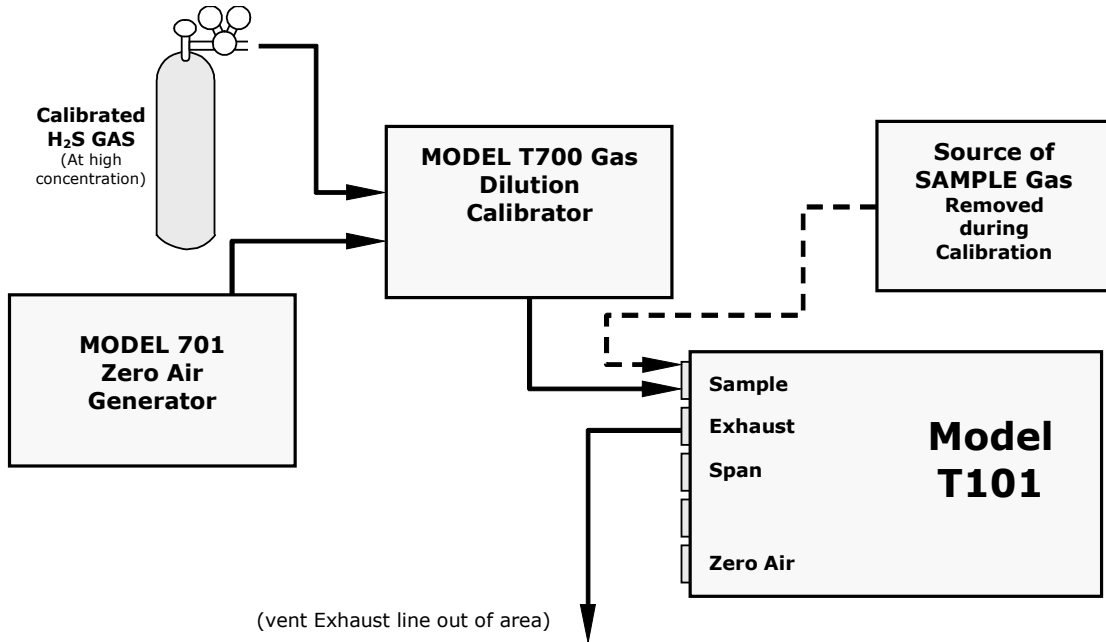
- Run tubing outside the enclosure or at least away from immediate area surrounding the instrument.

**Exhaust Outlet:**

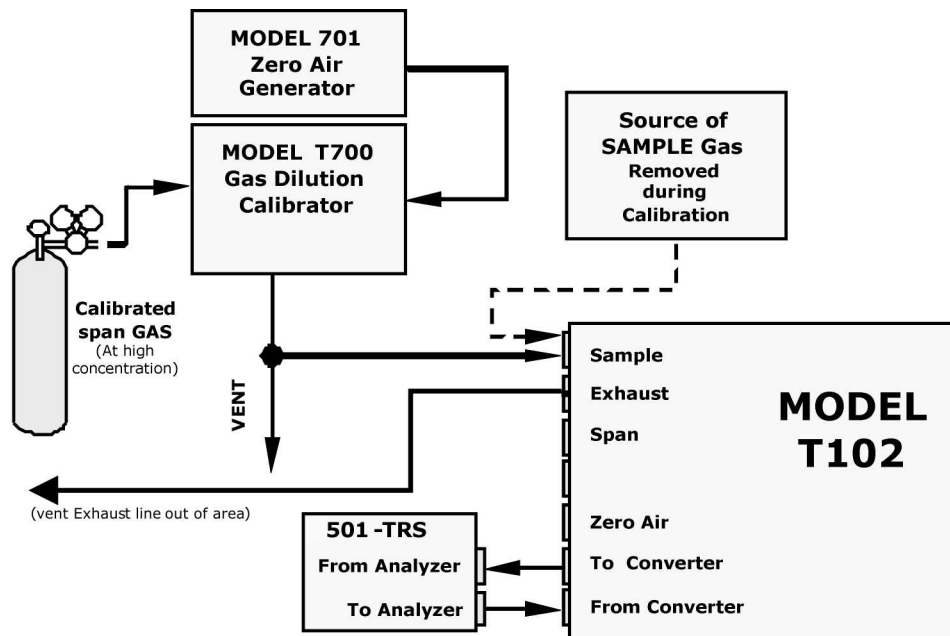
- Run tubing outside the enclosure.

### 2.3.2.2. BASIC CONNECTIONS USING GAS DILUTION CALIBRATOR

Figure 2-19 and Figure 2-21 illustrate pneumatic connections for two of the possible basic configurations.



**Figure 2-19. T101 Pneumatic Connections from Gas Dilution Calibrator – Basic Configuration**



**Figure 2-20. T102/501 Pneumatic Connections from Gas Dilution Calibrator – Basic Configuration**

### 2.3.2.3. BASIC CONNECTIONS USING BOTTLED SPAN GAS

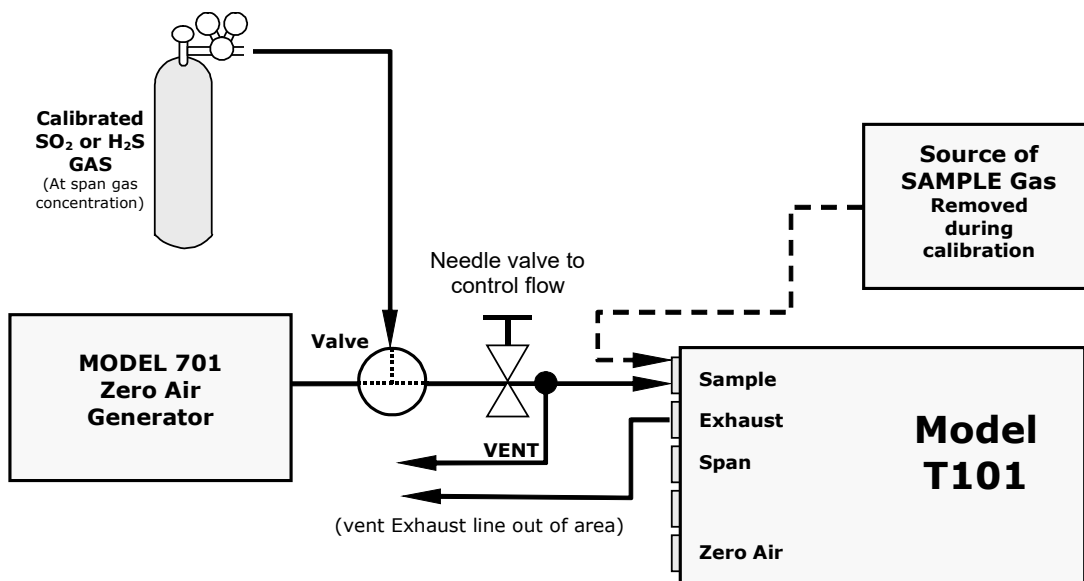


Figure 2-21. T101 Pneumatic Connections from Bottled Span Gas – Basic Configuration

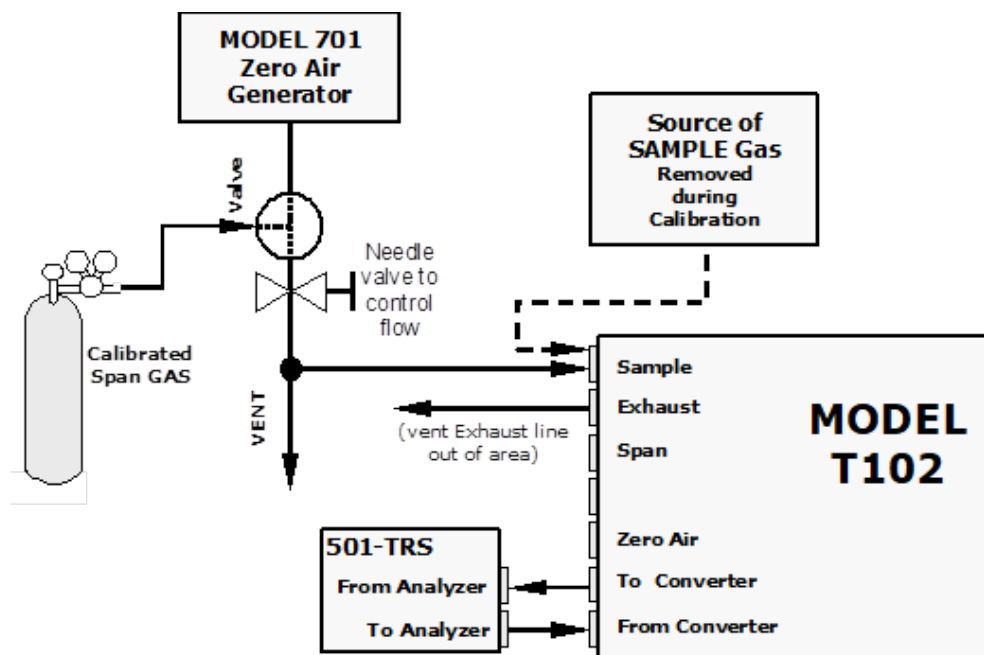


Figure 2-22. T102/501 Pneumatic Connections from Bottled Span Gas – Basic Configuration

For the analyzer’s basic configuration, in addition to tubing, pressure, venting, and exhaust requirements set out in Section 2.3.2.1, ensure the following:

#### 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

Connect exhaust line made of PTFE 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.

## CALIBRATOR VENTING

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

### 2.3.2.4. CONNECTIONS W/AMBIENT ZERO/AMBIENT SPAN (Z/S) VALVES (OPT 50A)

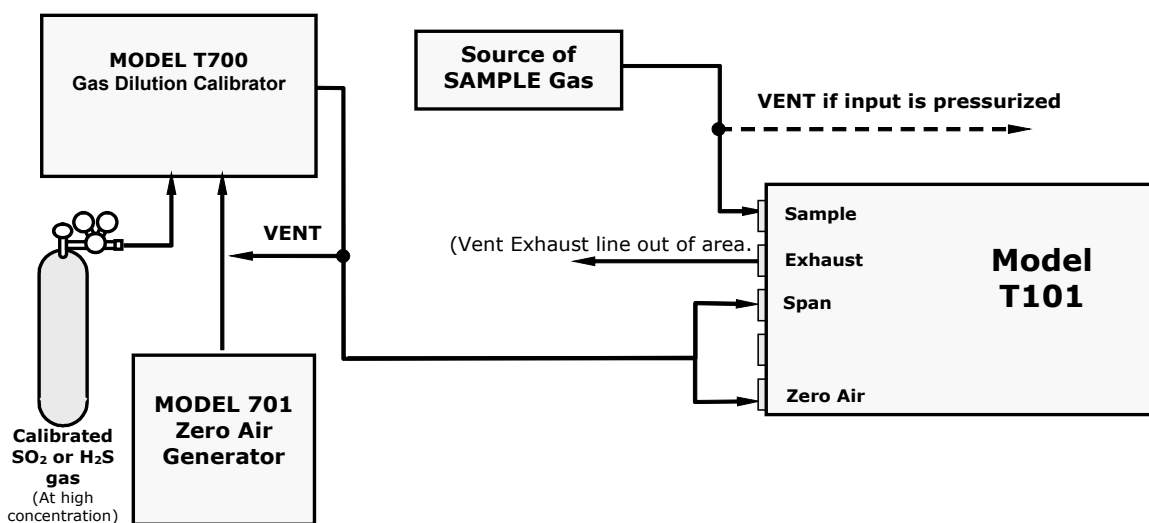


Figure 2-23. T101 Connections with Ambient Zero, Ambient Span Valves (Z/S) Option 50A

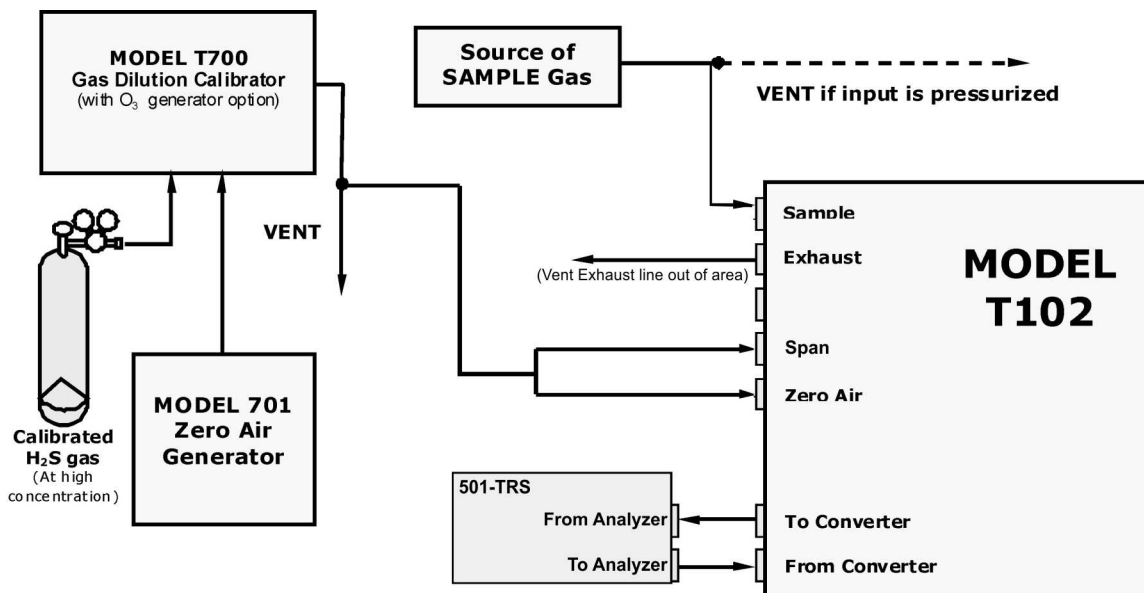


Figure 2-24. T102/501 Connections with Ambient Zero, Ambient Span Valves (Z/S) Option 50A

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 M701. Attach a gas line from the source of zero air to the ZERO AIR inlet.

## VENTING

Vent both the span gas and zero air supply lines.

### 2.3.2.5. ZERO SCRUBBER AND INTERNAL SPAN SOURCE (IZS) (OPT 50G)

#### ATTENTION

**COULD DAMAGE INSTRUMENT AND VOID WARRANTY**  
 Gas flow must be maintained at all times for units with IZS Options installed. The IZS option requires a permeation tube (customer supplied) which emits H<sub>2</sub>S. Insufficient gas flow can build up H<sub>2</sub>S to levels that will damage the instrument.

Remove the permeation device when taking the analyzer out of operation.

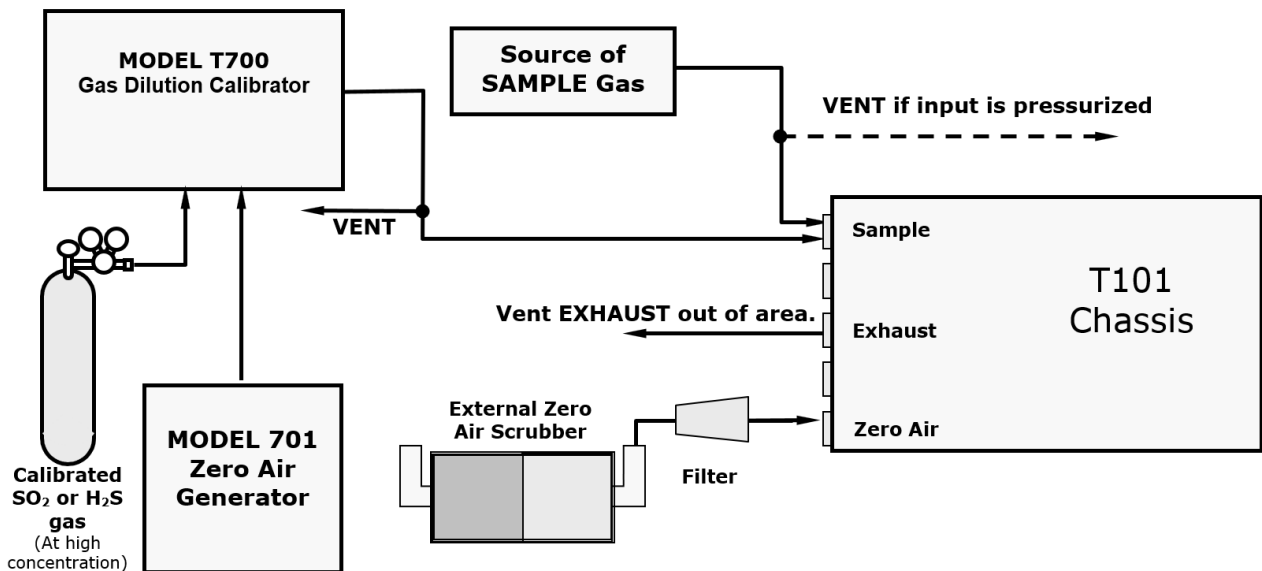


Figure 2-25. T101 Connections with Zero Scrubber and Internal Span Source (IZS) Option 50G

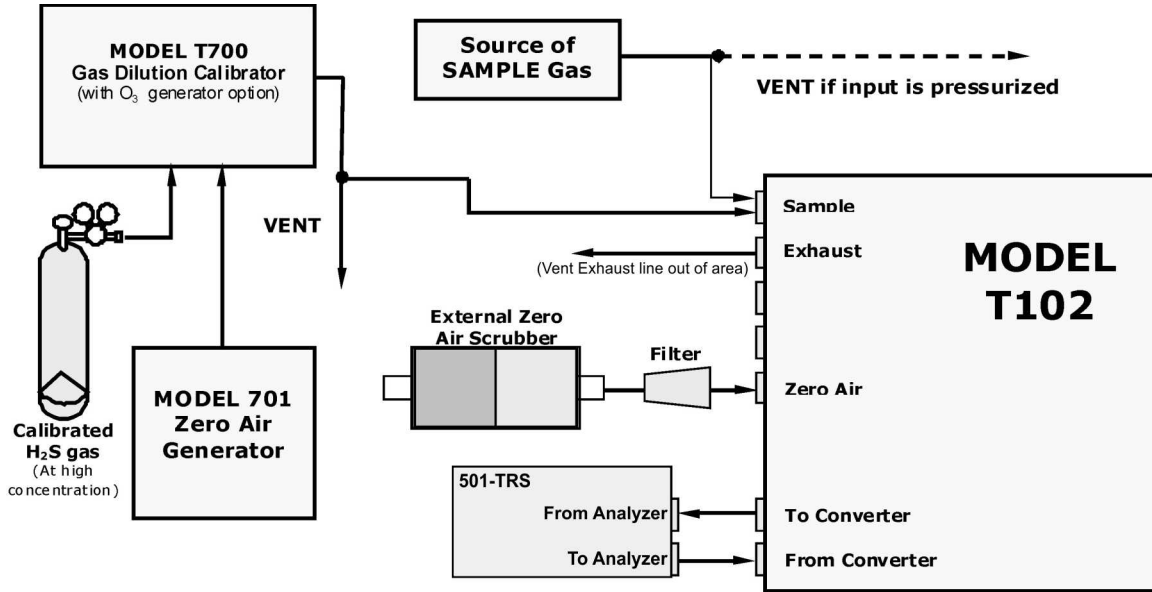


Figure 2-26. T102/501 Connections w/Zero Scrubber and Internal Span Source (IZS) Option 50G

### 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

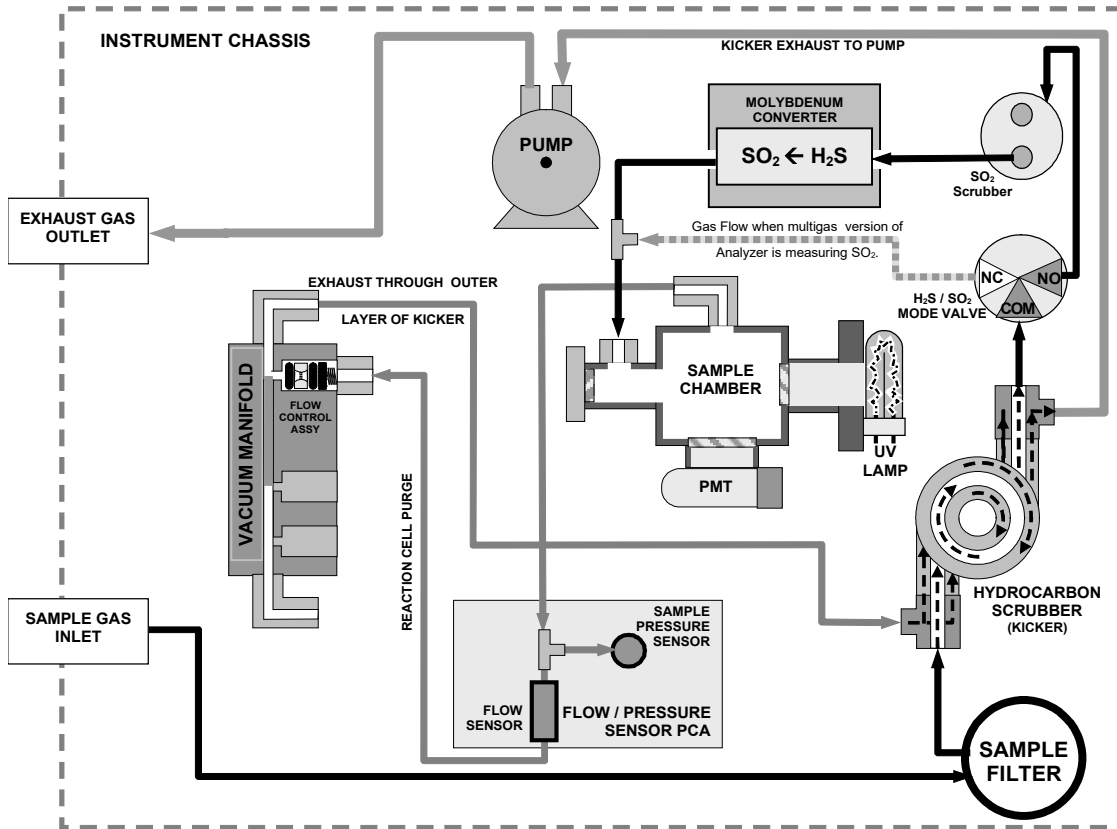


Figure 2-27. T101 Pneumatics, Basic Configuration

Table 2-7. T101 Basic Valve Operating States

GAS MODE	CONDITION OF H <sub>2</sub> S–SO <sub>2</sub> SWITCHING VALVE	VALVE PORT CONNECTION
H <sub>2</sub> S	Open to SO <sub>2</sub> Scrubber and Molybdenum Converter	COM → NO
SO <sub>2</sub>	Open to directly to Sample Chamber. Bypasses SO <sub>2</sub> Scrubber and Molybdenum Converter	COM → NC
H <sub>2</sub> S –SO <sub>2</sub>	Switches between above two states every 10 minutes.	--

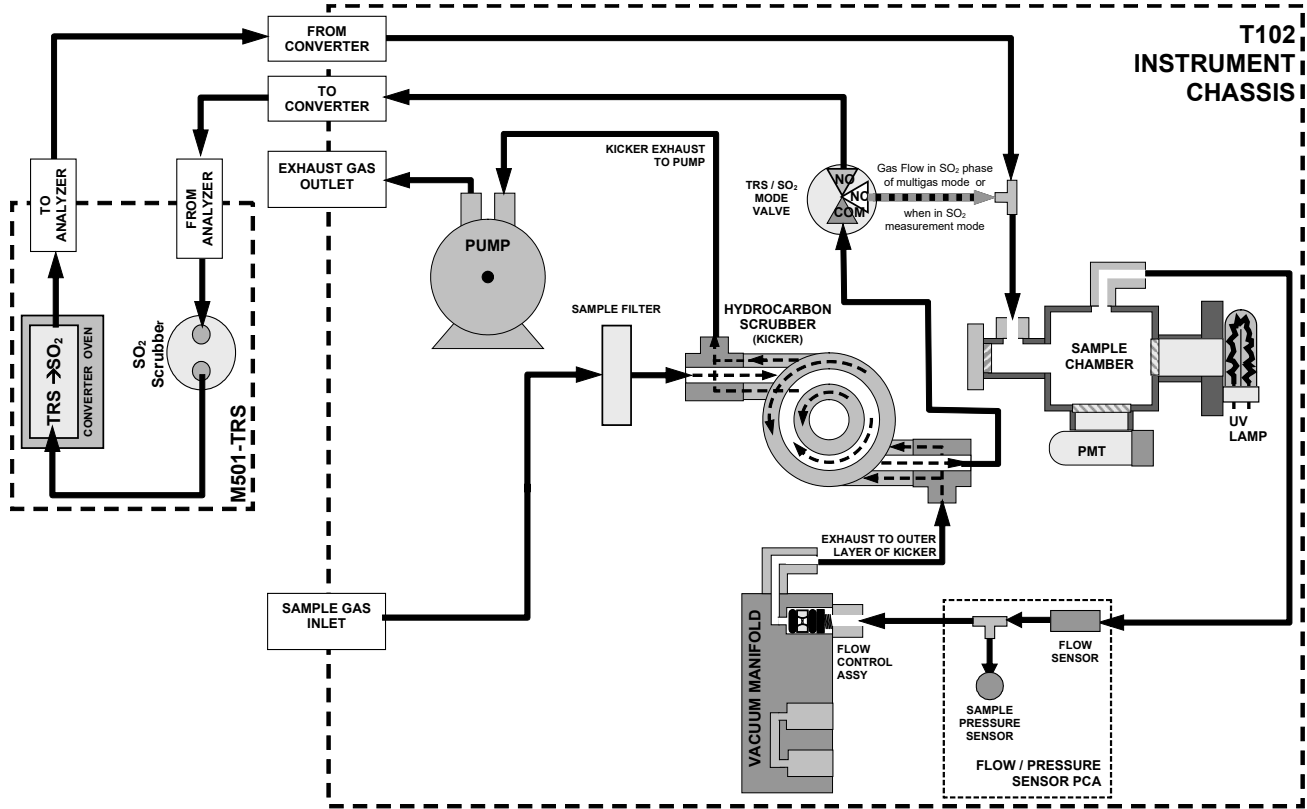


Figure 2-28. T102/501TRS Pneumatics, Basic Configuration

Table 2-8. T101 Basic Valve Operating States

GAS MODE	CONDITION OF H <sub>2</sub> S –SO <sub>2</sub> SWITCHING VALVE	VALVE PORT CONNECTION
TRS	Open to TRS Converter	COM → NO
SO <sub>2</sub>	Open to Sample Chamber	COM → NC
TRS –SO <sub>2</sub>	Switches between above two states every 10 minutes.	--

### 2.3.3.2. PNEUMATIC FLOW FOR ZERO/SPAN VALVES OPTION

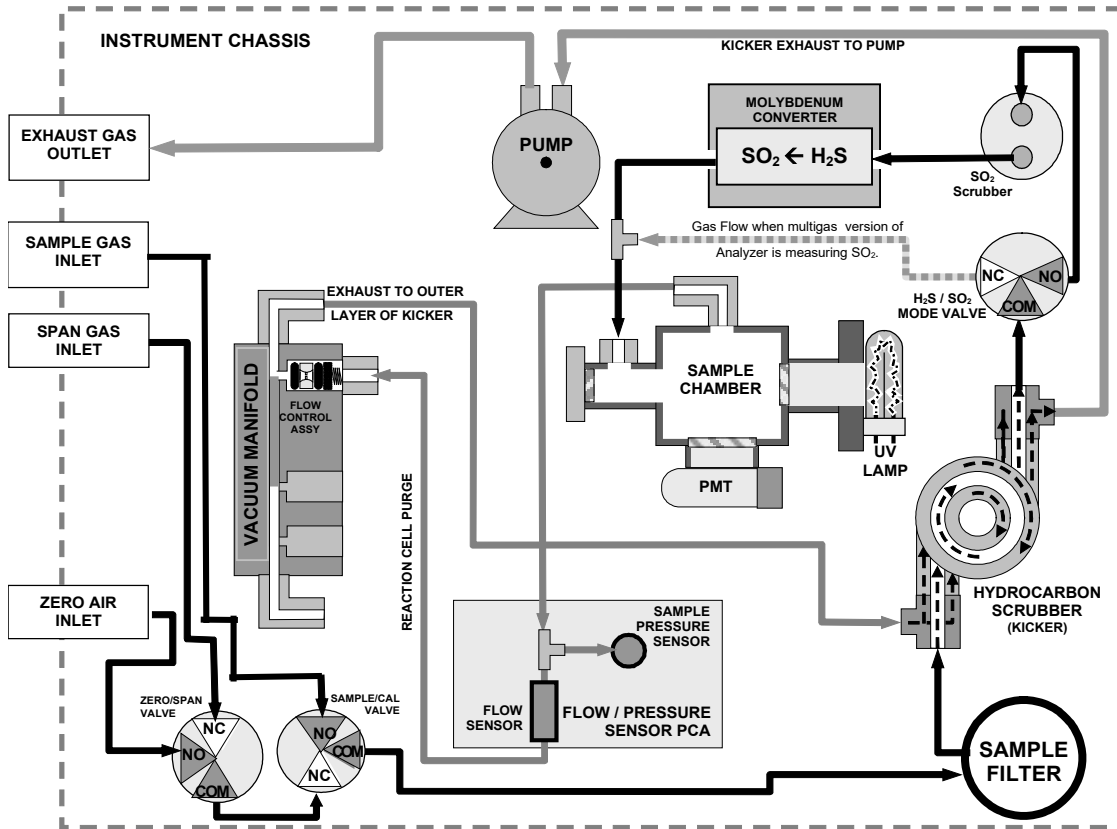


Figure 2-29. T101 Pneumatics with Zero/Span Valves Option

Table 2-9. 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

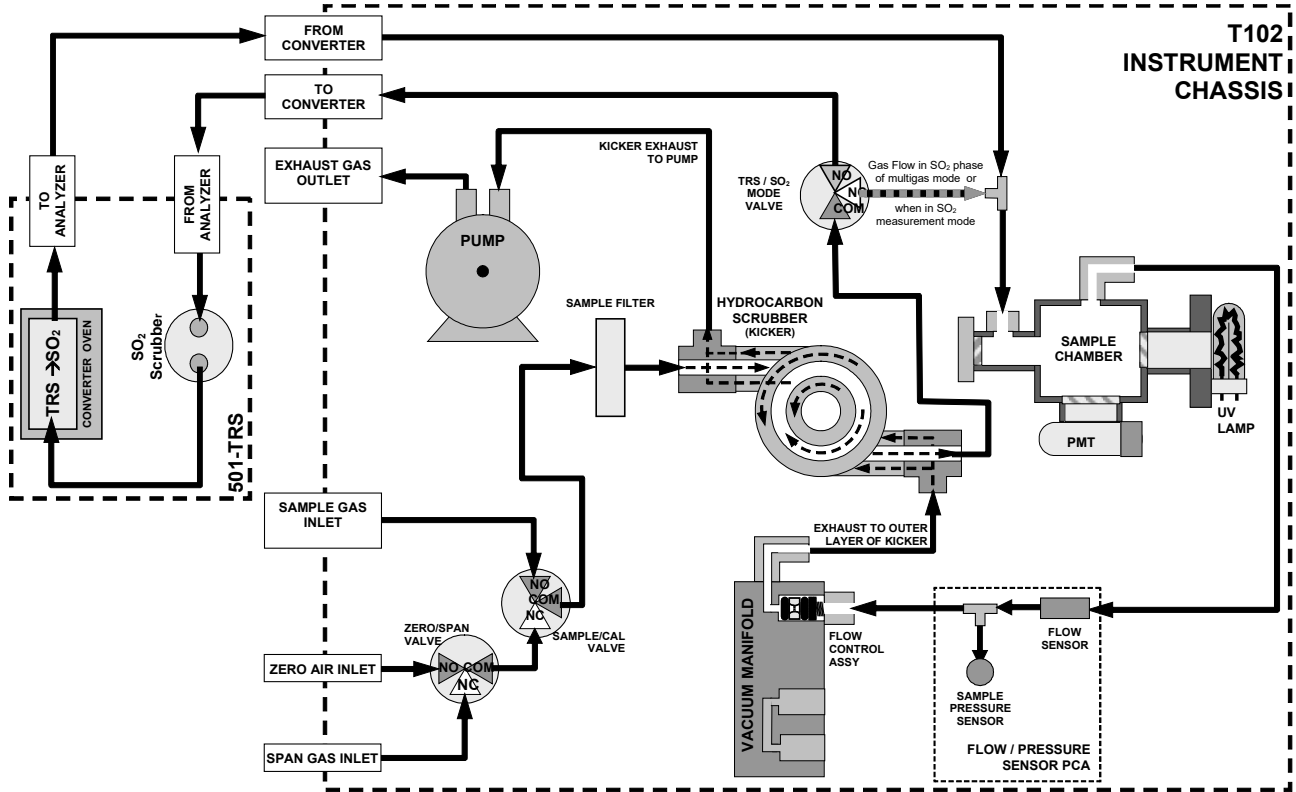


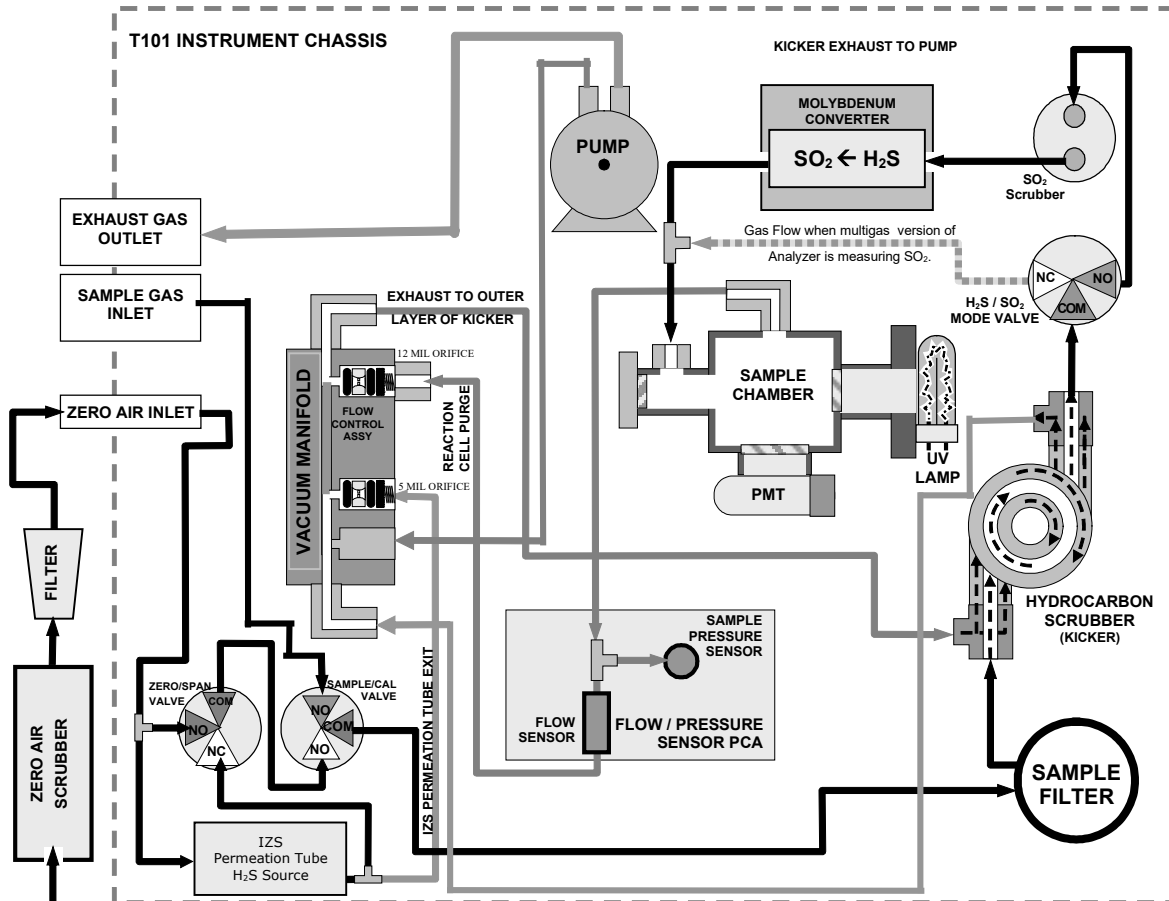
Figure 2-30. T102/501 Pneumatics with Zero/Span Valves Option

Table 2-10. Zero/Span and Sample/Cal Valve Operating States

MODE	VALVE	CONDITION	VALVE PORT CONNECTION
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 inlet	NC → COM
	Zero/Span	Open to ZERO AIR inlet	NO → COM
SPAN CAL	Sample/Cal	Open to zero/span inlet	NC → COM
	Zero/Span	Open to SPAN GAS inlet	NC → COM

### 2.3.3.3. PNEUMATIC FLOW FOR INTERNAL ZERO/SPAN (IZS) GAS GENERATOR OPTION

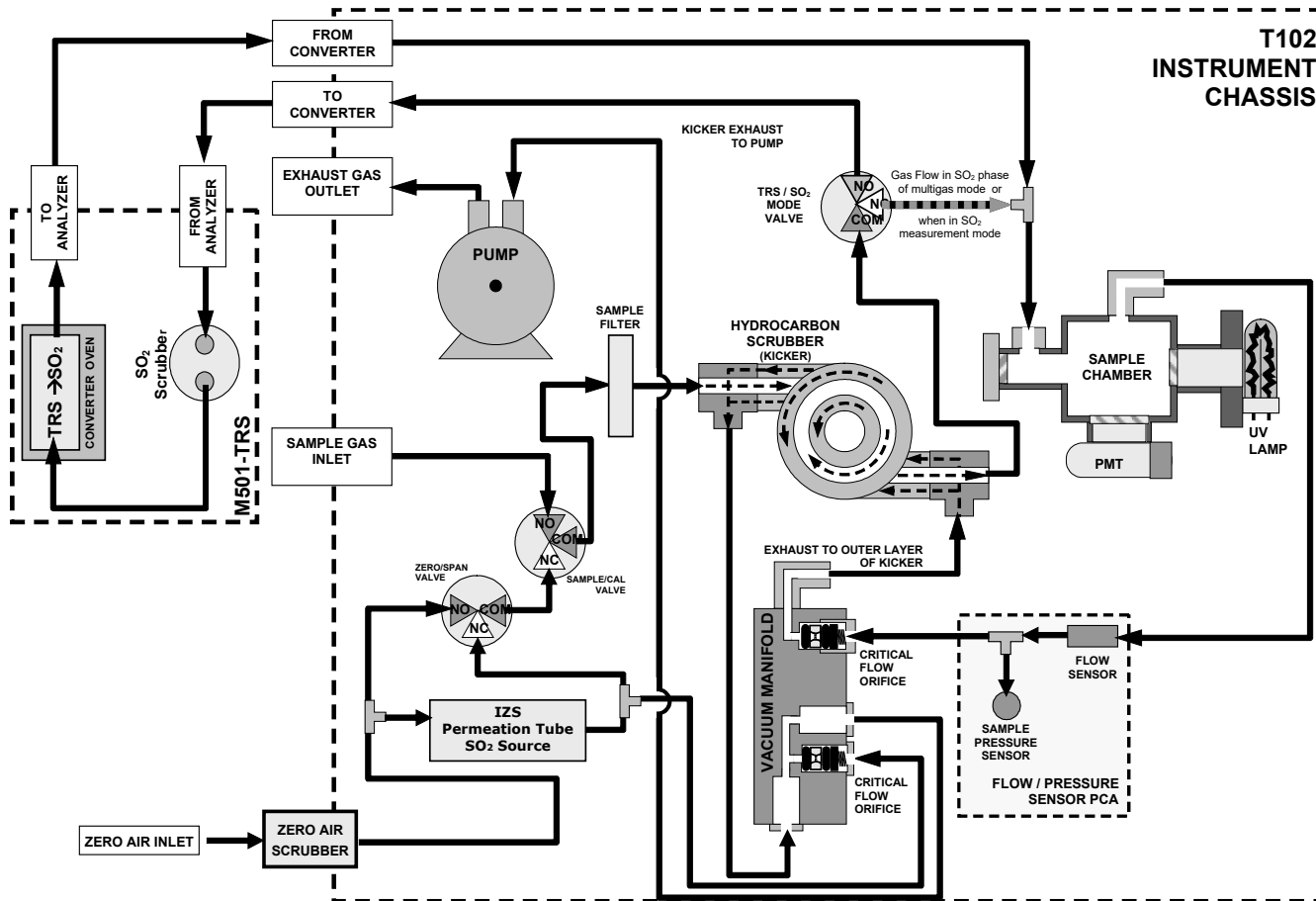
**Note** The permeation tube is not included in the IZS Option and must be ordered separately.



**Figure 2-31. T101 Pneumatics with IZS Option**

**Table 2-11. 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



**Figure 2-32. T102 Pneumatics with IZS Option**

**Table 2-12. IZS Valve Option Operating States**

MODE	VALVE	CONDITION	VALVE PORT CONNECTIONS
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

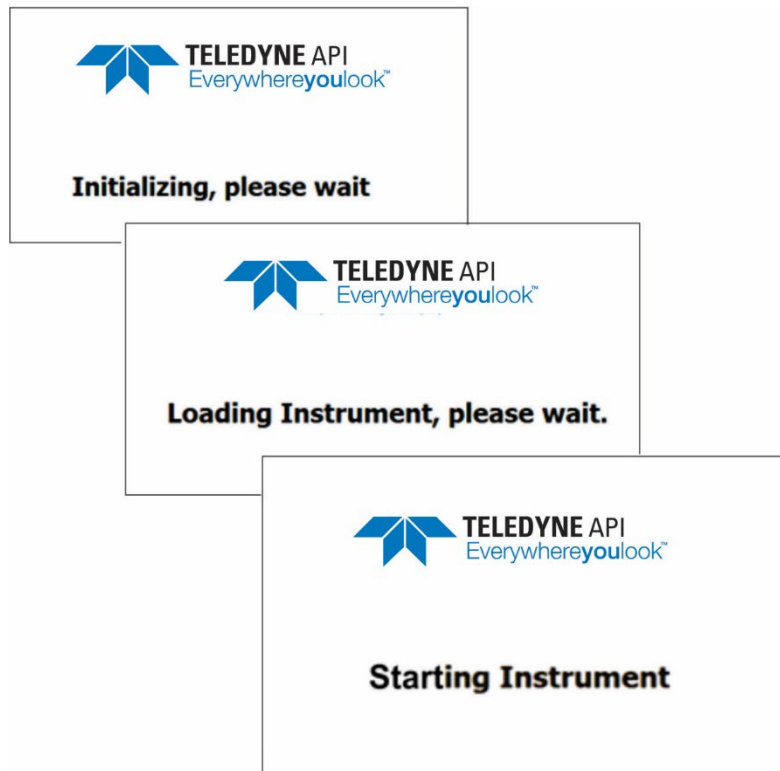
### 2.3.4. STARTUP, FUNCTIONAL CHECKS AND CALIBRATION

We recommend reading Section 7 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.

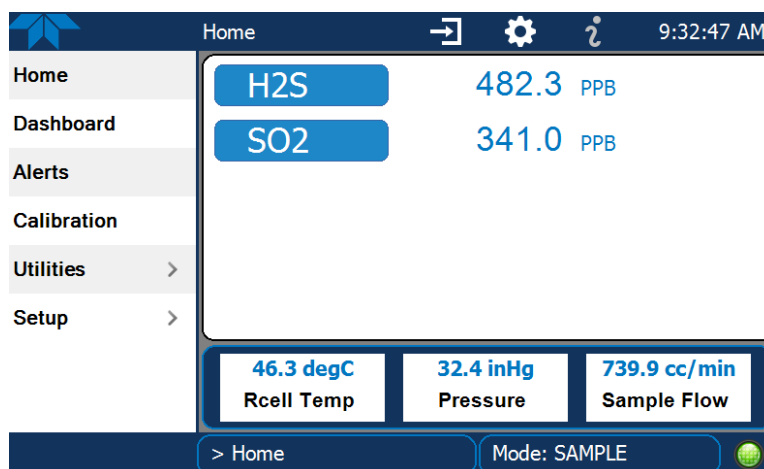
### 2.3.4.1. STARTUP

Upon initial startup of analyzers, a sequence of status screens (Figure 2-33) appear prior to the Home page (Figure 2-35).

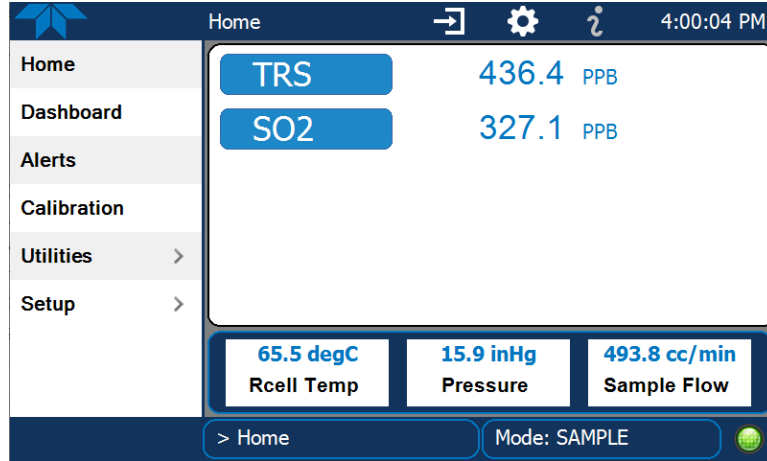


**Figure 2-33. Status Screens at Startup**

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



**Figure 2-34. T101 Typical Home Page**



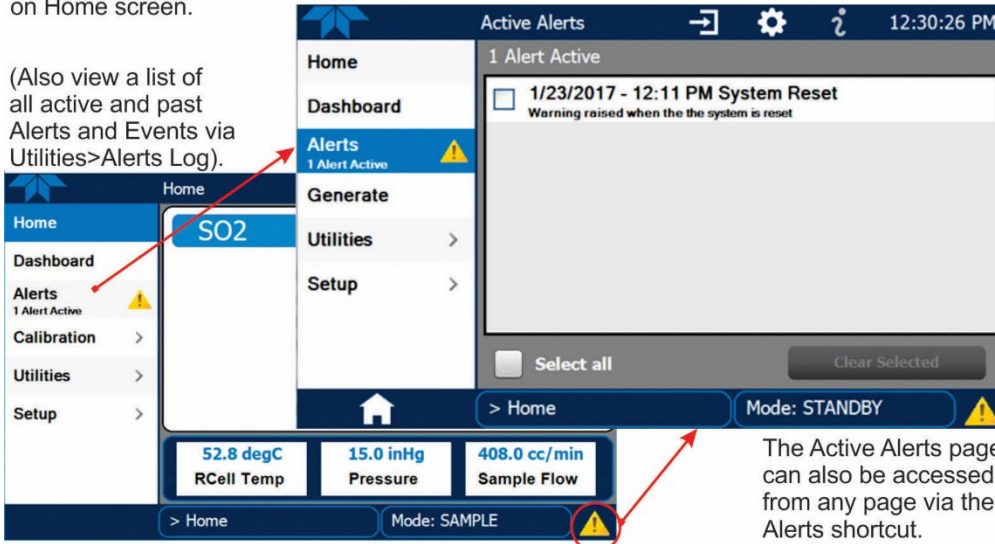
**Figure 2-35. T102 Typical Home Page**

### 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 2-36) 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.



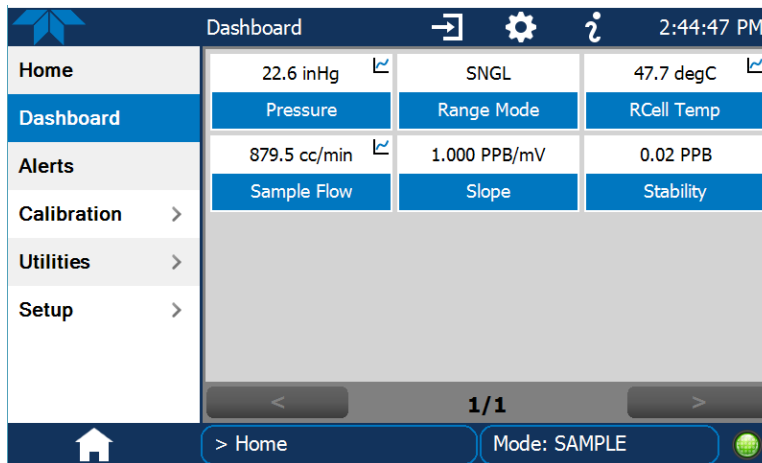
**Figure 2-36. Viewing Active Alerts Page**

If alerts of warning conditions persist after the warm up period or after being cleared, investigate their cause using the troubleshooting guidelines in Section 6.7.

### 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 6.7.2).



**Figure 2-37. 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

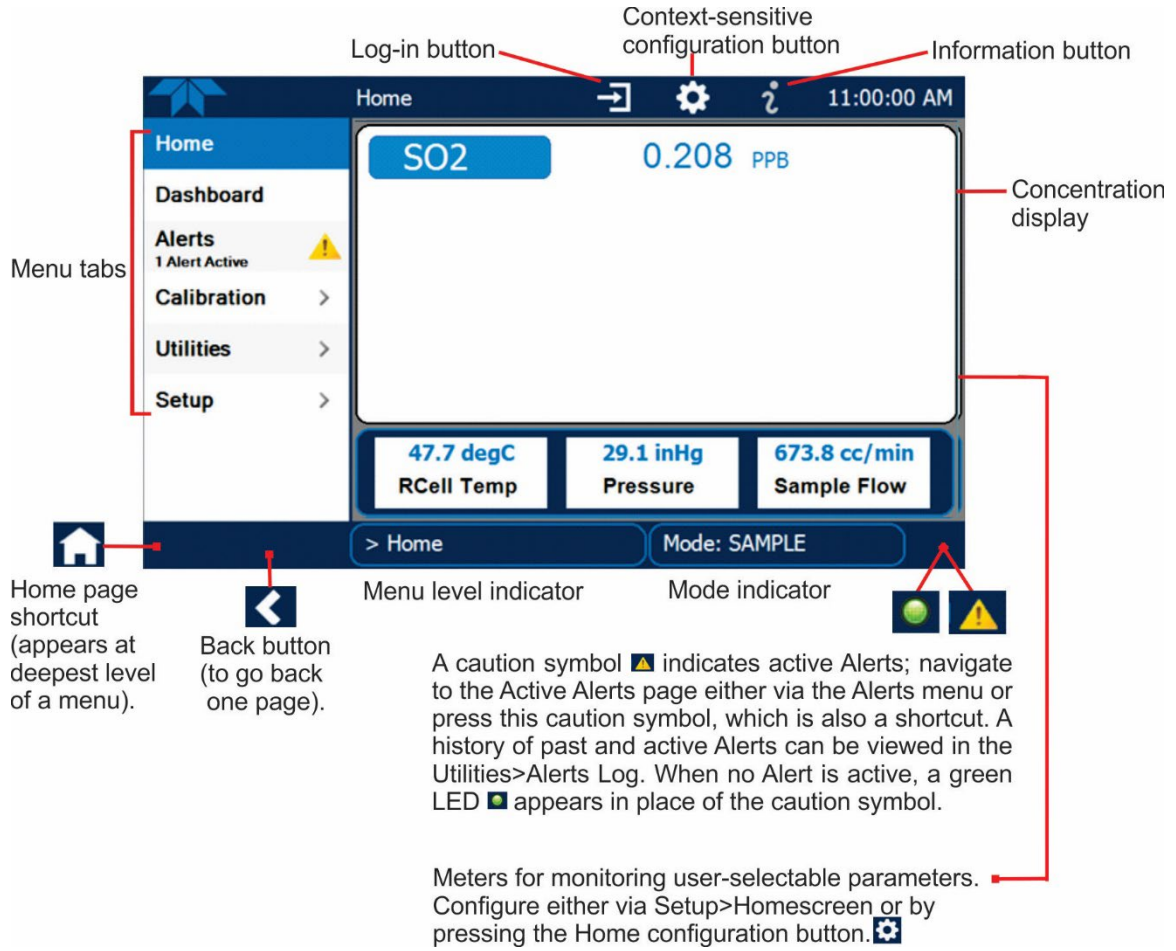
Table 2-13 describes the main menus and provides cross-references to the respective sections with configuration details.

**Table 2-13. Menu Overview**

MENU	DESCRIPTION	LOCATION
Home	View and plot concentration readings and other selectable parameter values (Figure 2-39).	Section 2.4.1
Dashboard	View user-selected parameters and their values, some of which can be displayed in a live-plot graph (Figure 2-40).	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 <sub>2</sub> 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 2-37) via selectable parameters.	Section 2.5.3
Auto Cal (with valve options)	When zero/span valve options installed, configure sequences for automatic calibration functions.	Section 5.3
Vars	Manually adjust several software variables that define specific operational parameters.	Section 2.5.5
Homescreen	Select up to three parameters to be displayed in the meters (Figure 2-38).	Section 2.5.6
Digital Outputs	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	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 6.5).	Section 2.5.9
Comm	View and configure network and serial communications.	Section 2.5.10

## 2.4.1. HOME PAGE

Figure 2-38 presents an orientation to the main display screen; Figure 2-39 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 2-38. User Interface Orientation**



# T101, T102

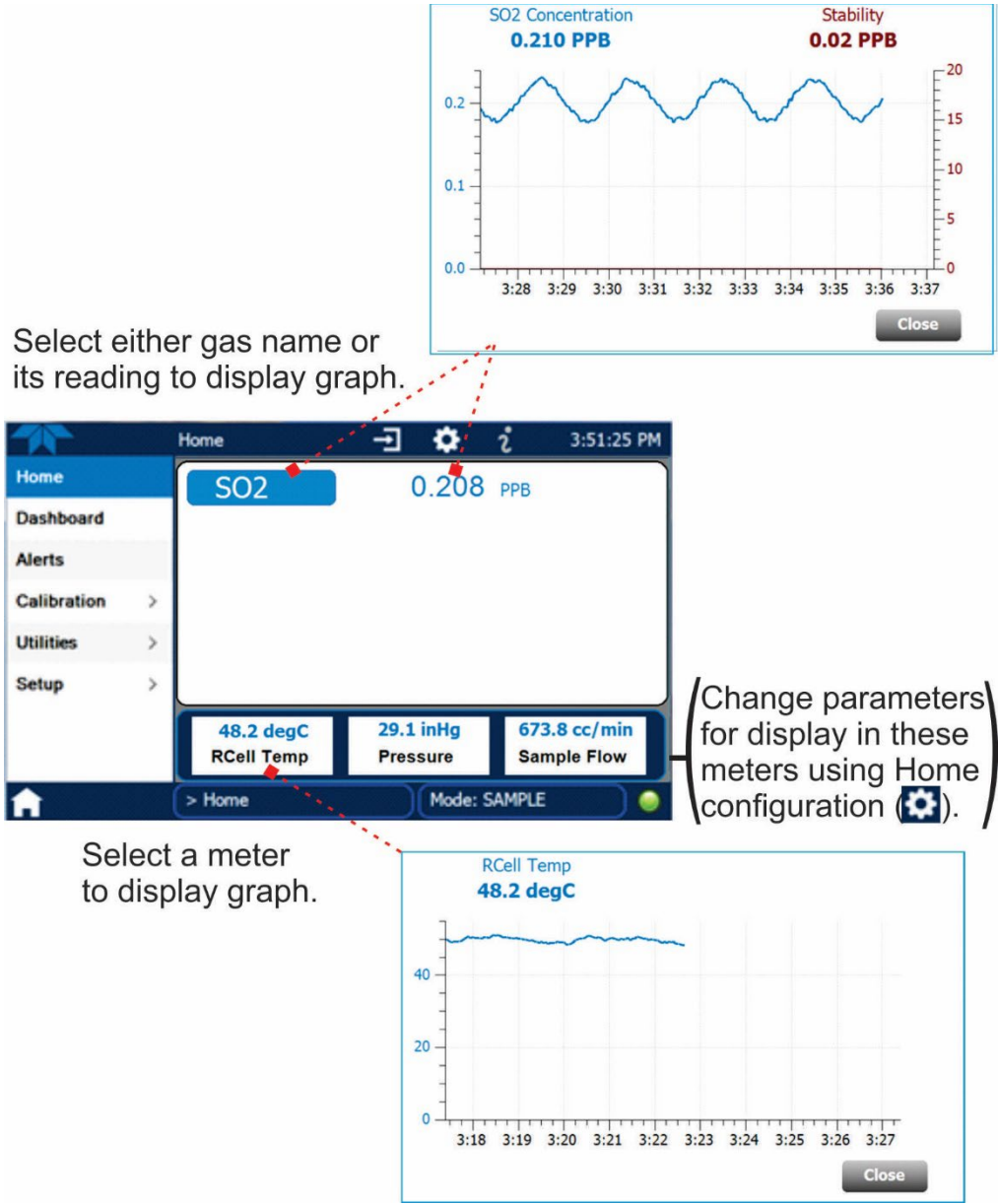
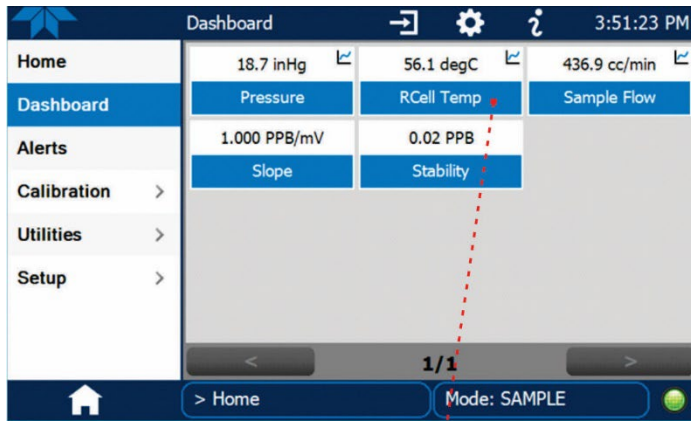


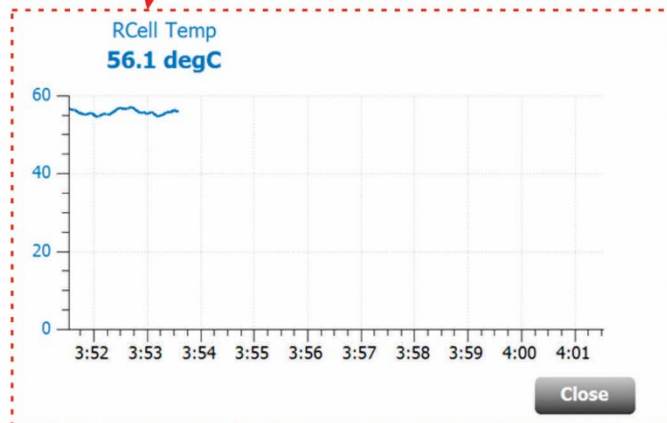
Figure 2-39. Concentration and Stability Graph (top) and Meter Graph (bottom)

## 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 2-40.



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



**Figure 2-40. Dashboard Page**

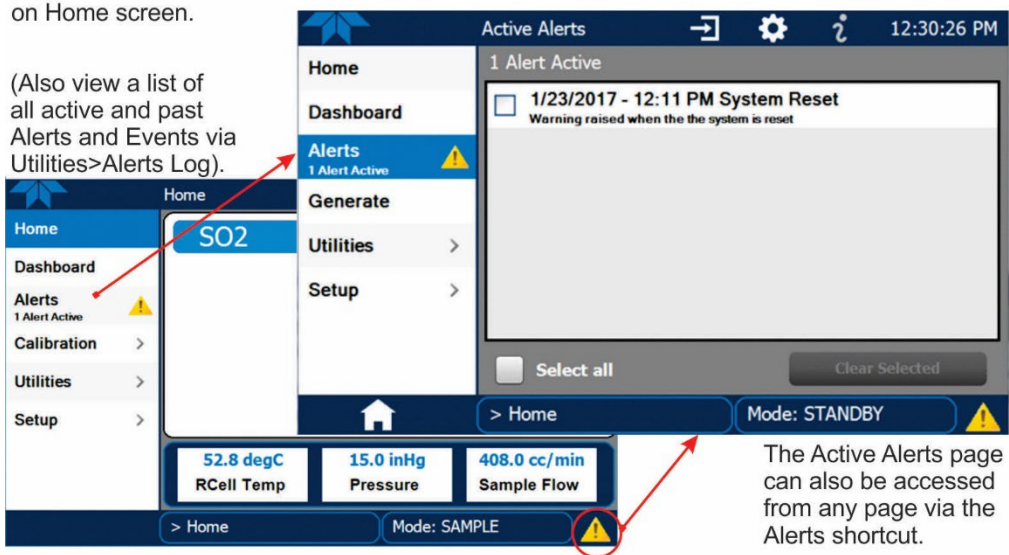
### 2.4.3. ALERTS

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

When Alerts are triggered, a caution symbol appears in both the Alerts menu tab and in the bottom right corner of the software interface, which serves as a shortcut to the Alerts page from any other page. View a list of currently active Alerts by pressing either the Alerts menu on the Home screen or by pressing the Alerts shortcut (Figure 2-41).

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.



**Figure 2-41. 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 2-42). However, Alerts can reappear if the conditions causing them are not resolved. For troubleshooting guidance, refer to Section 6.7.

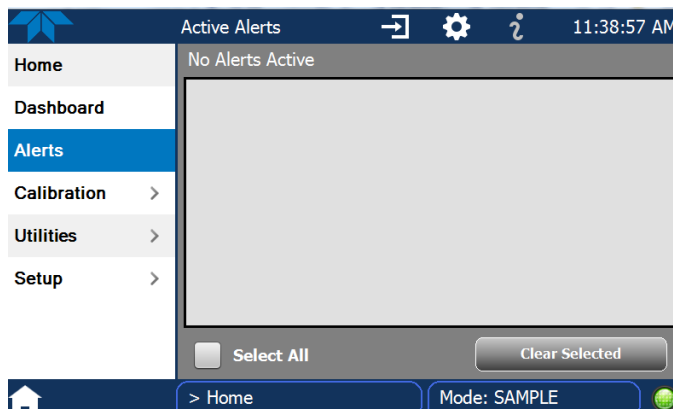


Figure 2-42. Active Alerts Cleared

Alerts and Events remain recorded in the Utilities>Alerts Log (Figure 2-43).

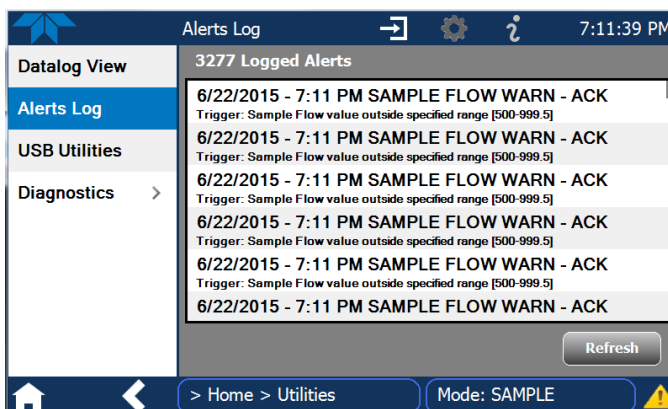


Figure 2-43. Utilities>Alerts Log of Active and Past Alerts and Events

## 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 2-14.

**Table 2-14. Utilities Submenu Descriptions**

UTILITIES MENU	DESCRIPTION
<b>Datalog View</b>	Displays the data logs that were configured via the Setup>Data Logging menu. From this list a log can be selected and filters applied to view the desired data. (For details on setting up and running the Data Logger, see Section 2.5.1).
<b>Alerts Log</b>	Displays a history of alerts that are triggered by factory-defined and user-defined Events, such as warnings and alarms (See Section 2.5.2 for Events configuration).
<b>USB Utilities</b>	Serves multiple purposes using a flash drive connected to the instrument's front panel USB port: <ul style="list-style-type: none"> <li>• download data from the instrument's Data Acquisition System (DAS), the Data Logger, to a flash drive (Section 2.5.1.3)</li> <li>• update firmware (Section 6.3)</li> <li>• transfer instrument configuration from/to other same-model instruments (Section 2.6)</li> <li>• download a basic operation functionality report (Section 6.3).</li> </ul>
<b>Diagnostics</b>	Provides access to various pages that facilitate troubleshooting.
Analog Inputs	Measure voltage signals of several analog input parameters. These can be logged in the internal data acquisition system (DAS), by configuring the Data Logger in the Setup>Data Logging menu (Section 2.5.1).
Analog Outputs	Show the voltage signals for the functions selected and configured in the Setup>Analog Outputs menu (Section 2.5.8).
Digital Inputs	Show whether specific available features are turned ON or OFF; for example, whether or not Maintenance Mode input or Language selection can be controlled through the front panel, or whether a zero or span calibration can be activated remotely when an external source is connected to the rear panel Control In connector.
Digital Outputs	Show the function of user-specified parameters configured in the Setup>Digital Outputs menu (Section 2.5.7).
Flow Cal	Used to calibrate the sample gas flow reading with actual flow measured by an external device. (See Section 6.6.9.3).
OE Test	Used to run either an electrical test (ETest) or an optics test (OTest) (Section 6.7.9.10).

## 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 Datalogger, 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

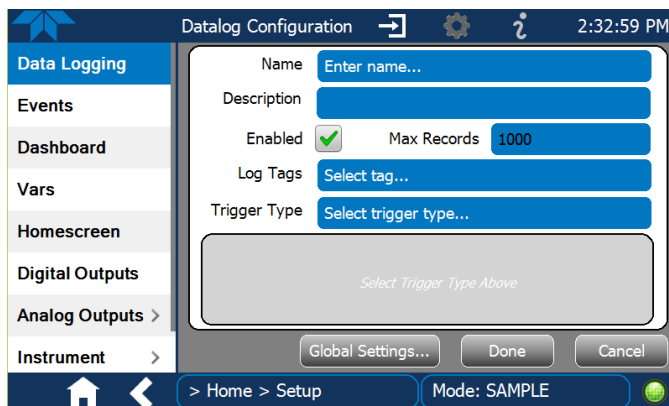
Use the Setup menu to configure the instrument's software features, to gather information on the instrument's performance, and to configure and access data from the Datalogger, the instrument's internal data acquisition system (DAS). Once the setups are complete, the saved configurations can be downloaded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

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

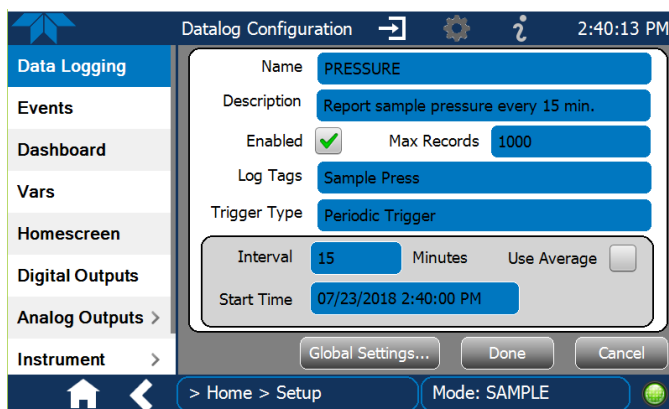
The Datalogger can be configured to capture and store user-defined data, which then can be viewed in the Alerts page, if elected, as well as downloaded from the instrument to a USB flash drive for examination and analysis.

Figure 2-44 shows a new log; Figure 2-45 shows a sample existing log, which can be edited or deleted, and Figure 2-46 provides illustrated instructions for setting up a new log, with Sections 2.5.1.1 and 2.5.1.2 providing additional details.

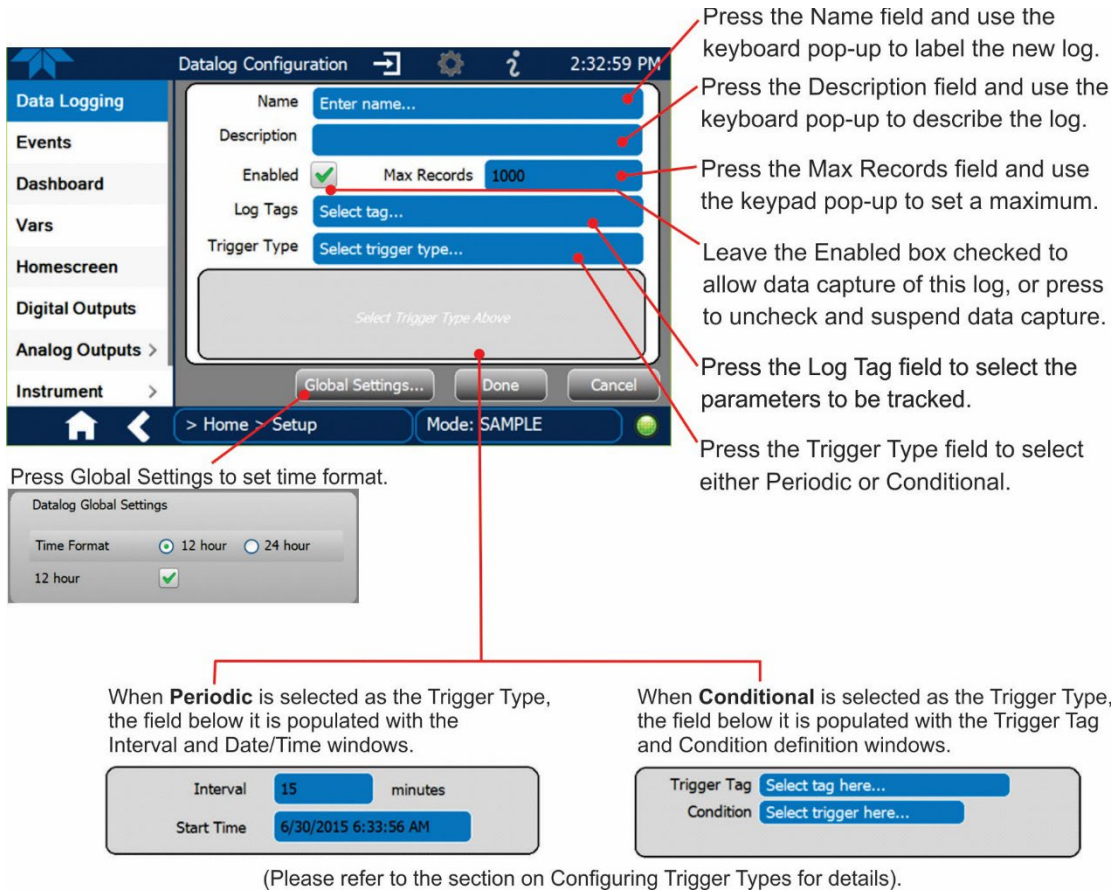
To transfer captured instrument data to a flash drive see Section 2.5.1.3.



**Figure 2-44. Datalog Configuration, New Log Page**



**Figure 2-45. 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.

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.

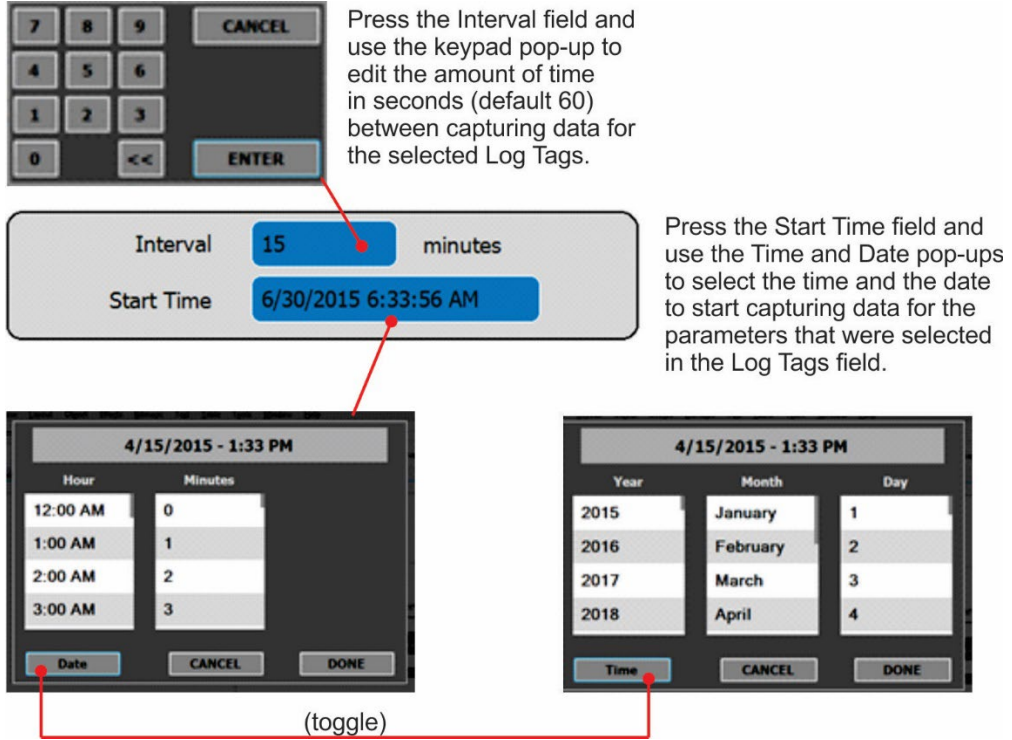
(Please refer to the section on Configuring Trigger Types for details).

**Figure 2-46. Creating a New Data Log**

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

### 2.5.1.1. CONFIGURING TRIGGER TYPES: PERIODIC

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



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

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

(toggle)

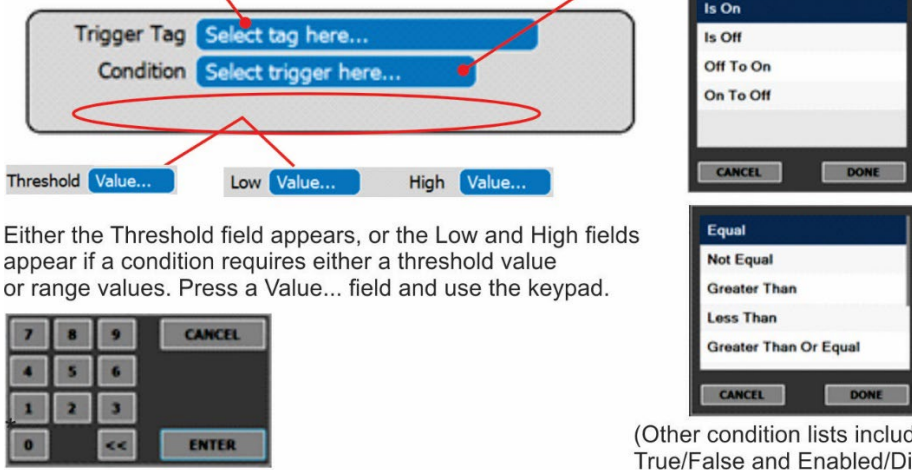
**Figure 2-47. Datalog Periodic Trigger Configuration**

### 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.

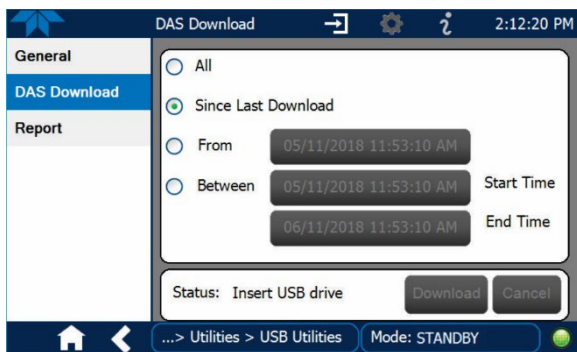
(Other condition lists include True/False and Enabled/Disabled)

**Figure 2-48. Datalog - Conditional Trigger Configuration**

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

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

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

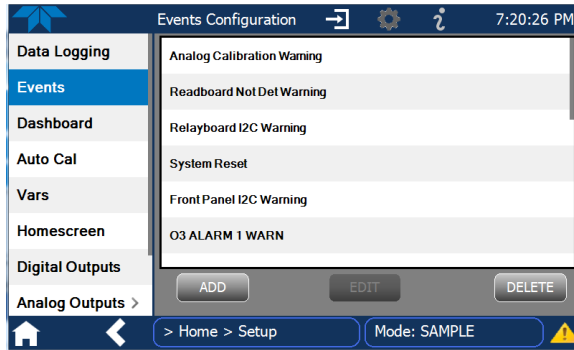


**Figure 2-49. DAS Download Page**

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.

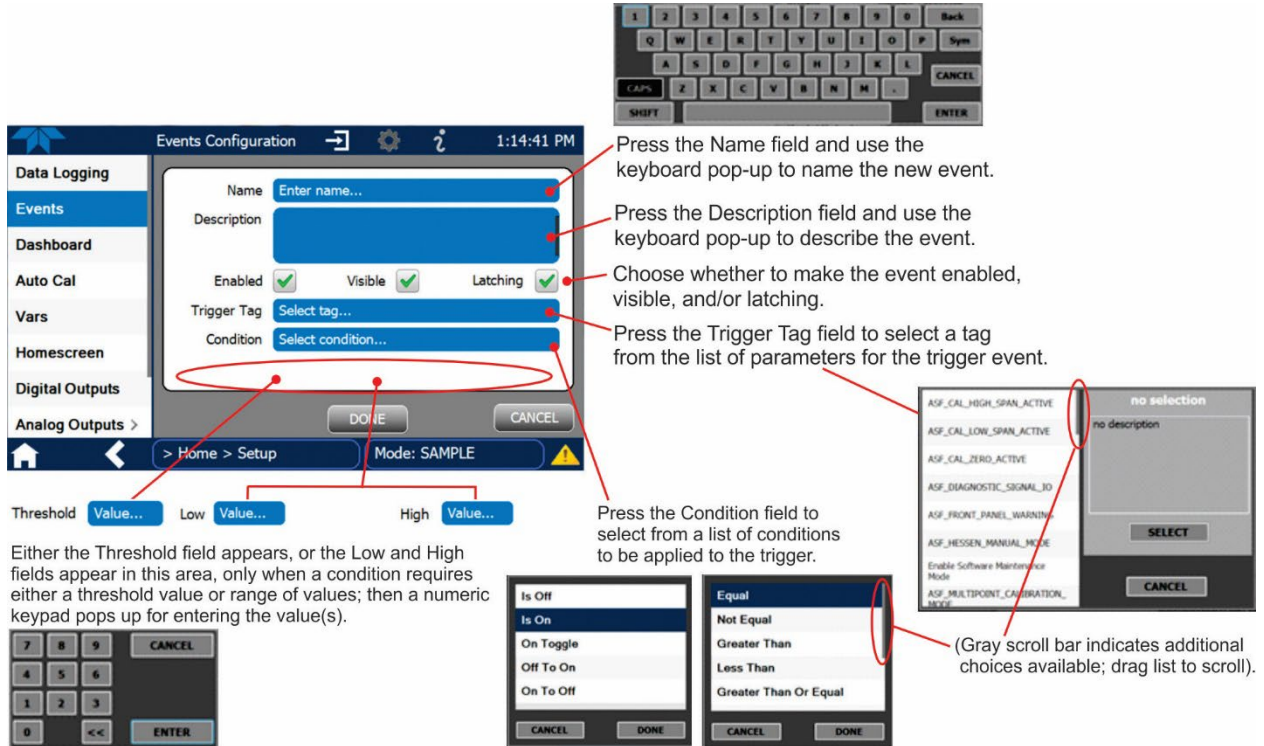
## 2.5.2. SETUP>EVENTS

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 2-50) under the Setup menu.



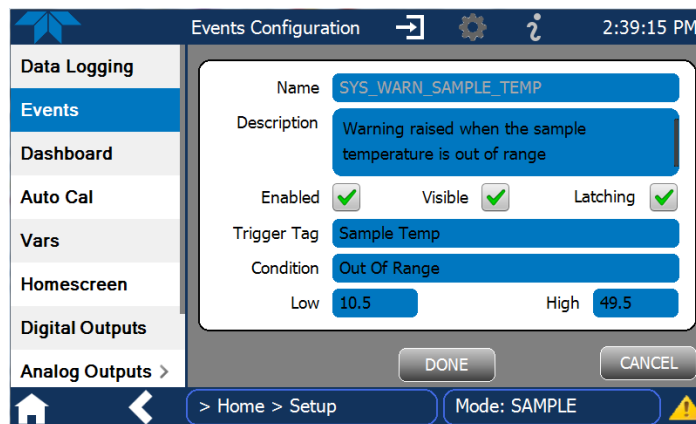
**Figure 2-50. Events List**

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 2-50). Press ADD to create a new Event (refer to Figure 2-51 for details), or select an existing Event to either Edit or Delete it (Figure 2-53).



**Figure 2-51. Event Configuration**

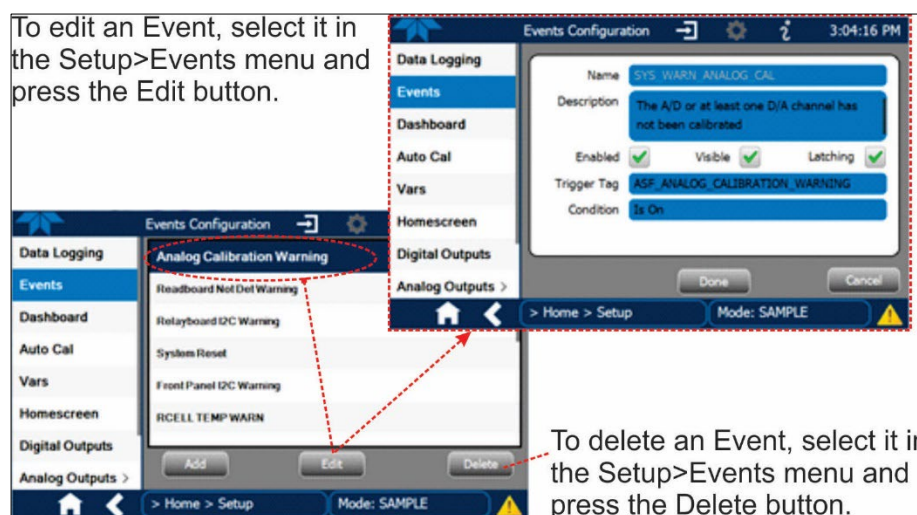
- Enabled  allows the choice of whether to track and record the Event (uncheck this box to “turn off” or deactivate the Event without deleting it). An Event must be enabled in order to use the Visible and the Latching options.
- Visible  allows the choice of whether or not to display the Event in the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



**Figure 2-52. Configured Event Sample**

### 2.5.2.1. EDITING OR DELETING EVENTS

Select an Event from the list (Figure 2-50) and press the Edit button to view or edit the details (Figure 2-52), or press the Delete button to delete the Event.



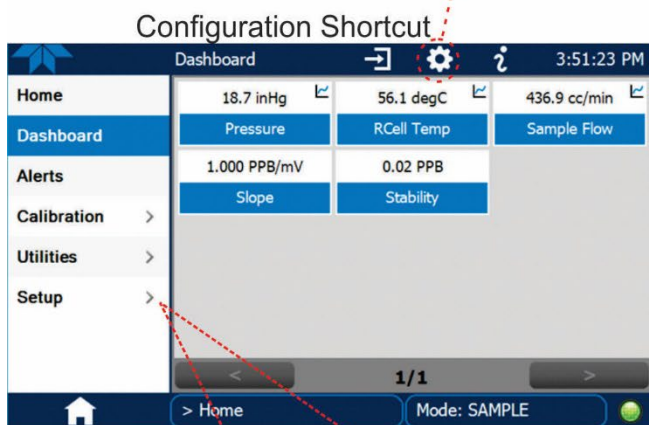
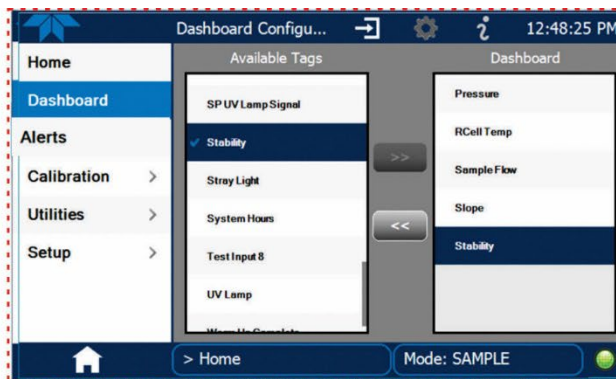
**Figure 2-53. Edit or Delete an Event**

### 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

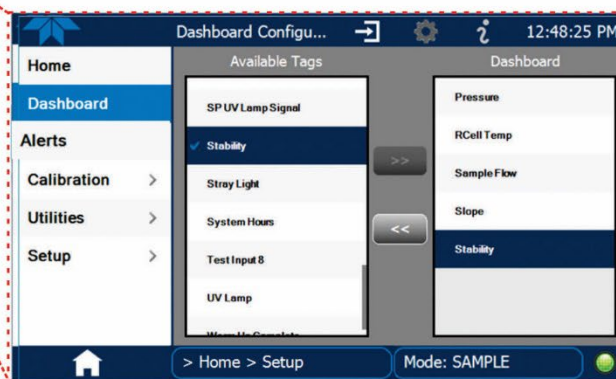
From Dashboard page, select the configuration shortcut, or navigate to Setup>Dashboard.



Configuration 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 2-54. Dashboard Display and Configuration**



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

Auto Cal is available with installed valve options (see Section 5.3).

## 2.5.5. SETUP>VARS

Vars are software variables that define operational parameters automatically set by the instrument's firmware, and are user-adjustable through this menu. Access the menu to see the list of variables (Vars); select a Var to view its description; touch the Edit button to change its setting(s). Table 2-15 describes some of the Vars.

**Table 2-15. Typical Variables with Descriptions**

VARIABLE	DESCRIPTION
<b>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.</b>	
<b>Background Periodic Report Upload</b>	Allow a periodic report to be automatically uploaded to cloud service at a frequency (in hours) set in the Report Upload Interval var.
<b>Daylight Savings Enable</b>	Enable or disable Daylight Savings Time (also see Setup>Instrument>Date/Time Settings)
<b>Dilution Factor Option</b>	<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 and the sampling method used to remove the gas from the stack dilutes the gas. Once the degree of dilution is known, this feature allows the user to add an appropriate scaling factor to the analyzer's SO<sub>2</sub> concentration calculations so that the undiluted values for measurement range and concentration are shown on the instrument's front panel display and reported via the instrument's various outputs.</p> <ol style="list-style-type: none"> <li>1. Set the appropriate units of measure (Setup&gt;Vars&gt;User Units).</li> <li>2. Select the reporting range mode (Setup&gt;Vars&gt;Range Mode) and set the reporting range upper limit (Setup&gt;Analog Output). Ensure that the upper span limit entered for the reporting range is the maximum expected concentration of the undiluted gas.</li> <li>3. Set the dilution factor as a gain, e.g., a value of 20 means 20 parts diluent and 1 part sample gas (Setup&gt;Vars&gt;Dilution Factor).</li> <li>4. 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.</li> </ol>
<b>Dynamic Zero Enable</b>	Dynamic zero automatically adjusts offset and slope of the SO <sub>2</sub> response when performing a zero point calibration during an AutoCal (Section 5.3).
<b>Dynamic Span Enable</b>	Dynamic span automatically adjusts the offsets and slopes of the SO <sub>2</sub> response when performing a span point calibration during an AutoCal (Section 5.3).
<b>Enable Software Maintenance Mode</b>	Set instrument to continue sampling, while ignoring calibration, diagnostic, and reset instrument commands. This feature is of particular use for instruments connected to Multidrop (2.3.1.7) or Hessen protocol networks.
<b>Instrument ID</b>	Set unique identifier number for the instrument when it is connected with other instruments in multidrop configuration or on the same Ethernet LAN, or when applying MODBUS or Hessen protocols (see Setup>Comm).
<b>Max Concentration Range</b>	Set the highest concentration expected, as this is used by the CPU to adjust Preamp physical ranges. (Section 5.1.4 provides more information).

VARIABLE	DESCRIPTION
<b>PRIGAS Precision</b>	Sets the number of significant digits to the right of the decimal point display of primary gas concentration and stability values. ( <b>SECGAS Precision</b> for secondary gas)
<b>Range Mode</b>	Controls range mode, single (SNGL) or dual (DUAL). (When set to DUAL, ensure that Max Concentration Range has been set).
<b>System Hours</b>	Total system runtime hours
<b>TPC Enable</b>	Enables or disables the Temperature and Pressure Compensation (TPC) feature (For information on TPC, see Section 7.4.3).
<b>User Conc Units</b>	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 2-55).



**Figure 2-55. Homescreen Configuration**

An orientation to the Homescreen was presented in Section 2.4.1, including Figure 2-38 and Figure 2-39.

## 2.5.7. SETUP>DIGITAL OUTPUTS

Specify the function of each digital output (connected through the rear panel STATUS connector) 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). (If the Motherboard Relay Option was installed, the four additional relays can also be mapped).

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).

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

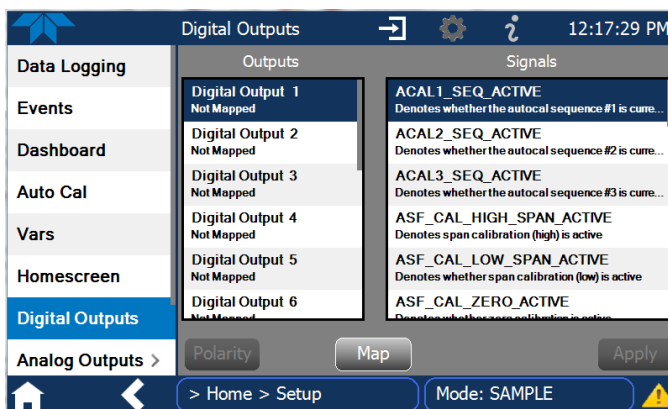
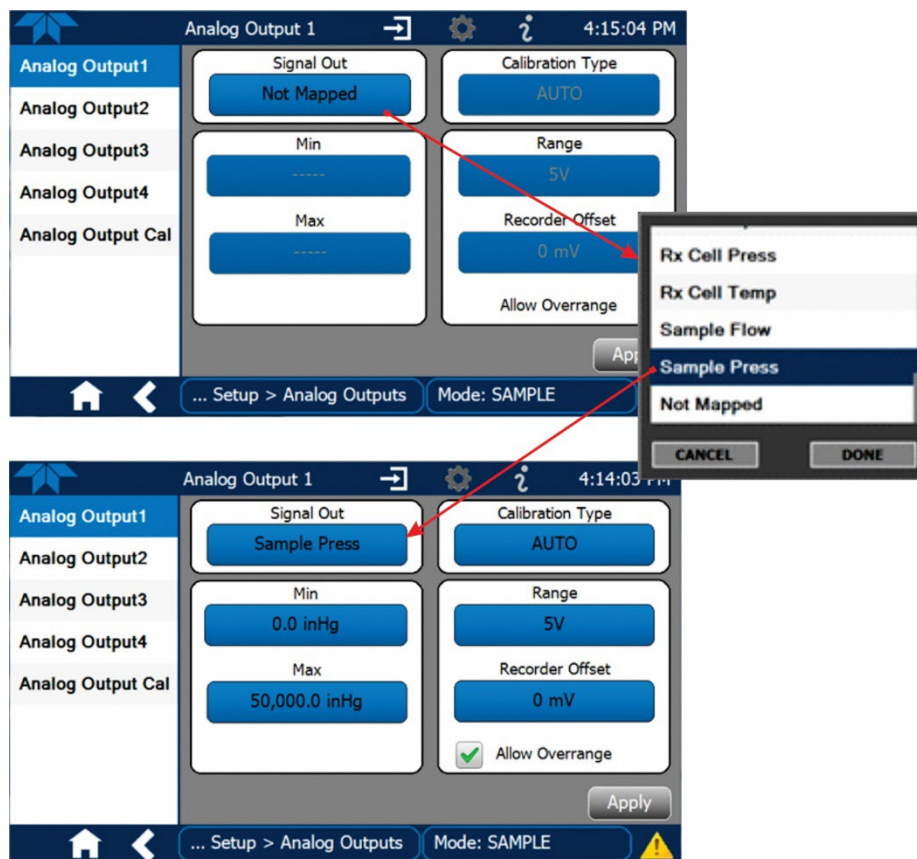


Figure 2-56. Digital Outputs Setup

## 2.5.8. SETUP>ANALOG OUTPUTS

Map the four user-configurable Analog Outputs to any of a wide variety of “Signals” present in the instrument and customize their respective configurations.



**Figure 2-57. Analog Output Configuration Example**

Refer to Figure 2-57 for the following:

- Signal Out: select a Signal for the output.
- Min/Max: edit minimum and maximum values associated with the selected Signal.
- Calibration Type:
  - AUTO for group calibration (Figure 2-58) of the analog outputs (cannot be selected when Current is selected for the Range)
  - MANUAL for individual calibration (Figure 2-59) of analog outputs where manual adjustments can be made (the only calibration type allowed when Current is selected for the Range). See Sections 2.5.8.1 and 2.5.8.2 .
- Range: assign a voltage or select Current (refer to Table 2-16).
- Recorder Offset: add a zero offset for recording slightly negative readings from noise around the zero point.
- Allow Overrange: check to allow a  $\pm 5\%$  over-range; uncheck to disable over-range if the recording device is sensitive to excess voltage or current.

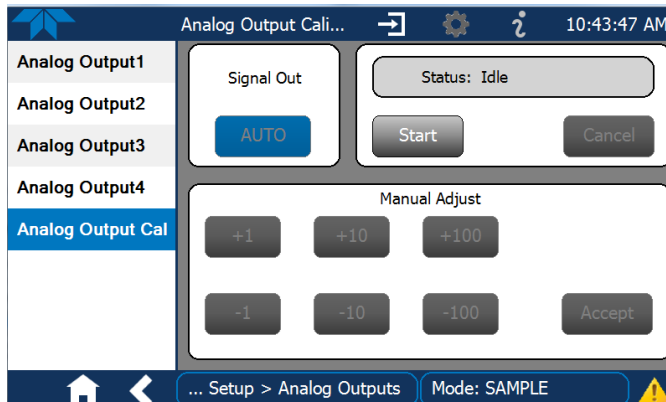


Figure 2-58. Analog Outputs Group Calibration Screen

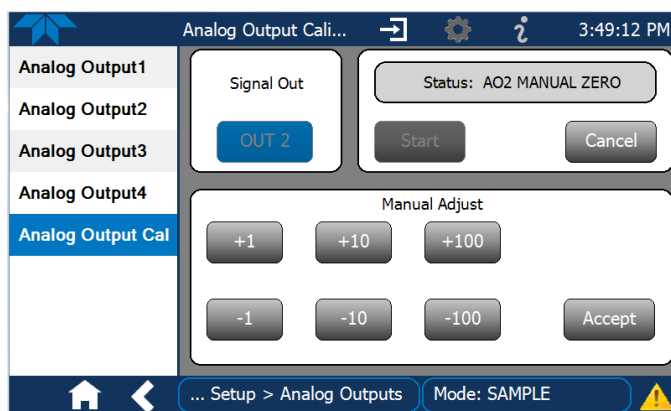


Figure 2-59. Analog Outputs Manual Calibration Screen (AOUT2 Example)

Table 2-16. Analog Output Voltage/Current Range

RANGE <sup>1</sup>	RANGE SPAN	MINIMUM OUTPUT	MAXIMUM OUTPUT
100mV	0-100 mVDC	-5 mVDC	105 mVDC
1V	0-1 VDC	-0.05 VDC	1.05 VDC
5V	0-5 VDC	-0.25 VDC	5.25 VDC
10V	0-10 VDC	-0.5 VDC	10.5 VDC
Current <sup>2</sup>	0-20 mA	0 mA	20 mA

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

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

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

### 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 2-60) and changing the output signal level in the Manual Adjust field of the Analog Outputs Calibration screen (Figure 2-59). Refer to Table 2-17 for voltage tolerances.

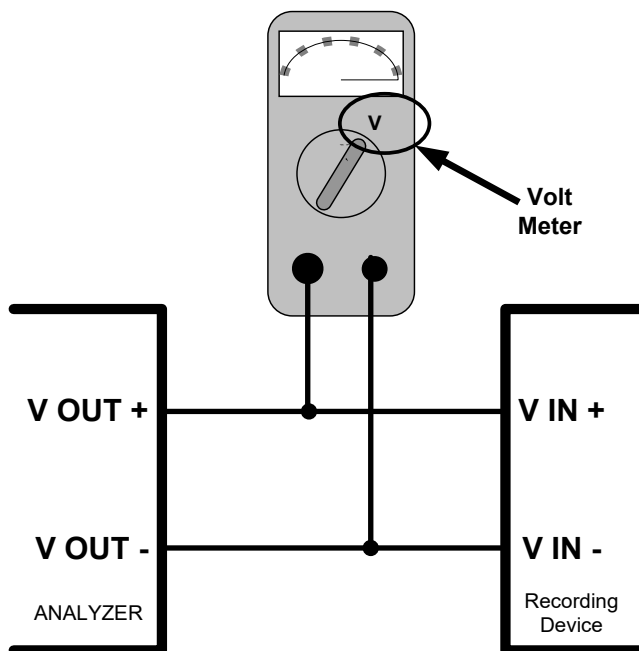


Figure 2-60. Setup for Checking / Calibrating DCV Analog Output Signal Levels

Table 2-17. Voltage Tolerances

FULL SCALE	ZERO TOLERANCE	SPAN VOLTAGE	SPAN TOLERANCE	MINIMUM ADJUSTMENT (1 COUNT)
0.1 VDC	±0.0005V	90 mV	±0.001V	0.02 mV
1 VDC	±0.001V	900 mV	±0.001V	0.24 mV
5 VDC	±0.002V	4500 mV	±0.003V	1.22 mV
10 VDC	±0.004V	4500 mV	±0.006V	2.44 mV

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

These instructions assume that the Current Loop Option is installed (Section 2.3.1.3).

This option places circuitry in series with the output of the D-to-A converter on the motherboard that changes the normal DC voltage output to a 0-20 milliamp signal.

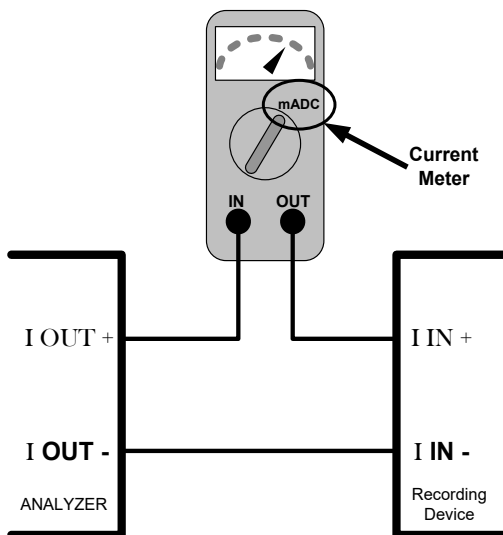
Adjusting the signal zero and span levels of the current loop output is done by raising or lowering the voltage output of the D-to-A converter circuitry on the analyzer's motherboard. This raises or lowers the signal level produced by the current loop option circuitry.

The software allows this adjustment to be made in 100, 10 or 1 count increments. Since the exact amount by which the current signal is changed per D-to-A count varies from output-to-output and instrument-to-instrument, you will need to measure the change in the signal levels with a separate, current meter placed in series with the output circuit. See Figure 2-9 for pin assignments and diagram of the analog output connector.



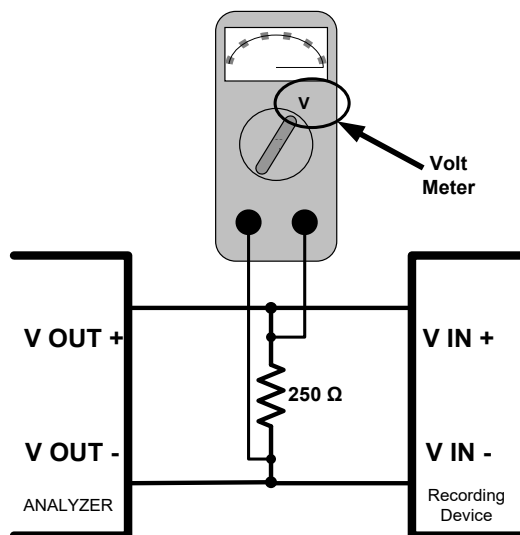
**CAUTION!**

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



**Figure 2-61. Setup for Checking / Calibration Current Output Signal Levels**

An alternate method for measuring the output of the Current Loop converter is to connect a 250 ohm  $\pm 1\%$  resistor across the current loop output in lieu of the current meter (see Figure 2-9 for pin assignments and diagram of the analog output connector). This allows the use of a voltmeter connected across the resistor to measure converter output as VDC or mVDC.



**Figure 2-62. Alternative Setup Using 250Ω Resistor for Checking Current Output Signal Levels**

In this case, follow the procedure above but adjust the output for the following values:

**Table 2-18. Current Loop Output Check**

% FS	VOLTAGE ACROSS RESISTOR FOR 2-20 MA	VOLTAGE ACROSS RESISTOR FOR 4-20 MA
0	500 mVDC	1000 mVDC
100	5000 mVDC	5000 mVDC

## 2.5.9. SETUP>INSTRUMENT

As presented in Table 2-19, view product and system information and network settings, edit network settings, and perform certain maintenance tasks.

**Table 2-19. 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).
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 6.5.
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 6.3).

## 2.5.10. SETUP>COMM (COMMUNICATIONS)

This menu is for specifying the various communications configurations.

### 2.5.10.1. COM1/COM2

Configure the instrument's COM1 or COM2 ports to operate in modes listed in Table 2-20.

**Table 2-20. COM1/COM2 Configuration**

MODE	DESCRIPTION
<b>Baud Rate</b>	Set the baud rate for the COM1 or COM2 port being configured.
<b>Command Prompt Display</b>	Enable/disable a command prompt to be displayed when in terminal mode.
<b>Data Bits</b>	Set the data bits to 7 or 8 (typically set in conjunction with Parity and Stop bits).
<b>Echo and Line Editing</b>	Enable/disable character echoing and line editing.
<b>Handshaking Mode</b>	Choose SOFTWARE handshaking for data flow control (do NOT use SOFTWARE handshaking mode when using MODBUS RTU for Protocol mode; select only HARDWARE or OFF for MODBUS RTU), or HARDWARE for CTS/RTS style hardwired transmission handshaking. (This style of data transmission handshaking is commonly used with modems or terminal emulation protocols). Or choose to turn OFF handshaking.
<b>Hardware Error Checking</b>	Enable/disable hardware error checking.
<b>Hardware FIFO</b>	Enable/disable the hardware First In – First Out (FIFO) for improving data transfer rate for that COM port.
<b>Modem Connection</b>	Select either a modem connection or a direct cable connection.
<b>Modem Init String</b>	Input an initialization string to enable the modem to communicate.
<b>Multidrop</b>	Enable/disable multidrop mode for multi-instrument configuration on a single communications channel. Multidrop requires a unique ID for each instrument in the chain (Setup>Vars>Instrument ID).
<b>Parity</b>	Select odd, or even, or no parity (typically set in conjunction with Data Bits and Stop Bits).
<b>Protocol</b>	Select among the communications protocols: TAPI, Hessen, MODBUS RTU, or MODBUS ASCII (MODBUS: Section 3.5.1; Hessen: Section 3.5.2).
<b>Quiet Mode</b>	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.
<b>RS-485</b>	Enable/disable the rear panel COM2 Port for RS-485 communication. RS-485 mode has precedence over Multidrop mode if both are enabled. Also, RS-485 configuration disables the rear panel USB port.
<b>Security</b>	Enable/disable the requirement for a password for this serial port to respond. The only command that is active is the request-for-help command (? CR).
<b>Stop bits</b>	Select either 0 or 1 stop bit (typically set in conjunction with Parity and Data bits).

### 2.5.10.2. TCP PORT1

TCP Port1 allows choosing whether or not to display the command prompt, editing the Port 1 number for defining the terminal control port by which terminal emulation software addresses the instrument, such as Internet or NumaView™ Remote software, and enabling or disabling security on this port.

### 2.5.10.3. TCP PORT2

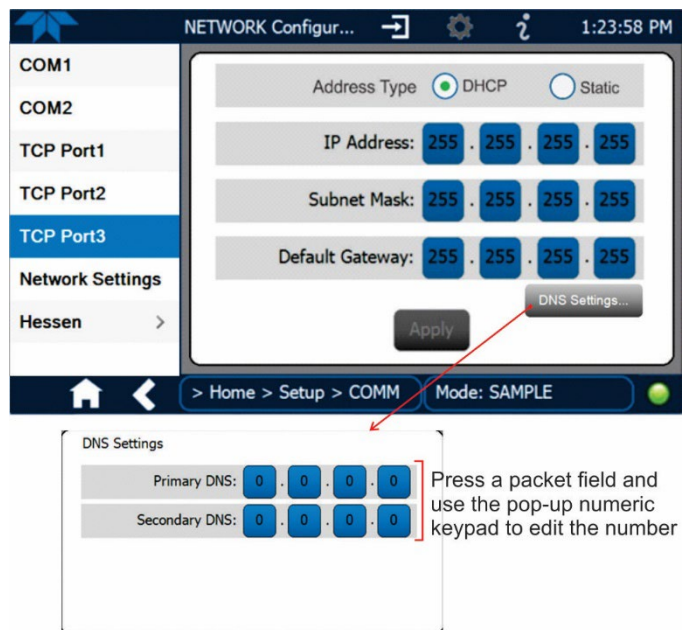
TCP Port2 is configured with the port number for MODBUS.

### 2.5.10.4. TCP PORT3

TCP Port3 is configured with the port number for Hessen.

### 2.5.10.5. 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 2-21 for information).



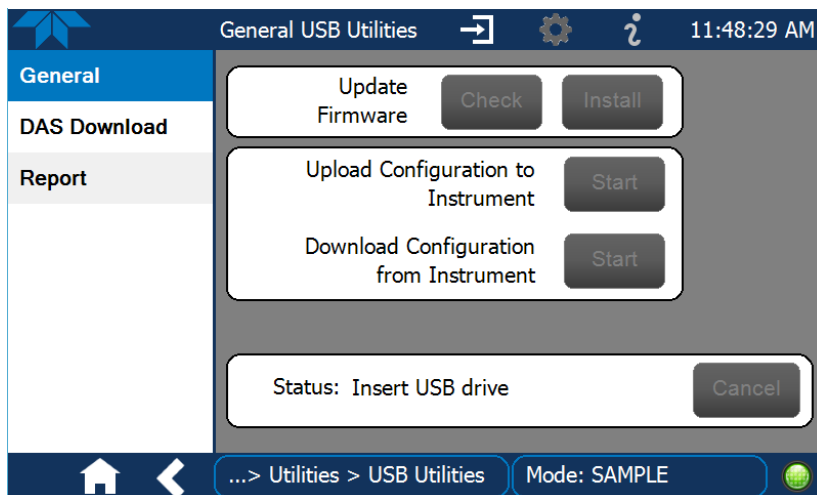
**Figure 2-63. Communications Configuration, Network Settings**

**Table 2-21. LAN/Ethernet Configuration Properties**

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

## 2.6. TRANSFERRING CONFIGURATION TO OTHER INSTRUMENTS

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



**Figure 2-64. 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.



## T101, T102

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



### 3. COMMUNICATIONS AND REMOTE OPERATION

This instrument's rear panel connections include an Ethernet port, a USB port (option) and two serial communications ports labeled RS232, which is the COM1 port in the software menu, and COM2 (refer to

Figure 2-3). These ports allow the ability to communicate with, issue commands to, and receive data from the analyzer through an external computer system or terminal. Connection instructions were provided in Section 2.3.1.7. Configuration information was provided in Section 2.5.10.

This section provides pertinent information regarding communication equipment, the communications ports, and communications protocol. Data acquisition is set up through the Datalogger (Section 2.5.1).

#### 3.1. DATA TERMINAL/COMMUNICATION EQUIPMENT (DTE DCE)

RS-232 was developed for allowing communications between data terminal equipment (DTE) and data communication equipment (DCE). Basic terminals always fall into the DTE category whereas modems are always considered DCE devices. The difference between the two is the pin assignment of the Data Receive and Data Transmit functions.

- DTE devices receive data on pin 2 and transmit data on pin 3.
- DCE devices receive data on pin 3 and transmit data on pin 2.

**To allow the analyzer to be used with terminals (DTE), modems (DCE) and computers (which can be either), a switch mounted below the serial ports on the rear panel, labeled DCE DTE (**

Figure 2-3), allows the user to set the RS-232 configuration for one of these two data devices. This switch exchanges the Receive and Transmit lines on RS-232 emulating a cross-over or null-modem cable. The switch has no effect on COM2.

#### 3.2. MODES, BAUD RATE AND SERIAL COMMUNICATION

Referring to Table 2-20, use the SETUP>COMM menu to configure COM1 (labeled RS232 on instrument rear panel) and/or COM2 (labeled COM2 on instrument rear panel) for communication modes, baud rate and serial communications. If using a USB option communication connection, setup requires that the instrument's baud rate and personal computer baud rate match.



### 3.2.1. SERIAL COMMUNICATION: RS-232

The RS232 and COM2 communications ports operate on the RS-232 protocol (default configuration). Configurations possible for these two ports are:

- RS232 port can also be configured to operate in single or RS-232 Multidrop mode (Option 62); refer to Section 2.3.1.7.
- COM2 port can be left in its default configuration for standard RS-232 operation including multidrop, or it can be reconfigured for half-duplex RS-485 operation (please contact the factory for this configuration).

**Note**

**When the rear panel COM2 port is in use, except for multidrop communication, the rear panel USB port cannot be used. (Alternatively, when the USB port is enabled, COM2 port cannot be used except for multidrop).**

A code-activated switch (CAS), can also be used on either port to connect typically between 2 and 16 send/receive instruments (host computer(s) printers, data loggers, analyzers, monitors, calibrators, etc.) into one communications hub. Contact Teledyne API Sales (front cover, this manual) for more information on CAS systems.

### 3.2.2. SERIAL COMMUNICATION: RS-485 (OPTION)

The COM2 port of the instrument’s rear panel is set up for RS-232 communication but can be reconfigured for RS-485 communication. Contact Technical Support for reconfiguration unless this option was elected at the time of purchase, then the rear panel was preconfigured at the factory.

## 3.3. 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 3-1. Ethernet Status Indicators**

LED	FUNCTION
amber (link)	On when connection to the LAN is valid.
green (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 2.5.10.5 for configuration details.

### 3.4. 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.

### 3.5. COMMUNICATIONS PROTOCOLS

MODBUS (Section 3.5.1) and Hessen (Section 3.5.2) are available with the analyzer. MODBUS registers are provided in Appendix A.

#### 3.5.1. MODBUS

These instructions assume that the user is familiar with MODBUS communications, and provide minimal information to get started. Please refer to the Teledyne API MODBUS manual, PN 06276, and to [www.modbus.org](http://www.modbus.org) for MODBUS communication protocols.

Minimum Requirements:

- Instrument firmware with MODBUS capabilities installed
- MODBUS-compatible software (TAPI uses MODBUS Poll for testing; see [www.modbustools.com](http://www.modbustools.com))
- Personal computer with communications cable (Ethernet or USB or RS232), and possibly a null modem adapter or cable

##### 3.5.1.1. MODBUS COM PORT CONFIGURATION

MODBUS communications can be configured for transmission over Ethernet or serial COM port through the Setup>Comm menu. Make the appropriate cable connections (Ethernet or COM port) between the instrument and a PC.

Check the instrument’s Modbus Units selection in the Setup>Vars menu and edit if needed.

Ethernet: MODBUS is available on TCP port 502. By default, port 502 is assigned to the instrument’s TCP Port 2. (Setup>Comm> TCP Port2, Figure 3-1).

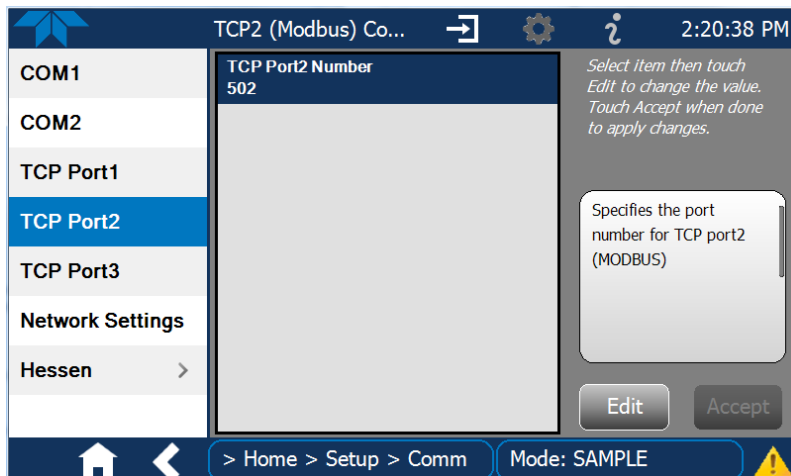


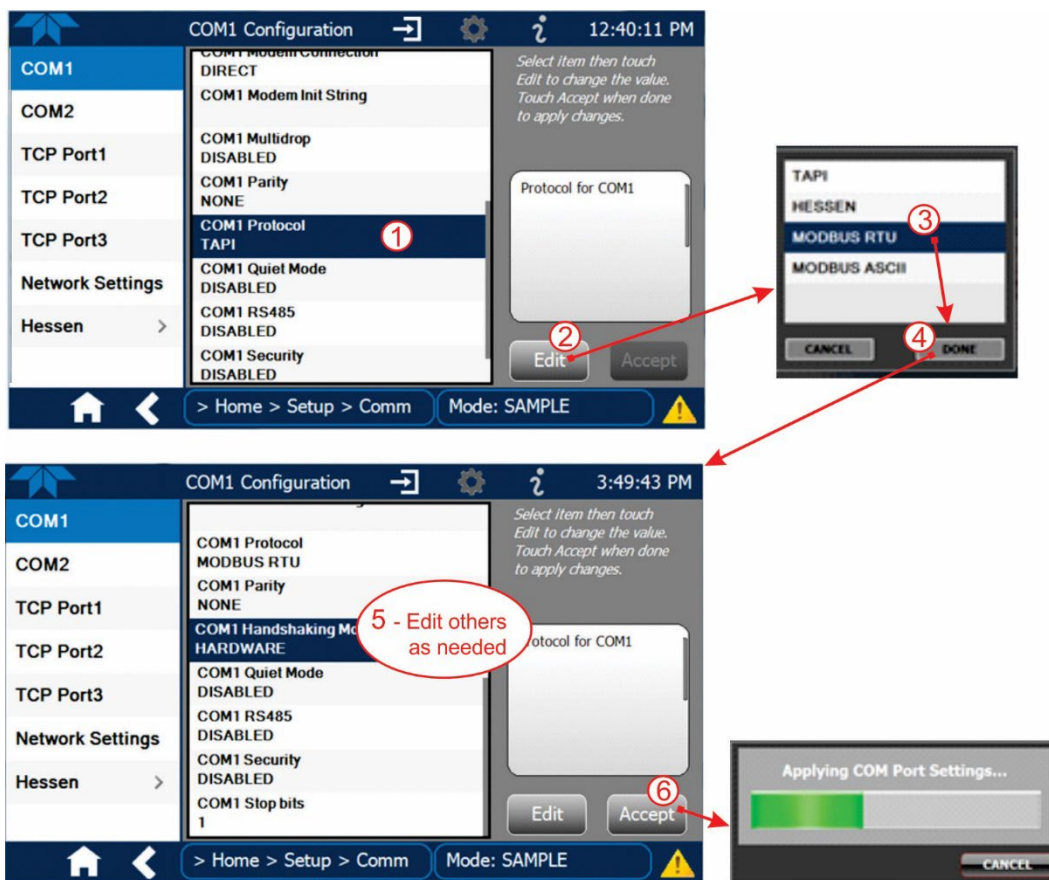
Figure 3-1. MODBUS via Ethernet

Serial COM: Both COM1 (labeled “RS232” on the instrument’s rear panel) and COM2 are configurable for RS-232 or RS-485 communication with either MODBUS RTU or MODBUS ASCII transmission modes. In the Setup>Comm COM1[COM2] menu, edit the Protocol parameter to select a MODBUS transmission mode; edit Baud Rate, Parity, Data Bits, etc., if necessary (see descriptions in Table 2-20).

**Important**

**When using MODBUS RTU, ensure that the COM1[COM2] Handshaking Mode is set to either Hardware or OFF. Do NOT set it to Software.**

Press the Accept button to apply the settings. (Figure 3-2 shows an example for MODBUS RTU).



**Figure 3-2. MODBUS via Serial Communication (example)**

**Important**

**When more than one analyzer is connected to the network, create a unique identification number for each in the Setup>Vars>Instrument ID menu.**

Next, for the settings to take effect, power off the analyzer, wait 5 seconds, and power it on again.

### 3.5.2. HESSEN

Hessen is a multidrop protocol, in which several remote instruments (slaves) are connected via a common communications channel to a host computer. Slaves respond only to commands sent by the host using their unique identification.

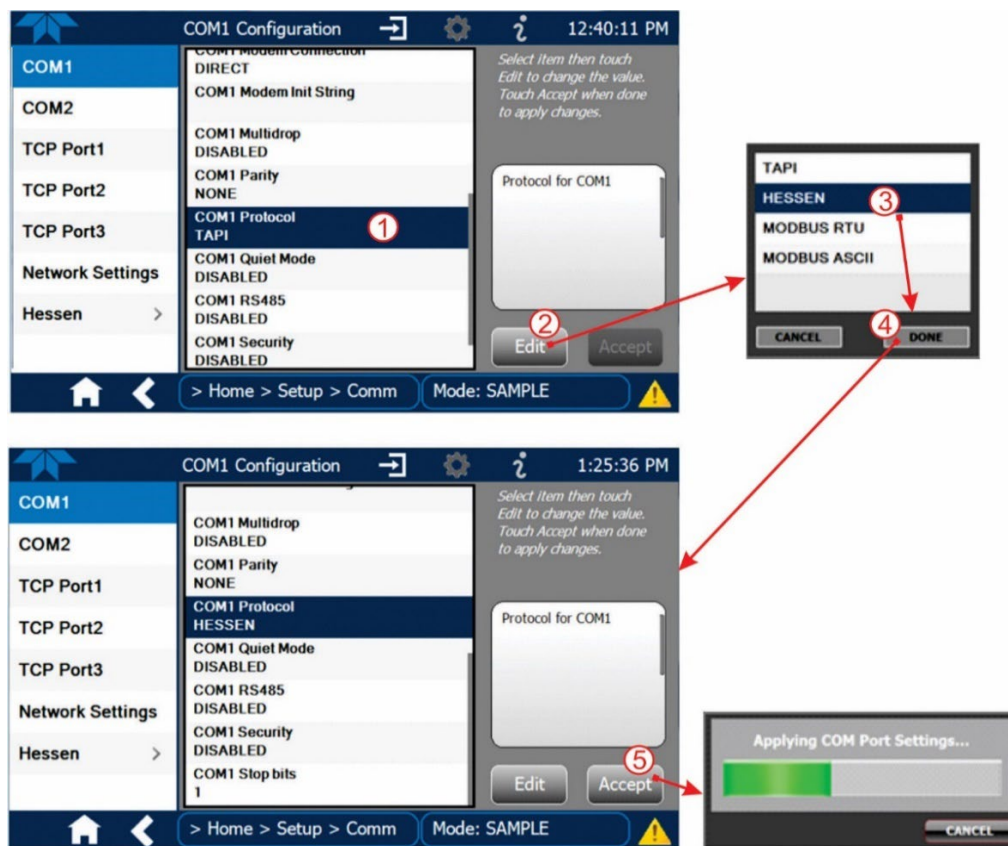
**Important** Create a unique identification number for each instrument in the multidrop chain via the Setup>Vars>Instrument ID menu.

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.

#### 3.5.2.1. HESSEN COM PORT CONFIGURATION

Configure the COM1/COM2 port for Hessen protocol through the Setup>Comm>COM1[COM2] menu: select COM1[COM2] Protocol and press Edit to select HESSEN, then press Accept.

Ensure that the communication parameters of the host computer are also properly set.



**Figure 3-3. Serial Communication, Setting Hessen Protocol**

**Note** The instrument software has a 200 ms latency period before it responds to commands issued by the host computer. This latency should present no problems, but be mindful of issuing commands to the instrument too frequently.

### 3.5.2.2. HESSEN SETTINGS CONFIGURATION

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

#### HESSEN PROTOCOL RESPONSE MODE

Set the response mode under Hessen Response Mode, referring to Table 3-2 for descriptions.

**Table 3-2. Teledyne API's Hessen Protocol Response Modes**

MODE ID	MODE DESCRIPTION
<b>CMD</b>	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.
<b>BCC</b>	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.
<b>TEXT</b>	Responses from the instrument are always delimited with <CR> at the beginning and the end of the string, regardless of the command encoding.

#### 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").

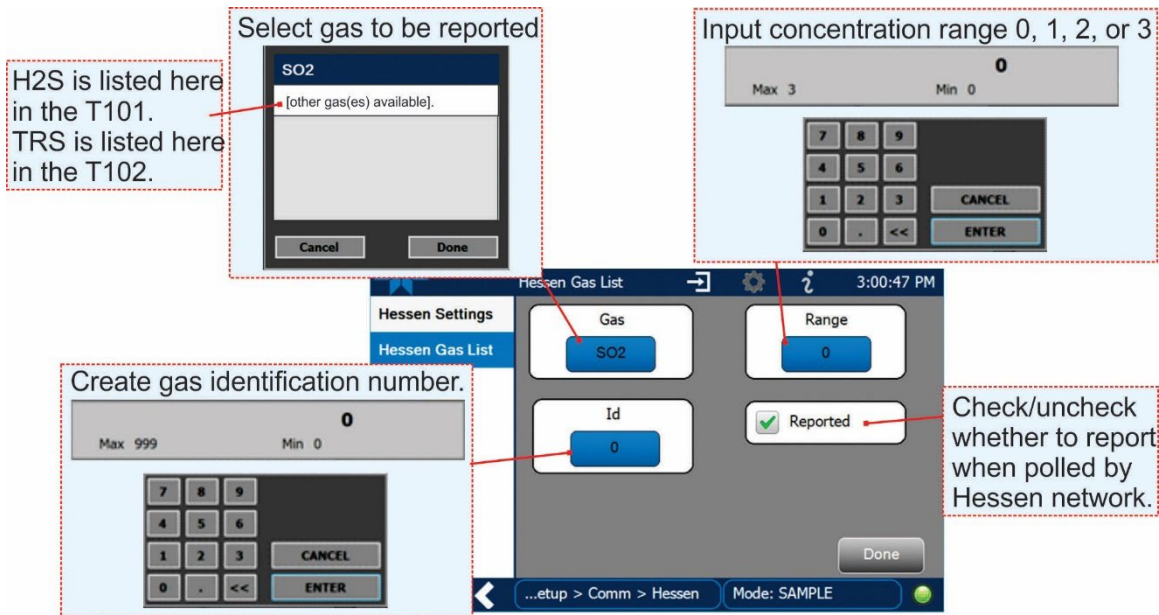
- The status bits are included in the instrument's responses to inform the host computer of its condition. Each bit can be assigned to one operational and warning message flag.
- It is possible to assign more than one flag to the same Hessen status bit. This allows the grouping of similar flags, such 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.

**Table 3-3. Hessen Status Flags and Default Bit Assignments**

STATUS FLAG NAME	DEFAULT BIT ASSIGNMENT
<b>WARNING FLAGS</b>	
SAMPLE FLOW WARNING	0001
PMT DET WARNING	0002
UV LAMP WARNING	0002
HVPS WARNING	0004
DARK CAL WARNING	0008
RCELL TEMP WARNING	0010
IZS TEMP WARNING	0020
PMT TEMP WARNING	0040
CONV TEMP WARNING	T101=1000, T102=1050
<b>OPERATIONAL FLAGS</b>	
Instrument Off	0100
In Manual Calibration Mode	0200
In Zero Calibration Mode	0400
In Span Calibration Mode	0800
<b>UNITS OF MEASURE FLAGS</b>	
UGM	0000
MGM	2000
PPB	4000
PPM	6000
<b>Spare/Unused Bits</b>	T101=100. 8000, T102=0080, 0100, 1000, 8000
<b>UNASSIGNED FLAGS</b>	
Box Temp Warning	Front Panel Warning
Sample Press Warning	Analog Cal Warning
System Reset	Cannot Dyn Zero
Rear Board Not Detected	Cannot Dyn Span
Relay Board Warning	Invalid Conc

### 3.5.2.3. HESSEN GAS LIST CONFIGURATION

Configure the Hessen Gas List in the Setup>Comm>Hessen>Hessen Gas List page. Choose the Gas, the concentration Range, and enter a unique gas ID. Refer to Figure 3-4 and to the table below.



Menu: Setup>Comm>Hessen>Hessen Gas List

**Figure 3-4. Hessen Gas List Configuration**

**Table 3-4. Hessen Gas List Definitions**

PARAMETER	DEFINITION
Gas	type of gas to be reported
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	specific gas identification (create unique Id to represent each gas)
Reported	choice of whether to report when polled by the Hessen network



## 4. MODEL 501 TRS OPERATION

**ATTENTION**

Do not operate the Model 501-TRS Converter without its cover installed. Oven temperature will not regulate properly without the cover in place.

**Important**

Do not change the factory-preprogrammed values, as this may cause undesirable effects on the converter's efficiency.

The Model 501 Total Reduced Sulfur (TRS) Converter oxidizes reduces sulfur compounds to SO<sub>2</sub> in a high temperature quartz oven. The 501 TRS has been preset specifically for the T102 analyzer and requires no hands-on operation. In order that the preprogrammed temperature settings efficiently control the proper operating states of the 501 TRS, make no adjustments. The out-of-limits alarms were also preset at the factory. If there is strong reason to make any adjustments, contact Teledyne API Technical Support (Section 6.9).

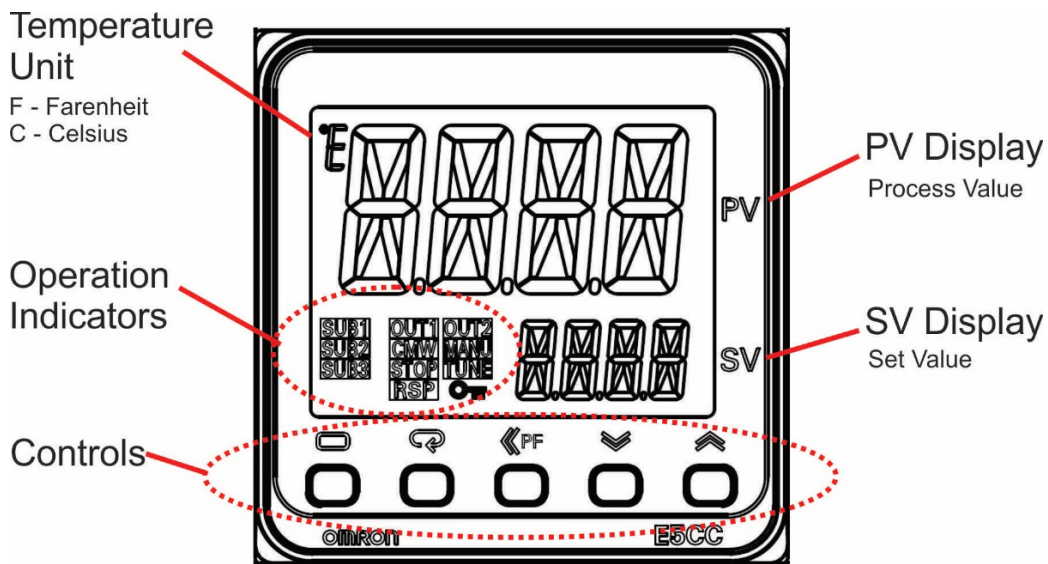


Figure 4-1. Model 501-TRS Interface

For details of the 501 Controller, please refer to its respective manual that was shipped with the instrument.

## 5. CALIBRATION

**Note**

**The Model 501-TRS Converter does not require field calibration.**

This section is organized into subsections as follows:

**SECTION 5.1 – Important Precalibration Information**

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

**SECTION 5.2 – Calibration Procedures:** describes the procedure for manually checking calibration and performing actual calibration of the instrument.

**SECTION 5.3 – Automatic Zero/Span Cal/Check (Auto Cal):** describes the procedure for using the AutoCal feature to check calibration or to calibrate the instrument. (The AutoCal feature requires that either the zero/span valve option or the internal span gas generator option be installed and operating).

**SECTION 5.4 – Calibration Quality Analysis:** describes how to evaluate quality of each calibration.

**SECTION 5.5 – EPA Protocol Calibration:** provides information regarding calibration using EPA protocol.

### 5.1. IMPORTANT PRECALIBRATION INFORMATION

**Note**

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

#### 5.1.1. CALIBRATION REQUIREMENTS

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

- Zero-air source
- Span gas source
- Gas lines - all gas line materials should be 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 analyzer's 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 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 Datalogger through the Setup>Data Logging menu; Section 2.5.1).

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

- See Section 5.2.1 for instructions for initial calibration of the analyzer in its base configuration.
- See Section 0 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 (Specifications Table 1-1).**

## 5.1.2. 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. If your analyzer is equipped with an IZS option, it is capable of creating zero air that is adequate for performing informal calibration checks. However, a zero air generator such as the TAPI Model 701 is still recommended for performing formal calibration operations, as it conditions ambient air by drying and removing pollutants.

### 5.1.2.1. T101 ZERO AIR

For the T101 analyzer, the Zero Air must be scrubbed of Hydrogen sulfide (H<sub>2</sub>S).

### 5.1.2.2. T102 ZERO AIR

For the T102 analyzer, the Zero Air must be scrubbed of total reduced sulfur (TRS), which includes not only H<sub>2</sub>S, but also many other gases that fall into this category.

## 5.1.3. CALIBRATION (SPAN) GAS

Cylinders of calibrated H<sub>2</sub>S gas traceable to NIST-Standard Reference Material specifications (also referred to as SRM's or EPA protocol calibration gases) are commercially available.

### 5.1.3.1. T101 SPAN GAS

Span gas is specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired measurement range. In the case of H<sub>2</sub>S, measurements made with the Model T101 UV Fluorescence H<sub>2</sub>S Analyzer it is recommended that you use a span gas with a H<sub>2</sub>S concentration equal to 90% of the measurement range for your application.

Some applications require a multipoint calibration procedure where span gases of different concentrations are needed. We recommend using a bottle of calibrated H<sub>2</sub>S 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 from 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 overnight.



### 5.1.3.2. T102 SPAN GAS

While it is possible to calibrate the T102 using SO<sub>2</sub> as the span calibration gas by setting the analyzer's gas measurement mode to SO<sub>2</sub>, TAPI recommends that H<sub>2</sub>S be used and that calibration operations be carried out with the analyzer's TRS gas measurement mode selected. Please note that verifying converter efficiency requires that the instrument be calibrated on both TRS and SO<sub>2</sub>, and the slope factors compared between the TRS and SO<sub>2</sub> modes.

It is recommended that the H<sub>2</sub>S span gas be equal to 90% of the analyzer's selected reporting range.

O<sub>2</sub> is a quenching agent in fluorescent Sulfur analyzers. If the balance gas is pure nitrogen, then false positive readings will result, both at zero and span. Therefore, users should either use cylinders with zero air as the balance gas, or use higher concentration cylinders with an N<sub>2</sub> balance, and dilute further with zero air using a calibrator, such as the TAPI Model T700.

Teledyne API offers an IZS option operating with permeation devices. The accuracy of these devices is about ±5%. Whereas this may be sufficient for quick, daily calibration checks, we strongly recommend using certified SO<sub>2</sub> span gases for accurate calibration.

### 5.1.4. PHYSICAL RANGE MEASUREMENTS

The analyzer has a low physical range and a high physical range that cover a wide total range of concentrations. Most 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).

To define the physical range for applications requiring greater resolution and sensitivity, navigate to the Setup>Vars menu and select Max Concentration Range; press the edit button and input the maximum value expected for the concentrations.

### 5.1.5. INTERFERENTS

The fluorescence method for detecting H<sub>2</sub>S is subject to interference from a number of sources. However, the analyzer has been designed to reject most of these interferences, including a chemical scrubber to remove the interferents from the sample stream.

### 5.1.6. PERMEATION TUBE OPTIONS

Teledyne API offers an optional internal span gas generator that utilizes a permeation tube as a span gas source (see Section 2.3.2.5). The accuracy of these devices is only about  $\pm 5\%$ . Whereas this may be sufficient for quick, daily calibration checks, we recommend using certified H<sub>2</sub>S span gas 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.**

### 5.1.7. 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 an 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 (Section 3.4) is a remote control program, which is also available as a convenient and powerful tool for data handling, download, storage, quick check and plotting.

## 5.2. CALIBRATION PROCEDURES

This section presents the steps for calibration and calibration checks for the following:

- basic configuration (Section 5.2.1)
- with valve options (Section 0)
- with IZS option (Section 5.3)

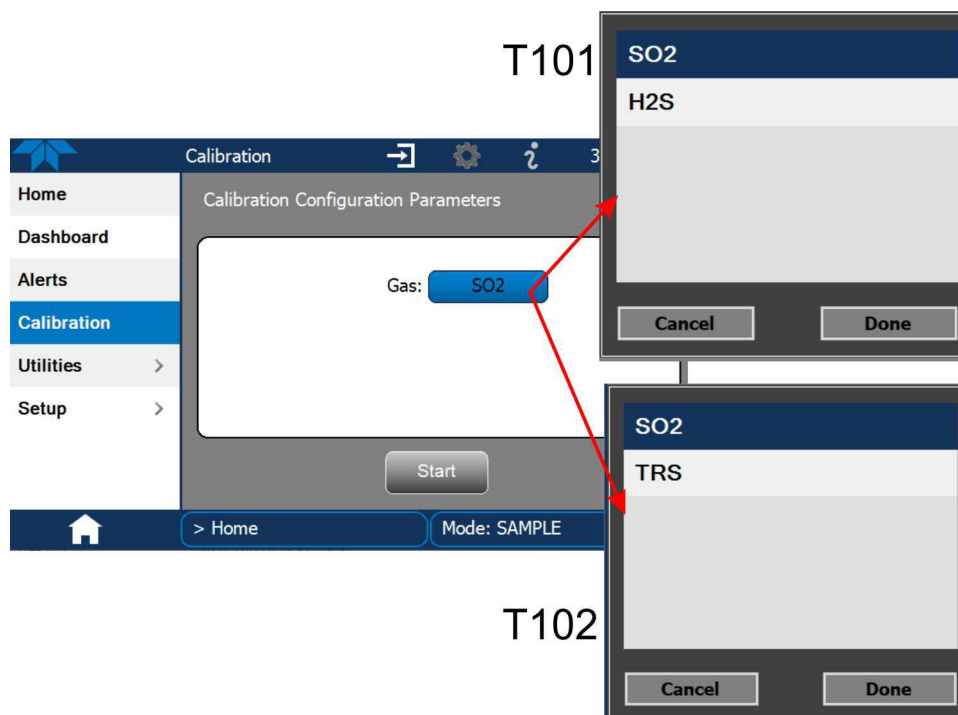
First verify/change (if needed) the settings in the Setu>Vars menu as follows:

- User Units (unit of Measure): PPB
- Max Concentration Range (highest concentration expected to measure)
- Range Mode: SNGL

### 5.2.1. 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 (either in the gas graph or in the Dashboard). Otherwise, follow the steps presented in Sections 5.2.1.1 and 5.2.1.2. after connecting the sources of zero air and span gas as shown in Section 2.3.2.

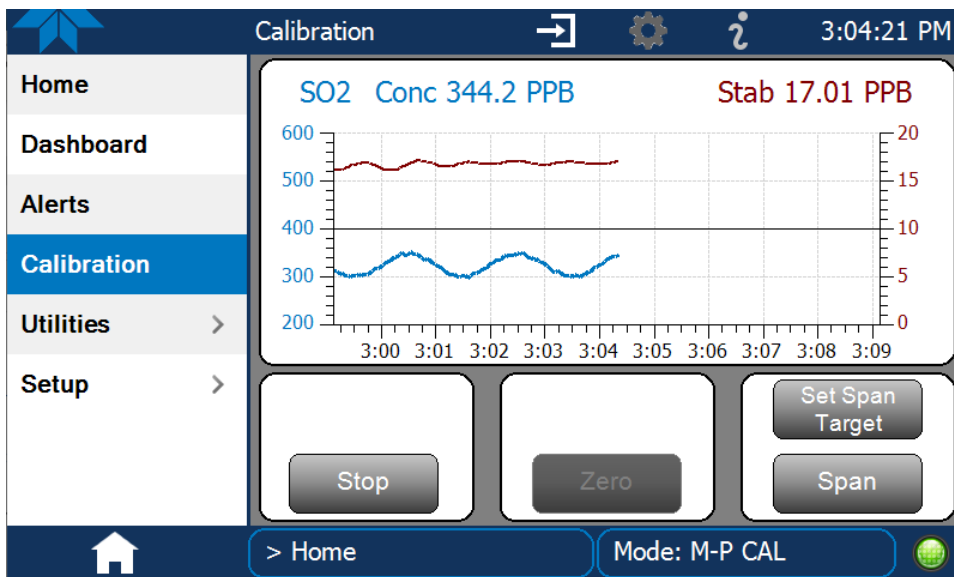
#### 5.2.1.1. ZERO CALIBRATION CHECK AND ACTUAL CALIBRATION, BASIC



**Figure 5-1. Calibration, Basic, Selectable Gas**

1. Go to the Calibration menu and select the Gas.
2. Input Zero air through the Sample port and press the Start button.
3. Either check or calibrate as follows:

- |   |   |
|---|---|
| <p><b>Check Only:</b></p> <ol style="list-style-type: none"> <li>a. Wait for reading to stabilize.</li> <li>b. Press Stop and check the reading.</li> </ol> | <p><b>Actual Calibration:</b></p> <ol style="list-style-type: none"> <li>a. Press the Zero button.</li> <li>b. Press Stop and check the reading.</li> </ol> |
|---|---|



**Figure 5-2. Multi-Point Calibration Page**

### 5.2.1.2. SPAN CALIBRATION CHECK AND ACTUAL CALIBRATION

1. While still in the Calibration menu, input Span gas through the Sample port and press the Start button.
2. Either check or calibrate as follows:
 

<p><b>Check Only:</b></p> <ol style="list-style-type: none"> <li>a. Wait to reach stability, then press Stop.</li> <li>b. Record the reading(s).</li> </ol>	<p><b>Actual Calibration:</b></p> <ol style="list-style-type: none"> <li>a. Press the Set Span Target button and enter the gas concentration (Figure 5-3).</li> <li>b. Verify the concentration reading is the same as the concentration being supplied.</li> <li>c. If correct, wait to reach stability, then press the Span button.</li> <li>d. In the Cal Result window, press OK.</li> </ol>
---	--
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 5-4 in Section 5.4, Calibration Quality Analysis, for expected/acceptable values).



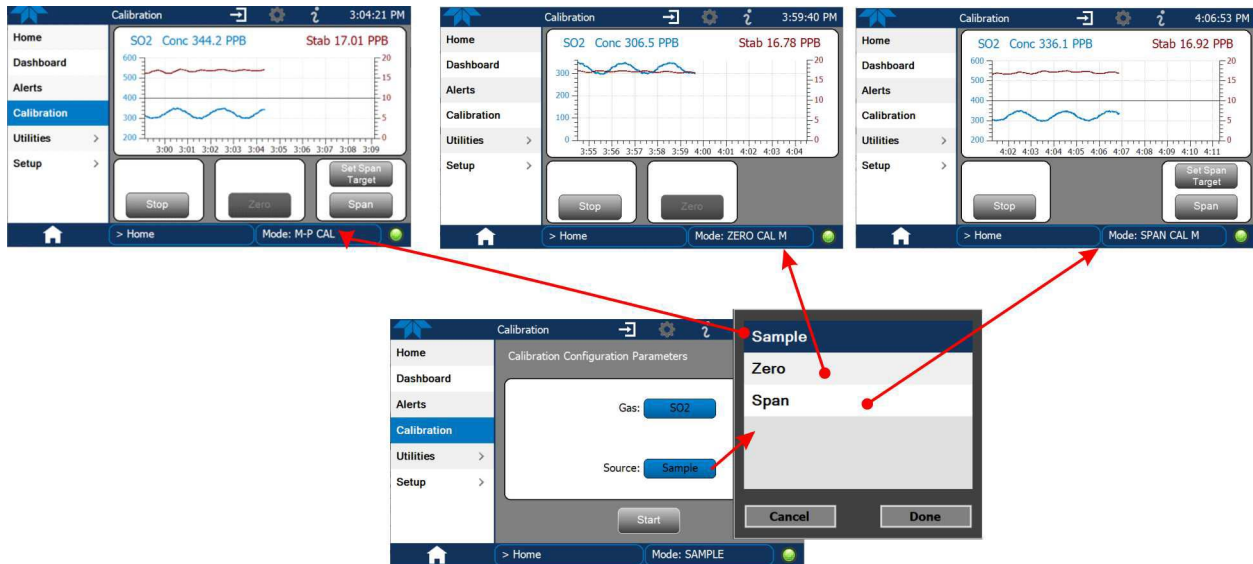
**Figure 5-3. Span Calibration Set Target**

## 5.2.2. CALIBRATION AND CHECK PROCEDURES WITH VALVE OPTIONS 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.

Navigate to the Calibration>Zero menu for Zero cal and to the Calibration>Span menu for Span cal (see Figure 5-4) and follow the instructions in Sections 5.2.1.1 and 5.2.1.2



**Figure 5-4. Calibration Screens for Valve Options**



## 5.2.2.1. USE OF ZERO/SPAN VALVE WITH REMOTE CONTACT CLOSURE

Contact closures for controlling calibration and calibration checks are located on the rear panel CONTROL IN connector. Instructions for setup and use of these contacts are in Section 2.3.1.5.

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

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

If contact closures are being used in conjunction with the analyzer's AutoCal (see Section 5.3) feature and the AutoCal attribute "Calibrate" is enabled (selection box is checked), the analyzer will not recalibrate the analyzer UNTIL the contact is opened. At this point, the new calibration values will be recorded before the instrument returns to SAMPLE mode.

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

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

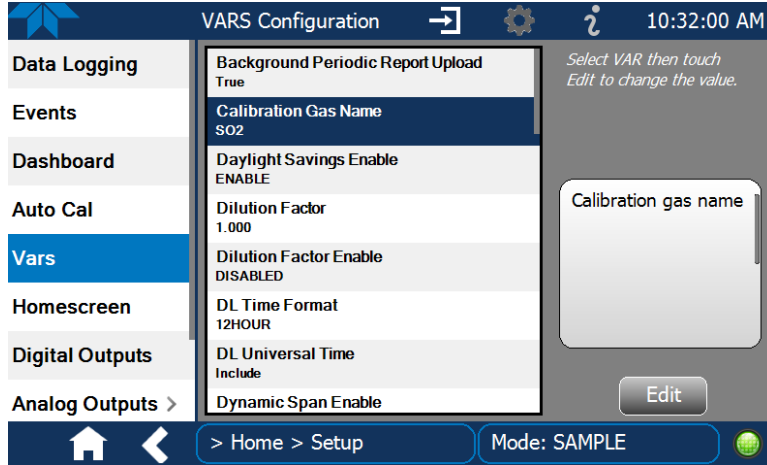
The Auto Cal feature allows unattended periodic operation of the ZERO/SPAN valve options by using the instrument's internal time of day clock. Auto Cal operates by executing preprogrammed calibrations or calibration checks set up by the user to initiate the various calibration states for the pre-selected gas (Vars>Calibration Gas Name) and to open and close valves appropriately. It is possible to set up and run up to three separate preprogrammed calibrations or calibration checks (labeled # 1, 2 and 3) for one gas. Each calibration or check can operate in either Zero mode or Span mode, or can be disabled.

First, navigate to Setup>Vars>Calibration Gas Name to select the gas (Figure 5-5), then select the Auto Cal menu to program one to three sequences.

### Important

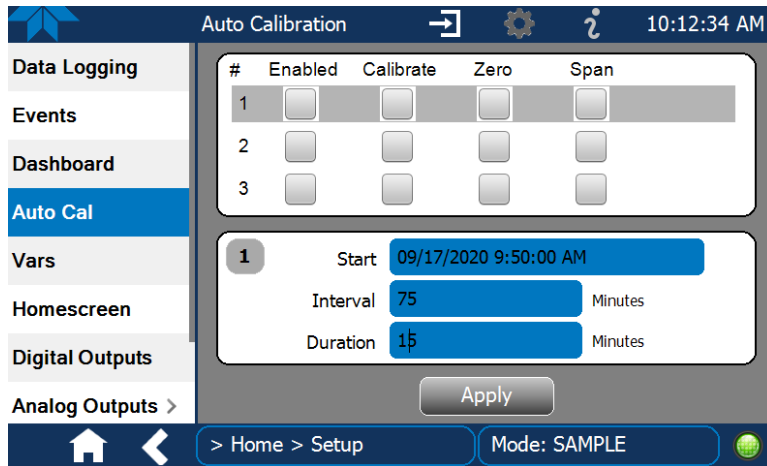
#### IMPACT ON READINGS OR DATA

- **The programmed STARTING\_TIME must be a minimum of 5 minutes later than the instrument's 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 new sequence that is initiated whether from a timer, the COM ports or the contact closure inputs will override any sequence that is in progress.**
- **It is recommended that calibrations be performed using external sources of Zero Air and Span Gas whose accuracy is traceable to EPA standards.**



**Figure 5-5. Gas Selection Menu for Auto Cal**

Table 5-1 describes the operation of each of the settings; Table 5-2 shows how to set up a calibration or check for Zero and Span, and Table 5-3 shows how to program the execution of each.



**Figure 5-6. Auto Cal Page**

**Table 5-1. Auto Cal States**

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

Table 5-2 shows how the selection boxes would be enabled/disabled for calibration checks and calibrations.

**Table 5-2. Auto Cal Setup Combinations**

MODE	ACTION	SETTINGS			
		Enabled	Calibrate	Zero	Span
Zero	Check	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Calibrate	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Span	Check	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Calibrate	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

For each sequence, there are four parameters that control operational details: Date, Time (both in the Start field), Interval, and Duration, as presented in Table 5-3.

**Table 5-3. Auto Cal 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).

## 5.4. 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 SO<sub>2</sub> Norm Offset and SO<sub>2</sub> Slope parameters.

Ensure that these parameters are within the limits listed in Table 5-4 and frequently compare them to those values on the *Final Test and Validation Data Sheet* that came with your instrument, which should not be significantly different. Otherwise, refer to the troubleshooting Section 6.7.6.

**Table 5-4. Calibration Data Quality Evaluation**

FUNCTION	MINIMUM VALUE	OPTIMUM VALUE	MAXIMUM VALUE
SO <sub>2</sub> SLOPE	-0.700	1.000	1.300
SO <sub>2</sub> Norm Offset	50.0 mV	<100	250.0 mV
H <sub>2</sub> S SLOPE	-0.700	1.000	1.300
H <sub>2</sub> S Norm Offset	50.0 mV	<100	250.0 mV
TRS SLOPE	-0.700	1.000	1.300
TRS Norm Offset	50.0 mV	<100	250.0 mV

## 5.5. EPA PROTOCOL CALIBRATION

When running the T101 for U.S. EPA compliance, always calibrate prior to use, adhering to the EPA designation requirements for this instrument. (The official List of Designated Reference and Equivalent Methods is published in the U.S. Federal Register: <http://www3.epa.gov/ttn/amtic/criteria.html>). Pay strict attention to the built-in warning features, periodic inspection, regular zero/span checks, regular test parameter evaluation for predictive diagnostics and data analysis, and routine maintenance. Any instrument(s) supplying the zero air and span calibration gasses used must themselves be calibrated, and that calibration must be traceable to an EPA/NIST primary standard.

Comply with Code of Federal Regulations, Title 40 (downloadable from the U.S. Government Publishing Office at <http://www.gpo.gov/fdsys/>) and with Quality Assurance Guidance documents (available on the EPA website, <http://www3.epa.gov/ttn/amtic/qalist.html>). Give special attention to specific regulations regarding the use and operation of ambient hydrogen sulfide (H<sub>2</sub>S) analyzers (UV Fluorescence).



## 6. MAINTENANCE AND SERVICE

Follow the maintenance schedule set forth in Section 6.1. Service and troubleshooting are covered in Section 6.7. To support your understanding of the technical details of maintenance and service, the principles of operation in Section 7 provides information about how the instrument works.

### ATTENTION

**COULD DAMAGE INSTRUMENT AND VOID WARRANTY**  
Avoid spraying anything directly onto any part of the analyzer.

### 6.1. MAINTENANCE SCHEDULE

Table 6-1 shows a typical maintenance schedule for the T101; Table 6-2. shows a typical maintenance schedule for the T102 system.

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



#### 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.

### Important

#### IMPACT ON READINGS OR DATA

A span and zero calibration check (see CAL CHECK REQ'D Column of Table 6-1) 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 5.2.1.1 and 5.2.1.2, 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 described in Section 5.3 with the CALIBRATE attribute set to OFF (not enabled).

**Table 6-1. T101 Maintenance Schedule**

ITEM	ACTION	FREQUENCY	CAL CHECK	DATE PERFORMED					
SO <sub>2</sub> scrubber	Replace	As required	Yes						
H <sub>2</sub> S → SO <sub>2</sub> Converter Catalyst	Replace	As required	Yes						
<sup>1</sup> Particulate filter	Change particle filter	Weekly	No						
Verify test functions	Review and evaluate	Weekly	No						
Zero/span check	Evaluate offset and slope	Weekly	--						
<sup>1</sup> Zero/span calibration	Zero and span calibration	Every 3 months	--						
<sup>1</sup> External zero air scrubber (optional)	Exchange chemical	Every 3 months	No						
<sup>1</sup> Perform flow check	Check Flow	Every 6 Months	No						
<sup>1</sup> Critical flow orifice & sintered filters	Replace	Annually	Yes						
Internal IZS Permeation Tube	Replace	As required	YES						
Perform pneumatic leak check	Verify Leak Tight	Annually or after repairs involving pneumatics	Yes						
<sup>2</sup> Pump diaphragm	Replace	At least Every 2 years or if <b>PRES</b> is ≥ 33.00 in-Hg-A	Yes						
PMT sensor hardware calibration	Low-level hardware calibration	On PMT/ preamp changes if 0.7 < <b>SLOPE</b> or <b>SLOPE</b> > 1.3	Yes						

**Table 6-2. T102 Maintenance Schedule**

ITEM	ACTION	FREQUENCY	CAL CHECK	DATE PERFORMED			
501 SO <sub>2</sub> scrubber	Replace scrubber material	As required	Yes				
<sup>1</sup> Particulate filter	Change particle filter	Weekly	No				
Verify basic functions	Review in Dashboard and evaluate	Weekly	No				
Zero/span check	Evaluate offset and slope	Weekly	--				
<sup>1</sup> Zero/span calibration	Zero and span calibration	Every 3 months	--				
<sup>1</sup> External zero air scrubber (option)	Exchange chemical	Every 3 months	No				
<sup>1</sup> Perform flow check	Check Flow	Every 6 Months	No				
<sup>1</sup> Sample chamber optics	Clean windows and filters	Annually or as necessary	Yes				
<sup>1</sup> Critical flow orifice & sintered filters	Replace	Annually	Yes				
Internal IZS Permeation Tube	Replace	Annually	YES				
Perform pneumatic leak check	Verify Leak Tight	Annually or after repairs involving pneumatics	Yes				
<sup>2</sup> Pump diaphragm	Replace	Every 2 years, or as necessary	Yes				
PMT sensor hardware calibration	Low-level hardware calibration	On PMT/ preamp changes if $0.7 < \text{SLOPE}$ or $\text{SLOPE} > 1.3$	Yes				
Desiccant bags	Replace	Any time sensor assy inspection plate is opened					

<sup>1</sup> These Items are required to maintain full warranty, all other items are strongly recommended.

<sup>2</sup> A pump rebuild kit is available from TAPI Technical Support including all instructions and required parts.

## 6.2. 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 (Section 3.4) 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 6-3. Predictive Uses for Dashboard Functions**

DASHBOARD FUNCTION	DAS FUNCTION	CONDITION	BEHAVIOR		INTERPRETATION
			EXPECTED	ACTUAL	
H2S/TRS STB <sup>1</sup>	N/A	Zero Gas	≤ 1 ppb with zero air	Increasing	<ul style="list-style-type: none"> <li>• Pneumatic Leaks – instrument &amp; sample system</li> <li>• Detector deteriorating</li> </ul>
PRES	SMPPRS	sample gas	Constant within atmospheric changes	Fluctuating	<ul style="list-style-type: none"> <li>• Developing leak in pneumatic system</li> </ul>
				Slowly increasing	<ul style="list-style-type: none"> <li>• Flow path is clogging up.</li> <li>• Developing leak in pneumatic system to vacuum</li> <li>- Check critical flow orifice &amp; sintered filter.</li> </ul>
				Slowly decreasing	<ul style="list-style-type: none"> <li>• Replace particulate filter</li> </ul>
DRK PMT	DRKPMT	PMT output when UV Lamp shutter closed	Constant within ±20 of check-out value	Significantly increasing	<ul style="list-style-type: none"> <li>• PMT cooler failure</li> <li>• Shutter Failure</li> </ul>
SO <sub>2</sub> Concentration	CONC1	At span with IZS option installed	Constant response from day to day	Decreasing over time	<ul style="list-style-type: none"> <li>• Change in instrument response</li> <li>• Degradation of IZS permeation tube</li> </ul>
		Standard configuration at span	stable for constant concentration	Decreasing over time	<ul style="list-style-type: none"> <li>• Drift of instrument response; UV Lamp output is excessively low; clean RCEL window</li> </ul>
SAMP FL	SMPFLW	Standard Operation	Stable	Slowly Decreasing	<ul style="list-style-type: none"> <li>• Flow path is clogging up.</li> <li>- Check critical flow orifice &amp; sintered filter.</li> <li>- Replace particulate filter</li> </ul>
				Fluctuating	<ul style="list-style-type: none"> <li>• Leak in gas flow path.</li> </ul>
LAMP RATIO	LAMPR	Standard Operation	Stable and near 100%	Fluctuating or Slowly increasing	<ul style="list-style-type: none"> <li>• UV detector wearing out</li> <li>• UV source Filter developing pin holes</li> </ul>
				Slowly decreasing	<ul style="list-style-type: none"> <li>• UV detector wearing out</li> <li>• Opaque oxides building up on UV source Filter</li> <li>• UV lamp aging</li> </ul>
H2S OFFS <sup>1</sup>	OFFSET1	During Zero Cal	Stable	Slowly increasing or decreasing	<ul style="list-style-type: none"> <li>• Bad PMT</li> <li>• Failed HVPS</li> <li>• Leak in sample gas flow</li> <li>• Contamination in zero gas source.</li> </ul>
H2S SLOPE <sup>1</sup>	SLOPE1	During Span Cal	Stable	Slowly increasing or decreasing	<ul style="list-style-type: none"> <li>• UV lamp aging</li> <li>• UV detector wearing out</li> <li>• Leak in Sample gas or calibration gas flow path</li> <li>• Deterioration / contamination of calibration gas source(s)</li> </ul>

<sup>1</sup> Shown as they appear when analyzer is in H<sub>2</sub>S mode. In SO<sub>2</sub> mode appear as SO<sub>2</sub> OFFS & SO<sub>2</sub> SLOPE. In multigas mode, both versions appear.

## 6.3. OPERATIONAL HEALTH CHECKS

Navigate to the Utilities>USB Utilities>Report menu (Figure 6-1) 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.

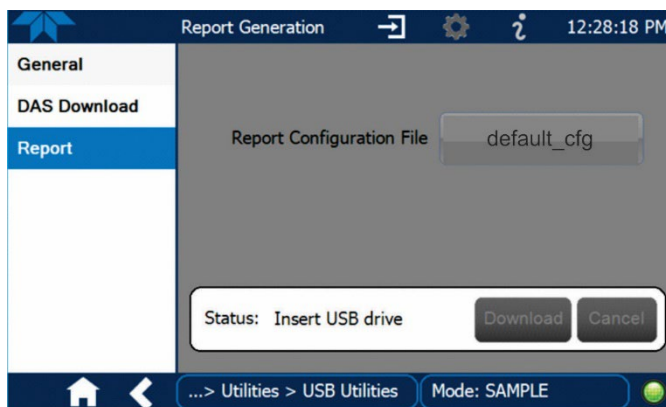


Figure 6-1. Report Generation Page

## 6.4. 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 (6.4.1) or manually (6.4.2).

### 6.4.1. 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 6-2). If an update is available, the Update button will be enabled.

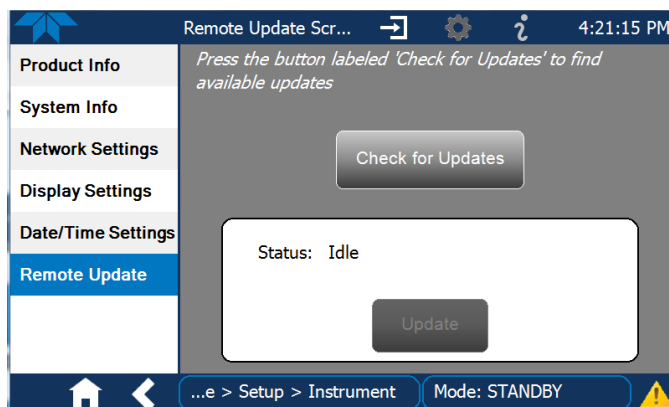
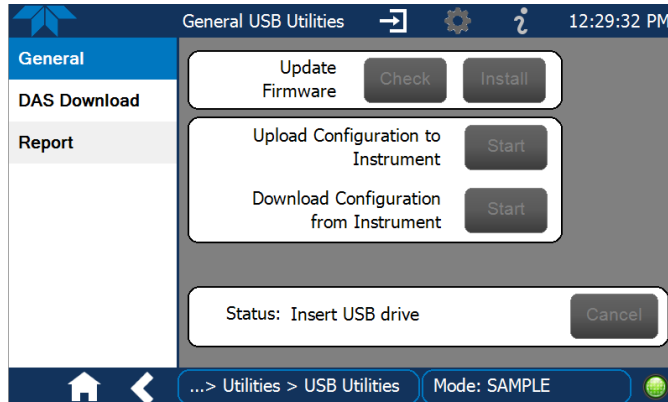


Figure 6-2. Remote Update Page

## 6.4.2. MANUAL RELOAD/UPDATE PROCEDURES

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

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

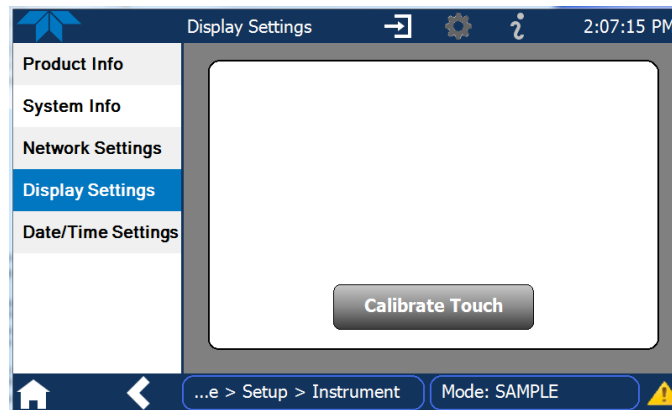


**Figure 6-3. Manual Update Page (and other utilities)**

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

### 6.4.3. TOUCHSCREEN DISPLAY CALIBRATION (FOR EARLIER INSTRUMENTS)

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



**Figure 6-4. Touchscreen Calibration Page**

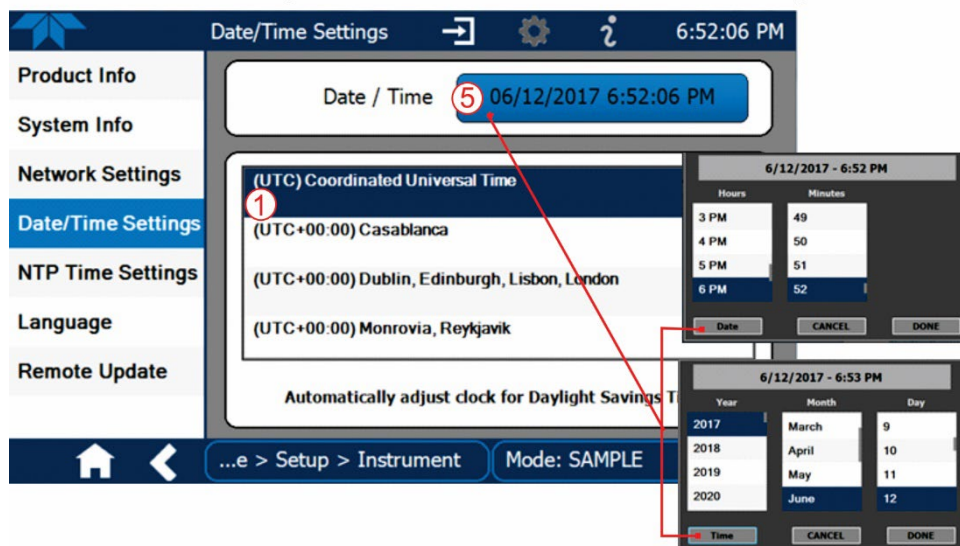
1. Connect a mouse to either of the front panel USB ports.
2. Navigate with the pointer to Setup>Instrument>Display Settings.
3. Click on “Calibrate Touch” and a crosshair appears in the center of the display screen.
4. Note that a timer function is enabled, allowing only 15 seconds to start the calibration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

## 6.5. 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 6-5. Time Zone Change Requirements**

## 6.6. HARDWARE MAINTENANCE PROCEDURES

Perform the following procedures as standard maintenance per Table 6-1.

### 6.6.1. REPLACING THE SAMPLE PARTICULATE 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  $\mu\text{m}$  pore size can clog up while retaining a clean look.

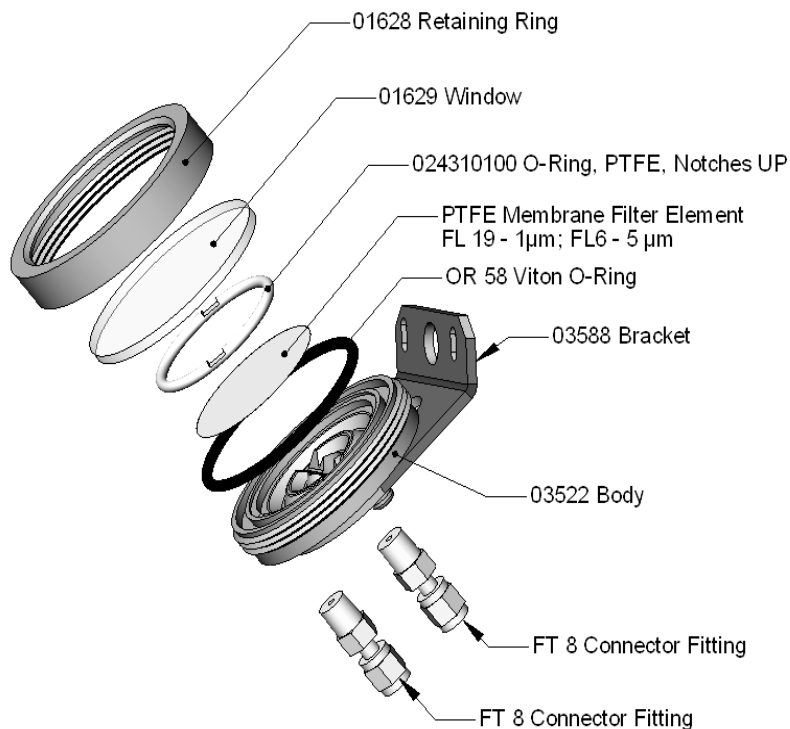
#### Important

#### 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 front panel and unscrew the retaining ring on the filter assembly.



**Figure 6-6. Replacing the Particulate Filter**

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



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

### 6.6.2. CHANGING/REMOVING THE IZS PERMEATION TUBE

1. Turn off the analyzer, unplug the power cord and remove the cover.
2. Locate the IZS oven in the rear left of the analyzer.
3. Remove the top layer of insulation if necessary.
4. Unscrew the black aluminum cover of the IZS oven (3 screws) using a medium Phillips-head screw driver.
  - 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.
7. Replace the analyzer cover, plug the power cord back in and turn on the analyzer.
8. Carry out an IZS span check to verify that the new permeation device works properly (see Section 5.3).
  - 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.**

### 6.6.3. MAINTAINING THE SO<sub>2</sub> SCRUBBER

The SO<sub>2</sub> scrubber (located inside the chassis of the T101, or located inside the 501-TRS of the T102 system) utilizes a consumable compound to absorb SO<sub>2</sub> from the sample gas that must be replaced periodically in order for the analyzer to continue measuring the desired gas accurately and reliably ( H<sub>2</sub>S in the T101 or TRS in the T102).

This material is capable of efficiently scrubbing SO<sub>2</sub> for up to 1000 ppm/hours. This means that if the SO<sub>2</sub> content of the sample gas is typically around 100 ppb, the scrubber will function for approximately 10,000 hours, a little over 13 months. However, if the typical ambient SO<sub>2</sub> level of the sample gas is higher, the scrubber will last a shorter time;

e.g., an ambient SO<sub>2</sub> level of 250 ppb would shorten the duration of the scrubber's efficiency to approximately 4000 hours or about 5 ½ months.

### **6.6.3.1. DETERMINING LIFE OF SO<sub>2</sub> SCRUBBER AND WHEN TO REPLACE**

To determine how long the SO<sub>2</sub> scrubber will operate efficiently:

Ensure that the Setup>Vars>Gas Measure Mode is set to **SO2** only (not multiple).

Let the analyzer operate in Sample Mode for 30 minutes, then note the SO<sub>2</sub> concentration.

Divide 1,000 by the SO<sub>2</sub> ppm concentration or 1,000,000 by the SO<sub>2</sub> ppb concentration.

EXAMPLE: If the SO<sub>2</sub> concentration is 0.125 ppm or 125 ppb:

$$1000 \text{ ppm/hr} \div 0.125 \text{ ppm}$$

$$1,000,000 \text{ ppb/hr} \div 125 \text{ ppb}$$

$$\text{Operational hours} = 8000 \text{ hrs}$$

### **6.6.3.2. CHECKING THE FUNCTION OF THE SO<sub>2</sub> SCRUBBER**

To check to see if your SO<sub>2</sub> scrubber is operating properly:

1. With the Measure Mode var set to H<sub>2</sub>S in the T101 or to TRS in the T102, introduce gas mixture into the sample gas stream that includes SO<sub>2</sub> at a concentration of at least 20% of the reporting range currently selected. For example, if the analyzer is set for a Single Range & 500 ppb, a concentration of 1000 ppb would be appropriate.
2. Note the gas concentration: An increase of more than 2% in the gas reading is an indication that the efficiency of the scrubber is decreasing to the point that the absorbing material should be replaced.

### **6.6.3.3. CHANGING THE SO<sub>2</sub> SCRUBBER MATERIAL**

1. Input zero air for 5 minutes.
2. Turn off instrument(s).
3. Locate the scrubber cartridge (white cylinder) respective to the instrument (refer to Figure 2-6 or Figure 2-8).
4. Disconnect the two fittings on the top of the scrubber.
5. Remove the two screws holding the scrubber to the instrument and remove the scrubber.
6. Take the two Teflon fittings off the instrument.
7. Empty the SO<sub>2</sub> scrubbing material into a hazmat bin.

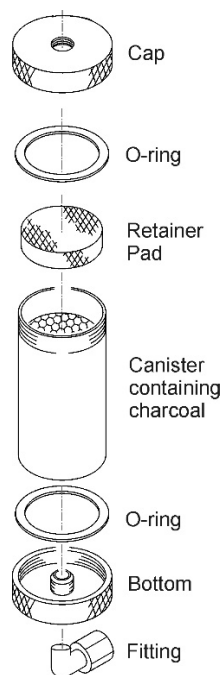
- Fill each side of the scrubber with new SO<sub>2</sub> scrubber material until it is ½ an inch from the bottom of the thread lines so about ½ inches from the top of the scrubber,

**Important** Do not fill it too high or the fitting will compact the material, causing gas flow restriction.

- Remove the Teflon tape from both of the removed fittings, and rewrap them with new Teflon tape.
- Install both fittings back onto the scrubber.
- Put the scrubber back into its instrument and replace the two screws on the bottom.
- Screw the two fittings back onto the top of the scrubber (either fitting can fit the inlet or the outlet).
- Return instrument(s) to normal operation.

#### 6.6.4. CHANGING THE EXTERNAL ZERO AIR SCRUBBER

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. Ensure that the analyzer is not in either the ZERO or SPAN calibration modes.



**Figure 6-7. Charcoal Canister Assembly**

- Locate the scrubber on the outside rear panel.
- Remove the old scrubber by disconnecting the 1/4" plastic tubing from the particle filter using 9/16" and 1/2" wrenches.
- Remove the particle filter from the cartridge using 9/16" wrenches.



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4. Unscrew the top of the scrubber canister and discard charcoal contents in accordance with 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 at the bottom.
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.

### 6.6.5. MAINTAINING THE T101'S H<sub>2</sub>S → SO<sub>2</sub> CONVERTER

The catalyst contained in the H<sub>2</sub>S → SO<sub>2</sub> converter of your T101 must be replaced periodically in order for the analyzer to continue measuring H<sub>2</sub>S accurately and reliably.

This material is capable of efficiently converting H<sub>2</sub>S into SO<sub>2</sub> for up to 6000 ppm/hours. This means that if the H<sub>2</sub>S content of the sample gas is typically around 600 ppb, the scrubber will function for approximately 10,000 hours, a little over 13 months. However, if the typical ambient H<sub>2</sub>S level of the sample gas is higher, the duration of the converter's efficiency would be shorter; e.g., if the ambient H<sub>2</sub>S level of the sample gas is 1000 ppb, the efficiency of the converter would be shortened to about 6000 hours or about 8 months.

#### 6.6.5.1. DETERMINING LIFE OF CONVERTER CATALYST AND WHEN TO REPLACE

To determine how long the H<sub>2</sub>S → SO<sub>2</sub> converter will operate efficiently:

1. Measure the amount of H<sub>2</sub>S in the sample gas.
2. Divide 6000 by the H<sub>2</sub>S concentration in ppm or 6,000,000 by the H<sub>2</sub>S concentration in ppb.

EXAMPLE: If the H<sub>2</sub>S concentration is 750 ppb:

$$6000 \text{ ppm/hr} \div 0.75 \text{ ppm}$$

$$6,000,000 \text{ ppb/hr} \div 750 \text{ ppb}$$

$$\text{Operational hours} = 8000 \text{ hrs}$$

#### 6.6.5.2. CHECKING THE EFFICIENCY OF THE H<sub>2</sub>S → SO<sub>2</sub> CONVERTER

To check whether the H<sub>2</sub>S → SO<sub>2</sub> converter is operating properly:

1. Set the analyzer to SO<sub>2</sub> measurement mode (Setup>Vars>Measure Mode).
2. Supply a gas with a known concentration of SO<sub>2</sub> to the sample gas inlet of the analyzer.
3. Wait until the analyzer's SO<sub>2</sub> concentration measurement stabilizes (should be 0.5 ppb or less before proceeding).

4. Record the stable SO<sub>2</sub> concentration
5. Set the analyzer to H<sub>2</sub>S measurement mode (Setup>Vars>Measure Mode).
6. Supply a gas with a known concentration of H<sub>2</sub>S, equal to that of the SO<sub>2</sub> gas used in steps 2-4 above, to the sample gas inlet of the analyzer.
7. Wait until the analyzer's concentration measurement stabilizes (should be 0.5 ppb or less before proceeding).
8. Record the stable H<sub>2</sub>S concentration
9. Divide the H<sub>2</sub>S concentration by the SO<sub>2</sub> concentration

EXAMPLE: If the SO<sub>2</sub> and H<sub>2</sub>S concentration of the two test gases used is 500 ppb:

Measured SO<sub>2</sub> concentration = 499.1 ppb

Measured H<sub>2</sub>S concentration = 490.3 ppb

Converter Efficiency=  $490.3 \div 499.1$

Converter Efficiency= 0.982 (98.2%)

10. It is recommended that the H<sub>2</sub>S → SO<sub>2</sub> converter catalyst material be replaced if the converter efficiency falls below 96% or whatever efficiency rating is specified by local regulatory requirements.

### 6.6.5.3. CHANGING THE H<sub>2</sub>S → SO<sub>2</sub> CONVERTER CATALYST MATERIAL

The H<sub>2</sub>S → SO<sub>2</sub> converter is located in the center of the instrument. The converter (see Figure 6-8 for the assembly) is designed for replacement of the cartridge only; the heater with built-in thermocouple can be reused.

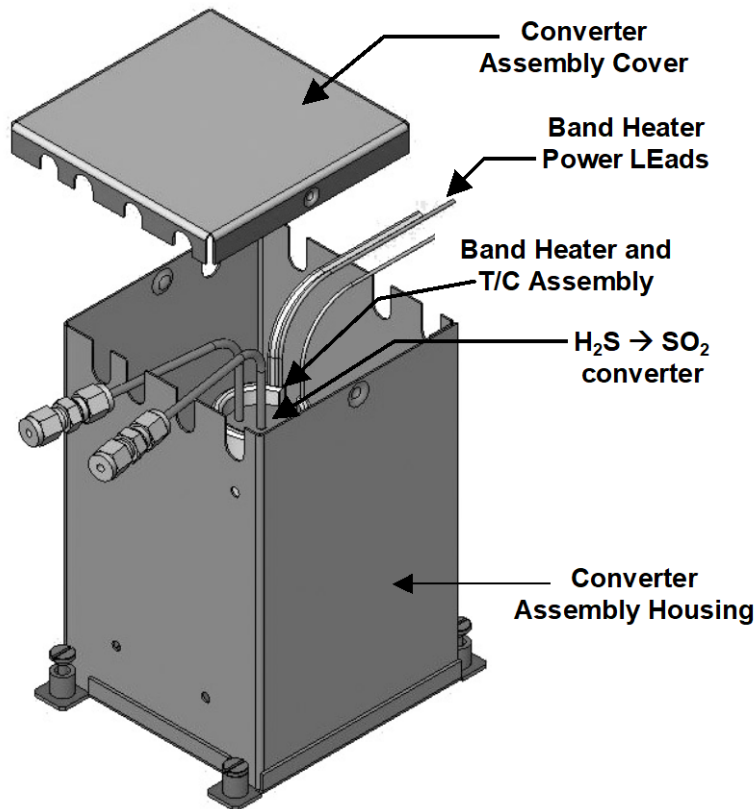
- Turn off the analyzer power, remove the cover and allow the converter to cool.
- Remove the top lid of the converter as well as the top layers of the insulation until the converter cartridge can be seen.



#### CAUTION

**The converter operates at 315° C. Severe burns can result if the assembly is not allowed to cool. Do not handle the assembly until it is at room temperature. This may take several hours..**

- Remove the tube fittings from the converter.
- Disconnect the power and the thermocouple of the converter. Unscrew the grounding clamp of the power leads with a Phillips-head screw driver.
- Remove the converter assembly (cartridge and band heater) from the can. Make a note of the orientation of the tubes relative to the heater cartridge.
- Unscrew the band heater and loosen it, take out the old converter cartridge.



**Figure 6-8. H<sub>2</sub>S - SO<sub>2</sub> Converter Assembly**

- Wrap the band heater around the new replacement cartridge and tighten the screws using a high-temperature anti-seize agent such as copper paste. Make sure to use proper alignment of the heater with respect to the converter tubes.
- Replace the converter assembly, route the cables through the holes in the housing and reconnect them properly. Reconnect the grounding clamp around the heater leads for safe operation.
- Re-attach the tube fittings to the converter and replace the insulation and cover.
- Replace the instrument cover and power up the analyzer.

### 6.6.6. MAINTAINING THE T102's 501-TRS → SO<sub>2</sub> CONVERTER

The T102 relies on the SO<sub>2</sub> scrubber of the 501-TRS in order for the TRS → SO<sub>2</sub> conversion to take place.

The SO<sub>2</sub> scrubber of the 501-TRS utilizes a consumable compound to absorb SO<sub>2</sub> from the sample gas before the TRS is converted to SO<sub>2</sub>. This material must be replaced periodically in order for the analyzer to continue measuring TRS accurately and reliably.

This material is capable of efficiently scrubbing SO<sub>2</sub> for up to 1000 ppm-hours. This means that if the SO<sub>2</sub> content of the sample gas is typically around 100 ppb, the scrubber will function for approximately 10,000 hours, a little over 13 months. If, however, the typical ambient SO<sub>2</sub> level of the sample gas is 250 ppb, the scrubber would only last for approximately 4000 hours or about 5 ½ months.

### 6.6.6.1. CHECKING THE EFFICIENCY OF THE TRS → SO<sub>2</sub> CONVERTER

To check to see if your TRS → SO<sub>2</sub> converter is operating properly:

1. Set the analyzer for TRS gas measurement mode in the Setup>Vars menu.
2. Bypass the scrubber inside the 501-TRS.
  1. Unscrew the pneumatic fittings from the scrubber.
  2. Connect them with a stainless steel or Teflon<sup>®</sup> union.
3. Supply a gas with a known concentration of SO<sub>2</sub> to the sample gas inlet of the analyzer.
4. Wait until the analyzer's output concentration measurement stabilizes. TRS Stability (view in Dashboard; configure Dashboard if needed) should be 0.5 ppb or less before proceeding.
5. Record the stable SO<sub>2</sub> concentration (although the concentration is labeled TRS, we are measuring SO<sub>2</sub>).
6. Supply a gas with a concentration of H<sub>2</sub>S equal to that of the SO<sub>2</sub> gas used in steps 2 through 5 above, to the sample gas inlet of the analyzer.
7. Wait until the analyzer's output concentration measurement stabilizes. This can be determined by setting the analyzer's display to show the TRS Stability function, which should be 0.5 ppb or less before proceeding.
8. Record the stable TRS concentration.
9. Divide the TRS concentration by the SO<sub>2</sub> concentration.

EXAMPLE: If the SO<sub>2</sub> and TRS concentration of the two test gases used is 500 ppb:

Measured SO<sub>2</sub> concentration = 499.1 ppb

Measured TRS concentration = 490.3 ppb

Converter Efficiency =  $490.3 \div 499.1$

Converter Efficiency = 0.982 (98.2%)

10. If TRS → SO<sub>2</sub> converter efficiency is below 90% check for one of the following possible causes:
  - **Pneumatic leak**
    - Perform a leak check (Section 6.6.9.2) with the 501-TRS connected.
  - **Plugged or constricted pneumatic flow**
    - Perform a sample flow check (Section 6.6.9.3).

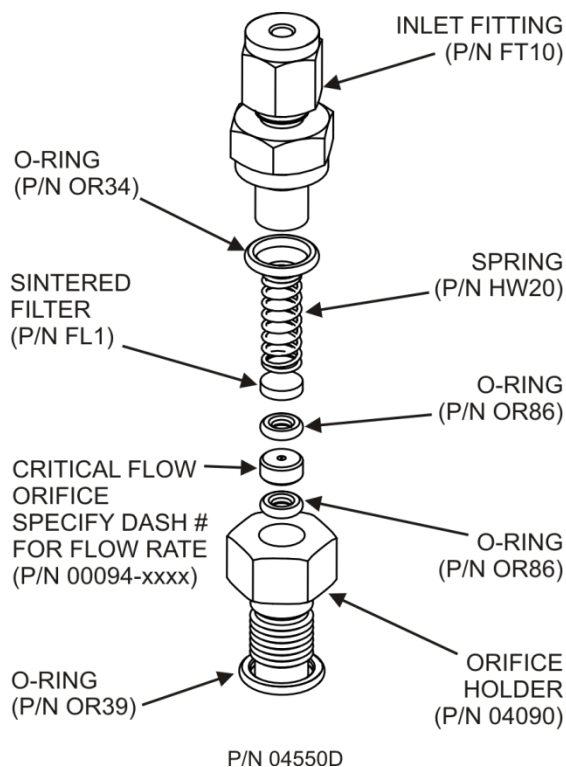


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- Disconnect the gas feed line from the **FROM ANALYZER** port of the 501-TRS. Attach the flow meter to the port and repeat the test. Isolates the portions of the pneumatic system downstream from the TRS → SO<sub>2</sub> switching valve but includes the 501-TRS in the flow test.
  - Attach the flow meter to the **FROM CONVERTER** port at the back of the T102. Retest. This bypasses 501-TRS during the flow test.
  - **Improper Set point temperature**
    - Call Teledyne API's Technical Support for advice.
  - **Incorrect/wrong concentration Span Gas used in efficiency test**
    - Independently verify the concentration of the span gas.
  - **Contaminants in the converter chamber, pneumatic lines**
    - Sometimes contaminants such as tiny particles of scrubber material from the 501-TRS' SO<sub>2</sub> scrubber can get into the converter tube and react with the TRS → SO<sub>2</sub> conversion process. This can occur if the filter material inside the scrubber lets any particulates through.
11. Call TAPI Technical Support for instructions on cleaning the converter tube and 501-TRS pneumatic lines.

## 6.6.7. SERVICING CRITICAL FLOW ORIFICES

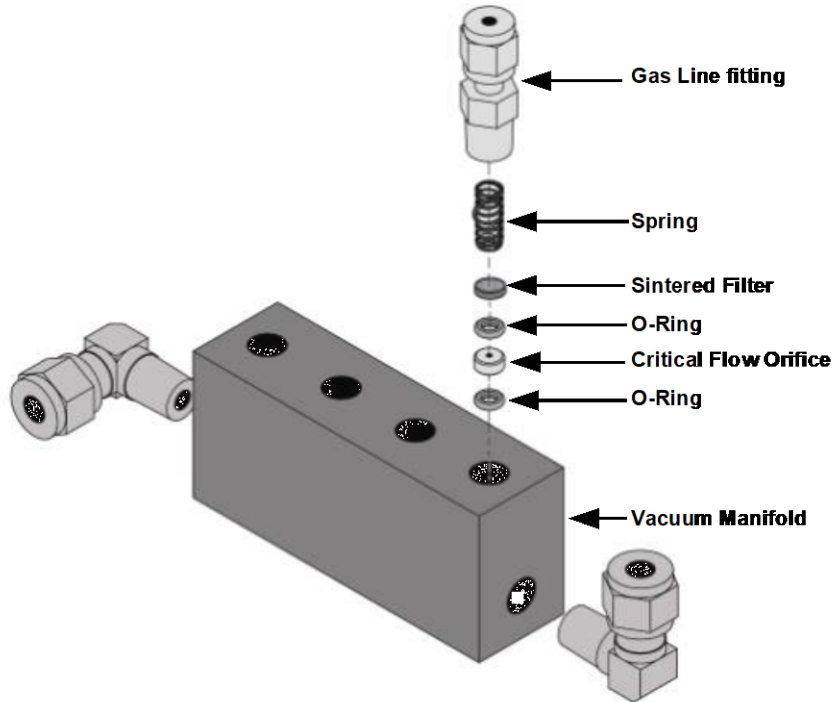
A critical flow orifice, located on the exhaust manifold maintains the proper flow rate of gas through the analyzer. Despite the fact that these flow restrictors are protected by sintered stainless steel filters, they can, on occasion, clog up, particularly if the instrument is operated without a sample filter or in an environment with very fine, sub-micron particle-size dust.



**Figure 6-9. 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 pressure sensor assembly.
3. Disconnect the pneumatic line.
4. Unscrew the NPT fitting.



**Figure 6-10. Critical Flow Orifice 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 and let the part dry.
8. Using a new filter and o-rings, reassemble the parts as shown in Figure 6-9.
9. Reinstall the NPT fitting and connect all tubing
10. Power up the analyzer and allow it to warm up for 60 minutes.
11. Perform a leak check.

## 6.6.8. CHECKING FOR LIGHT LEAKS

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 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 6.6.9).

## 6.6.9. 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.**

### 6.6.9.1. 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. If not already running, turn the analyzer ON, and allow at least 30 minutes for flows to stabilize.
2. Cap the sample inlet port (cap must be wrench-tight).
3. After several minutes, when the pressures have stabilized, note the Sample Pressure reading.
  - If equal to within 10% and less than 10 in-Hg-A, the instrument is free of large leaks.
  - It is still possible that the instrument has minor leaks.
  - If the reading greater 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).
4. When finished, switch off the pump and open the cap to the sample inlet port slowly to minimize inrush flow.

### 6.6.9.2. 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  $\leq 15$  psi, a shutoff valve and a pressure gauge may be used.

#### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

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

**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.



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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.
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.

### 6.6.9.3. PERFORMING FLOW CHECKS/CALIBRATIONS

#### Important

#### IMPACT ON READINGS OR DATA

**For accurate measurements use a separate, calibrated 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 pneumatic paths, most likely critical flow orifices or sintered filters (Section 6.6.5).

#### FLOW CHECK

Low flows indicate blockage somewhere in the pneumatic pathway.

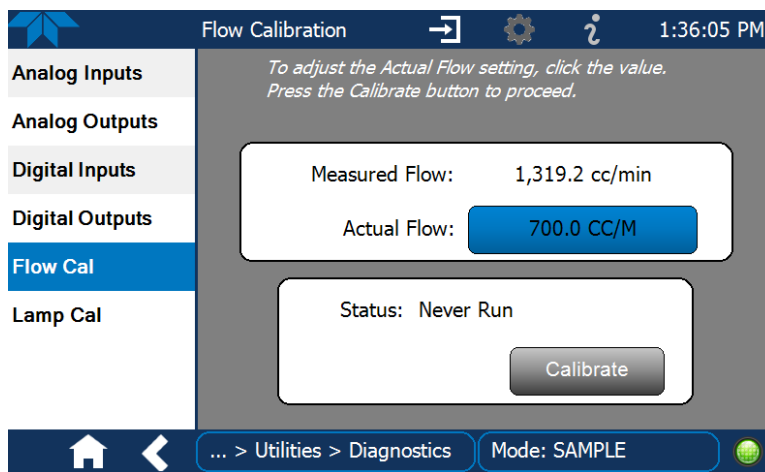
To check the Sample flow with the external flow meter:

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 6-11), 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 6-11. Flow Calibration Menu**

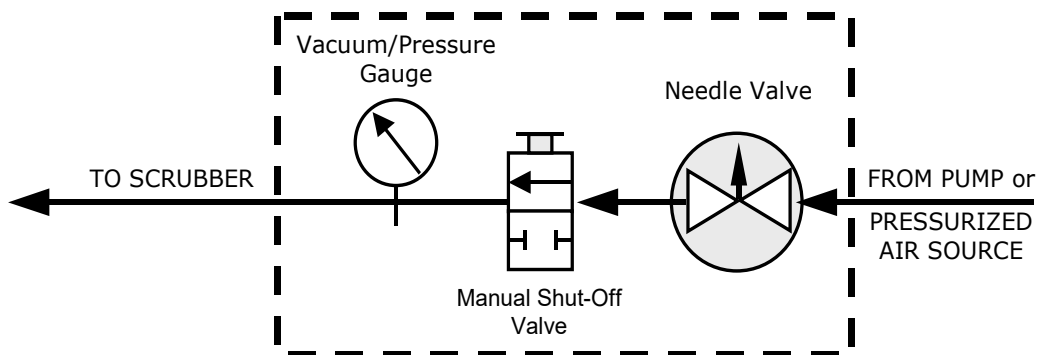
## 6.6.10. CHECKING THE HYDROCARBON SCRUBBER (KICKER)

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.

### 6.6.10.1. CHECKING THE SCRUBBER FOR LEAKS

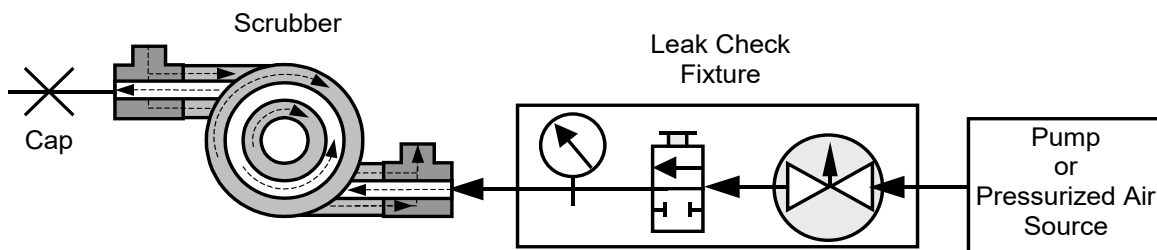
Leaks in the outer tubing of the scrubber can be found using the procedure described in Section 6.6.9.2. Use the following method to determine if a leak exists in the inner tubing of the scrubber.

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 6-12.



**Figure 6-12. 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 6-13. Hydrocarbon Scrubber Leak Check Setup**

7. Use the needle valve to adjust the air input until the gauge reads 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.

## 6.7. 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 6-4).
2. Examine the values of all basic functions in the Dashboard and compare them to factory values. Note any major deviations from the factory values and take corrective action.
3. Use the internal electronic status LEDs to determine whether the electronic communication channels are operating properly.
  - Verify that the DC power supplies are operating properly by checking the voltage test points on the relay PCA.
  - Note that the analyzer's DC power wiring is color-coded and these colors match the color of the corresponding test points on the relay PCA.
4. Suspect a leak first!
  - Customer service data indicate that the majority of all problems are eventually traced to leaks in the internal pneumatics of the analyzer or the diluent gas and source gases delivery systems.
  - Check for gas flow problems such as clogged or blocked internal/external gas lines, damaged seals, punctured gas lines, damaged / malfunctioning pumps, etc.
5. Follow the procedures defined in Section 2.3.4.3 to confirm that the analyzer's vital functions are working (power supplies, CPU, relay PCA, PMT cooler, etc.).

## 6.7.1. FAULT DIAGNOSIS WITH ALERTS

Table 6-4 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 (power supply, relay PCA, motherboard) has failed rather than an indication of the specific failures referenced by the warnings.

Table 6-4. Warning Alerts, Fault Conditions and Possible Causes

WARNING	FAULT CONDITION	POSSIBLE CAUSES
<b>ANALOG CAL WARNING</b>	The instrument's A/D circuitry or one of its analog outputs is not calibrated	<ul style="list-style-type: none"> <li>• A parameter for one of the analog outputs, even one not currently being used, has been changed and the analog output calibration routine was not re-run</li> <li>• A/D circuitry failure on motherboard</li> <li>• Other motherboard electronic failure</li> </ul>
<b>BOX TEMP WARNING</b>	Temperature of chassis is outside specified limits. (typically < 7°C or > 48°C)	<ul style="list-style-type: none"> <li>• Box Temperature typically runs ~7°C warmer than ambient temperature</li> <li>• Poor/blocked ventilation to the analyzer</li> <li>• Stopped Exhaust Fan</li> <li>• Ambient Temperature outside of specified range</li> </ul>
<b>CANNOT DYN SPAN <sup>1</sup></b>	Dynamic Span operation failed. (Contact closure span calibration failed while the <i>Dynamic Span Var</i> was set to <i>Enabled</i> ).	<ul style="list-style-type: none"> <li>• Measured concentration value is too high or low</li> <li>• Concentration Slope value to high or too low</li> </ul>
<b>CANNOT DYN ZERO <sup>2</sup></b>	Dynamic Zero operation failed. (Contact closure zero calibration failed while the <i>Dynamic Zero Var</i> was set to <i>Enabled</i> ).	<ul style="list-style-type: none"> <li>• Measured concentration value is too high</li> <li>• Concentration Offset value to high</li> </ul>
<b>CONFIG INITIALIZED</b>	Configuration and Calibration data reset to original Factory state or erased.	<ul style="list-style-type: none"> <li>• Failed Disk on Module</li> <li>• User erased data</li> </ul>
<b>DARK CAL WARNING</b>	Dark Cal signal is too high Dark offset above limit specified indicating that too much stray light is present in the sample chamber.	<ul style="list-style-type: none"> <li>• Light leak in reaction cell</li> <li>• Shutter solenoid is not functioning</li> <li>• Failed relay board</li> <li>• I<sup>2</sup>C bus failure</li> <li>• Loose connector/wiring</li> <li>• PMT preamp board bad or out of cal</li> </ul>
<b>DATA INITIALIZED</b>	Data Storage in DAS was erased before the last power up occurred.	<ul style="list-style-type: none"> <li>• Failed Disk-on-Module</li> <li>• User cleared data.</li> </ul>
<b>HVPS WARNING</b>	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"> <li>• High voltage power supply is bad</li> <li>• High voltage power supply is out of cal</li> <li>• A/D converter circuitry is bad</li> </ul>
<b>IZS TEMP WARNING <sup>3</sup></b>	On units with IZS options installed: Permeation tube temperature is outside specified limits.	<ul style="list-style-type: none"> <li>• Bad IZS heater</li> <li>• Bad IZS temperature sensor</li> <li>• Bad relay controlling the IZS heater</li> <li>• Entire relay board is malfunctioning</li> <li>• I<sup>2</sup>C bus malfunction</li> <li>• Failure of thermistor interface circuitry on motherboard</li> </ul>



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WARNING	FAULT CONDITION	POSSIBLE CAUSES
<b>PMT TEMP WARNING</b>	PMT temperature outside of warning limits.	<ul style="list-style-type: none"> <li>PMT fan not operating</li> <li>Failed PMT Temperature Sensor</li> <li>Failed PMT TEC</li> <li>Failed PMT TEC driver circuit</li> <li>Failed PMT Preamp PCA</li> <li>Loose wiring between PMT temperature sensor and PMT Preamp board</li> <li>Malfunction of analog sensor input circuitry on motherboard</li> </ul>
<b>PMT DET WARNING</b>	PMT detector output is outside of operational limits.	<ul style="list-style-type: none"> <li>Failed PMT</li> <li>Malfunctioning PMT preamp board</li> <li>A/D converter circuitry failure</li> </ul>
<b>RCELL TEMP WARN</b>	Sample chamber temperature is out of range.	<ul style="list-style-type: none"> <li>Failed reaction cell heater</li> <li>Failed reaction cell temperature sensor</li> <li>Malfunctioning relay controlling the reaction cell heater</li> <li>Entire relay board malfunctioning</li> <li>I<sup>2</sup>C bus malfunctioning</li> <li>Heater configured for wrong voltage type</li> </ul>
<b>REAR BOARD NOT DET</b>	Motherboard not detected on power up. (CPU unable to communicate with motherboard).	<p>This warning only appears on Serial I/O COM Port(s). Front panel display will be frozen, blank or will not respond.</p> <p>Failure of motherboard</p>
<b>RELAY BOARD WARN</b>	The CPU unable to communicate with the Relay PCA.	<ul style="list-style-type: none"> <li>I<sup>2</sup>C Bus failure</li> <li>Failed Relay Board</li> <li>Loose connectors/wiring</li> </ul>
<b>SAMPLE FLOW WARN</b>	The flow rate of the sample gas is outside the specified limits.	<ul style="list-style-type: none"> <li>Failed Sample Pump</li> <li>Blocked Sample Inlet/Gas Line</li> <li>Dirty Particulate Filter</li> <li>Leak downstream of Critical Flow Orifice</li> <li>Failed flow sensor circuitry</li> </ul>
<b>SAMPLE PRES WARN</b>	<p>Sample Pressure is &lt;10 in-Hg or &gt; 35 in-H</p> <p>Note: Normally 29.92 in-Hg at sea level decreasing at 1 in-Hg per 1000 ft of altitude (with no flow – pump disconnected)</p>	<p>If sample pressure is &lt; 10 in-hg:</p> <ul style="list-style-type: none"> <li>Blocked particulate filter</li> <li>Blocked sample inlet/gas line</li> <li>Failed pressure sensor/circuitry</li> </ul> <p>If sample pressure is &gt; 35 in-hg:</p> <ul style="list-style-type: none"> <li>Blocked vent line on pressurized sample/zero/span gas supply</li> <li>Bad pressure sensor/circuitry</li> </ul>
<b>SYSTEM RESET</b>	The computer has rebooted.	<p>This message occurs at power on. If it is confirmed that power has not been interrupted:</p> <ul style="list-style-type: none"> <li>Failed +5 VDC power</li> <li>Fatal Error caused software to restart</li> <li>Loose connector/wiring</li> </ul>



WARNING	FAULT CONDITION	POSSIBLE CAUSES
<b>UV LAMP WARNING</b>	The UV lamp intensity measured by the reference is outside of specified limits.	<ul style="list-style-type: none"> <li>• UV lamp is bad</li> <li>• Reference detector is bad or out of adjustment.</li> <li>• Mother board analog sensor input circuitry has failed.</li> <li>• Fogged or damaged lenses/filters in UV light path</li> <li>• A/D converter circuitry failure</li> <li>• Light leak in reaction cell</li> <li>• Shutter solenoid stuck in closed position</li> </ul>

<sup>1</sup> Clears the next time successful span calibration is performed.

<sup>2</sup> Clears the next time successful zero calibration is performed.

<sup>3</sup> Only appears if the IZS option is installed.

### 6.7.2. 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 7).

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.**

**Table 6-5. Dashboard Functions - Possible Causes for Out-of-Range Values**

DASHBOARD FUNCTION	NOMINAL VALUES	POSSIBLE OUT-OF-RANGE CAUSE(S)
Stability	≤1 ppb 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 cm <sup>3</sup> /min ± 10%	Faults are caused due to: clogged critical flow orifice; pneumatic leak; faulty flow sensor; sample line flow restriction.
PMT	-20 to 150 mV with Zero Air	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>
Norm PMT	0-5000 mV, 0-20,000 ppb @ Span Gas Concentration	Noisy Norm PMT value (assuming unchanging SO <sub>2</sub> concentration of sample gas); Calibration error; HVPS problem; PMT problem.
UV Lamp	2000 - 4000 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 600 mV will cause UV LAMP warning. Most likely cause is a UV lamp in need of replacement.
Lamp Ratio	30 TO 120%	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 (Utilities>Diagnostics menu). Out of range lamp ratio may be due to: malfunctioning UV lamp; UV lamp position out of alignment; faulty lamp transformer; aging or faulty UV detector; dirty optical components; pin holes or scratches in the UV optical filters; light leaks.
Stray Light	≤ 100 ppb / Zero Air	High stray light could be caused by: aging UV filter; contaminated reaction cell; light leak; pneumatic leak.
Dark Lamp	-50 to +200 mV	High dark UV detector could be caused by: light leak; shutter not closing completely; high electronic offset.
Dark PMT	-50 to +200 mV	High dark PMT reading could be due to: light leak; shutter not closing completely; high pmt temperature; high electronic offset.
HVPS	≈ 400 V to 900 V	Incorrect HVPS reading could be caused by; HVPS broken; preamp board circuit problems.
RCell Temp	50°C ± 1°C	Incorrect temperature reading could be caused by: malfunctioning heater; relay board communication (I <sup>2</sup> C bus); relay burnt out
Box Temp	Ambient + ≈ 5°C	Incorrect temperature reading could be caused by: Environment out of temperature operating range; broken thermistor; runaway heater
PMT Temp	7°C ± 2°C Constant	Incorrect temperature reading could be caused by: TEC cooling circuit broken; High chassis temperature; 12V power supply
IZS (option) Temp	50°C ± 1°C	Malfunctioning heater; relay board communication (I <sup>2</sup> C bus); relay burnt out
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; span gas concentration incorrect; 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.

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

The signal I/O functions in the Utilities>Diagnostics menu allows access to the digital and analog I/O in the analyzer. Some of the digital signals can be controlled through the Setup menu. These signals, combined with a thorough understanding of the instrument's principles of operation (Section 7), are useful for troubleshooting in three ways:

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

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

### 6.7.4. USING THE INTERNAL ELECTRONIC STATUS LEDs

Several color-coded LEDs are located inside the instrument to assist in determining if the analyzer's CPU, I<sup>2</sup>C communications bus and Relay board are functioning properly.

#### 6.7.4.1. CPU STATUS INDICATOR

DS5, a red LED located on the motherboard (Figure 6-14), flashes when the CPU is running the main program loop. After power-up, approximately 30 – 60 seconds, DS5 should flash on and off. If the front panel displays properly but DS5 does not flash, then the program files may have become corrupted or the CPU may be defective; contact Teledyne API's Technical Support Department (see Section 6.9) because it may be possible to recover operation of the analyzer. If after 30 – 60 seconds DS5 is steadily off or steadily on, the CPU board is likely locked up and should the analyzer not respond (either with locked-up or dark front panel), then replace the CPU.

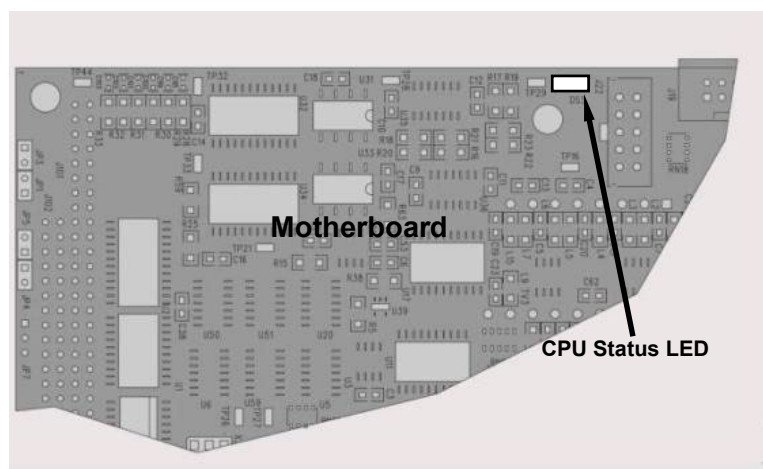


Figure 6-14. CPU Status Indicator

### 6.7.4.2. RELAY PCA WATCHDOG AND STATUS LEDs

There are several LEDs located on the Relay PCA (some are not used on this model), which indicate the status of the analyzer’s heating zones and valves. The most important of the LEDs is D1 (see Figure 6-15), which indicates the health of the CPU or the I<sup>2</sup>C bus: if either stops functioning, D1 will stay either ON or OFF, and after 30 seconds the “Watchdog Circuit” will automatically .

#### RELAY PCA STATUS LEDs

LEDs that remain continuously on or continuously off (not blinking) indicate a default state for their respective components as described in Table 6-6.

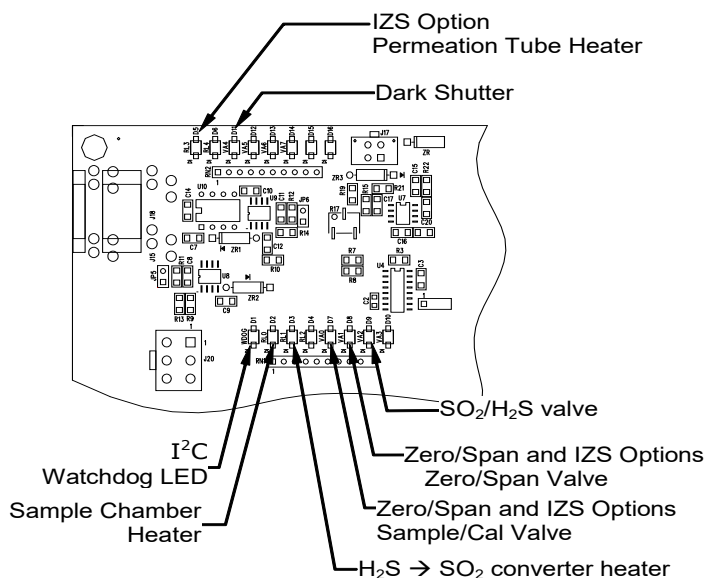


Figure 6-15. Relay PCA Status LED Locations

Table 6-6. Relay PCA Watchdog and Status LED Failure Indications

LED	COLOR	FUNCTION	STATUS WHEN LIT	STATUS WHEN UNLIT
D1	RED	Watchdog circuit	Cycles On/Off every 3 seconds under control of the CPU.	
D2	YELLOW	Sample chamber heater	HEATING	NOT HEATING
D3	YELLOW	H <sub>2</sub> S → SO <sub>2</sub> converter heater	HEATING	NOT HEATING
D4	YELLOW	Unused	N/A	N/A
D5	YELLOW	IZS heater Perm. Tube (option)	HEATING	NOT HEATING
D6	YELLOW	Unused	N/A	N/A
D7	GREEN	Sample/Cal Valve (option)	Valve open to zero/span valve.	Valve open to sample inlet
D8	GREEN	Zero/Span Valve (option)	Valve open to zero gas inlet	Valve open to span gas inlet
D9	GREEN	SO <sub>2</sub> /H <sub>2</sub> S valve	Gas stream bypasses H <sub>2</sub> S → SO <sub>2</sub> converter. Analyzer measuring SO <sub>2</sub>	Valve open to H <sub>2</sub> S → SO <sub>2</sub> converter. Analyzer measuring H <sub>2</sub> S.
D10	GREEN	Unused	N/A	N/A
D11	GREEN	UV Lamp Shutter	Shutter open	Shutter closed
D12-14	GREEN	Unused	N/A	N/A

## 6.7.5. FLOW PROBLEMS

The standard analyzer has one main flow path. With the IZS option installed, there is a second flow path through the IZS oven that runs whenever the IZS is on standby to purge H<sub>2</sub>S from the oven chamber. The IZS flow is not measured so there is no reading for it on the front panel display. 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. The use of an independent, external flow meter to perform a flow check as described in Section 6.6.9.3 is essential. Refer to the pneumatic flow diagrams as needed for reference.

### 6.7.5.1. 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) shows nothing instead of a numerical value.

#### 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 an AC voltmeter to ensure that the pump is supplied with the proper AC power. If AC power is supplied properly but the pump is not running, replace the pump.

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 a 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.
  - 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 6.6.9.
  - 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 6.6.9.2.

### 6.7.5.2. HIGH FLOW

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

- Ensure to vent excess pressure and flow just before the analyzer inlet ports.
- When supplying sample, zero or span gas at ambient pressure, a high flow could indicate a broken critical flow orifice (very unlikely case), allowing more than nominal flow, or were replaced with an orifice of wrong specifications.
- If the flows are within 15% above normal, we recommend measuring and recalibrating the flow electronically (Section 6.6.9.3), 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.

### 6.7.5.3. 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.

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.

## 6.7.6. CALIBRATION PROBLEMS

This section describes possible causes of calibration problems.

### 6.7.6.1. NEGATIVE CONCENTRATIONS

Negative concentration values can be caused by:

- A slight, negative signal is normal when the analyzer is operating under zero gas and the signal is drifting around the zero calibration point. This is caused by the analyzer's zero noise and may cause reported concentrations to be negative for a few seconds at a time down to -5 ppb, but should alternate with similarly high, positive values.
- Miscalibration is the most likely explanation for negative concentration values. If the zero air contained some H<sub>2</sub>S 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 H<sub>2</sub>S. The same problem occurs, if the analyzer was zero-calibrated using ambient air or span gas.
- If the response Offset function for H<sub>2</sub>S is greater than 150 mV, a failed PMT or high voltage supply, or sample chamber contamination, could be the cause.

### 6.7.6.2. 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. Confirm response by supplying H<sub>2</sub>S span gas of about 80% of the range value to the analyzer
2. Check the sample flow for proper value.



## T101, T102

3. Check for disconnected cables to the sensor module.
4. Carry out an electrical test with the ELECTRICAL TEST procedure (Run ETest) in the Utilities>Diagnostics>OE Test menu. See Electrical Test (ETest) in Section 6.7.9.10.
  - If this test produces a concentration reading, the analyzer's electronic signal path is correct.
5. Carry out an optical test using the OPTIC TEST procedure (Run OTest) in the Utilities>Diagnostics>OE Test menu. See Optic Test (OTest) in Section 6.7.9.10.
  - If this test results in a concentration signal, then the PMT sensor and the electronic signal path are operating properly.
  - If the analyzer passes both ETest and 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.

### 6.7.6.3. 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 6.6.9.
2. Consider examining 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 6.6.9.3) 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.

### 6.7.6.4. 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 H<sub>2</sub>S span gas source is accurate.
  - This can be done by comparing the source with another calibrated analyzer, or by having the H<sub>2</sub>S source verified by an independent traceable photometer.
3. Check for leaks in the pneumatic systems as described in Section 6.6.9.
  - Leaks can dilute the span gas and, hence, the concentration that the analyzer measures may fall short of the expected concentration.



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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 6.7.10.4 on how to carry out a low-level hardware calibration.

### 6.7.6.5. 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 H<sub>2</sub>S and SO<sub>2</sub>-free air. Check any zero air scrubber for performance. It may need to be replaced (Section 6.6.3).
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 6.6.9.

### 6.7.6.6. 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 6.6.9.
- 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 SO<sub>2</sub> 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 H<sub>2</sub>S span value is continuously trending downward, the IZS permeation tube may require replacement.



## 6.7.6.7. 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.

## 6.7.7. MODEL 501-TRS CONVERTER HEATING PROBLEMS

First, check that the controller is in operational mode.

If it is, then look at the thermocouple for a possible cause of a heating problem:

- Check that the thermocouple leads are securely connected to the wiring block at the back of the controller.
- Check that the wiring block/socket is correctly plugged onto the socket on the back of the controller.
- Check the resistance across the thermocouple leads for opens or shorts.

Another cause could be that the heater is malfunctioning; in that case, call Technical Support (Section 6.9).

## 6.7.8. OTHER PERFORMANCE PROBLEMS

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

### 6.7.8.1. EXCESSIVE NOISE

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

- Ensure that the sample or span gas supply is leak-free and carry out a detailed leak check as described under Section 6.6.9.

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.

An excessively noisy TRS measurement can be caused by hysteresis or fluctuations in the temperature of the TRS converter oven.

- Contact the factory for troubleshooting guidance.

### 6.7.8.2. SLOW RESPONSE

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

- Dirty or plugged sample filter or sample lines.
- Sample inlet line is too long.
- Dirty or plugged critical flow orifices. Check flows, pressures and, if necessary, change orifices (Section 6.6.5).
- 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 H<sub>2</sub>S calibration gas source to become stable. Wait until stability is low.

## 6.7.9. SUBSYSTEM CHECK FOR TROUBLESHOOTING

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

### 6.7.9.1. 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 on the Relay PCA, Motherboard and CPU should turn on as soon as the power is supplied.

- If they do not, check the circuit breaker built into the ON/OFF switch on the instrument's front panel.



#### WARNING – ELECTRICAL SHOCK HAZARD

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

If the pump and the heaters are not working correctly and incorrect power configuration is suspected, check the serial number label located on the instrument's rear panel to ensure that the instrument was configured for the same voltage and frequency being supplied.

### 6.7.9.2. DC POWER SUPPLY

If the analyzer's AC mains power is working, but the unit is still not operating properly, there may be a problem with one of the instrument's switching power supplies, which convert AC power to 5 and  $\pm 15$  V (PS1) as well as +12 V DC power (PS2). The supplies can either have DC output at all or a noisy output (fluctuating).

To assist tracing DC Power Supply problems, the wiring used to connect the various printed circuit assemblies and DC powered components and the associated test points on the relay board follow a standard color-coding scheme as defined in Table 6-7.

**Table 6-7. DC Power Test Point and Wiring Color Code**

NAME	TEST POINT#	COLOR	DEFINITION
DGND	1	Black	Digital ground
+5V	2	Red	
AGND	3	Green	Analog ground
+15V	4	Blue	
-15V	5	Yellow	
+12V	6	Purple	
+12R	7	Orange	12 V return (ground) line

A voltmeter should be used to verify that the DC voltages are correct as listed in Table 6-8. An oscilloscope, in AC mode and with band limiting turned on, can be used to evaluate if the supplies are excessively noisy ( $>100$  mV peak-to-peak).

**Table 6-8. DC Power Supply Acceptable Levels**

POWER SUPPLY	VOLTAGE	CHECK RELAY BOARD TEST POINTS				MIN V	MAX V
		FROM TEST POINT		TO TEST POINT			
		NAME	#	NAME	#		
PS1	+5	DGND	1	+5	2	+4.80	+5.25
PS1	+15	AGND	3	+15	4	+13.5	+16.0
PS1	-15	AGND	3	-15V	5	-14.0	-16.0
PS1	AGND	AGND	3	DGND	1	-0.05	+0.05
PS1	Chassis	DGND	1	Chassis	N/A	-0.05	+0.05
PS2	+12	+12V Ret	6	+12V	7	+11.8	+12.5
PS2	DGND	+12V Ret	6	DGND	1	-0.05	+0.05

### 6.7.9.3. I<sup>2</sup>C Bus

Verify operation of the I<sup>2</sup>C bus by checking whether the LEDs are flashing at the Relay PCA's D1 and the Valve Driver PCA's D2. If both are solid lit (not flashing) or are not on, and the DC power supplies are operating properly, there is a problem with the I<sup>2</sup>C bus.

### 6.7.9.4. LCD/DISPLAY MODULE

Assuming that there are no wiring problems and that the DC power supplies are operating properly, the display screen should light and show the splash screen and other indications

of its state as the CPU goes through its initialization process. However, if pressing a control button on the touch screen does not change the display, either the touch-screen controller or the internal USB bus may be malfunctioning.

You can verify this failure by logging on to the instrument remotely with Teledyne API's NumaView™ Remote software (Section 3.4). If the analyzer responds to remote commands and the display changes accordingly, the touch-screen interface may be faulty.

### 6.7.9.5. RELAY PCA

The Relay PCA can be most easily checked by observing the condition of its status LEDs (see Section 6.7.4.2), and using the Utilities>Diagnostics> menu (see Section 6.7.3) to toggle each LED ON or OFF.

If D1 on the relay board is flashing, but toggling an output using the I/O functions in the Utilities>Diagnostics menu does not toggle the output's status LED, then there is a circuit problem, or possibly a blown driver chip, on the relay board.

If D1 on the Relay PCA is flashing and the status indicator for the output in question (Heater power, Valve Drive, etc.) toggles properly using the I/O functions in the Utilities>Diagnostics menu, then the associated device or its control device (driver) on the Relay PCA is malfunctioning.

Several of the control devices are in sockets and can be easily replaced. The following table lists the control device associated with a particular function:

**Table 6-9. Relay PCA Control Devices**

FUNCTION	CONTROL DEVICE	SOCKETED
Valve0 – Valve3	U5	Yes
Valve4 – Valve7	U6	Yes
All heaters	K1-K5	Yes

### 6.7.9.6. MOTHERBOARD

#### A/D FUNCTIONS

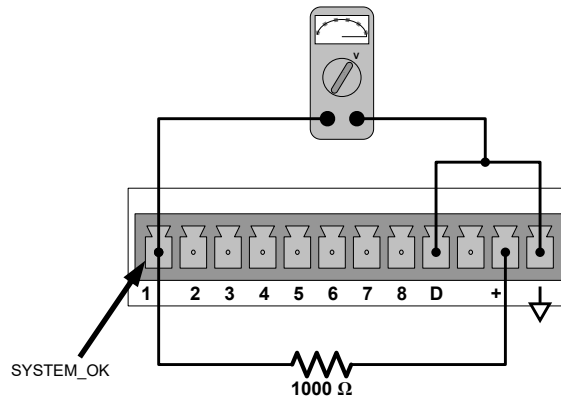
The simplest method to check the operation of the A-to-D converter on the motherboard is to navigate to the Dashboard and check the two A/D reference voltages and input signals that can be easily measured with a voltmeter (configure the Dashboard to show the Ref 4096mV and Ref Ground parameters).

- The nominal value for **REF\_4096\_MV** is 4096 mV ± 10 mV.
- The nominal value for **REF\_GND** is 0 mV ± 3 mV
  - If these signals are stable to within ±0.5 mV, the basic A/D converter is functioning properly.
  - If these values fluctuate largely or are off by more than specified above, one or more of the analog circuits may be overloaded or the motherboard may be faulty.

Choose one parameter in the Dashboard function list such as **SAMPLE PRESSURE** (refer to previous section on how to measure it). Compare the voltage at its origin (refer to the Interconnects Diagram in Appendix B with the voltage displayed. If the wiring is intact but

there is a difference of more than  $\pm 10$  mV between the measured and displayed voltage, the motherboard may be faulty

## STATUS OUTPUTS



**Figure 6-16. Typical Set Up of Status Output Test**

To test the status output electronics:

1. Connect a jumper between the “D” pin and the “∇” pin on the status output connector.
2. Connect a 1000 ohm resistor between the “+” pin and the pin for the status output that is being tested.
3. Connect a voltmeter between the “∇” pin and the pin of the output being tested.
4. In the Utilities>Diagnostics>Digital Outputs menu (see Section 6.7.3), scroll through the outputs until you get to the output in question.
5. Alternately turn on and off the output noting the voltage on the voltmeter.
  - It should vary between 0 volts for ON and 5 volts for OFF.

## CONTROL INPUTS

The control input bits can be tested by applying a trigger voltage to an input and watching changes in the analyzer’s Mode field at the bottom of the interface:

To test the “A” and “B” control inputs on the CONTROL IN connector:

1. Connect a jumper from the +5 V pin on the STATUS connector to the U on the CONTROL IN connector.
2. Connect a second jumper from the ∇ pin on the STATUS connector to the A pin on the CONTROL IN connector. The instrument should switch from **SAMPLE** mode to **ZERO CAL R** mode.
3. Connect a second jumper from the ∇ pin on the STATUS connector to the B pin on the CONTROL IN connector. The instrument should switch from **SAMPLE** mode to **SPAN CAL R** mode.

In each case, the analyzer should return to SAMPLE mode when the jumper is removed.



## 6.7.9.7. PNEUMATIC PRESSURE / FLOW SENSOR ASSEMBLY

The pressure/flow sensor circuit board, located behind the sensor assembly, can be checked with a voltmeter using the following procedure, which assumes that the wiring is intact and that the motherboard and the power supplies are operating properly.

- Measure the voltage across TP1 and TP2, it should be  $10.0 \pm 0.25$  V. If not, the board may be faulty and in need of replacement.
- Measure the voltage across capacitor C2; it should be  $5.0 \pm 0.25$  V. If not, the board may be faulty and in need of replacement.

## SAMPLE PRESSURE SENSOR CHECK

Measure the voltage across test points TP1 and TP4.

- With the sample pump disconnected or turned off, this voltage should be  $4500 \pm 250$  mV.
- With the pump running, it should be about 0.2 V less as the sample pressure drops by about 1 in-Hg-A from ambient pressure.

If this voltage is significantly different, the pressure transducer S2 or the board may be faulty. A leak in the sample system to vacuum may also cause this voltage to be between about 0.6 and 4.5. Ensure that the front panel reading of the sample pressure is at about 1 in-Hg-A less than ambient pressure.

## 6.7.9.8. CPU

There are two major types of CPU board failures, a complete failure and a failure associated with the Disk on Module (DOM). If either of these failures occurs, contact the factory.

For complete failures, assuming that the power supplies are operating properly and the wiring is intact, the CPU is faulty if on power-on, the watchdog LED on the motherboard is not flashing.

- In some rare circumstances, this failure may be caused by a bad IC on the motherboard, specifically U57, the large, 44 pin device on the lower right hand side of the board. If this is true, removing U57 from its socket will allow the instrument to start up but the measurements will be invalid.
- If the analyzer stops during initialization (the front panel display shows a fault or warning message), it is likely that the DOM, the firmware or the configuration and data files have been corrupted.

## 6.7.9.9. RS-232 COMMUNICATIONS

### GENERAL RS-232 TROUBLESHOOTING

Teledyne API's analyzers use the RS-232 communications protocol to allow the instrument to be connected to a variety of computer-based equipment. Problems with RS-232 connections usually center around 4 general areas:

- Incorrect cabling and connectors. See Section 2.3.1.7 under RS-232 Connection for connector and pin-out information.
- The BAUD rate and protocol are incorrectly configured. See Section 2.3.1.7 under RS-232 Connection.



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- If a modem is being used, additional configuration and wiring rules must be observed. See Sections 3.1 and 3.2.
- Incorrect setting of the DTE – DCE Switch. See Section 3.1 to set correctly.
- The cable (P/N 03596) that connects the serial COM ports of the CPU to J12 of the motherboard may not be properly seated (see Figure 2-16 for location of J12).

### **ANALYZER/MODEM OR TERMINAL OPERATION TROUBLESHOOTING**

These are the general steps for troubleshooting problems with a modem connected to a Teledyne API analyzer.

1. Check cables for proper connection to the modem, terminal or computer.
2. Check to ensure that the DTE-DCE is in the correct position as described in Section 3.1.
3. Check to ensure that the set up command is correct.
4. Verify that the Ready to Send (RTS) signal is at logic high. The analyzer sets pin 7 (RTS) to greater than 3 volts to enable modem transmission.
5. Ensure that the BAUD rate, word length, and stop bit settings between modem and analyzer match.
6. Use the RS-232 test function to send “w” characters to the modem, terminal or computer.
7. Get your terminal, modem or computer to transmit data to the analyzer (holding down the space bar is one way); the green LED should flicker as the instrument is receiving data.
8. Ensure that the communications software or terminal emulation software is functioning properly.

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

The PMT detects the light emitted by the UV-excited fluorescence of SO<sub>2</sub> (see Principles of Operation, Section 7). 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 ETEST, OTEST 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 6-28). 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 signal of about 2000±1000 mV.

To activate the optics test, go to the Utilities>Diagnostics>OE Test menu and press the Run OTest button.

#### 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.**

#### ELECTRICAL TEST (ETEST)

The electrical test function creates a current, which is substituted for the PMT signal and feeds it into the preamplifier board.

- This signal is generated by circuitry on the pre-amplifier board itself and tests the filtering and amplification functions of that assembly along with the A/D converter on the motherboard.
- It does not test the PMT itself.
- The electrical test should produce a PMT signal of about 2000 ±1000 mV.

To activate the electrical test, go to the Utilities>Diagnostics>OETest menu and press the Run ETest button.

If the instrument passes the OTEST but fails the ETEST, the preamplifier board may be faulty or need a hardware calibration.

#### HIGH VOLTAGE POWER SUPPLY (HVPS)

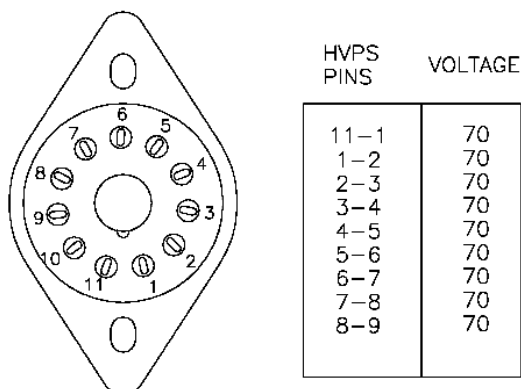
The HVPS is located in the interior of the sensor module and is plugged into the PMT tube (refer to Figure 6-28). It requires 2 voltage inputs.

- 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 6.7.10.4.

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).
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 6.1).
  - If any faults are found in the test, you must obtain a new HVPS as there are no user serviceable parts inside the supply.

### 6.7.9.11. PMT TEMPERATURE CONTROL PCA

The temperature control PCA is located on the sensor housing assembly, under the slanted shroud, next to the cooling fins and directly above the cooling fan.

If the red LED located on the top edge of this assembly is not glowing, the control circuit is not receiving power. Check the analyzer's power supply, the relay board's power distribution circuitry and the wiring that connects them to the PMT temperature control PCA.



### TEC CONTROL TEST POINTS

Four test points are also located at the top of this assembly they are numbered left to right start with the T1 point immediately to the right of the power status LED. These test points provide information regarding the functioning of the control circuit.

- To determine the current running through the control circuit, measure the voltage between T1 and T2. Multiply that voltage by 10.
- To determine the drive voltage being supplied by the control circuit to the TEC, measure the voltage between T2 and T3.
  - If this voltage is zero, the TEC circuitry is most likely open.
  - If the voltage between T2 and T3 = 0 VDC and the voltage measured between T1 and T2 = 0 VDC there is most likely an open circuit or failed op amp on control PCA itself.
  - If the voltage between T2 and T3 = 0 VDC and the voltage measured between T1 to T2 is some voltage other than 0 VDC, the TEC is most likely shorted.
- T4 is tied directly to ground. To determine the absolute voltage on any one of the other test points make a measurement between that test point and T4.

### 6.7.9.12. 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  $-20^{\circ}$  C or less).

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

### 6.7.9.13. TEMPERATURE SENSORS

#### BOX TEMPERATURE SENSOR

The box temperature sensor (thermistor) is mounted on the motherboard below the bottom edge of the CPU board when looking at it from the front. It cannot be disconnected to check its resistance.

- Box temperature will vary with, but will usually read about 5° C higher than, ambient (room) temperature because of the internal heating zones from the reaction cell and other devices.
- To check the box temperature functionality, we recommend checking the Box Temp signal voltage in the Utilities>Diagnostics>Analog Inputs menu (Section 6.7.3).
- At about 30° C, the signal should be around 1500 mV.
- To check the accuracy of the sensor, use a calibrated external thermometer / temperature sensor to verify the accuracy of the box temperature by:
- Placing it inside the chassis, next to the thermistor labeled XT1 (above connector J108) on the motherboard.
- Compare its reading to the value of the PMT TEMP.

#### PMT TEMPERATURE SENSOR CONTROL

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

The PMT cooler uses a Peltier, thermo-electric cooler element supplied with 12 V DC power from the switching power supply PS2. The temperature is controlled by a proportional temperature controller located on the preamplifier board.

- Voltages applied to the cooler element vary from 0.1 to 12 VDC.
- The temperature set point (hard-wired into the preamplifier board) will vary by  $\pm 1^\circ$  C due to component tolerances.
- The actual temperature will be maintained to within 0.1° C around that set point.

To check the operation of the PMT temperature control system:

1. Turn off the analyzer and let its internal components cool / heat to ambient temperature.
2. Turn on the analyzer.
3. Set the front panel to show the PMT TEMP function (Setup>Dashboard).
  - The temperature should fall steadily to 6-10° C.
  - If the temperature fails to drop after 20 minutes or to reach this point after 60 minutes, there is a problem in the cooler circuit.
  - If the control circuit on the preamplifier board is faulty, a temperature of  $-1^\circ$  C will be reported.

## 6.7.10. SERVICE PROCEDURES

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

### Note

Regular maintenance procedures are discussed in Section 6.5 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.

### 6.7.10.1. DISK-ON-MODULE REPLACEMENT PROCEDURE

#### ATTENTION

#### COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Servicing of circuit components requires electrostatic discharge protection, i.e. ESD grounding straps, mats and containers. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty. For information on preventing ESD damage, refer to 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.

Replacing the Disk-on-Module (DOM) will cause loss of all DAS data; it may also cause loss of some instrument configuration parameters unless the replacement DOM carries the exact same firmware version. Whenever changing the version of installed software, the memory must be reset. Failure to ensure that memory is reset can cause the analyzer to malfunction, and invalidate measurements. After the memory is reset, the A/D converter must be re-calibrated, and all information collected in Step 1 below must be re-entered before the instrument will function correctly. Also, zero and span calibration should be performed.

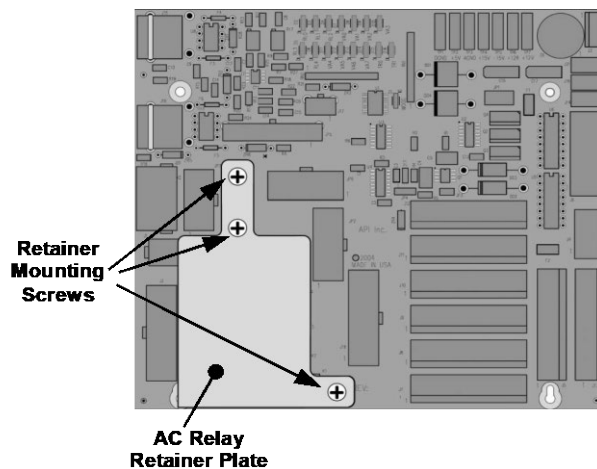
1. Document all analyzer parameters that may have been changed, such as range, auto-cal, analog output, serial port and other settings before replacing the DOM.
2. Turn off power to the instrument, fold down the rear panel by loosening the mounting screws.

3. While looking at the electronic circuits from the back of the analyzer, locate the Disk-on-Module in the right-most socket of the CPU board.
4. The DOM should carry a label with firmware revision, date and initials of the programmer.
5. Remove the nylon standoff clip that mounts the DOM over the CPU board, and lift the DOM off the CPU. Do not bend the connector pins.
6. Install the new Disk-on-Module, making sure the notch at the end of the chip matches the notch in the socket.
7. It may be necessary to straighten the pins somewhat to fit them into the socket. Press the chip all the way in.
8. Close the rear panel and turn on power to the machine.
9. If the replacement DOM carries a firmware revision, re-enter all of the setup information.

### 6.7.10.2. REMOVING / REPLACING THE RELAY PCA FROM THE INSTRUMENT

This is the most commonly used version of the Relay PCA. It includes a bank of solid state AC relays. This version is installed in analyzers where components such as AC powered heaters must be turned ON & OFF.

A retainer plate is installed over the relay to keep them securely seated in their sockets.



**Figure 6-17. Relay PCA with AC Relay Retainer In Place**

The Relay retainer plate installed on the relay PCA covers the lower right mounting screw of the relay PCA. Therefore, when removing the relay PCA, the retainer plate must be removed first.

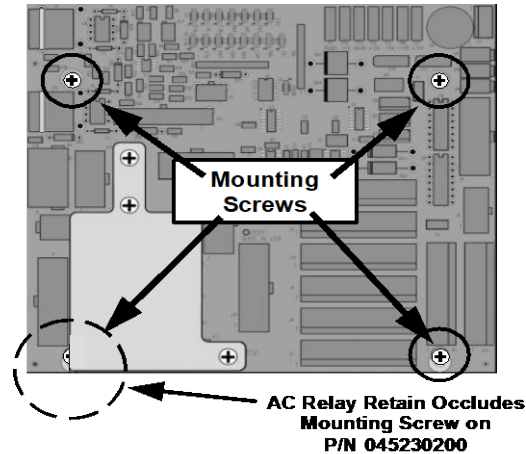


Figure 6-18. Relay PCA Mounting Screw Locations

### 6.7.10.3. 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



While the PMT or HVPS can be removed through the front panel without un-mounting the entire sensor module, we recommend turning off the instrument, opening its top cover and removing the entire assembly so that further repairs can be carried out 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).



## 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 SO<sub>2</sub> measurement.
- After any repair or service has been performed on the sensor module, the analyzer should be allowed to warm up for 60 minutes.
- Always perform a leak check and calibrate the analyzer before placing it back into service.

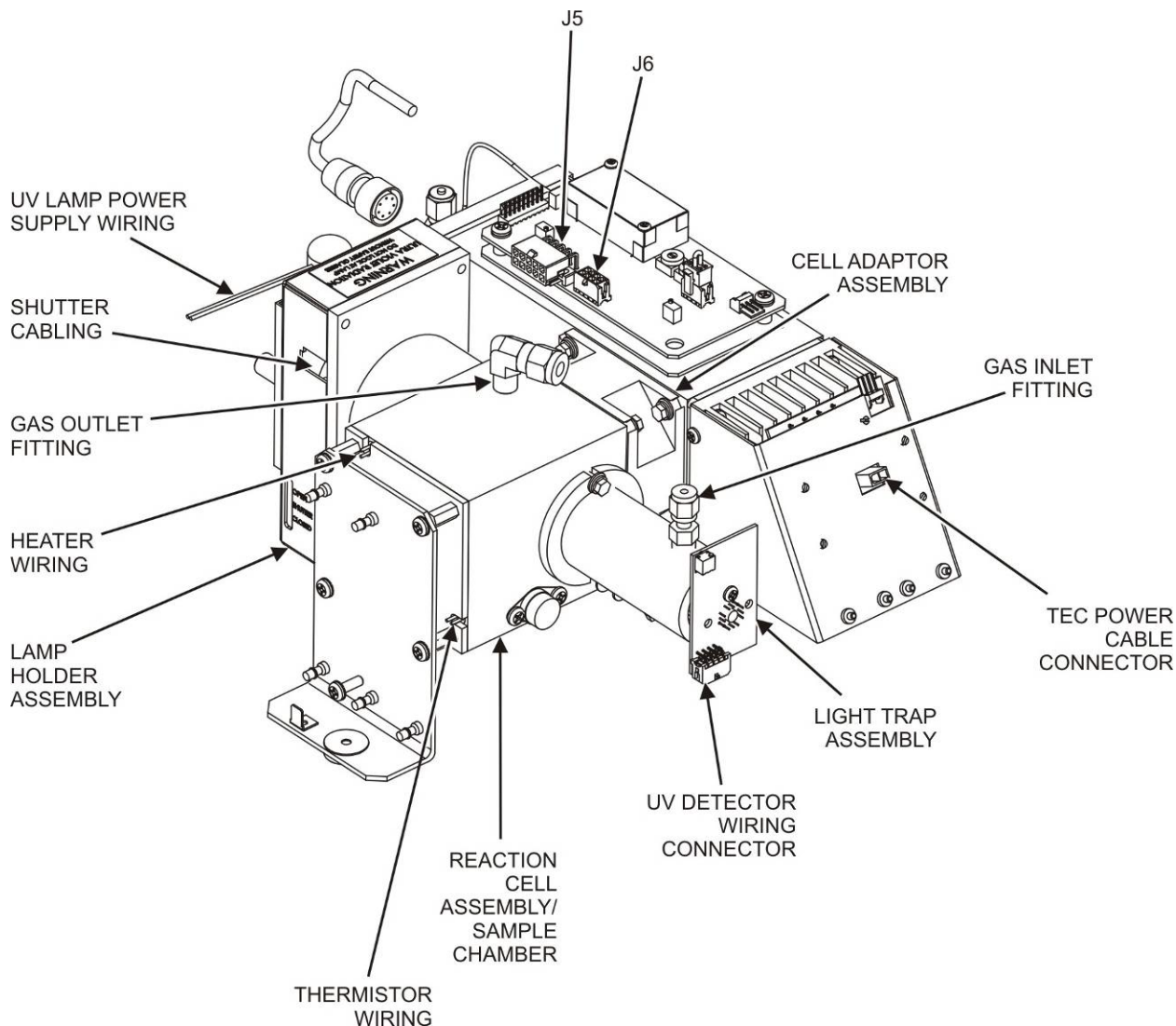
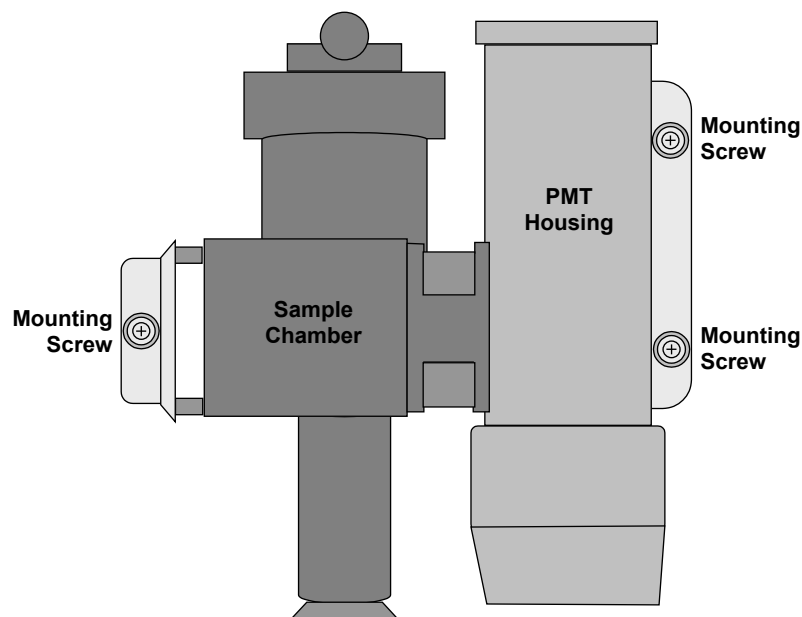


Figure 6-19. Sensor Module Wiring and Pneumatic Fittings

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 6-19)
  - 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
  - Shutter cabling
  - Reaction cell thermistor wiring (yellow)
  - Reaction cell heater wiring (red)
  - UV detector wiring
  - TEC power cable
  - PMT wiring (connectors J5 & J6 on the PMT preamplifier PCA)
5. Remove the three sensor module mounting screws.



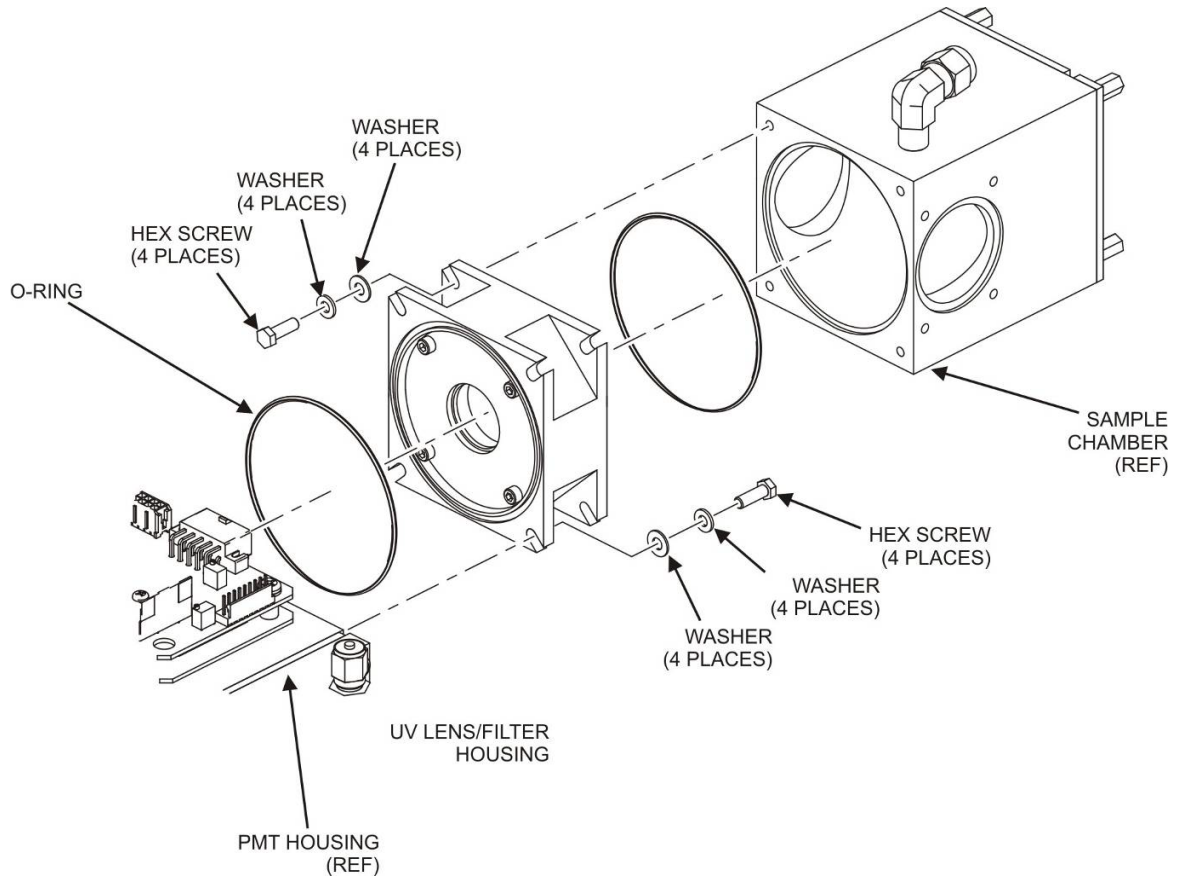
**Figure 6-20. Sensor Module Mounting Screws**

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

## CLEANING THE PMT LENS AND PMT FILTER

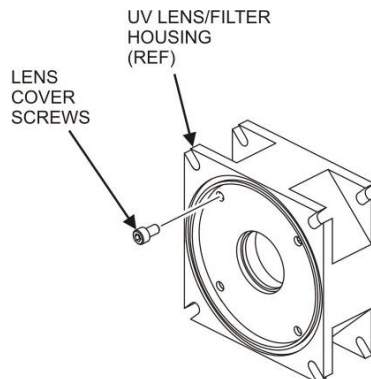
To clean the PMT Lens and filter:

1. Remove the sensor module as described above.



**Figure 6-21. 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.

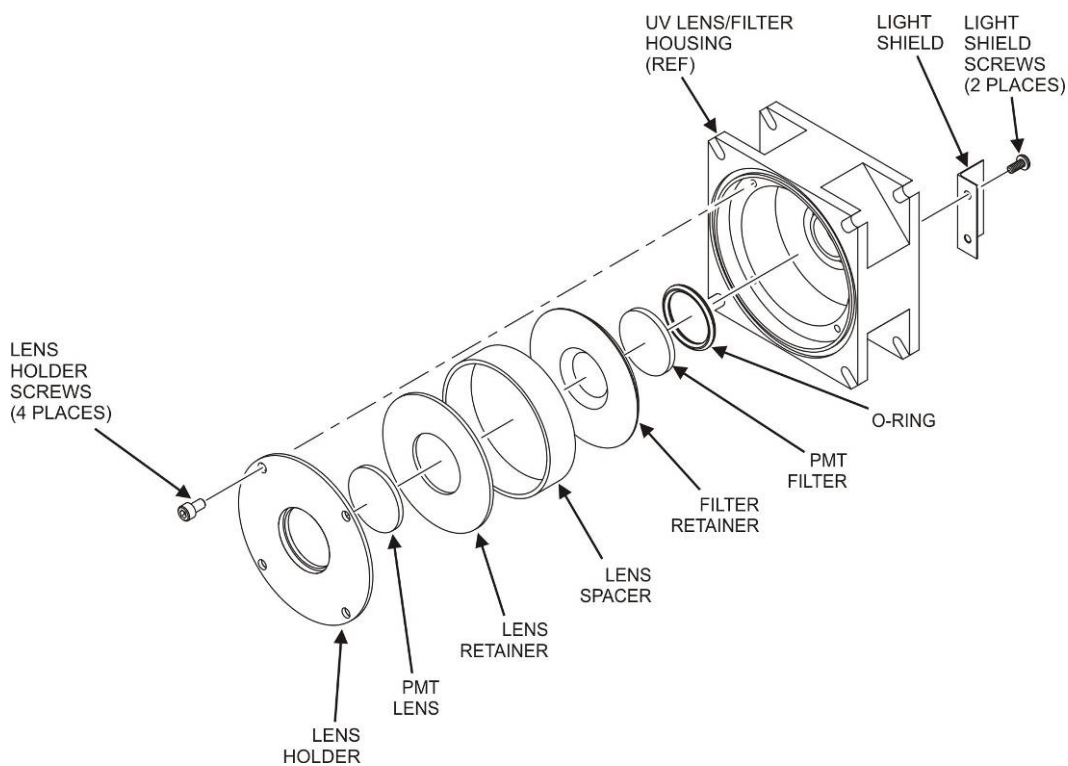


**Figure 6-22. UV Lens Housing / Filter Housing**



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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 6-23. 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

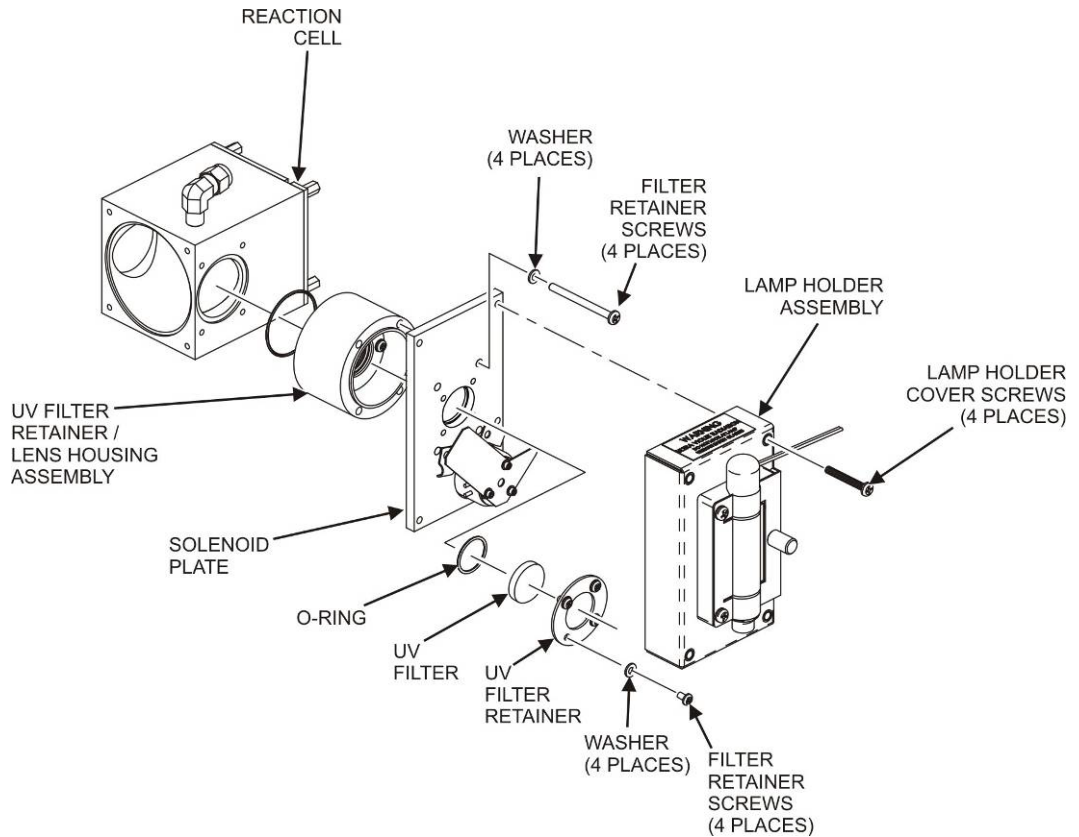
**Use gloves and a clean plastic covered surface during assembly. Cleanliness of the inside of the light shield, the UV lens filter housing and the PMT lens is especially important.**

## 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. Unplug J4 connector from the motherboard to allow tool access.
3. Alternatively, remove the sensor module as described above.
4. Remove 4 screws from the shutter cover (refer to the preceding figures that apply) and remove the cover.
5. Remove 4 screws from the UV filter retainer.



**Figure 6-24. Disassembling the Shutter Assembly**

6. Carefully remove the UV filter.
7. Install the UV filter.
8. Handle carefully and never touch the filter's surface.
9. UV filter's wider ring side should be facing out.
10. Install UV filter retainer and tighten screws.
11. Install the shutter cover and minifit connector. Tighten 4 shutter cover screws.
12. Reinstall the sensor module and Plug J4 connector into the motherboard.



### ADJUSTING THE UV LAMP (*PEAKING THE LAMP*)

There are three ways in which ambient conditions can affect the UV Lamp output and therefore the accuracy of the SO<sub>2</sub> concentration measurement. These are:

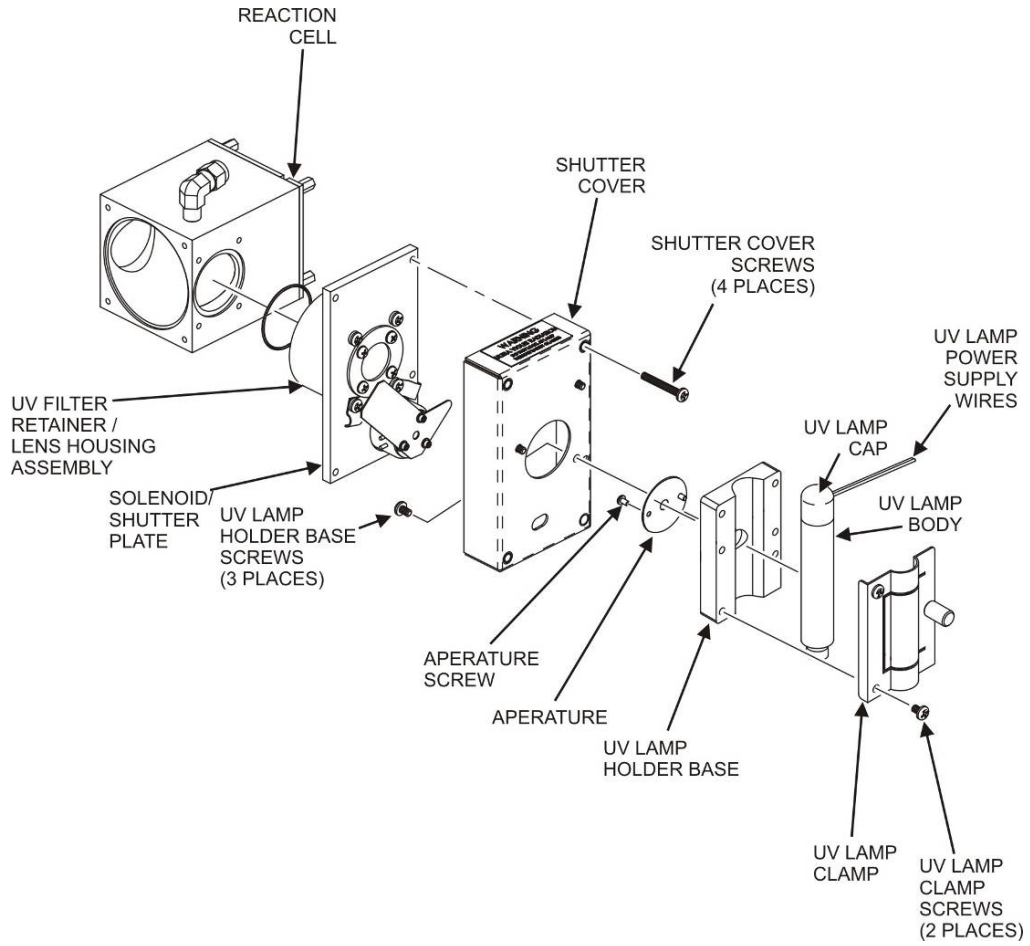
- **Line Voltage Change:** UV lamp energy is directly proportional to the line voltage. This can be avoided by installing adequate AC Line conditioning equipment such as a UPS/surge suppressor.
- **Lamp Aging:** Over a period of months, the UV energy will show a downward trend and can be up to 50% in 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 analyzers ability to accurately measure SO<sub>2</sub>.



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**Figure 6-25. Shutter Assembly**

1. Set the Dashboard to show the **UV LAMP** function.
2. Slightly loosen the large brass thumbscrew located on the shutter housing (refer to Figure 6-26) so that the lamp can be moved.

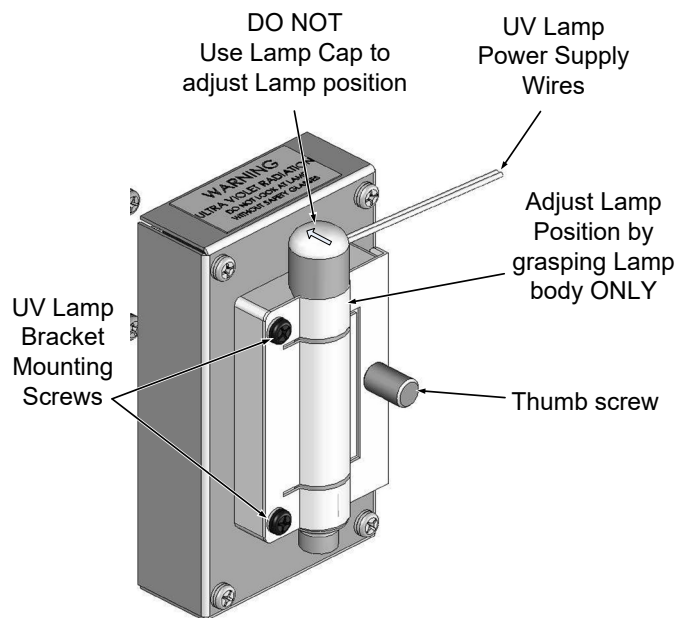


Figure 6-26. UV Lamp Adjustment

**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 6-25). Inattention to this detail could twist and potentially disconnect the lamp's power supply wires.

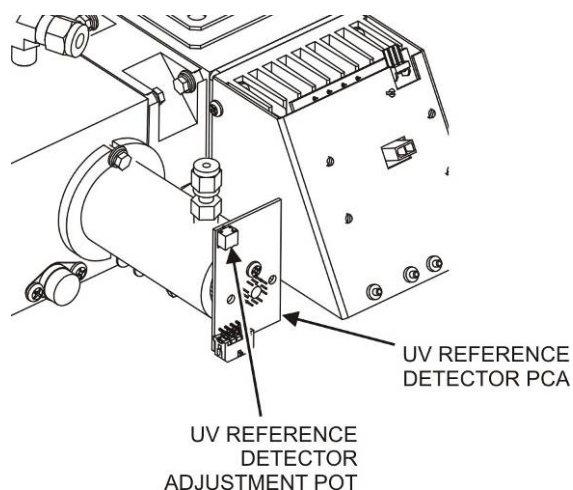
3. While watching the **UV LAMP** reading, slowly rotate the lamp or move it back and forth vertically until the **UVLAMP** reading is at its maximum.
4. Compare the **UVLAMP** reading to the information in Table 6-10 and follow the instructions there.

Table 6-10. UV Lamp Signal Troubleshooting

UVLAMP_SIGNAL	RECOMMENDED ACTION
3500mV±200mV.	No Action Required
> 4900mV at any time.	Adjust the UV reference detector potentiometer (Figure 6-27) until <b>UV LAMP</b> reads approximately 3600mV before continuing to adjust the lamp position.
>3700mV or < 3300mV	Adjust the UV reference detector potentiometer (Figure 6-27) until <b>UV LAMP</b> reads as close to 3500mV as possible.
.< 600mV	Replace the lamp



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**Figure 6-27. Location of UV Reference Detector Potentiometer**

5. Finger tighten the thumbscrew.



### 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).



### 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.

## REPLACING THE UV LAMP

To replace the UV Lamp:

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 6-25 and Figure 6-26) on the shutter 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 6-25)**  
**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 section 0.
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.**

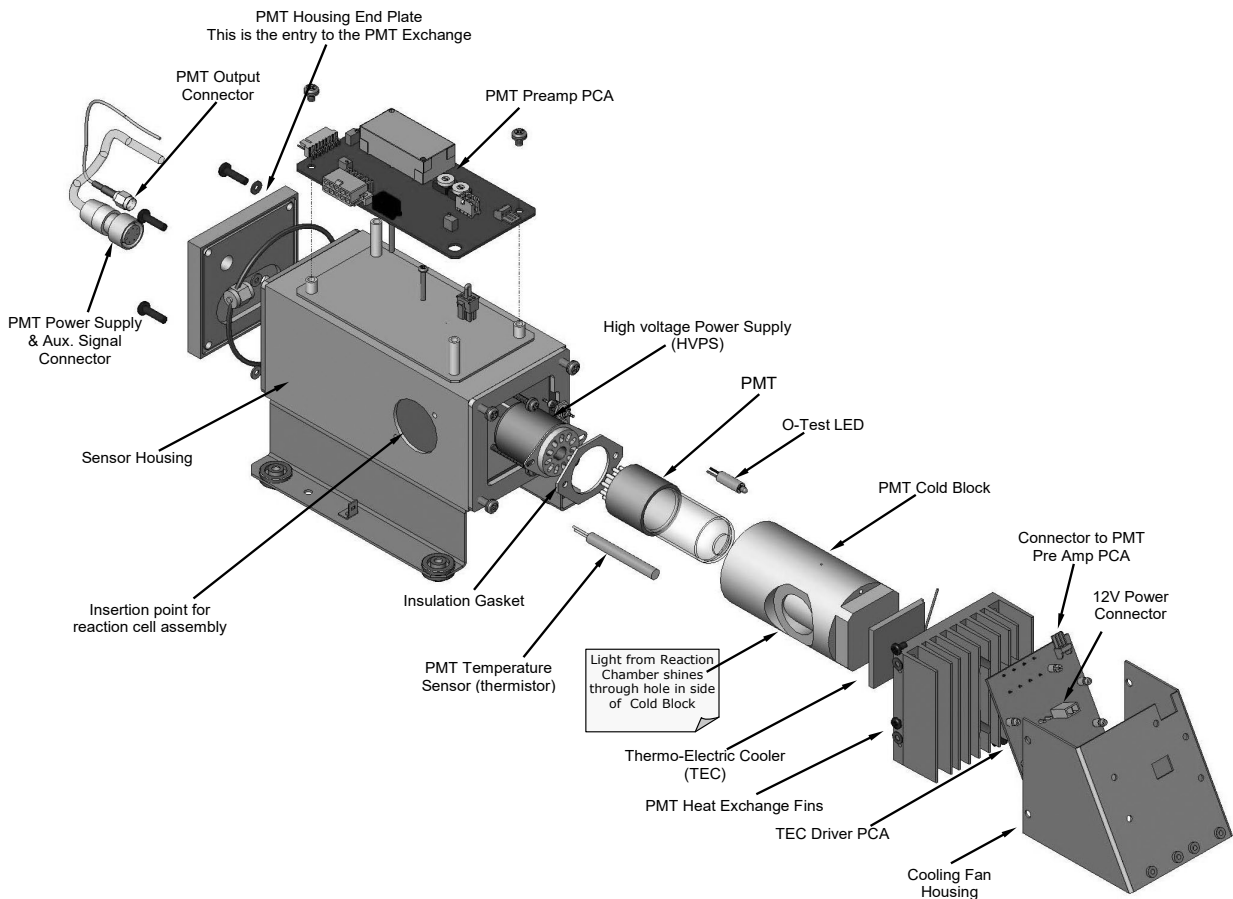
11. Calibrate the lamp (Utilities>Diagnostics menu).

## 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 recommend 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 6-28. PMT Assembly**

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

**Note**

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

8. Remove the desiccant bags from the PMT housing.
9. Unscrew the PMT assembly, which is held to the cold block by two plastic screws.
10. Discard the plastic screws and replace with new screws at the end of this procedure (the threads get stripped easily and it is recommended to use new screws).
11. Along with the plate, slide out the optic test (O-Test) LED and the thermistor that measures the PMT temperature.
  - Thermistor will be coated with a white, thermal conducting paste.
  - Do not contaminate the inside of the housing with this grease, as it may contaminate the PMT glass tube on re-assembly.

12. Carefully take out the assembly consisting of the HVPS, the insulation gasket and the PMT.
13. Change the PMT or the HVPS or both, clean the PMT glass tube with a clean, anti-static wipe and do not touch it after cleaning.
14. If the cold block or TEC is to be changed:
  - Disconnect the TEC driver board from the preamplifier board, remove the cooler fan duct (4 screws on its side) including the driver board.
  - Disconnect the driver board from the TEC and set the sub-assembly aside.
15. Remove the end plate with the cooling fins (4 screws) and slide out the PMT cold block assembly, which contains the TEC.
16. Unscrew the TEC from the cooling fins and the cold block and replace it with a new unit.
17. Reassemble this TEC subassembly in reverse order.
  - Ensure to use thermal grease between TEC and cooling fins as well as between TEC and cold block and that the side opening in the cold block will face the reaction cell when assembled.
  - Evenly tighten the long mounting screws 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.**

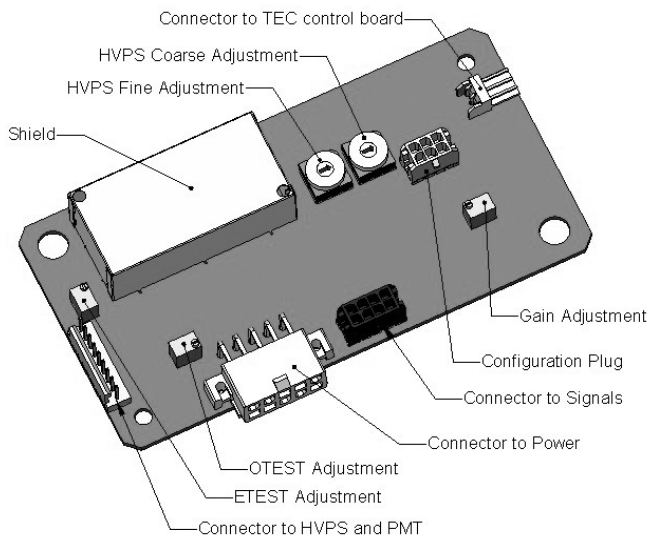
18. Reinsert the TEC subassembly in reverse order.
  - Ensure that the O-ring is seated properly and the assembly is tightened evenly.
19. Insert the O-Test LED and thermistor into the cold block, insert new desiccant bags and carefully replace the end plate by making sure that the O-ring is properly in place.
  - Improperly placed O-rings will cause leaks, which – in turn – cause moisture to condense on the inside of the cooler and likely cause a short in the HVPS.
20. Reinsert the PMT/HVPS subassembly in reverse order.
  - Don't forget the insulation gasket between HVPS and PMT.
  - Use new plastic screws to mount the PMT assembly on the PMT cold block.
21. Install new silica gel packets (desiccant bags).
22. Reconnect the cables and the reaction cell (evenly tighten these screws).
23. Replace the sensor assembly into the chassis and fasten with four screws and washers.
24. Reconnect all electrical and pneumatic connections.
25. Leak check the system (see Section 6.6.9).

26. Turn ON the analyzer.
27. Verify the basic operation of the analyzer using the ETEST and OTEST features (Section 6.7.9.10) or zero and span gases, then carry out a hardware calibration of the analyzer followed by a zero/span point calibration Section 5.2.1).

#### 6.7.10.4. T101 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 of the acceptable range and all other more obvious causes for this problem have been eliminated.

1. Set the instrument reporting range to **SINGLE**.
2. Perform a full zero calibration using zero air.
3. Let the instrument run for one hour to stabilize the lamp and run a lamp calibration from the diagnostic menu. This is required to ensure proper scaling of the **NORM PMT** value.
4. Locate the Preamp PCA (Figure 2-6).
5. Locate the following components on the Preamp board (Figure 6-29):
  - HVPS coarse adjustment switch (Range 0-9, then A-F)
  - HVPS fine adjustment switch (Range 0-9, then A-F)
  - Gain adjustment potentiometer (Full scale is 10 turns).



**Figure 6-29. Pre-Amplifier Board Layout**

6. Turn the gain adjustment potentiometer 12 turns clockwise to its maximum setting.
7. While feeding 400 ppb H<sub>2</sub>S (or 80% range value) to the analyzer and waiting until the STABIL value is below 0.5 ppb look at the front panel and scroll to the NORM PMT value. This value should always be two times the span gas concentration in ppb. With 400 ppb H<sub>2</sub>S, the NORM PMT should show 800 mV on a properly calibrated analyzer.
8. Set the HVPS coarse adjustment to its minimum setting (0). Set the HVPS fine adjustment switch to its maximum setting (F).



## T101, T102

9. Set the HVPS coarse adjustment switch to the lowest setting that will give you more than 800 mV NORM PMT signal. The coarse adjustment typically increments the NORM PMT signal in 100-300 mV steps.
10. Adjust the HVPS fine adjustment such that the NORM PMT value is just above 800 mV. It may be necessary to go back and forth between coarse and fine adjustments if the proper value is at the threshold of the min/max coarse setting.

### ATTENTION

**Do not overload the PMT by accidentally setting both adjustment switches to their maximum setting. Start at the lowest setting and increment slowly: no sooner than every 10 seconds between adjustments.**

11. Adjust the NORM PMT value with the gain potentiometer down to  $800 \pm 10$  mV. This is the final very-fine adjustment.
12. Perform software span and zero calibrations to normalize the sensor response to its new PMT sensitivity.
13. Review the slope and offset values:
  - The slope values should be  $1.000 \pm 0.300$ .
  - The offset values should be  $<250$  mV.

### 6.7.10.5. T102 PMT SENSOR HARDWARE CALIBRATION (“FACTORY CAL”)

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

1. Set the instrument reporting range to Single and 500 ppb.
2. Perform a full zero–point calibration using zero air.
3. Let the instrument stabilize by allowing it to run for one hour.
4. Adjust the UV Lamp (Section 6.7.10.3).
5. Perform a lamp calibration (Utilities>Diagnostics>Lamp Cal).
6. Locate the Preamp PCA (see Figure 2-7).
7. Locate the following components on the Preamp board (Figure 6-29):
  - HVPS coarse adjustment switch (Range 0-9, then A-F)
  - HVPS fine adjustment switch (Range 0-9, then A-F)
  - Gain adjustment potentiometer (Full scale is 10 to 12 turns).
8. Set the HVPS coarse adjustment to its minimum setting (0).
9. Set the HVPS fine adjustment switch to its maximum setting (F).
10. Turn the gain adjustment potentiometer clockwise to its maximum setting.
11. Set the front panel display to show TRS Stability.



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12. Feed 400 ppb span gas into the analyzer.

### Note

**If a reporting range other than 500 ppb is used in this procedure:**

**Use a span gas equal to 80% of the reporting range and adjust the PMT to a target NORM PMT value of twice the ppb value of the span gas, e.g., if the reporting range is 800 ppb, use 640 ppb span gas, and adjust the PMT until NORM PMT equals  $1280 \text{ mV} \pm 10 \text{ mV}$ .**

13. Wait until the Stability value is below 0.5 ppb,
14. View the **NORM PMT** value in the Dashboard.
15. Set the HVPS coarse adjustment switch to the lowest setting that will give you more than 1000 mV NORM PMT signal.  
  
The coarse adjustment typically increments the **NORM PMT** signal in 100-300 mV steps.
16. Adjust the HVPS fine adjustment such that the **NORM PMT** value is at or just above 800 mV.

### ATTENTION

**Do not overload the PMT by accidentally setting both adjustment switches to their maximum setting. Start at the lowest setting and increment slowly: no sooner than every 10 seconds between adjustments.**

17. Continue adjusting the both the coarse and fine switches until **NORM PMT** is as close to 800 mV as possible.
18. Adjust the gain adjustment potentiometer until the NORM PMT value is  $800 \text{ mV} \pm 10 \text{ mV}$ .
19. Perform span and zero-point calibrations to normalize the sensor response to its new PMT sensitivity.
20. Review the slope and offset values.



### 6.7.10.6. REPLACING THE TRS CONVERTER HEATING TUBE

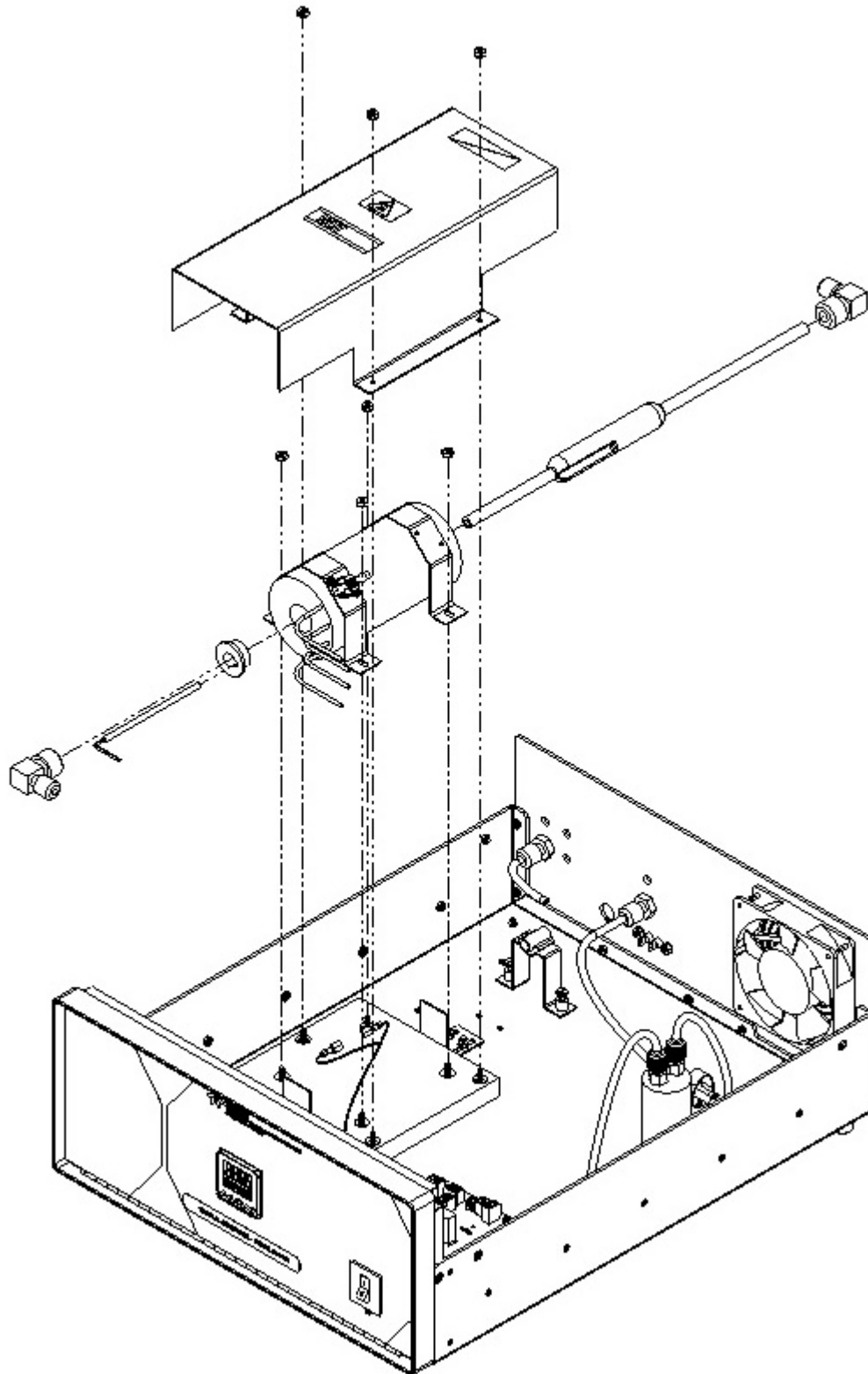


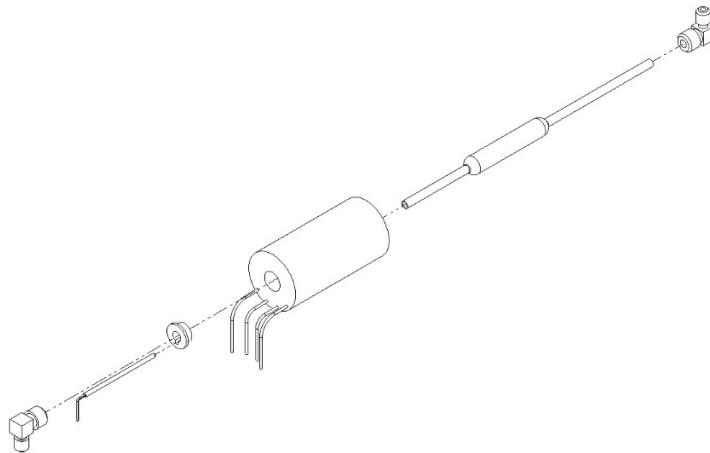
Figure 6-30. 501-TRS Heating Tube Orientation



**CAUTION – PERSONAL SAFETY HAZARD**

The converter tube and heater are very hot: **DO NOT TOUCH** until the 501-TRS is powered off and cooled to room temperature.

1. Turn off and remove all power to the 501-TRS
2. Allow it to cool to room temperature before continuing with this replacement procedure. This may take 30 minutes or more.
3. Remove the instrument's top cover and locate the tube in the assembly.
4. Loosen the pneumatic fittings at each end of the tube and remove the gas lines from the converter tube.
5. Remove the front ceramic bobbin from the converter tube. The thermocouple assembly will come with it.



**ATTENTION**

**HANDLE WITH CARE**

The ceramic bobbins at each end of the heater assembly are fragile.

6. Slide a new tube into the heater coil assembly.
7. Make sure that the thermocouple is slid through its notch on the center hole of the front converter bobbin and properly seated in the corresponding indentation in the body of the quartz heater tube.
8. Reattach the front bobbin onto the converter tube.
9. Reattach the gas lines and retighten the pneumatic fittings.
10. Reassemble the converter cover and reattach the M501-TRS top cover.

**Note**

The 501-TRS will not operate properly without top cover in place. The air cooling required to stabilize the temperature of the converter tube is dependent on air flow patterns that exist only with the top cover in place.

11. Restart the 501-TRS.
12. Check the converter efficiency.

### 6.7.10.7. REPLACING THE TRS THERMOCOUPLE

Continuous operation at high temperatures will eventually degrade the performance of the thermocouple used to sense the temperature of the quartz oven. The following instructions are for replacing the thermocouple in the Converter Heater Block with the thermocouple supplied in the kit that must be obtained from TAPI. Figure 6-31 through Figure 6-34 provide illustrations for this procedure.

**Note**

**The Type S thermocouple has a red wire and a black wire. If you have any other wire colors, please call Sales for the correct part.**

To get started, you will need the following tools:

- Nut driver, 5/16
- Nut driver, 11/32
- Diagonal cutter
- Philips head screwdriver #2



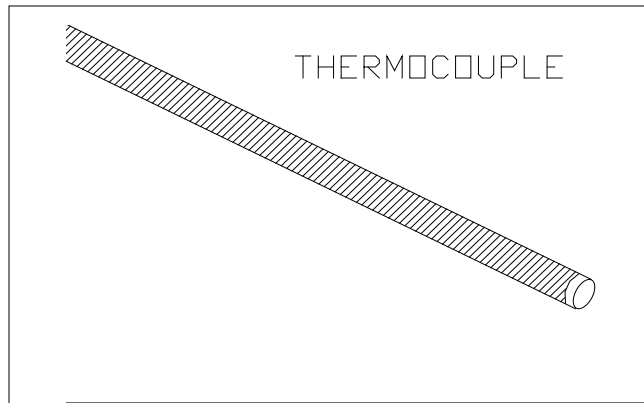
**CAUTION – PERSONAL SAFETY HAZARD**

**The converter tube and heater are very hot: DO NOT TOUCH until the 501-TRS is powered off and cooled to room temperature.**

1. Turn off and remove all power to the 501-TRS and allow it to cool to room temperature before continuing with this replacement procedure. This may take 30 minutes or more.
2. Remove the cover from the Converter chassis.
3. Unscrew the (4) nuts that secure the front panel to the chassis. They are located just behind the Front Panel along the top.
4. Lower the Front Panel to gain easier access to the end of the quartz tube.
5. Unscrew the (3) nuts that secure the Heater cover that protects the Heater Block and quartz tube. Remove this cover.
6. Cut the tie-wrap that secures the thermocouple to the fitting at the end of the quartz tube.
7. Loosen the Teflon fitting at the end of the quartz tube, taking care to not put any stress on the tube, and slide the fitting off the tube.
8. Remove the thermocouple.
9. Disconnect the thermocouple wires from the Temperature Controller.

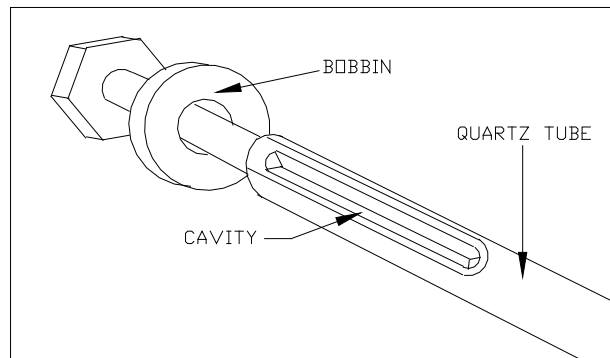


## T101, T102



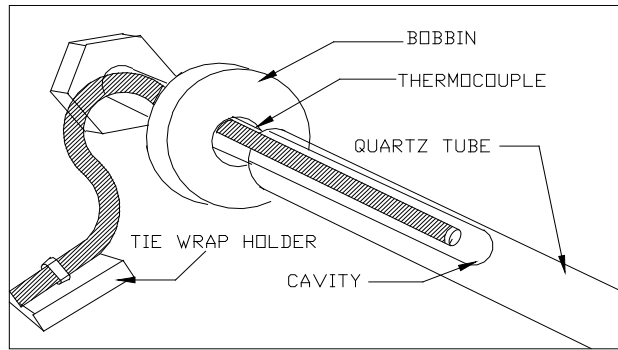
**Figure 6-31. Thermocouple**

10. In preparation for installing the new thermocouple, take note of the end of the Heater Block, where there is an indentation (cavity) in the wide part of the quartz tube. This is where the thermocouple you are installing will reside. Refer to Figure 6-32.



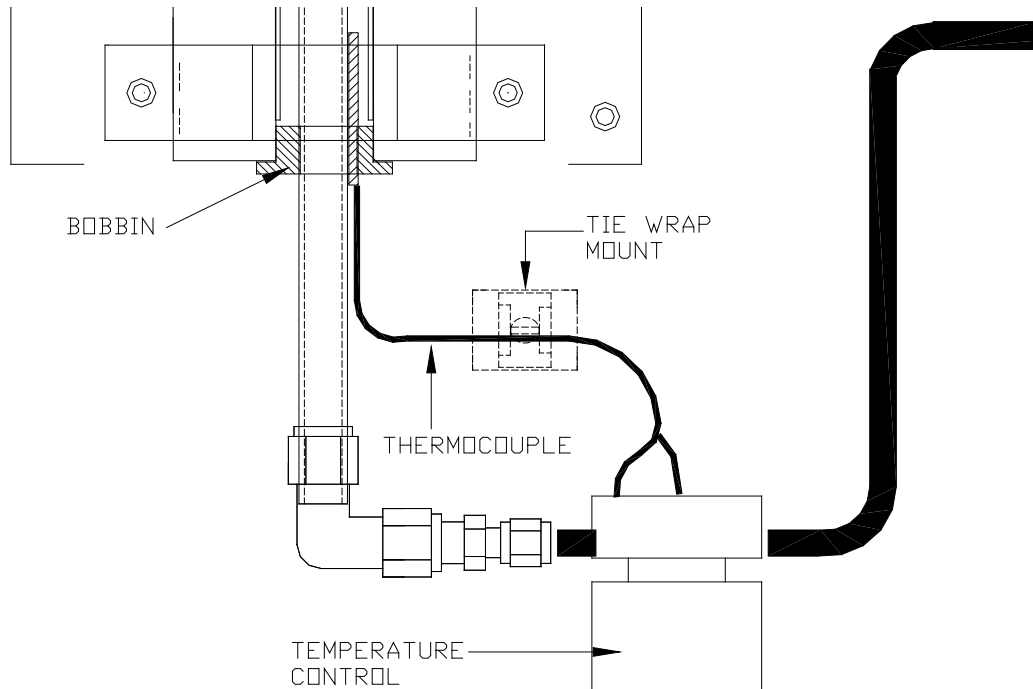
**Figure 6-32. Cavity for Thermocouple**

11. The thermocouple should slide into the Heater Block and into the indentation of the quartz.
12. Align the thermocouple with this cavity and carefully push the thermocouple all the way into the cavity until it comes to a stop, which is the end of the cavity of the quartz tube.
13. Ensure the thermocouple is seated flat. If it is not, the quartz tube will have to be replaced. (Check with TAPI Tech Support for Part #).
14. The thermocouple should now be properly seated in the cavity of the quartz tube. Refer to Figure 6-33.



**Figure 6-33. Thermocouple Installed**

15. Reconnect the Teflon fitting that was removed earlier from the end of the quartz tube. Take care not to put any stress on the quartz tube as you tighten Teflon fitting.
16. Clean the chassis where the Tie-Wrap Hold-Down will be placed (alcohol is recommended) and place the Tie-Wrap Hold-Down as shown in Figure 6-34.



**Figure 6-34. Tie-Wrap Hold-Down Location**

17. Form the Thermocouple wire so that it rests in the cavity with little movement.
18. Connect the two wires of the thermocouple to the Temperature Controller. The Black wire should be connected to Pin 1 and the Red wire should be connected to Pin 2. (If the wires are of any other color, STOP. Get the correct part from TAPI Sales or call Technical Support).
19. At this point, all connections have been made, both electrically and pneumatically. A leak check should be performed on the Converter to verify that all connections are leak free. If a leak is detected, the leak should be resolved before continuing.

20. Install the inner cover of the Heater Block and secure with the three nuts. Close the Front Panel and secure with the four nuts. Install the top cover on the Converter chassis.
21. The Converter is now ready for the application of power. You will be looking for an indication from the temperature controller that it is functioning correctly and driving the heater to the desired “set” temperature. Apply power now.
22. Verify that the “process” temperature is indicating that the desired temperature is stable and being regulated.

The converter is now ready for operation.

## 6.8. FREQUENTLY ASKED QUESTIONS

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

QUESTION	ANSWER
Why does the ENTR button sometimes disappear on the front panel display?	Sometimes the ENTR button will disappear if you select a setting that is invalid or out of the allowable range for that parameter, such as trying to set the 24-hour clock to 25:00:00 or a range to less than 1 or more than 20000 ppb. Once you adjust the setting to an allowable value, the ENTR button will re-appear.
Why is the ZERO or SPAN button deactivated during calibration?	This happens when the measured gas concentration differs significantly from the span or zero gas concentration value entered by the user. This prevents accidental recalibration of the analyzer to an out-of-range response curve. EXAMPLE: The span set point is 400 ppb but gas concentration being measured is only 50 ppb.
How do I enter or change the value of my Span Gas?	See Section 5.2.1.2.
Can I automate the calibration of my analyzer?	Any analyzer with zero/span valve or IZS option can be automatically calibrated using the instrument's AutoCal feature (Section 5.3).
Can I use the IZS option to calibrate the analyzer?	Yes. However, the accuracy of the IZS option's permeation tube is only $\pm 5\%$ . To achieve highest accuracy, it is recommended to use cylinders of calibrated span gases in combination with a zero air source.
How do I measure the sample flow?	For accurate measurement, attach a calibrated flow meter to the sample inlet port, and get a reading while the instrument is operating. The sample flow should be as specified in Table 1-1. (To calibrate, use the Utilities>Diagnostics menu; refer to Section 6.6.9.3).
How often do I need to change the particulate filter?	Refer to the Maintenance Schedule in Table 6-1. Keep in mind that highly polluted sample air may require more frequent changes.
How long does the sample pump last?	The sample pump should last one to two years and the pump head should be replaced when necessary. If the reaction cell pressure value goes above 10 in-Hg-A, on average, the pump head needs to be rebuilt.
Why does my RS-232 serial connection not work?	There are several possible reasons: <ul style="list-style-type: none"> <li>• The wrong cable: please use the provided or a generic “straight-through” cable (do not use a “null-modem” type cable) and ensure the</li> </ul>



## T101, T102

QUESTION	ANSWER
	<p>pin assignments are correct (Section 2.3.1.7 under RS-232 Connection).</p> <ul style="list-style-type: none"> <li>• The DCE/DTE switch on the back of the analyzer is not set properly; ensure that both green and red lights are on (Section 3.1).</li> <li>• The baud rate of the analyzer's COM port does not match that of the serial port of your computer/data logger (Table 2-20).</li> </ul>
<p>How do I make the instrument's display and my data logger agree?</p>	<p>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.</p> <p>Use the data logger itself as the metering device during calibration procedures.</p>
<p>Do the critical flow orifices of my analyzer require regular replacement?</p>	<p>No. The o-rings and the sintered filter associated with them require replacement once a year, but the critical flow orifices do not.</p> <p>See Section 6.6.5 for instructions.</p>
<p>How do I set up and use the contact closures (Control Inputs) on the rear panel of the analyzer?</p>	<p>See Section 2.3.1.5.</p>

## 6.9. 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](mailto:api-techsupport@teledyne.com)

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



## 7. PRINCIPLES OF OPERATION

The T101 UV Fluorescence H<sub>2</sub>S Analyzer is a microprocessor controlled analyzer that determines the concentration of hydrogen sulfide (H<sub>2</sub>S), 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 H<sub>2</sub>S in the sample gas is converted into SO<sub>2</sub> which is then exposed to ultraviolet light causing the SO<sub>2</sub> molecules to change to an excited state (SO<sub>2</sub>\*). As these SO<sub>2</sub>\* molecules decay back into SO<sub>2</sub>, they fluoresce. The instrument measures the amount of fluorescence to determine the amount of SO<sub>2</sub> is present in the sample chamber and by inference therefore the amount of H<sub>2</sub>S present in the sample gas.

The T102 UV Fluorescence TRS Analyzer is a modified T101, which, when used in conjunction with the Model 501-TRS, determines the concentration of total reduced sulfur (TRS) in a sample gas drawn through the system. Where the T101 uses an internal converter, the T102 uses an external converter.

Calibration of either analyzer is performed in the 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 H<sub>2</sub>S in the T101 or TRS in the T102 system 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, UV lamp ratio and the amount of stray light present and measurements of the temperature and pressure of the sample gas to compute the final H<sub>2</sub>S/TRS concentration.

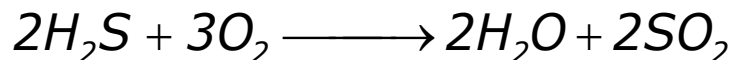
### 7.1. SULFUR DIOXIDE (SO<sub>2</sub>) SENSOR PRINCIPLES OF OPERATION

#### 7.1.1. T101 SENSOR PRINCIPLES

The T101 H<sub>2</sub>S analyzer is basically an SO<sub>2</sub> analyzer with an H<sub>2</sub>S → SO<sub>2</sub> conversion stage inserted into the gas stream before the sample gas enters the sample chamber.

The H<sub>2</sub>S to SO<sub>2</sub> converter receives sample gas from which the SO<sub>2</sub> has been removed by a scrubber. Once the naturally occurring SO<sub>2</sub> is removed from the sample gas, the special converter changes the H<sub>2</sub>S in the sample stream to SO<sub>2</sub> using a high-temperature catalytic oxidation.

The chemical process is:



Equation 7-1

The converter is a heated stainless steel core containing a catalyst across which the sample gas passes just before induction into the reaction cell. The temperature of the converter is maintained by a heater controlled by the CPU via the I<sup>2</sup>C bus and the relay card. The converter is enclosed in high-temperature insulation and encased in a stainless steel

housing, and is most efficient when it operates at 315°C, converting 95% of the H<sub>2</sub>S into SO<sub>2</sub>.

When the converter is operating at peak efficiency there is a nearly 1:1 relationship between the amount of H<sub>2</sub>S entering the catalytic converter and the amount of SO<sub>2</sub> leaving it. Therefore, by measuring the amount of SO<sub>2</sub> in the gas after it leaves the converter, the amount of H<sub>2</sub>S originally present on the sample gas can be directly inferred. This is accomplished by measuring the ultraviolet fluorescence of the SO<sub>2</sub> in the sample chamber.

### 7.1.2. T102 SENSOR PRINCIPLES

The T102 Total Reduced Sulfur (TRS) analyzer is basically an SO<sub>2</sub> analyzer with a TRS → SO<sub>2</sub> converter (the Model 501-TRS) inserted into the gas stream before the sample gas enters the sample chamber.

The 501-TRS, receives sample gas from the T102 after it has been passed through a particulate filter and has been scrubbed of hydrocarbon interferences. Once inside the 501-TRS the sample gas is scrubbed of all naturally occurring SO<sub>2</sub>, then passed through a special quartz converter which heats the gas to a very high temperature causing it to react with the O<sub>2</sub> present in the sample gas creating SO<sub>2</sub> in the following manner .



**Equation 7-2**

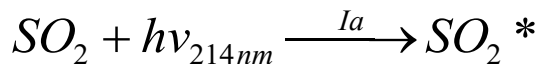
For TRS compounds, the converter is most efficient when it operates at 850°C, converting >95% of the TRS into SO<sub>2</sub>. The converter temperature is viewable on the 501-TRS converter's front panel display.

When the converter is operating at peak efficiency, there is a nearly 1:1 relationship between the amount of TRS entering the converter and the amount of SO<sub>2</sub> leaving it. Therefore, by measuring the amount of SO<sub>2</sub> in the gas after it leaves the converter, the amount of TRS originally present on the sample gas can be directly inferred.

### 7.1.3. SO<sub>2</sub> ULTRAVIOLET FLUORESCENCE MEASUREMENT PRINCIPLE

The physical principle upon which the T101/T102's measurement method is based is the fluorescence that occurs when sulfur dioxide (SO<sub>2</sub>) is changed to an excited state (SO<sub>2</sub>\*) by ultraviolet light with wavelengths in the range of 190 nm-230 nm. This reaction is a two-step process.

The first stage (Equation 7-3) occurs when SO<sub>2</sub> molecules are struck by photons (hν) of the appropriate ultraviolet wavelength. In the case of the T101/T102, 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 SO<sub>2</sub> absorbs some of energy from the UV light, causing one of the electrons of the SO<sub>2</sub> molecule to move to a higher energy orbital state (SO<sub>2</sub>\*).



(Equation 7-3)

The amount of SO<sub>2</sub> converted to SO<sub>2</sub>\* 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 SO<sub>2</sub> as the light travels through the sample gas.

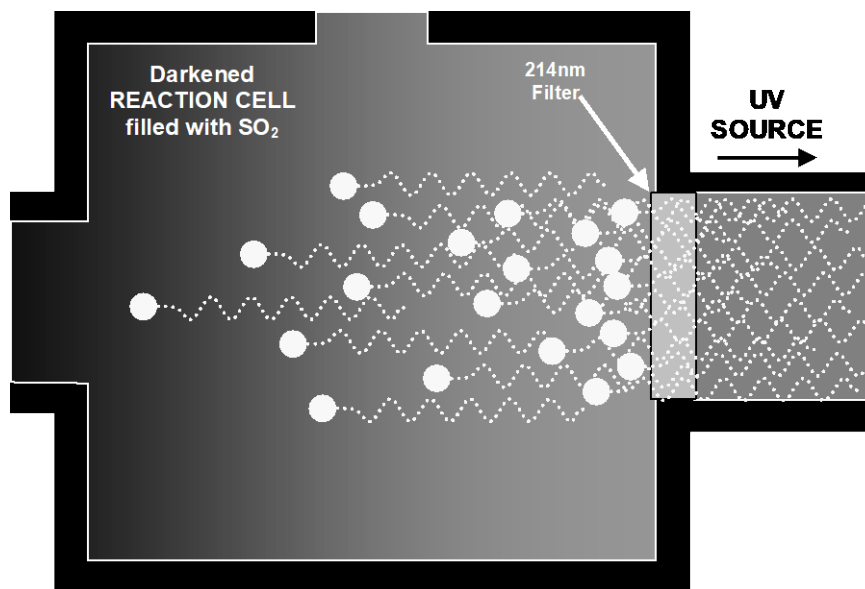


Figure 7-1. UV Absorption

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

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

(Equation 7-4)

Where:

***I*<sub>0</sub>** = Intensity of the excitation UV light

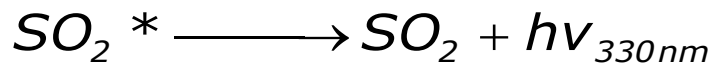
***a*** = The absorption coefficient of SO<sub>2</sub> (a constant)

***SO*<sub>2</sub>** = Concentration of SO<sub>2</sub> in the sample chamber

***x*** = The distance between the UV source and the SO<sub>2</sub> molecule(s) being affected (path length)

The second stage of this reaction occurs after the SO<sub>2</sub> reaches its excited state (SO<sub>2</sub>\*). Because the system will seek the lowest available stable energy state, the SO<sub>2</sub>\* molecule

quickly returns to its ground state (Equation 7-5) 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 7-5)

The amount of detectable UV given off by the decay of the  $SO_2^*$  is affected by the rate at which this reaction occurs ( $k$ ).

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

(Equation 7-6)

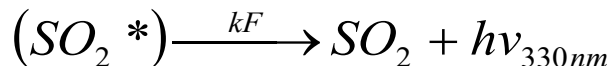
Where:

**F** = the amount of fluorescent light given off.

**k** = the rate at which the  $SO_2^*$  (excited state) decays into  $SO_2$ .

**$SO_2^*$**  = Amount of excited-state  $SO_2$  in the sample chamber.

Therefore:



(Equation 7-7)

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 ( $a$ ) of  $SO_2$  is constant, the amount of fluorescence ( $F$ ) is a result of:

- The amount of  $SO_2^*$  created which is affected by the variable factors from (Equation 7-4) above: concentration of  $SO_2$ ; intensity of UV light ( $I_0$ ); path length of the UV light ( $x$ ) and;
- The amount of fluorescent light created which is affected by the variable factors from (Equation 7-7): the amount of  $SO_2^*$  present and the rate of decay ( $k$ ) which changes based on the temperature of the gas.

The amount of fluorescent light emitted ( $F$ ) is directly related to the concentration of the  $SO_2$  in the Sample Chamber when:

- the intensity of the light ( $I_0$ ) is known
- the path length of excited light is short ( $x$ )
- the temperature of the gas is known and compensated for so that the rate of  $SO_2^*$  decay is constant ( $k$ )
- no interfering conditions are present (such as interfering gases or stray light);

The 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 ( $I_0$ ).
- 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.
- 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  $\text{SO}_2$  in the sample gas.

#### 7.1.4. UV LIGHT PATH

The optical design of the sample chamber optimizes the fluorescent reaction between  $\text{SO}_2$  and UV Light (refer to Figure 7-2) and assure that only UV light resulting from the decay of  $\text{SO}_2^*$  into  $\text{SO}_2$  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  $\text{SO}_2$  into  $\text{SO}_2^*$  (330 nm) and a special reference detector circuit constantly measures lamp intensity (refer to (Equation 7-4)). A Photo Multiplier Tube (PMT) detects the UV given off by the  $\text{SO}_2^*$  decay (214 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  $\text{SO}_2^*$  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<sup>®</sup> that absorbs stray light.

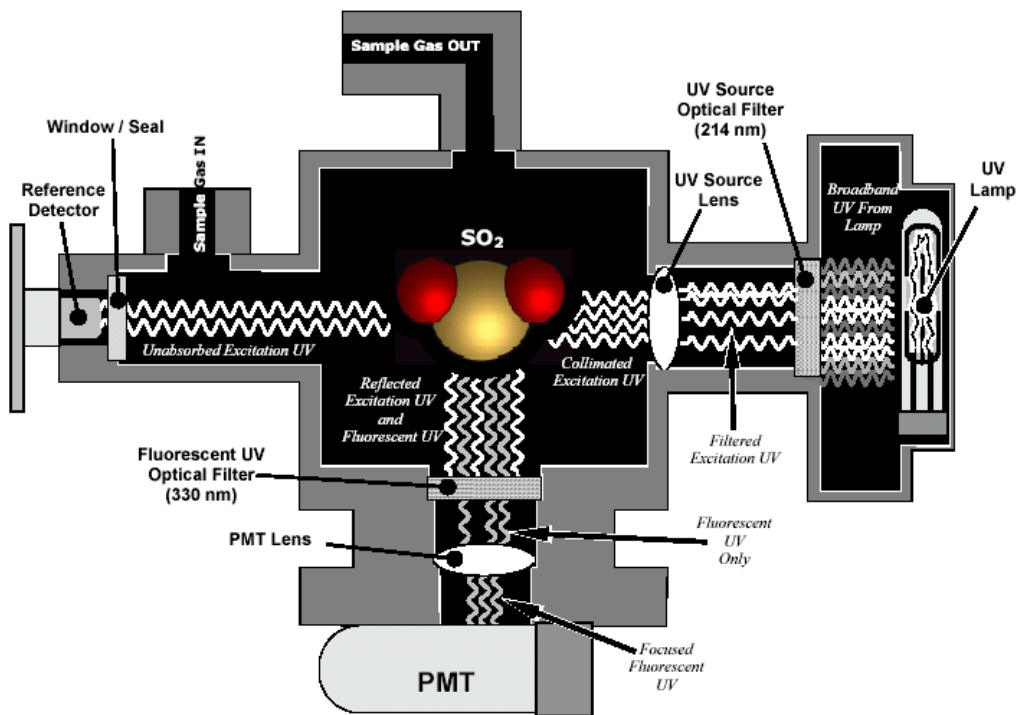


Figure 7-2. UV Light Path

#### 7.1.4.1. T102 ADDITIONAL UV LIGHT PATH DESCRIPTIONS

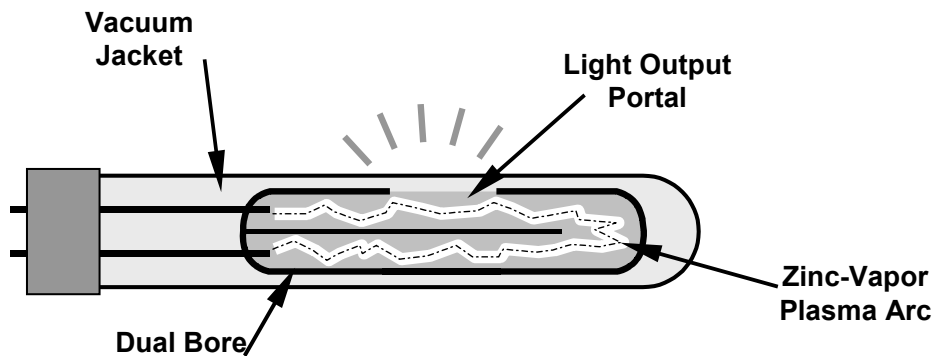
In addition to the UV Light Path described above, the T102 accounts for minor electronic offsets that are inherent in the operation of both the reference detector and the PMT. To account for these offsets the T102 includes a shutter, located between the UV Lamp and the source filter, that periodically cuts off the UV light from the sample chamber. This happens every 30 minutes. The analyzer records the outputs of both the reference detector and the PMT during this dark period and factors them into the SO<sub>2</sub> concentration calculation.

- The reference detector offset is stored and displayed as **DARK LAMP**.
- The PMT offset is stored and displayed as **DARK PMT**.

#### 7.1.5. UV SOURCE LAMP

The source of excitation UV light is a low pressure zinc-vapor lamp. An AC 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<sub>2</sub> to SO<sub>2</sub><sup>\*</sup>, 214.3 nm (refer to Figure 7-4).

The lamp is constructed with a vacuum jacket surrounding a double-bore lamp element (refer to Figure 7-3). 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 7-3. Source UV Lamp Construction**

### 7.1.6. 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.

### 7.1.7. PHOTO-MULTIPLIER TUBE (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 7-4). Therefore, a much more sensitive device is needed to detect this light with enough resolution to be meaningful. The analyzer uses a Photo Multiplier Tube or PMT for this purpose.

A PMT is typically a vacuum tube containing a variety of specially designed electrodes. Photons enter the PMT and strike a negatively charged photo cathode causing it to emit electrons. These electrons are accelerated by a high voltage applied across a series of special electrodes called dynodes that multiply the amount of electrons until a useable current signal is generated. This current increases or decreases with the amount of detected light.

### 7.1.8. OPTICAL FILTERS

The analyzer uses two stages of optical filters to enhance performance. The first stage conditions the UV light used to excite the  $\text{SO}_2$  by removing frequencies of light that are not needed to produce  $\text{SO}_2^*$ . The second stage protects the PMT detector from reacting to light not produced by the  $\text{SO}_2^*$  returning to its ground state.

#### 7.1.8.1. UV SOURCE OPTICAL FILTER

Zinc-vapor lamps output light at other wavelengths beside the 214nm required for the  $\text{SO}_2 \rightarrow \text{SO}_2^*$  transformation including a relatively bright light of the same wavelength at which

SO<sub>2</sub>\* fluoresces as it returns to its SO<sub>2</sub> 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 SO<sub>2</sub>\* decay, it would drown out the SO<sub>2</sub>\* fluorescence.

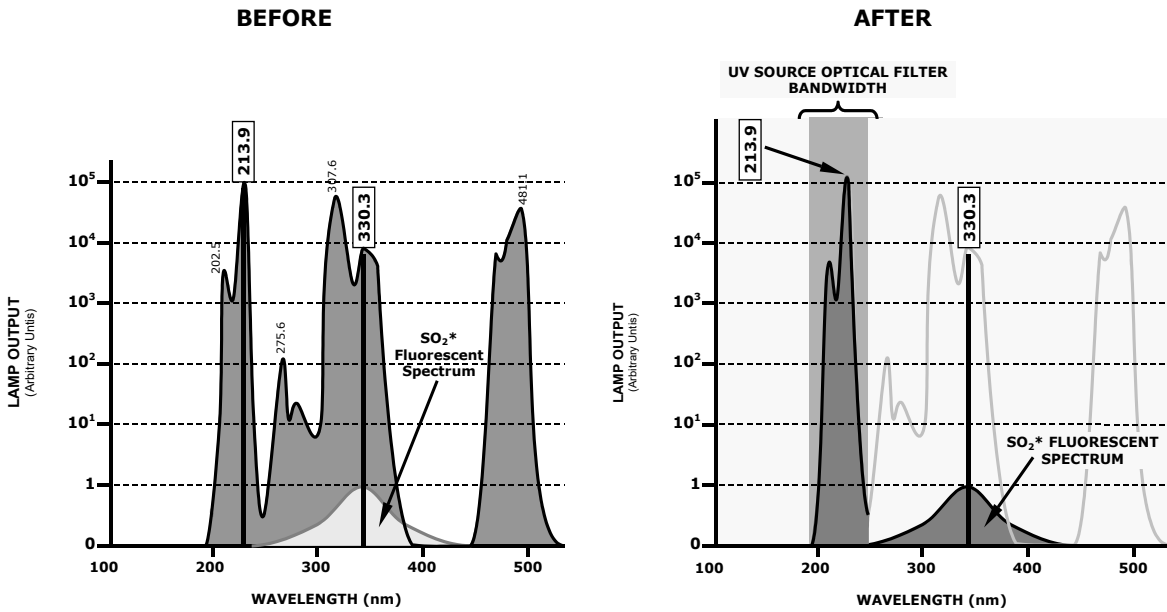


Figure 7-4. Excitation Lamp UV Spectrum Before/After Filtration

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 SO<sub>2</sub> into SO<sub>2</sub>\* (refer to Figure 7-4).



### 7.1.8.2. PMT OPTICAL FILTER

The PMT used in the analyzer 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 SO<sub>2</sub> 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 7-2) and the PMT strips away light outside of the fluorescence spectrum of decaying SO<sub>2</sub>\* (refer to Figure 7-5) including reflected UV from the source lamp and other stray light.

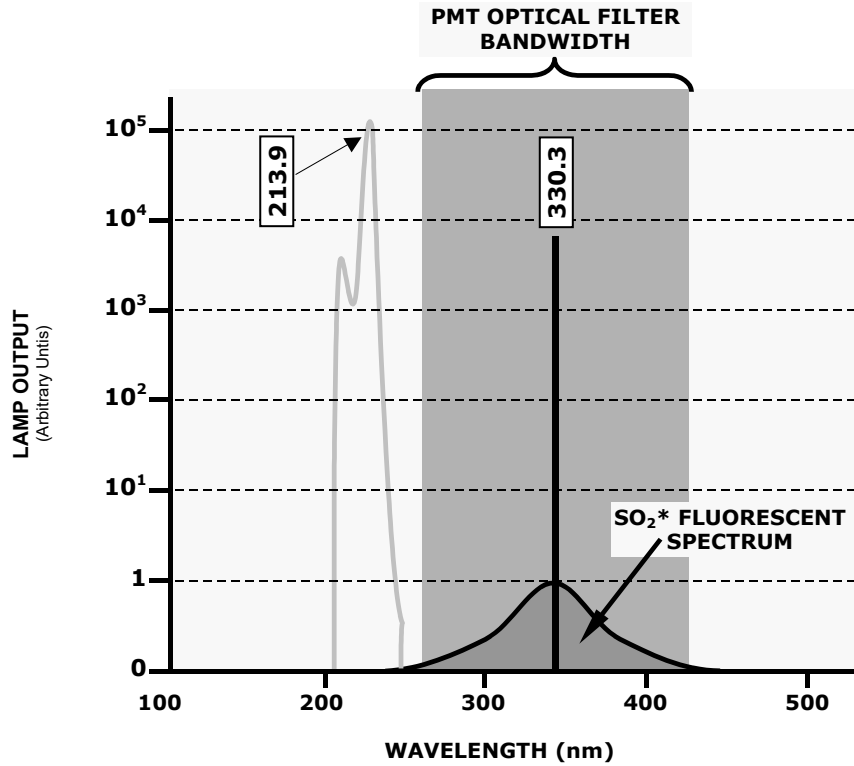
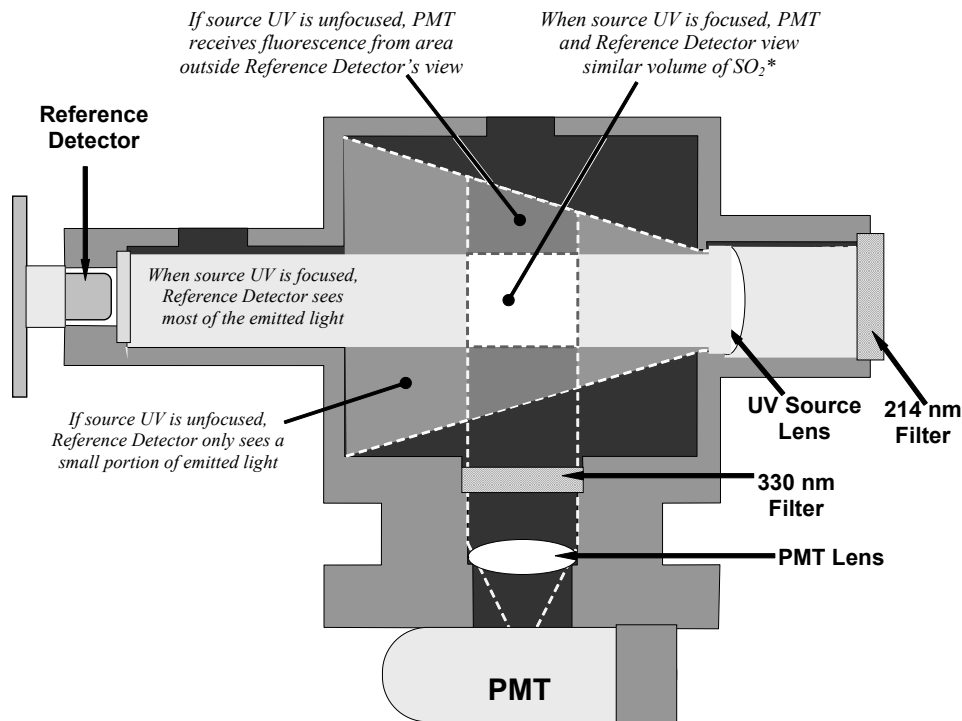


Figure 7-5. PMT Optical Filter Bandwidth

## 7.1.9. OPTICAL LENSES

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



**Figure 7-6. 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 reflected light from the UV lamp reaching the PMT, and by ensuring that all of the light emitted by the source lamp, passes through the 214 nm filter and not absorbed by the SO<sub>2</sub> 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 SO<sub>2</sub>\* being measured by the PMT, eliminating a possible source of measurement offset.

## 7.1.10. MEASUREMENT INTERFERENCES

It should be noted that the fluorescence method for detecting H<sub>2</sub>S is subject to interference from a number of sources. The T101 has been successfully tested for its ability to reject interference from most of these sources.



## 7.1.10.1. DIRECT INTERFERENCE

Since the T101 measures H<sub>2</sub>S by converting it to SO<sub>2</sub>, the most significant interfering gas for this measurement would be ambient SO<sub>2</sub> that is present in the sample gas. The T101 circumvents this by passing the sample gas through a chemical scrubber that removes all SO<sub>2</sub> from the sample gas before the H<sub>2</sub>S → SO<sub>2</sub> conversion takes place. This ensures that the only SO<sub>2</sub> present in the sample chamber is the result of the H<sub>2</sub>S → SO<sub>2</sub> conversion. Obviously to make sure that the analyzer operates correctly it is important to make sure that this scrubber is functioning properly.

The second most common source of interference is from other gases that fluoresce in a similar fashion to SO<sub>2</sub> 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 SO<sub>2</sub>. For critical applications where high levels of NO are expected an optional optical filter is available that improves the rejection of NO (contact Technical Support for more information).

- The analyzer has several methods for rejecting interference from these gases:
- A special scrubber (kicker) mechanism removes any PNA chemicals present in the sample gas before it reaches the sample chamber.
- The exact wavelength of light needed to excite a specific non-SO<sub>2</sub> 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.

## 7.1.10.2. 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 SO<sub>2</sub>\* in the sample chamber. The analyzer prevents this from occurring by having a very short light path between the area where the SO<sub>2</sub>\* fluorescence occurs and the PMT detector. Because the light path is so short, the amount of O<sub>3</sub> needed to cause a noticeable effect would be much higher than could be reasonably expected in any application for which this instrument is intended.

## 7.1.10.3. DILUTION

Certain gases with higher viscosities can lower the flow rate through the critical flow orifice that controls the movement of sample gas through the analyzer reducing the amount of sample gas in the sample chamber and thus the amount of SO<sub>2</sub> available to react with 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.



## 7.1.10.4. THIRD BODY QUENCHING

While the decay of  $\text{SO}_2^*$  to  $\text{SO}_2$  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  $\text{SO}_2^*$  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.

The most significant interferents in this regard are nitrogen oxide (NO), carbon dioxide ( $\text{CO}_2$ ), water vapor ( $\text{H}_2\text{O}$ ) and molecular oxygen ( $\text{O}_2$ ). 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.

## 7.1.10.5. LIGHT POLLUTION

Because the analyzer measures light as a means of calculating the amount of  $\text{SO}_2$  present, obviously stray light can be a significant interfering factor. It removes this interference source 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 7.1.8; remove UV with wavelengths extraneous to the excitation and decay of  $\text{SO}_2/\text{SO}_2^*$ .
- Most importantly, during instrument calibration the difference between the value of the most recently recorded PMT offset and the PMT output while measuring zero gas (calibration gas devoid of  $\text{H}_2\text{S}$ ) is recorded as the test function **OFFSET**. This **OFFSET** value is used during the calculation of the  $\text{H}_2\text{S}$  concentration.

Since this offset is assumed to be due to stray light present in the sample chamber, it is also multiplied by the **SLOPE** and recorded as the function **Stray Light**.



## 7.2. 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).

### 7.2.1. SAMPLE GAS FLOW

The flow of gas through the Analyzer is created by a small internal pump that pulls air through the instrument.

### 7.2.2. FLOW RATE CONTROL

A special flow control assembly located in the exhaust vacuum manifold (refer to pneumatic flow diagrams in Section 2.3.3) is used to maintain a constant flow rate of the sample gas through the instrument. This assembly consists of:

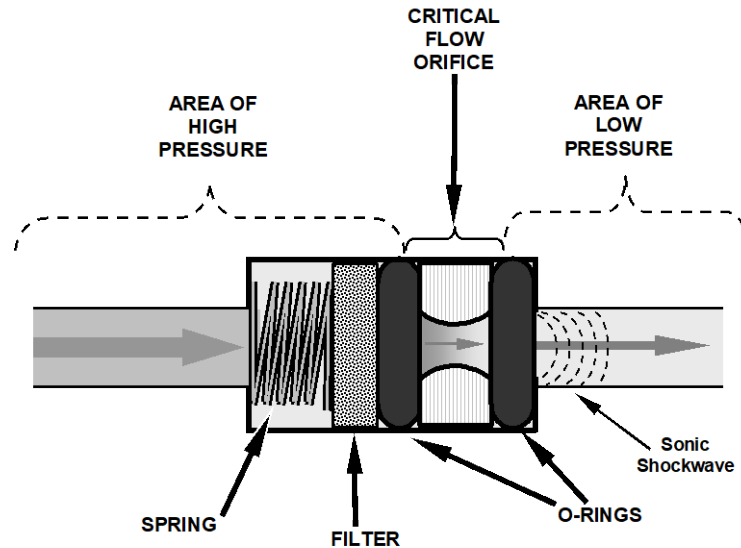
- A critical flow orifice.
- Two o-rings: Located just before and after the critical flow orifice, the o-rings seal the gap between the walls of assembly housing and the critical flow orifice.
- A spring: Applies mechanical force needed to form the seal between the o-rings, the critical flow orifice and the assembly housing.

#### 7.2.2.1. 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 7-7. 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 used in the T101 is designed to provide a flow rate of 600 cm<sup>3</sup>/min.

#### **7.2.2.2. SAMPLE PARTICULATE FILTER**

To remove particles in the sample gas, the analyzer is equipped with a Teflon membrane filter of 47 mm diameter (also referred to as the sample filter) with a 1 μm or 5 μm pore size. The filter is accessible through the front panel, which folds down, and should be changed according to the Maintenance Schedule.

### 7.2.3. HYDROCARBON SCRUBBER (KICKER)

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. 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.

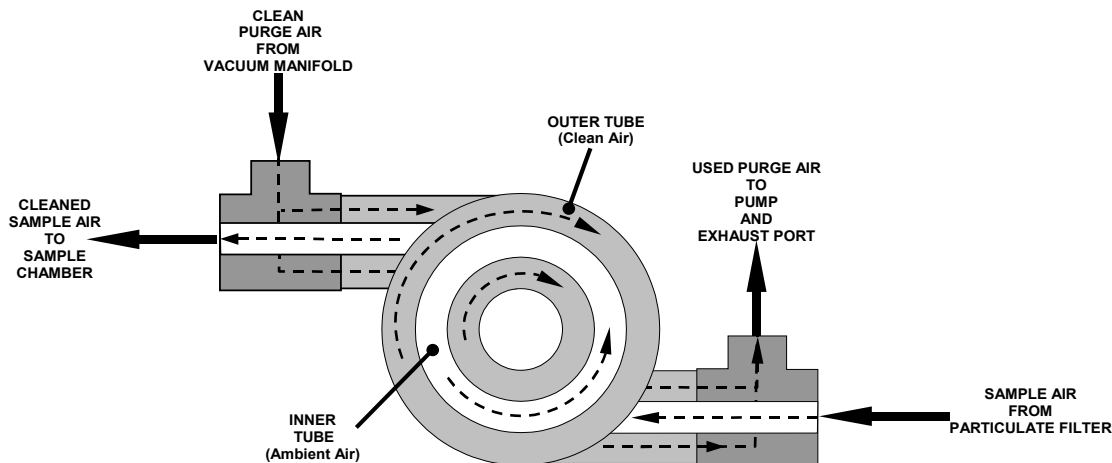


Figure 7-8. Hydrocarbon Scrubber (Kicker)

In this analyzer some of the cleaned air from the inner tube is returned to be used as the purge gas in the outer tube (refer to Figure 7-8). 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.

### 7.2.4. SO<sub>2</sub> SCRUBBER

In order to ensure that no ambient SO<sub>2</sub> interferes with the T101's H<sub>2</sub>S or T102's TRS measurements, the sample gas is passed through a chemical scrubber that removes SO<sub>2</sub> from the sample stream before it is passed through the respective converter. The scrubber is a Teflon encased, stand-alone unit (located inside the T101 chassis and inside the 501 chassis for the T102) that contains a room-temperature tube with scrubber material, which is expended as it removes SO<sub>2</sub>. The frequency of replacing the scrubber's material depends on the levels of SO<sub>2</sub> in the sample gas.

## 7.2.5. PNEUMATIC SENSORS

The analyzer uses two pneumatic sensors to verify gas streams. These sensors are located on a printed circuit assembly, called the pneumatic pressure/flow sensor board.

### 7.2.5.1. 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 7.2.2). 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 viewable in the Dashboard as Pressure.

### 7.2.5.2. SAMPLE FLOW SENSOR

A thermal-mass flow sensor is used 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 viewable in the Dashboard as Sample Flow.

## 7.2.6. MULTIGAS MEASUREMENT AND SWITCHING VALVE

When activated for operation the multigas measurement mode allows the instrument to measure either or both gases via a Teflon<sup>®</sup> switching valve. This valve, under CPU control via the I<sup>2</sup>C bus and the relay board, directs the sample gas stream either through the SO<sub>2</sub> scrubber and H<sub>2</sub>S (or TRS) → SO<sub>2</sub> converter (H<sub>2</sub>S/TRS measurement mode) or directly to the sample chamber bypassing the converter, allowing the analyzer to measure only SO<sub>2</sub>. The cycle for this operation is

**Table 7-1. Multigas Valve Cycle-Phases**

GAS MODE	SWITCHING VALVE STATUS	DEFAULT TIMES	ACTIVITY
T101: H <sub>2</sub> S T102: TRS	Gas stream directed through scrubber and converter	0 – 3 minutes	Wait period. Ensures sample chamber has been flushed of previous gas.
		3 – 10 m	Analyzer measures florescence in sample chamber
SO <sub>2</sub>	Gas stream bypasses through scrubber and converter	0 – 3 minutes	Wait period (dwell time). Ensures sample chamber has been flushed of previous gas.
		3 – 10 m	Analyzer measures florescence in sample chamber

Cycle repeats every ~20 minutes

## 7.3. ELECTRONIC OPERATION

### 7.3.1. OVERVIEW

Figure 7-9 shows a block diagram of the major electronic components of the analyzer.

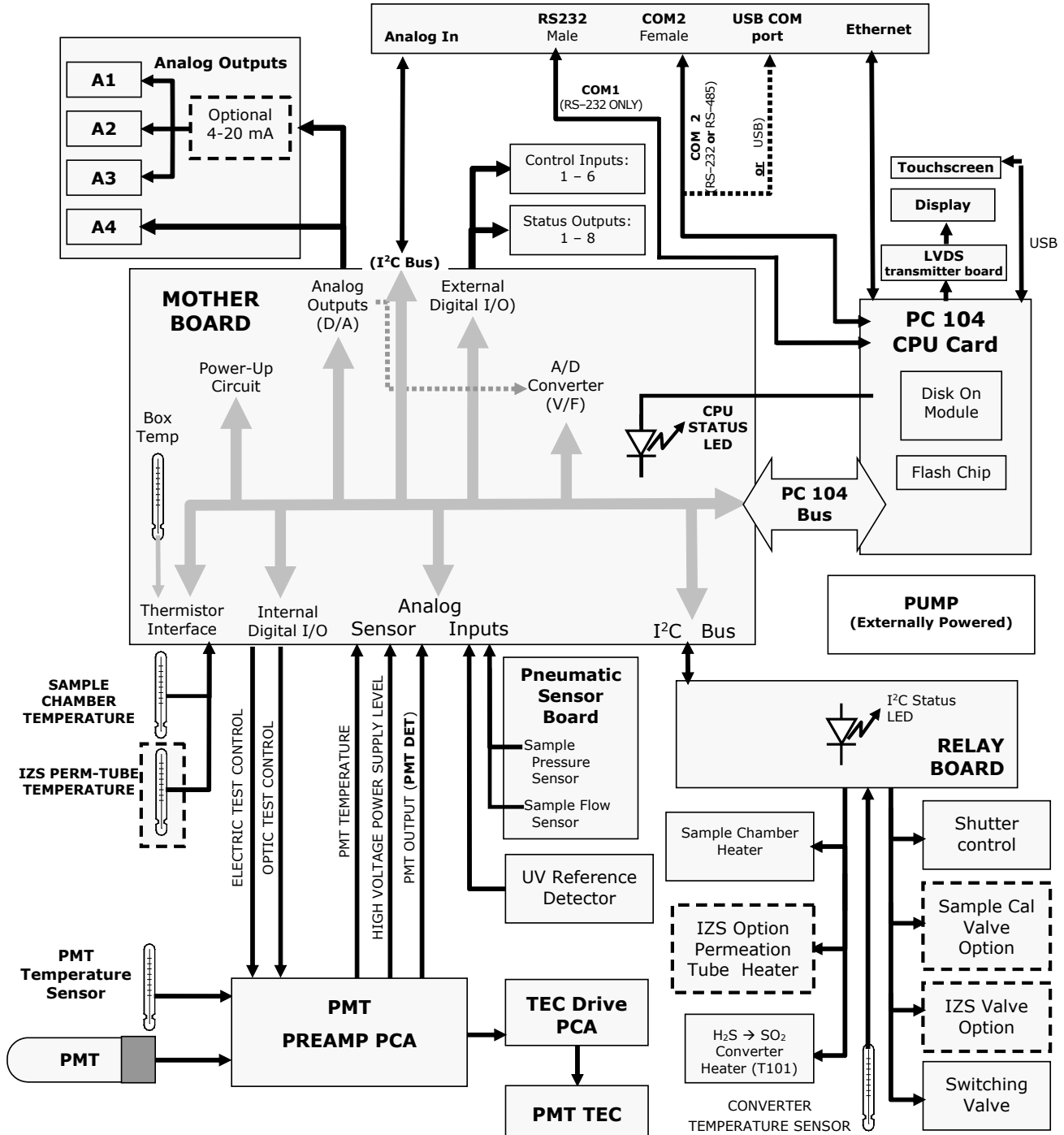


Figure 7-9. Electronic Block Diagram

The core of the analyzer is a microcomputer/central processing unit (CPU) that controls various internal processes, interprets data, makes calculations, and reports results using specialized firmware developed by Teledyne API. It communicates with the user as well as receives data from and issues commands to a variety of peripheral devices via a separate printed circuit assembly onto which the CPU is mounted: the motherboard.

The motherboard is directly mounted to the inside rear panel and collects data, performs signal conditioning duties and routes incoming and outgoing signals between the CPU and the analyzer's other major components.

Concentration data are generated by the Photo Multiplier Tube (PMT), which produces an analog current signal corresponding to the brightness of the fluorescence reaction in the sample chamber. This current signal is amplified to a DC voltage signal (Dashboard parameter **PMT**) by a PMT preamplifier printed circuit assembly (located on top of the sensor housing). **PMT** is converted to digital data by a bi-polar, analog-to-digital converter, located on the motherboard.

In addition to the PMT signal, a variety of sensors report the physical and operational status of the analyzer's major components, again through the signal processing capabilities of the motherboard. These status reports are used as data for the H<sub>2</sub>S concentration calculation (e.g. pressure and temperature reading used by the temperature/pressure compensation feature) and as trigger events for certain warning messages and control commands issued by the CPU. They are stored in the CPU's memory and, in most cases, can be viewed through the front panel display.

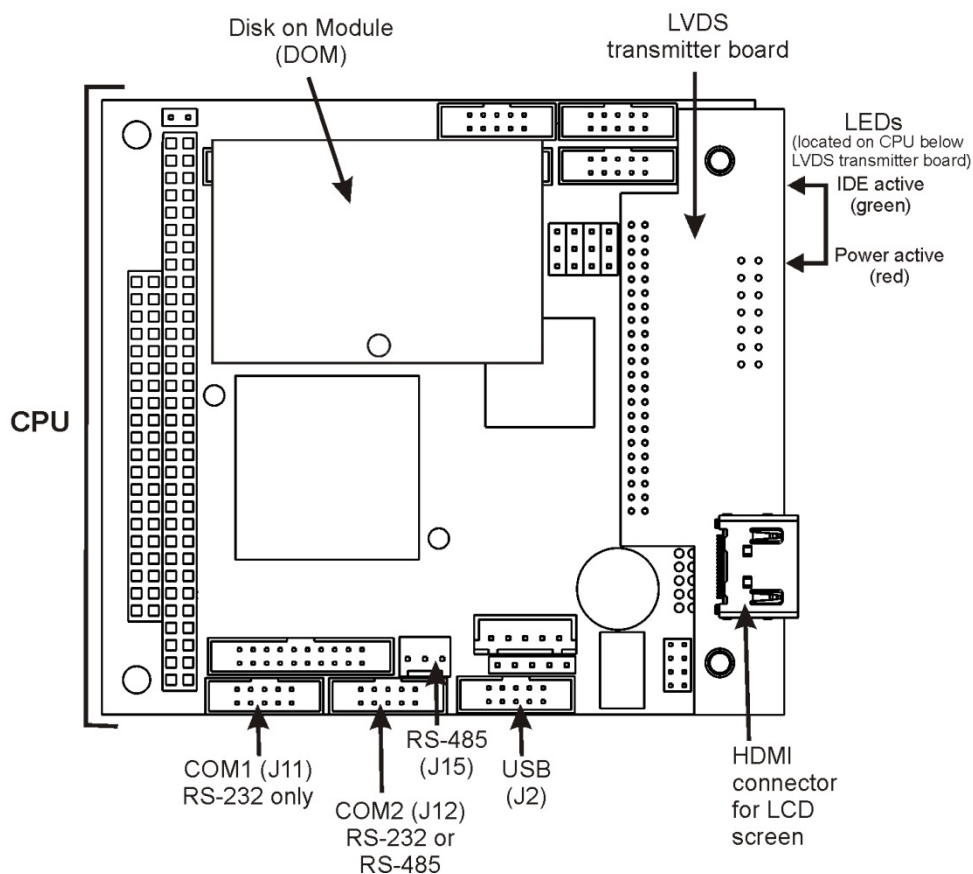
The CPU communicates with the user and the outside world in a variety of ways:

- Through the analyzer's front panel LCD touch-screen interface
- RS-232 and RS-485 serial I/O channels
- Various analog voltage and current outputs
- Several digital I/O channels
- Ethernet

Finally, the CPU issues commands (also over the I<sup>2</sup>C bus) to a series of relays and switches located on a separate printed circuit assembly, the relay board (located in the rear of the chassis on its own mounting bracket) to control the function of key electromechanical devices such as valves and heaters.

### 7.3.2. CPU

The unit's CPU card, installed on the motherboard located inside the rear panel, is a low power (5 VDC, 720mA max), high performance, Vortex86SX-based microcomputer running Windows CE. Its operation and assembly conform to the PC 104 specification. The CPU includes two types of non-volatile data storage: a Disk-on-Module (DOM) and an embedded flash chip. The DOM is a 44-pin IDE flash drive with storage a 512 MB capacity. It is used to store the computer's operating system, the Teledyne API firmware, and most of the operational data generated by the analyzer's internal data acquisition system (DAS). The non-volatile, embedded flash chip includes 2MB of storage for calibration data as well as a backup of the analyzer configuration.



**Figure 7-10. CPU Board**

### 7.3.3. SENSOR MODULE

The sensor module (Figure 7-11) consists of a Sample Chamber subassembly and a PMT subassembly. These subassemblies have different tasks: to activate the UV light that initiates the fluorescence reaction, to detect the intensity of that reaction, to produce a current signal proportional to that intensity, and to sense and control key conditions to ensure the accuracy and stability of the measurements.

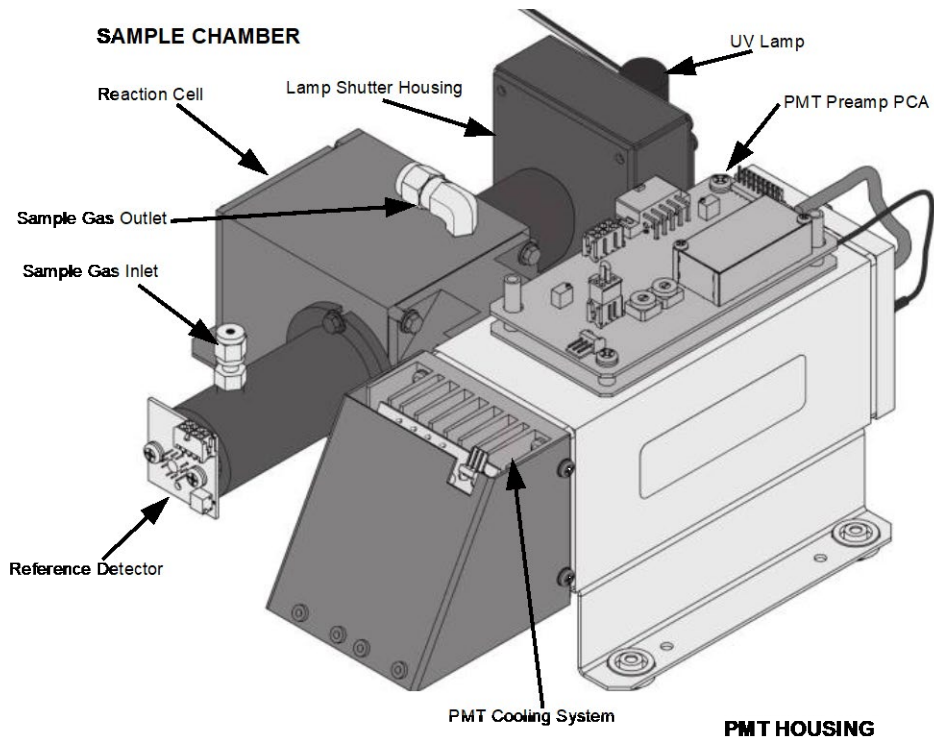


Figure 7-11. Sensor Module: Sample Chamber and PMT Housing

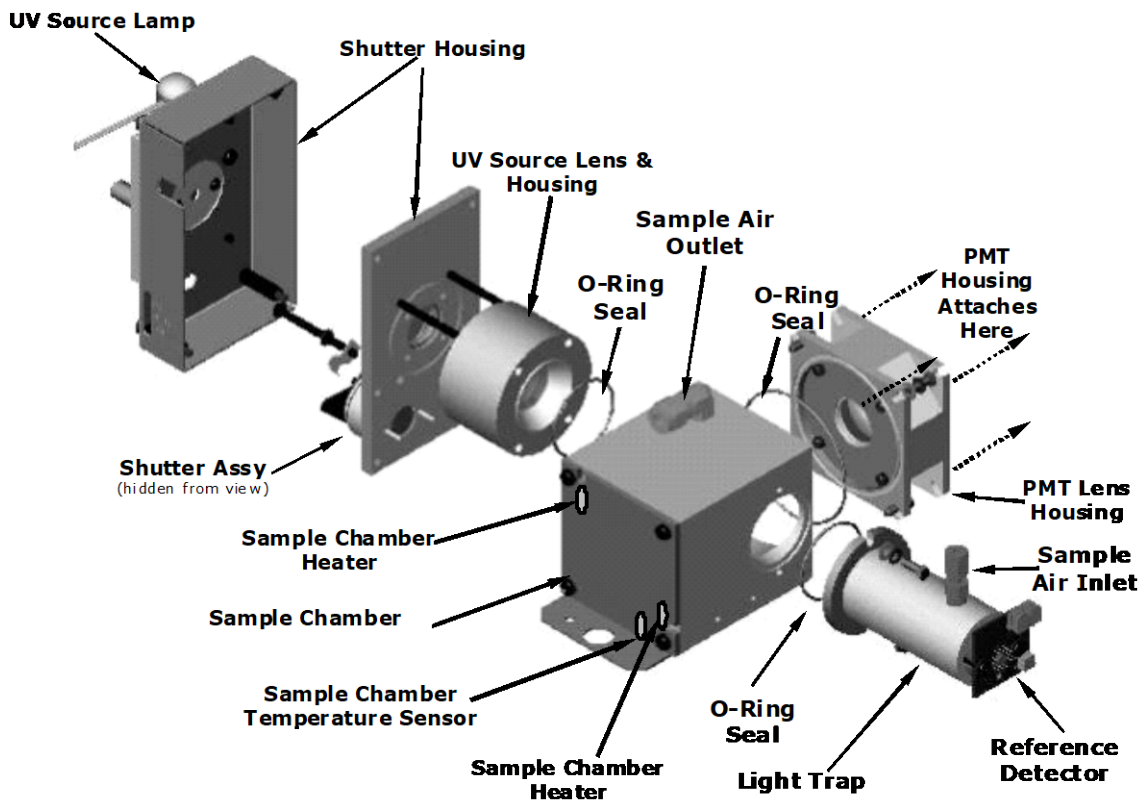


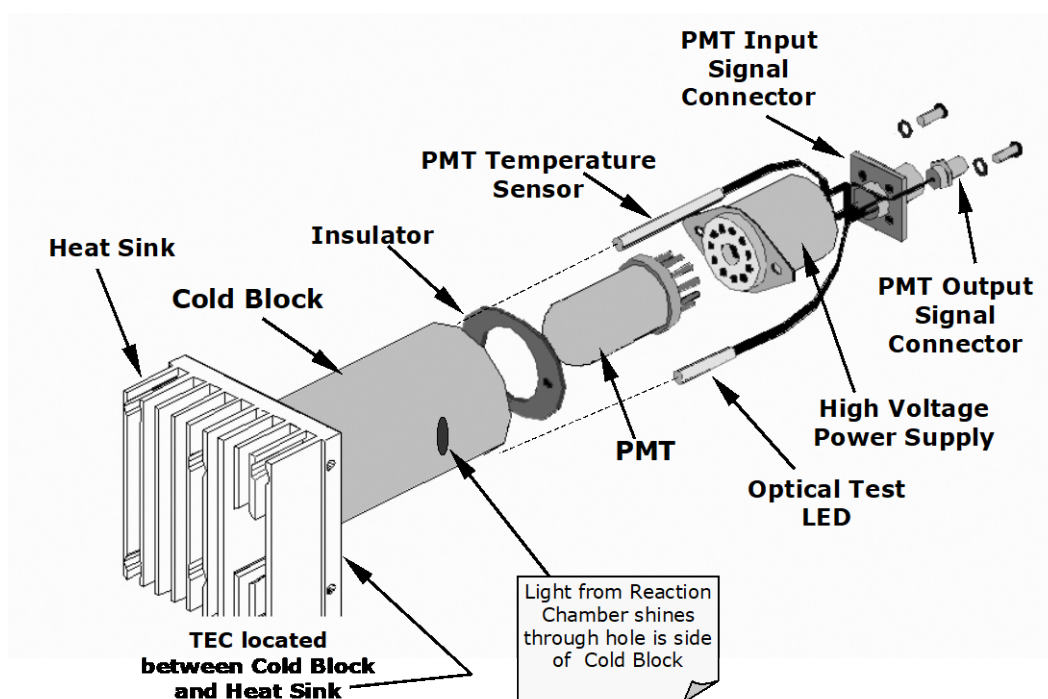
Figure 7-12. Exploded View of Sample Chamber Assembly

### 7.3.3.1. SAMPLE CHAMBER HEATING CIRCUIT

One key component of the sample chamber is the heating circuit. In order to reduce temperature effects, the sample chamber is maintained at a constant 50°C, just above the high end of the instrument's operation temperature range. Two AC heaters, one embedded into the top of the sample chamber, the other embedded directly below the reference detector's light trap, provide the heat source. These heaters operate off of the instrument's main AC power and are controlled by the CPU through a power relay on the relay board. A thermistor, also embedded in the bottom of the sample chamber, reports the cell's temperature to the CPU through the thermistor interface circuitry of the motherboard.

### 7.3.4. PHOTO MULTIPLIER TUBE (PMT)

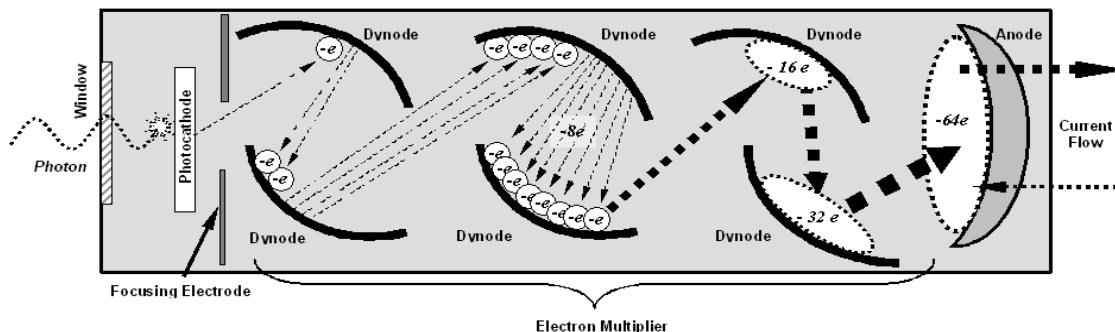
The PMT detects the amount of fluorescence created by the SO<sub>2</sub> and UV light reaction in the sample chamber.



**Figure 7-13. PMT Assembly**

A typical PMT is a vacuum tube containing a variety of specially designed electrodes. Photons from the reaction are filtered by an optical high-pass filter, enter the PMT and strike a negatively charged photo cathode causing it to emit electrons. A high voltage potential across these focusing electrodes directs the electrons toward an array of high voltage dynodes.

The dynodes in this electron multiplier array are designed so that each stage multiplies the number of emitted electrons by emitting multiple, new electrons. The greatly increased numbers of electrons emitted from one end of the electron multiplier are collected by a positively charged anode at the other end, which creates a useable current signal. This current signal is amplified by the preamplifier board and then reported to the motherboard.



**Figure 7-14. Basic PMT Design**

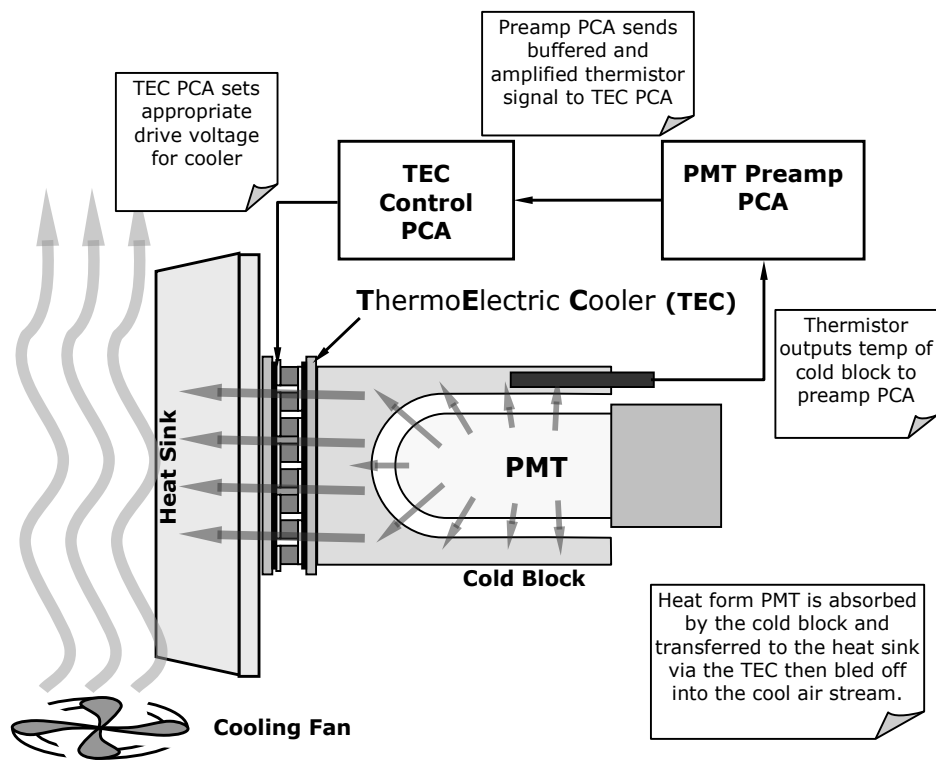
A significant performance characteristic of the PMT is the voltage potential across the electron multiplier. The higher the voltage, the greater the number of electrons emitted from each dynode of the electron multiplier, in effect making the PMT more sensitive and responsive to smaller variations in light intensity, but also adding noise (this is referred to as “dark noise”).

- The gain voltage of the PMT is usually set between 450 V and 800 V.
- This parameter is viewable in the Dashboard as HVPS.
- For information on when and how to set this voltage, see Section 6.7.10.4.

The PMT is housed inside the PMT module assembly (see Figure 6-28). This assembly also includes the high voltage power supply required to drive the PMT, an LED used by the instrument’s optical test function, a thermistor that measures the temperature of the PMT and various components of the PMT cooling system including the Thermo-Electric Cooler (TEC).

### 7.3.5. PMT COOLING SYSTEM

The performance of the analyzer's PMT is significantly affected by temperature. Variations in PMT temperature are directly reflected in the signal output of the PMT. Also, the signal-to-noise ratio of the PMT output is radically influenced by temperature as well. The warmer the PMT is, the noisier its signal becomes until the noise renders the concentration signal useless. To alleviate this problem a special cooling system exists that maintains the PMT temperature at a stable, low level.



**Figure 7-15. PMT Cooling System**

#### 7.3.5.1. THERMOELECTRIC COOLER (TEC)

The core of the PMT cooling system is a solid state heat pump called a thermoelectric cooler (TEC). Thermoelectric coolers transfer heat from a one side of a special set of semiconductor junctions to the other when a DC current is applied. The heat is pumped at a rate proportional to the amount of current applied. In this analyzer the TEC is physically attached to a cold block that absorbs heat directly from the PMT and a heat sink that is cooled by moving air (refer to Figure 7-15). A Thermocouple embedded into the cold block generates an analog voltage corresponding to the current temperature of the PMT. The PMT Preamp PCA conditions and amplifies this signal then passes it on to the TEC Control Board.

#### 7.3.5.2. TEC CONTROL BOARD

The TEC control board is located on the sensor housing assembly, under the slanted shroud, next to the cooling fins and directly above the cooling fan. Using the amplified PMT temperature signal from the PMT preamplifier board (see Section 7.3.5), it sets the drive



## T101, T102

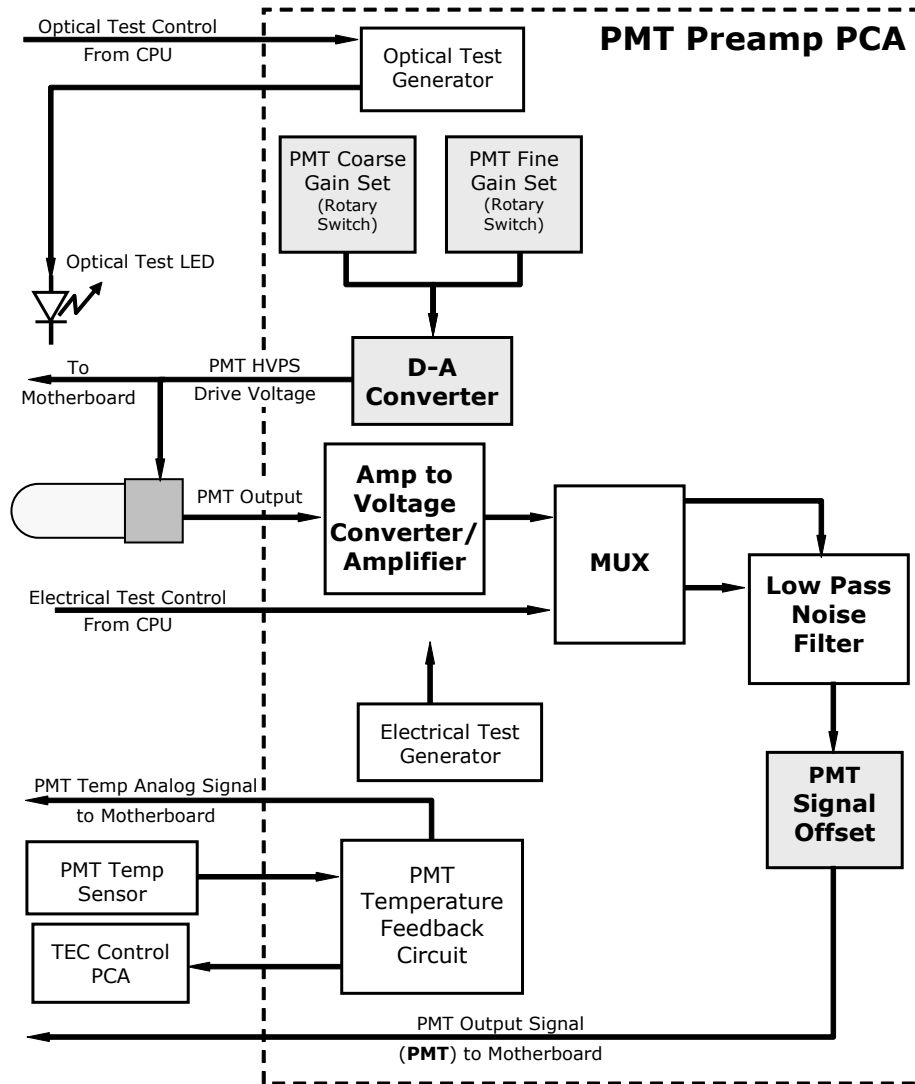
voltage for the thermoelectric cooler. The warmer the PMT gets, the more current is passed through the TEC causing it to pump more heat to the heat sink.

- A red LED located on the top edge of this circuit board indicates that the control circuit is receiving power.
- Four test points are also located at the top of this assembly.

### 7.3.6. PMT PREAMPLIFIER

The PMT preamplifier board amplifies the PMT signal into a useable analog voltage that can be processed by the motherboard into a digital signal to be used by the CPU to calculate the H<sub>2</sub>S concentration of the gas in the sample chamber.

The output signal of the PMT is controlled by two different adjustments. First, the voltage across the electron multiplier array of the PMT is adjusted with a set of two hexadecimal switches. Adjusting this voltage directly affects the HVPS voltage and, hence, the signal from the PMT. Secondly, the gain of the amplified signal can further be adjusted through a potentiometer. These adjustments should only be performed when encountering problems with the software calibration that cannot be rectified otherwise.



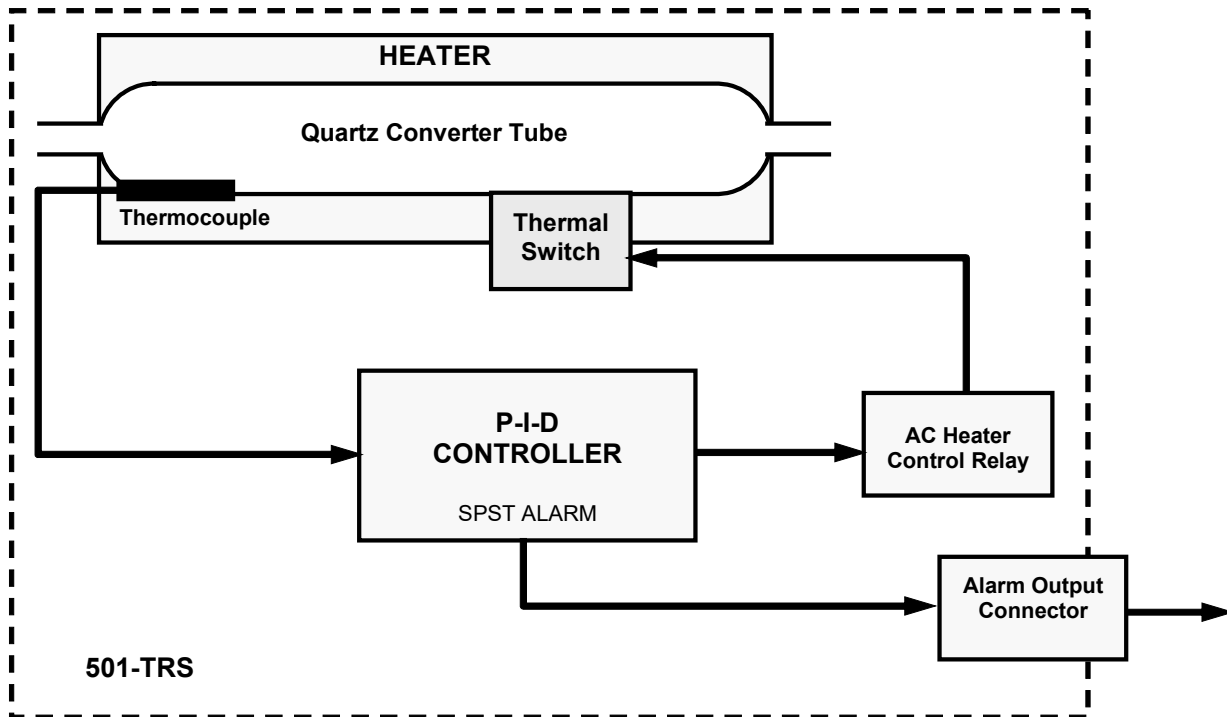
**Figure 7-16. PMT Preamp Block Diagram**

The PMT preamplifier PCA also operates two different tests used to calibrate and check the performance of the sensor module.

- The electrical test (Utilities>Diagnostics>OE Test, ETest) circuit generates a constant, electronic signal intended to simulate the output of the PMT (after conversion from current to voltage). By bypassing the detector's actual signal, it is possible to test most of the signal handling and conditioning circuitry on the PMT preamplifier board. See Section 6.7.9.10 for instructions on performing this test.
- The optical test (Utilities>Diagnostics>OE Test, OTest) feature causes an LED inside the PMT cold block to create a light signal that can be measured with the PMT. If zero air is supplied to the analyzer, the entire measurement capability of the sensor module can be tested including the PMT and the current to voltage conversion circuit on the PMT preamplifier board. See Section 6.7.9.10 for instructions on performing this test.

### 7.3.7. MODEL 501-TRS ELECTRONICS

The nucleus of the converter is a pre-programmed P-I-D temperature controller that manages the temperature of the instrument’s AC powered converter oven based on analog input from the thermocouple attached to the converter’s chamber.



**Figure 7-17. 501-TRS Electronic Block Diagram**

The P-I-D controller determines the differences between the actual temperature (called the Process Value or PV) of the oven, compares it to the target temperature (called the Set Point or SV) and changes the percentage of time the heater is turned on versus the time it is turned off accordingly. The higher the proportion of ON-time versus OFF-time the faster the oven is heated. For instance, if the PV is much lower than the SV the P-I-D will keep the heater turned on 100% of the time resulting in a relatively rapid increase in the temperature of the oven. As the PV approaches the same temperature as the SV the ON cycles get shorter compared to the OFF cycles.

The 501-TRS’s P-I-D controller includes sophisticated software that allows the controller to track the rate change in temperature of the oven compared to the percentage of heater-ON time and predict the proportion needed to reach and maintain the proper oven temperature with a minimal amount of overshoot or fluctuation.

However, while the P-I-D Controller includes many safeguards that prevent runaway heating of the converter oven, as an additional safety backup the 501-TRS includes a heat sensitive switch that automatically interrupts power to the heater before the oven temperature reaches critical levels. In addition, a single SPST alarm output is triggered should the PV rise or fall outside the pre-programmed alarm setpoints.

The relay is normally open, and the contact closes in the alarm condition. The relay contacts are isolated (dry) SPST, 220VAC / 30 VDC 1 Amp, resistive load. This alarm output is available via a connector on the rear panel of the 501-TRS.



## 7.3.8. FLOW AND PRESSURE SENSOR BOARD

The flow and pressure sensors of the analyzer are located on a printed circuit assembly just behind the PMT sensor. The signals of this board are supplied to the motherboard for further signal processing. All sensors are linearized in the firmware and can be span calibrated from the front panel.

## 7.3.9. RELAY BOARD

The relay board is the central switching unit of the analyzer. It contains power relays, status LEDs for all heated zones and valves as well as valve drivers, thermocouple amplifiers, power distribution connectors and the two switching power supplies of the analyzer. The relay board communicates with the motherboard over the I2C bus and is the main board for trouble-shooting power problems of any kind.

### 7.3.9.1. HEATER CONTROL

The analyzer uses a variety of heaters for its individual components. All heaters are AC powered and can be configured for 100/120 VAC or 220/230VAC at 50-60 Hz.

The two sample chamber heaters are electronically connected in parallel for analyzers at 100/120 VAC line power and in series for units configured for 220/230 VAC. One configuration plug on the relay board determines the power configuration for the entire analyzer.

In order to operate efficiently, the H<sub>2</sub>S  $\square$  SO<sub>2</sub> converter must be heated to 315°C. An AC band heater wrapped around the converter cartridge contains two heater coils that are also configured in parallel or in series depending on the Type of AC power being supplied. A thermocouple imbedded in the heater measures the temperature and feeds a small voltage to the relay board's thermocouple amplifier, which, in turn, transmits the linearized analog voltage to the motherboard. This information is sent to the CPU via the instrument's I2C buss. The CPU returns activate/deactivate signals to the appropriate relay also via the I2C buss.

On units with IZS options installed, an additional set of AC heaters is attached to the IZS oven. Some special T101 models may have other, non-standard heating zones installed, such as a bypass manifold.



## 7.3.9.2. VALVE CONTROL

The relay board also hosts two valve driver chips, each of which can drive up four valves. In its basic configuration the analyzer requires no valve control to operate. However, on units with either the zero/span valve or the IZS option installed, the valve control is used. Manifold valves, which may also be present in certain special versions of the analyzer, would also use valve control.

## 7.3.9.3. STATUS LEDs AND WATCHDOG CIRCUITRY

Status LEDs are located on the analyzer's relay board to indicate the status of the analyzer's heating zones and valves as well as a general operating watchdog indicator. The functions and behaviors of these LEDs were presented in Table 6-6.

The most important of the status LED's on the relay board is the red I<sup>2</sup>C bus watch-dog LED. It is controlled directly by the analyzer's CPU over the I<sup>2</sup>C bus. Special circuitry on the Relay PCA watches the status of D1. Should this LED ever stay ON or OFF for 30 seconds, indicating that the CPU or I<sup>2</sup>C bus has stopped functioning, this Watchdog Circuit automatically shuts all valves and turns off all heaters.

## 7.3.10. MOTHERBOARD

This PCA provides a multitude of functions including, A/D conversion, digital input/output, PC-104 to I<sup>2</sup>C translation, temperature sensor signal processing and is a pass through for the RS-232 and RS-485 signals.

### 7.3.10.1. A TO D CONVERSION

Analog signals, such as the voltages received from the analyzer's various sensors, are converted into digital signals that the CPU can understand and manipulate by the analog to digital (A/D) converter. Under the control of the CPU, this functional block selects a particular signal input and then converts the selected voltage into a digital word.

The A/D converter consists of a Voltage-to-Frequency (V-F) converter, a Programmable Logic Device (PLD), three multiplexers, several amplifiers and other associated devices. The V-F converter produces a frequency proportional to its input voltage. The PLD counts the output of the V-F during a specified time, and sends the result of that count, in the form of a binary number, to the CPU.

The A/D can be configured for several different input modes and ranges, but in this analyzer it is used in unipolar mode with a +5V full scale. The converter includes a 1% over and under-range. This allows signals from -0.05V to +5.05V to be fully converted.

For calibration purposes, two reference voltages are supplied to the A/D converter: Reference ground and +4.096 VDC. During calibration, the device measures these two voltages, outputs their digital equivalent to the CPU. The CPU uses these values to compute the converter's offset and slope and uses these factors for subsequent conversions.



## 7.3.10.2. SENSOR INPUTS

The key analog sensor signals are coupled to the A/D through the master multiplexer from two connectors on the motherboard. 100K terminating resistors on each of the inputs prevent cross talk from appearing on the sensor signals.

**PMT DETECTOR OUTPUT:** The PMT detector output from the PMT preamplifier is used in the computation of the SO<sub>2</sub> concentration displayed in the Dashboard and reported through the instrument's analog outputs and COM ports.

**HIGH VOLTAGE POWER SUPPLY (HVPS) LEVEL:** The PMT high voltage is based on the drive voltage from the preamplifier board. It is digitized and sent to the CPU which then calculates the voltage setting of the HVPS.

**PMT TEMPERATURE:** The PMT temperature is measured with a thermistor inside the PMT cold block. Its signal is amplified by the PMT temperature feedback circuit on the preamplifier board and is digitized and sent to the CPU which calculates the current temperature of the PMT.

**SAMPLE GAS PRESSURE SENSOR:** This sensor measures the gas pressure at the exit of the sample chamber.

**SAMPLE FLOW SENSOR:** This sensor measures the flow rate of the sample gas as it exits the sample chamber.

## 7.3.10.3. THERMISTOR INTERFACE

This circuit provides excitation, termination and signal selection for several negative coefficient, thermistor temperature sensors located inside the analyzer.

**REACTION CELL TEMPERATURE (Rx Cell Temp) SENSOR:** A thermistor that measures the temperature inside the reaction cell manifold, which is used by the CPU to control the reaction cell heating circuit and as a parameter in the temperature/pressure compensation algorithm.

**BOX TEMPERATURE (Box Temp) SENSOR:** A thermistor that measures the analyzer's inside temperature, which is then reported through the front panel display. It is also used as part of the H<sub>2</sub>S calculation when the instrument's Temperature/Pressure Compensation feature is enabled (Setup>Vars>TPC Enable).

**INTERNAL SPAN GAS GENERATOR (Option) OVEN\_TEMPERATURE:** This thermistor reports the temperature of the optional internal span gas generator's SO<sub>2</sub> permeation source to the CPU as part of a control loop that keeps the tube at a high constant temperature (necessary to ensure that the permeation rate of SO<sub>2</sub> is constant).

### Note

**There are two thermistors that monitor the temperature of the PMT assembly:**

**One is embedded in the cold block of the PMT's TEC. Its signal is conditioned by the PMT preamplifier PCA and reported to the CPU via the motherboard (see Section 7.3.10.2).**

**The second is located on the PMT Preamplifier PCA and is used only as a reference for the preamplifier circuitry. Its output is neither reported nor stored.**



## 7.3.11. ANALOG OUTPUTS

The analyzer comes equipped with four configurable analog outputs on the instrument's rear panel analog connector, labeled A1, A2, A3 and A4. A variety of scaling measurement and electronic factors apply to these signals.

**OUTPUT LOOP-BACK:** All of the functioning analog outputs are connected back to the A/D converter through a Loop-back circuit. This permits the voltage outputs to be calibrated by the CPU without need for any additional tools or fixtures.

## 7.3.12. EXTERNAL DIGITAL I/O

The external digital I/O controls the Status Outputs and the Control Inputs.

## 7.3.13. I<sup>2</sup>C DATA BUS

I<sup>2</sup>C is a two-way, clocked, bi-directional digital serial I/O bus that is used widely in commercial and consumer electronic systems. A transceiver on the Motherboard converts data and control signals from the PC-104 bus to I<sup>2</sup>C format. The data are then fed to the relay board, optional analog input board and valve driver board circuitry.

## 7.3.14. POWER UP CIRCUIT

This circuit monitors the +5V power supply during start-up and sets the Analog outputs, External Digital I/O ports, and I<sup>2</sup>C circuitry to specific values until the CPU boots and the instrument software can establish control.

## 7.3.15. POWER SUPPLY/CIRCUIT BREAKER

The analyzer operates on 100 VAC, 115 VAC or 230 VAC power at either 50Hz or 60Hz. Individual units are set up at the factory to accept any combination of these five attributes. As illustrated in Figure 7-18 below, power enters the analyzer through a standard IEC 320 power receptacle located on the rear panel of the instrument. From there it is routed through the ON/OFF switch located in the lower right corner of the front panel.

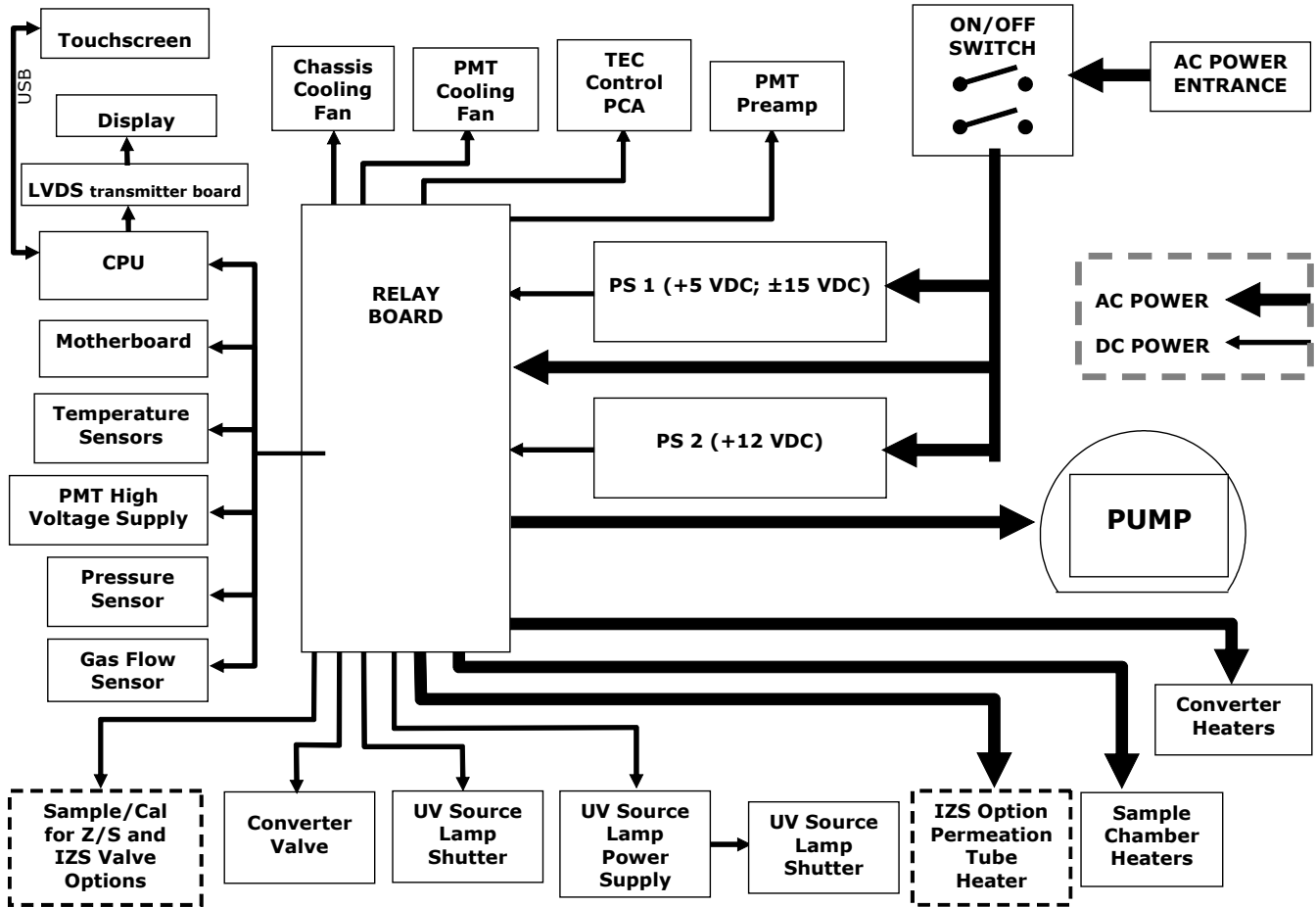
AC line power is stepped down and converted to DC power by two DC power supplies. One supplies +12 VDC, for various valves and valve options, while a second supply provides +5 VDC and ±15 VDC for logic and analog circuitry as well as the TEC cooler. All AC and DC Voltages are distributed through the relay board.

A 6.75 ampere circuit breaker is built into the ON/OFF switch. In case of a wiring fault or incorrect supply power, the circuit breaker will automatically turn off the analyzer.



### WARNING – ELECTRICAL SHOCK HAZARD

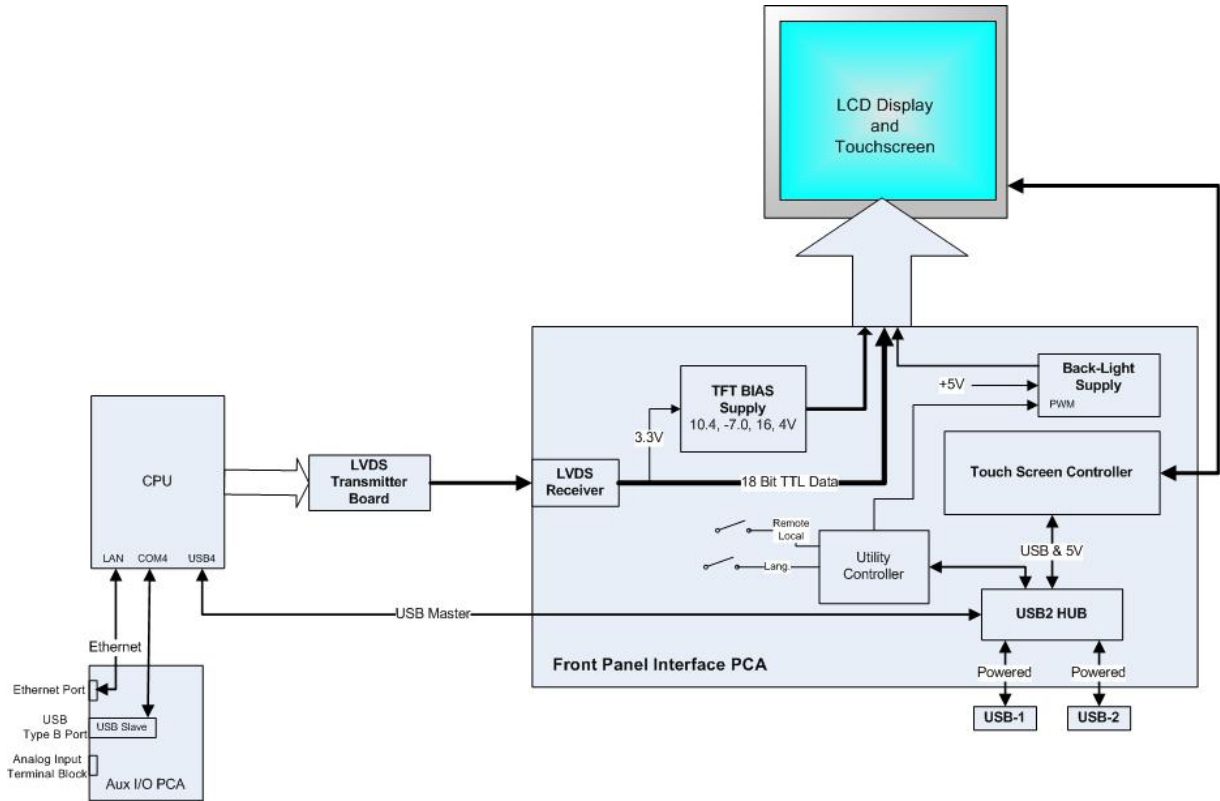
Should the AC power circuit breaker trip, investigate and correct the condition causing this situation before turning the analyzer back on.



**Figure 7-18. Power Distribution Block Diagram**

### 7.3.16. FRONT PANEL TOUCHSCREEN/DISPLAY INTERFACE

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



**Figure 7-19. Front Panel and Display Interface Block Diagram**

### 7.3.16.1. LVDS TRANSMITTER BOARD

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

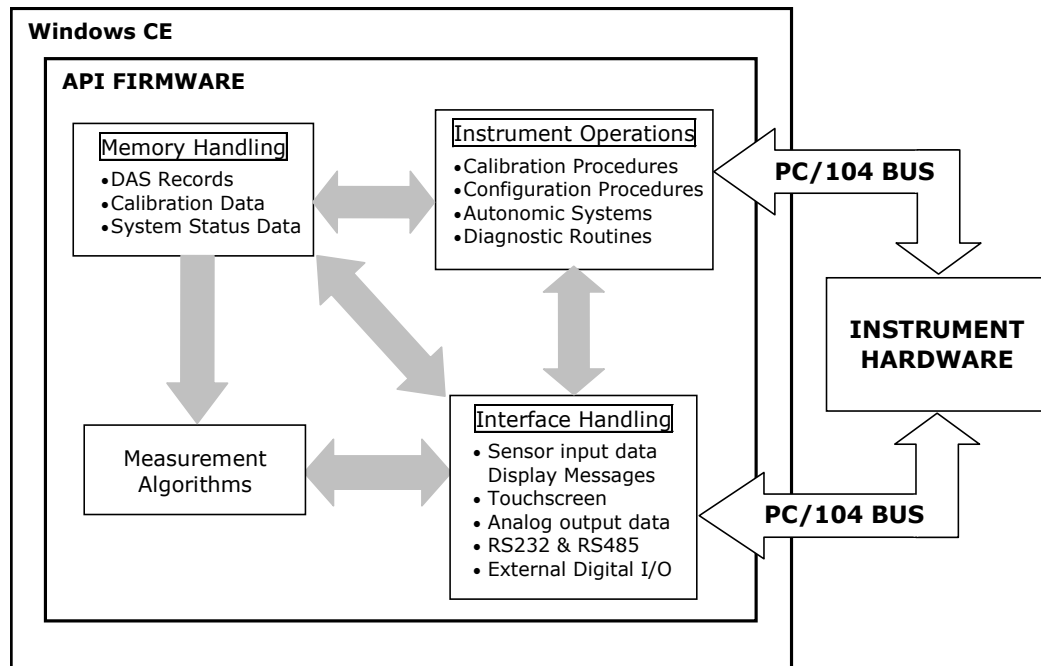
### 7.3.16.2. FRONT PANEL TOUCHSCREEN/DISPLAY INTERFACE PCA

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

- power supply circuitry for the LCD display module
- USB hub for communications with the touchscreen controller and the two front panel USB device ports
- circuitry for powering the display backlight

## 7.4. SOFTWARE OPERATION

The analyzer has a high performance, 86-based microcomputer running Windows CE. Inside the WINDOWS CE shell, special software developed by Teledyne API interprets user commands via the various interfaces, performs procedures and tasks, stores data in the CPU's various memory devices and calculates the concentration of the sample gas.



**Figure 7-20. Basic Software Operation**

### 7.4.1. 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.

## **7.4.2. 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.



### 7.4.3. 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 SO<sub>2</sub> concentration calculation. To account for this, the analyzer software includes a feature that allows the instrument to compensate changes in ambient pressure during the SO<sub>2</sub> calculations.

When the TPC feature is enabled, the analyzer's SO<sub>2</sub> 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 7-8). As ambient pressure increases, the compensated SO<sub>2</sub> concentration is decreased.

$$PRESSCO = \frac{SAMPLE\_PRESSURE (" HG - A) \times SAMP\_PRESS\_SLOPE}{29.92 (" HG - A)}$$

(Equation 7-8)

**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.

### 7.4.4. 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 <sub>2</sub> into NO, etc.)
CEM	<i>Continuous Emission Monitoring</i>
Chemical elements that may be included in this document:	
CO <sub>2</sub>	carbon dioxide
C <sub>3</sub> H <sub>8</sub>	propane
CH <sub>4</sub>	methane
H <sub>2</sub> O	water vapor
HC	general abbreviation for hydrocarbon
HNO <sub>3</sub>	nitric acid
H <sub>2</sub> S	hydrogen sulfide
NO	nitric oxide
NO <sub>2</sub>	nitrogen dioxide
NO <sub>x</sub>	nitrogen oxides, here defined as the sum of NO and NO <sub>2</sub>
NO <sub>y</sub>	nitrogen oxides, often called odd nitrogen: the sum of NO <sub>x</sub> plus other compounds such as HNO <sub>3</sub> (definitions vary widely and may include nitrate (NO <sub>3</sub> ), PAN, N <sub>2</sub> O and other compounds as well)
NH <sub>3</sub>	ammonia
O <sub>2</sub>	molecular oxygen
O <sub>3</sub>	ozone
SO <sub>2</sub>	sulfur dioxide
cm <sup>3</sup>	metric abbreviation for <i>cubic centimeter</i> (replaces the obsolete abbreviation “cc”)
CPU	<i>Central Processing Unit</i>
DAC	<i>Digital-to-Analog Converter</i>
DAS	<i>Data Acquisition System</i>
DCE	<i>Data Communication Equipment</i>
DFU	<i>Disposable Filter Unit</i>
DHCP	<i>Dynamic Host Configuration Protocol</i> . A protocol used by LAN or Internet servers to automatically set up the interface protocols between themselves and any other addressable device connected to the network
DOM	<i>Disk On Module</i> , a 44-pin IDE flash drive with up to 128MB storage capacity for instrument’s firmware, configuration settings and data
DOS	<i>Disk Operating System</i>
DRAM	<i>Dynamic Random Access Memory</i>
DR-DOS	<i>Digital Research DOS</i>



## T101, T102

Term	Description/Definition
DTE	<i>Data Terminal Equipment</i>
EEPROM	<i>Electrically Erasable Programmable Read-Only Memory</i> also referred to as a FLASH chip or drive
ESD	<i>Electro-Static Discharge</i>
ETEST	<i>Electrical Test</i>
Ethernet	a standardized (IEEE 802.3) computer networking technology for local area networks (LANs), facilitating communication and sharing resources
FEP	<i>Fluorinated Ethylene Propylene</i> polymer, one of the polymers that Du Pont markets as <i>Teflon</i> <sup>®</sup>
Flash	non-volatile, solid-state memory
FPI	<i>Fabry-Perot Interface</i> : a special light filter typically made of a transparent plate with two reflecting surfaces or two parallel, highly reflective mirrors
GFC	<i>Gas Filter Correlation</i>
I <sup>2</sup> C bus	a clocked, bi-directional, serial bus for communication between individual analyzer components
IC	<i>Integrated Circuit</i> , a modern, semi-conductor circuit that can contain many basic components such as resistors, transistors, capacitors, etc., in a miniaturized package used in electronic assemblies
IP	<i>Internet Protocol</i>
IZS	<i>Internal Zero Span</i>
LAN	<i>Local Area Network</i>
LCD	<i>Liquid Crystal Display</i>
LED	<i>Light Emitting Diode</i>
LPM	<i>Liters Per Minute</i>
MFC	<i>Mass Flow Controller</i>
M/R	<i>Measure/Reference</i>
NDIR	<i>Non-Dispersive Infrared</i>
MOLAR MASS	<p>the mass, expressed in grams, of 1 mole of a specific substance. Conversely, one mole is the amount of the substance needed for the molar mass to be the same number in grams as the atomic mass of that substance.</p> <p>EXAMPLE: The atomic weight of Carbon is 12 therefore the molar mass of Carbon is 12 grams. Conversely, one mole of carbon equals the amount of carbon atoms that weighs 12 grams.</p> <p>Atomic weights can be found on any Periodic Table of Elements.</p>
NDIR	<i>Non-Dispersive Infrared</i>
NIST-SRM	<i>National Institute of Standards and Technology - Standard Reference Material</i>
PC	<i>Personal Computer</i>
PCA	<i>Printed Circuit Assembly</i> , the PCB with electronic components, ready to use
PC/AT	<i>Personal Computer / Advanced Technology</i>
PCB	<i>Printed Circuit Board</i> , the bare board without electronic component
PFA	<i>Per-Fluoro-Alkoxy</i> , an inert polymer; one of the polymers that <i>Du Pont</i> markets as <i>Teflon</i> <sup>®</sup>
PLC	<i>Programmable Logic Controller</i> , a device that is used to control instruments based on a logic level signal coming from the analyzer
PLD	<i>Programmable Logic Device</i>
PLL	<i>Phase Lock Loop</i>



## T101, T102

Term	Description/Definition
PMT	<i>Photo Multiplier Tube</i> , a vacuum tube of electrodes that multiply electrons collected and charged to create a detectable current signal
P/N (or PN)	<i>Part Number</i>
PSD	<i>Prevention of Significant Deterioration</i>
PTFE	<i>Poly-Tetra-Fluoro-Ethylene</i> , a very inert polymer material used to handle gases that may react on other surfaces; one of the polymers that <i>Du Pont</i> markets as <i>Teflon</i> <sup>®</sup>
PVC	<i>Poly Vinyl Chloride</i> , a polymer used for downstream tubing
Rdg	Reading
RS-232	specification and standard describing a serial communication method between DTE (Data Terminal Equipment) and DCE (Data Circuit-terminating Equipment) devices, using a maximum cable-length of 50 feet
RS-485	specification and standard describing a binary serial communication method among multiple devices at a data rate faster than RS-232 with a much longer distance between the host and the furthest device
SAROAD	<i>Storage and Retrieval of Aerometric Data</i>
SLAMS	<i>State and Local Air Monitoring Network Plan</i>
SLPM	<i>Standard Liters Per Minute</i> of a gas at standard temperature and pressure
STP	<i>Standard Temperature and Pressure</i>
TCP/IP	<i>Transfer Control Protocol / Internet Protocol</i> , the standard communications protocol for Ethernet devices
TEC	<i>Thermal Electric Cooler</i>
TPC	<i>Temperature/Pressure Compensation</i>
USB	<i>Universal Serial Bus</i> : a standard connection method to establish communication between peripheral devices and a host controller, such as a mouse and/or keyboard and a personal computer or laptop
VARS	<i>Variables</i> , the variable settings of the instrument
V-F	<i>Voltage-to-Frequency</i>
Z/S	<i>Zero / Span</i>

## APPENDIX A – MODBUS REGISTERS

MODBUS Register Address (dec., 0-based)	Description	Units
<b>MODBUS Floating Point Input Registers (32-bit IEEE 754 format; read in high-word, low-word order; read-only)</b>		
0	PMT detector reading	mV
2	UV lamp intensity reading	mV
4	UV lamp ratio of calibrated intensity	%
6	PMT electrical offset	mV
8	UV lamp electrical offset	mV
10	SO <sub>2</sub> slope for range #1	PPB/mV
12	SO <sub>2</sub> slope for range #2	PPB/mV
14	H <sub>2</sub> S/TRS slope for range #1	PPB/mV
16	H <sub>2</sub> S/TRS slope for range #2	PPB/mV
18	SO <sub>2</sub> offset for range #1	mV
20	SO <sub>2</sub> offset for range #2	mV
22	H <sub>2</sub> S/TRS offset for range #1	mV
24	H <sub>2</sub> S/TRS offset for range #2	mV
26	SO <sub>2</sub> concentration for range #1 during zero/span calibration, just before computing new slope and offset	PPB
28	SO <sub>2</sub> concentration for range #2 during zero/span calibration, just before computing new slope and offset	PPB
30	H <sub>2</sub> S/TRS concentration for range #1 during zero/span calibration, just before computing new slope and offset	PPB
32	H <sub>2</sub> S/TRS concentration for range #2 during zero/span calibration, just before computing new slope and offset	PPB
34	SO <sub>2</sub> concentration for range #1	PPB
36	SO <sub>2</sub> concentration for range #2	PPB
38	H <sub>2</sub> S/TRS concentration for range #1	PPB
40	H <sub>2</sub> S/TRS concentration for range #2	PPB
42	Concentration stability #1	PPB
44	Stray light reading	PPB
46	Reaction cell temperature	°C
48	IZS temperature	°C
50	PMT temperature	°C
52	Converter efficiency factor for range #1	—
54	Converter efficiency factor for range #2	—
56	Sample flow rate	cc/m
58	Sample pressure	“Hg
60	Internal box temperature	°C
62	High voltage power supply output	Volts
64	Diagnostic test input (TEST_INPUT_8)	mV



# T101, T102

MODBUS Register Address (dec., 0-based)	Description	Units
66	Diagnostic test input (TEST_INPUT_11)	mV
68	Diagnostic temperature input (TEMP_INPUT_4)	°C
70	Diagnostic temperature input (TEMP_INPUT_5)	°C
72	Diagnostic temperature input (TEMP_INPUT_6)	°C
74	Ground reference (REF_GND)	mV
76	4096 mV reference (REF_4096_MV)	mV
78	Pre-amplified UV lamp intensity reading	mV
80 <sup>1</sup>	Converter temperature	°C
82 <sup>5</sup>	Oxygenator flow rate	cc/m
84 <sup>6</sup>	Concentration stability #2	PPB
86 <sup>7</sup>	UV lamp stability	mV
100 <sup>4</sup>	TRS slope for range #1	PPB/mV
102 <sup>4</sup>	TRS slope for range #2	PPB/mV
104 <sup>4</sup>	TRS offset for range #1	mV
106 <sup>4</sup>	TRS offset for range #2	mV
108 <sup>4</sup>	TRS concentration for range #1 during zero/span calibration, just before computing new slope and offset	PPB
110 <sup>4</sup>	TRS concentration for range #2 during zero/span calibration, just before computing new slope and offset	PPB
112 <sup>4</sup>	TRS concentration for range #1	PPB
114 <sup>4</sup>	TRS concentration for range #2	PPB
116 <sup>4</sup>	TRS converter efficiency factor for range #1	—
118 <sup>4</sup>	TRS converter efficiency factor for range #2	—
<b>MODBUS Floating Point Holding Registers</b> (32-bit IEEE 754 format; read/write in high-word, low-word order; read/write)		
0	Maps to SO2_SPAN1 variable; target conc. for range #1	Conc. units
2	Maps to SO2_SPAN2 variable; target conc. for range #2	Conc. units
4	Maps to H2S_SPAN1 variable; target conc. for range #1	Conc. units
6	Maps to H2S_SPAN2 variable; target conc. for range #2	Conc. units
100 <sup>4</sup>	Maps to TRS_SPAN1 variable; target conc. for range #1	Conc. units
102 <sup>4</sup>	Maps to TRS_SPAN2 variable; target conc. for range #2	Conc. units
<b>MODBUS Discrete Input Registers</b> (single-bit; read-only)		
0	PMT detector warning	
1	UV detector warning	
2	Dark calibration warning	
3	Box temperature warning	
4	PMT temperature warning	
5	Reaction cell temperature warning	
6	Sample pressure warning	
7	HVPS warning	

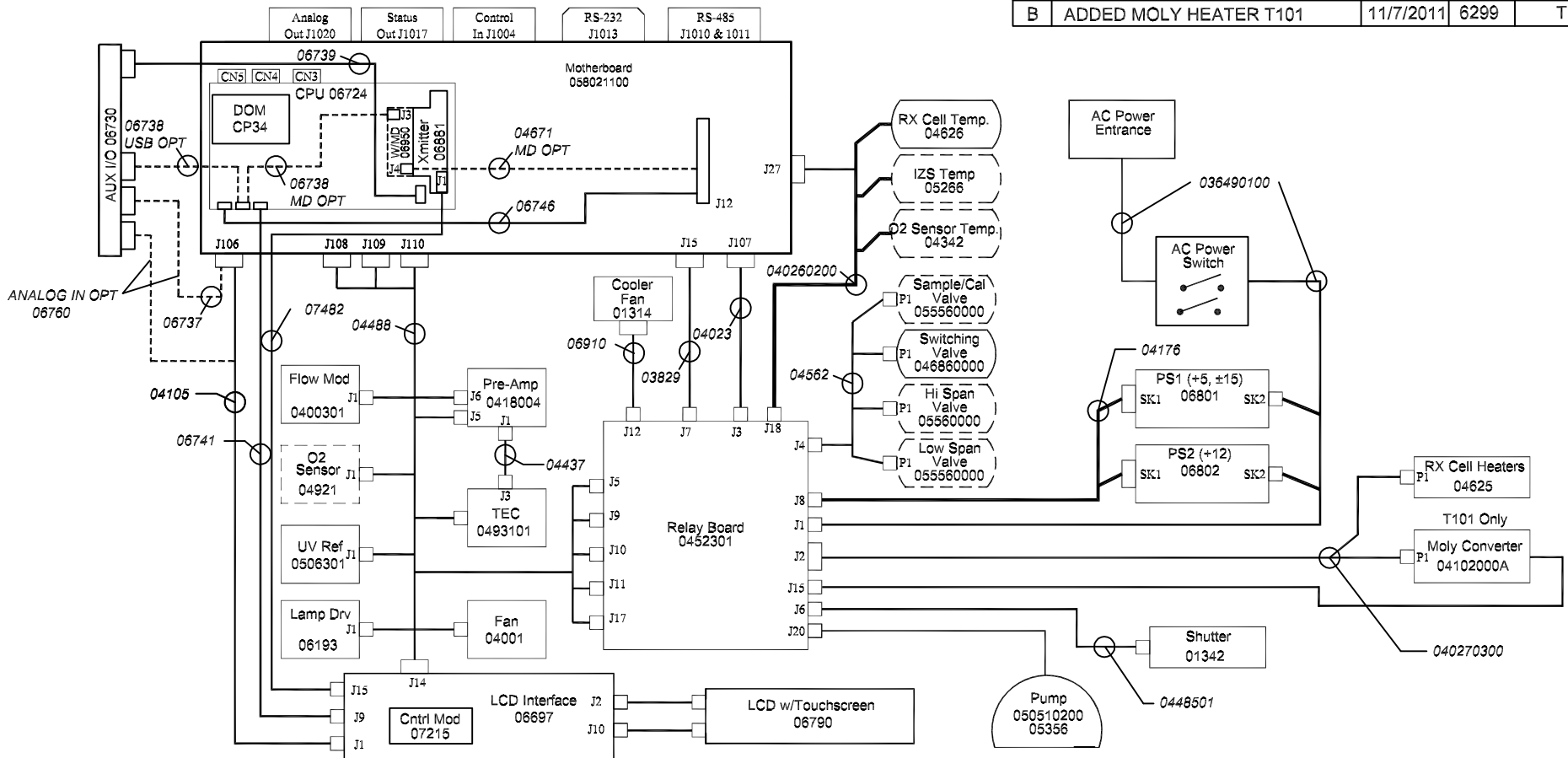


# T101, T102

MODBUS Register Address (dec., 0-based)	Description	Units
8	System reset warning	
9	Rear board communication warning	
10	Relay board communication warning	
11	Front panel communication warning	
12	Analog calibration warning	
13	Dynamic zero warning	
14	Dynamic span warning	
15	Invalid concentration	
16	In zero calibration mode	
17	In span calibration mode	
18	In multi-point calibration mode	
19	System status is OK (same meaning as <i>SYSTEM_OK</i> I/O signal)	
20	Sample flow warning	
21	IZS temperature warning	
22 <sup>1</sup>	Converter temperature warning	
23 <sup>5</sup>	Oxygenator flow warning	
24 <sup>2</sup>	SO <sub>2</sub> concentration alarm limit #1 exceeded	
25 <sup>2</sup>	SO <sub>2</sub> concentration alarm limit #2 exceeded	
26 <sup>2</sup>	H <sub>2</sub> S/TRS concentration alarm limit #1 exceeded	
27 <sup>2</sup>	H <sub>2</sub> S/TRS concentration alarm limit #2 exceeded	
28 <sup>2+4</sup>	TRS concentration alarm limit #1 exceeded	
29 <sup>2+4</sup>	TRS concentration alarm limit #2 exceeded	
<b>MODBUS Coil Registers (single-bit; read/write)</b>		
0	Maps to relay output signal 36 ( <i>MB_RELAY_36</i> in signal I/O list)	
1	Maps to relay output signal 37 ( <i>MB_RELAY_37</i> in signal I/O list)	
2	Maps to relay output signal 38 ( <i>MB_RELAY_38</i> in signal I/O list)	
3	Maps to relay output signal 39 ( <i>MB_RELAY_39</i> in signal I/O list)	
20 <sup>3</sup>	Triggers zero calibration of range #1 (on enters cal.; off exits cal.)	
21 <sup>3</sup>	Triggers span calibration of range #1 (on enters cal.; off exits cal.)	
22 <sup>3</sup>	Triggers zero calibration of range #2 (on enters cal.; off exits cal.)	
23 <sup>3</sup>	Triggers span calibration of range #2 (on enters cal.; off exits cal.)	
<sup>1</sup>	T101	
<sup>2</sup>	Concentration alarm option	
<sup>3</sup>	Set <i>DYN_ZERO</i> or <i>DYN_SPAN</i> variables to <i>ON</i> to enable calculating new slope or offset. Otherwise, a calibration check is performed.	
<sup>4</sup>	Triple-gas option	
<sup>5</sup>	T108	
<sup>6</sup>	T108U	
<sup>7</sup>	Optional	

# Appendix B - T101, T102 Interconnects

REVISIONS				
REV	DESCRIPTION	DATE	DCN	APPROVED
A	INITIAL RELEASE	9/3/10	5833	KV
B	ADDED MOLY HEATER T101	11/7/2011	6299	TN



PRINTED DOCUMENTS ARE UNCONTROLLED

**KEY:**

1. All part numbers in *Italic* identify cables that are referred to in the accompanying document 073650100.
2. All items in Dashed boxes are optional.

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		
TOLERANCES ARE: FRACTIONS ± 1/32 DECIMALS ± .01(0.76) ANGULAR ± 0° 30'	DO NOT SCALE DRAWING	
TREATMENT	NA	
FINISH	SIMILAR TO	

CONTRACT:		NA	
APPROVALS	DATE	TITLE	
DRAWN KV	4/10	INTERCONNECT DRAWING T100X	
CHECK		SIZE	REV
CCB		B	B
ISSUED		CAGE CODE NO.	DWG. NO.
		1JZF4	06908
		SCALE	SHEET
		DNS	1 OF 1

**TELEDYNE**  
Advanced Pollution Instrumentation  
A Teledyne Technologies Company

**INTERCONNECT DRAWING T100X**

SIZE: **B** CAGE CODE NO.: **1JZF4** DWG. NO.: **06908** REV: **B**

SCALE: **DNS** FILE: **06908** SHEET: **1 OF 1**

# Pyxis GC

CARRIER FREE ANALYSER

The logo for Pyxis GC BTEX, featuring the text 'Pyxis GC' in a large, bold, blue font, with 'CARRIER FREE ANALYSER' in a smaller font below it. To the right is a blue square containing the letters 'GC' in white, with 'BTEX' in white text below it.

## User's Manual

PUBLICATION ISSUED BY:

# POLLUTION S.r.l

## USER GUIDE REVISION HISTORY

Current version: 1.4

Description: User guide for PyxisGC BTEX

Code	Version	Edition
MT-EN0309-0	1.0	19/07/2019
MT-EN0309-1	1.1	29/07/2020
MT-EN0309-2	1.2	17/09/2020
MT-EN0309-3	1.3	20/09/2021
MT-EN0309-4	1.4	07/03/2022

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# 1 INTRODUCTION

This manual provides an experienced technician with the necessary requirements for the installation, setup and simple maintenance of the PyxisGC BTEX system.

## 1.1 Overview





PyxisGC BTEX is a compact air quality monitoring system for real-time monitoring of ppb and sub-ppb concentrations of aromatic volatiles in ambient air. The following aromatic compounds can be measured: benzene, toluene, ethylbenzene and xylenes (BTEX).

## 1.2 About PyxisGC BTEX

The monitoring station accommodates a gas chromatograph (GC) module which performs GC measurements continuously. Integrated in a double-walled outdoor enclosure (IP 55), the GC module for BTEX analyses includes an embedded PC and full software system for remote technical support, data management and analytics. Due to the absence of carrier gas cylinders, the periodic maintenance is significantly reduced. The analytical core is based on proprietary silicon micromachined Micro-Electro-Mechanical-Systems (MEMS).

## 1.3 Key icons

The following symbols are used in the manual. These are intended to catch the user's eye and draw attention to relevant information.

	<b>IMPORTANT INFORMATION</b> -> indications on the correct functioning of the system considered useful for the customer
	<b>GOOD TO KNOW – TRICKS</b> -> these are intended to point out a fact that may be helpful in understanding a concept
	<b>WARNING</b> -> it indicates an action that might keep the user from making a mistake, keep them from destroying equipment or keep them from creating a situation that could cause personal injury. Please refer to the “General Safety Guidelines” for additional information.
	<b>DANGER</b> -> it is intended to highlight an action regarding the potential risk of personal injury or fatality that could result from improper access or techniques. Please refer to the “General Safety Guidelines” for additional information.

## 1.4 Safety requirements

An inappropriate use of the PyxisGC BTEX can damage the instrument and may cause bodily harm. Before using the instrument, the user must read and understand all the indications contained in this manual to guarantee safe operation and to work safely with the instrument.

In this manual, the following icons show conditions and practices which may result in personal injury and/or equipment damage:



**WARNING:** it indicates a situation in which could cause personal injury.



**DANGER:** it is used to indicate immediate danger and what special precautions should be taken. Carelessness will result in equipment damage, personal serious injury or fatality.

### General safety guidelines

- Do not use the instrument before reading and understanding the manual
- Do not open the instrument until all external power supplies have been disconnected
- Installation and replacement of any part should only be carried out by trained and qualified personnel using only parts from the manufacturer
- When opening covers or removing parts, exercise extreme care as live parts or connections can be exposed
- Before switching on the power, check that the operating voltage of the instrument matches the power supply of the local area
- When a grounding conductor becomes necessary, it must be connected to the grounding terminal before using the instrument

## 2 SYSTEM OVERVIEW

### 2.1 Description

PyxisGC BTEX is the air quality monitoring system for real-time monitoring of ppb and sub-ppb concentrations of BTEX for indoor and outdoor applications. The analytical module installed inside integrates a sampling pump and a carrier gas generator using ambient air, strongly decreasing the maintenance requirements. The instrument is delivered with fixed settings already adapted to the specific application.

### 2.2 Overview

PyxisGC BTEX technology is unique: inside the analytical core there is a pre-concentrator and a GC separation column, both based on a proprietary silicon MEMS, and a miniaturized Photoionization detector (PID) that quantifies the peaks. A general overview of the instrument is shown in Figure 1.

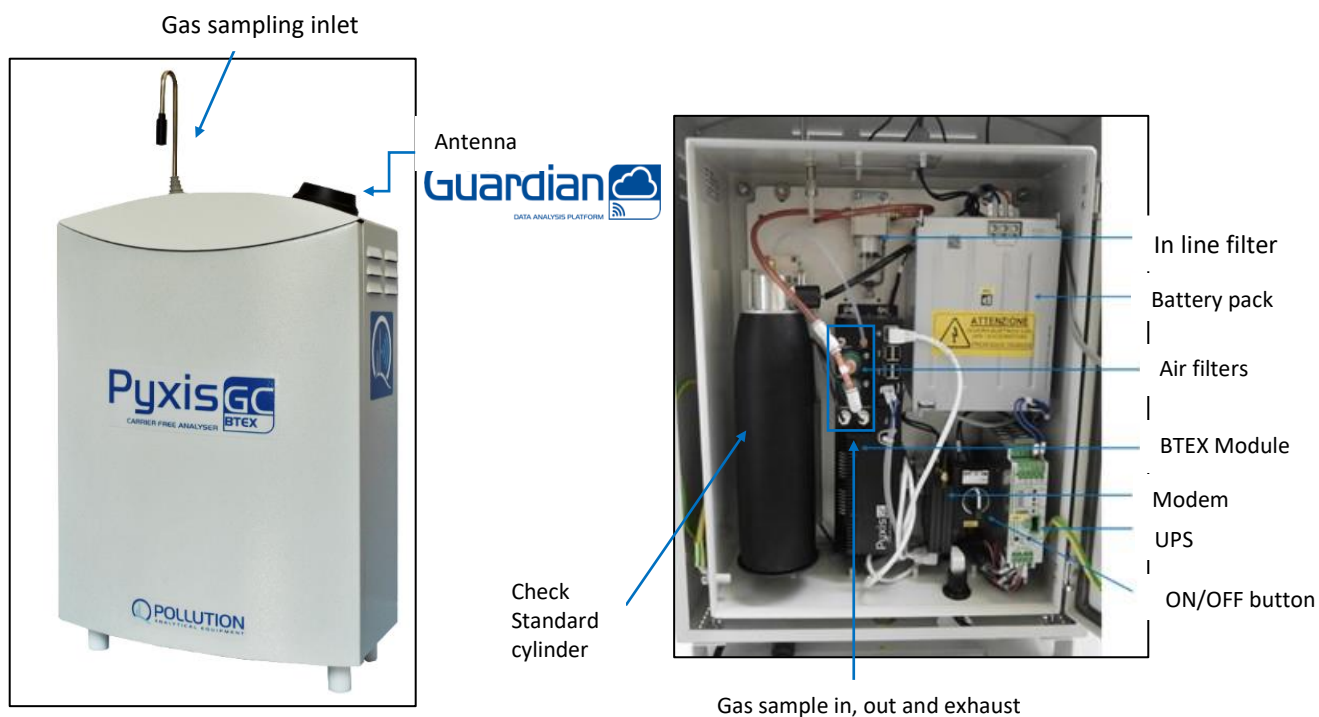


Fig. 1 PyxisGC BTEX overview

The PyxisGC BTEX schematic diagram is shown in Fig. 2. Filtered ambient air is pumped into the two analytical module inlets: “sample in” to be preconcentrated and “air filter” to be used directly as carrier gas through the separation column.

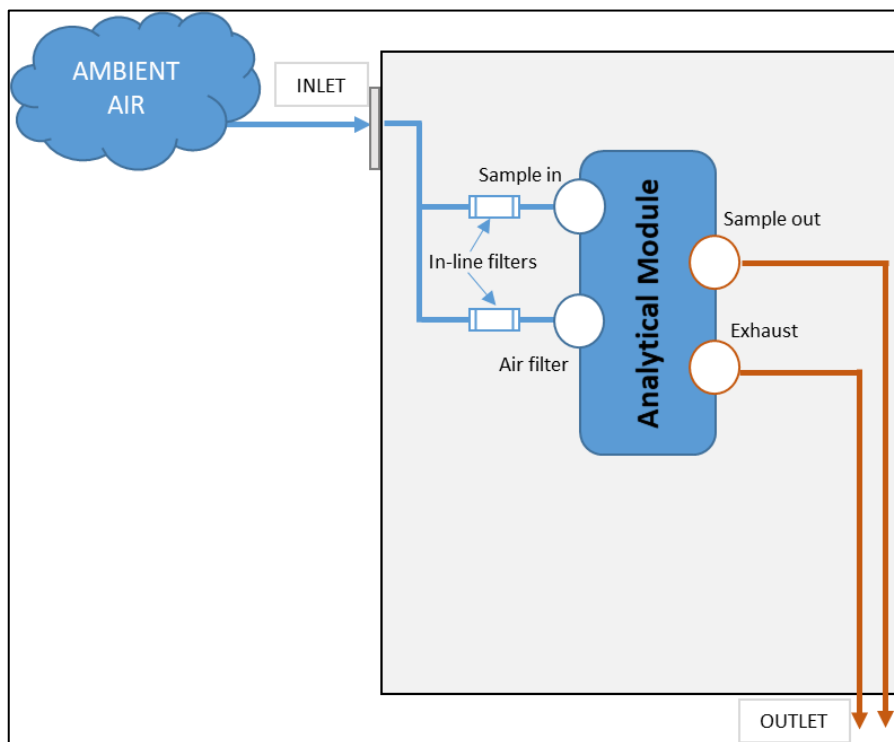


Fig. 2 PyxisGC BTEX schematic diagram

The analytical module installed inside the PyxisGC BTEX consists of the following main blocks:

- A. Sampling and pre-concentration unit
- B. Gas-chromatographic (GC) separation unit
- C. PID detector unit
- D. Manifold for flow distribution
- E. Housing, including cooling fans and electrical connectors
- F. Embedded mini-PC for control, acquisition and data processing

The internal sections of the analytical module can be identified below in Figure 3.

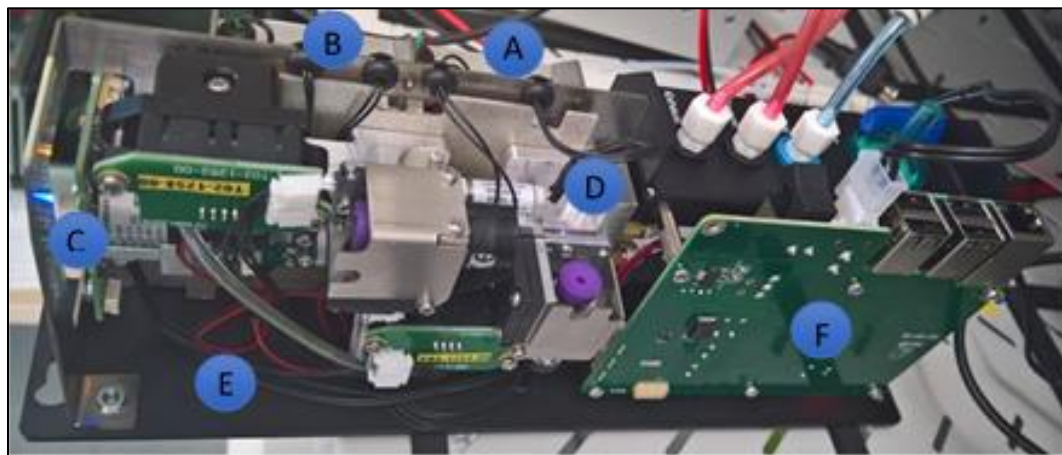


Fig. 3 PyxisGC BTEX internal sections

## 2.3 Specifications

<b>Size and Weight</b>	<ul style="list-style-type: none"> <li>with/without auto-calibration system: 420mm x 620mm x 210mm; 11,5 – 13 Kg</li> <li>with integrated UPS, w/without auto-calibration system: 420mm x 620mm x 210mm; 17,5 – 19 Kg</li> </ul>
<b>Operating Temperature</b>	From -5°C to 50°C
<b>Instrument control</b>	Integrated PC board
<b>Data storage</b>	16 GB Internal Flash Memory
<b>Power input</b>	100-230VAC, 2A
<b>Power consumption</b>	12V DC, 1A, Max. 3A (analytical module)
<b>Carrier gas</b>	Ambient Air, <10 sccm
<b>Sampling</b>	Sample Flow Rate 250 - 450 sccm
<b>Detector</b>	High-sensitivity PID - Photo Ionization Detector (10.6 eV)
<b>Analytical performance</b>	[0.5 – 80] µg/m <sup>3</sup> , benzene with 10 min analysis cycles “Smart City” configuration [1 – 160] µg/m <sup>3</sup> , benzene with 10 min analysis cycles “Fence Line” configuration
<b>Lower detection limit</b>	<0.2 µg/m <sup>3</sup> (0.05ppb) benzene
<b>Communication interfaces</b>	Ethernet, Wi-Fi, 4G
<b>Instrument control and data access</b>	<ul style="list-style-type: none"> <li>Local WebServer, accessible with a common browser (IE, Firefox, Chrome)</li> <li>MODBUS over TCP server</li> <li>IoT service “Pollution Guardian”</li> </ul>

Table 2. PyxisGC BTEX specifications

## 2.4 GC module

The operating principle of the PyxisGC BTEX module consists in an analytical cycle with a complete set of sequential system states which implement a complete measurement. The result of each single measurement cycle is a chromatogram, which is processed to extract the area of the peaks of the aromatics, namely benzene, toluene, ethylbenzene and xylenes. The area of each peak is linearly correlated, by means of a calibration factor, to the concentration of each single aromatic component sampled during a sampling cycle.



-> In the current set-up, PyxisGC BTEX has a fixed cycle duration of 10 minutes.

This means that the area of each of the BTEX peaks is computed 6 times every hour. The area of each peak is proportional to an average concentration of the compound, as sampled during approximately 6 minutes during a 10-minute cycle. The previous 4 minutes are used for the cleaning of the pre-concentrator between successive measurement cycles.

In more detail, the states during a 10 minutes cycle are described in table 1 below. The timings reported in table 1 refer to a standard analytical cycle, and may be changed by re-configuring the method stored on the PyxisGC BTEX controller embedded PC.

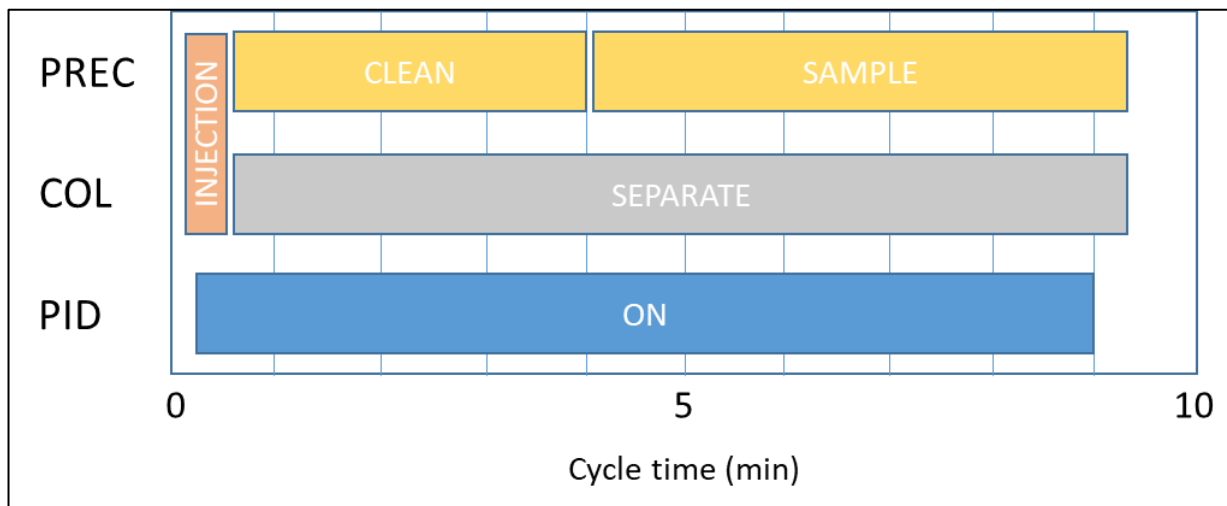


Table 1: States of the single PyxisGC BTEX unit during a standard measurement cycle

As can be seen from Table 1, the pre-concentrator samples the air during the final ≈350s. The contents of the pre-concentrator are injected 20s after the beginning of a cycle. During the last 30s of each cycle, all units are idle.



-> This means that the chromatogram peaks acquired by the PID detector refer to the air sampled during the previous cycle!

A typical example of a chromatogram acquired by the PID detector is shown below in Figure 4. All concentration values can be expressed in ppb or  $\mu\text{g}$  calculating the area below each peak and considering the response factor calibrated for each compound. In this example, the benzene peak elutes with a maximum signal at T=125s and has a concentration of 0.22 ppb. The toluene peak elutes at 211s and is 2.57 ppb. The ethylbenzene elutes at 257s and has a concentration of 1.08 ppb, with a clear interferent overlapping. Finally, the xylene (actually a mixed of the three main xylene isomers) elutes at 390s and is 13.49 ppb.

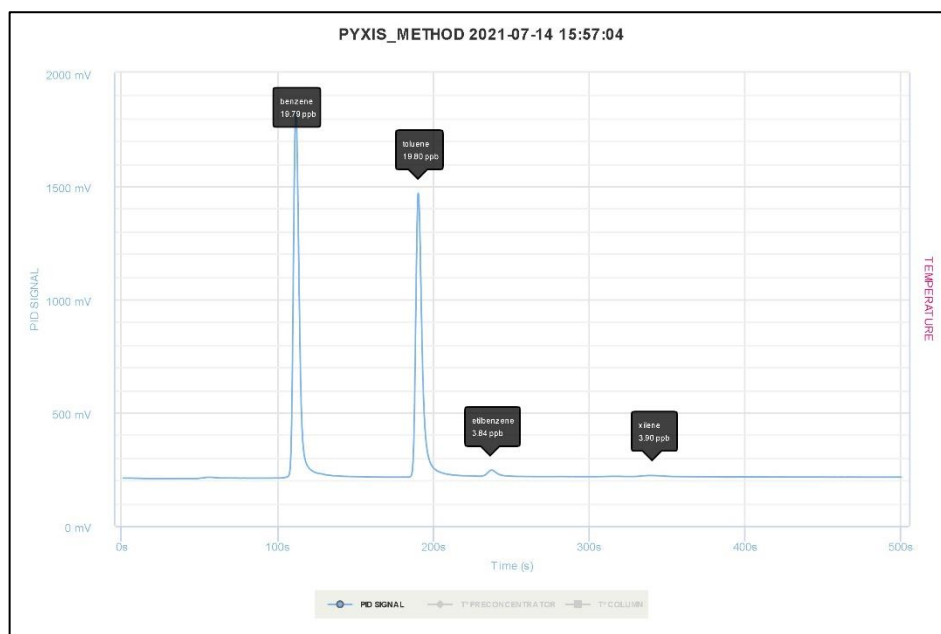


Figure 4: example of chromatograph acquired by a PyxisGC BTEX system.



-> The instrument is delivered with fixed settings already adapted to the specific application.

## 2.5 Calibration

In order to maintain the analytical performance of the instrument, periodic calibrations are required. The photo ionisation detector (PID) allows to measure any compound with ionization energy (IE) lower than that of the lamp photons. In this case, a 10.6 eV lamp is used. The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. For further information, see Sections 3.6 and 4.1.6.



-> Depending on the final application and the accuracy specification required, the calibration interval can change. Please contact our technicians to decide initially a specific interval according to your needs.

## 2.6 User interface

There are two different ways to interact with PyxisGC BTEX:

### 2.6.1 PyxisGC BTEX “direct connection”

The instrument is controlled by an industrial embedded single board computer which runs a webpage. Using a web browser it is possible to connect to the instrument over WiFi or Ethernet cable (see Section 3.8).

The following options are available through the graphic user interface (GUI):

- Instrument control
- Real-time and historical data viewing and management
- Instrument calibration
- Settings update

Further information can be found in Sections 4.1.1 - 4.1.8.

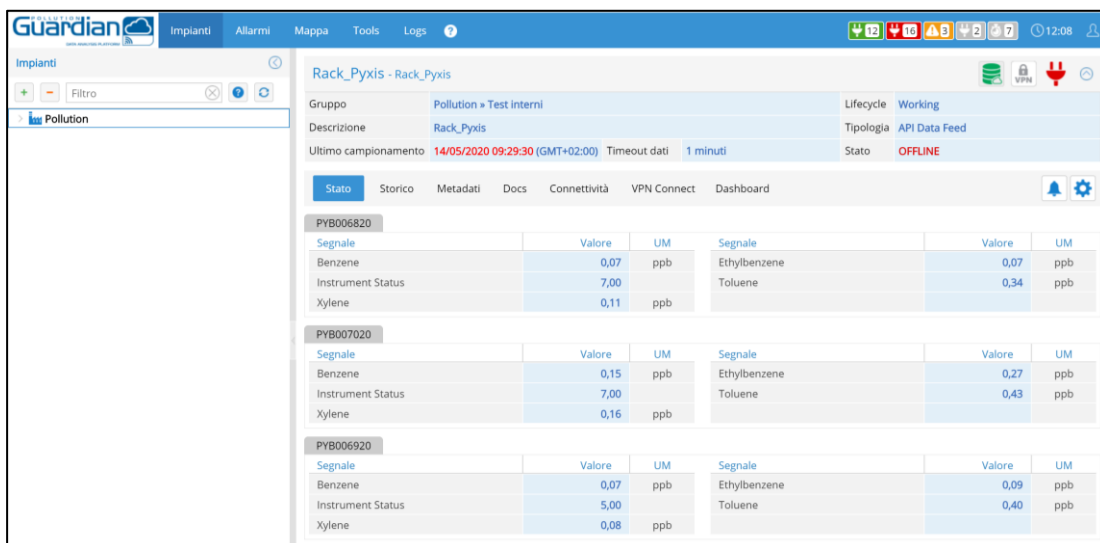
### 2.6.2 Pollution Guardian



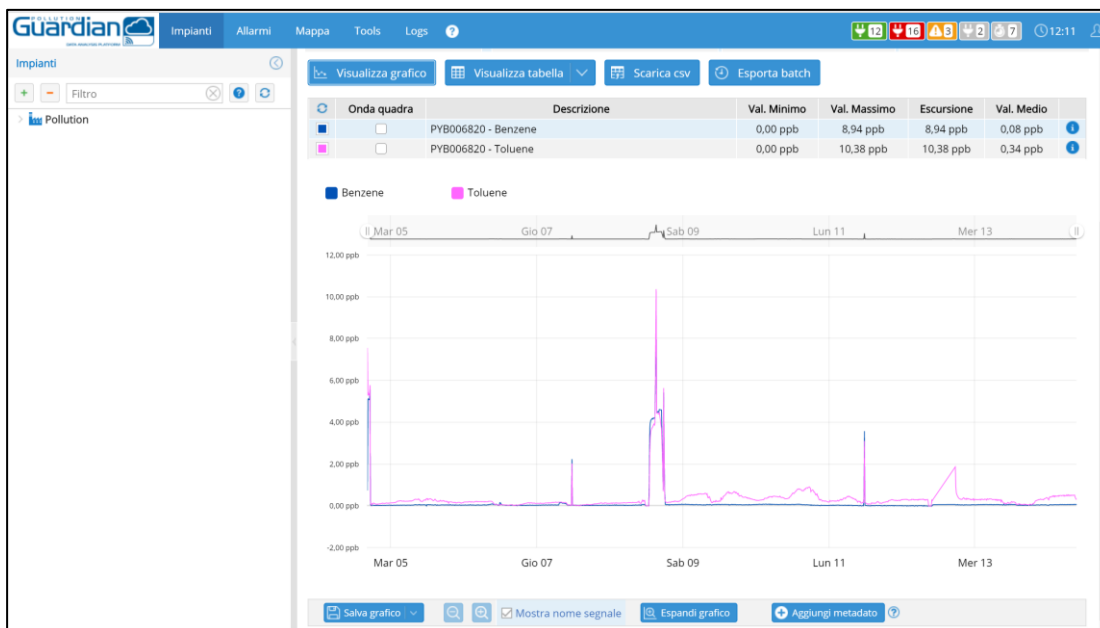
Pollution Guardian ([www.pollutionguardian.com](http://www.pollutionguardian.com)) is the cloud-based software of Pollution Analytical Equipment. It allows the final user to access all the reference instruments through third party servers. The first step is to set-up the SIM card (for details see paragraph 2.6.3).

Once an account has been configured the following actions can be carried out in the cloud:

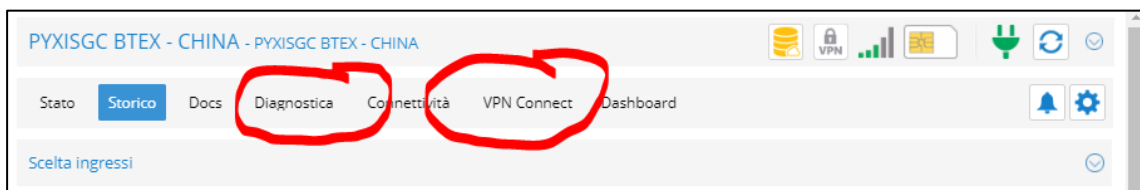
- Communicate with your instrument from anywhere in the world at any time:



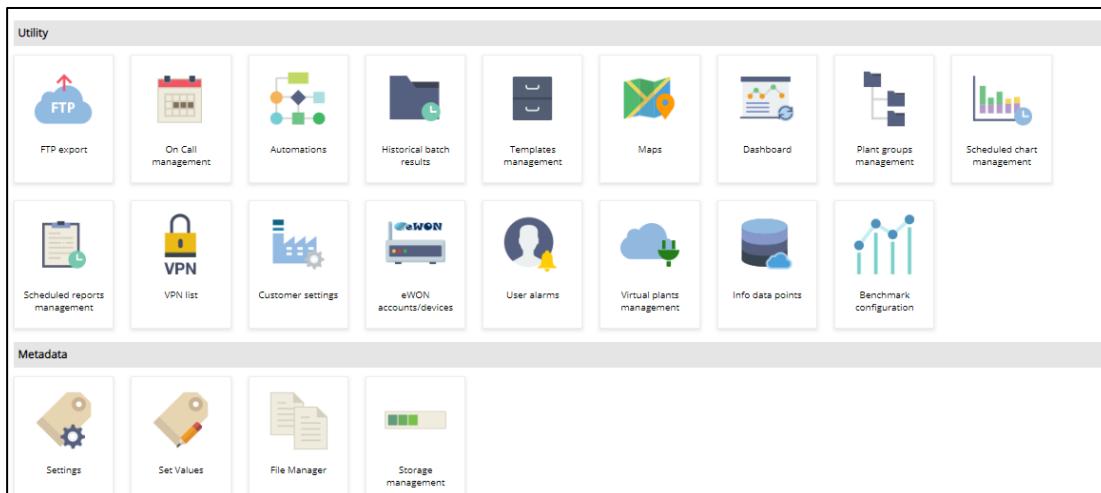
- Use advanced charting features to view concentration trends of the selected compounds over a period of time, including MIN/MAX/MEAN values and the possibility to download all values in .csv format:



- Receive fast and comprehensive technical support from your Pollution Analytical Equipment distributor or Pollution technical support team once the VPN connection is active:



- Automatically export data to multiple users via email or to an FTP server.

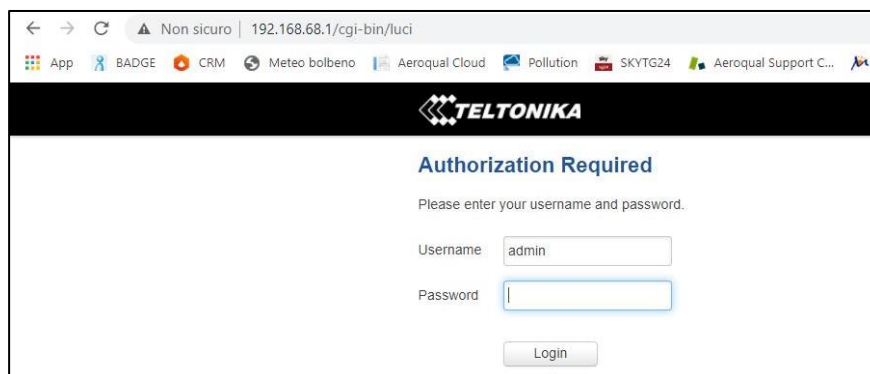


### 2.6.3 SIM card set-up

Using an appropriate SIM card, the modem can be directly connected online to upload the stored data. The SIM fits in a dedicated slot on the lower side of the modem. In this configuration, the Ethernet plug remains free.

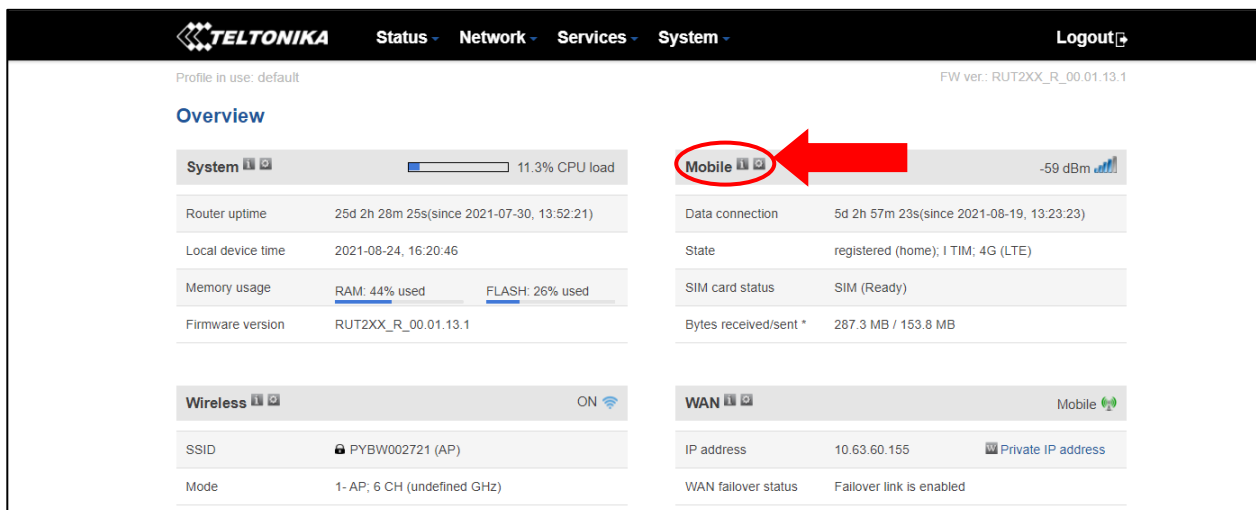
In order to use the SIM connection, the customer have to:

- connect to the wireless connection named PYBW0XXXX (or similar)
- open a browser and type 192.168.68.1
- the following page will appear

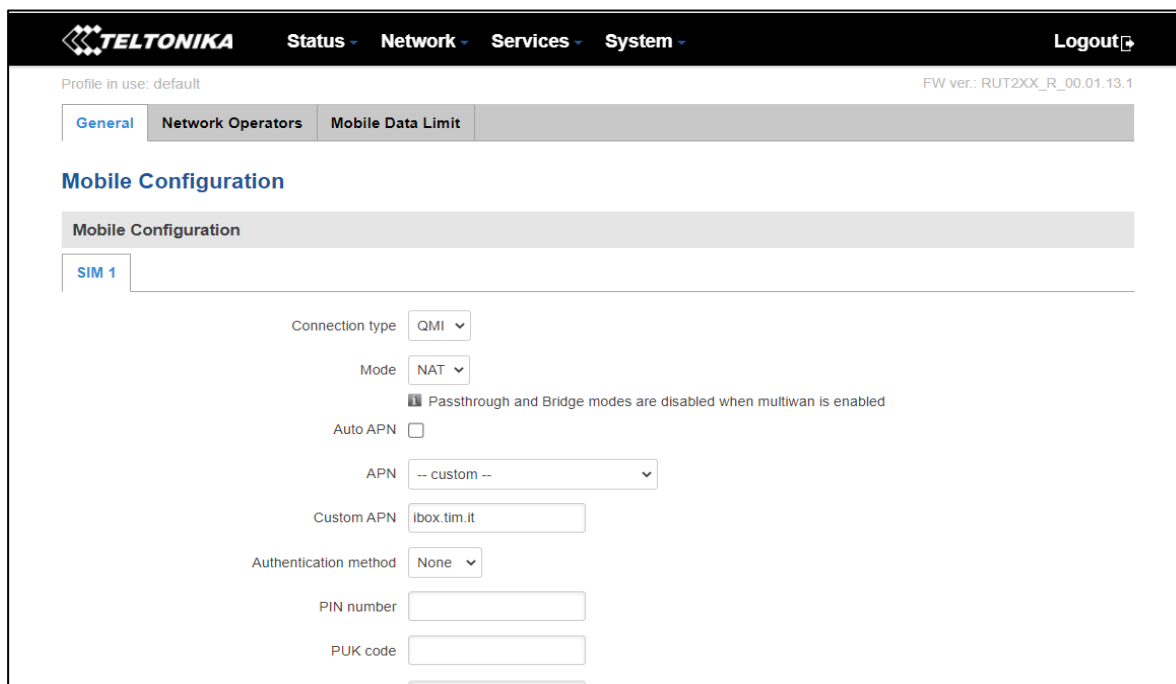


- login with:  
username = admin  
password = Pollution00

- click on the gear icon near “Mobile”



- write the SIM operator’s APN in the “Custom APN” row and click on “Save” at the end of the page.



- the system is now connected online and able to upload the stored data.

## 2.7 Historical data

The PyxisGC BTEX module compiles historical data that can be used for custody transfer needs, verifies instrument operation over time and provides a limited data backup for communication link reliability. Data memorized by the PyxisGC BTEX module can be collected via cloud interface or through the “direct connection”. Further information is included in Section 4.

## 3 INSTALLATION

Before starting-up the instrument, the user needs to carefully read this chapter, which illustrates the required procedures for field installation of the PyxisGC BTEX.



-> It is highly recommended to complete the first setup in the laboratory to check that the flow, the electrical and the communication systems are working properly.

### 3.1 Unpacking and inspection

The PyxisGC BTEX is shipped in a custom-made carton with moulded protective inserts. Ensure that there is no damage in the container.

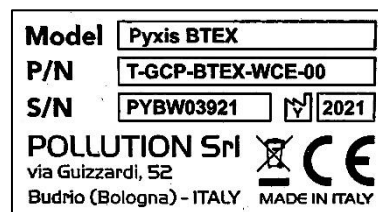


**WARNING:** If there is any visible external damage to the container, contact immediately the trucking company and claim for a freight damage.

Carefully remove all the internal and external packing material and remove all the items inside.

Verify the serial number label on the documentation, which must match the serial number of the instrument, which can be found into the cabinet, on the top-left side. (see Label 1 for example)

Check the packing list included. Ensure that there is no damage or noticeable defects on any component of the PyxisGC BTEX.



Label 1- Example of instrument serial number



**WARNING:** If any part is missing, contact immediately Pollution Analytical Equipment.

### 3.2 Description

According to the final use of the instrument (indoor, outdoor, fence line monitoring), the user must identify a proper site which ensures stable and reliable analyses. If any additional information is required, contact Pollution technicians before the installation.

### 3.3 Assembly

PyxisGC BTEX, thanks to the reduced weight and sizes, can be wall-mounted or leaning on the ground according to the final application.



-> The installation type will be different from time to time. If you require assistance please contact our technicians before the installation of the instrument.

### 3.4 Power requirements

Every PyxisGC BTEX integrates an AC/DC converter to supply the required 12VDC to the instrument and to the other electronic parts installed inside the cabinet. The other end of the plug must be wired to the mains power: 100-240VAC, 50-60Hz.



**WARNING:** Do not change this power supply without having consulted the manufacturer. Any change in the power supply conditions will void the warranty.

### 3.4.1 UPS + Battery (optional)

An uninterruptible power supply (UPS) can be integrated inside the cabinet. Thanks to the UPS, the system can work properly even in case of a power failure or disconnection. In fact, the UPS unit is equipped with a battery that guarantees up to 5 hours of normal operation of the analytical instrument in the absence of the mains power supply (until a complete discharge of the battery). At the end of the backup time, the instrument powers off, and in order to power it on again it is necessary to deliver the mains power. If the mains power does recover during this battery backup period, the instrument will keep working regularly.



-> Due to the UPS, to switch off the system it is not enough to unplug the power supply because the battery would start providing power to the analytical module. To do that, it is necessary not only to disconnect the power supply but also to turn the switch counterclockwise and release it. The instrument can be turned on again connecting the power supply.



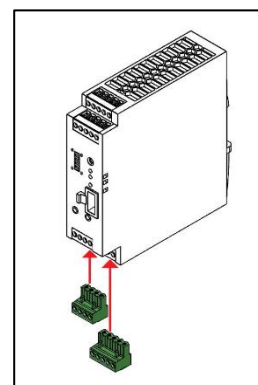
-> In order to switch on the instrument powered by the battery (if the mains power is disconnected), keep the switch clockwise for 5 seconds and then, as soon as the UPS is reactivated, release it.

#### 3.4.1.1 First start-up

In order to prevent the backup battery overdischarge, the instrument is shipped with the battery disconnected from the UPS.

The first time the instrument is used, it will be necessary to plug-in the two green connectors in the appropriate seats of the UPS as indicated in *Image 1*.

**Without doing this operation the instrument will not work.**



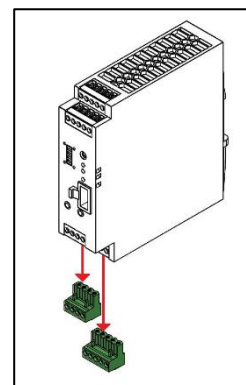
*Image 1 – How to plug-in the two connectors*

#### 3.4.1.2 Store the instrument

If the instrument is expected to be stored for long periods of time (more than a month), the battery will overdischarge and it will become unusable.

In order to prevent this inconvenience, it is mandatory to:

- fully recharge the battery
- disconnect the battery from the UPS, unplugging the two green connectors as shown in *Image 2*
- fully recharge the battery periodically (every 3 months maximum)



*Image 2 - How to unplug the two connectors*

### 3.5 Carrier gas

Filtered ambient air is used as carrier gas in the PyxisGC BTEX module. Therefore, no cylinders/tanks are necessary. There is a specific filter in the sampling line that guarantees a proper filter conditioning:

- In-line filter with a polycarbonate bowl: it has a modular connection and filtration size of 5µm.



**WARNING:** If the system is installed in a strongly polluted place, an additional external particulate filter may be necessary in the inlet sampling line.

### 3.6 Connection to graphic user interface (GUI)

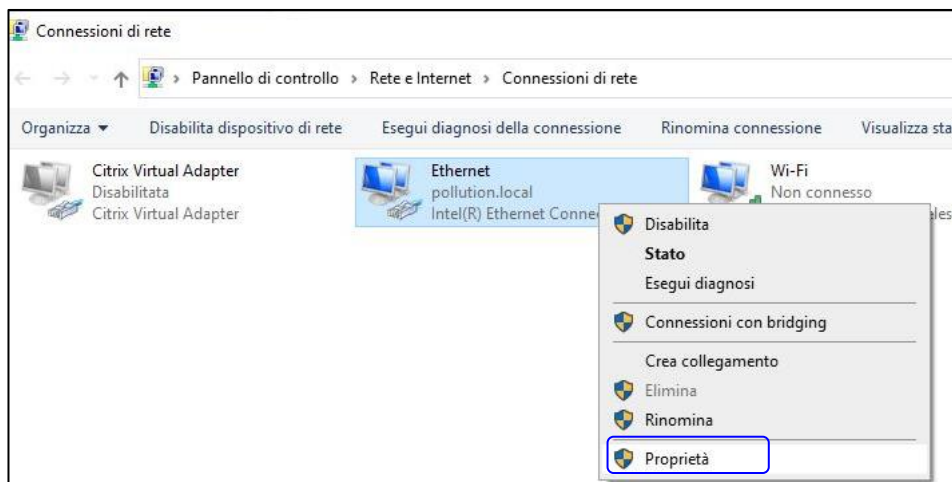
There are 3 different available options to access the GUI of the PyxisGC:

- Ethernet connection
- WI-FI connection
- VPN connection

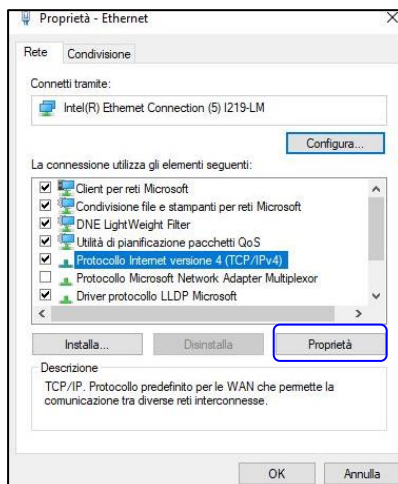
#### 3.6.1 Ethernet connection

First thing to do in order to connect to the Pyxis with an Ethernet cable is to change the IP address of the computer, following next steps:

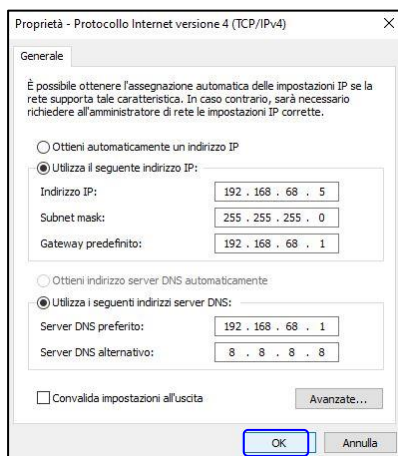
- Open the control panel
- Under “Network and Internet”, click on “View network status and tasks”
- On the left, click on “Change adapter settings”
- Click with right button on the ethernet connection and then on “Properties”



- Select “Internet protocol version 4 (TCP/IPv4) and click on “Proprieties”



- Set a static IP for the computer as following:



- Click on “OK” and on “Close” to save the modify

Now the client is able to connect through the ethernet connection to the device, in the following two ways:

1. Through the RJ45 port available in the bottom of the cabinet (main solution, more stable).  
Connect the computer to the device through the RJ45 port available in the bottom of the system.
2. Through the RJ45 port available on the PyxisGC BTEX module.  
Connect the computer to the device through the RJ45 port available on the GC module.

In both cases, the client must open a browser and type the following address:

**192.168.68.2**

And the login page of the user interface will be shown.

### 3.6.2 Wireless Connection

PyxisGC generates 2 Wi-Fi. The client must connect to the WIFI called PYBW0XXXX (where XXXX will be the specific serial number of the instrument). In order to connect with WI-FI to the device, the client has to change the IP address of his computer, following the instructions described at point 3.6.1, but changing proprieties of WI-FI connection, settings it as follows:



For the wireless connection, the system PyxisGC BTEX must be powered up (if it is not yet). Then, the customer needs to scan the wireless network and to search for PYBW0XXXX network and click connect. The following password is necessary:

**p@ssw0rd**



When the Wifi icon looks like this:

the client must open up a browser and

type the following address:

**192.168.68.2**

The following web page (or similar) will open up.

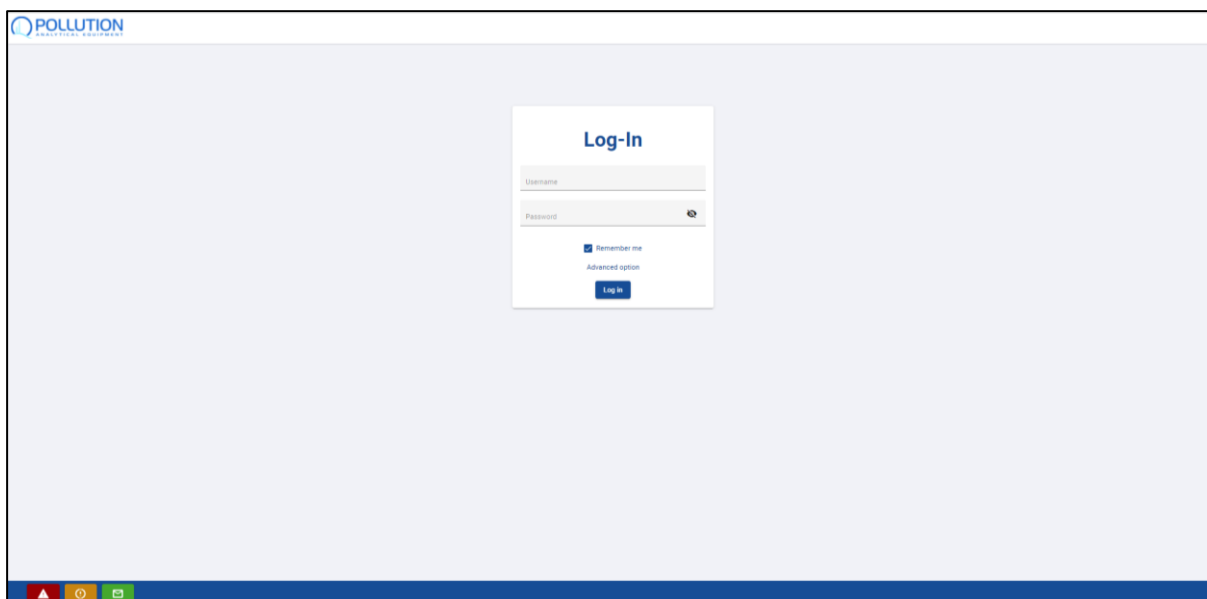


Fig. 5: PyxisGC BTEX log-in page

### 3.6.3 VPN connection

It's also possible to remotely connect to the PyxisGC BTEX from the Pollution Guardian, seeing the user interface and operating on the device settings. To have information about this option, please contact Pollution technical department.

## 4 OPERATION

### 4.1.1 LOG-IN

The first page of the GUI allows the user to log-in. There are different user levels according to the user experience and needs. The basic level is the Operator, which allows managing all the main features of the instrument.



-> Operator credentials are “Username: Operator” and “Password: Operator”. To access as an Advanced user, please contact Pollution Service department.

Once logged-in, the user has the possibility to access with a common browser to the local webserver of the PyxisGC BTEX to the following pages:

- HOME
- METHODS (only available for the Advanced level)
- TRENDS
- DATA BROWSER
- CALIBRATION
- SETTINGS
- ACCOUNT

### 4.1.2 HOME

The four tabs are Start Analysis, Real-Time, Status and Last Measure Report.

#### START ANALYSIS

Before starting the analytical cycle, the instrument must be in Status READY. Select the method to be loaded from the scrolling menu (Fig. 7). Then, it is mandatory to write the location and a general description of the analysis (comments are optional).



-> “Description” has a limited number of characters. For longer descriptions, it is recommended to use the “Comment” field.



-> This information can be useful later to search for a series of measurements in Data Browser and Calibration pages.

Once completed the previous part, click on the green button to load the method and start the measurement cycle.

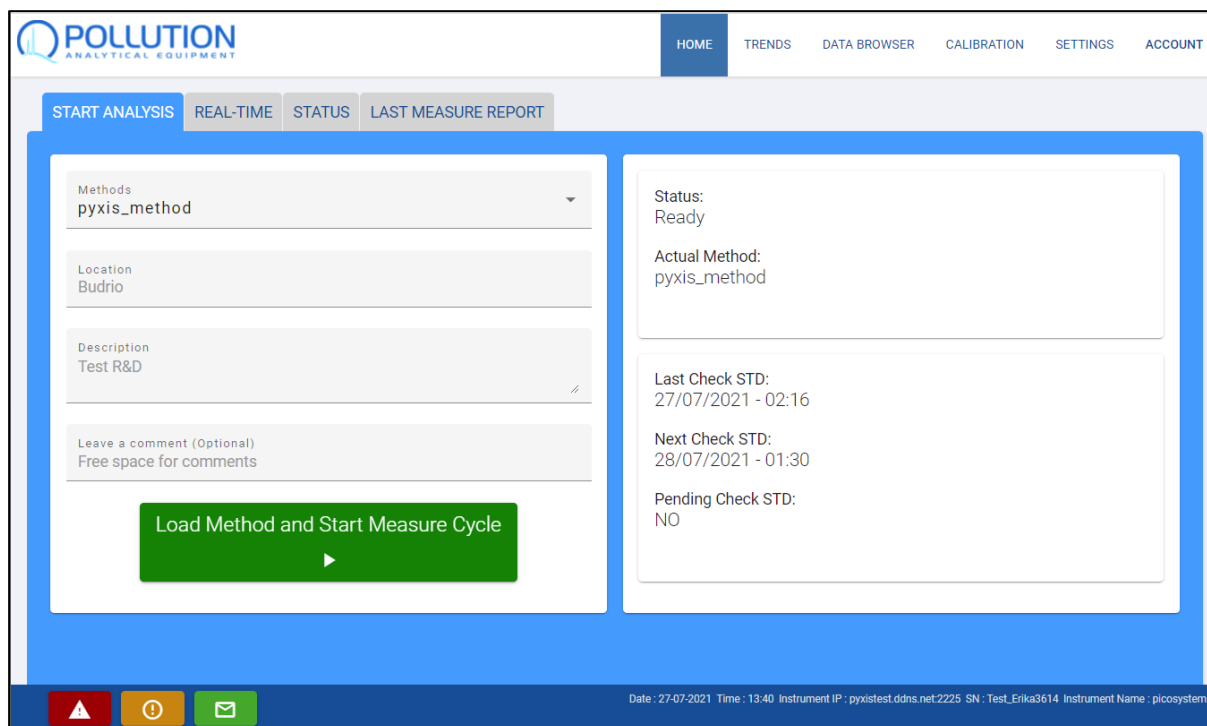


Figure 7: Start Analysis view



-> Check if the instrument is in Manual or Automatic mode (see paragraph 4.1.7 Settings): in the first case, the instrument performs one single measurement and then it stops, whereas in the Automatic mode it keeps working continuously.

Inside the box, in the right side of the screen, it is possible to see the instrument status and the method in use. In the instruments which integrate the check standard module, the information regarding the Last Check STD measure and when the next one is going to take place are available. In addition, it is highlighted when the user performs a Manual Check STD and has not accepted or rejected the new Response Factor (in this case, the Pending Check STD message will be YES). To see this part, see the paragraph 4.1.6 Calibrations



-> The dark blue bottom line appears in all pages and includes relevant information. On the left side the icons reveals Warning/Error messages, whereas on the right side the date, time, IP and serial number are shown.

## REAL-TIME

In this page you can see the real-time view of the chromatogram. By default, only the PID signal is plotted (Fig. 8). However, it is possible to select also the preconcentrator and separation column temperatures. The chromatogram view in full screen is available by clicking on the three bar symbol. The graphic can be zoomed and unzoomed in real-time.

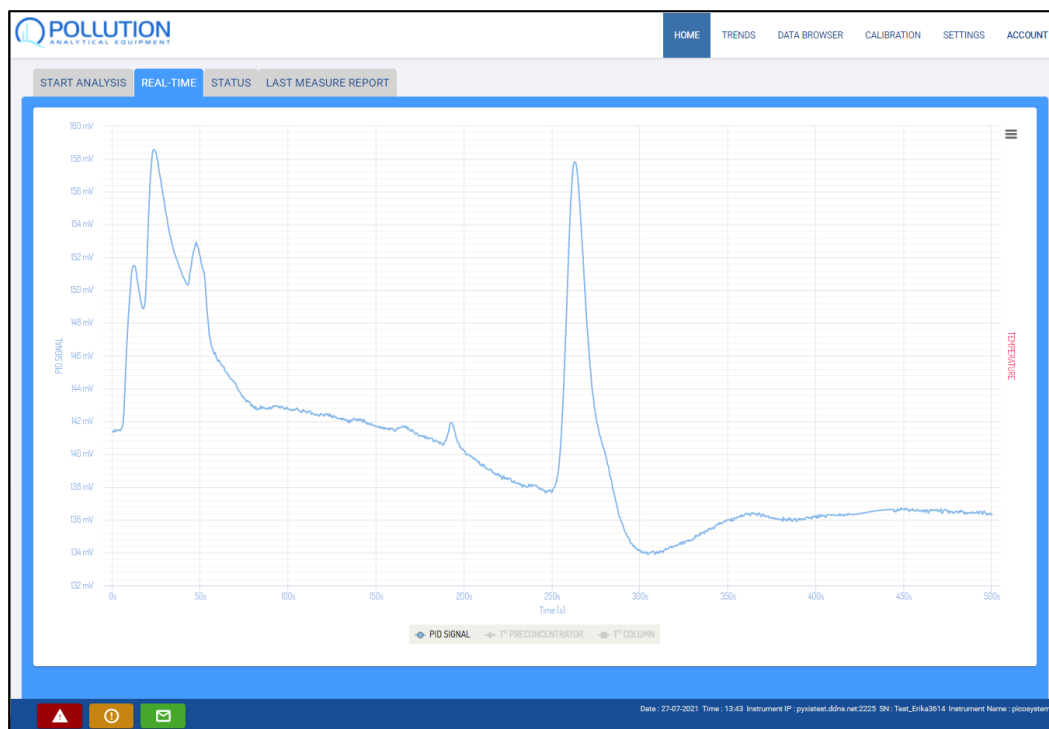


Figure 8: Real-Time view

### STATUS

Status allows a general overview of the main PyxisGC parameters in real-time (Fig. 9). Values are automatically refreshed every 3 seconds. The instrument scheme can be slightly different according to its configuration (with/without check standard unit).

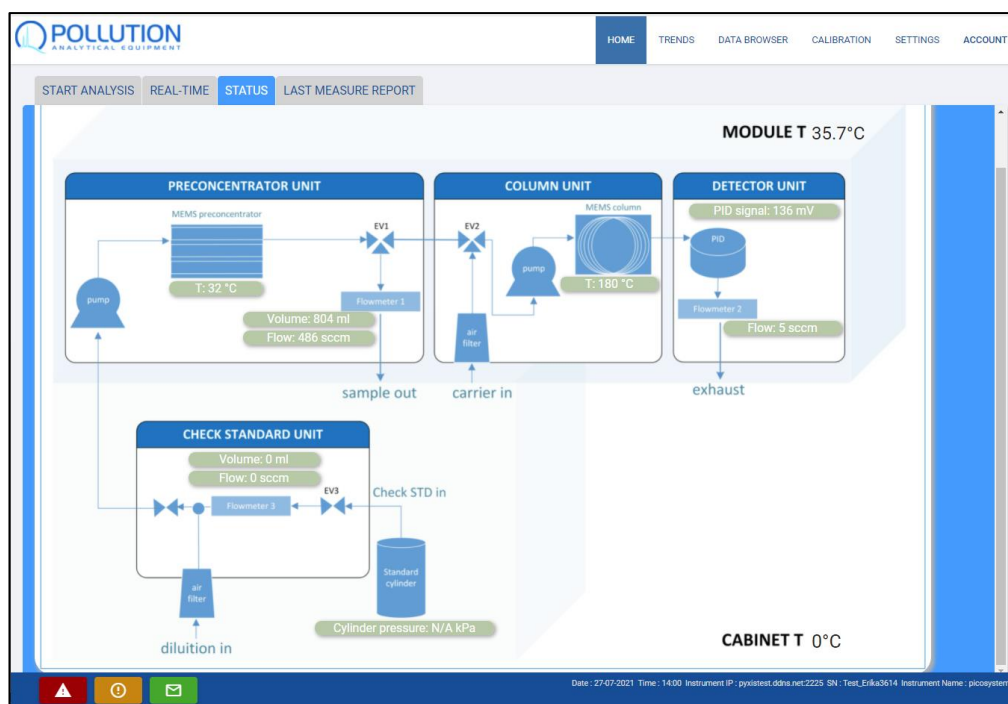
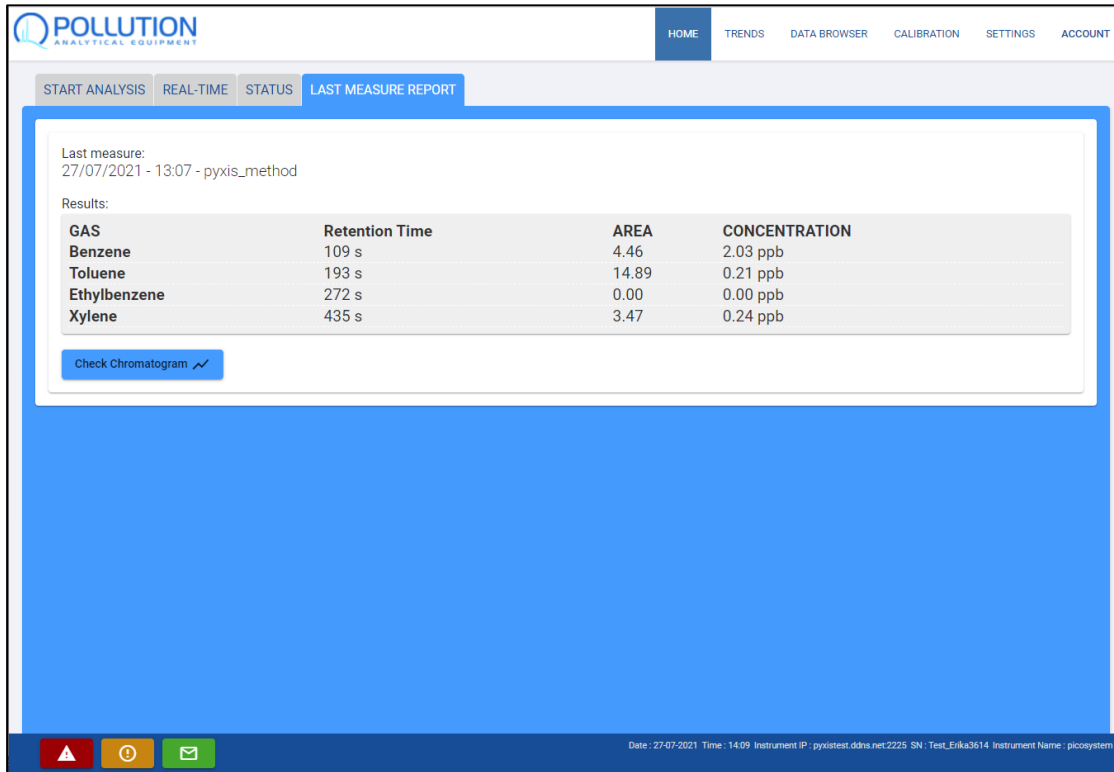


Figure 9: Status view

## LAST MEASURE REPORT

This page shows the last measure results: date, time and peaks' retention time, area and concentration (Fig. 10). It is possible to open directly the reference chromatogram by clicking the "Check chromatogram" blue button.



Last measure:  
27/07/2021 - 13:07 - pyxis\_method

Results:

GAS	Retention Time	AREA	CONCENTRATION
Benzene	109 s	4.46	2.03 ppb
Toluene	193 s	14.89	0.21 ppb
Ethylbenzene	272 s	0.00	0.00 ppb
Xylene	435 s	3.47	0.24 ppb

Check Chromatogram ✓

Date : 27-07-2021 Time : 14:09 Instrument IP : pyxisitest.ddns.net:2225 SN : Test\_Erika3614 Instrument Name : picosystem

Figure 10: Last measure report tab

### 4.1.3 METHODS (for advanced users)

The GUI allows creating or editing analytical methods. From the main page, Method List, the user has an overview of the current available methods in the system and knows which of them are calibrated and which are not.

It is possible to create, edit or delete a method (Fig. 11). To create a new method, the GUI gives the user the possibility to define all the analytical parameters from the beginning or to clone all of them from another existing method. In any case, all new methods (cloned or not) are considered initially as “not-calibrated”.



-> When a not-calibrated method is loaded to perform an analytical cycle, the GUI allows starting the measurements but reminds the user that the method to use is not calibrated. If the user decides to proceed, the measurements will not be valid and will not be shown in the TRENDS plot.

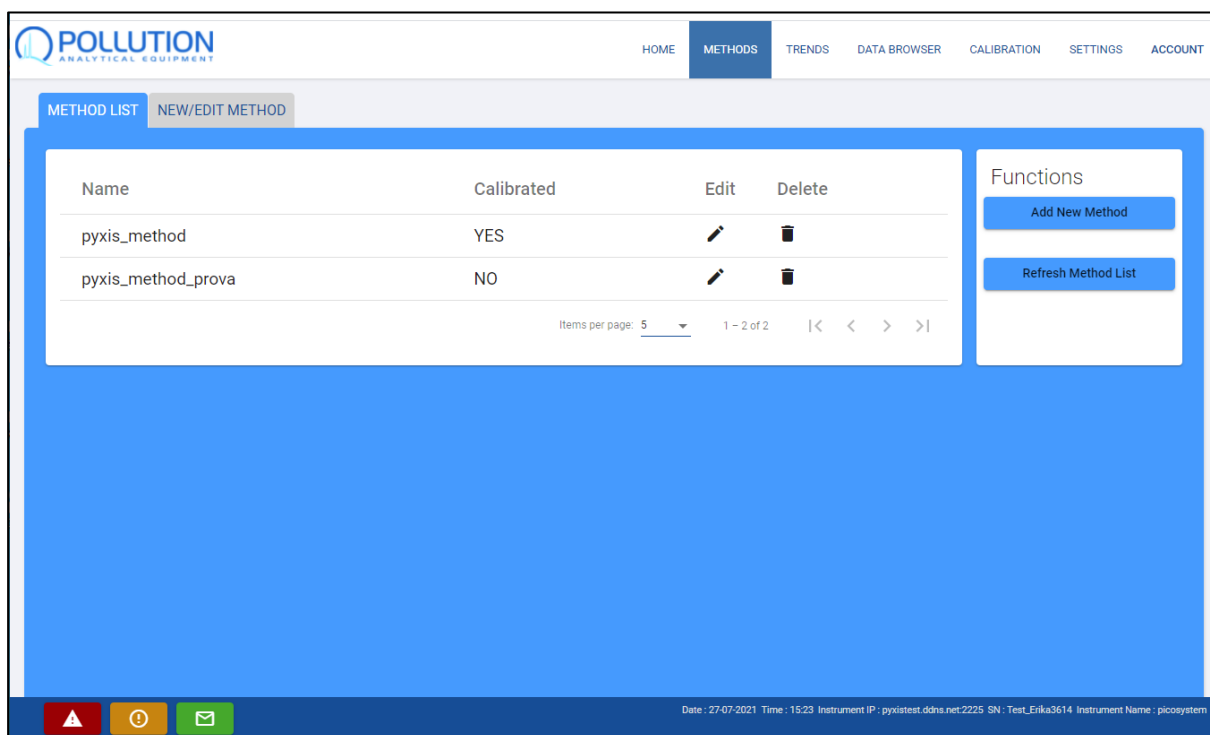


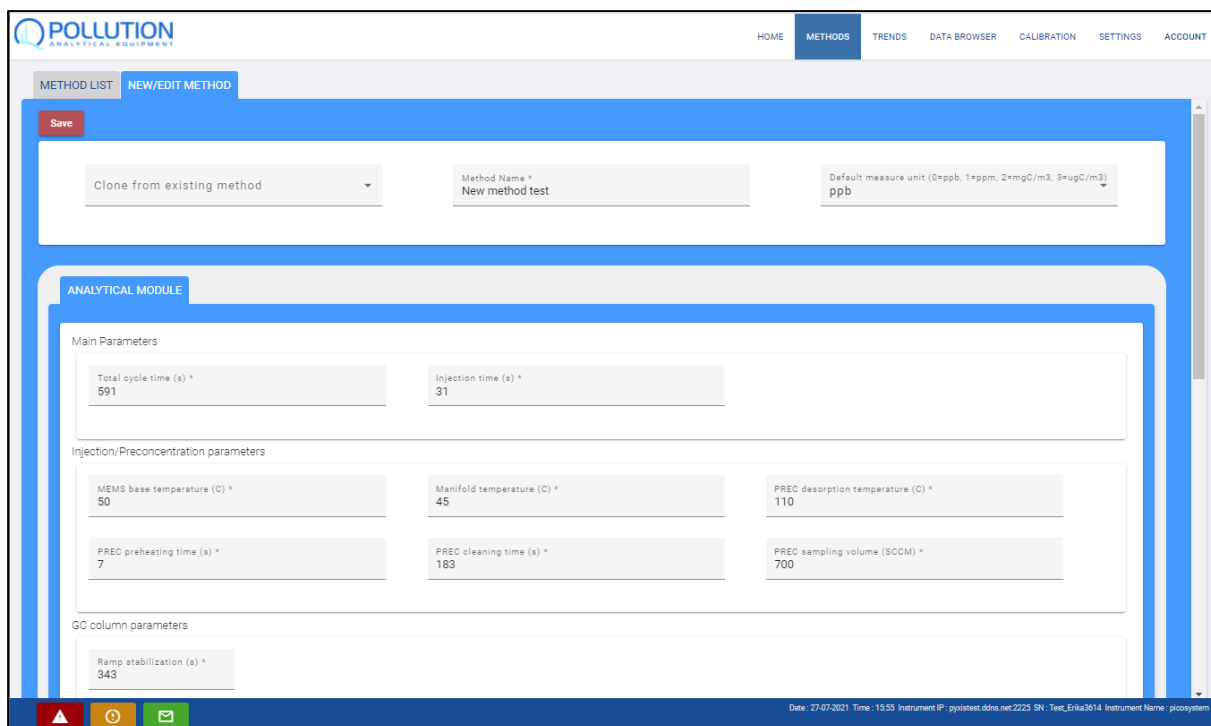
Figure 11: Method list view

In the tab of New/Edit Method, it is possible to fulfil the required fields paying attention to remaining between the minimum and maximum values for each one. At the top of the page it is possible to select the method name, to decide whether to clone all the parameters of an existing method and to choose the measure unit (ppb or  $\mu\text{g}/\text{m}^3$ ).

Below, the analytical method parameters are divided in four different categories (Fig. 12):

- Main parameters: total cycle time and injection time
- Injection/preconcentration parameters: these are related to the preconcentration step of the analytical cycle

- **GC column parameters:** to define the ramp steps and the column stabilization time at its maximum temperature. The start temperature of each ramp step is fixed, and the user can adjust the gradient by modifying the duration and the end temperature
- **PID parameters:** these deal with the PID configuration (gain, sampling rate, duration and initial delay). Two of them, Gain and Sampling Rate, must be selected from a scrolling menu



The screenshot displays the 'NEW/EDIT METHOD' interface. At the top, there is a navigation bar with 'HOME', 'METHODS', 'TRENDS', 'DATA BROWSER', 'CALIBRATION', 'SETTINGS', and 'ACCOUNT'. Below this, a 'METHOD LIST' and 'NEW/EDIT METHOD' tab are visible. A 'Save' button is located in the top left corner of the main form area. The form contains several input fields and dropdown menus:

- 'Clone from existing method' dropdown menu.
- 'Method Name \*' text input field containing 'New method test'.
- 'Default measure unit (0=ppb, 1=ppm, 2=mgO/m3, 3=ugO/m3)' dropdown menu set to 'ppb'.

The 'ANALYTICAL MODULE' section is highlighted and contains three sub-sections:

- Main Parameters:**
  - 'Total cycle time (s) \*' input field: 591
  - 'Injection time (s) \*' input field: 31
- Injection/Preconcentration parameters:**
  - 'MEMS base temperature (C) \*' input field: 50
  - 'Manifold temperature (C) \*' input field: 45
  - 'PREC desorption temperature (C) \*' input field: 110
  - 'PREC preheating time (s) \*' input field: 7
  - 'PREC cleaning time (s) \*' input field: 183
  - 'PREC sampling volume (SCCM) \*' input field: 700
- GC column parameters:**
  - 'Ramp stabilization (s) \*' input field: 343

At the bottom of the interface, there is a status bar with system information: 'Date: 27-07-2021 Time: 15:55 Instrument IP: pyxis-test.ddns.net:2225 SN: Test\_Erika3614 Instrument Name: picosystem'. There are also three small icons (up arrow, refresh, and envelope) on the left side of the status bar.

Figure 12: New method view

#### 4.1.4 TRENDS

This page shows the concentration daily trend of every BTEX compound. The period loaded by default corresponds to the latest 30 days and can be modified in the tab “Select Date Period” (Fig. 13). Then, selecting a specific date in the block “Select day”, the daily trends appear in the graphic.



-> The daily trend of each compound can be inactivated in the graphic by clicking over the specific compound.

Beyond the Date filter, there are others available to help users to improve their search:

- **Method:** this includes the method name used for the measures to be searched. The method name must be included in the method list name
- **Location:** it concerns the location indicated on the Start Analysis page before starting a series of measurements. Only the measures that include part of the text written in the location field will be displayed (query with “like” criterion, in which the search is accomplished by matching a specific similar pattern, not an exact one)
- **Comment:** if the series of measurements includes a comment, it can be filtered here. Again, only the measures that include part of the text entered in the location field will be displayed (query with “like” criterion)
- **Username:** to view only the series of measurements carried out by a single username. A scrollable menu is available to select the current user’s list

It is important to point out that in a single search, one, more than one, or all filters can be used at the same time (Fig. 14).



Figure 13: Trends view with a real trend

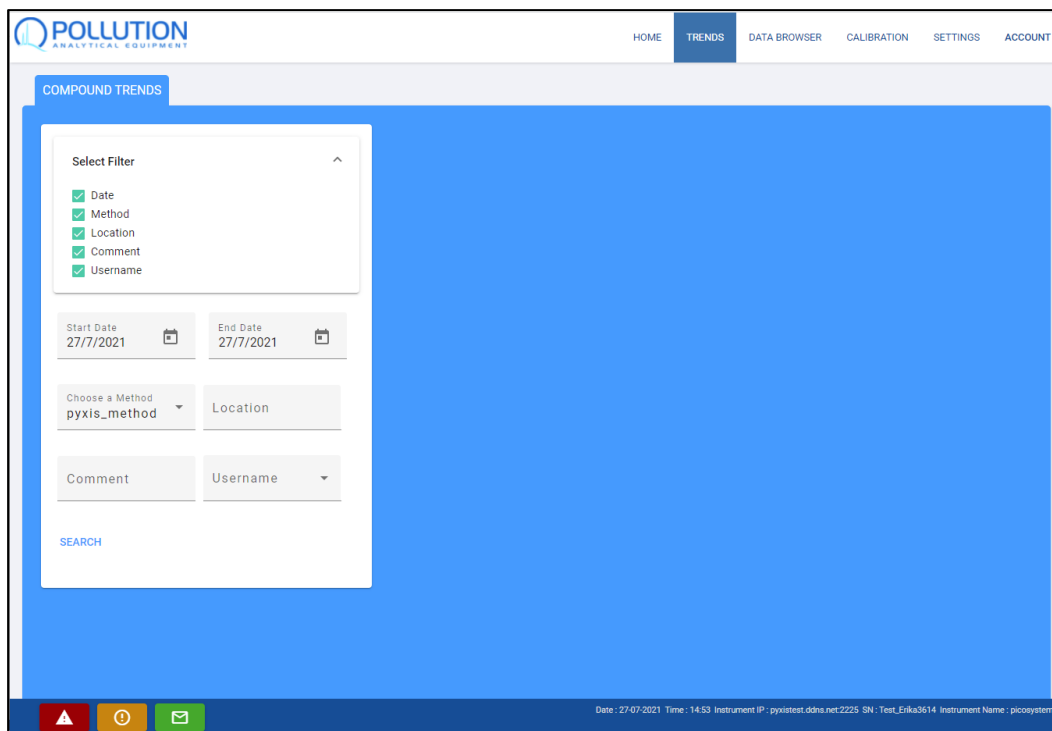


Figure 14: Trends view with all filters selected



-> Searches of long periods of time may need several tens of seconds before uploading the full trend.



-> If the Data filter is not selected, the search will look for all the available measurements in the database and it might take some time.

The following measurements are not shown in the TRENDS view: check standards and not valid measurements. For further information regarding the latter, please see paragraph 6 Troubleshooting.

The triple bar in the upper right corner of the graphic allows exporting the trends in different formats and gives the possibility to view the image in full screen.

Finally, by clicking in one single point of the trend graphic it is possible to open the chromatogram related to this measurement (Fig. 15).

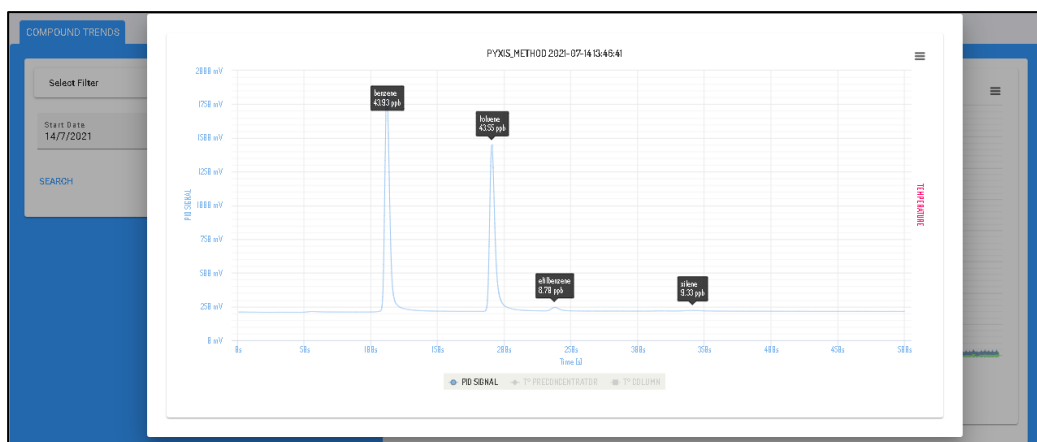


Figure 15: Chromatogram linked directly in the Trends

#### 4.1.5 DATA BROWSER

All saved chromatograms, obtained with a method calibrated or not, are shown in the data browser. The working principle of the filters is the same described in TRENDS. In addition, the possibility to filter by the Description defined for each set of measurements is available and works the same way as Comment and Location (query with “like” criterion).

Measurements can be filtered as well by type (calibrated, measured or both) and can be ordered from the most recent one or from the oldest one.

Once the search with the selected filters is over, open the chromatograms by clicking in the symbol below the *Show* column. Then, the chromatograph is shown on the right part of the screen with the relative peaks' concentration, with the measure unit which is related to the unit used in this method (Fig. 16). From the three line bar it is possible to download the chromatogram picture in .png, .jpeg or .svg, or the chromatogram values in .csv or .xls.

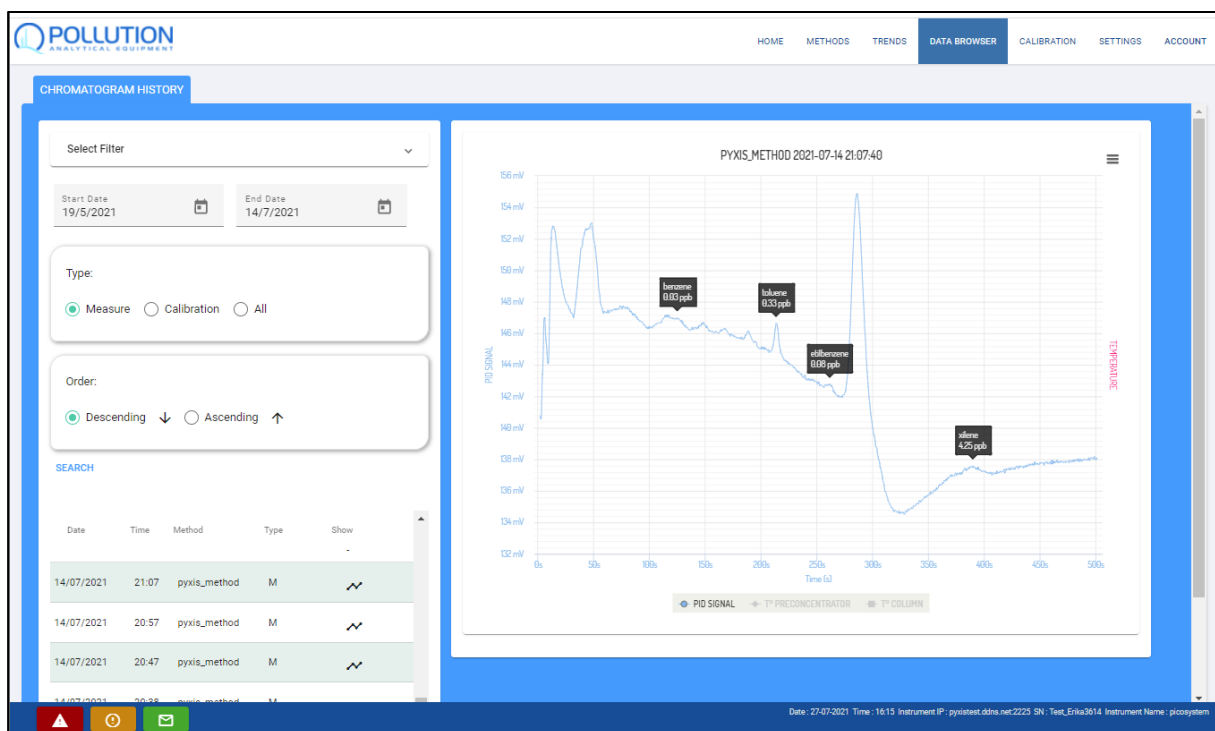


Figure 16: Data browser: chromatogram view

#### 4.1.6 CALIBRATION

All instruments are calibrated and must meet rigorous performance standards before being shipped. Then, periodic calibrations are necessary during in-field test campaigns due to PID lamp power decay and instrumental drift. There are two ways to calibrate the instrument:

##### Laboratory calibration

Only qualified technicians must carry out this operation. The calibration kit must consist of at least:

- Calibration gas specific to the analyses
- A two-stage pressure regulator to maintain the gas pressure stable during the calibration (max 5 bar)
- Preferably, stainless steel tubing to connect the calibration cylinder to the instrument to avoid potential cross contamination. As an alternative, a standard fluoropolymer can be used.



-> It is advised to use a certified calibration gas to improve the analytical performance of the instrument. Purchase calibration gas only from a reliable calibration gas supplier.

At any time, the analytical module can be removed from the cabinet and send back to the factory or to one of our authorised service providers for factory calibration.

### **Autocheck (optional)**

PyxisGC BTEX can integrate an additional module with the hardware and software necessary to perform automatically regular check standards. These can be performed at different intervals according to customer needs. The check standard kit includes a cylinder with a low concentration of Toluene with its own pressure reducer. The analytical module is an updated version which integrates a pressure sensor and a dilution system to reach the low concentrations required for proper check standard analyses.

The calibration page is the core of the instrument's GUI. In a PYXISGC BTEX with a standard module, the user can:

- View all the saved chromatograms and calibrate the method used in those measurements: **Calibration** tab
- Visualize the all the saved calibration measurements: **Calibration Database** tab

In the instruments with the Check Standard Unit integrated, two more tabs are available to manage the scheduling and results of the Check Standard measurements:

- **Scheduled Check Standard Settings**
- **Last Check Standard report**

## **CALIBRATION**

This page allows modifying manually the calibration values based on an existing chromatogram in the database of the instrument. The previous procedure to filter the database must be carried out to select a saved chromatogram (see 4.14 TRENDS). Figure 17 depicts a search done with only the Data filter.

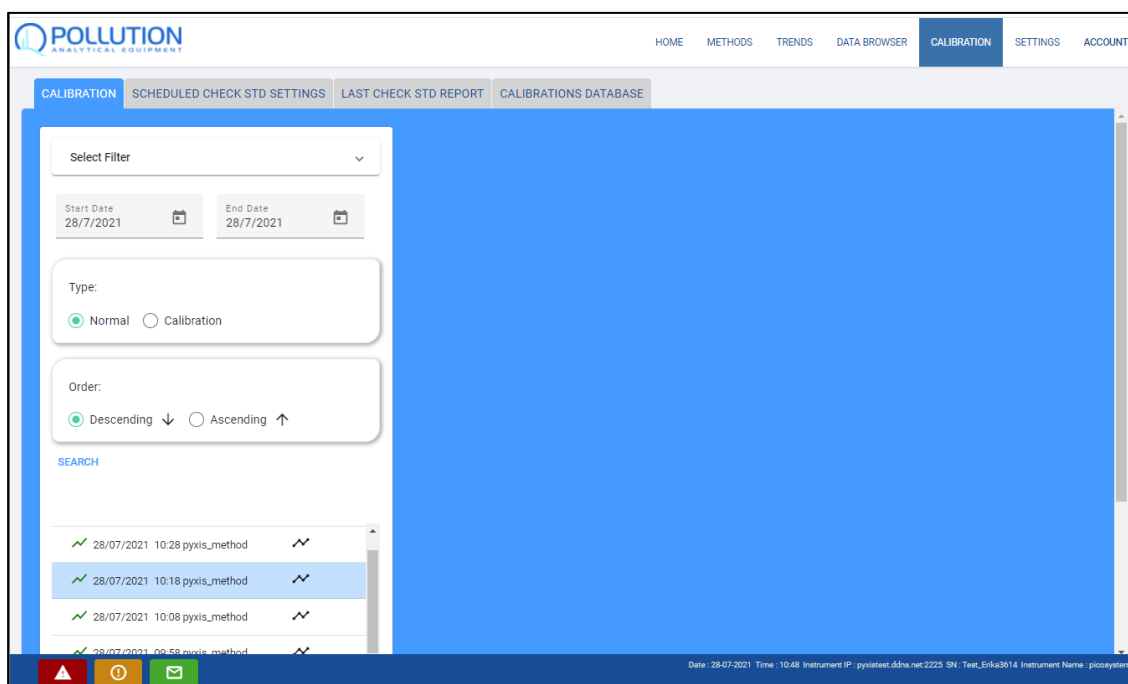


Figure 17: Calibration view: search with only data filter

Once the calibration chromatogram has been selected, a pop-up window with the calibration panel appears (Figure 18).

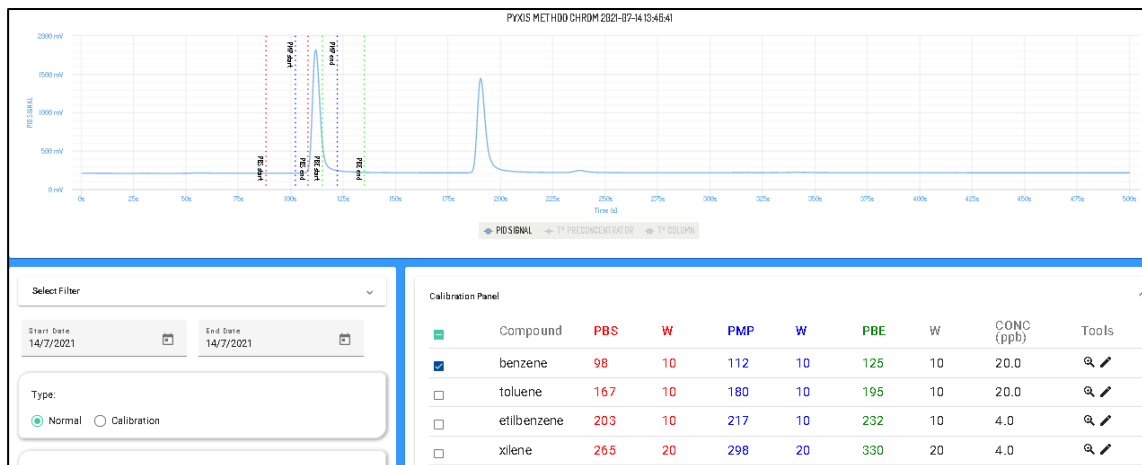


Figure 18: Calibration view: chromatogram and calibration panel

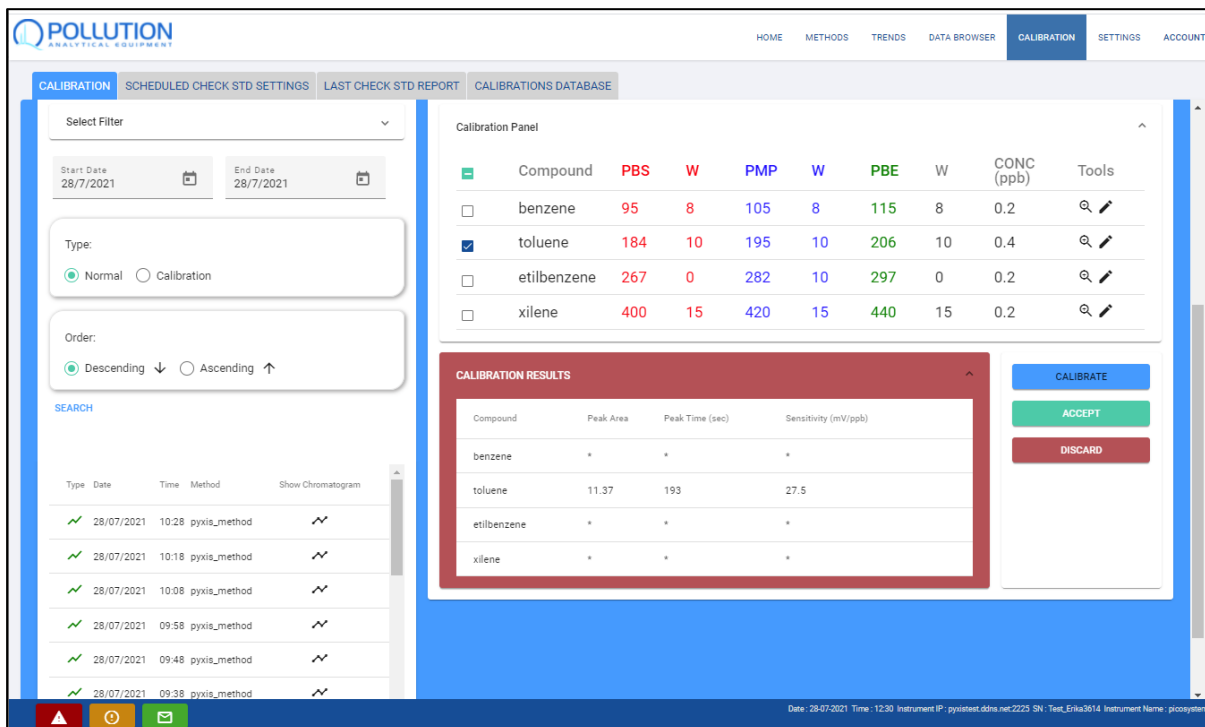
First of all, it is necessary to choose the BTEX compound(s) which need to be calibrated. Then, the user needs to adjust the six peak integration parameters according to the peak(s) position and write the reference concentration used (in the measure unit of the method in use). To modify each peak parameters, click on the pencil symbol in the Tools column. Then, adjust the time of each compound based on the “start”, “maximum” and “end” intervals.



-> See Appendix C to get further information about the peak area calculation procedure.



-> In order to better centre each peak, it is possible to zoom it with the magnifying glass in the Tools column.



The screenshot displays the Calibration view in the software interface. The top navigation bar includes HOME, METHODS, TRENDS, DATA BROWSER, CALIBRATION (selected), SETTINGS, and ACCOUNT. The main interface is divided into several sections:

- Left Panel:** Contains filters for Start Date (28/7/2021) and End Date (28/7/2021), Type (Normal selected, Calibration unselected), and Order (Descending selected, Ascending unselected).
- Search Table:** Lists calibration runs with columns for Type, Date, Time, Method, and Show Chromatogram. All entries show a green checkmark.
- Calibration Panel:** A table with columns for Compound, PBS, W, PMP, W, PBE, W, and CONC (ppb). It lists benzene, toluene, etilbenzene, and xilene with their respective values.
- Calibration Results:** A table with columns for Compound, Peak Area, Peak Time (sec), and Sensitivity (mV/ppb). It shows results for benzene, toluene, etilbenzene, and xilene.
- Buttons:** CALIBRATE (blue), ACCEPT (green), and DISCARD (red) buttons are located to the right of the Calibration Results table.

The status bar at the bottom indicates: Date: 28-07-2021 Time: 12:30 Instrument IP: pyxisstest.dhs.net:2225 SN: Test\_Erika3014 Instrument Name: prosystem

Figure 19: Calibration view: calibration results update

Once the peak has been properly centred, click on the blue button Calibrate to see the Peak Area, Peak Time, and Sensitivity (=Response Factor). To finalize the calibration step and to update the method, click on the green button Accept (Fig. 19). Otherwise, it is possible to discard the results and to review the calibration panel values.



-> To update the method with the new response factors, the analytical cycle must be stopped and the instrument needs to be in status READY.

**SCHEDULED CHECK STD SETTINGS** -> this tab is available only for those instruments which include the Check Standard Unit.

Check standard measurements can be carried out in two different modalities: MANUAL and AUTOMATIC. The first one can be performed in real-time with the instrument stopped and with status READY, whereas the second one needs to be scheduled.



-> A new MANUAL Check Standard cycle can be performed when the "Start Check STD Cycle" button turns green.

There are two separated functions which can be managed from this page: the scheduler and the check standard settings (Fig. 20):

- **SCHEDULER:** this block affects only the AUTOMATIC check standards. It allows programming the frequency of the check standard measurements. After choosing the frequency, the user can select the days, the day of the week or the day of the month and the time. To update the new scheduler, click on the green button SAVE PARAMETERS at the bottom of the page. Then, the next check standard date is updated accordingly.

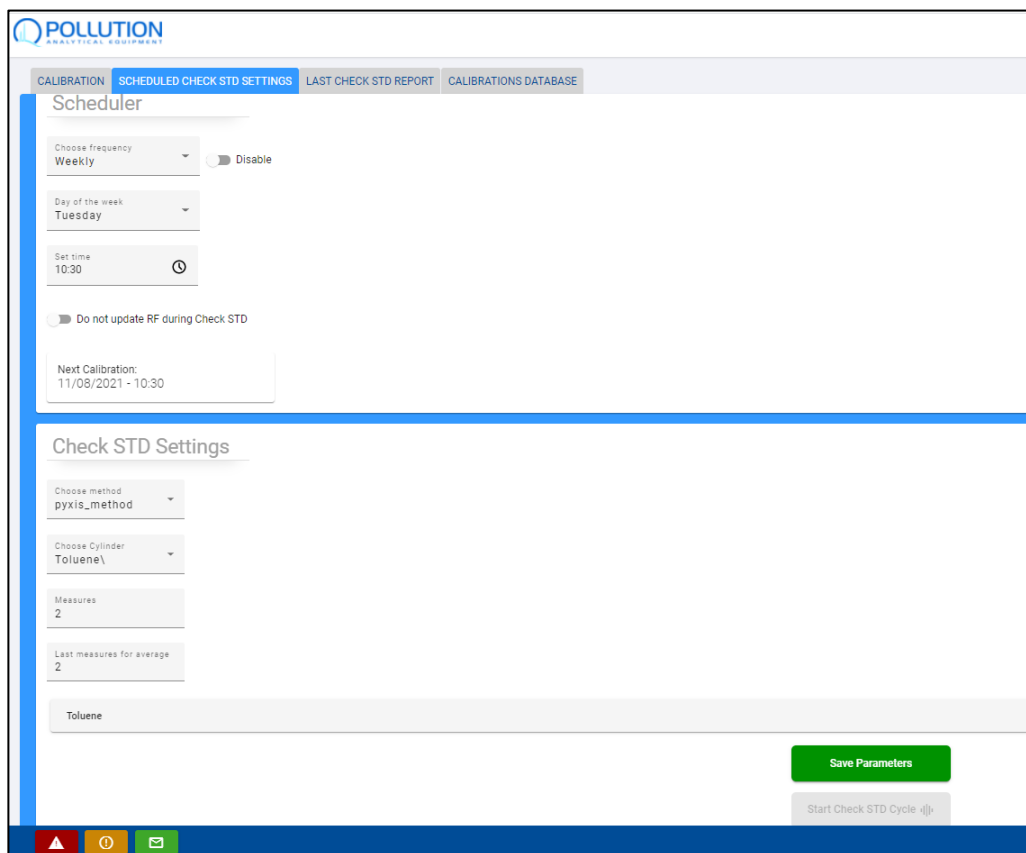
There are two other options available:

- 1) scroll the bar behind DISABLE to stop the automatic check standard measurements;
- 2) scroll the bar below set time to avoid updating the new Response Factor after each check standard cycle.

- **CHECK STD SETTINGS:** this part involves both the MANUAL and the AUTOMATIC check standard settings. Once the method and the cylinder are selected, the user defines the number of measurements to be carried out with the reference cylinder during the check standard, and how many of them are considered for the response factor average calculations. In addition, it is possible to decide the acceptable drift in % to avoid updating the new response factor of the gas/es available in the cylinder.



-> To obtain a stable value of the reference gas, it is advisable to perform at least 3 measurements during the Check STD cycle.



The screenshot displays the 'SCHEDULED CHECK STD SETTINGS' page. The 'Scheduler' section includes a 'Choose frequency' dropdown set to 'Weekly', a 'Disable' toggle switch, a 'Day of the week' dropdown set to 'Tuesday', a 'Set time' field set to '10:30', and a 'Do not update RF during Check STD' toggle switch. Below this, a 'Next Calibration' box shows '11/08/2021 - 10:30'. The 'Check STD Settings' section features a 'Choose method' dropdown set to 'pyxis\_method', a 'Choose Cylinder' dropdown set to 'Toluene\', 'Measures' set to '2', and 'Last measures for average' set to '2'. A 'Toluene' label is visible at the bottom of this section. A green 'Save Parameters' button and a grey 'Start Check STD Cycle' button are located at the bottom right of the interface.

Figure 20: Scheduled Check Standard Settings: scheduler and Check STD Settings blocks

**LAST CHECK STD REPORT** -> this tab is available only for those instruments which include the Check Standard Unit, and involves only the MANUAL check standard measurements.

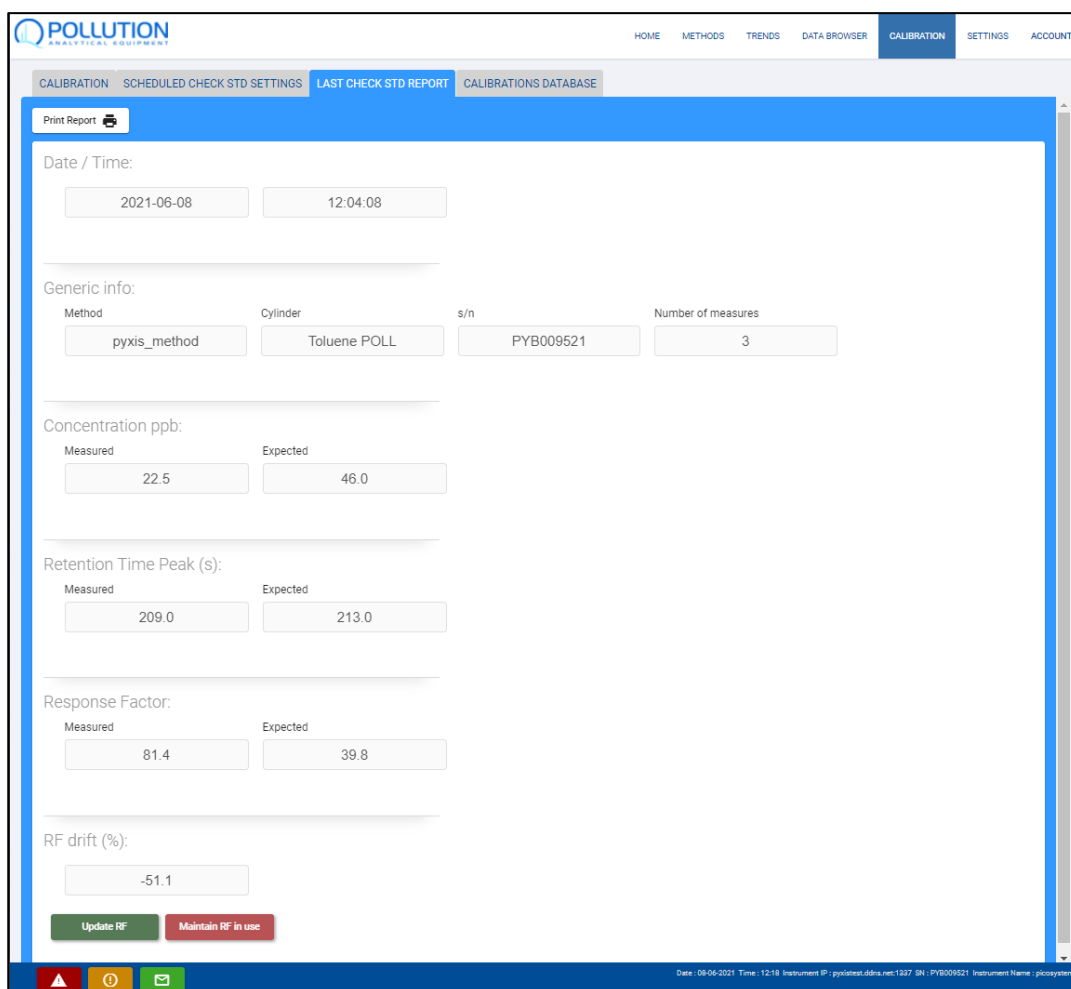
As soon as the manual check standard cycle ends, a new report with all the relevant information of the analytical cycle is shown in this page (Fig 21). This includes:

1. Date and Time of the report
2. Generic info: method and cylinder, serial number of the instrument and number of measurements
3. Concentration: "measured" versus "expected", in the unit of measurement of the method
4. Retention time peak: "measured" versus "expected", both in seconds
5. Response Factor: again, "measured" versus "expected", with the relative drift in %



-> "Measured" defines the values of concentration, retention time and response factor obtained with the current parameters available in the method

-> "Expected" concerns the new calculated parameters according to the dilution obtained from the gas cylinder and the new retention time of the peak(s) available



Date / Time:	
2021-06-08	12:04:08

Generic info:			
Method	Cylinder	s/n	Number of measures
pyxis_method	Toluene POLL	PYB009521	3

Concentration ppb:	
Measured	Expected
22.5	46.0

Retention Time Peak (s):	
Measured	Expected
209.0	213.0

Response Factor:	
Measured	Expected
81.4	39.8

RF drift (%)
-51.1

Buttons: Update RF (green), Maintain RF in use (red)

Footer: Date: 08-06-2021 Time: 12:18 Instrument IP: pyxisat.dhs.net:1227 SN: PYB009521 Instrument Name: pyxisystem

Figure 21: Example of a Last check STD report with a Toluene cylinder

At the end, the user can decide whether to update or not the new Response Factor and Retention Time of the reference peak(s). A Print Report button in the upper part of the page allows downloading the current report.

Users can keep working with the instrument in manual or automatic mode even without accepting or not the new Response Factor. In this case, the Start Analysis page will show that there is a new Check STD report pending.



-> Once the new RF is accepted or rejected, the report will disappear and only the RF drift value will be available in the Calibrations Database tab.

## CALIBRATIONS DATABASE



-> For the sake of simplicity, calibrations and check standard are named the same way in this tab. Nevertheless, it is important to point out that calibrations are carried out with a certified cylinder with all the BTEX compounds, whereas a check STD generally considers only one BTEX gas, and the given drift in terms of RF and Retention Time is then spread to the other compounds.

All reference measurements (or cycle of measurements) used to calibrate or check the response factor of the BTEX peaks are available in this tab. Following a searching by date, it is possible to open a new table showing all the following information: Date, Time, Calibrator, Mode and Validity.

Please find below further information on Mode and Validity:

- **Calibration Mode:** this can be
  - M** for manual check STD
  - A** for automatic check STD
  - R** for general calibrations reprocessing a saved chromatogram in the database
- **Validity:** only for automatic check STD. There are four different reasons why an automatic check STD does not fulfil the validity requirements:
  - 1) the check STD cylinder is empty;
  - 2) the cylinder in used is expired;
  - 3) the new response factor has drifted too much (normally over 12%);
  - 4) the instrument has been switched off during the check standard cycle. If none of these circumstances apply, the calibration will be valid.

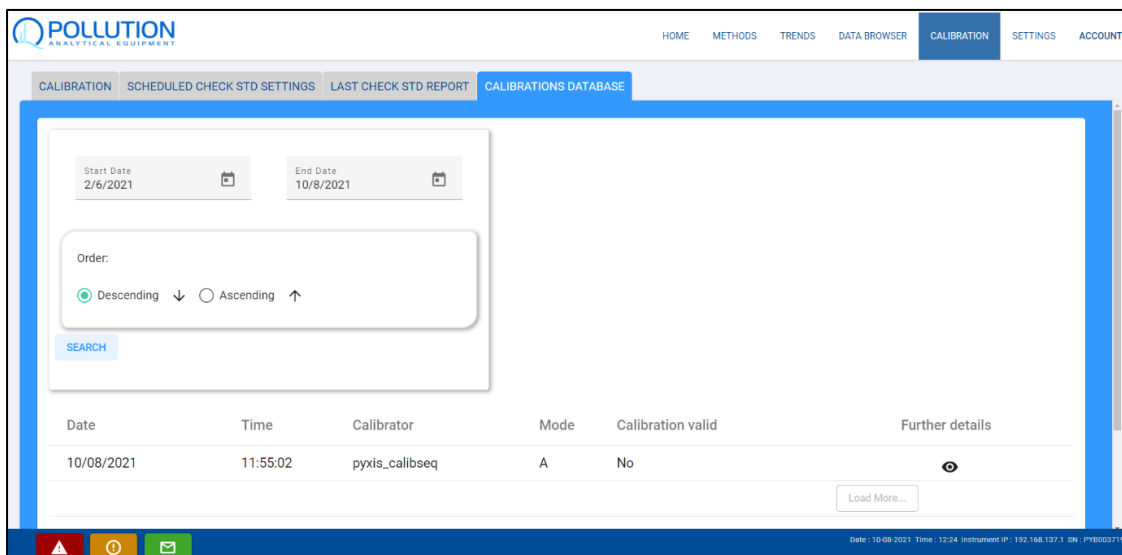


Figure 22: Calibrations database: search table

By clicking in the eye symbol of the Further Details column, the user has the possibility to retrieve the relevant information of each calibration: the reference chromatograms, the name of the method used, and for the manual and automatic check STD, the absolute drift and the relative drift of the response factor (Fig. 23).

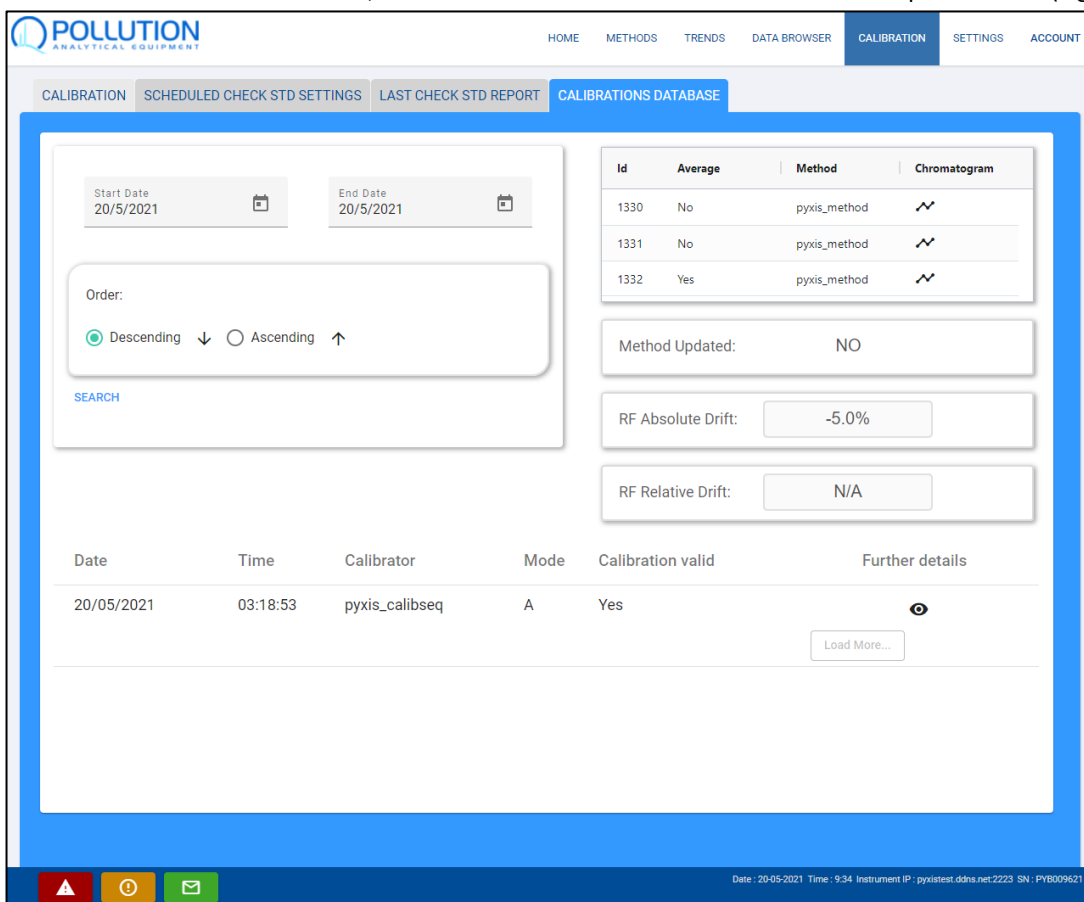


Figure 23: Calibrations database: further details information



-> The R mode calibrations are always performed manually with a reference chromatogram which contains some or all the BTEX compounds. Therefore, the method is always updated and there will be no absolute or relative drift since these are reset.



-> The absolute drift is calculated between the current response factor in use for the reference compound(s) of the cylinder, and the value of the latest calibration type R. On the other side, the relative drift considers the drift between the latest two consecutive calibrations. For example, the next calibration after a type R one, has always the same value for the absolute and the relative drift.

#### 4.1.7 SETTINGS

There are different tabs available in this page. According to the user level, some of them might not be available or have limited control.

##### SETTINGS

This tab is divided into two parts: on the left we have information on the instrument concerning the various FW/SW versions of its different functional blocks; on the other hand there are several machine settings that can be configurable by all users:

- Instrument IP
- Date and time
- Timezone
- Measurement mode

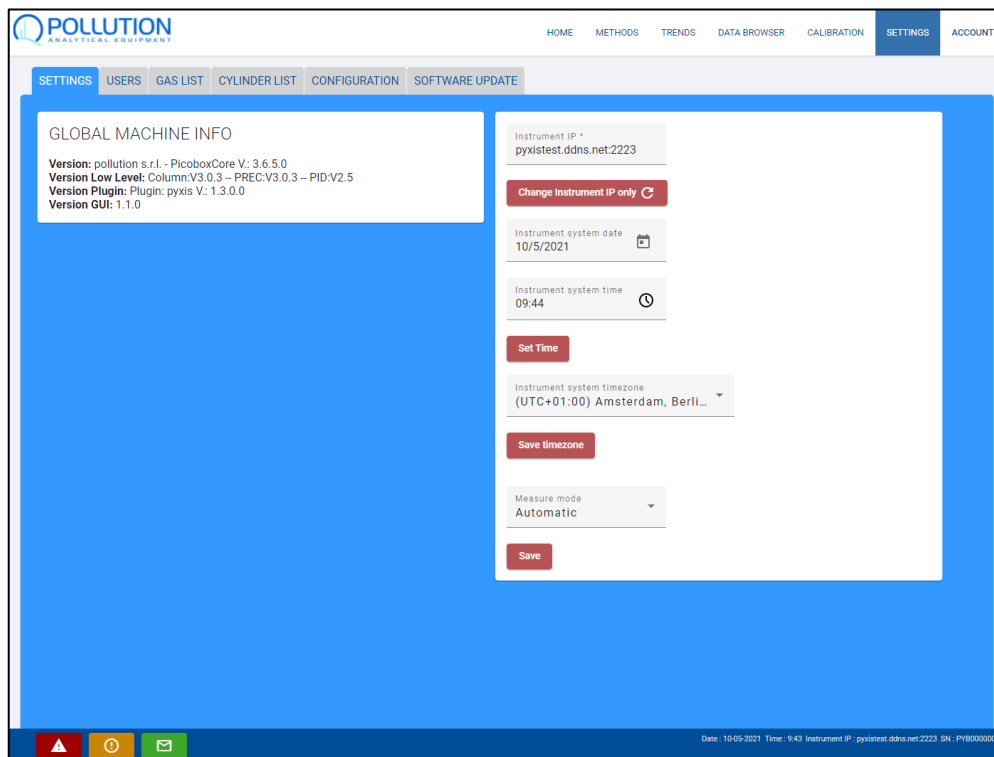


Figure 24: General instrument settings view

## USERS

In this view it is possible to create, modify or delete users of different levels. In addition, the state of each available user can be modified (changing its state from enabled to disabled).

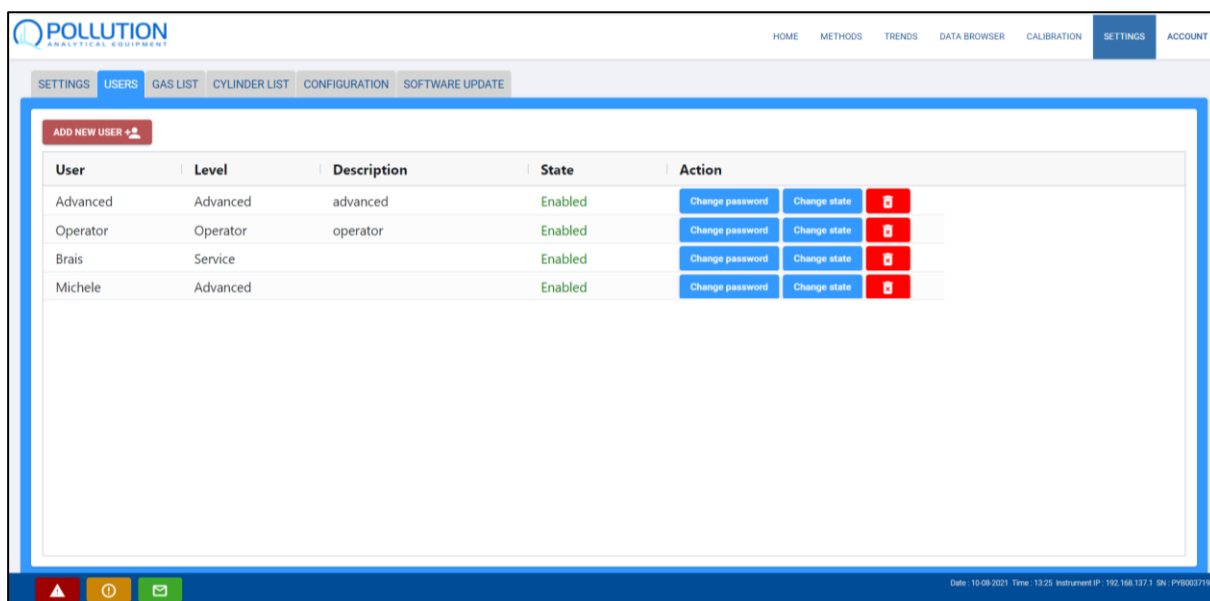
There are different levels of users. The basic one is the Operator, and this allows managing all the main features of the instrument.



-> The username must be unique and cannot be repeated for different users. If you try to enter an existing or a previous username, the system will show an error message.



-> Each user can create a new one with its same (or inferior) level. This means that an advanced user can add a new username advanced or operator, whereas the operator can only create another operator user level.







User	Level	Description	State	Action
Advanced	Advanced	advanced	Enabled	Change password Change state 
Operator	Operator	operator	Enabled	Change password Change state 
Brais	Service		Enabled	Change password Change state 
Michele	Advanced		Enabled	Change password Change state 

Figure 25: Users view

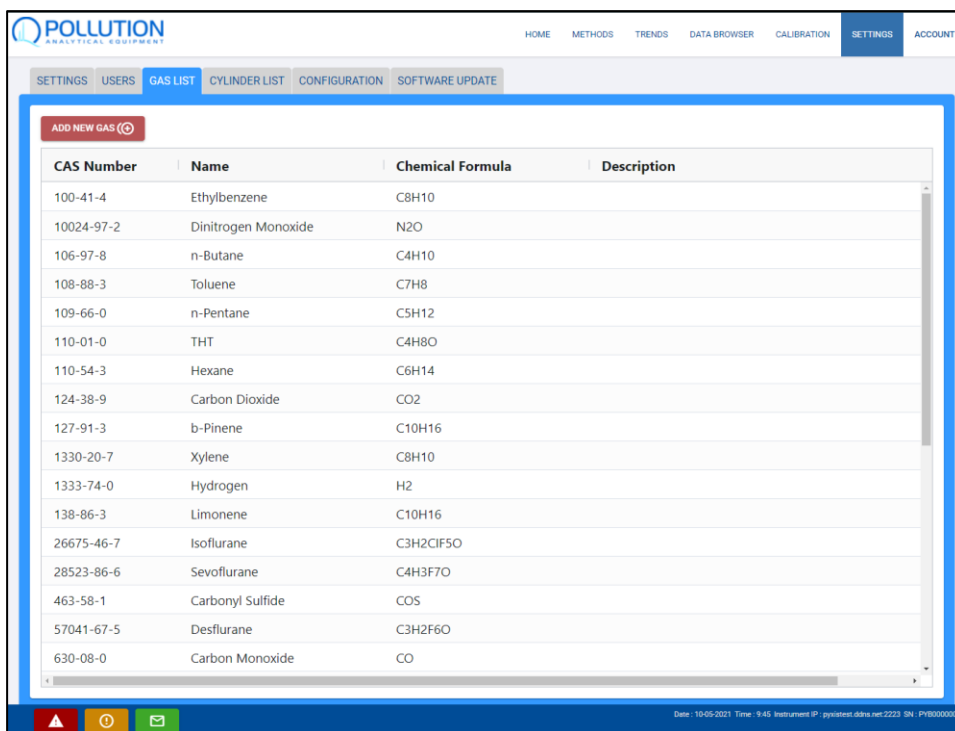
## GAS LIST

The list with all the available gases integrated in the software database is shown here. If the user needs to create a new cylinder (see next tab CYLINDER LIST), the reference gas(es) to be included must appear in this list. Otherwise, they must be added manually.

This tab is only available for the Service level. Nevertheless, for PYXISGC-BTEX, only the four main aromatic compounds are necessary and they are already uploaded in the list (Fig. 26).



-> Even though there is a long list of gases, this does not mean that the instrument can separate and identify all of them. Please keep in mind that PYXIS technology is specifically designed for BTEX measurements.



CAS Number	Name	Chemical Formula	Description
100-41-4	Ethylbenzene	C8H10	
10024-97-2	Dinitrogen Monoxide	N2O	
106-97-8	n-Butane	C4H10	
108-88-3	Toluene	C7H8	
109-66-0	n-Pentane	C5H12	
110-01-0	THT	C4H8O	
110-54-3	Hexane	C6H14	
124-38-9	Carbon Dioxide	CO2	
127-91-3	b-Pinene	C10H16	
1330-20-7	Xylene	C8H10	
1333-74-0	Hydrogen	H2	
138-86-3	Limonene	C10H16	
26675-46-7	Isoflurane	C3H2ClF5O	
28523-86-6	Sevoflurane	C4H3F7O	
463-58-1	Carbonyl Sulfide	COS	
57041-67-5	Desflurane	C3H2F6O	
630-08-0	Carbon Monoxide	CO	

Figure 26: Gas List: general view



-> To add a new gas, please press the button "Add a new gas" and fulfil the required fields of the new pop-up.



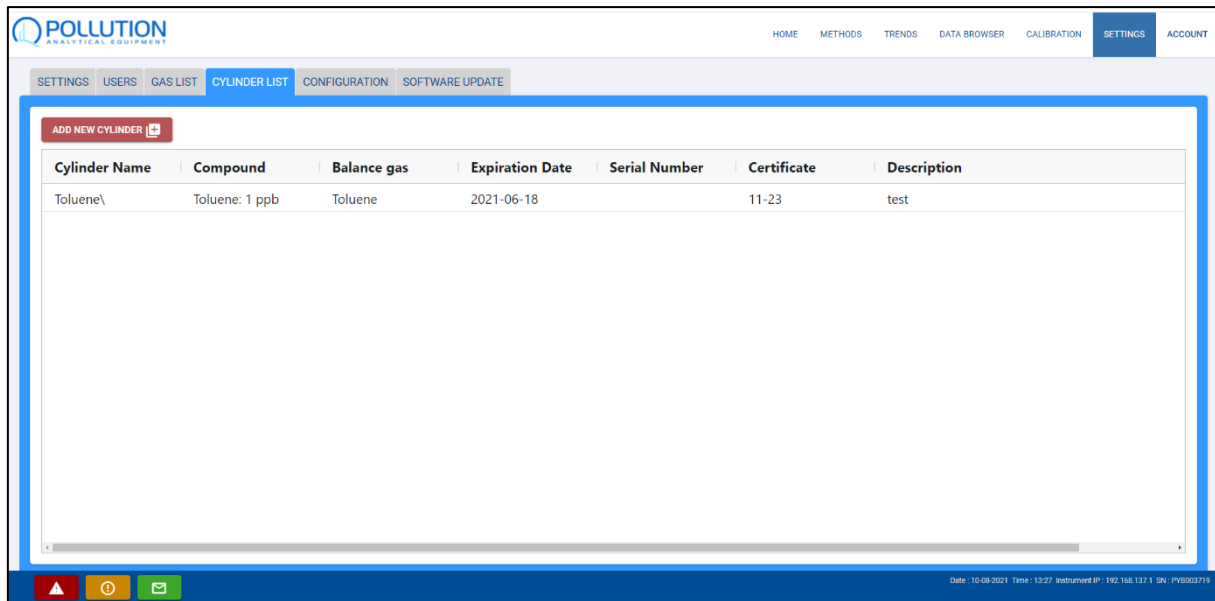
-> The CAS number is a unique and unambiguous numerical designation for every specific chemical substance that is maintained by the Chemical Abstracts Service (CAS) of the American Chemical Society.

## CYLINDER LIST

This view shows all the available cylinders to be used for the check standard measurements (Fig. 27).



-> If your user level allows it, before adding a new cylinder, make sure that your reference gases appear in the general gas list.



Cylinder Name	Compound	Balance gas	Expiration Date	Serial Number	Certificate	Description
Toluene\	Toluene: 1 ppb	Toluene	2021-06-18		11-23	test

Figure 27: Cylinder List view

To create a new cylinder, press the specific red button “Add new cylinder”. A new pop-up in the centre of the screen will open, with all the necessary fields to be fulfilled to complete the process (Fig. 28). The requested information are:

Cylinder name: mandatory field which helps to identify the cylinder in the different pages

Certificate: mandatory field regarding the number/title of the cylinder certification

Serial Number: this optional field allows writing the cylinder s/n

Balance gas: from the scrollable menu, select the used balance gas

Expiration date: mandatory field; this is a critical information because all the check standard measurements carried out with this cylinder after this date are considered as not valid by the instrument

Date cylinder: the date in which the cylinder is filled

Description: available field in case a detailed description helps the user to better identify the cylinder

Compound: the first scrollable menu shows the gas list from which the gas(es) of the cylinder must be chosen; the second field must contain the concentration of each gas; the third one consists of the available units of measurements available (generally ppb, ppm, mg/m<sup>3</sup> and µg/m<sup>3</sup>)

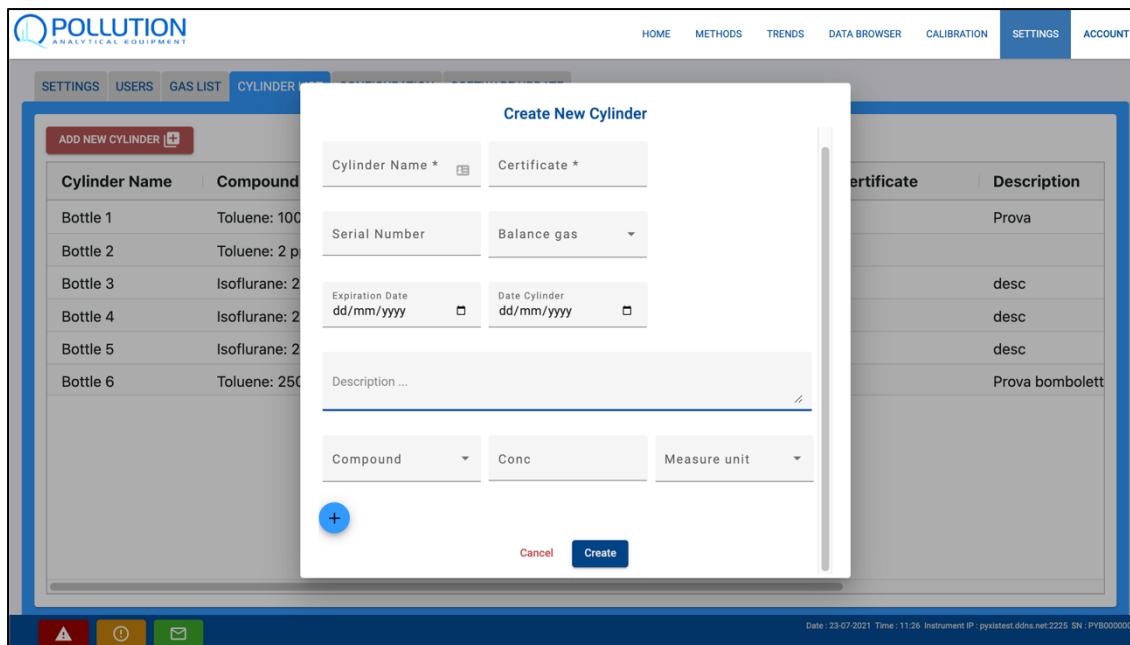


Figure 28: Cylinder List: pop-up to create a new cylinder

## CONFIGURATION

Specific configuration parameters can be updated from this view, and their modification can damage irreparably the instrument. For this reason, it is available only for Service level users.

## SOFTWARE UPDATE

The software version can be updated remotely from this advanced user interface. Nevertheless, to avoid problems of incompatibility between the different SW and GUI versions released, this option is only available for Service level users.

### 4.1.8 ACCOUNT

The latest page in the main menu allows viewing the username connected and to log-out to the Log-In view.



-> The number of parallel sessions with different users logged in is limited to ten. Therefore, it is strongly advisable to remember to log-out after each session.

## 4.2 Pollution Guardian

In addition to Pollution Direct Connection, the user has the possibility to connect through a web browser to the instrument with the cloud-based software called Pollution Guardian.

First, go to the website [www.pollutionguardian.com](http://www.pollutionguardian.com). Login using the email and password which must be previously configured by Pollution technicians (see paragraph 2.6.2).

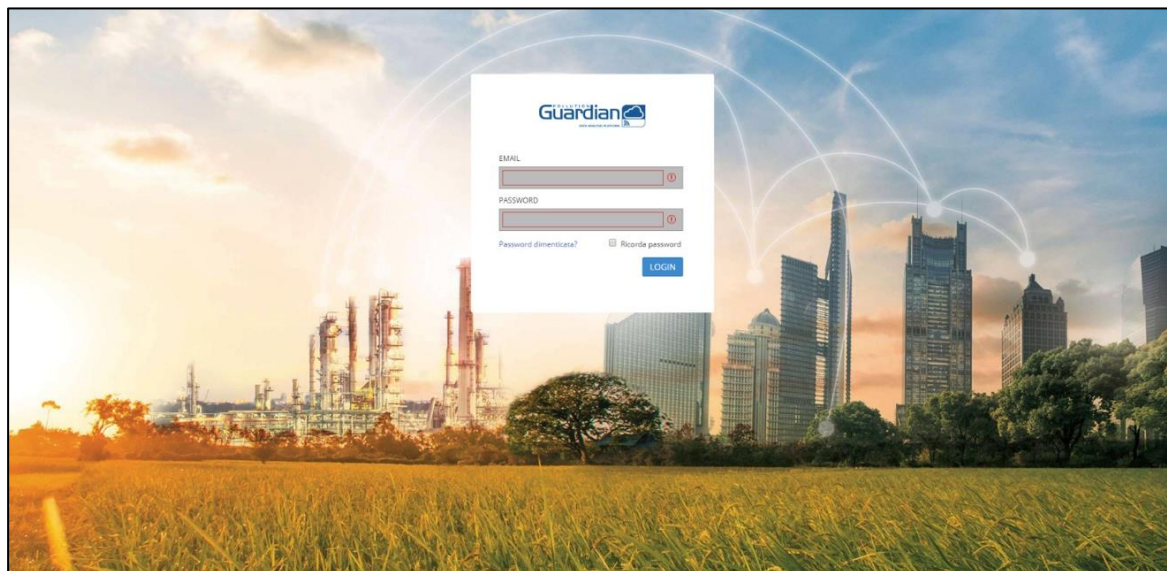


Fig. 29 Pollution Guardian website

Once logged-in, the user has on the right side all its activated installations. Selecting one of them, the following actions can be carried out:

- **STATUS:** check the current status of the instruments connected to this installation
- **HISTORICAL DATA:** select the input signals which want to be analysed for each instrument; choose the interval FROM/TO; and then it is possible to 1) view the chart, 2) view the table and 3) download the table in a “.csv.” format
- **DOCS:** it is possible to upload relevant documents regarding this installation
- **DIAGNOSTICS:** description of different error signals
- **CONNECTIVITY:** check the connectivity status to the instrument
- **VPN CONNECTION:** when this feature is activated, it allows the user to connect through VPN directly to the selected instrument
- **DASHBOARD:** a default dashboard is already designed for the installation with all the output signals of the installation

The screenshot displays the Pollution Guardian web interface. The top navigation bar includes 'Impianti', 'Allarmi', 'Mappa', 'Tools', and 'Logs'. The main content area is titled 'PYXIS - calibration - Long Term Pollution Testing Station @ Pollution'. It features a sidebar on the left with a search bar containing 'pyxis' and a tree view showing 'Pollution' > 'Test interni' > 'PYXIS - calibration'. The main area shows a status bar with 'Stato', 'Storico', 'Docs', 'Diagnostica', 'Connettività', 'VPN Connect', and 'Dashboard'. Below this, there are four sections, each representing a calibration station (collaudo 1 to 4). Each section contains a table of pollutant levels and instrument status.

PYXIS collaudo 1 - Errore: Timeout risposta periferica - 27/06/2019 14:40:01					
Benzene	0,11	ppb	Toluene	0,10	ppb
Ethylbenzene	0,29	ppb	Xylene	0,40	ppb
Instrument Status	Running		Modbus Version	1,40	

PYXIS collaudo 2					
Benzene	13,69	ppb	Toluene	14,73	ppb
Ethylbenzene	15,20	ppb	Xylene	21,26	ppb
Instrument Status	Running		Modbus Version	1,40	

PYXIS collaudo 3					
Benzene	4,11	ppb	Toluene	4,91	ppb
Ethylbenzene	4,05	ppb	Xylene	2,00	ppb
Instrument Status	Running		Modbus Version	1,40	

PYXIS collaudo 4					
Benzene	-297,61	ppb	Toluene	-1,78	ppb
Ethylbenzene	-1,70	ppb	Xylene	24,93	ppb
Instrument Status	Running		Modbus Version	1,40	

Fig. 30 Pollution Guardian main page with all the activated installations

## 5 SERVICE AND MAINTENANCE

**Filters** are the only consumable parts that user should replace following a schedule that is strongly dependent on the kind of application in which instrument is installed.

For this reason, the frequency of this activity will depend upon local environmental conditions. Environments with higher particle concentrations, for example, will require more frequent filter changes.

The 10.6eV PID lamp has a life expectancy of 10.000 hours of continuous use. Over a lifetime of usage, the lamp power will decay, and therefore the sensitivity of the sensor will do too. This can be up to 10-15% per month, and it should be taken into account when considering calibration periods.

### 5.1 Contacting Pollution Analytical Equipment for service

Replacement of the consumable parts should be carried out only by qualified personnel and by using parts from the manufacturer.

Please contact Pollution's service department via e-mail for authorization and instructions prior to shipping any items for repair.

Service e-mail address: [service@pollution.it](mailto:service@pollution.it)

## 6 TROUBLESHOOTING

STATUS	POSSIBLE CAUSE	POSSIBLE SOLUTION	MANUAL REFERENCE
Low regulator pressure	<ul style="list-style-type: none"> <li>- Span gas low</li> <li>- Pressure sensor reading failed</li> </ul>	<ul style="list-style-type: none"> <li>- Change span gas bottle</li> <li>- Check connection of the pressure sensor</li> </ul>	Chapter 3.7
Instrument switched off	<ul style="list-style-type: none"> <li>- Input voltage out of standard</li> </ul>	<ul style="list-style-type: none"> <li>- Check the power supply according to the proper working specifications</li> <li>- Replace the cable</li> </ul>	Chapter 3.4
Baseline unstable	<ul style="list-style-type: none"> <li>- Improper filtration of the carrier gas flow</li> </ul>	<ul style="list-style-type: none"> <li>- Replace the carrier gas filter</li> </ul>	Chapter 5
Not valid measurements	<ul style="list-style-type: none"> <li>- The preconcentrator module does not reach the target volume</li> </ul>	<ul style="list-style-type: none"> <li>- Check the preconcentrator MEMS</li> <li>- Replace the preconcentrator pump</li> </ul>	Contact Pollution Service department
Log-in error	<ul style="list-style-type: none"> <li>- The number of access of different users without logging-out has reached its maximum</li> </ul>	<ul style="list-style-type: none"> <li>- Restart the instrument</li> </ul>	Chapter 4.1.8

### 6.1 Trouble shooting support

If troubleshooting instructions do not lead to a resolution and assistance is required, the user can contact Pollution service department.

## 7 COMPLIANCE

PyxisGC BTEX is compliant with the following Standards:

- EN 14662-3:2015

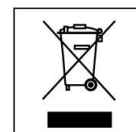
## 8 APPENDIX

### A) ACRONYMS AND DEFINITIONS

TERM	DEFINITION
BTEX	Benzene, Toluene, Ethylbenzene and Xylene (three main xylene isomers)
GC	Gas Chromatograph
IP	Ingress Protection
MEMS	Micro-Electro-Mechanical-Systems
PID	Photolonization Detector
UPS	Un-interruptible Power Supply

### B) DISPOSAL OF ELECTRIC AND ELECTRONIC EQUIPMENT

Appliances of an electrical and electronic nature must be disposed of in accordance with the prescriptions provided in EU Directive 2002/96/EC on Waste Electronic and Electrical Equipment (WEEE).



**WARNING:** The user must dispose of the equipment at an authorized consortium or centre for WEEE handling and recovery. Failure to observe this prescription is punishable by law.

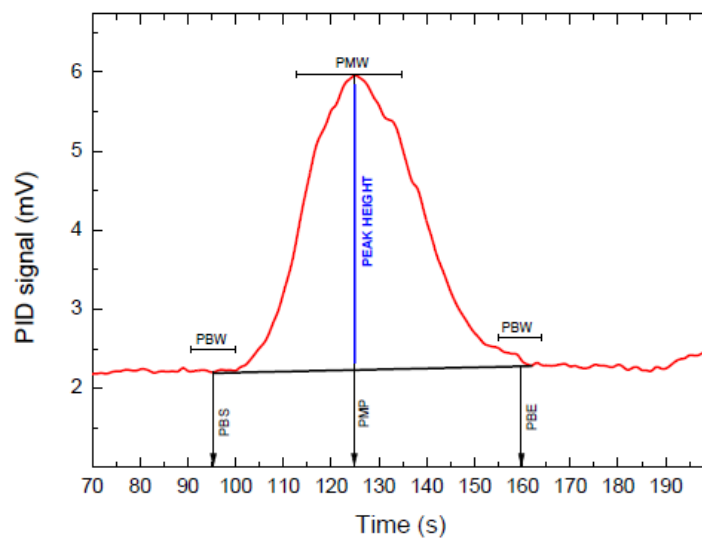
### C) PEAK AREA CALCULATION PROCEDURE

The 5 AREA SEARCH PARAMETERS of BTEX compounds are:

- PBS** = Peak base start time (in seconds)
- PBE** = Peak base end time (in seconds)
- PBW** = Peak base search width (in seconds)
- PMP** = Peak maximum position (in seconds)
- PMW** = Peak maximum search width (in seconds)

The peak area is calculated as the area below the PID signal. This area is manually selected and it is centered in the peak maximum height and starts/ends in the PBS and PBE points (at a maximum distance of PBW seconds). To modify these parameters, select in the "tool" column of the calibration panel the pen figure. It is highly advisable to use the zoom feature to easily identify the position of each peak.

A visual representation of the five search parameters which can be manually modified in the calibration panel are shown below.





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