



User Manual

Models T750 and T750U

Portable Calibrators

with NumaView™ Software

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TRADEMARKS

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SAFETY MESSAGES

Important safety messages are provided throughout this manual for the purpose of avoiding personal injury or instrument damage. Please read these messages carefully. Each safety message is associated with a safety alert symbol, any of which may be found throughout this manual and inside the instrument. The symbols with messages are defined 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 instrument should only be used for the purpose and in the manner described in this manual. If you use this instrument in a manner other than that for which it was intended, unpredictable behavior could ensue with possible hazardous consequences.

NEVER use a gas analyzer to sample any combustible gas(es)!

Technical Assistance regarding the use and maintenance of this instrument or any other Teledyne API product is available by contacting Teledyne API's Technical Support Department:

Telephone: 800-324-5190

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or by accessing various 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



Cet instrument doit être utilisé aux fins décrites et de la manière décrite dans ce manuel. Si vous utilisez cet instrument d'une autre manière que celle pour laquelle il a été prévu, l'instrument pourrait se comporter de façon imprévisible et entraîner des conséquences dangereuses!

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 the following link: http://www.teledyne-api.com/terms_and_conditions.asp).

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 at http://www.teledyne-api.com/terms_and_conditions.asp

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 downloaded from our website.

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APPENDIX

APPENDIX – INTERCONNECT DIAGRAM



1. INTRODUCTION

The Model T750 and Model T750U are portable, microprocessor-controlled calibrators for precision gas analyzers, with the T750U designed for precision trace-level gas analyzers. Using a combination of highly accurate mass flow controllers and compressed sources of standard gases, calibration standards are provided for multipoint span and zero calibrations. The T750 can be equipped with an optional, programmable ozone generator that includes an internal gas phase titration (GPT) chamber for accurate, dependable ozone calibrations. This option can also include a UV photometer option for even more precise control of the ozone generator. The standard T750U has all these features and is designed for producing stable ozone concentrations not only in a high range mode similar to the T750, but also in a low range or fractional mode for producing much lower levels of ozone down to 3 ppb.

As many as 50 independent calibration sequences may be programmed into these portable calibrators, covering time periods of up to one year. Sequence setup is simple and intuitive, and may be actuated manually, automatically, or by a remote signal. The sequences may be uploaded remotely, including remote editing. All programs are maintained in non-volatile memory.

The T750 and the T750U provide fast response, repeatability, overall accuracy and ease of operation, and may be combined with a Teledyne API Zero Air Generator to provide the ultimate in easy to use, precise calibration for your gas analyzers.

1.1. T750 SPECIFICATIONS

Specifications are based on constant conditions.

Specifications are subject to change without notice.

Table 1-1. T750 System Specifications

| PARAMETER | SPECIFICATION | |
|-------------------------------|--|---------------------------|
| Flow Measurement Accuracy | $\pm 1.0\%$ of Full Scale | |
| Repeatability of Flow Control | $\pm 0.2\%$ of Full Scale | |
| Linearity of Flow Measurement | $\pm 0.5\%$ of Full Scale | |
| Flow Range of Diluent Air | 0 to 10 SLPM – Optional Ranges: 0 to 5 SLPM; 0 to 20 SLPM | |
| Flow Range of Cylinder Gases | 0 to 100 cc/min – Optional Ranges: 0 to 50 cc/min; 0 to 200 cc/min | |
| Zero Air Required | 10 SLPM @ 30 psi – Optional: 20 SLPM @ 30 psi | |
| Input Pressure | 20 to 40 psig | |
| Response Time | 60 Seconds (98%) | |
| AC Power | Rating | Typical Power Consumption |
| | 100-240 V~ 50/60 Hz, 1.5 A | 115 V: 76 W 230 V: 80 W |
| Analog Outputs | 1 user configurable output | |
| Analog Output Ranges | 10V, 5V, 1V, 0.1V (selectable) Range with 5% under/over-range | |
| Analog Output Resolution | 1 part in 4096 of selected full-scale voltage (12 bit) | |
| Standard I/O | 1 Ethernet: 10/100Base-T 2 RS-232 (300 – 115,200 baud) 2 USB device ports 12 digital control outputs 12 digital control inputs 8 digital status outputs | |
| Optional I/O | 1 USB com port 1 RS485 Multidrop RS232 | |
| 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 $\leq 2000\text{m}$ | |
| Materials | Cal Gas Output Wetted Surfaces: PTFE Cal Gas Output Manifold: Glass-coated Steel | |
| Dimensions (H x W x D) | 9" x 17" x 21" (229 mm x 432 mm x 533 mm) | |
| Weight | 37 lbs (16.78 kg); 46.6 lbs (21.14 kg) with optional photometer, GPT, and O ₃ generator | |

Table 1-2. T750 Options Specifications

| PARAMETER | SPECIFICATION |
|---|---|
| T750 Ozone Generator Option | |
| Maximum Output | 5.5 ppm SLPM |
| Minimum Output | 100 ppb SLPM |
| Response Time: | 180 seconds to 98% |
| T750 O₃ Photometer Option | |
| Full Scale Range | 0 - 100 ppb to 0 - 10 ppm (user selectable) |
| Precision | 1.0 ppb |
| Linearity | 1.0% of reading |
| Rise/Fall Time | < 20 sec (photometer response) |
| Response Time | 180 sec to 95% (system response) |
| Zero Drift | < 1.0 ppb / 24 hours |
| Span Drift | < 1% / 24 hours |
| Minimum Gas Flow Required | 800 cc/min |

1.2. T750U SPECIFICATIONS

Table 1-3. T750U System Specifications

| PARAMETER | SPECIFICATION |
|-------------------------------|--|
| Flow Measurement Accuracy | ± 1.0% of Full Scale |
| Repeatability of Flow Control | ± 0.2% of Full Scale |
| Linearity of Flow Measurement | ± 0.5% of Full Scale |
| Flow Range of Diluent Air | 0 to 10 SLPM – Optional Ranges: 0 to 5 SLPM; 0 to 20 SLPM |
| Flow Range of Cylinder Gases | 0 to 200 cc/min – Optional Ranges: 0 to 50 cc/min; 0 to 100 cc/min |
| Zero Air Required | 10 SLPM @ 30 psi – Optional: 20 SLPM @ 30 psi |
| Input Pressure | 20 to 40 psig |
| AC Power | Rating |
| | 100-240 V~ 50/60 Hz, 1.5 A |
| Typical Power Consumption | |
| 115 V: 76 W 230 V: 80 W | |
| Analog Outputs | 1 user configurable output |
| Analog Output Ranges | 10V, 5V, 1V, 0.1V (selectable) |
| Analog Output Resolution | 1 part in 4096 of selected full-scale voltage (12 bit) |
| Standard I/O | 1 Ethernet: 10/100Base-T |
| | 2 RS-232 (300 – 115,200 baud) |
| | 2 USB device ports |
| | 12 digital control outputs |
| | 12 digital control inputs |
| Optional I/O | 8 digital status outputs |
| | 1 USB com port |
| | 1 RS485 |
| Operating Temperature Range | 5-40°C |
| Humidity Range | 0 - 95% RH, non-condensing |

| PARAMETER | SPECIFICATION |
|--------------------------|--|
| Environmental Conditions | Installation Category (Over Voltage Category) II Pollution Degree 2 Intended for Indoor Use Only at Altitudes $\leq 2000\text{m}$ |
| Dimensions (H x W x D) | 9" x 17" x 21" (229 mm x 432 mm x 533 mm) |
| Weight | 46.6 lbs (21.14 kg) 3-MFC 45.1 lbs (20.46 kg) 2-MFC |

Table 1-4. T750U GPT and Option Specifications

| PARAMETER | SPECIFICATION |
|--|--------------------------------------|
| T750U NO₂ Generation (GPT Modes) | |
| Minimum Output | 20 ppb SLPM |
| Minimum Concentration: | 3 ppb |
| Precision | $\pm 2.0\%$ (with GPTPS) |
| T750U Ozone Generator Option | |
| Maximum Output | 5.5 ppm SLPM |
| Minimum Output | 20 ppb SLPM |
| Minimum Ozone Concentration | 3 ppb |
| Response Time | 180 seconds to 98% |
| Optical Feedback | Standard |
| T750U UV Photometer Option | |
| Range | 100 ppb to 10 ppm (selectable) |
| Precision | 1.0 ppb |
| Linearity | 1.0% of reading |
| Rise/Fall Time | <20 seconds (photometer response) |
| Response Time | 180 seconds to 95% (system response) |
| Zero Drift | <1.0 ppb / 24 hours |

1.3. APPROVALS AND CERTIFICATIONS

The Teledyne API Models T750 and T750U Calibrators were tested and certified for Safety and Electromagnetic Compatibility (EMC). This section presents the compliance statements for those requirements and directives.

1.3.1. SAFETY

IEC 61010-1:2010, 3rd Ed, Safety requirements for electrical equipment for measurement, control, and laboratory use.

CE: 2014/35/EU, Low-Voltage Directive

1.3.2. EMC

EN 61326-1 (IEC 61326-1), Class A Emissions/Industrial Immunity

FCC 47 CFR Part 15B, Class A Emissions

CE: 2014/30/EU, Electromagnetic Compatibility Directive



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1.4. OTHER TYPE CERTIFICATIONS

For additional certifications, please contact Technical Support:

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

Phone: +1 858-657-9800

Fax: +1 858-657-9816

Email: sda_techsupport@teledyne.com



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2. GETTING STARTED

Please note the following cautionary messages, and then proceed to the steps for unpacking.



CAUTION – AVOID PERSONAL INJURY

Depending on configuration the calibrator can weigh between ~37 and 47 lbs (16.8 - 21.3 kg). To avoid personal injury, we recommend using two persons to lift and carry the calibrator.



CAUTION – AVOID WARRANTY INVALIDATION

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>.



CAUTION – AVOID DAMAGE TO THE INSTRUMENT

BEFORE operating instrument, remove dust plugs from pneumatic ports.

Ensure that there is adequate support for the calibrator's weight.

NEVER allow instrument to run with the case closed – keep lid open to vent while operating, and ensure that the cooling fan/vents are not blocked; the vents are provided by a grill around the sides, visible when the case is open.

NEVER attempt to lift the calibrator by the interior handles attached to the control/display and input panel.



WARNING – ELECTRICAL SHOCK HAZARD

Never disconnect electronic circuit boards, wiring harnesses or electronic subassemblies while the unit is under power.

2.1. UNPACKING

Note

Although this product is portable, it must be properly packaged any time it ships for any reason; store the original shipping containers/materials for such use. If the calibrator does need servicing, refer to the Warranty page in this manual, page iv.

1. Before opening, inspect the received package(s) for external shipping damage. If damaged, please advise the shipper first, then Teledyne API.
2. Remove the calibrator from its shipping carton.
3. Open the lid and check for damage inside.
4. Check the line voltage and frequency label on the instrument to ensure that it matches the local power source.

2.2. VENTILATION AND CLEARANCE

Always keep portable calibrator's lid open to vent while operating.

Do not block vent grills.

2.3. INSTRUMENT LAYOUT

2.3.1. INPUT AND CONTROL PANEL

Figure 2-1 shows the location of the Input and Control Panel components. The two USB ports are provided for connecting customer-supplied peripheral devices such as a mouse as an alternative to touching the control interface, and/or a flash drive to download software/firmware updates.

Figure 2-2 shows the display screen, the orientation to which is described in Section 3.2.1, Figure 3-1. (The Communications and Output panel is presented in Section 2.3.2).

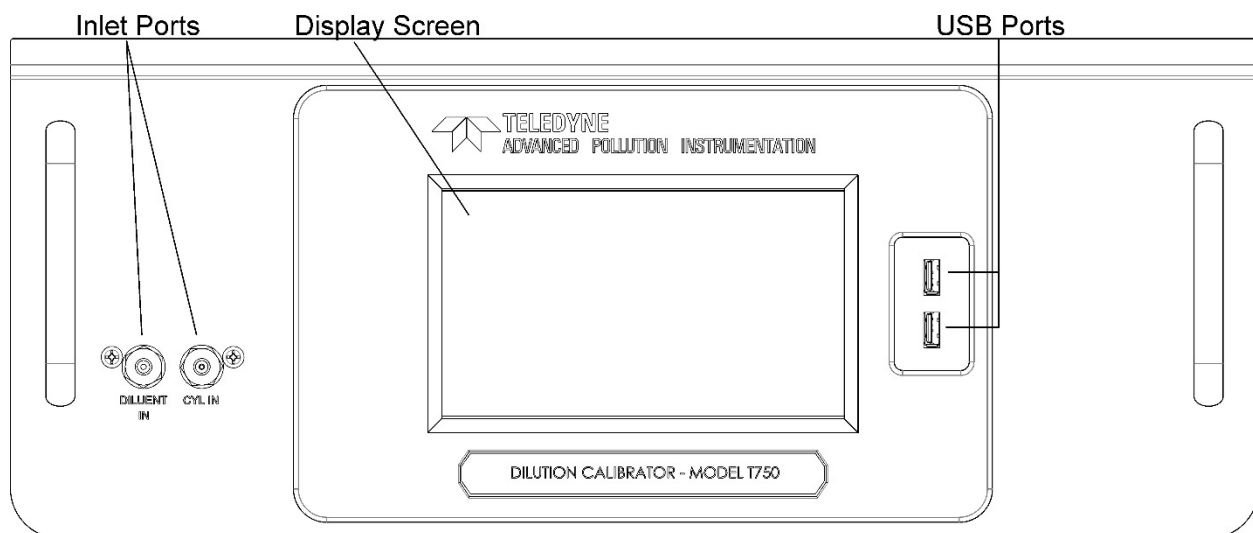


Figure 2-1. Control/Display and Input Panel (shown with Model T750 label)

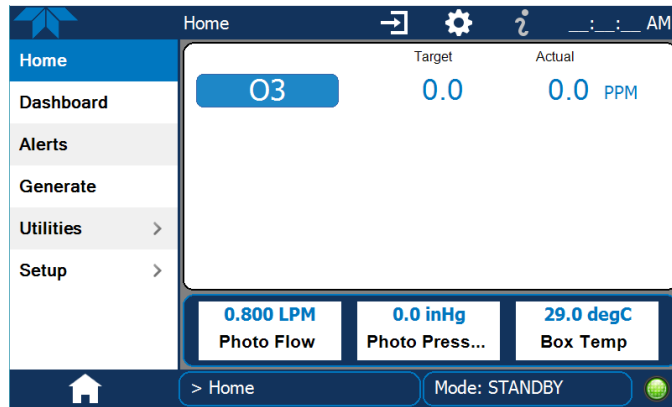


Figure 2-2. Display Screen and Touch Control

The Input and Control Panel liquid crystal display (LCD) screen includes touch control. Upon calibrator start-up, the LCD shows a splash screen and other initialization indicators before the main display appears.



CAUTION – AVOID DAMAGING TOUCHSCREEN

Do not use hard-surfaced instruments such as pens to operate the touch screen

2.3.2. COMMUNICATIONS AND OUTPUT PANEL

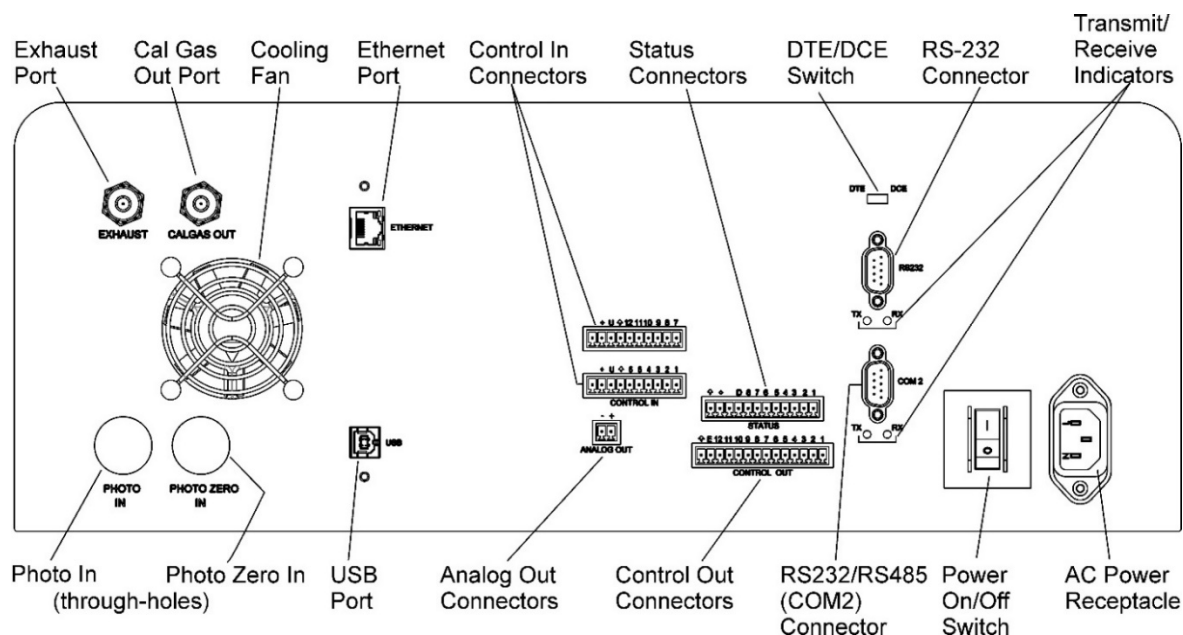


Figure 2-3. Communications and Output Panel

Table 2-1. Communications and Output Panel Description

| COMPONENT | FUNCTION |
|---------------------------|--|
| EXHAUST | Exhaust gas from ozone generator (and from photometer option if installed) – must be vented out of area. |
| CAL GAS OUT | Outlet for calibration gas |
| Fan | For cooling: pulls ambient air through chassis from side vents; exhausts through rear. |
| ETHERNET | Connector for network or Internet remote communication, using Ethernet cable. |
| CONTROL IN | For remotely activating the zero and span calibration modes. |
| STATUS | For outputs to devices such as Programmable Logic Controllers (PLCs). |
| DCE DTE | Switch to select either data terminal equipment or data communication equipment during RS-232 communication. (Section 5.1.1) |
| RS-232 | Serial communications port for RS-232 only. |
| RX TX | LEDs indicate receive (RX) and transmit (TX) activity on the when blinking. |
| COM 2 | Serial communications port for RS-232 or RS-485 (option). |
| AC Power Connector | Connector for three-prong cord to apply AC power to the instrument |
| Rocker Switch | Power on/off control |
| CONTROL OUT | 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. |
| USB | Connector for direct connection (option) to a personal computer, using USB cable. |
| PHOTO IN | Measurement gas input for O ₃ photometer (option) |
| PHOTO ZERO IN | Inlet for photometer Zero Gas (option) |
| ZERO AIR IN | Inlet for external zero air source – MUST BE CAPPED WHEN NOT CONNECTED. |



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2.3.3. INTERNAL LAYOUT

Figure 2-4 shows the internal layout of the calibrator.

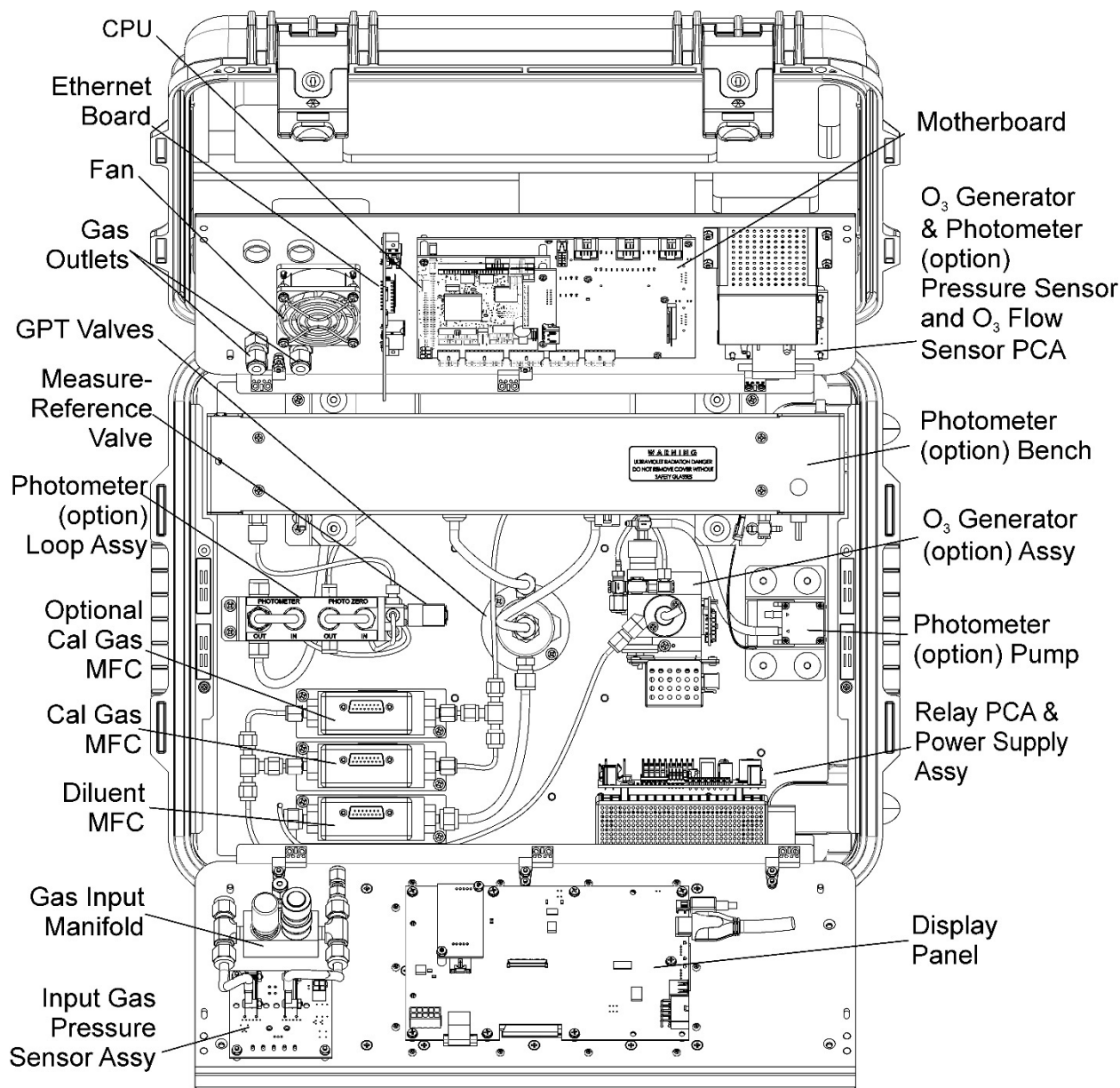


Figure 2-4. Internal Layout (components labeled “option” are standard in T750U)



2.4. CONNECTIONS AND STARTUP

This section presents the electrical (Section 2.4.1) and pneumatic (Section 2.4.2) connections for setting up and preparing the instrument for initial startup, which is presented in Section 2.5).

2.4.1. ELECTRICAL CONNECTIONS

Note

To maintain compliance with EMC standards, it is required that the power cord length be no greater than 3 meters.

2.4.1.1. Power Connection

Adhere to all cautionary messages!

Verify the correct line voltage and frequency configuration on the serial number tag of the calibrator. Connect the power cord from the calibrator's AC power receptacle to the proper power source.

WARNING – ELECTRICAL SHOCK HAZARD



- High Voltages are present inside the calibrator's case.
- Power connection must have functioning ground connection.
- Ensure that the power cord is properly grounded and adequately rated for the power rating of this instrument (see Specifications table).
- Turn off calibrator power before disconnecting or connecting electrical subassemblies.

CAUTION – AVOID PERSONAL INJURY



- DO NOT look at the photometer UV lamp; UV light can cause eye damage.
- Always wear glasses made from Safety UV filtering glass (plastic glasses are inadequate).

2.4.1.2. Connecting the Analog Output Channel

The analog output channel must be set by the user who can map it to any one of several functions, such as concentration value, temperatures, pressures, etc. The output signals range between 0 and 5 VDC.

To access these signals attach a strip chart recorder and/or data-logger to the analog output connector on the communications and output panel of the calibrator.

Configure and calibrate this channel through the **Setup>Analog Outputs** menu (Section 3.3.9), and view its output from the **Utilities>Diagnostics>Analog Outputs** menu.

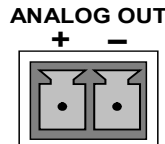


Figure 2-5. Analog Output Connector

2.4.1.3. Connecting the Status Outputs (Digital Outputs)

The status outputs report calibrator conditions via optically isolated NPN transistors, which 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.

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.

The status outputs are accessed via a 12-pin connector on the calibrator's communications and output panel labeled STATUS. The function of each pin is defined in Table 2-2. Select each output as desired and map to the signals available in the **Setup>Digital Outputs**.

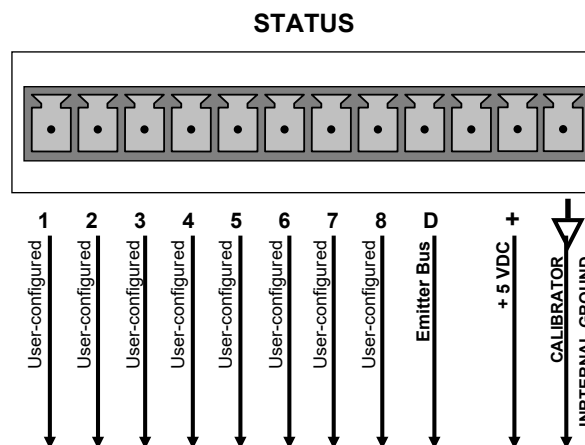



Figure 2-6. Status Output Connector

Table 2-2. Status Output Pin Assignments


| OUTPUT # | STATUS DEFINITION | CONDITION |
|---|----------------------|---|
| 1-8 | User-selected | |
| D | Emitter Bus | The emitters of the transistors on pins 1 to 8 are bussed together. |
| (blank) | No connection | |
| + | DC POWER | + 5 VDC |
|  | Digital Ground | The ground level from the calibrator's internal DC power supplies. |

2.4.1.4. Connecting the Control Inputs (Digital Inputs)

The calibrator is equipped with 12 digital control inputs that can be used to initiate various user programmable calibration sequences and can be turned ON or OFF in the **Utilities>Diagnostics** menu.

Access to these inputs is via two separate 10-pin connectors, labeled CONTROL IN, that are located on the calibrator's communications and output panel.

Table 2-3. Control Input Pin Assignments

| CONNECTOR | INPUT | DESCRIPTION |
|-----------------------------|---|--|
| labeled + thru 1 | 1 to 6 | Can be used as either 6 separate on/off switches or as bits 1 through 6 of a 12-bit wide binary activation code |
| labeled + thru 7 | 7 to 12 | Can be used as either 6 separate on/off switches or as bits 7 through 12 of a 12-bit wide binary activation code |
| both |  | Chassis ground. |
| labeled + thru 1 | U | Input pin for +5 VDC required to activate pins 1 – 6. This can be from an external source or from the "+" pin of the instrument's STATUS connector. |
| labeled + thru 7 | U | Input pin for +5 VDC required to activate pins 7 – 12. This can be from an external source or from the "+" pin of the instrument's STATUS connector. |
| both | + | Internal source of +5V used to actuate control inputs when connected to the U pin. |

There are two methods for energizing the control inputs (Figure 2-7): The internal +5V available from the pin labeled "+" is the most convenient method. However, if full isolation is required, an external 5 VDC power supply should be used.

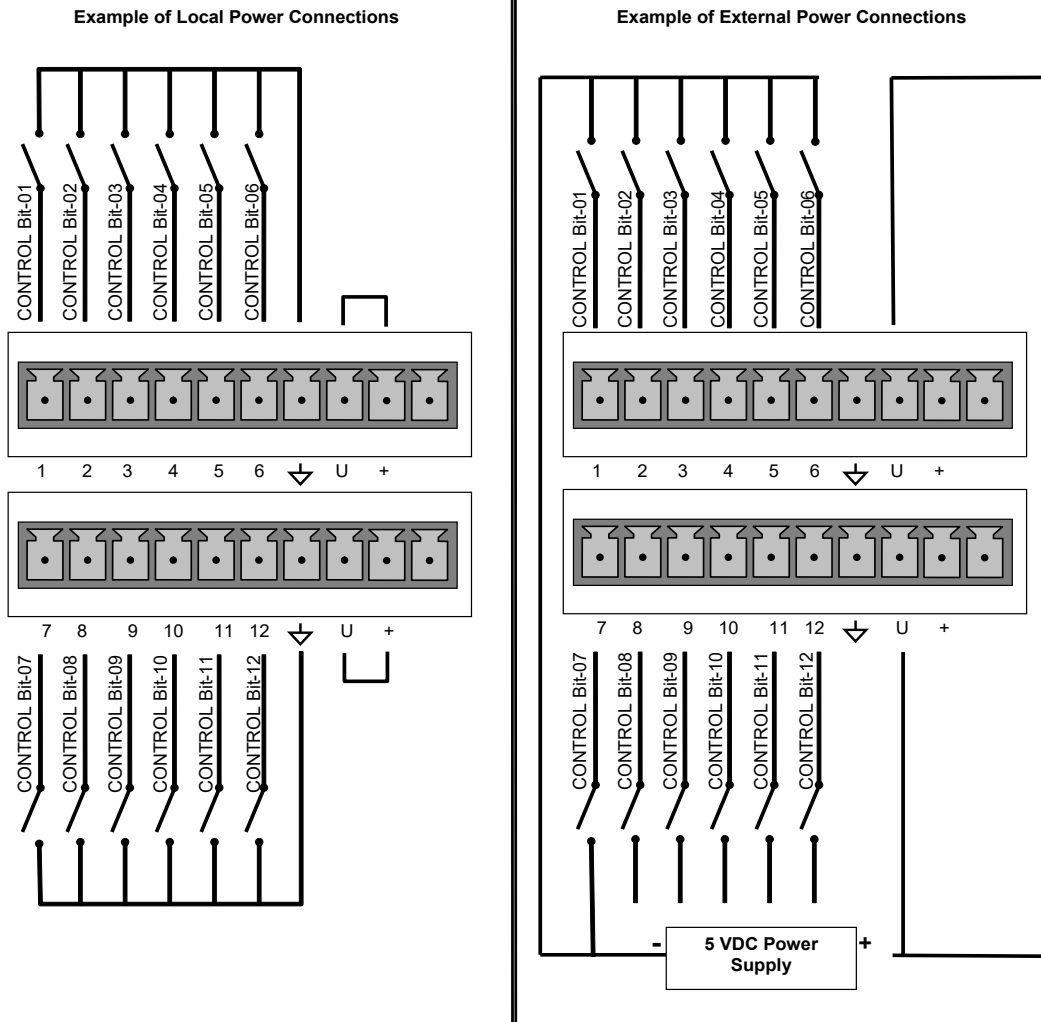


Figure 2-7. Digital Control Input Connectors

2.4.1.5. Connecting the Control Outputs (Digital Outputs)

The calibrator is equipped with 12 opto-isolated, digital control outputs, which may be used to interface with devices that accept logic-level digital inputs, such as programmable logic controllers (PLCs), data loggers, or digital relays/valve drivers.

These outputs are accessed via a 14-pin connector on the calibrator's communications and output panel and can be activated in any of three places in the **Setup>Sequence** menu (see Section 4.2.7.4 for instructions on assigning the control outputs to specific calibration sequences or as a default method when sequences are not running).

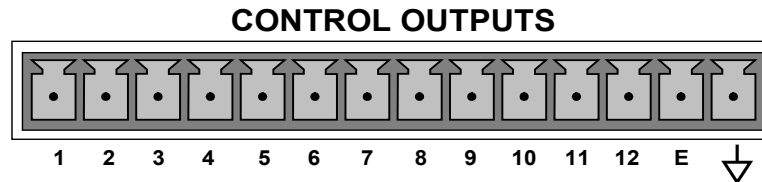



Figure 2-8. Digital Control Output Connector

Note

Most PLCs have internal provisions for limiting the current the input will draw. When connecting to a unit that does not have this feature, external resistors must be used to limit the current through the individual transistor outputs to $\leq 50\text{mA}$ ($120\ \Omega$ for 5V supply).

Table 2-4. Control Output Pin Assignments

| PIN # | STATUS DEFINITION | CONDITION |
|---|-----------------------------------|--|
| 1 - 12 | Outputs 1 through 12 respectively | Closed if the sequence or sequence step activating output is operating |
| E | Emitter Bus | The emitters of the transistors on pins 1 to 8 are bussed together. |
|  | Digital Ground | The ground level from the calibrator's internal DC power supplies. |

2.4.1.6. Connecting the Communication Interfaces

The T-Series instruments are equipped with connectors for remote communications interfaces.

In addition to using the appropriate cables, each type of communication method must be configured using the **Setup>Comm** menu, which is presented later in this manual (Section 3.3.11).

ETHERNET CONNECTION

For network or Internet communication with the instrument, connect an Ethernet cable from Ethernet interface connector to an Ethernet port.

The calibrator firmware supports dynamic IP addressing or DHCP for remote operation via an Ethernet connection. Although the calibrator is shipped with DHCP enabled by default, it should be manually assigned a static IP address (**Setup>Comm>Network Settings** menu, Section 3.3.11.4).

USB OPTION CONNECTION

For direct communication between the instrument and a personal computer (PC), connect a USB cable between the instrument and desktop or laptop USB ports. (If this option is installed, the COM2 port can only be used for RS232 multidrop communication). Computer and instrument baud rates must match (**Setup>Comm>COM[1, 2]** menu, Section 3.3.11.1).

RS-232 AND RS-485 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 (Option 60B) or a DB9-female-to-DB25-male cable (Option 60A), as applicable, from the communications and output panel RS-232 port to the device.

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 2-9) before using.

RS-232 COM PORT CONNECTOR PIN-OUTS

Electronically, the difference between the DCE and DTE 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.

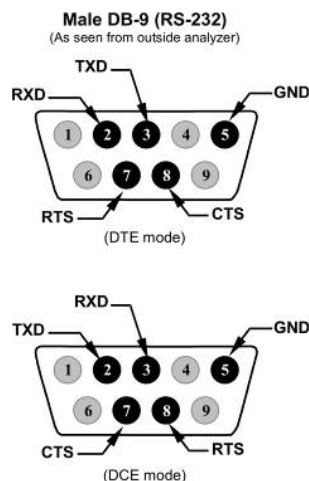


Figure 2-9. Connector Pin-Outs for RS-232 Mode

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 below the RS-232 port. Once a cable is connected between the calibrator and a computer or modem, both the red and green LEDs should be on.

If the LEDs are not lit, locate the small switch on the communications and output panel to switch it between DTE and DCE modes.

If both LEDs are still not illuminated, ensure that the cable properly constructed.

RS-232 COM PORT DEFAULT SETTINGS

Received from the factory, the calibrator is set up to emulate a DCE or modem, with Pin 3 of the DB-9 connector designated for receiving data and Pin 2 designated for sending data. (See Section 3.3.11 for configuration).

- **RS-232 (COM1):** RS-232 (fixed)
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)
Baud rate: 115200 bits per second (baud)
Data Bits: 8 data bits with 1 stop bit
Parity: None

RS-232 MULTI-DROP (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 calibrator's communications and output 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 electrostatic 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, see *Fundamentals of ESD* manual, PN 04786, available on 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 2-10. 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, lay the communications and output 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 Figure 2-10,. (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 2-10, and note that the CPU's COM2 connector is not used in Multidrop):
 - J3 on the Multidrop/LVD S PCA to the CPU's COM1 connector
 - J4 on the Multidrop/LVDS PCA to J12 on the motherboard
 - J1 on the Multidrop/LVDS PCS to the LCD display and touchscreen panel



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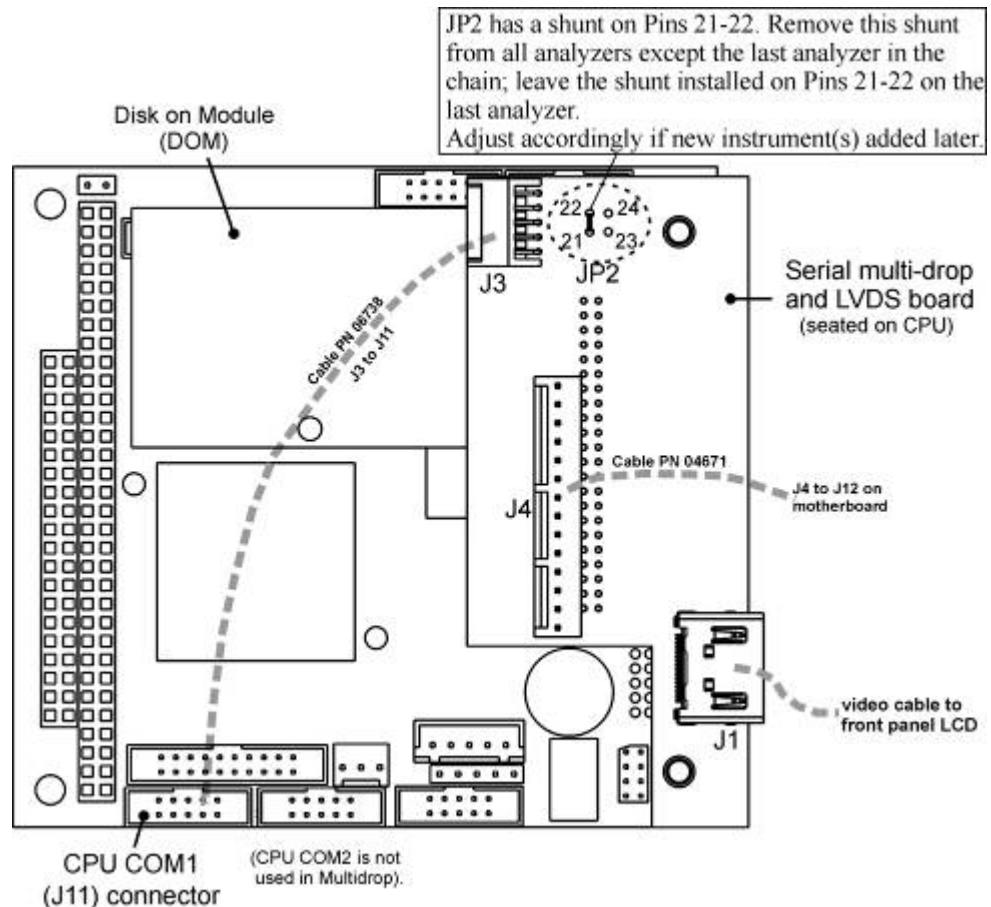


Figure 2-10. Jumper and Cables for Multidrop Mode

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 2-11 use straight-through DB9 male → DB9 female cables to interconnect the host RS232 port to the first calibrator's RS232 port; then from the first calibrator's COM2 port to the second calibrator's RS232 port; from the second calibrator's COM2 port to the third calibrator's RS232 port, etc., connecting in this fashion up to eight calibrators, subject to the distance limitations of the RS-232 standard.
6. On the communications and output panel of each calibrator, 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).

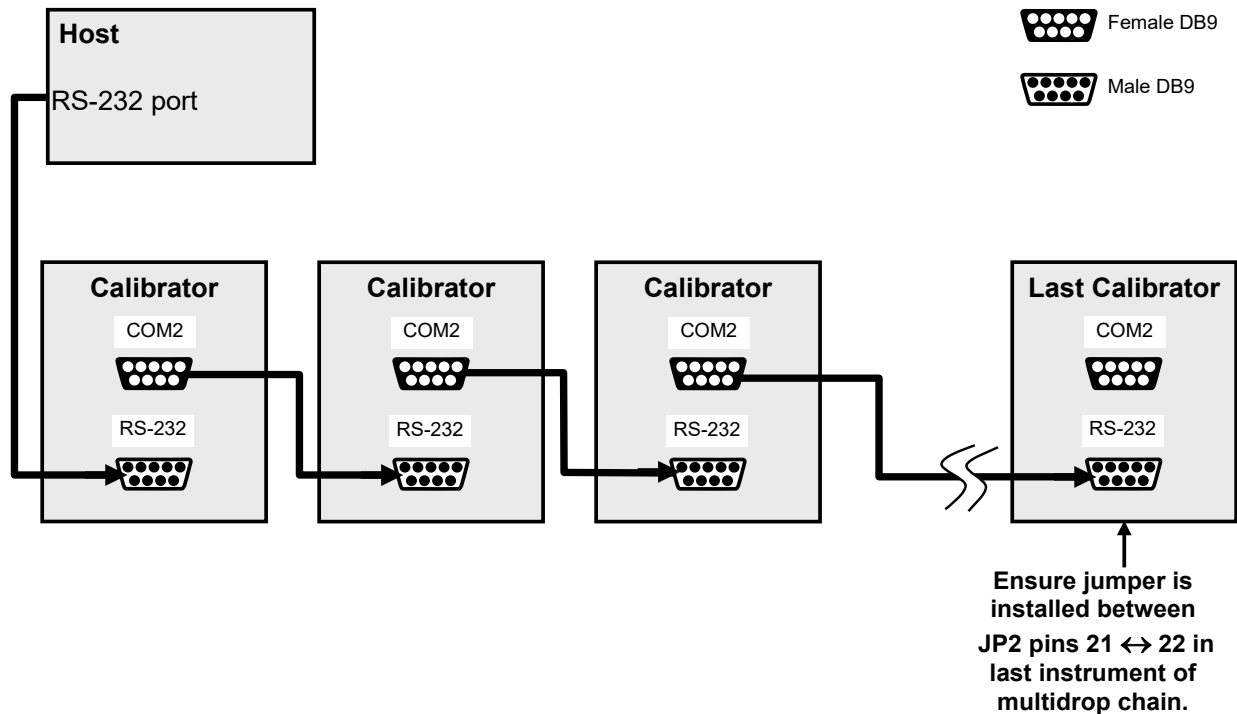


Figure 2-11. RS-232-Multidrop PCA Host/Calibrator Interconnect Diagram

7. *Before* communicating from the host, power on the instruments and check that the Machine ID code is unique for each.
 - a. Navigate to **Setup>Vars>Instrument ID**.
 - b. to change the identification number, select the VAR, press the Edit button and use the keypad to assign a new ID
 - c. Press/select ENTER to accept the new ID for that instrument.
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).

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

RS-485 CONNECTION

As delivered from the factory, COM2 is configured for RS-232 communications. This port can be reconfigured for operation as a non-isolated, half-duplex RS-485 port. Using COM2 for RS-485 communication disables the USB port. To reconfigure this port for RS-485 communication, please contact the factory.

2.4.2. PNEUMATIC CONNECTIONS

This section presents the pneumatic input and output connections; Section 2.4.3 presents the pneumatic flow diagrams.

Note

Each time the pneumatic configuration is changed for any purpose, a backpressure compensation calibration must be performed (Section 6.2.3).

CAUTION – RISK OF INHALATION AND ASPHYXIATION



When this calibrator is used to generate ozone (O₃), it must be properly vented outside the room or enclosure. Follow connection illustrations and instructions carefully.

CAUTION – Avoid Damage to the Instrument



Do not operate this instrument without first removing dust plugs from inlet and outlet/exhaust ports!

2.4.2.1. About Diluent Gas (Zero Air)

Zero Air is similar in chemical composition to the Earth's atmosphere but scrubbed of all components that might affect the calibrator's readings.

- Diluent Air should be dry (approximately -20°C of Dew Point).
- Diluent Air should be supplied at a gas pressure of between 25 PSI and 35 PSI with a flow greater than the flow rate for the calibrator. For the standard unit this means greater than 10 SLPM.
- For calibrators with the 20 SLPM diluent flow option the diluent air should be supplied at a gas pressure of between 30 PSI and 35 PSI.
- T750 calibrators with optional O₃ generators installed require that the zero air source supply gas flowing at a continuous rate of at least 100 cm³/min.
- If the calibrator is also equipped with an internal photometer, the zero air source supply gas must be capable of a continuous rate of flow of at least 1.1 SLPM.

Zero Air can be purchased in pressurized canisters or created using a Teledyne API's Model 701 Zero Air Generator.

2.4.2.2. About Calibration Gas

Calibration gas is a gas specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired measurement range. Usually it is a single gas type mixed with N₂ although bottles containing multiple mixtures of compatible gases are also available (e.g. H₂S, O₂ and CO mixed with N₂).

- Calibration gas should be supplied at a pressure of between 25 PSI and 35 PSI with a flow greater than the flow rate for the calibrator.

NIST TRACEABLE CALIBRATION GAS STANDARDS

All calibration gases should be verified against standards of the National Institute for Standards and Technology (NIST). To ensure NIST traceability, we recommend acquiring

cylinders of working gas that are certified traceable to NIST Standard Reference Materials (SRM). These are available from a variety of commercial sources.

MINIMUM CALIBRATION GAS SOURCE CONCENTRATION

To determine the minimum Cal Gas Concentration required by your system:

1. Determine the Total Flow required by your system by adding the gas flow requirement of each of the analyzers in the system.
2. Multiply this by 1.5.
3. Decide on a Calibration Gas flow rate.
4. Determine the Calibration Gas ratio by dividing the Total Flow by the Calibration Gas Flow Rate.
5. Multiply the desired target calibration gas concentration by the result from step 4.

EXAMPLE: Your system has two analyzers each requiring 2 SLPM of cal gas flow.

$$2 \text{ SLPM} + 2 \text{ SLPM} = 4 \text{ SLPM}$$

$$4 \text{ SLPM} \times 1.5 = 6 \text{ SLPM} = \text{Total Gas Flow Rate}$$

If the T750 calibrator is configured so that the cal gas flow rate is 2 SLPM (therefore the Diluent Flow Rate would need to be set at 4 SLPM) the Calibration Gas ratio would be:

$$6 \text{ SLPM} \div 2 \text{ SLPM} = 3:1$$

Therefore, if your Target Calibration Gas Concentration is intended to be 200 ppm, the minimum required source gas concentration for this system operating at these flow rates would be:

$$3 \times 200\text{ppm} = 600 \text{ ppm}$$

2.4.2.3. Connecting Diluent Gas to the Calibrator

1. Attach the zero air source line to the port labeled Diluent In.
2. Use the fittings provided with the calibrator to connect the zero air source line.
 - First, finger tighten.
 - Then using the properly sized wrench, make an additional 1 and ¼ turn.

2.4.2.4. Connecting Calibration Source Gas to the Calibrator

Connect the source gas line to the CYL IN port (see Figure 2-1).

- Source gas delivery pressure should be regulated between 25 PSI to 30 PSI.
- Use stainless steel tubing with a 1/8 inch outer diameter.

2.4.2.5. Connecting Gas Outputs from the Calibrator



CAUTION – ASPHYXIATION HAZARD

Exhaust and Cal Gas Out ports must be vented properly. Carefully adhere to the pneumatic connection instructions

SETUP FOR DIRECT CONNECTIONS TO OTHER INSTRUMENTS

Use this setup if you are connecting the T750 calibrator directly to other instruments without the use of any shared manifolds.

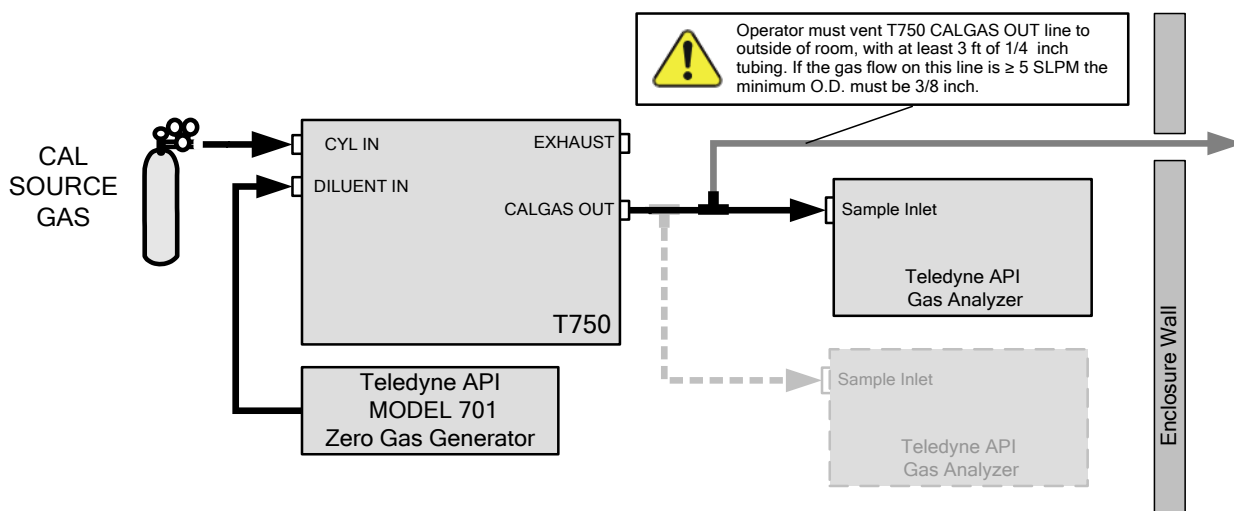


Figure 2-12. Set up for T750 – Connecting the Basic T750 to a Sample Manifold

To determine if the gas flow on the vent line is ≥ 5 SLPM, subtract the gas flow for each instrument connected to the outlets of the T750 from the TOTAL FLOW setting for the calibrator (see Section 2.5.5).

If the T750 has the optional O₃ photometer installed, remember that this option requires 800 cc³/min (0.8 SLPM) of additional flow (see Section 2.5.5 or Figure 2-18).

EXAMPLE: Your system has two analyzers each requiring 2 SLPM of cal gas flow and the T750 includes the O₃ photometer. If the TOTAL FLOW rate for the calibrator is set at 10 SLPM:

$$10 \text{ SLPM} - 2 \text{ SLPM} - 2 \text{ SLPM} - 0.8 \text{ SLPM} = 5.2 \text{ SLPM}$$

Therefore, the vent would require a gas line with an O.D. 3/8 inch.



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CONNECTING THE CALIBRATOR TO A SAMPLE GAS MANIFOLD

Use this setup when connecting the T750 calibrator to an analyzer network using a sample manifold. In this case, the sampling cane and the manifold itself act as the vent for the T750.

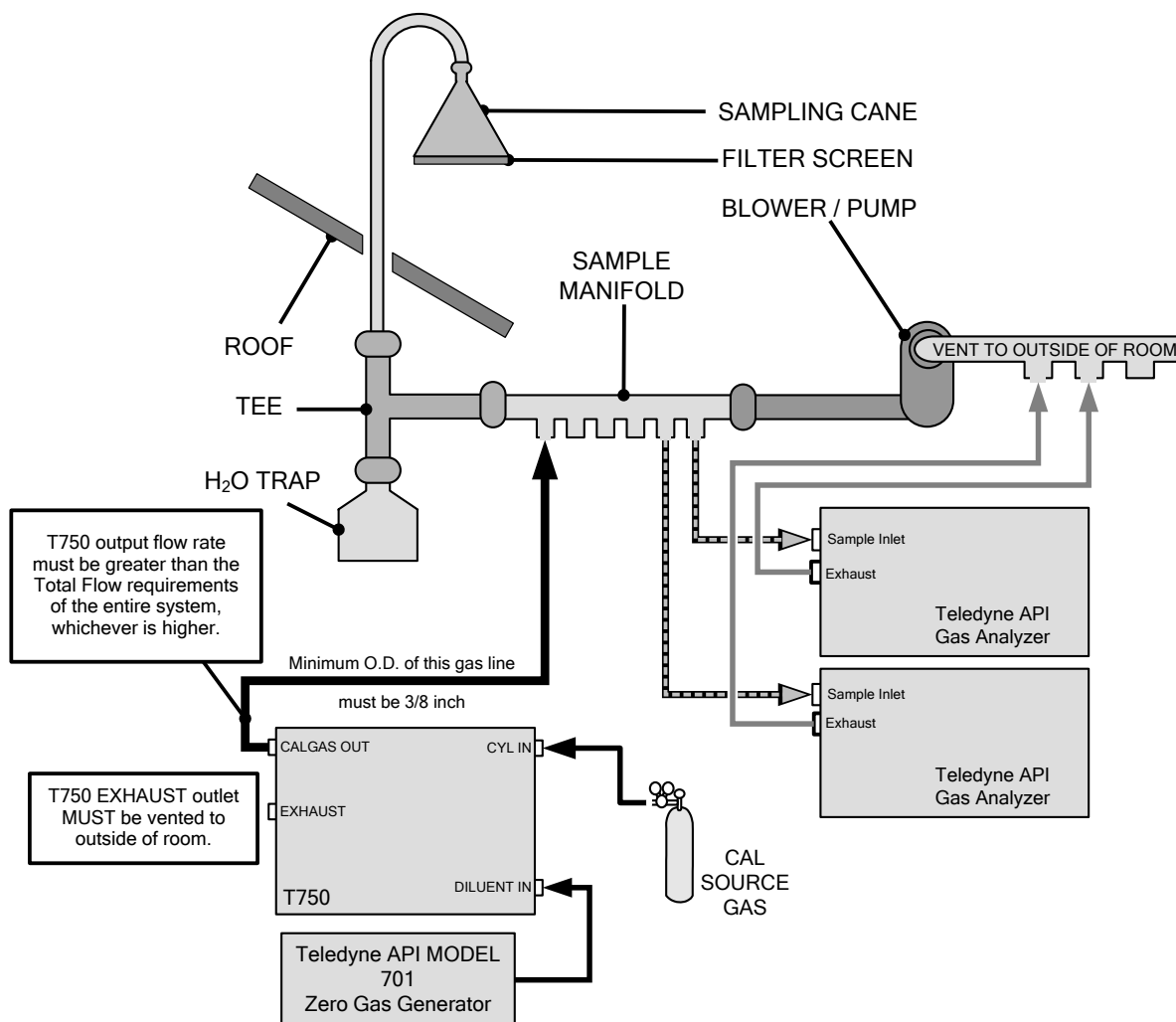


Figure 2-13. Connections to a Sample Gas Manifold

Note

- This is the recommended method for connecting the T750 calibrator to a system with analyzers that DO NOT have internal zero/span valves.
- The manifolds as shown in the above drawing are oriented to simplify the drawing. Their actual orientation in your set-up is with the ports facing upward. All unused ports must be capped.
- When initiating calibration, wait a minimum of 15 minutes for the calibrator to flood the entire sampling system with calibration gas.

CONNECTING THE CALIBRATOR TO A CALIBRATION MANIFOLD

Using a calibration manifold provides a pneumatic interface between the calibration system and other devices (or systems) which use the calibrator's gas output. Calibration manifolds usually have one or more ports for connections to other external devices (such as an analyzer).

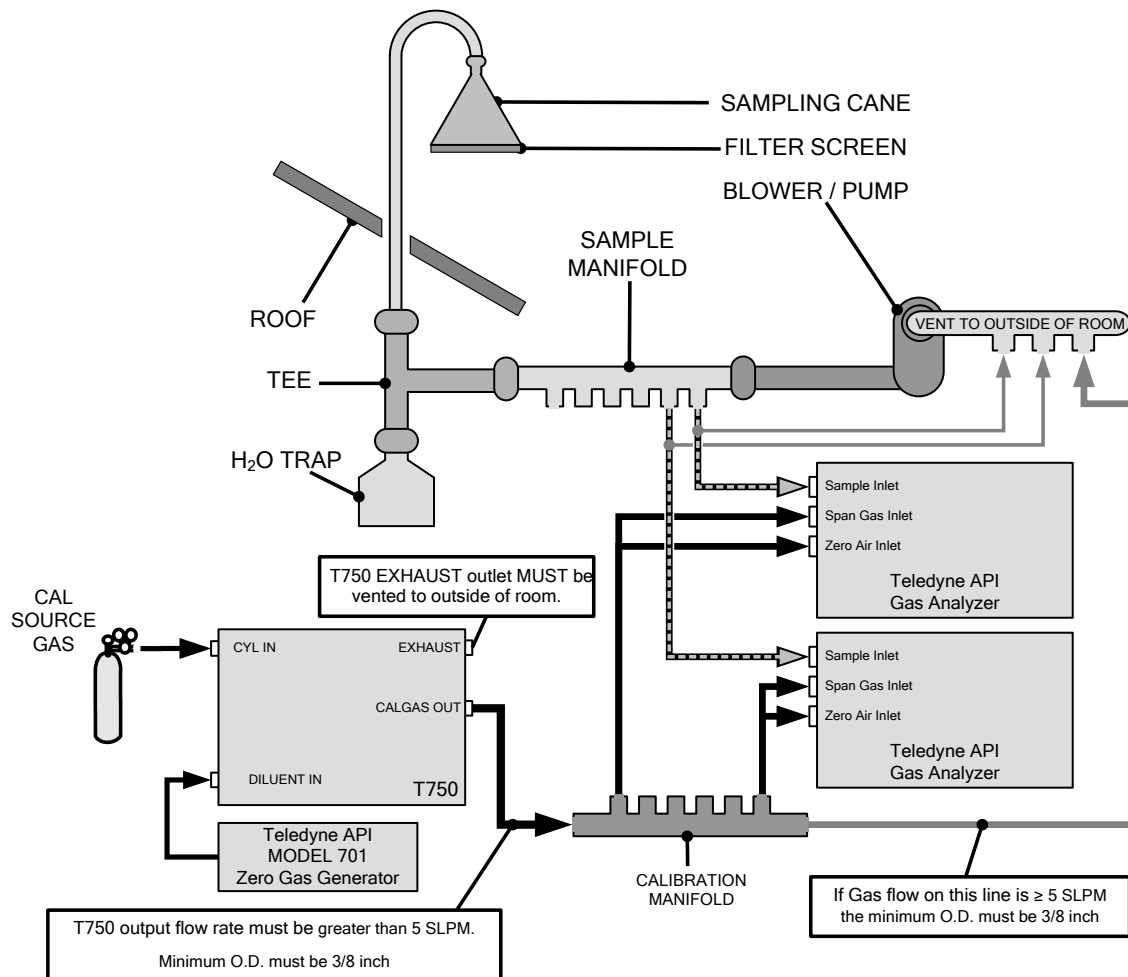


Figure 2-14. Connections to Calibration Manifold

Note

- This method requires the analyzers connected to the calibration system have internal zero/span valves.
- The manifold should be kept as clean as possible to avoid loss of sample gas flow from blockages or constrictions.
- The manifolds as shown in the above drawing are oriented to simplify the drawing. Their actual orientation in your set-up is with the ports facing upward. All unused ports must be capped.
- When initiating calibration, wait a minimum of 15 minutes for the calibrator to flood the entire calibration manifold with calibration gas.



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CALIBRATION MANIFOLD EXHAUST/VENT LINE

The manifold's excess gas should be vented outside of the room. This vent should be of large enough internal diameter to avoid any appreciable pressure drop, and it must be located sufficiently downstream of the output ports to assure that no ambient air enters the manifold due to eddy currents or back diffusion.

CONNECTING THE CALIBRATOR TO A DUAL SPAN GAS/ZERO AIR CALIBRATION MANIFOLD

Another type of calibration setup utilizes separate span gas and the zero air manifolds (see Figure 3 17).

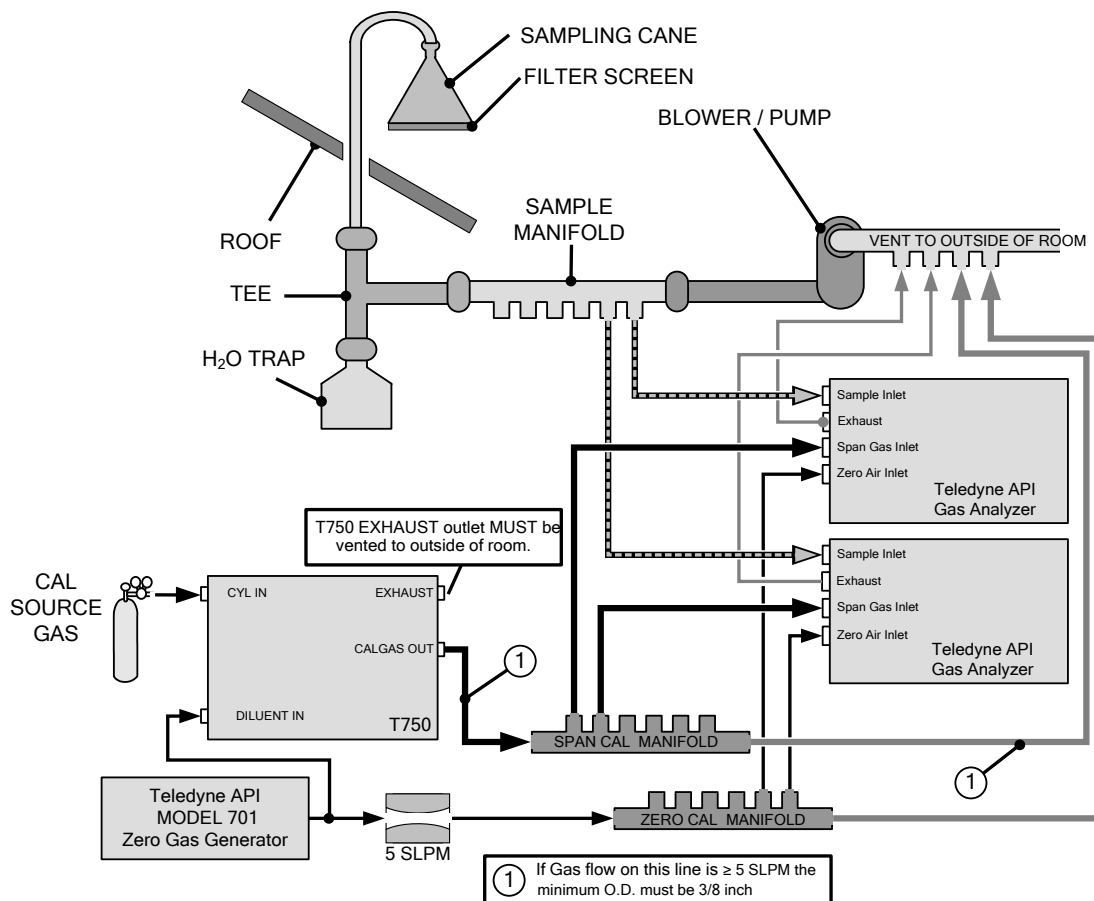


Figure 2-15. Connections to a Dual Span Gas / Zero Air Manifold

Note

This set up is subject to the same notes and conditions as the single calibration manifold described previously with the following two exceptions:

- The T750 total gas flow rate (Cal Gas Flow Rate + Diluent Flow Rate) out should be greater than the Total Flow requirements of the entire system.
- The manifolds as shown in the above drawing are oriented to simplify the drawing. Their actual orientation in your set-up is with the ports facing upward. All unused ports must be capped.

SPAN GAS/ZERO AIR CALIBRATION MANIFOLD EXHAUST/VENT LINES

The span and zero air manifolds' excess gas should be vented to a suitable vent outside of the room. This vent should be of large enough internal diameter to avoid any appreciable pressure drop, and it must be located sufficiently downstream of the output ports to assure that no ambient air enters the manifold due to eddy currents or back diffusion.

2.4.3. PNEUMATIC FLOW DIAGRAMS

The diagrams that apply to the T750U are those that include both the Ozone Generator and the Photometer: Figure 2-18 and Figure 2-20.

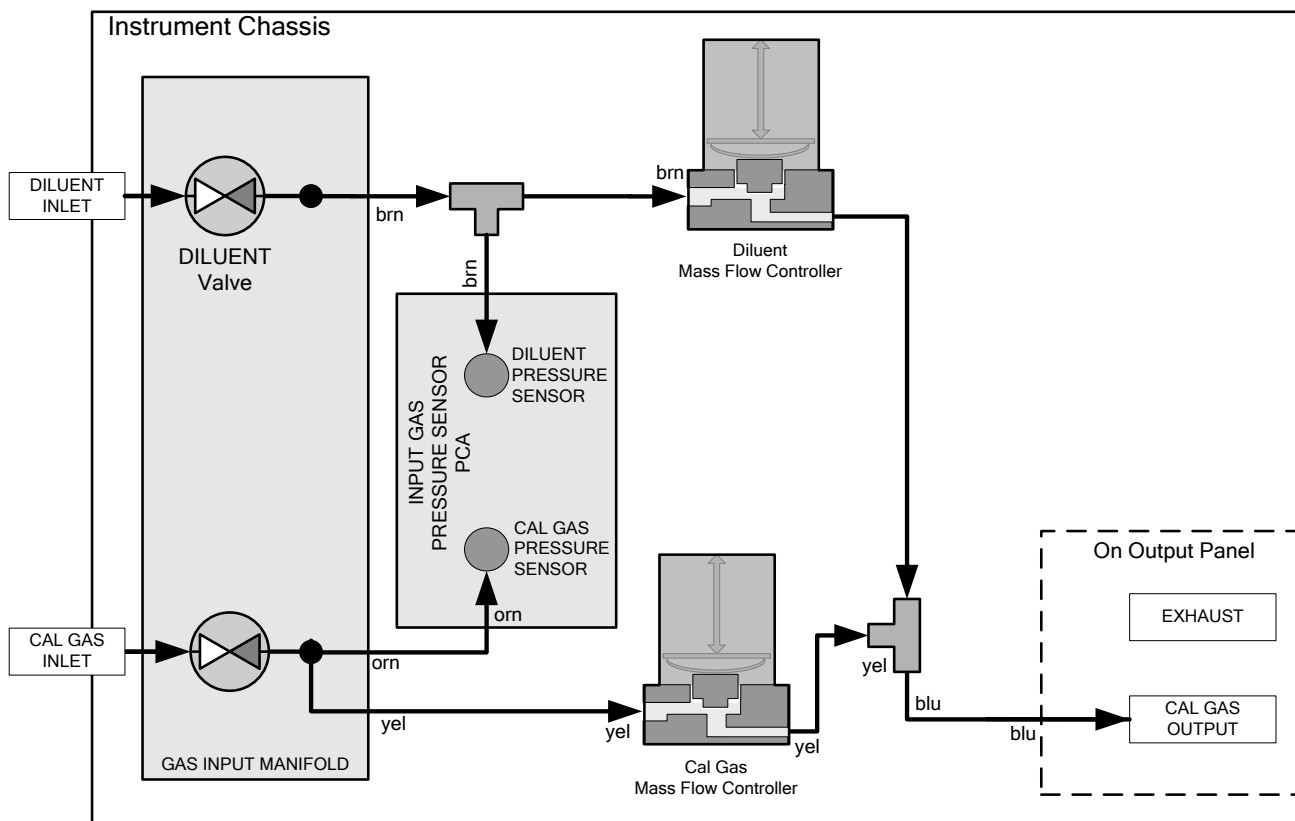


Figure 2-16. T750 Pneumatic Diagram – Base Unit

The standard T750 Portable Calibrator is equipped with one calibration gas mass flow controller (flow rate 0 – 100 cm³/min) and one diluent gas mass flow controller (flow rate 0-10 SLPM).

2.4.3.1. Flow Diagrams with Other Pneumatic Connections

Some of the T750 Portable Calibrator's optional equipment requires additional pneumatic connections.

O₃ GENERATOR OPTION

Because ozone (O₃) quickly breaks down into molecular oxygen (O₂), this calibration gas cannot be supplied in precisely calibrated bottles like other gases such as SO₂, CO, CO₂, NO, H₂S, etc. The optional O₃ generator extends the capabilities of the T750 Portable Calibrator to dynamically generate calibration gas mixtures containing O₃.

Additionally, a glass mixture volume, designed to meet US EPA guidelines for Gas Phase Titration (GPT), is included with this option. This chamber, in combination with the O₃ generator, allows the T750 to use the GPT technique to more precisely create NO₂ calibration mixtures.

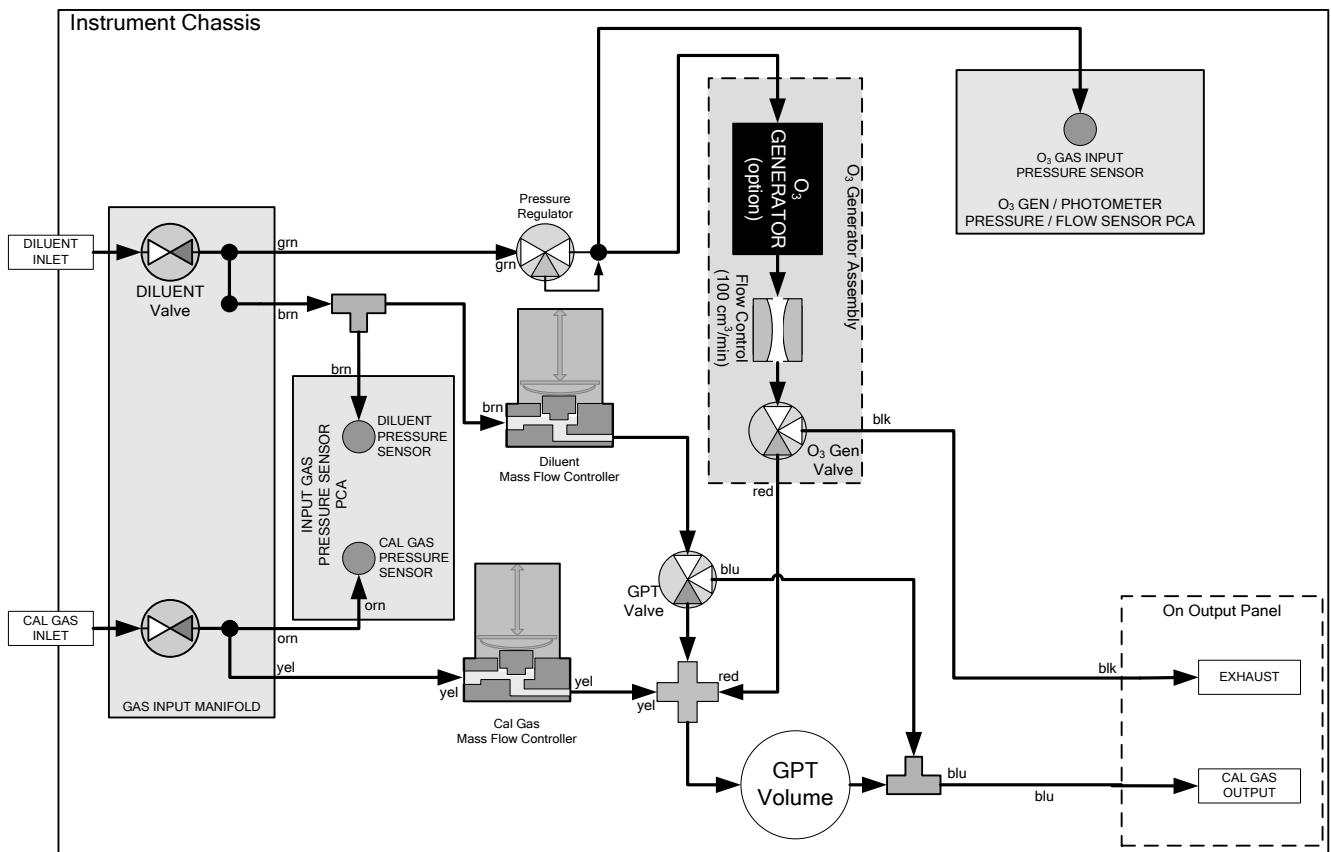


Figure 2-17. T750 Pneumatics with Optional O₃ Generator and GPT Chamber

Table 2-5. Valve States for T750 Calibrator with Optional O₃ Generator.

| MODE | VALVES (X = Closed; O = Open) D = Degenerated; E = Energized | | | | MFCs | | |
|-------------------------|--|------------|-----|--------------------|-----------------|-------------------|---------|
| | CYL IN | DILUENT IN | GPT | O ₃ GEN | CAL1 | CAL2 ¹ | DILUENT |
| Generate Source Gas | O ² | O | D | D | ON ³ | ON ³ | ON |
| Generate O ₃ | X | O | D | E | OFF | OFF | OFF |
| Leak Check 0-17% | X | O | D | D | ON | ON | ON |
| Leak Check 17%-100% | X | X | D | D | ON | ON | ON |
| GPT | O ² | O | E | E | ON ³ | ON ³ | ON |
| GPTZ | O | O | E | E | ON | ON | ON |
| GPTPS | X | O | D | E | OFF | OFF | ON |
| STANDBY | X | O | D | D | OFF | OFF | OFF |

¹ Only present if multiple cal gas MFC option is installed.

² The valve associated with the cylinder containing the chosen source gas is open.

³ In instruments with multiple MFCs, the CPU chooses which MFC to use depending on the target gas flow requested.

The output of the O₃ generator can be controlled in either of two ways, configured through the **Setup>Vars>O₃ Gen Mode** menu:

- **CONSTANT mode:** By selecting a specific, constant drive voltage (corresponding to a specific O₃ concentration) for the generator, or;
- **BENCH mode:** The user selects a desired O₃ concentration, and the calibrator's CPU sets the intensity of the O₃ generator's UV lamp to a drive voltage corresponding to that concentration.

See Section 9.7 for more details on the operation of the O₃ generator.

In addition to the diluent gas, calibration source gas, and gas output connections discussed in the preceding sections, this option also requires an O₃ exhaust line be connected to the EXHAUST outlet on the output panel of the T750.

Note

- **The EXHAUST line must be vented to atmospheric pressure using maximum of 10 meters of ¼" PTFE tubing.**
- **Venting must be outside the shelter or immediate area surrounding the instrument.**

O₃ GENERATOR WITH PHOTOMETER OPTION

The photometer option increases the accuracy of the T750 calibrator's optional O₃ generator by directly measuring O₃ content of the gas output by the generator.

The photometer's operation is based on the principle that ozone molecules absorb UV light of a certain wavelength. A mercury lamp internal to the photometer emits UV light at that wavelength. This light shines down a hollow glass tube that is alternately filled with sample gas (the measure phase), and zero gas (the reference phase). A detector, located at the other end of the glass tube, measures the brightness of the UV light after it passes through the gas

in the tube. The O₃ content of the gas is calculated based on the ratio the UV light intensity during the measure phase (O₃ present) and the reference phase (no O₃ present).

When the photometer option is installed, a third more precise and stable option, called the BENCH feedback mode, exists for controlling the output of the O₃ generator. In BENCH mode the intensity of the O₃ generator's UV lamp is controlled (and therefore the concentration of the O₃ created) by the T750's CPU based on the actual O₃ concentration measurements made by the photometer.

The O₃ photometer option requires that the O₃ generator also be installed. See Sections 9.7 and 9.8 for more details on their operation.

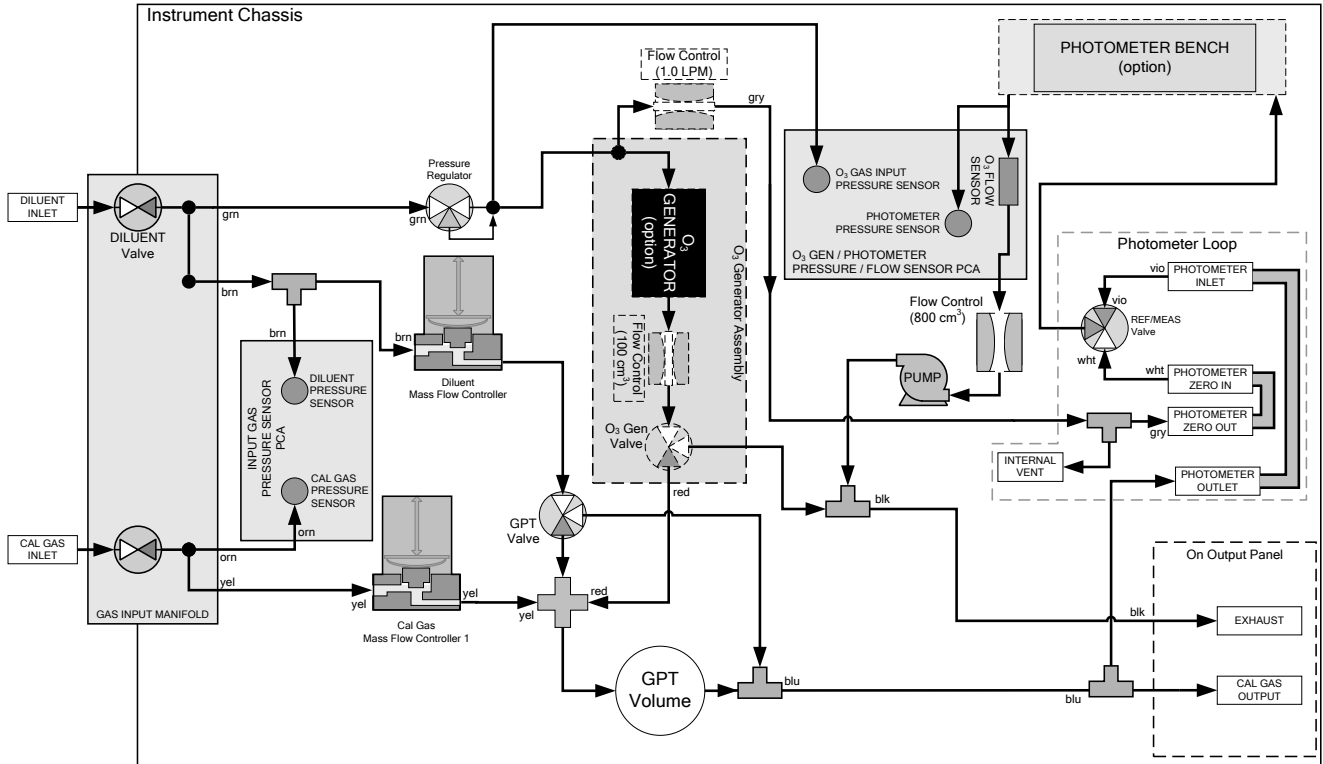


Figure 2-18. Flow with O₃ Generator and Photometer (Options in T750)

Table 2-6. Valve States with Optional O₃ Generator and Photometer (Options in T750)

| GAS TYPE | VALVES (X = Closed; O = Open) (D = Deenergized; E = Energized) | | | | | MFCs | | | PHOT PUMP |
|-------------------------|--|------------|-----|--------------------|-----------------|-----------------|-------------------|---------|-----------------|
| | CYL IN | DILUENT IN | GPT | O ₃ GEN | PHOT M/R | CAL | CAL2 ¹ | DILUENT | |
| Generate Source Gas | O | O | D | D | Reference Phase | ON ³ | ON ² | ON | OFF |
| Generate O ₃ | X | O | D | E | Switching | OFF | OFF | OFF | ON ³ |
| Leak Check 0-17% | X | O | D | D | | ON | ON | ON | |
| Leak Check 17%-100% | X | X | D | D | | ON | ON | ON | |
| GPT | O | O | E | E | Reference Phase | ON ² | ON ² | ON | OFF |
| GPTZ | O | O | E | E | Reference Phase | ON | ON | ON | OFF |
| GPTPS | X | O | D | E | Switching | OFF | OFF | ON | ON ³ |
| STANDBY | X | O | D | D | Reference Phase | OFF | OFF | OFF | OFF |

¹ Only present if multiple cal gas MFC option is installed.

² In an instrument with multiple MFCs the CPU chooses which MFC to use depending on the target gas flow requested.

³ When generating O₃ or in GPT Pre-Set mode, the photometer pump is the primary creator of gas flow through the T750. Flow rates are controlled by critical flow orifice(s) located in the gas stream

In addition to the connections discussed in the previous sections, this option also requires the following:

- Loop back lines must be connected between:
 - PHOTOMETER OUTLET fixture and the PHOTOMETER INLET fixture.
 - PHOTOMETER ZERO OUT fixture and the PHOTOMETER ZERO IN fixture.
- An O₃ exhaust line must be connected to the **EXHAUST** outlet.

See Figure 2-4. Internal Layout for the location of these fixtures.

Note

- The **EXHAUST** line must be vented to atmospheric pressure using maximum of 10 meters of 1/4" PTFE tubing.
- Venting must be outside the shelter or immediate area surrounding the instrument.

MULTIPLE CALIBRATION SOURCE GAS MFC'S

An optional third mass flow controller can be added on the calibration gas stream. When this option is installed, the T750 has both calibration gas MFCs on the same gas stream, installed in parallel (see Figure 2-19 and Figure 2-20). The calibrator turns on the MFC with the lowest flow rate that can accommodate the requested flow and can therefore supply the most accurate flow control. When a flow rate is requested that is higher than the highest rated MFC (but lower than their combined maximum flow rating), both controllers are activated.

EXAMPLE:

- Calibrator with one calibration gas MFC configured for 0-5 SLPM:
Maximum gas flow = 5 SLPM
Minimum gas flow = 500 cm³/min
- Calibrator with two calibration gas MFCs configured for 0-1 SLPM and 0-5 SLPM:

Calibration gas flow rates:

- 5.001 to 6.000 SLPM; both MFCs active
- 1.001 SLPM – 5.000 SLPM; High MFC active;
- 0.100 SLPM – 1.000 SLPM; Low MFC active

When the third MFC option is installed, the Dashboard parameters that show the MFC actual and target flows, Cal Flow Actual and Ca Flow Targ, show the sum of the flows of all the active MFCs. On the other hand, the Dashboard parameter that show the pressure measurement, Cal Gas Press, shows the pressure for only one MFC, not the sum as it is assumed that gas pressure is the same for all MFCs.

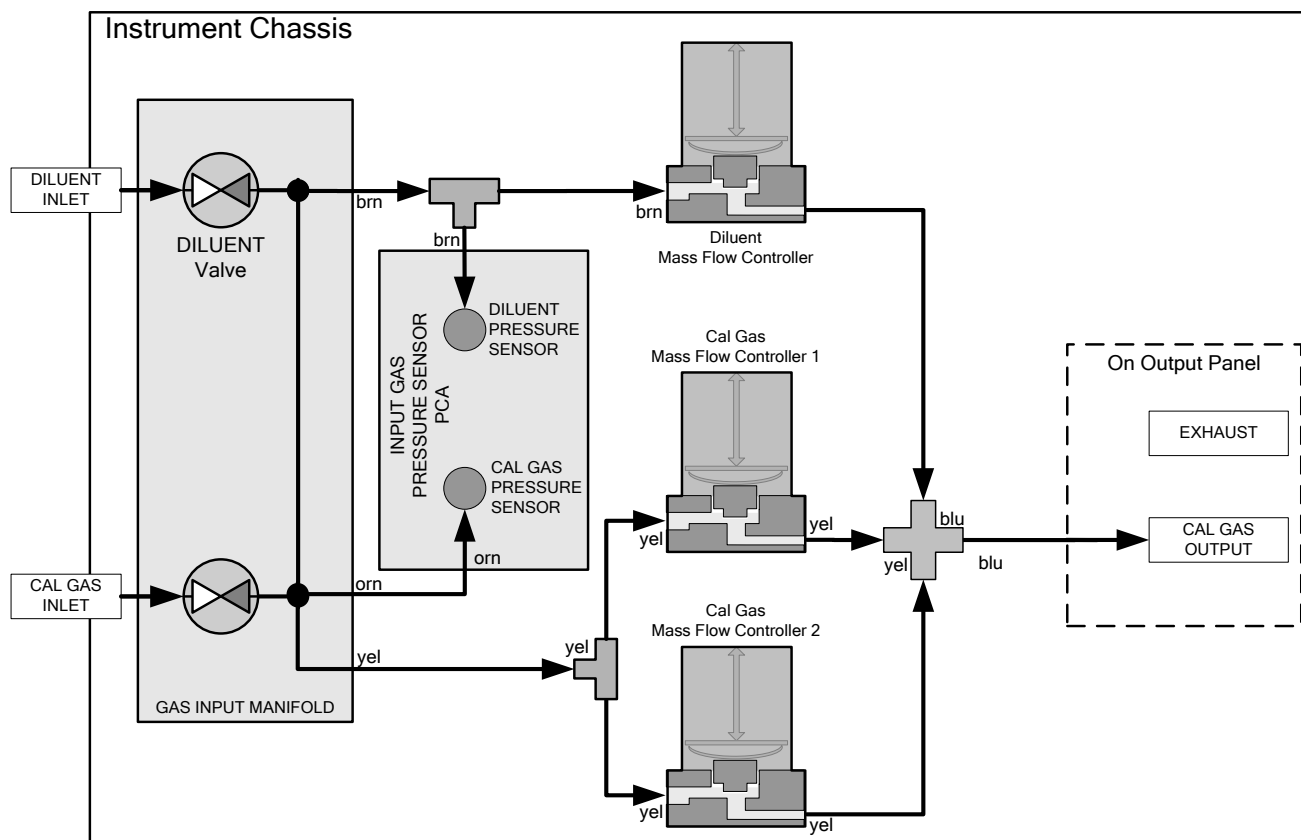


Figure 2-19. Basic T750 with Multiple Calibration Gas MFCs

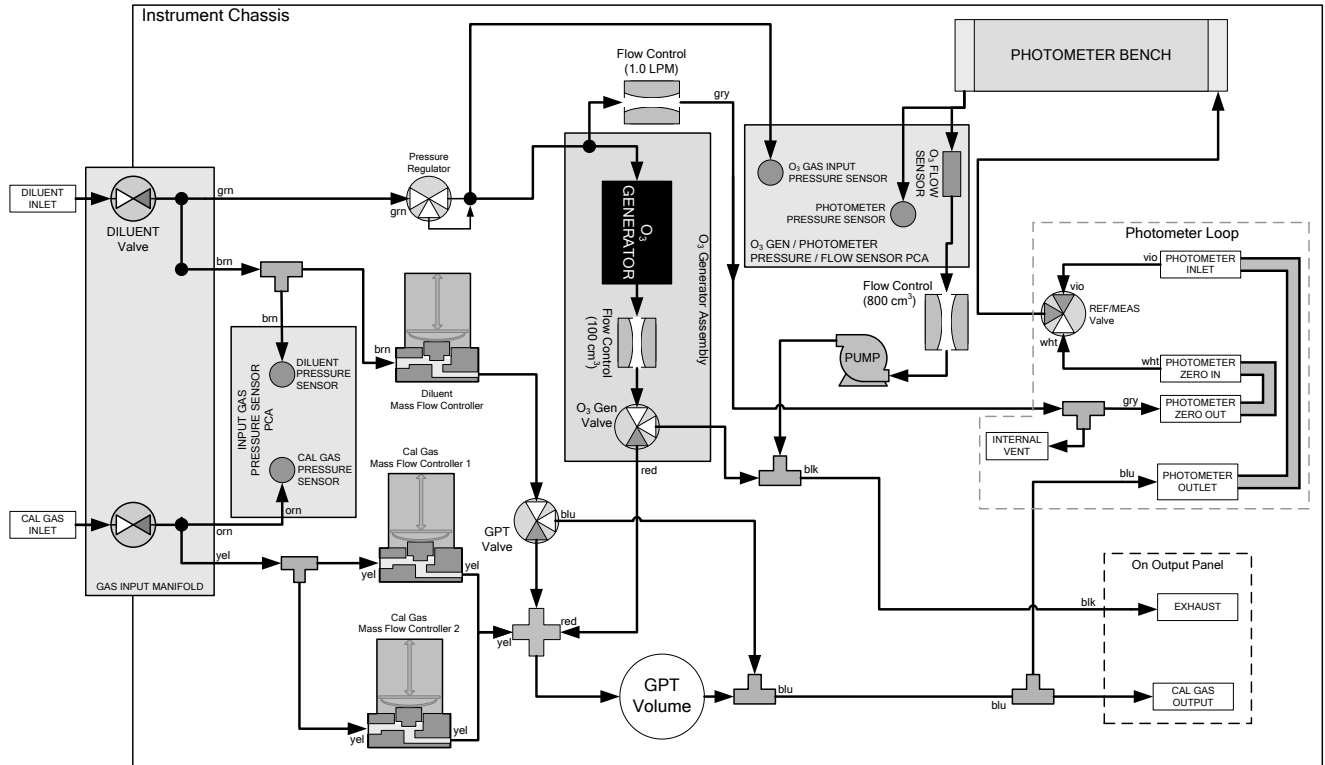


Figure 2-20. Flow with Multiple Cal Gas MFCs and O₂ Generator and Photometer (options in T750)

2.5. STARTUP, FUNCTIONAL CHECKS, AND INITIAL CALIBRATION

Ensure that you are familiar with the principles of operation by reading Section 9.

After making all of the electrical and pneumatic connections, turn on the instrument. The exhaust fan (and pump if photometer options is installed) should start immediately. A sequence of status screens (Figure 2-21) appear on the display, followed by the Home page (Figure 2-22) with the calibrator in **STANDBY** mode after completing the boot-up sequence.

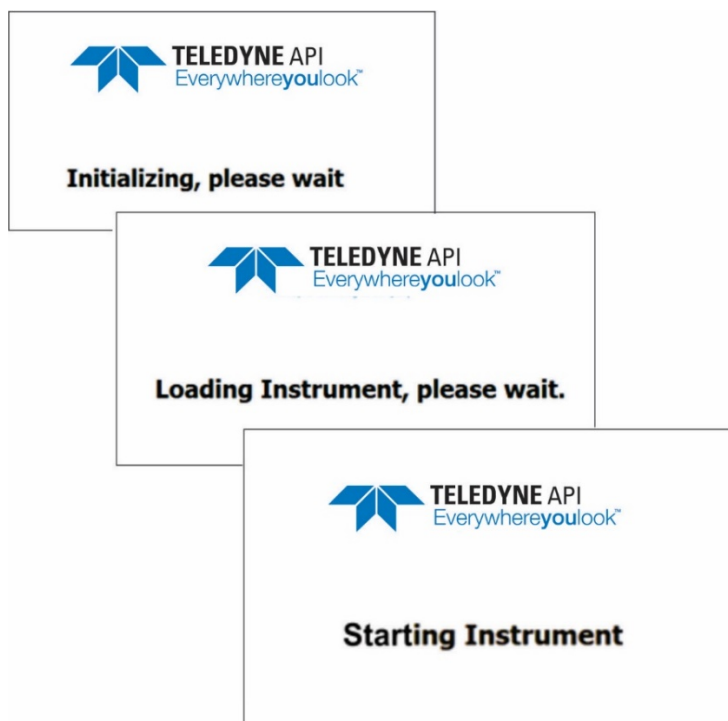


Figure 2-21. Status Screens at Startup

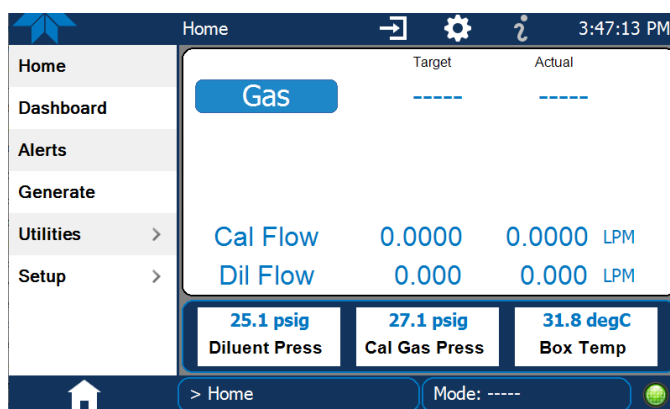


Figure 2-22. Initial Home Page (in Standby Mode, prior to Gas Setup)

The portable calibrator requires at least 30 minutes for all of its internal components to reach a stable operating temperature, during which time most warnings and other messages, called Alerts, will be suppressed.

2.5.1. ALERTS: WARNINGS AND OTHER MESSAGES

The Alerts page (Figure 2-23) shows the status of any active warning conditions or user-configured Events. (Section 3.2.3 provides more detailed information about Alerts, and Section 3.3.2 addresses Events).

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

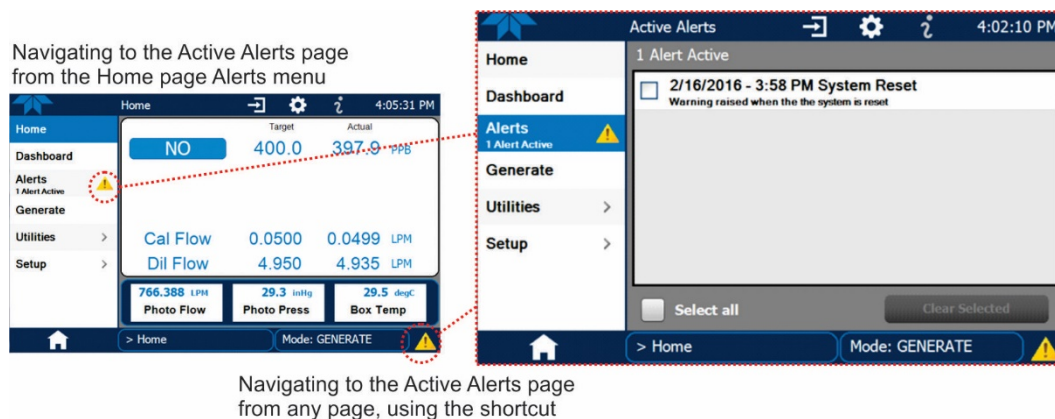


Figure 2-23. Viewing Active Alerts Page

(If alerts of warning conditions persist after the warm up period or after being cleared, investigate their cause using the troubleshooting guidelines in Section 8).

In the meantime, check the functionality of the instrument (Section 2.5.2).

2.5.2. FUNCTIONAL CHECKS

After the minimum warm-up period, view the Dashboard page to check that the instrument is functioning within allowable operating parameters according to the Final Test and Validation Data sheet that accompanied the instrument. These parameters must stabilize for effective calibrator functionality. (If any functional parameters are not displayed, configure the Dashboard through the **Setup>Dashboard** menu to add them; see Section 3.3.3 for details).

- Check values for the operating parameters in the Dashboard page against the instrument's Final Calibrated Test and Validation Data sheet, which lists these values as they appeared before the instrument left the factory.
- Verify MFC capacities through the **Utilities>Diagnostics** menu; select each MFC and note the value in the Flow Range field.



2.5.3. CALIBRATION GAS SETUP

The T750 calibrator can accept up to four different user defined gases. This allows using:

- Less common component gases not included in the T750's default list;
- More than one bottle of the same gas but at different concentrations. In this case, different user-defined names are created for the different bottles of gas.

EXAMPLE: Two bottles of CO₂ are being used, allow the calibrator to create two different CO₂ calibration gases at the same flow rate.

Since identical names must not be assigned to two different bottles, one bottle can be programmed using the default name "CO₂" and the other bottle programmed by assigning a user defined name such as "CO₂A".

Alternatively, both bottles can be assigned user defined names; e.g. CO₂A and CO₂B

User defined gas names are added to the T750's gas library and will appear as choices during the various calibrator operations along with the default gas names listed in the interface.

In its default state, the T750's four user-defined gases are named USR1, USR2, USR3 and USR4, each with a default MOLAR mass of 28.890 (the MOLAR mass of ambient air). All four are enabled.

To define a user gas you must first define the GAS NAME and then set the MOLAR MASS through the **Setup>Gas>Cylinder>User Gases** menu.

SETTING THE MOLAR MASS

The molar mass of a substance is the mass, expressed in grams, of 1 mole of that 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.

EXAMPLE: The atomic weight of Carbon is 12.011 therefore the molar mass of Carbon is 12.011 grams, conversely, one mole of carbon equals the amount of carbon atoms that weighs 12.011 grams.

Atomic weights can be found on any Periodic Table of Elements.

To determine the Molar mass of a gas, add together the atomic weights of the elements that make up the gas.

EXAMPLE: The chemical formula for Propane is C₂H₈. Therefore, the molecular mass of propane is:

$$(12.011 \times 2) + (1.008 \times 8) = 24.022 + 8.064 = 32.086$$

Note

If the contents of the bottle are predominantly N₂, use the molar mass of N₂ (28.01).

DEFINING THE CALIBRATION SOURCE GAS

To define the source gas, navigate to the **Setup>Gas>Cylinder>Port** menu and click the appropriate button to select the gas name (default ZERO) and to configure its concentration and units.



2.5.4. SELECTING AN OPERATING MODE FOR THE O₃ GENERATOR

The O₃ Generator can be set to operate in either of two modes: Constant or Bench.

CNST (CONSTANT) MODE

In Constant mode, the O₃ output of the generator is based on a single, constant, drive voltage, and there is no Feedback loop control by the calibrator's CPU.

BNCH (BENCH) MODE

In Bench mode, the O₃ concentration control loop will use the photometer's O₃ measurement as input. To select a default O₃ generator mode, press

2.5.5. GAS FLOW RATE SETUP

The default total gas flow rate for the T750 Portable Calibrator is 2 SLPM. The calibrator uses this flow rate, along with the concentrations programmed into the calibrator for the component gas cylinders during set up, to compute individual flow rates for both diluent gas and calibration source gases in order to produce calibration mixtures that match the desired output concentrations.

This Total Flow rate may be changed to fit the user's application. Once the flow is changed, then the new flow value becomes the total flow for all the gas concentration generated and computes again the individual flow rates of the component gases and diluent accordingly.

Note

The minimum total flow should equal 150% of the flow requirements of all of the instruments to which the T750 will be supplying calibration gas.

Example: If the T750 is will be expected to supply calibration gas mixtures simultaneously to a system composed of three analyzers, each requiring 2 SLPM, the proper Total Flow output should be set at: $(2 + 2 + 2) \times 1.5 = 9.000$ SLPM.

The flow rate can be configured in the **Setup>Vars** menu by editing the **Target Flow** parameter.

Note

It is not recommended that you set the TOTAL FLOW rate to be <10% or >100% of the full scale rating of the diluent MFC.

OTHER FACTORS AFFECTING THE TOTAL FLOW

The **TOTAL FLOW** is also affected by the following:

- The **Generate>AUTO** menu (see Section 4.2.1), or
- As part of a **Generate** step within a sequence (see Table 3-2 and Section 3.3.7).

The operator can individually set both the diluent flow rate and flow rates for the component gas cylinders as part of the following:

- The **Generate>MANUAL** menu (see Section 4.2.2), or
- As part of a **Manual** step when programming a sequence (see Table 3-2 and Section 3.3.7).

2.5.6. START GENERATING

Once startup is initiated and functions are checked and working properly, the portable calibrator is ready to generate ozone at the default flow as set up at the factory:

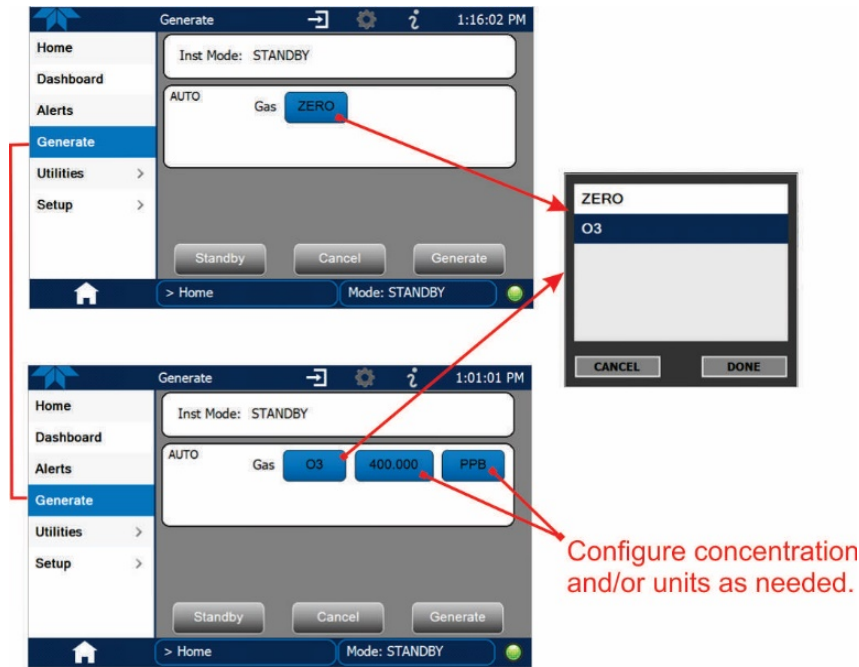


Figure 2-24. Basic Generate Initiation

If the calibrator's application requires a different output flow, follow the procedures set forth in Section 2.5.5.

Section 3 provides information on the menu system, including feature and function configurations. Additional operation instructions, including using the calibrator as an O₃ photometer, are presented in Section 4.



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3. CONFIGURATION

This section first provides an overview of the menu (hierarchy with brief descriptions, Section 3.1), followed by an orientation to the main menu pages (Section 3.2), then configuration guidance in the Setup submenus (Section 3.3).

3.1. MENU OVERVIEW

Table 3-1 describes the menus and provides cross-references for expanded details.

Table 3-1. Menu Overview

| MENU | DESCRIPTION | LOCATION |
|------------------|--|-----------------|
| Home | View and plot concentration readings and selectable meter readings. | Section 3.2.1 |
| Dashboard | View user-selected parameters and their readings, some of which can be displayed in a live-plot graph. | Section 3.2.2 |
| 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 3.2.3 |
| Generate | Generate calibration either ozone or zero; execute Sequences created in Setup>Sequences, and Levels created in Setup>Levels. | Section 3.2.4 |
| Utilities | View logs, download data and firmware updates, copy configurations between instruments, and run diagnostics. | Section 3.2.5 |
| Datalog View | Displays the data logs that were configured via the Setup>Data Logging menu. From this list a log can be selected and filters can be applied to view the desired data, which is downloadable through the Utilities>USB Utilities page. | Section 3.2.5.1 |
| Alerts Log | Displays a history of Alert messages triggered by factory-defined and user-defined Events, such as warnings and alarms (See Section 3.3.2 for Events configuration). | Section 3.2.5.2 |
| USB Utilities | Serves multiple purposes using a flash drive connected to the instrument's front panel USB port: <ul style="list-style-type: none"> • download data from instrument's Data Acquisition System (DAS), the Data Logger, to a flash drive (Section 3.2.5.3) • update firmware (Section 7.3) • transfer instrument configuration from/to other instruments of the same model (Section 3.2.5.3) • download a basic operation functionality report (Section 7.2) | Section 3.2.5.3 |



T750, T750U

| MENU | DESCRIPTION | | LOCATION |
|----------------------------|---|--|---------------------------|
| Diagnostics | Provides access to various pages that facilitate troubleshooting. | | (various) |
| Analog Inputs | This page shows voltage signals of several analog input parameters, including those from other instrumentation when the External Analog Inputs Option is installed. | | Section 8.1.3 |
| Analog Outputs | Shows voltage signals for one parameter (configured through Setup>Analog Outputs, Section 3.3.9). | | Section 8.2 |
| Digital Inputs | Shows whether specific available Signal In features are active (ON) or inactive (OFF). | | Section 2.4.1.4 |
| Digital Outputs | Activate (ON)/deactivate (OFF) user-specified Signal Out features (configured in the Setup>Digital Outputs menu, Section 3.3.6). | | Section 8.1.3 |
| Photo Flow Cal | Calibrate photometer option SLPM flow. | | Section 6.2.3 |
| Output Flow Cal | Calibrate the output SLPM flow. | | Section 6.2.3 |
| Diluent MFC Cfg | Configure Flow Range, Slope, and Offsets for the Diluent Mass Flow Controller | | Section 6.1 |
| Cal1 MFC Cfg | Configure Flow Range, Slope, and Offsets for the standard cal gas Mass Flow Controller | | Section 6.1 |
| Cal2 MFC (opt) Cfg | Configure Flow Range, Slope, and Offsets for the optional 2 nd cal gas Mass Flow Controller | | Section 6.1 |
| O3 Gen Cal | Calibrate the ozone generator for concentrations above 50 PPB | | Section 6.3 |
| O3 Gen Frac Cal (T750U) | Calibrate the ozone generator for concentrations up to 50 PPB | | Section 6.3 |
| Auto Leak Check | Runs an automatic checks for drop in internal gas pressure and displays any drop in pressure | | Section 7.4 |
| Back Pressure Compensation | Calibrate to compensate any impact on the internal measure/reference pressure. | | Section 6.2.3 |
| Bench Cal | Calibrate the photometer bench with zero/span | | Sections 6.2.2.1, 6.2.2.2 |
| Pressure Cal | Calibrate ozone, regulator, and photometer pressures. | | Section 6.4 |



T750, T750U

| MENU | DESCRIPTION | LOCATION |
|-----------------|--|----------------------------------|
| Setup | Configure a variety of features and functions through these submenus for customized operation. | Section 3.3 |
| 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 and downloaded to a flash drive via the Utilities>USB Utilities menu (Section 3.2.5.3). Also, select configured Events (Section 3.3.2) and create customized triggers for data logging functions. | Section 3.3.1 |
| Events | Select parameters and define the conditions by which they are to be flagged and recorded in the Alerts log (Section 3.2.5.2) when they are triggered. | Section 3.3.2 |
| Dashboard | Monitor instrument functionality (Section 3.2.2) via selectable parameters. | Section 3.3.3 |
| Vars | Manually adjust several software variables that define specific operational parameters. | Section 3.3.4 |
| Homescreen | Configure the parameters to be displayed in the three meters (Section 3.2.1 and Figure 2-22) along the bottom of the display. | Section 3.3.5 |
| Digital Outputs | Map the rear-panel digital outputs (labeled STATUS) to a variety of signals present in the instrument to monitor the status of operating conditions, or custom Events. (See Setup>Events). | Section 3.3.6 |
| Sequences | Create new or edit existing executable calibration sequences and the steps within the sequences. | Section 3.3.7 |
| Levels | Create individual flow and concentration outputs for LEADS. | Section 3.3.8 |
| 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 3.3.9 |
| 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 | Section 3.3.10 |
| Comm | View and configure network and serial communications. | Section 3.3.11 |
| Gas | Configure and customize gas(es), incl. concentration and units | Sections 3.3.12, 2.5.3 and 2.5.4 |

3.2. MAIN MENU PAGES

This section describes the pages of the main menu: Home, Dashboard, Alerts, Generate, and Utilities, and drills into further descriptions of the Utilities submenus. The Setup menu warrants a section of its own (Section 3.3) with instructions for configuring the various features and functions of the calibrator.

3.2.1. HOME

Figure 3-1 shows the features of the main interface from the Home page. The meters at the bottom of the display are user-selectable (see Section 3.3.5).

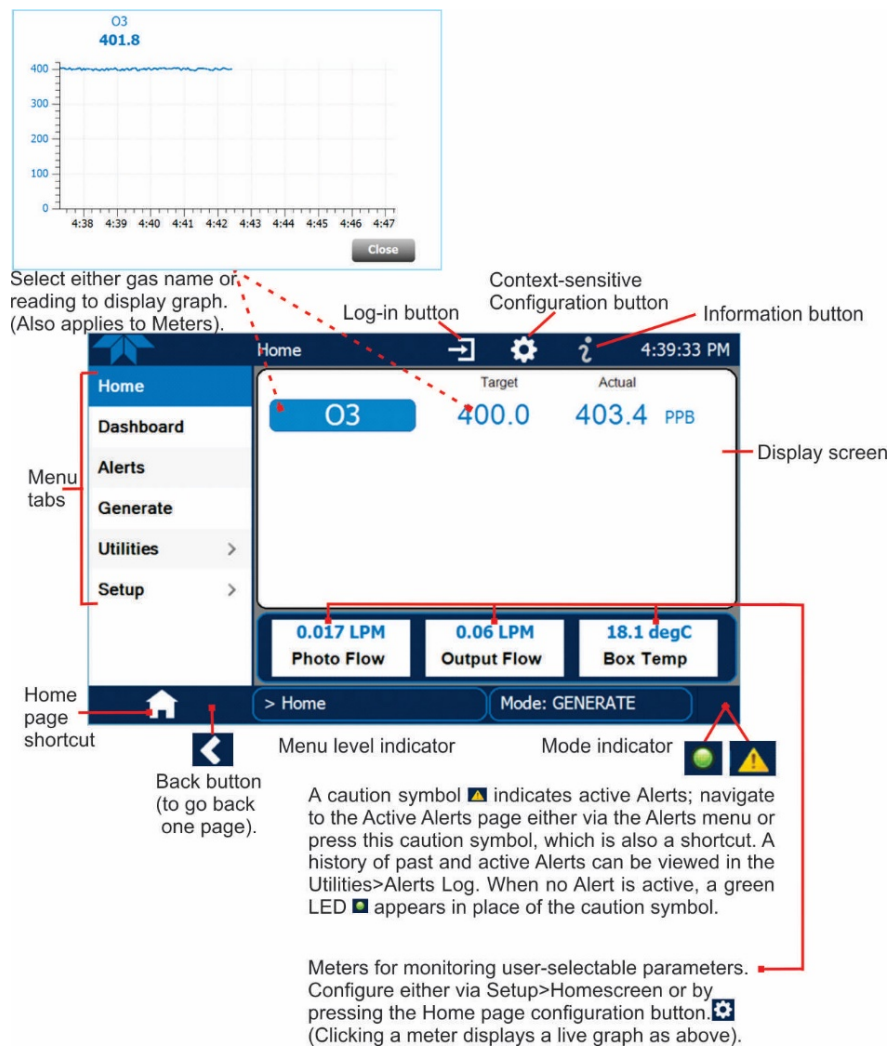


Figure 3-1. User Interface Orientation

Note

The last page on display prior to drilling into a menu remains on display until a choice in the menu is selected.

3.2.2. DASHBOARD

The dashboard displays an array of user-selected parameters and their values (Figure 3-2). 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 3-3. Depending on the number of available parameters selected, the Dashboard can have more than one page. See Section 3.3.3. for configuration details.

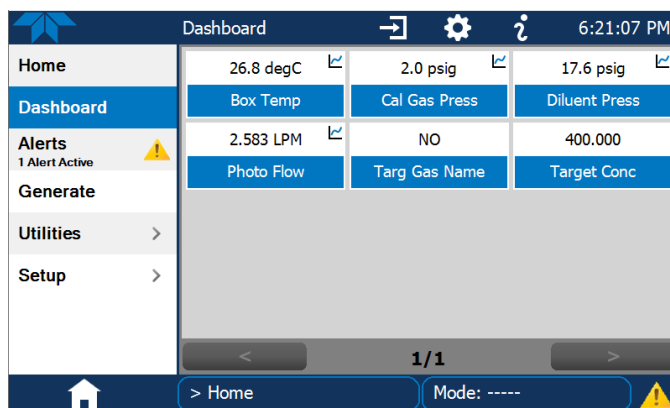


Figure 3-2. Dashboard Page

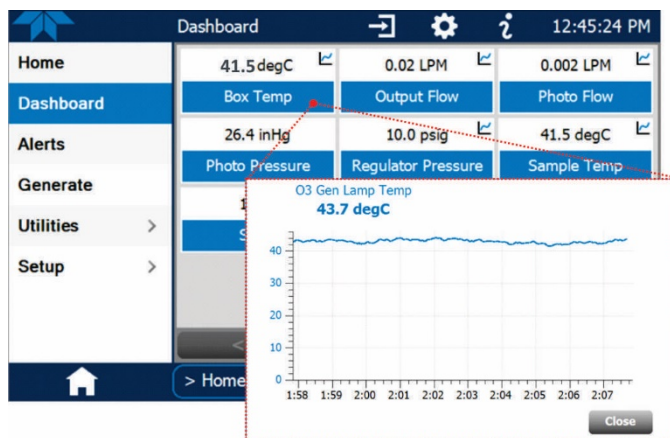


Figure 3-3. Viewing a Live Plot from Dashboard Page

Three of the dashboard parameters can be set up for continuous display as meters located below the concentration display of the Home page through the **Setup>Homescreen** menu (Section 3.3.5).

3.2.3. 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 3.3.2). 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 3-4).

While Alerts can be cleared from the Active Alerts page, they remain recorded in the **Utilities>Alerts Log**. To configure Events, see Section 3.3.2.

Navigate to the Active Alerts page via the Alerts menu on Home screen.

(Also view a list of all active and past Alerts and Events via Utilities>Alerts Log).

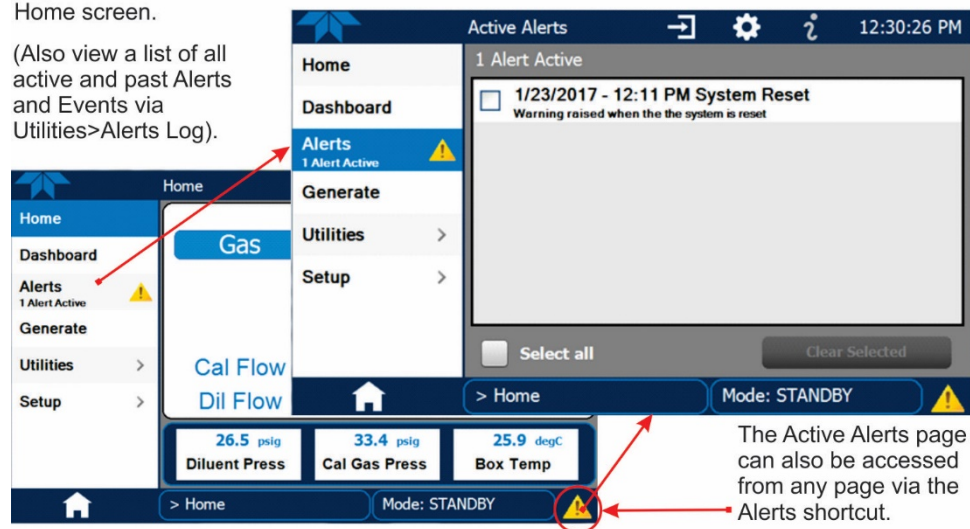


Figure 3-4. Navigating to the Active Alerts Page

Alerts appear as either latching or non-latching:

- Latching. displayed in Active Alerts screen when an Event is triggered and must be cleared by the user).
- Non-latching: (Active Alerts screen continuously updates based on the Event criteria, clearing on its own).

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 3-5). However, Alerts can reappear if the conditions causing them are not resolved. For troubleshooting guidance, refer to the instrument's user manual.

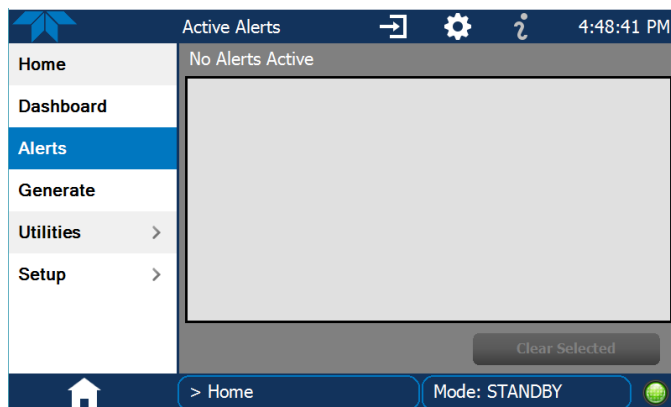


Figure 3-5. Active Alerts Cleared

3.2.4. GENERATE

The Generate menu is used to generate the desired calibration gas mixtures after initial gas setup (Section 3.3.12, **Setup>Gas**). The Generate menu is presented in greater detail in Section 4.2.

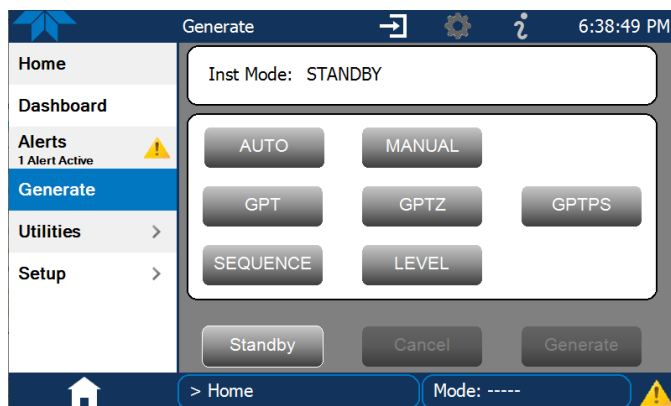


Figure 3-6. Generate Menu (GPT buttons available with O₃ Generator Option)

3.2.5. UTILITIES

The Utilities menu opens to the Datalog View, the Alerts Log, the USB Utilities, and the Diagnostics submenus.

3.2.5.1. Datalog View

The Datalog View tab displays a list of data logs that were configured in the **Setup>Data Logging** menu (Section 3.3.1). From this list a log can be selected and filters applied to view the desired data.

3.2.5.2. Alerts Log

The Alerts Log holds a history of alerts that were triggered by factory-defined and user-defined Events, such as warnings and alarms.

3.2.5.3. USB Utilities (Downloads and Updates)

The USB Utility page serves multiple purposes using a flash drive connected to the instrument's front panel USB port:

- downloading Data Acquisition System (DAS) data from the instrument to a flash drive (presented below).
- updating firmware (presented below and in Section 7.3).
- copying a configuration from one instrument to other same-model instruments (presented below).
- downloading a basic operation functionality report (presented below and in Section 7.2)

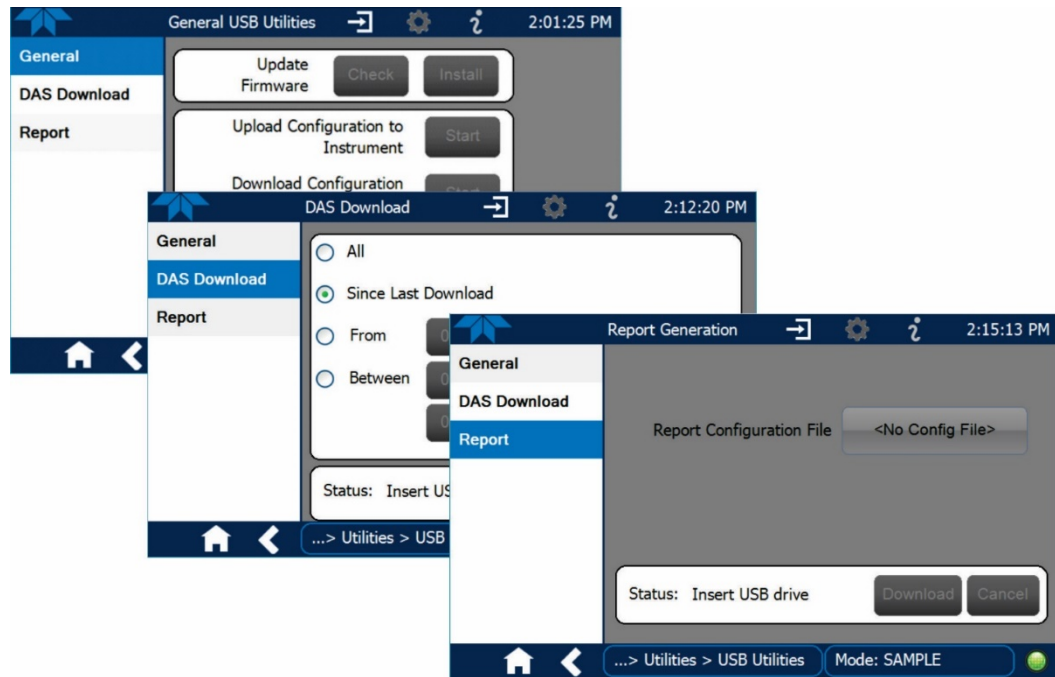


Figure 3-7. USB Utilities Pages

The Status field shows when an inserted flash drive has been detected, at which time firmware updates, configuration copying and DAS downloading can be carried out.

DOWNLOADING DAS (DATA ACQUISITION SYSTEM) DATA

DAS data (collected by the Datalogger, Section 3.3.1) can be downloaded from the instrument to a flash drive through the **Utilities>USB Utilities>DAS Download** menu, as follows:

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.

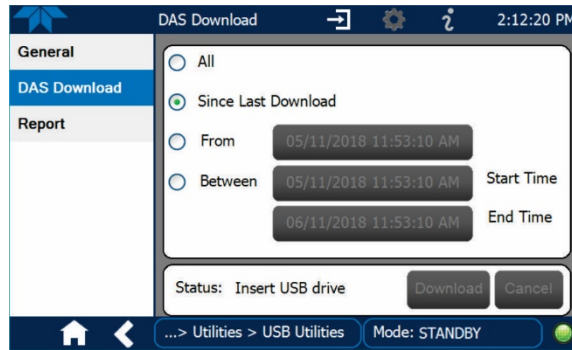


Figure 3-8. Das Download Page

2. To copy the data to the flash drive, press the Start button next to “Download DAS Data from Instrument.” (The Cancel button will be enabled).
3. When complete, as indicated in the Status field, the Cancel button becomes the Done button: press Done and then remove the flash drive.

UPDATING FIRMWARE

It is possible to check for firmware updates, reload current firmware, and to update firmware remotely. Because this is a maintenance item and there is more than one way to implement an update, instructions are provided in Section 7.3.

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.

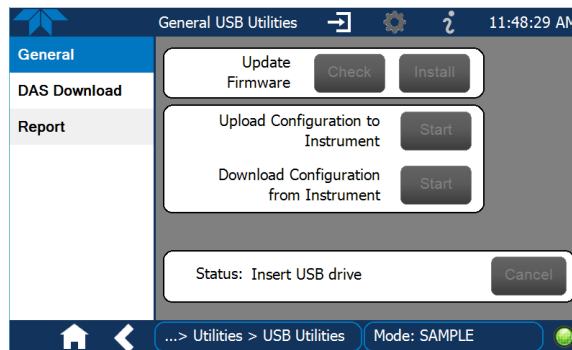


Figure 3-9. Configuration Transfer

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

GENERATING A REPORT

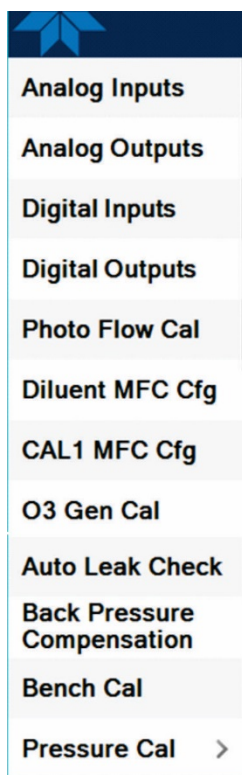
The Report page is used typically for monitoring the functionality of the instrument. Because it is used in maintenance and troubleshooting, the Report feature is presented in Section 7.2.

3.2.5.4. Diagnostics

The Diagnostics menu provides access to several diagnostics submenus, which can be helpful in troubleshooting (Section 8). When an item in the menu is selected, the display shows its description. Table 3-1 on page 53 also provides descriptions.

Note

Some Diagnostics items do not appear in the menu unless the instrument has been placed in Standby mode (see Home>Generate menu).



3.3. SETUP (CONFIGURING THE CALBRATOR'S FEATURES/FUNCTIONS)

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.

3.3.1. SETUP>DATA LOGGING

Set up the Data Logger to track and report instrument data based on user-configurable periodic timers or conditional triggers (presented next in this section) or Event-based triggers (Section 3.3.2). In the **Setup>Data Logging** menu (Figure 3-10), press the ADD button to create a new log (Figure 3-11), or select an existing log from the Data Logging list and press the EDIT or DELETE button to make the desired changes).

Later, to transfer the captured (logged) from the instrument to a flash drive, use the **Utilities>USB Utilities** menu (refer to Section 3.2.5.3).

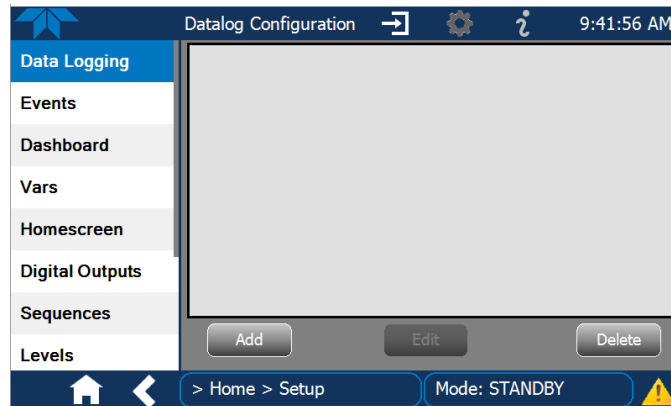


Figure 3-10. Setup>Data Logging Page

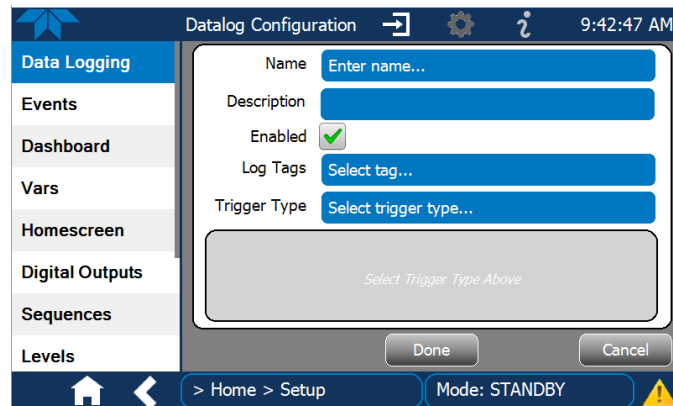


Figure 3-11. Datalog Configuration, New Log Page



3.3.1.1. Creating a User-Defined Data Log

The screenshot shows the 'Datalog Configuration' screen. The left sidebar contains a menu with 'Data Logging' selected. The main area has fields for 'Name' (with a red dot), 'Description' (with a red dot), 'Enabled' (checked), 'Log Tags' (with a red dot), and 'Trigger Type' (with a red dot). Below these is a large empty box. At the bottom are 'Done' and 'Cancel' buttons. A keyboard pop-up is shown in the top right corner. Red lines connect the annotations to the corresponding fields on the screen.

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.

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 one or more parameters for the new data log.

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

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

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

Interval 15 minutes
Start Time 6/30/2015 6:33:56 AM

Trigger Tag Select tag here...
Condition Select trigger here...

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

Figure 3-12. Datalog Configuration



3.3.1.2. Configuring Trigger Types for the Datalogger

PERIODIC TRIGGER

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 time.

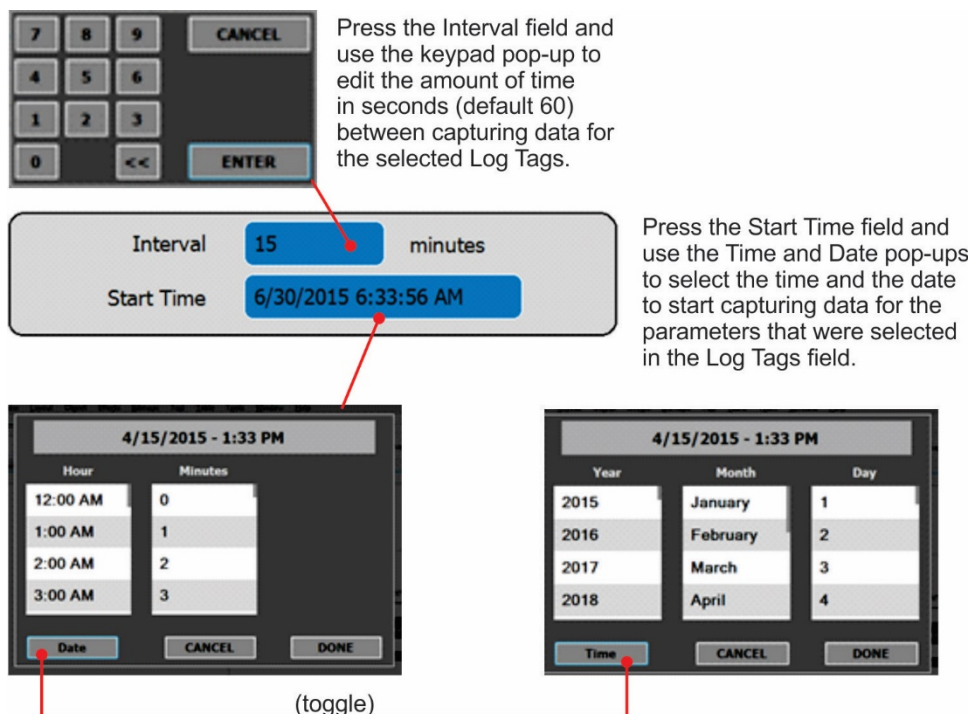


Figure 3-13. Datalog Periodic Trigger Configuration

CONDITIONAL TRIGGER

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

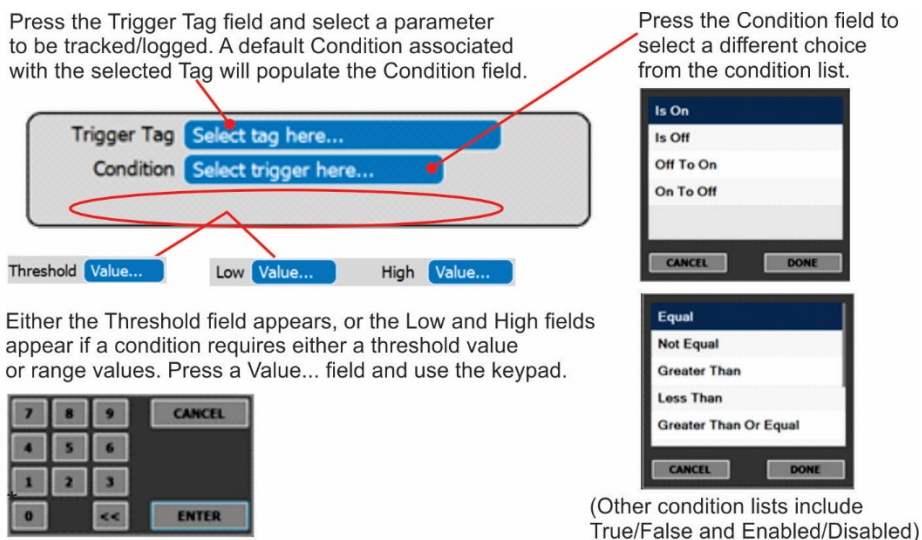


Figure 3-14. Datalog - Conditional Trigger Configuration

3.3.2. SETUP>EVENTS

Events are occurrences that relate to any operating function, and are used to define the conditions that will trigger Alerts (Section 3.2.3). Events can provide diagnostic information about the instrument, typically referred to as “Warnings”, or they can provide additional instrument functionality, such as concentration alarms. Some Events are standard and not editable while others are user-configurable, described here.

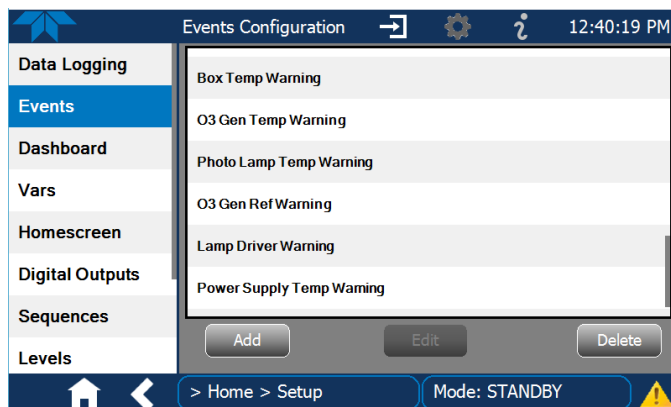


Figure 3-15. Events List

3.3.2.1. Creating User-defined Events

In the **Setup>Events** menu (Figure 3-15) press ADD to create a new Event. Figure 3-16 depicts the steps for creating an Event. In the center of the display, the Enabled box allows the choice of whether to track and record the Event. The Visible box allows the choice of whether or not to display the Event in the Alerts tab when it is triggered, although it will still be recorded. The third box allows the choice of whether or not to make it a Latching Event.

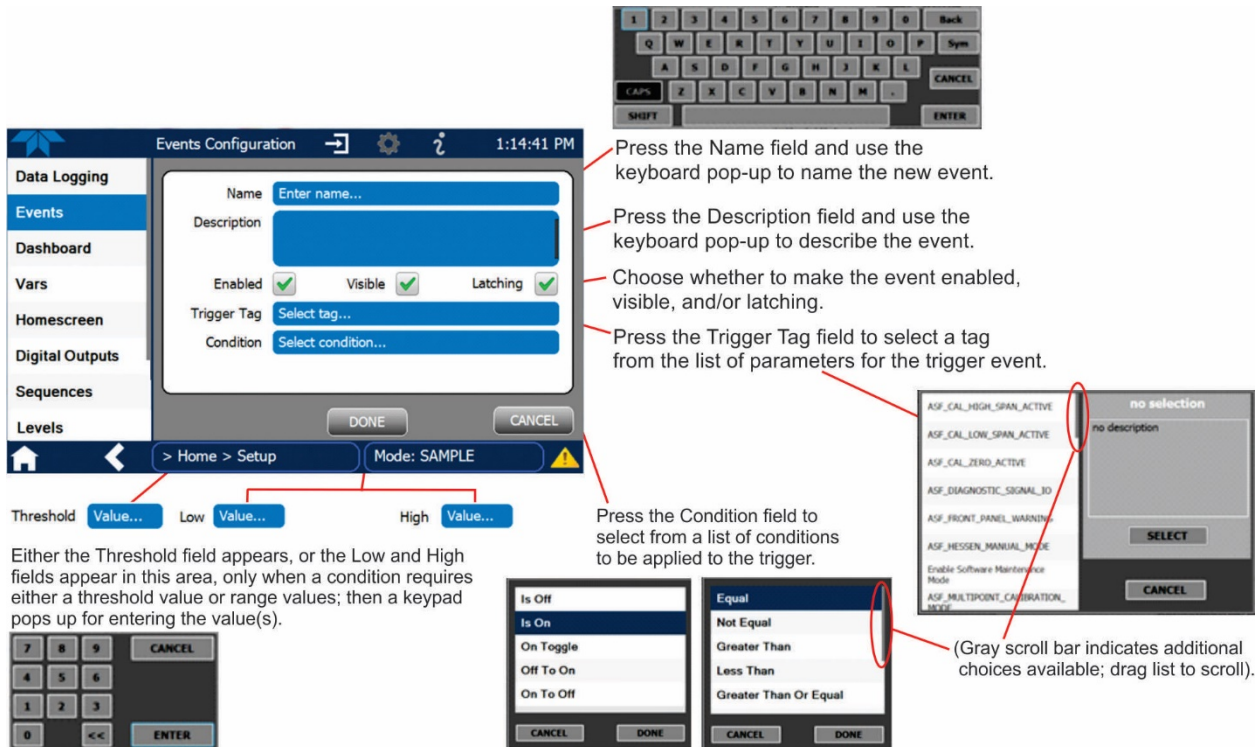


Figure 3-16. Event Configuration

3.3.2.2. Editing or Deleting Events

Select an Event from the list (Figure 3-15) and press the EDIT button to view or edit the details (Figure 3-17). Press/click the field(s) to edit. To delete an Event, select the Event from the list and press the DELETE button (shown in Figure 3-15).

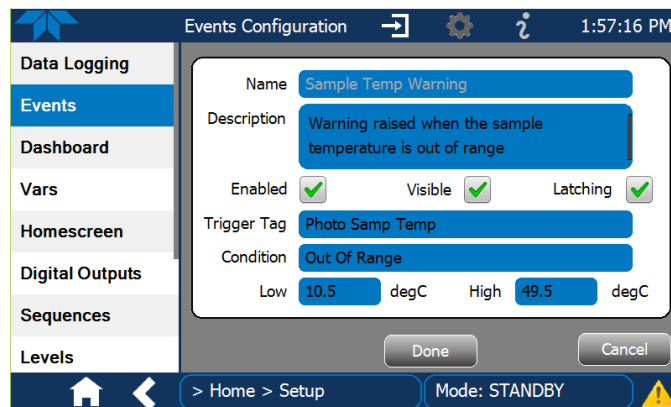


Figure 3-17. Existing Event for Viewing or Editing

3.3.3. SETUP>DASHBOARD

The Dashboard can be configured to display an array of parameters and can extend to more than one Dashboard page.




- To add a parameter for display in the Dashboard, select from the “Available Tags” column and press the right-pointing button .
- To remove a parameter from the Dashboard, select a tag from the “Dashboard” column and press the left-pointing button .



Figure 3-18. Dashboard Configuration Page through Setup Menu

The Dashboard Configuration page can also be reached by pressing the shortcut icon  while in the Dashboard page.

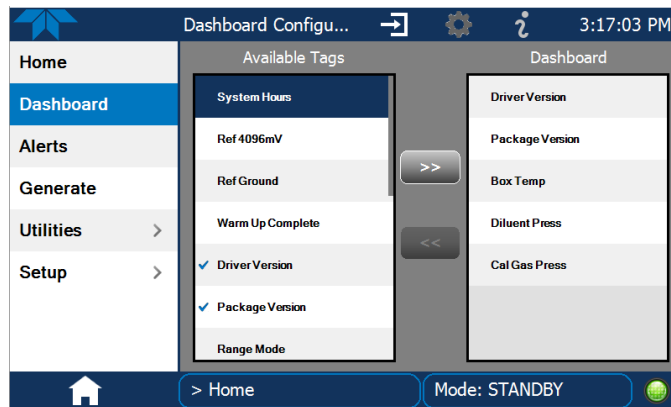


Figure 3-19. Dashboard Configuration Page through Dashboard Shortcut

3.3.4. SETUP>VARS (VARIABLES)

The calibrator has several user-adjustable software variables, which define certain operational parameters. Select a Var to see a description of its purpose in the pane to the right; press the Edit button to change its setting(s).

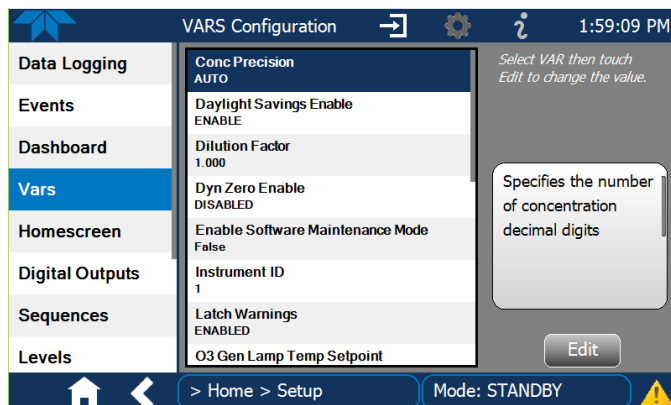


Figure 3-20. Vars Configuration Page

3.3.5. SETUP>HOMESCREEN

Configuring the Homescreen involves selecting a parameter to display in each of the three meters located below the concentration display. From the **Setup>Homescreen** menu scroll through the list of available tags and select one, then touch a meter to apply. Repeat for the other two meters.

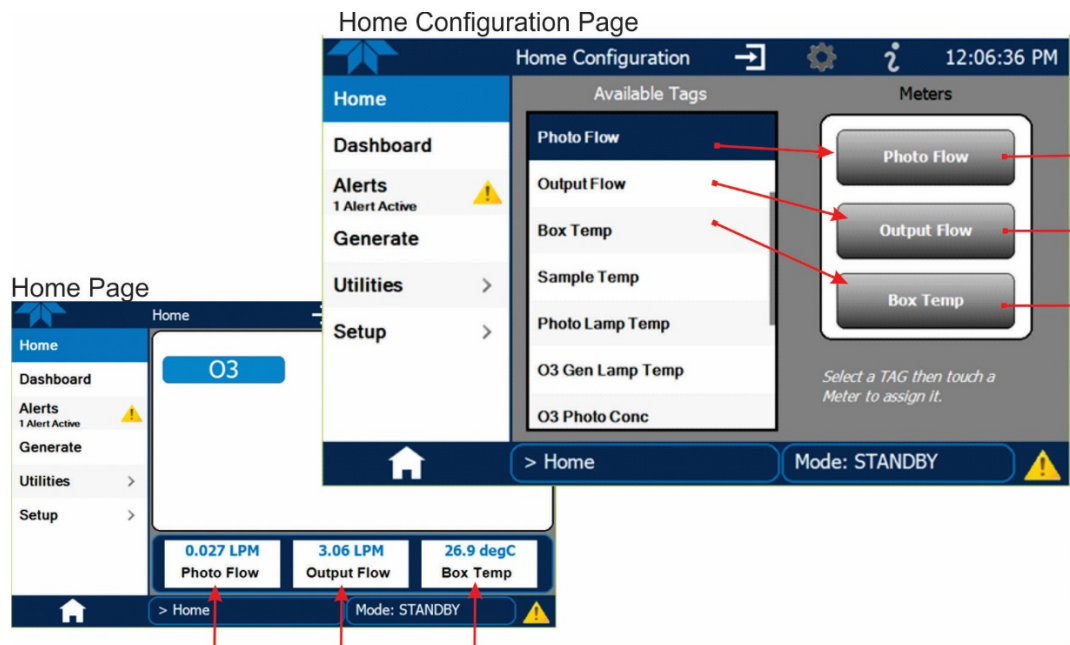


Figure 3-21. Home Configuration through Setup>Homescreen Menu

Home Configuration can also be reached by shortcut while in the Home page by pressing the context-sensitive configuration button  located at the top of the interface.

3.3.6. SETUP>DIGITAL OUTPUTS (STATUS)

Specify the function of each Digital Output for status and map it to any of a wide variety of “Signals” present in the instrument. The Digital Outputs 1 thru 8 correspond to pins 1 thru 8 on the rear panel STATUS connector. (MB Relay 1 thru 4 do not apply in the calibrator).

To map a status Digital Output to a Signal, select a pin in the Outputs list, then select from the Signals list and press the Map button; if needed, change the polarity by pressing the Polarity button. Save any changes by pressing the Apply button or discard the changes by instead pressing the Home button (a pop-up provides a warning that the changes will be lost, and it will prompt for confirmation to apply changes or not).

These status outputs are visible in the **Utilities>Diagnostics>Digital Outputs** menu and are labeled “Digital Output [#]” followed by the signal name. When selected, their state can be changed between ON and OFF. (Note that the Digital Outputs list in the **Utilities>Diagnostics** menu also includes the Control Outputs and other functions).

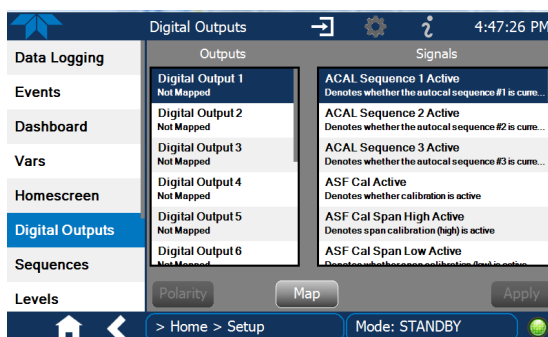


Figure 3-22. Digital Status Outputs Setup

3.3.7. SETUP>SEQUENCES

To configure automatic calibration operations, use the **Setup>Sequences** menu (Figure 3-23) to create new sequences, edit existing sequences, and edit steps within a sequence. Each sequence is a database of single or multiple steps where each single step is an instruction that causes the instrument to perform an operation.

Note

Last in = first out: the last step input into the program during configuration under “Edit Steps” is the first step executed, which means that multiple steps must be input in their reverse order; advanced planning is recommended.

The last instruction in a sequence should always be to place the calibrator in STANDBY mode. With the “Last in First out” rule, Standby should be the first step that is input into the sequence.

When the start time is set for a date/time that has passed, the sequence will properly calculate the next run time based on that past date/time.

Figure 3-24 shows the main screens in Sequence configuration.

Table 3-2 describes the components used in calibration sequence configuration.

Subsections 3.3.7.1 through 3.3.7.3 provide additional information.

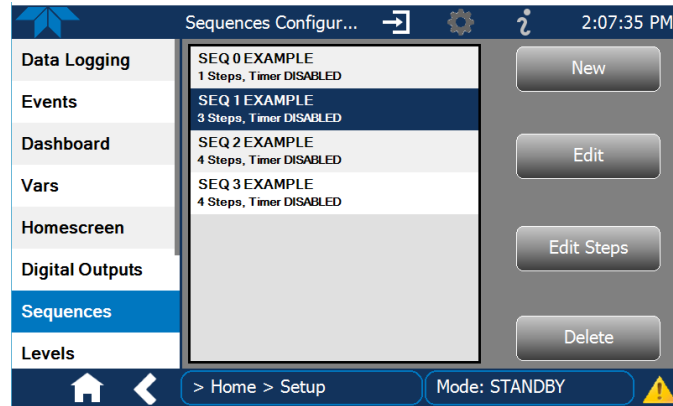


Figure 3-23. Example List of Configured Sequences

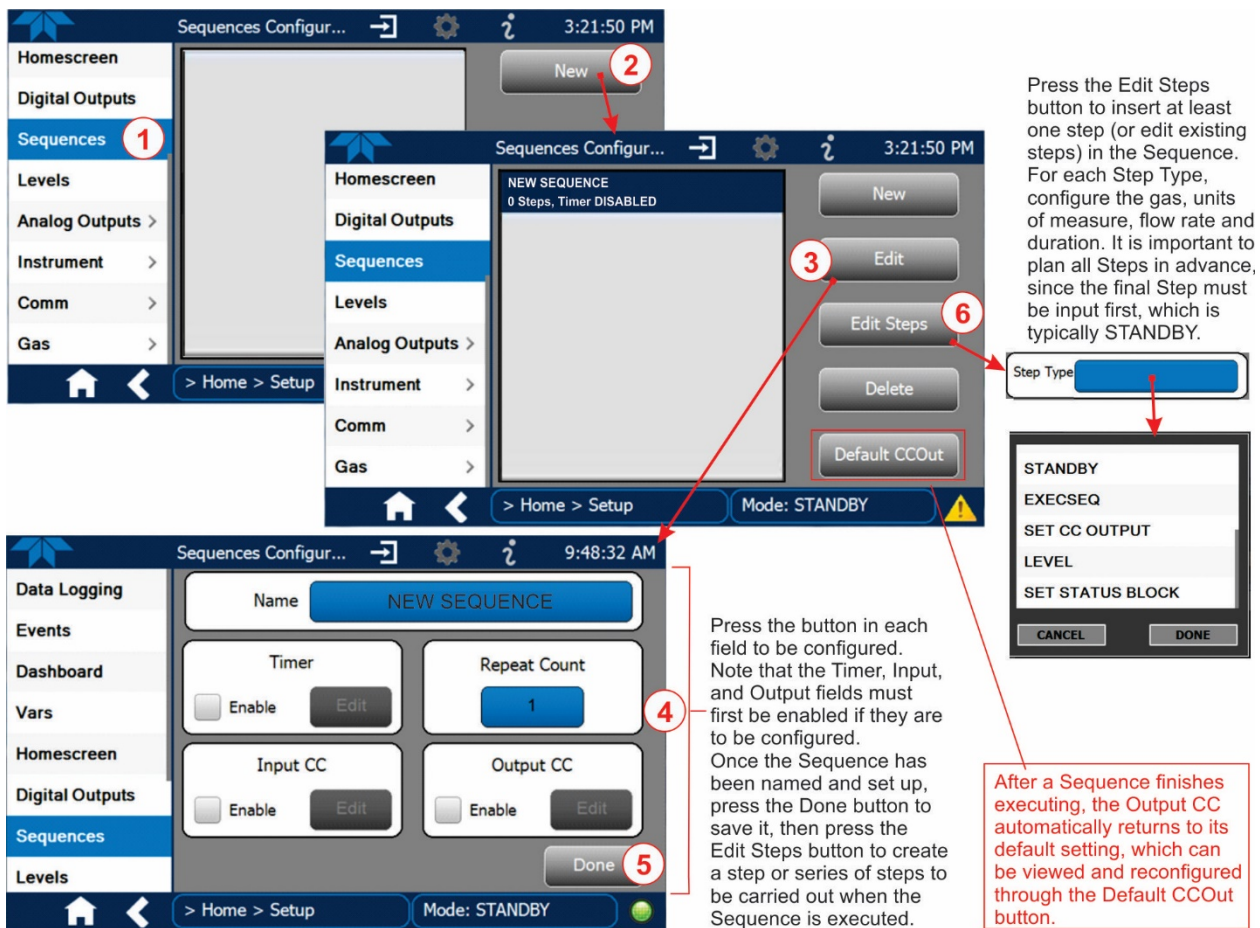


Figure 3-24. Configuring a Sequence

Table 3-2. Automatic Calibration Sequence Set Up Attributes

| ATTRIBUTE | DESCRIPTION | |
|---------------------|--|--|
| Name | Allows the user to create a text string of up to 10 characters identifying the sequence. | |
| Timer Enable | Check the Enable box to activate an internal automatic timer to initiate sequences using the calibrator's built in clock. The sequence can be set up to start at a predetermined date and time. Press the Edit button to configure the Timer. | |
| | Timer Start | Edit this field to set the date and time to start running the sequence. |
| | Timer Delta | Edit this field to set interval changes in days and/or hours and minutes, where the sequence repeats after the set delay time. |
| Repeat Count | Number of times, between 0 and 100, to execute the same sequence. A value of 0 (zero) causes the sequence to execute indefinitely. | |
| Input CC | Enable and edit this attribute to specify which of the Digital Control Inputs will initiate the sequence, allowing the entire sequence to be triggered from an external source, such as a data logger, where the calibrator operates in a slave mode. | |
| Output CC | <p>Enable and edit this attribute to allow the calibrator to control devices that accept logic-level digital inputs, such as programmable logic controllers (PLCs), data loggers, or digital relays/valve drivers. This instruction causes the sequence to set or reset the calibrator's digital control outputs. It is very useful in situations where the control outputs are being used to trigger other devices that need to be turned off and on in synch with the operation of the calibrator as it progress through the sequence. The CC Outputs can be used as:</p> <ul style="list-style-type: none"> • 12 separate ON/OFF switches assigned to separate calibration sequences, or; • A 12-bit wide bus allowing the user to define activation codes for up to 4095 separate calibration sequences. <p>Specify which of the 12 Digital Control Outputs will be active when the sequence is operating, or specify which ones to activate/deactivate while running individual steps within a calibration sequence.</p> <p>NOTE: once a sequence is finished executing, the Output CC will continue running in its default configuration as set up through the "Default CCOut" button located at the bottom right of the Setup>Sequence page; it is recommended that the Default CCOut configuration be viewed/edited as needed.</p> | |
| Steps | <p>Steps are the actions that the Sequence is to execute. NOTE: the first step input in the Edit Steps page will be the last step executed by the Sequence. (In other words, the Steps must be input in reverse order so that the first step displays at the top). In addition, it is strongly recommended that each Sequence end with an instruction to return the instrument to Standby mode; therefore, the STANDBY step should be the first Step that is input. Existing steps can be changed (Edit) or permanently removed (Delete). Press the Done button to accept the Steps and return to the Sequence list. The Step Types include:</p> | |
| | GENERATE | Puts the instrument into GENERATE mode. Similar in operation and effect to the GENERATE > AUTO function used at the Input and Control Panel. |
| | STANDBY | Stops generating and ends the sequence. It is strongly recommended to always insert this as a last step of the Sequence. |
| | EXECSEQ | Used fto create nested sequences, this step calls a previously configured sequence to be executed at this time. The "calling" sequence will resume running when the "called" sequence (selected in this EXECSEQ step) is completed. A maximum of 5 levels of nested sequences is allowed. |
| | SET CC OUTPUT | Allows the sequence to activate the digital control outputs. Similar to the OUTPUT CC attribute, but can be set and reset by individual steps. It is very useful in situations where the control outputs are being used to trigger other devices that need to be turned off and on in sync with the operation of the calibrator as it progresses through the sequence. |
| | LEVEL | Like EXECSEQ, this step type executes a Level (Section 3.3.8). |

| ATTRIBUTE | DESCRIPTION | |
|-----------|-------------------------|---|
| | SET STATUS BLOCK | <p>Enable1 is for Status Block 1, which corresponds to the physical CONTROL OUTPUT connector. To configure, press the respective Enable box and check the desired box(es) whose numbers correspond to the Pin numbers.</p> <p>Enable 2 is for Status Block 2, which does not correspond to any physical output but is used to communicate status over the serial data port.</p> |

3.3.7.1. Setting up Control Inputs for a Sequence

The calibrator's control inputs (Figure 2-3) allow the entire sequence to be triggered from an external source. This feature allows the calibrator to operate in a slave mode so that external control sources, such as a data logger can initiate the calibration sequences.

The calibrator's control inputs connector has:

- 12 separate ON/OFF switches assigned to separate calibration sequences or;
- A 12-bit wide bus allowing the user to define activation codes for up to 4095 separate calibration sequences.

To assign a **CC INPUT** pattern/code to a particular sequence in the **Setup>Sequences** menu:

1. Select the desired Sequence (or create a new Sequence).
2. In the Input CC field check the Enable box.
3. Press the Edit button.
4. Check the desired control input pin(s).
5. Press Done.

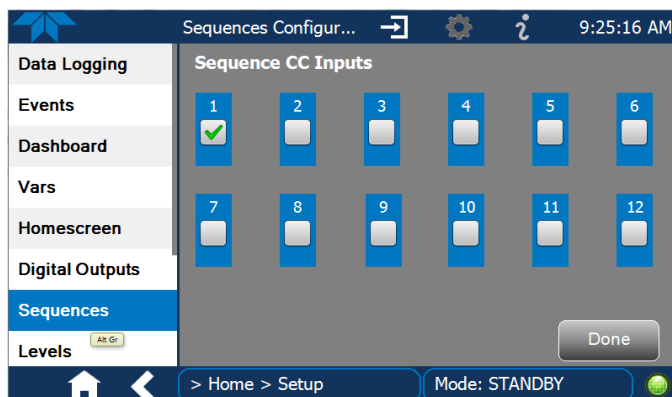


Figure 3-25. Sequence CC Inputs Setup Page

3.3.7.2. Setting up Control Outputs for a Sequence

The calibrator's control outputs allow setting up the calibrator to control devices that accept logic-level digital inputs, such as programmable logic controllers (PLCs), data loggers, or digital relays/valve drivers.

They can be used as:

- 12 separate ON/OFF switches assigned to separate calibration sequences, or
- a 12-bit wide bus allowing the user to define activation codes for up to 4095 separate calibration sequences.

They can be set so that they are:

- active whenever a particular calibration sequence is operating, or
- activated or deactivated as individual steps within a calibration sequence.

To assign a **CC OUTPUT** pattern/code to a particular sequence in the **Setup>Sequences** menu:

1. Select the desired Sequence (or create a new Sequence).
2. In the Output CC field check the Enable box.
3. Press the Edit button to open the Sequence CC Outputs page.
4. Check the desired control output pin(s).
5. Press Done.

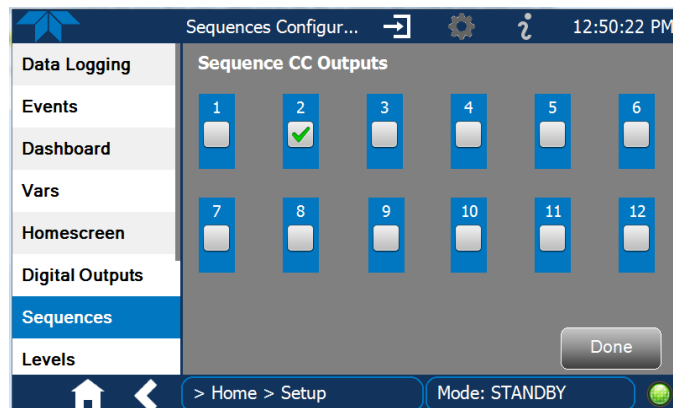


Figure 3-26. Sequence CC Outputs Setup Page

3.3.7.3. Activating, Editing, Deleting Sequences

To **activate** a sequence, in the Generate menu, press the Sequence button and select the desired sequence. Sections 4.2.7.1 through 4.2.7.6 describe additional ways to activate.

Edit: Setup>Sequences>[select a sequence]>Edit allows you to edit a Sequence's various attributes, such as name, timer, repeat count, input and output CCs.

Edit Steps: Setup>Sequences>[select a sequence]>Edit Steps allows you to edit the steps with the selected Sequence.

Delete: Setup>Sequences>[select a sequence]>Delete will entirely delete the selected Sequence.

3.3.8. SETUP>LEVELS

When the calibrator is equipped with a version of firmware that includes support for LEADS, there are a few parameters that can be programmed to carry out a single-step operation called a Level, starting with assigning a number (ID) to identify it. Unlike Sequences, Levels are not time based and do not include characteristics such as start time or duration; therefore, a single LEVEL cannot switch between different concentration levels. Separate concentration outputs must be programmed into separate LEVELs. Up to twenty Levels can be programmed, using a range of ID numbers from 0-98; ID 99 is reserved for “Standby” (Refer to Section 4.2.7.6 for information about LEADS).

To program a Level, use the following instructions and refer to Figure 3-27:

1. With the instrument in Standby mode (**Generate>Standby**), navigate to the **Setup>Levels** menu.
2. Click the “New” button in the Levels Configuration page (default level ID is “0”, and the default Action is “Generate”).
3. Use the Edit button to start programming the new Level.
4. Use the Level field to assign a different ID (numeric keypad pops up).
5. In the Action field press the GENERATE button to bring up the next screen for selecting a gas.
6. Press the Gas button to select either ZERO or O3. (The Step Type field has only one choice). If selecting O3, edit the target concentration and units as needed, and press DONE
7. To configure one or both of two Status output blocks, click the respective Enable checkbox, then press the Edit button:
 - Status Block1: This block corresponds to the physical CONTROL OUTPUT connector.
 - Status Block2: The second status block does not correspond to any physical output but is used to communicate status over the serial data port.
8. Press the Done button to complete the programming for the individual Level.

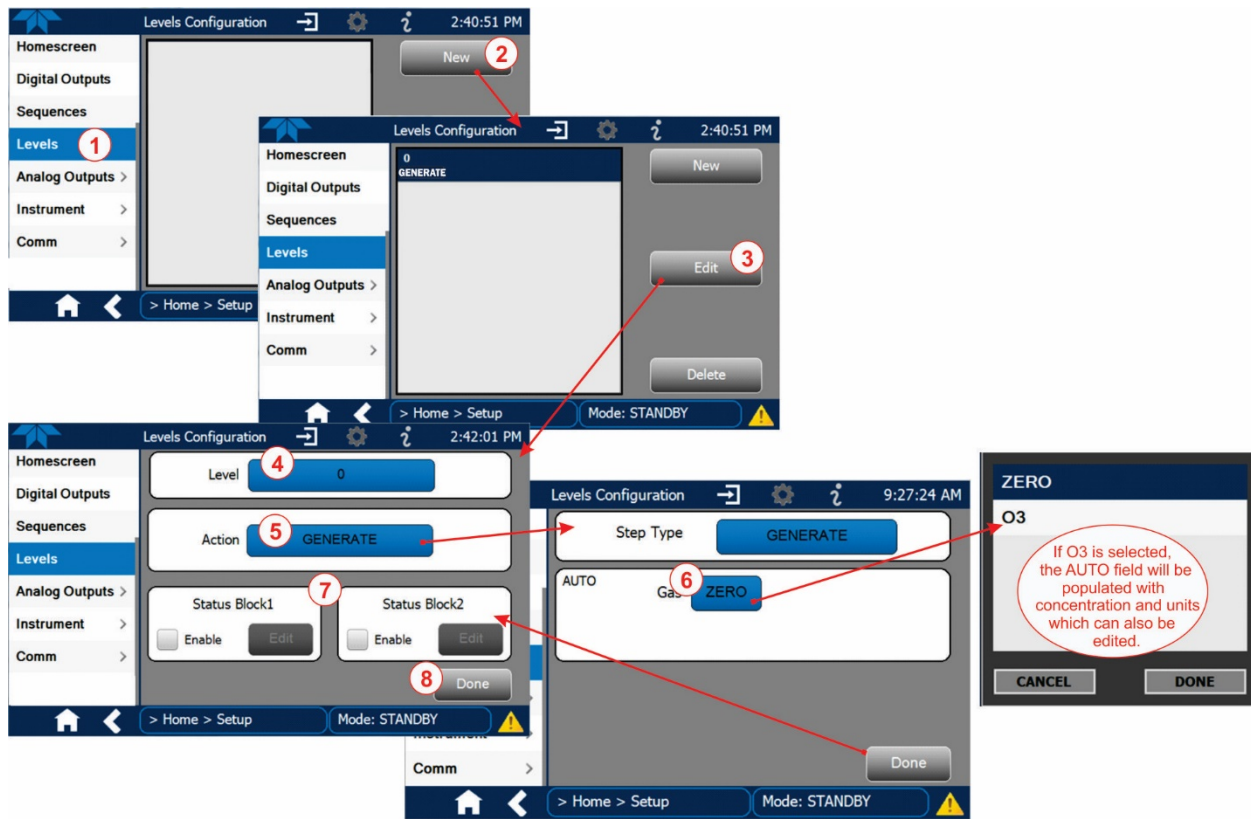


Figure 3-27. Levels Programming and Editing

3.3.8.1. Editing/Deleting Levels

To edit an existing Level, navigate to the **Setup>Levels** menu, select a Level and start with Step 3 above.

To delete an existing Level, navigate to the **Setup>Levels** menu, select a Level and press the Delete button.

3.3.8.2. Activating Levels

See Section 4.2.8.1 for methods of activating Levels.

3.3.9. SETUP>ANALOG OUTPUTS

The **Setup>Analog Outputs** menu provides the ability to configure and calibrate the analog output that was connected per Section 2.4.1.2. It can set by the user to carry the signal level of any one of the parameters listed in the **Setup>Analog Outputs>Analog Output Cfg** menu and will output an analog VDC signal that rises and falls in relationship to the value of that parameter.

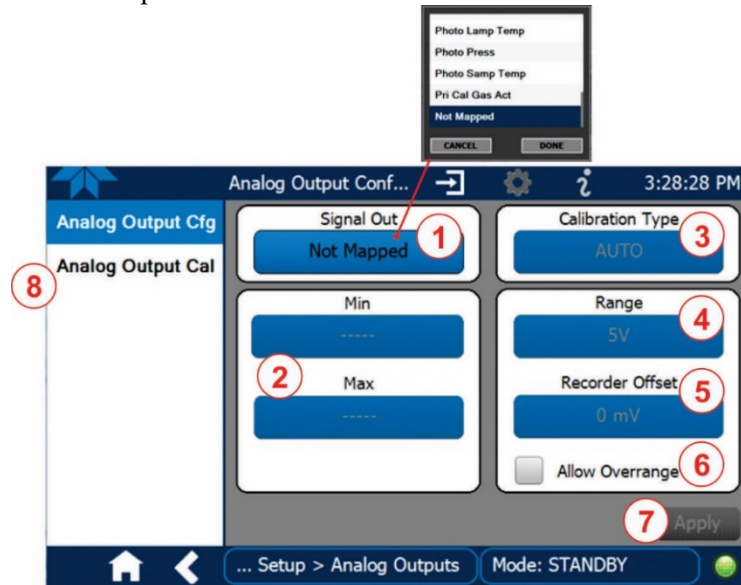


Figure 3-28. Analog Output Configuration

1. In the **Setup>Analog Outputs>Analog Output Cfg** menu press the button in the Signal Out field and select a function from the pop-up list. (Select “Not Mapped” when calibrator not connected to an external recording device; this disables all other fields in the Analog Output Configurator).
2. In the Min Max fields input the minimum and maximum values for the parameter being configured, e.g., voltage range, Subsection 3.3.9.1).
3. In the Calibration Type field, select either AUTO or MANUAL.
 - AUTO sets the software to automatically calibrate the user-selected Signal Out function.
 - MANUAL allows fine and coarse adjustments when calibrating the user-selected Signal Out function; it should be used for the 0.1V range or in cases where the outputs must be closely matched to the characteristics of the recording device. Start the calibration after configuration is complete.
4. In the Range field select the full-scale value of the output (see Section 3.3.9.1).
5. In the Recorder Offset field, input a bipolar voltage offset (see Section 3.3.9.2). This field is not available when Range is set to Current loop.
6. Either check the box to allow $\pm 5\%$ over range, or leave it blank to disallow over range if your recording device is sensitive to excess voltage or current.
7. Press the Apply button.
8. Back out and go into the Analog Output Cal menu to calibrate the instrument under the new settings.

3.3.9.1. Analog Output Voltage Range Configuration

In its standard configuration, the analog outputs are set to output 0 – 5 VDC signals. Several other output ranges are available (see Table 3-3). Each range is usable from -5% to + 5% of the rated span.

Table 3-3. Analog Output Voltage Range Min/Max

| RANGE SPAN | MINIMUM OUTPUT | MAXIMUM OUTPUT |
|------------|----------------|----------------|
| 0-100 mVDC | -5 mVDC | 105 mVDC |
| 0-1 VDC | -0.05 VDC | 1.05 VDC |
| 0-5 VDC | -0.25 VDC | 5.25 VDC |
| 0-10 VDC | -0.5 VDC | 10.5 VDC |

The default offset for all ranges is 0 VDC.

3.3.9.2. Adding a Recorder Offset to the Analog Output

Some analog signal recorders require that the zero signal be significantly different from the baseline of the recorder in order to record slightly negative readings from noise around the zero point. This can be achieved in the calibrator by defining a zero offset, a small voltage (e.g., 10% of span).

3.3.9.3. Calibrating the Analog Output

When the Analog Output is configured/reconfigured, it must be calibrated. Navigate to the analog output in the **Setup>Analog Outputs>Analog Output Cal** menu. The analog output was configured in the Analog Output Cfg menu (Section 3.3.9) to be calibrated automatically (AUTO) or adjusted manually (MANUAL).

AUTO

The Signal Out field will show whether the Analog Output signal was set for automatic calibration, press the Start button. During automatic calibration, the instrument tells the output circuitry to generate a zero mV signal and high-scale point signal (usually about 90% of chosen analog signal scale) then measures actual signal of the output. Any error at zero or high-scale is corrected with a slope and offset.

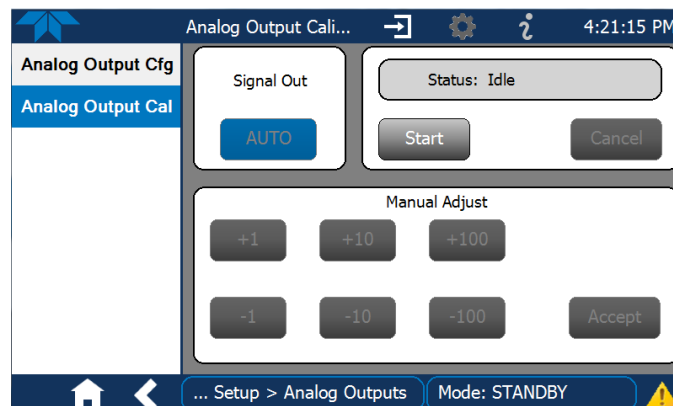


Figure 3-29. Analog Output Auto Calibration Page

MANUAL

For highest accuracy, the voltages of the analog outputs can be manually calibrated with a voltmeter connected across the output terminals (see Figure 3-30) and by changing the actual output signal level using the Manual Adjust buttons in 100, 10 or 1 count increments (Figure 3-31).

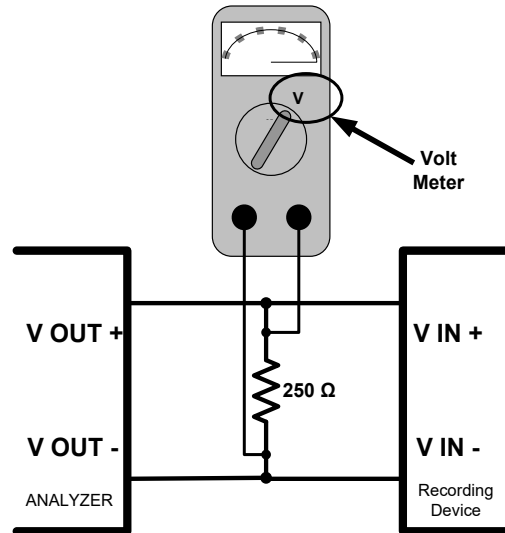


Figure 3-30. Setup for Manually Calibrating the Analog Output

Table 3-4. Voltage Tolerances for the Analog Output Calibration

| 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 |

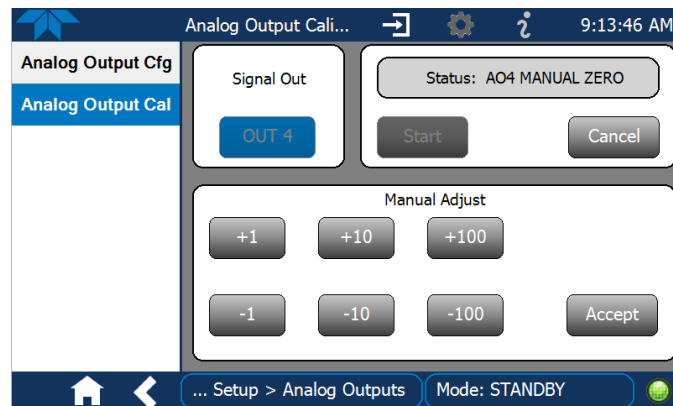


Figure 3-31. Analog Output Manual Calibration Page

3.3.10. SETUP>INSTRUMENT

The Instrument page shows product information and configurable instrument settings.

Model, Part, and Serial Numbers, Package and Driver Versions, and options information.

Platform, version, memory, etc.

Network settings, configurable in Setup>Comm menu.

Adjust date, hour, minutes, time zone (enable DST in Setup>Vars).

Configure Network Time Protocol settings for clock synchronization.

Select a language.

Get software/firmware updates when instrument is connected to an Internet-connected network.

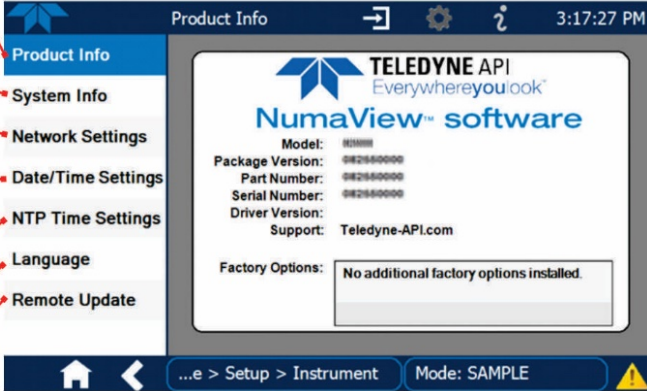


Figure 3-32. Setup>Instrument Menu

3.3.11. SETUP>COMM (COMMUNICATIONS)

This menu is for specifying the various communications configurations.

3.3.11.1. COM1/COM2

Configure the instrument's COM1 or COM2 ports to operate in modes listed and described in Table 3-5.

Table 3-5. COM1/COM2 Configuration

| MODE | DESCRIPTION |
|--------------------------------|--|
| Baud Rate | Set the baud rate for the COM1 or COM2 port being configured. (If using a PC, both computer and instrument baud rates must match). |
| Command Prompt Display | Enable/disable a command prompt to be displayed when in terminal mode. |
| Data Bits | Set the data bits to 7 or 8 (typically set in conjunction with Parity and Stop bits). |
| Echo and Line Editing | Enable/disable character echoing and line editing. |
| Handshaking Mode | Choose SOFTWARE handshaking for data flow control (do NOT use SOFTWARE handshaking mode when using MODBUS RTU for Protocol mode; select only HARDWARE or OFF for MODBUS RTU), or HARDWARE for CTS/RTS style hardwired transmission handshaking. (This style of data transmission handshaking is commonly used with modems or terminal emulation protocols). Or choose to turn OFF handshaking. |
| Hardware Error Checking | Enable/disable hardware error checking. |
| Hardware FIFO | Enable/disable the hardware First In – First Out (FIFO) for improving data transfer rate for that COM port. |
| Modem Connection | Select either a modem connection or a direct cable connection. |
| Modem Init String | Input an initialization string to enable the modem to communicate. |



T750, T750U

| MODE | DESCRIPTION |
|-------------------|---|
| Multidrop | 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). |
| Parity | Select odd, or even, or no parity (typically set in conjunction with Data Bits and Stop Bits). |
| Protocol | Select among the communications protocols: TAPI (serial communication), MODBUS RTU, or MODBUS ASCII. (See Section 5 for remote operation). |
| Quiet Mode | Enable/disable Quiet mode, which suppresses any feedback from the analyzer (such as warning messages) to the remote device and is typically used when the port is communicating with a computer program where such intermittent messages might cause communication problems. Such feedback is still available, but a command must be issued to receive them. |
| RS-485 | 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. |
| Security | Enable/disable the requirement for a password for this serial port to respond. The only command that is active is the request-for-help command (? CR). |
| Stop bits | Select either 0 or 1 stop bit (typically set in conjunction with Parity and Data bits). |

3.3.11.2. TCP Port1

TCP Port1 allows choosing whether or not to display the command prompt, and to edit the Port 1 number for defining the terminal control port by which terminal emulation software addresses the instrument; also allows or disabling security on this port.

3.3.11.3. TCP Port2

TCP Port2 is configured with the port number for MODBUS.

3.3.11.4. 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 3-6 for information).

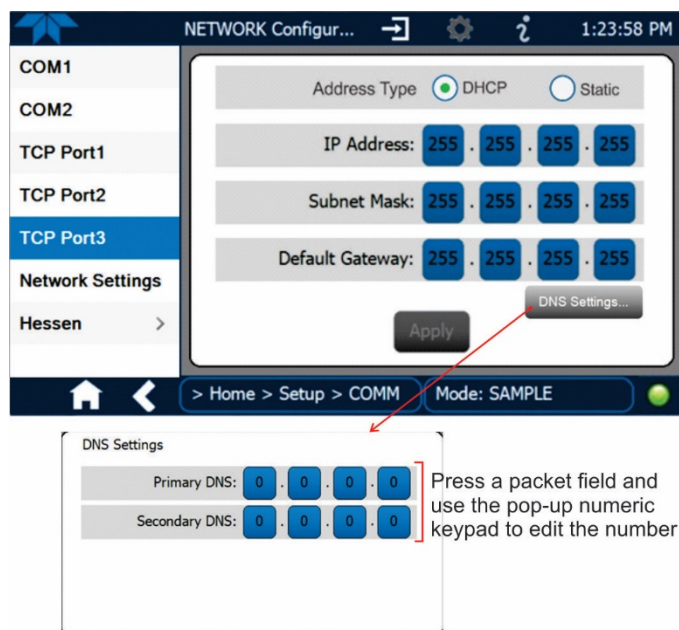


Figure 3-33. Communications Configuration, Network Settings

Table 3-6. LAN/Ethernet Configuration Properties

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

3.3.12. SETUP>GAS

The portable calibrator generates calibration gases of various concentrations by precisely mixing component gases of known concentrations with diluent (zero air). When the instrument is equipped with the optional O₃ generator and photometer, it can also use the gas phase titration method (Section 4.2.3) for generating very precise concentrations of NO₂.

To program into the calibrator's memory the concentrations of the component gases being used, see Sections 2.5.3 and 2.5.4.

4. OPERATION

The portable calibrator can be in either Generate mode or Standby mode (set in the Generate menu). When in basic Generate mode, the calibrator is engaged in producing calibration gas mixtures. When in Standby mode, the calibrator and its subsystems are inactive, during which time other operations can be completed, such as configurations in the Setup menu. The calibrator can also automatically perform several functions in a series of steps called a Sequence (Section 4.2.1), first programmed by the user through the Setup>Sequence menu (Section 3.3.7) or a Level if using Dasibi (Section 4.2.7.6), programmed through the **Setup>Levels** menu (Section 3.3.8).

4.1. STANDBY MODE

When the portable calibrator is in Standby mode, it is at rest. All internal valves are closed except the diluent inlet valve. The mass flow controllers are turned off. On units with O₃ generator and photometer options installed, these subsystems are inactive.

- The **Setup>Gas** submenu is only available when the instrument is in Standby mode.
- Some functions under the Setup menu, those that conflict with accurate creation of calibration gas mixtures, automatically place the calibrator into STANDBY mode when activated.
- The MFCs are turned OFF when the calibrator is Standby mode, so their pressures are not monitored during that time. This prevents erroneous MASS FLOW WARNING messages from appearing.

Note

- **The calibrator should always be placed in Standby mode (Generate>Standby) when not needed to produce calibration gas.**
- **The last step of any calibration sequences (Section 3.3.7) should always be the STANDBY instruction.**

Table 4-1 shows the status of the T750's various pneumatic components when the calibrator is in STANDBY mode. Figure 4-1 shows the pneumatic flow path during Standby mode, including options.

Table 4-1. Status of Internal Pneumatics During Standby Mode

| VALVES (X = Closed; O = Open) D = Deenergized; E = Energized | | | | | MFCs | | | PHOT |
|--|------------|-----|-----------------------------------|-----------------------|------|-------------------|---------|-------------------|
| CYL IN | DILUENT IN | GPT | O ₃ GEN ^{2,3} | PHOT M/R ¹ | CAL1 | CAL2 ¹ | DILUENT | PUMP ² |
| X | O | D | D | Reference Phase | OFF | OFF | OFF | OFF |

¹ Only present if multiple cal gas MFC option is installed.

² Present with photometer option.

³ Present with O₃ Generator option.

In instruments with optional O₃ generators installed, airflow is maintained during Standby mode so that the generator can continue to operate at its most efficient temperature.

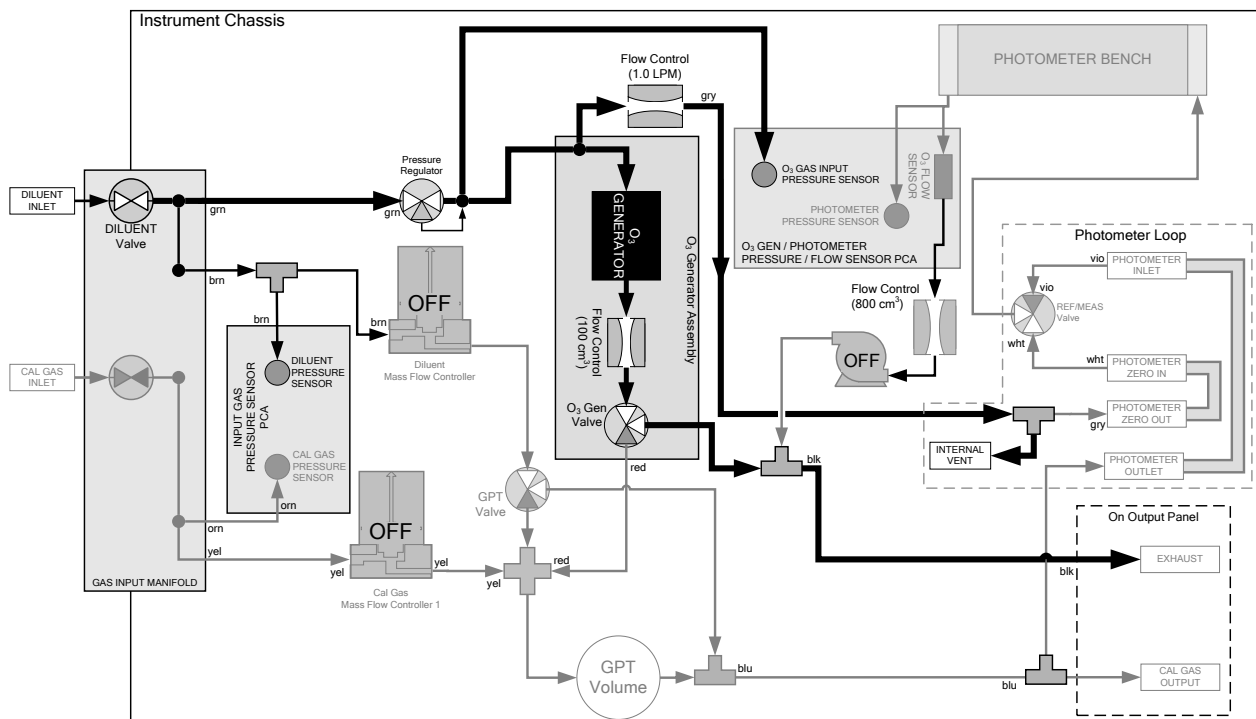


Figure 4-1. Gas Flow through T750 with O₃ Generator and Photometer Options during Standby

4.2. GENERATE MODE

The Generate menu is used to generate the desired calibration gas mixtures based on the source gas concentration entered during initial setup (Section 3.3.12, **Setup>Gas**). With the O₃ generator (if option installed in T750), various concentrations of O₃ can be generated, and the Gas Phase Titration feature becomes available.

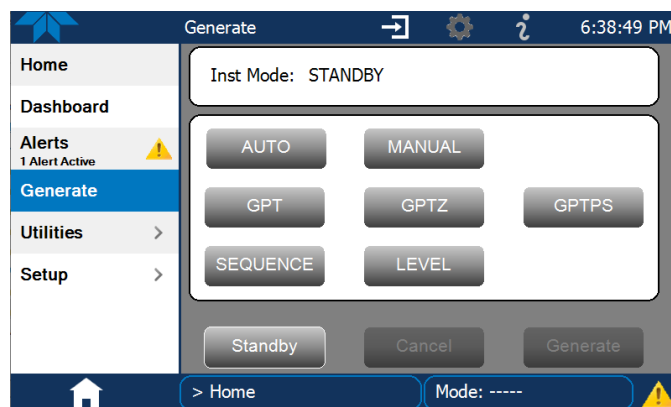


Figure 4-2. Generate Menu (GPT buttons available with O₃ Generator Option)

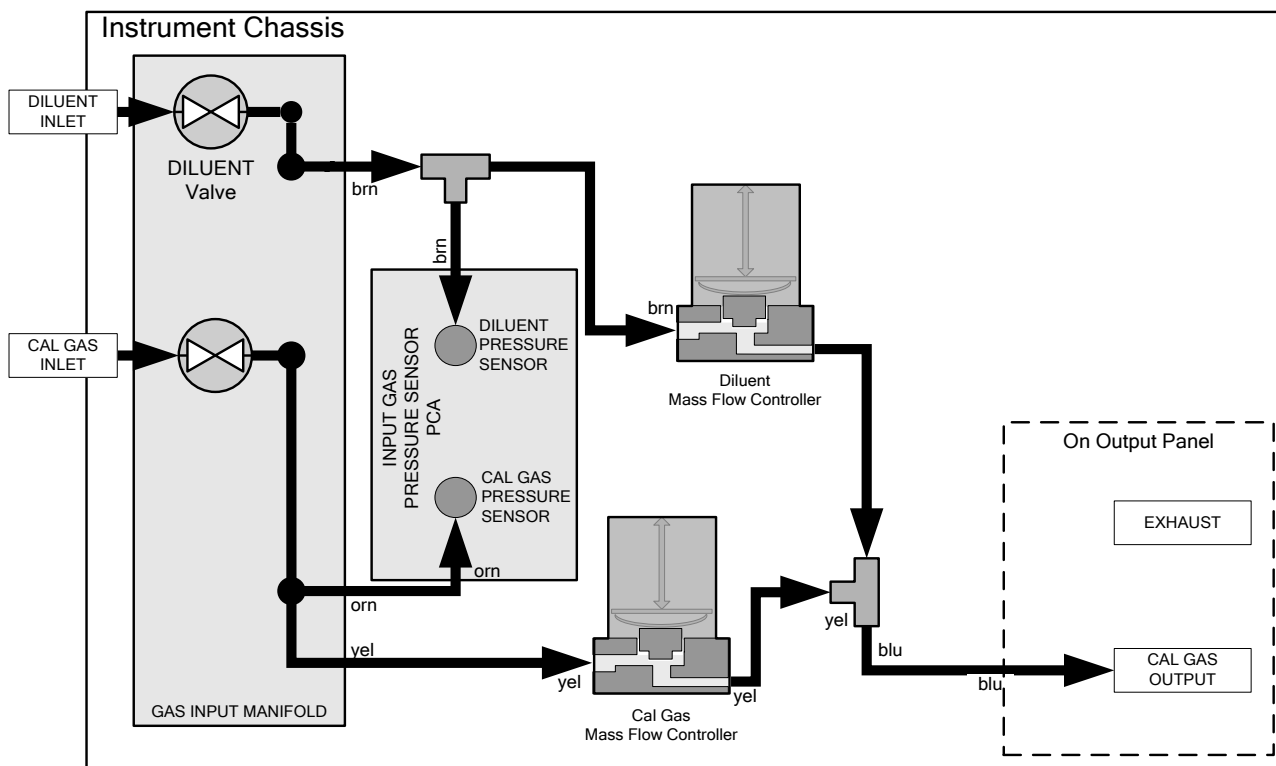


Figure 4-3. Gas Flow through Basic T750 in GENERATE Mode

Table 4-2 shows the status of the T750's various pneumatic components when the calibrator is in **GENERATE** mode:

Table 4-2. Status of Internal Pneumatics During GENERATE Mode

| GAS TYPE | VALVES (X = Closed; O = Open) (D = Deenergized; E = Energized) | | | | | MFCs | | | PHOTO PUMP ³ |
|--------------------------------|--|---------------|-----|------------------------------------|--------------------------|-----------------|-------------------|---------|----------------------------|
| | CYL IN | DILUENT IN | GPT | O ₃ GEN ⁴ | PHOT M/R ¹ | CAL1 | CAL2 ¹ | DILUENT | |
| Generate Source Gas | O | O | D | D | Reference Phase | ON ² | ON ² | ON | OFF |
| Generate O₃ | X | O | D | E | Switching | OFF | OFF | OFF | ON |

¹ Only present if multiple cal gas MFC option is installed.

² In instruments with multiple MFCs, the CPU chooses which MFC to use depending on the target gas flow requested.

³ Present with photometer option.

⁴ Present with O₃ Generator option.

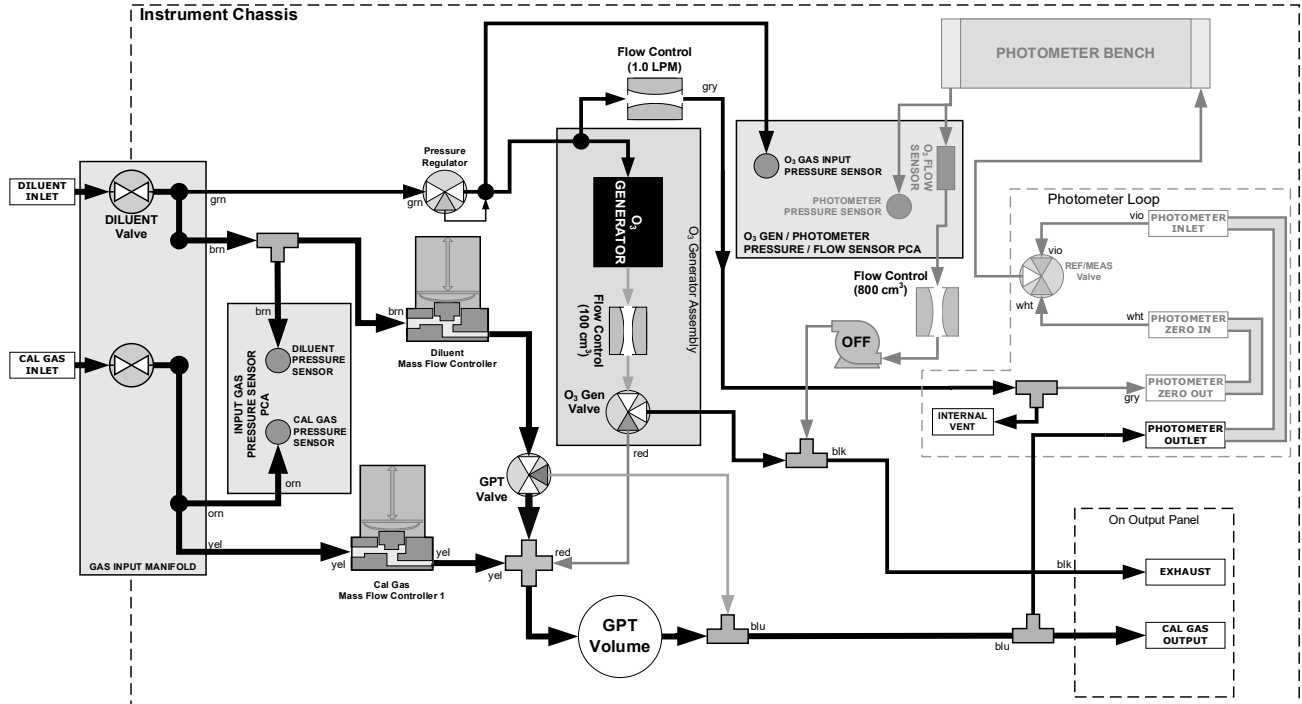


Figure 4-4. Gas Flow through T750 with O₃ Options when Generating Non-O₃ Source Gas

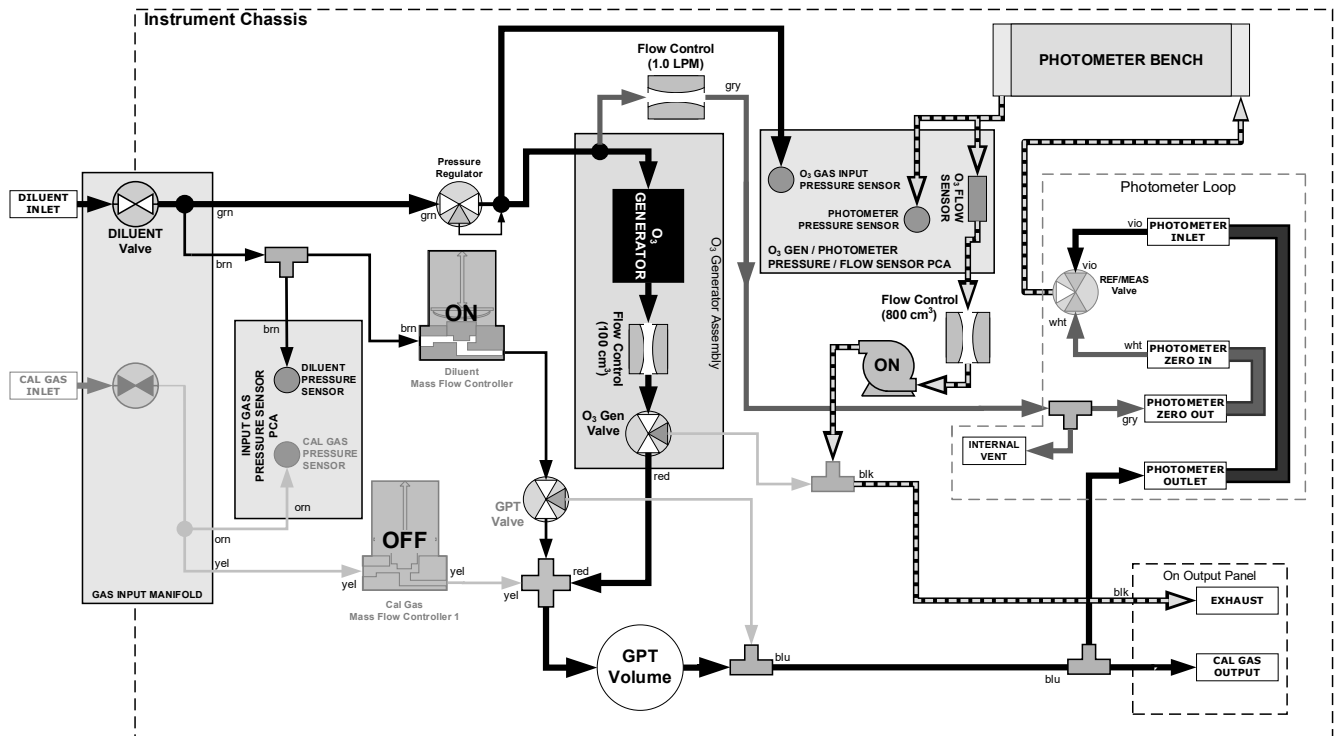


Figure 4-5. Gas Flow through T750 with O₃ Options when Generating O₃

4.2.1. GENERATE>AUTO

This is the simplest procedure for generating calibration gas mixtures: select the component gas, the target concentration, the units, and the total flow to be output by the calibrator. The calibrator automatically calculates and sets the individual flow rates for the Diluent and selected gas to create the desired calibration mixture. Total Flow is defined by the user depending on system requirements. See Section 2.5.5 for more information.

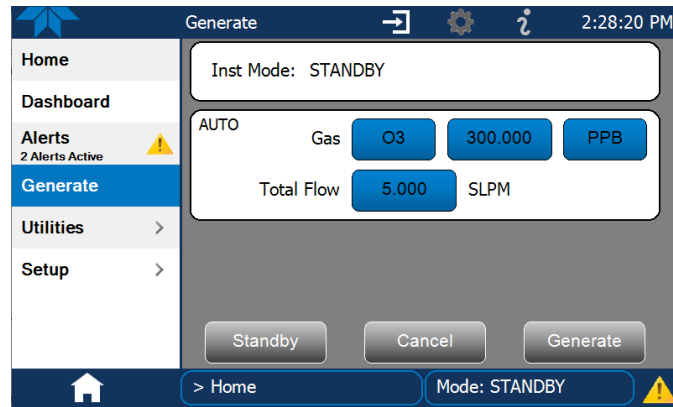


Figure 4-6. Generate>AUTO Page

4.2.2. GENERATE>MANUAL

This mode provides complete the user with more complete control of the gas mixture process, which requires the user set the both the component gas flow rate and diluent airflow rate. This allows control of the mixing ratio and total calibration gas flow rate.

In addition, if the T750 calibrator is equipped with the optional O₃ generator, and O₃ is to be included in the calibration mixture (e.g. using the GPT functions), the user also needs to set the ozone generator mode and set point.

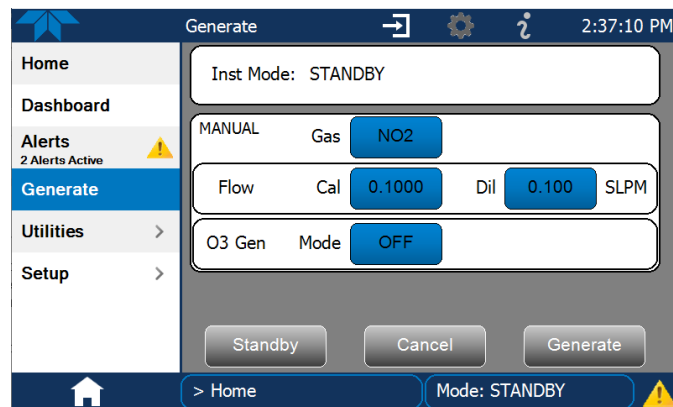


Figure 4-7. Generate>MANUAL Page

Note

The minimum total flow should equal 150% of the flow requirements of all of the instruments to which the T750 will be supplying calibration gas.

Example:

If the T750 will supply calibration gas mixtures simultaneously to a system of three analyzers, each requiring 2 SLPM, the Total Flow output should be set at: $(2 + 2 + 2) \times 1.5 = 9.000$ SLPM.

4.2.2.1. Determining the Source Gas Flow Rate

To determine the required flow rate of the component source gas, use the following formula:

Equation 4-1

$$GAS_{flow} = \frac{C_f \times Totalflow}{C_i}$$

WHERE:

C_f = target concentration of diluted gas

Totalflow = total gas flow requirements of the system

C_i = concentration of the source gas

GAS_{flow} = source gas flow rate

EXAMPLE:

- A target concentration of 200 ppm of SO₂ is needed.
- The total required flow of the system is 9.000 SLPM
- The actual concentration of the SO₂ Source is 600 ppm
- The required source gas flow rate would be:

$$GAS_{flow} = (200 \text{ ppm} \times 9.000 \text{ SLPM}) \div 600 \text{ ppm}$$

$$GAS_{flow} = 1800.000 \text{ ppm/SLPM} \div 600 \text{ ppm}$$

$$GAS_{flow} = 3.000 \text{ SLPM}$$

4.2.2.2. Determining the Diluent Gas Flow Rate

To determine the required flow rate of the diluent gas use the following formula:

Equation 4-2

$$DIL_{flow} = Totalflow - GAS_{flow}$$

WHERE:

Totalflow = total gas flow requirements of the system

GAS_{flow} = source gas flow rate (from Equation 4-1)

DIL_{flow} = required diluent gas flow

EXAMPLE:

- If the total flow requirement of the system is 9.000 SLPM,
- The source gas flow rate is set at 3.00 SLPM.
- The required source gas flow rate would be:

$$DIL_{flow} = 9.0 \text{ SLPM} - 3.0 \text{ SLPM}$$

$$DIL_{flow} = 6.0 \text{ SLPM}$$

4.2.2.3. Determining the Diluent Gas Flow Rate with O₃ Generator Option

If the O₃ generator is installed and in use, Equation 4-2 will be slightly different, as shown in Equation 4-3 since the O₃ flow is a constant value, typically 105 cm³/min.

Equation 4-3

$$DIL_{flow} = Totalflow - O_{3flow}$$

WHERE:

DIL_{flow} = required diluent gas flow

Totalflow = total gas flow requirements of the system.

O_{3flow} = the flow rate set for the O₃ generator; a constant value (typically about 0.105 SLPM)

EXAMPLE:

- If the total flow requirement of the system is 9.000 SLPM,
- The source gas flow rate is set at 0.105 SLPM.
- The required source gas flow rate would be:

$$DIL_{flow} = 9.0 \text{ SLPM} - 0.105 \text{ SLPM}$$

$$DIL_{flow} = 8.895 \text{ SLPM}$$

Note

It is not recommended to set any flow rate to <10% or >100% of the full scale rating of that associated mass flow controller. WITH MULTIPLE CALIBRATIONS MASS FLOW CONTROLLERS INSTALLED:

The combined flow potential of both mass flow controllers is available with the following limits:

10% of the lowest rated MFC to 100% of the combined full-scale ratings for both mass flow controllers.

The T750 will automatically select the MFC with the lowest flow rate that can accommodate the requested flow, thereby affording the most precise flow control.

If no single MFC can accommodate the requested flow rate, multiple mass flow controllers are used.

4.2.3. GENERATE>GPTZ, GPTPS, GPT: UNDERSTANDING GAS PHASE TITRATION (GPT)

Gas phase titration (GPT) provides an alternative method to UV photometry for ozone analysis. This section first describes the principles of GPT, then provides the information necessary for performing GPT Zero (GPTZ), GPT Preset (GPTPS), and GPT with the O₃ Generator and Photometer option.

Note

It is strongly recommended that GPTZ and GPTPS be performed prior to running GPT.

4.2.3.1. Meeting USEPA Guidelines for GPT Calibration

The USEPA has published guidelines for the pneumatic parameters involving GPT calibrations. These guidelines are meant to ensure that the O₃/NO reaction is complete, and that the risk of producing other un-wanted reactions is minimized. These guidelines are published in the U.S. 40 CFR pt. 50, appendix F. In this appendix are requirements for the Residence Time in the reaction volume as well as a Dynamic Parameter specification.

For the purposes of calculating these parameters, the volume of the GPT reaction chamber is 130 cc.

4.2.3.2. GPT Theory

The principle of GPT is based on the rapid gas phase reaction between NO and O₃, which produces quantities of NO₂ as shown by the following equation:

Equation 4-4



It has been empirically determined that under controlled circumstances the NO-O₃ reaction is very efficient (<1% residual O₃), therefore the concentration of NO₂ resulting from the mixing of NO and O₃ can be precisely predicted and controlled as long as the following conditions are met:

- The amount of O₃ used in the mixture is known.
- The amount of NO used in the mixture is **AT LEAST** 10% greater than the amount of O₃ in the mixture.
- The volume of the mixing chamber is known.
- The NO and O₃ flow rates (from which the time the two gases are in the mixing chamber) are low enough to give a residence time of the reactants in the mixing chamber of >2.75 ppm min.

Given the above conditions, the amount of NO₂ being output by the T750 will be equal to (at a 1:1 ratio) to the amount of O₃ added.

Since the O₃ flow rate of the T750's O₃ generator is a set fixed value (typically about 0.105 SLPM) and the GPT chamber's volume is known, once the **TOTAL GAS FLOW** requirements, the source concentration of NO, and the target concentration for the O₃ generator are entered into the calibrator's software. The T750 adjusts the NO flow rate and diluent (zero air) flow rate to create the appropriate NO₂ concentration at the output.

4.2.3.3. Choosing an Input Concentration for the NO

It is important to ensure that there is enough NO in the GPT chamber to use up all of the O₃. Excess O₃ will react with the resulting NO₂ to produce NO₃. Since NO₃ is undetectable by most NO_x analyzers, this will result in false low readings.

The EPA requires that the NO content of a GPT mixture be at least 10% higher than the O₃ content. Since there is no negative effect of too much NO in the GPT chamber, API recommends an NO concentration value higher (as much as twice as high as the highest intended target NO₂ value) and kept constant. As long as the flow rate remains constant, three of the four conditions listed in Section 4.2.3.1 above are therefore constant and the NO₂ output can be easily and reliably varied by simply changing the O₃ concentration.

EXAMPLE:

- Calibration values of NO₂ from 200 ppb to 450 ppb will be needed.
- The NO gas input concentration should be no lower than 495 ppb and can be as high as 900 ppb.



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4.2.3.4. Determining the Total Flow for GPT Calibration Mixtures

The total flow rate is defined by the user depending on system requirements.

The minimum total flow should equal 150% of the flow requirements of all of the instruments to which the T750 will be supplying calibration gas.

Example:

If the T750 will be expected to supply calibration gas mixtures simultaneously to a system composed of three analyzers, each requiring 2 SLPM, the proper Total Flow output should be set at: $(2 + 2 + 2) \times 1.5 = 9.000$ SLPM

Note

It is not recommended to set any flow rate to <10% or >100% of the full scale rating of that associated mass flow controller.

WITH MULTIPLE CALIBRATIONS MASS FLOW CONTROLLERS INSTALLED:

- The full combined flow potential of both mass flow controllers is available to use with the following limits: 10% of the lowest rated MFC to 100% of the combined full-scale ratings for both mass flow controllers.
- The T750 automatically selects the MFC with the lowest flow rate that can accommodate the requested flow, thereby affording the most precise flow control.

If no single MFC can accommodate the requested flow rate, multiple mass flow controllers are used

4.2.4. GENERATE>GPTZ: GENERATING GPT FLOW CONDITIONS (TO BE RUN PRIOR TO PERFORMING GPTPS AND GPT)

To evaluate and calculate the catalytic converter efficiency (CE), GPTZ should be run first for best accuracy of GPT. GPTZ simulates the flow condition of GPT without generating ozone. This provides accuracy of the NO reading. To initiate GPTZ,

Note

The ozone lamp does not turn on during GPTZ.

The following table and Figure show the status of the T750's internal pneumatic components and internal gas flow when the instrument is in **GPTZ** generating mode.

Table 4-3. Status of Internal Pneumatics During GENERATE → GPTZ Mode

| MODE | VALVES (X = Closed; O = Open) (D = Deenergized; E = Energized) | | | | | MFCs | | | PHOTO PUMP ³ |
|------|--|------------|-----|------------------------------------|-----------------------|-----------------|-------------------|---------|-------------------------|
| | CYL IN | DILUENT IN | GPT | O ₃ GEN ^{3, 4} | PHOT M/R ¹ | CAL1 | CAL2 ¹ | DILUENT | |
| GPTZ | O | O | E | E | Reference Phase | ON ² | ON ² | ON | OFF |

¹ Only present if multiple cal gas MFC option is installed.

² In instruments with multiple MFCs, the CPU selects the MFC to use based on the target gas flow requested.

³ Present with photometer option.

⁴ Present with O₃ generator option.

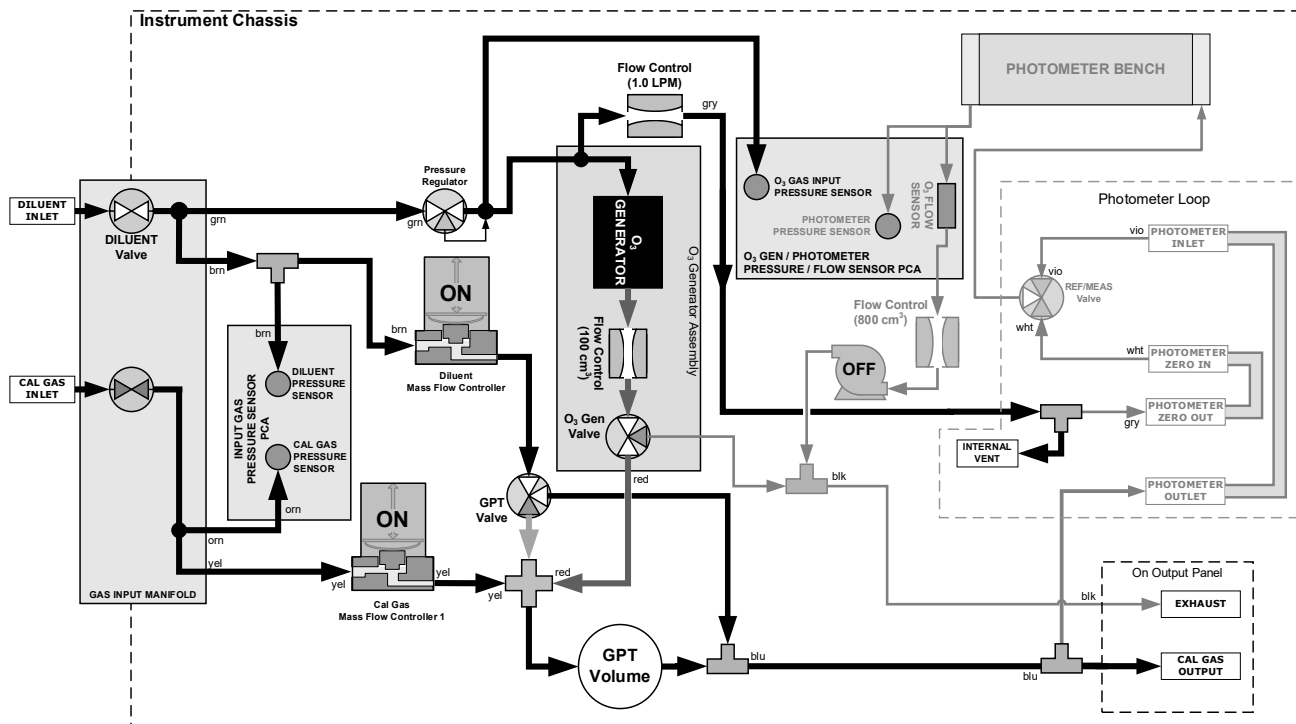


Figure 4-8. Gas Flow through T750 with O₃ Options when in GPTZ Mode

In the Generate page, press the GPTZ button and configure the parameters according to:

- NO source gas concentration
- Target O₃ concentration (equal to the target NO₂ concentration to be generated)
- TOTAL GAS FLOW for the mixture output

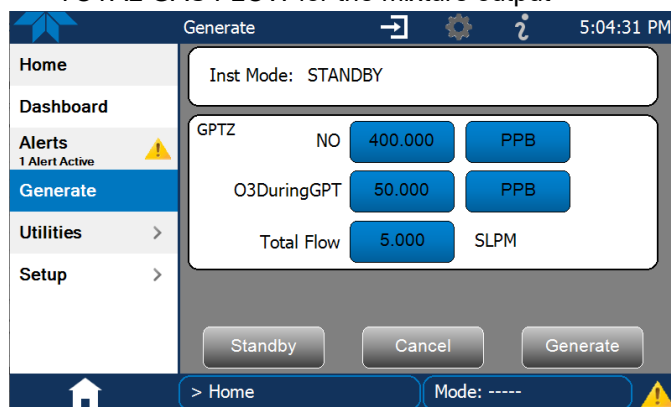


Figure 4-9. Sample Generate GPTZ Page

Then press the Generate button.



4.2.5. GENERATE>GPTPS: PERFORMING A GPT PRE-SET (TO BE RUN AFTER GPTZ AND PRIOR TO GPT)

The GPT Pre-Set (GPTPS) feature *simulates* a GPT mixing operation in order to determine the *exact output* of the calibrator's O₃ generator. As described in Section 4.2.3.2, all other things being equal, the concentration of the NO₂ being generated by the GPT feature will be equal to the amount of O₃ used. Therefore, the more accurately the O₃ generator performs, the more accurate the NO₂ output will be.

When operating in GPTPS mode, diluent gas (zero air) is substituted for the NO gas that would be mixed with the O₃ in normal GPT mode. The resulting unaffected O₃ output of the O₃ generator is shunted through the T750's internal photometer, which measures the ACTUAL O₃ concentration in the gas.

Once the *exact* O₃ concentration being output by the generator is determined, the calibrator's software adjusts the O₃ drive voltage up or down so that the output of the generator matches as closely as possible, the target concentration requested. This adjusted generator setting will be used during any subsequent real GPT operation.

Note

The T750 has a learning algorithm during the O₃ generation (see Section 4.2) or Gas Phase Titration Pre-Set Mode (GPTPS). It may take up to one hour for each new concentration/flow (point) that is entered into the instrument. Once the instrument has several points memorized in its cache, any new point that is entered will automatically be estimated within $\pm 1\%$ error (with photometer) and $\pm 10\%$ error (with O₃ generator and GPTPS).

This adjustment is only valid for the O₃ concentration used during the Pre-Set operation. GPT Pre-Sets must be re-run for each different target NO₂ value.

In order to keep the resulting concentration of O₃ consistent with the GPT mixture being simulated, the instrument's software adjusts the flow rate of the diluent gas to substitute an amount of diluent gas equal to the amount of NO gas that would normally be used. The following table and figures show the status of the T750's internal pneumatic components and internal gas flow when the instrument is in GPTPS generating mode.

Table 4-4. Status of Internal Pneumatics During GENERATE → GPTPS Mode

| MODE | VALVES (X = Closed; O = Open) (D = Deenergized; E = Energized) | | | | | MFCs | | | PHOT PUMP ³ |
|-------|--|---------------|-----|---------------------------------------|--------------------------|------|-------------------|---------|---------------------------|
| | CYL IN | DILUENT IN | GPT | O ₃ GEN ^{2, 3} | PHOT M/R ¹ | CAL1 | CAL2 ¹ | DILUENT | |
| GPTPS | X | O | E | E | Switching | OFF | OFF | ON | ON |

¹ Only present if multiple cal gas MFC option is installed.

² Present with O₃ generator option.

³ Present with photometer option.

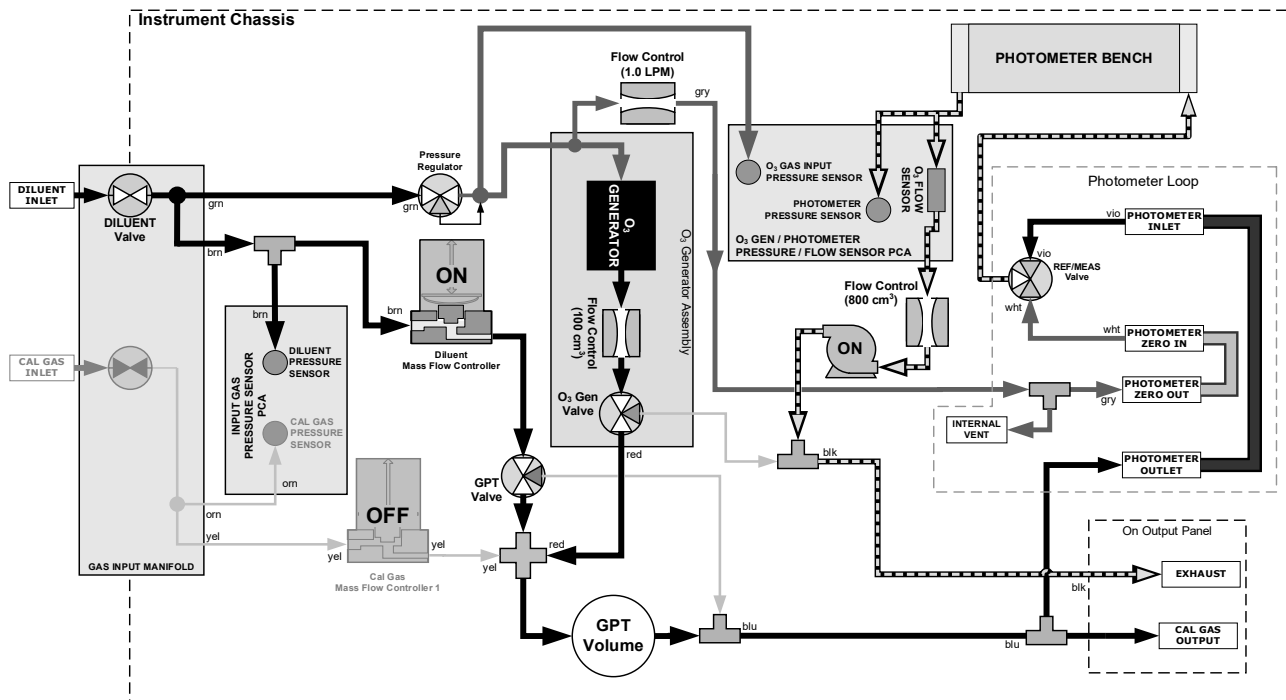


Figure 4-10. Gas Flow through T750 with O₃ Options when in GTPS Mode

In the Generate page, press the GTPS button and configure the parameters according to:

- NO source gas concentration
- Target O₃ concentration (equal to the target NO₂ concentration to be generated)
- TOTAL GAS FLOW for the mixture output

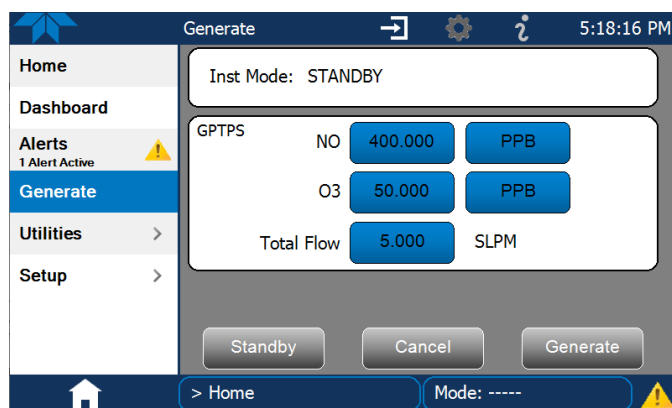


Figure 4-11. Sample Generate GTPS Page

Then press the Generate button.

4.2.6. GENERATE>GPT: PERFORMING A GAS PHASE TITRATION CALIBRATION

After having performed a GPTZ, followed by a GPTPS, it is time for the GPT.

IMPORTANT

IMPACT ON READINGS OR DATA

It is required that a GPT Pre-Set (GPTPS, Section 4.2.5) be performed before initiating any GPT gas generation.

The following table and Figure show the status of the T750's internal pneumatic components and internal gas flow when the instrument is in GPT generating mode.

Table 4-5. Status of Internal Pneumatics During GENERATE → GPT Mode

| MODE | VALVES (X = Closed; O = Open) (D = Deenergized; E = Energized) | | | | | MFCs | | | PHOT PUMP ³ |
|------|--|------------|-----|------------------------------------|-----------------------|-----------------|-------------------|---------|------------------------|
| | CYL IN | DILUENT IN | GPT | O ₃ GEN ^{3, 4} | PHOT M/R ¹ | CAL1 | CAL2 ¹ | DILUENT | |
| GPT | O | O | E | E | Reference Phase | ON ² | ON ² | ON | OFF |

¹ Only present if multiple cal gas MFC option is installed.

² In instruments with multiple MFCs, the CPU chooses which MFC to use depending on the target gas flow requested.

³ Present in T750 with photometer option.

⁴ Present in T750 with O₃ generator option.

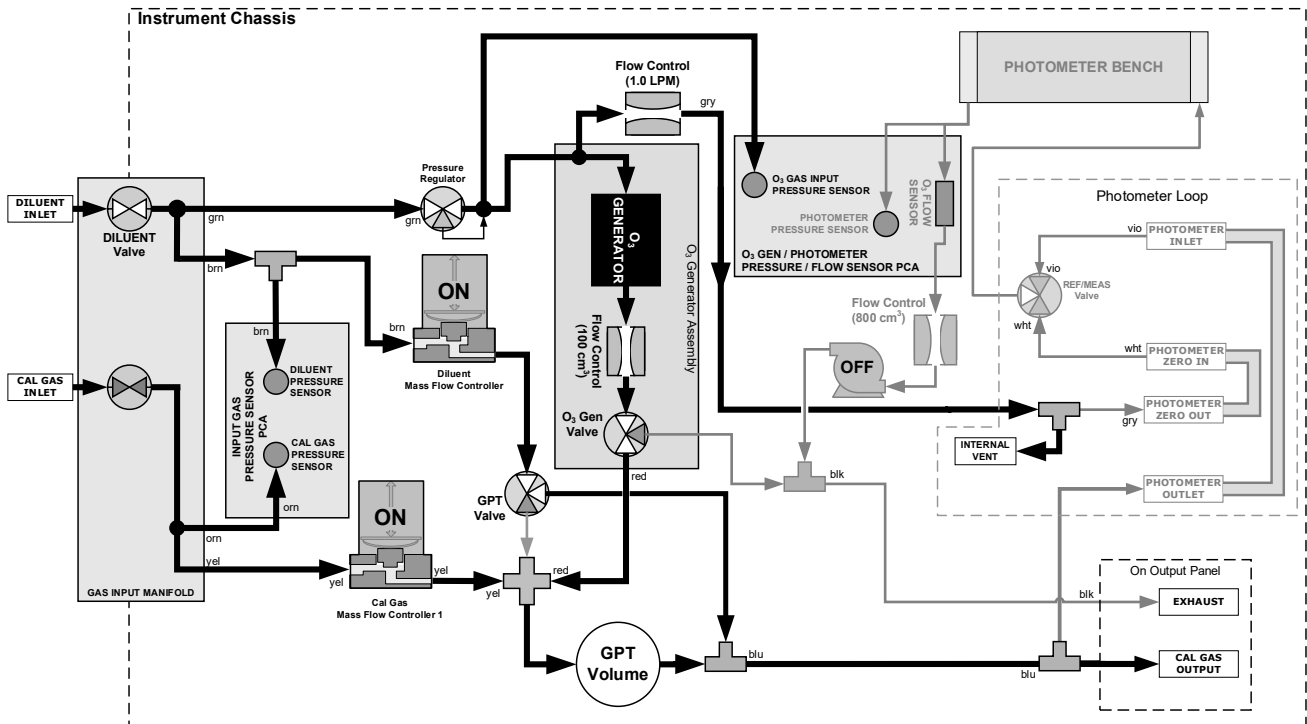


Figure 4-12. Gas Flow through T750 with O₃ Options when in GPT Mode

In the Generate page, press the GPT button and configure the parameters according to:

- NO source gas concentration and units
- Target O3 concentration (equal to the target NO₂ concentration to be generated) and units
- Total Flow in SLPM for the mixture output

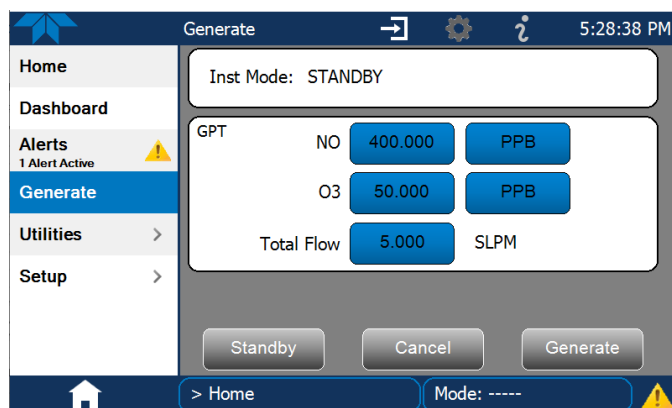


Figure 4-13. Sample Generate GPT Page

Then press the Generate button.

4.2.7. GENERATE>SEQUENCE: AUTOMATIC OPERATION USING SEQUENCES

The calibrator can be set up to perform automatic calibration sequences. Each sequence is a database of single or multiple steps where each single step is an instruction that causes the instrument to perform a calibration operation. These steps are grouped under a user-defined sequence name, and each sequence is configured in the **Setup>Sequence** menu (Section 3.3.7). These sequences can perform all of the calibration operations available (see Table 3-2) for manual operation; they can be configured to be triggered by any of several methods:

- touchscreen
- internal timer: preprogrammed in the Sequence
- the external digital control inputs
- communications interface (such as RS-232 or Ethernet)
- sub-processes in another sequence

4.2.7.1. Activating a Sequence from the Touchscreen

In the Generate menu, press the SEQUENCE button, and in the EXECSEQ field that appears, select the name of the sequence in the scrollable list and press the Generate button.

Suspend the Sequence by pressing the Standby button.

4.2.7.2. Activating a Sequence with the Internal Timer

Typically a sequence will start automatically at the time that was input when first configured (Section 3.3.7) if the Timer was enabled. To enable the Timer or change the settings, navigate to the **Setup>Sequences** menu, select the sequence by name and in the Timer field check the Enable box. Press the Edit button to either view or change the Timer settings.



4.2.7.3. Activating a Sequence with the External Digital Control Inputs

This method triggers the sequence from an external control source that was electrically connected per the instructions in Section 2.4.1.4, so that the calibrator can operate in a slave mode. To enable the Input CC feature, navigate to the **Setup>Sequences** menu, select the sequence by name and in the Input CC field check the Enable box. Press the Edit button to either view or change the switch settings. (Refer to Section 3.3.7 and Table 3-2 for configuration information).

4.2.7.4. Activating a Sequence or Defaulting to Control Other Devices

This method triggers the sequence to set or reset the calibrator's digital control outputs. It is very useful in situations where the control outputs are being used to trigger other devices that need to be turned off and on in synch with the operation of the calibrator as it progresses through the sequence. To enable this feature, navigate to the **Setup>Sequences** menu, select the sequence by name and in the Output CC field check the Enable box. Press the Edit button to either view or change the switch settings. (Refer to Section 3.3.7 and Table 3-2 for configuration information).

4.2.7.5. Activating a Sequence as a Subprocess in another Sequence

This method is a way of nesting other often-used operations (subprocesses) within a sequence. Subprocess are sequences that can be reused rather than be recreated for other new sequences. Create the subprocess as sequence through the **Setup>Sequences** menu; then insert it as a nested sequence while creating or editing the “overhead” sequence with the EXECSEQ step.

4.2.7.6. Activating a Sequence through a Communications Interface

This is a method that is carried out through remote communication control. See Section 5.

4.2.8. GENERATE>LEVEL: AUTOMATIC OPERATION USING LEADS LEVELS

The calibrator can be equipped with a version of firmware that includes support for LEADS, a data collection and analysis system specifically designed for handling meteorological and environmental data, particularly when there is a need to integrate data and control instrumentation from several different manufacturers. When a T750/T750U calibrator is equipped with the optional LEADS software used in conjunction with data loggers located in a central data analysis facility, it is possible to collect and buffer data between the various calibrators, analyzers and metrological equipment remotely located at an air monitoring station.

Because LEADS was originally developed for use with TNRCC using Dasibi 5008 calibrators, the LEADS version of the T750/T750U includes support for Dasibi “Dot” serial data commands and operational “LEVELs”. (For more information on the LEADS system, please go to <http://www.meteostar.com/>).

The Dasibi “Dot” commands form a text-based (ASCII) data protocol that is transmitted between a control computer, such as a XENO data logger, and a calibrator or ambient gas analyzer over an RS-232 connection. The details of the protocol are beyond the scope of this document, but in its simplest form the protocol is based on a two or three digit integer



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preceded by a control-A and a period (.) and then followed by a “!” and a two digit checksum.

EXAMPLE:

^A.xxx!nn

A T750/T750U equipped with LEADS software can be simultaneously operated over the same COM port using standard Teledyne API's serial data commands.

4.2.8.1. Activating Levels

Levels are individually started and stopped either by an operator locally by using the touchscreen menu or remotely through a serial data operation over the RS-232 or Ethernet ports.

To activate an existing Level, from Home page navigate to the Generate menu, press the LEVEL button, then select the Level by its ID, and press the Generate button. To stop, press the Standby button.



5. COMMUNICATIONS AND REMOTE OPERATION

This instrument's output and communications panel connections include an Ethernet port and serial communications ports. This section provides pertinent information regarding communication equipment, the communications ports, and communications protocol. Data acquisition is set up through the Datalogger (Section 3.3.1).

5.1. USING THE COMMUNICATION PORTS

The communications ports were described in Section 2.4.1.6, along with their connection instructions, and their setup instructions were provided in Section 3.3.11. These ports allow the ability to communicate with, issue commands to, and receive data from the analyzer through an external computer system or terminal.

5.1.1. 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, as previously described in RS-232 Com Port Connector Pin-outs under Section 2.4.1.6.

To enable the analyzer to be used with terminals (DTE), modems (DCE) and computers (which can be either), a switch mounted on the electrical connections 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.

5.1.2. MODES, BAUD RATE AND SERIAL COMMUNICATION

Referring to Table 3-5, 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.

5.1.3. 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).
- 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 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.

5.1.4. 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.

5.2. ETHERNET

When using the Ethernet interface, the analyzer can be connected to any standard 10BaseT or 100BaseT Ethernet network via low-cost network hubs, switches or routers. The interface operates as a standard TCP/IP device on port 3000. This allows a remote computer to connect through the network to the analyzer using NumaView™ Remote, terminal emulators or other programs.

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

Table 5-1. Ethernet Status Indicators

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

The instrument is shipped with DHCP enabled by default, which allows it 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 3.3.11.4 for configuration details.

5.3. NUMAVIEW™ REMOTE

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



5.4. MODBUS PROTOCOL AND COM PORT CONFIGURATION

The following set of instructions assumes that the user is familiar with MODBUS communications, and provides minimal information to get started. For additional instruction, please refer to the Teledyne API MODBUS manual, PN 06276. Also refer to 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)
- Personal computer with communications cable (Ethernet or USB or RS232)
- Possibly a null modem adapter or cable

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.

Ethernet MODBUS is available on TCP Port2 with the default number, 502, which can be checked through the **Setup>Comm> TCP Port2** menu.

Serial COM Both COM1 (labeled “RS232”) 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 3-5). Press the Accept button to apply the settings.

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.

Important

When more than one instrument 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 instrument, wait 5 seconds, and power it on again.



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6. CALIBRATION AND VERIFICATION

Basic electronic calibration of the Calibrator is performed at the factory. Normally there is no need to perform this factory calibration in the field however, the performance of several of the instrument's key subsystems should be verified periodically and if necessary adjusted. These subsystems are:

- Mass Flow Controllers: The accuracy of the mass flow controller outputs is intrinsic to achieving the correct calibration mixture concentrations; therefore, the accuracy of their output should be checked and if necessary adjusted every 6 months (see Section 6.1).
- O₃ Photometer: The O₃ photometer performance should be periodically verified against an external standard (see Section 6.2).
- O₃ Generator: The O₃ generator should be periodically calibrated (see Section 6.3).

6.1. VERIFYING AND CALIBRATING THE MFCs

View the parameters for each MFC under the **Utilities>Diagnostics** menu.

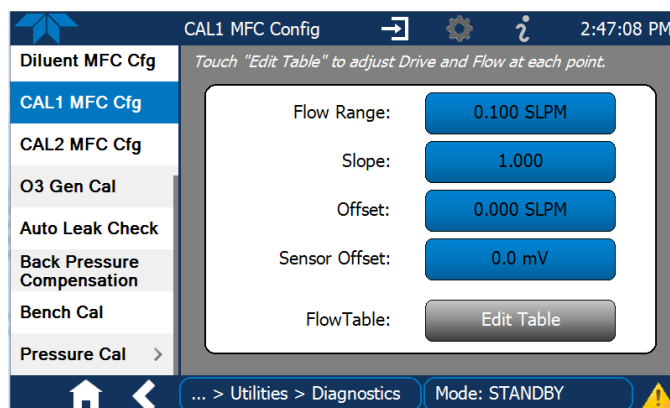


Figure 6-1. MFC Config Page

The Flow Table for each MFC sets its output at each of 20 equally spaced control points along its entire performance range. In the **Utilities>Diagnostics** menu view the Flow Table field for each MFC by clicking the Edit Table button. For each calibration point, the following is displayed:

- The drive voltage in 20 equal, incremental steps from 0 mVDC to 5000 mVDC;
- The expected flow rate corresponding to each drive voltage point (each equal to 1/20th of the full scale for the selected mass flow controller).

This table can also be used to calibrate the output of the MFCs by adjusting either the control voltage of a point or its associated flow output value (see Section 6.1.2).

Table 6-1. Examples of MFC Calibration Points

| CAL POINT | DRIVE VOLTAGE | MFC FULL SCALE | | | |
|--------------|------------------|-------------------|----------|----------|-----------|
| | | 1.0 SLPM | 3.0 SLPM | 5.0 SLPM | 10.0 SLPM |
| | | MFC TARGET OUTPUT | | | |
| 0 | 000 mV | 0.000 | 0.000 | 0.000 | 0.000 |
| 1 | 250 mV | 0.050 | 0.150 | 0.250 | 0.500 |
| 2 | 500 mV | 0.100 | 0.300 | 0.500 | 1.000 |
| 3 | 750 mV | 0.150 | 0.450 | 0.750 | 1.500 |
| 4 | 1000 mV | 0.200 | 0.600 | 1.000 | 2.000 |
| 5 | 1250 mV | 0.250 | 0.750 | 1.250 | 2.500 |
| 6 | 1500 mV | 0.300 | 0.900 | 1.500 | 3.000 |
| 7 | 1750 mV | 0.350 | 1.050 | 1.750 | 3.500 |
| 8 | 2000 mV | 0.400 | 1.200 | 2.000 | 4.000 |
| 9 | 2250 mV | 0.450 | 1.350 | 2.250 | 4.500 |
| 10 | 2500 mV | 0.500 | 1.500 | 2.500 | 5.000 |
| 11 | 2750 mV | 0.550 | 1.650 | 2.750 | 5.500 |
| 12 | 3000 mV | 0.600 | 1.800 | 3.000 | 6.000 |
| 13 | 3250 mV | 0.650 | 1.950 | 3.250 | 6.500 |
| 14 | 3500 mV | 0.700 | 2.100 | 3.500 | 7.000 |
| 15 | 3750 mV | 0.750 | 2.250 | 3.750 | 7.500 |
| 16 | 4000 mV | 0.800 | 2.400 | 4.000 | 8.000 |
| 17 | 4250 mV | 0.850 | 2.550 | 4.250 | 8.500 |
| 18 | 4500 mV | 0.900 | 2.700 | 4.500 | 9.000 |
| 19 | 4750 mV | 0.950 | 2.850 | 4.750 | 9.500 |
| 20 | 5000 mV | 1.000 | 3.000 | 5.000 | 10.000 |

6.1.1. SETUP FOR VERIFYING AND CALIBRATING THE MFCs

Note A separate, calibrated flow meter is required for the procedure.

1. Turn off the calibrator.
2. Open the calibrator's front panel for easiest access to the MFC output ports.
3. Attach the flow meter directly to the output port of the MFC to be checked/tested. (shows their locations).
4. Turn ON power to the calibrator.
5. Ensure the calibrator is in Standby mode (change in Generate page if needed).

6.1.2. VERIFYING AND CALIBRATING THE MFCs

Once the external flow meter is connected to the output of the MFC being verified/calibrated, perform the following steps (refer to Figure 6-2):

1. In the Diagnostics menu select the MFC to be tested and press the Edit Table button in the Flow Table field.
2. Check the Enable Drive box to start the flow.

3. Scroll to each calibration point in the table and check that the external flow meter is reading within 1% of the value in the flow table (\pm flow meter accuracy):
 - a. If it is, scroll to the next calibration point in the flow table and repeat.
 - b. If not, press the Edit Flow button and adjust the flow value to match that of the external flow meter
4. If any flow values were adjusted in Step 3, press the Apply button. (If changes were made without pressing the Apply button, a prompt will appear when the Done button is pressed, asking whether to save the changes).
5. Press the Done button when adjustments are completed; this will stop the flow and return to the Diagnostics menu.

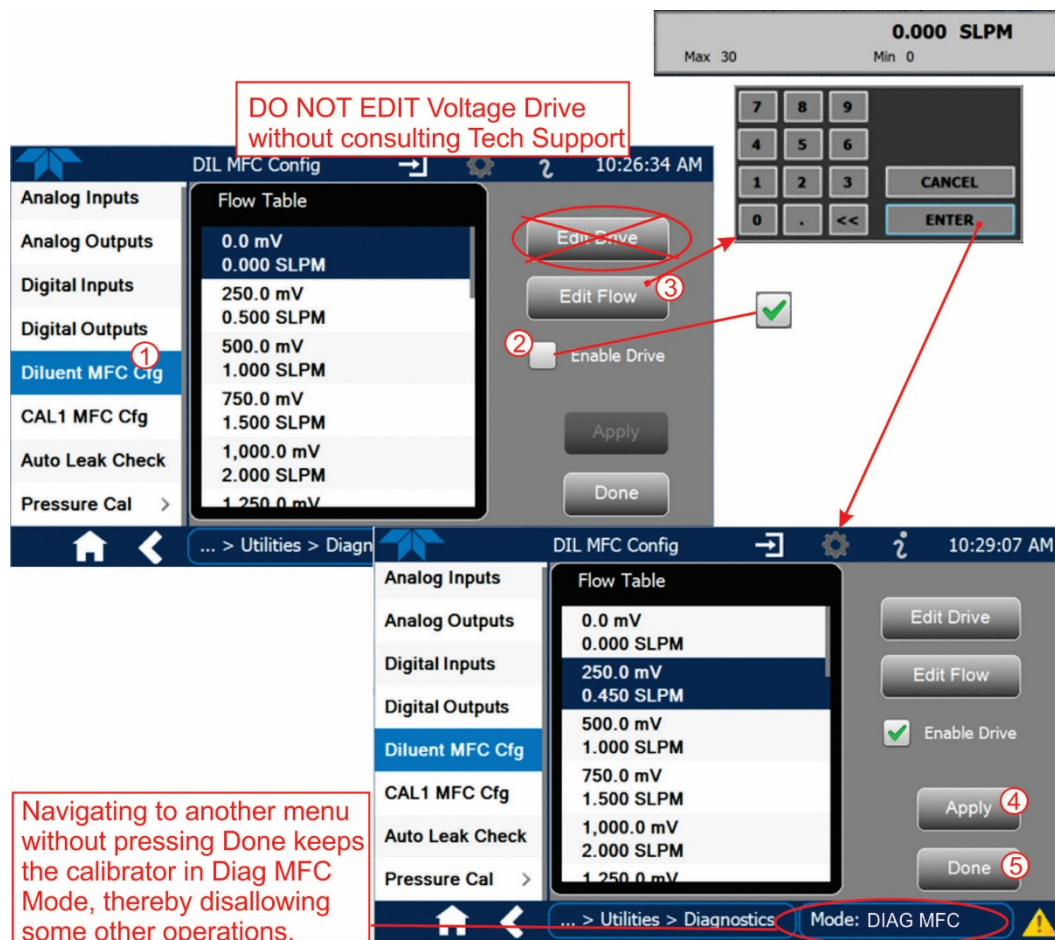


Figure 6-2. MFC Calibration

6.2. VERIFYING AND CALIBRATING THE O₃ PHOTOMETER (OPTION IN T750)

The accuracy of calibration mixtures involving O₃ produced by the T750 depends entirely on the accuracy of the photometer; therefore, it is very important that the photometer is operating properly and accurately.

Setup illustration and instructions for verification are presented in Section 6.2.1. Setup for calibration differs and instructions are presented in Section 6.2.2. In either case, an external source of zero air (such as a Teledyne API's Model 701 Zero Air Generator) is required.

6.2.1. SETUP AND VERIFICATION OF O₃ PHOTOMETER PERFORMANCE

Note This operation requires an external reference photometer.

Set up the calibrator and reference photometer as illustrated in Figure 6-3

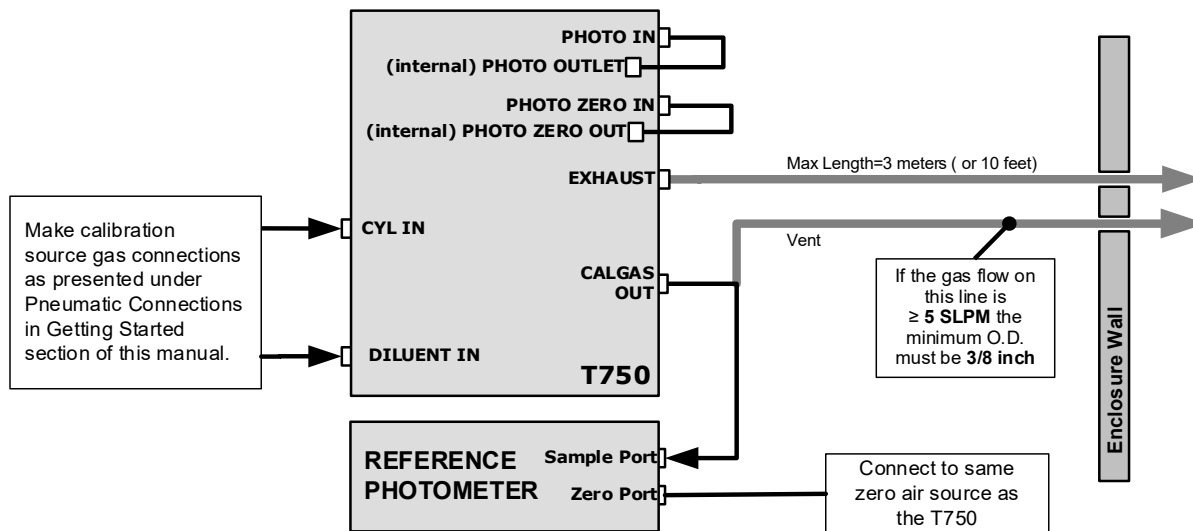


Figure 6-3. Set up for Verifying O₃ Photometer

To verify the performance of the internal photometer, place the calibrator in Standby mode (in Generate menu), and perform the following steps (refer to Figure 6-4):

1. In the Generate menu press the AUTO button.
2. In the pop-up window press the button in the Gas field.
3. Change the Gas selection to O₃, and set the target concentration, units of measure, and total flow appropriately.
4. Press the Generate button and view the target settings in the upper portion of the display.
5. Go to Home page and wait about 10 minutes or more until the reading under "Actual" stabilizes before comparing that value to the reading of the reference photometer to ensure they are within 1% of each other (If not, calibrate per Section 6.2.2).

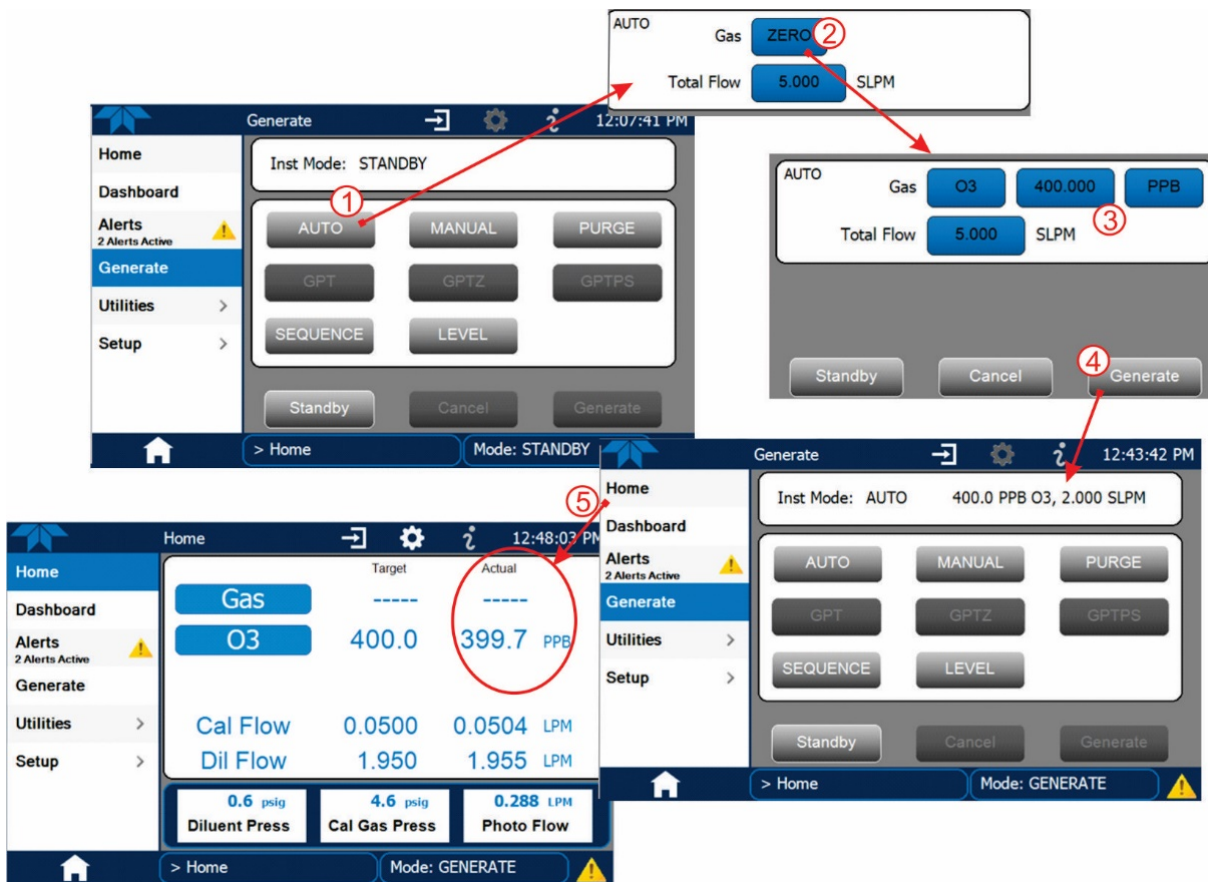


Figure 6-4. O₃ Photometer Performance Verification

6.2.2. SETUP AND CALIBRATION OF O₃ PHOTOMETER

Note This procedure requires external sources for zero air and O₃ as well as an external reference photometer.

Calibrating the internal photometer requires a different setup than that for verification. There are two ways to make the connections between the instruments for calibration: either with direct connections or with calibration manifolds.

- Figure 6-5 shows the external zero air and O₃ sources as well as the reference photometer connected directly to the fixtures on the calibrator.
- Figure 6-6 shows the external zero air and O₃ sources as well as the reference photometer connected to the calibrator via calibration manifolds for both zero air and O₃.

Note A minimum of 1.1 SLPM is required for the external zero air source.

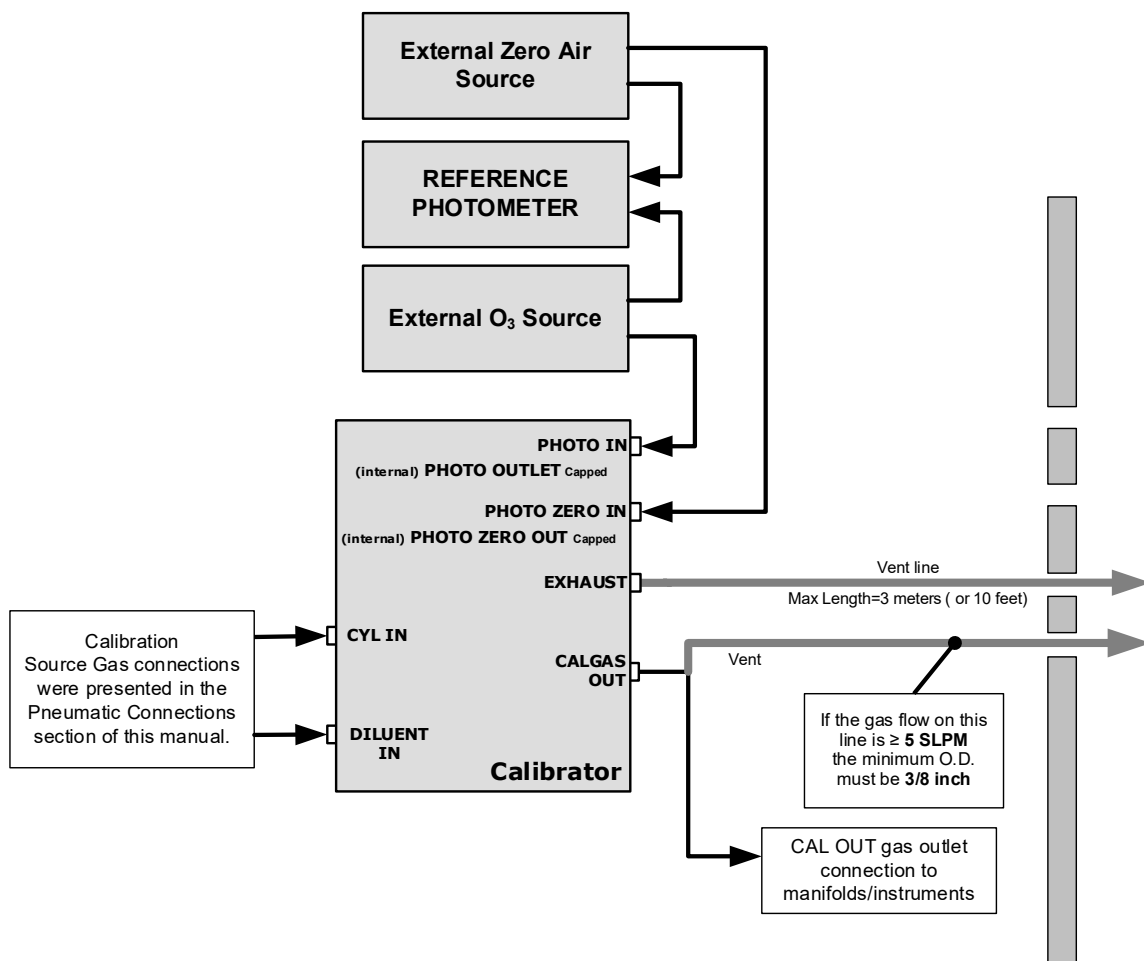


Figure 6-5. External Photometer Calibration Setup with Direct Connections

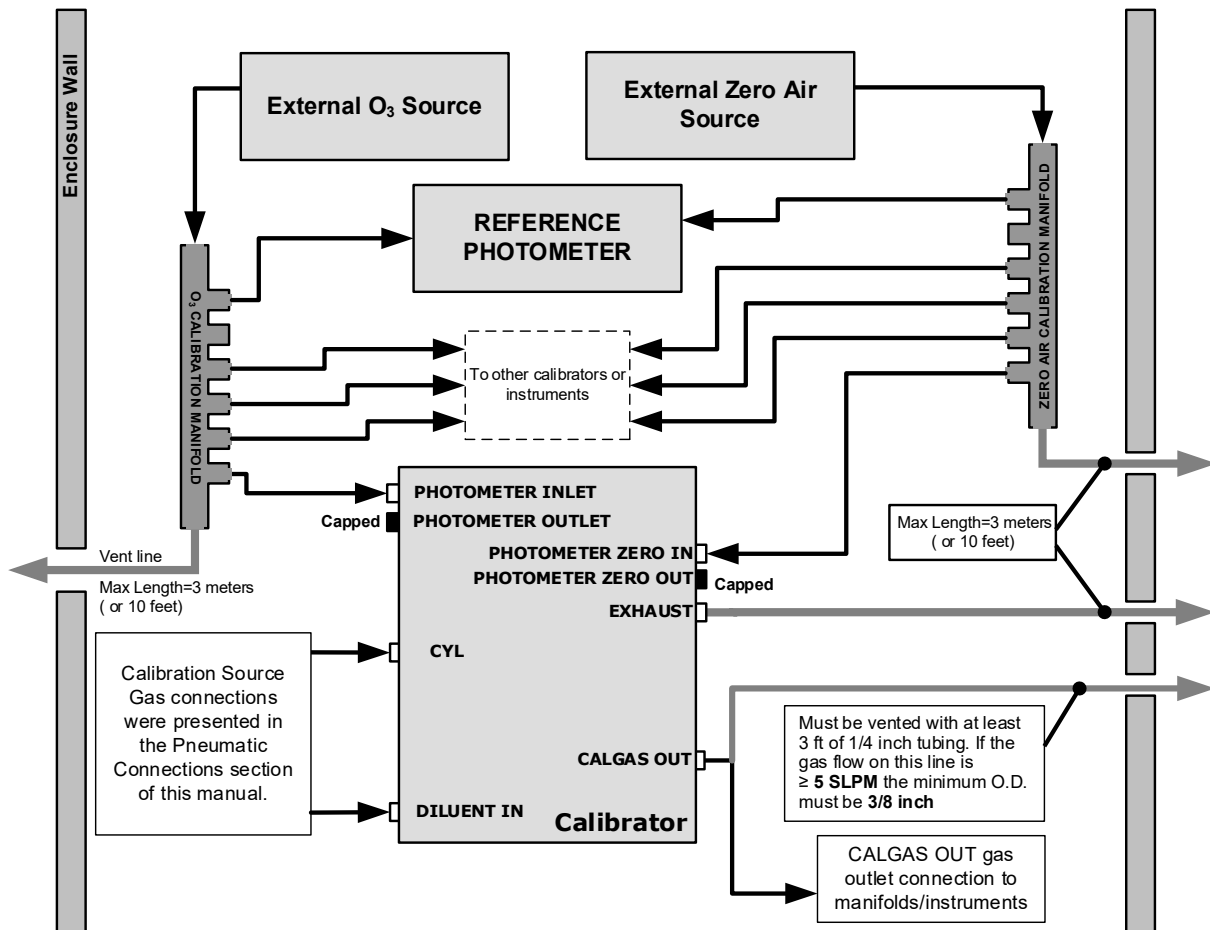


Figure 6-6. External Photometer Calibration Setup with Calibration Manifolds

Note

The manifolds as shown in the above drawing are oriented to simplify the drawing. The actual orientation in your setup is with the ports facing upward. All unused ports should be capped. A minimum of 1.1 SLPM is required for the external zero air source.

The manifold's excess gas should be vented to a suitable vent outside of the room. The internal diameter of this vent should be of large enough to avoid any appreciable pressure drop, and it must be located sufficiently downstream of the output ports to assure that no ambient air enters the manifold due to eddy currents or back diffusion.

Note

It is recommended that the calibration manifold's exhaust vent have a minimum internal diameter of 3/8 inch and a maximum length of 3 meters (or 10 feet).

The photometer's Zero calibration procedures are presented in Section 6.2.2.1, followed by the photometer's Span calibration in Section 6.2.2.2. Refer to

1. Navigate to the **Utilities>Diagnostics** menu.
2. Select the Bench Cal function.

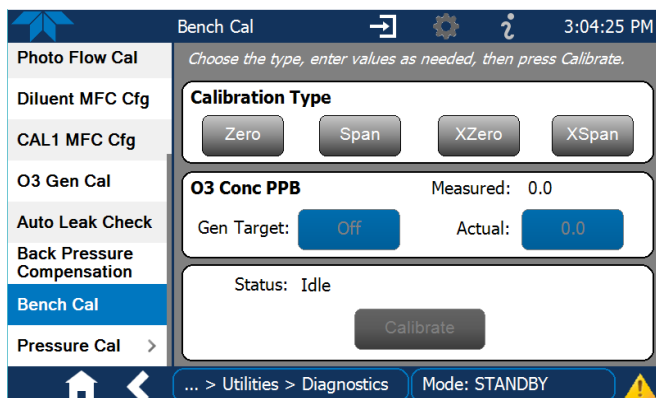


Figure 6-7. O₃ Photometer Bench Cal Page

6.2.2.1. Photometer Zero Calibration

To set the zero point offset for the portable calibrator's photometer:

1. Ensure that the calibrator is in Standby mode (Generate menu).
2. Navigate to the **Utilities>Diagnostics>Bench Cal** menu.
3. Press either the Zero button if using the internal O₃ generator or the XZero button if using an external O₃ generator.
4. Allow Zero air to flow into the PHOTO IN port for at least 10 minutes.
5. In the Status field press the Calibrate button.
6. On the next screen, either confirm performing the Bench Calibration by pressing Yes, or leave photometer bench calibration values unchanged by pressing No, which will return the display to the Bench Cal page.

6.2.2.2. Photometer Span Calibration

To set the response SLOPE for the portable calibrator's photometer:

1. Ensure that the calibrator is in Standby mode (Generate menu).
2. In the **Utilities>Diagnostics>Bench Cal** menu, press either the Span button if using the internal O₃ generator or the XSpan button if using an external O₃ generator.
3. Allow calibration gas (a 400 ppb O₃ span concentration is recommended) to flow into the PHOTO IN port for at least 10 minutes.
4. In the O₃ Conc PPB field press the button for Actual and input the exact span cal value as measured by the reference photometer, then press Enter.
5. In the Status field press the Calibrate button.
6. On the next screen, either confirm performing the Bench Calibration by pressing Yes, or leave photometer bench calibration values unchanged by pressing No, which will return the display to the Bench Cal page.

6.2.3. O₃ PHOTOMETER (OPTION IN T750) GAS FLOW CALIBRATION

The photometer sample gas flow rate is measured directly by a flow sensor located on the pressure / flow sensor PCA. A slope factor, stored in the calibrator's memory the last time a Photo Flow calibration was performed, is applied to the reading from that sensor.

The measured photometer sample gas flow value is viewable in the Dashboard as Photo Flow (configure via Setup>Dashboard) and can be output to the Data Logger (see Section 3.3.1 for configuration).

Note The procedure described in this section requires a calibrated external flow meter.

To calibrate the flow of gas through the portable calibrator's optional photometer bench:

1. Connect the external flow meter's output connection directly to the EXHAUST port of the portable calibrator.
2. Power on the calibrator and navigate to the **Utilities>Diagnostics>Photo Flow Cal** page.

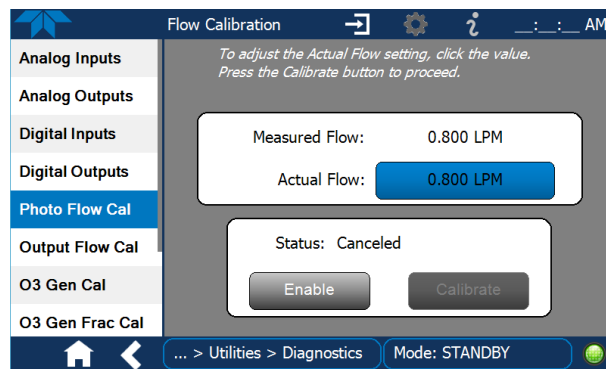


Figure 6-8. Photometer Flow Calibration Page

3. Press the Enable button and allow a few minutes for the external flow meter to stabilize.
4. Press the Actual Flow button and input the reading from the external flow meter.
5. Press the Calibrate button, which updates the measured flow within a few seconds.

6.2.4. O₃ PHOTOMETER BACKPRESSURE COMPENSATION CALIBRATION

Any time there is a pneumatic configuration change, there is risk of impacting the internal measure/reference pressure. To compensate for this, a backpressure compensation calibration is required after each change. Set the calibrator to generate ozone in the **Generate** menu at the flow rate intended for operation. Then navigate to the **Utilities>Diagnostics>Back Pressure Compensation** menu to run the calibration (Figure 6-9).

The operation will take a few minutes.

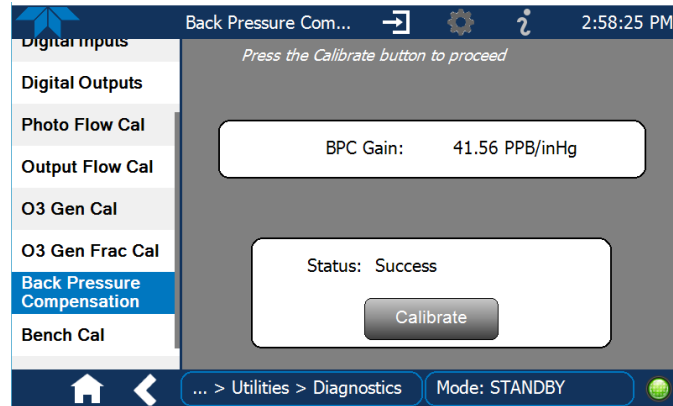


Figure 6-9. Back Pressure Compensation

6.3. CALIBRATING THE O₃ GENERATOR (OPTION IN T750)

Note The O₃ Generator calibration process will run 1 – 1.5 hours.

The calibrator's software includes a routine for automatically calibrating the O₃ generator, based on calibration tables of drive voltages stored in the calibrator's memory. These tables are used by the calibrator to set initial O₃ generator drive settings according to the concentration that is requested.

Note An external reference photometer is required for this procedure.

Figure 6-10 shows the setup connections.

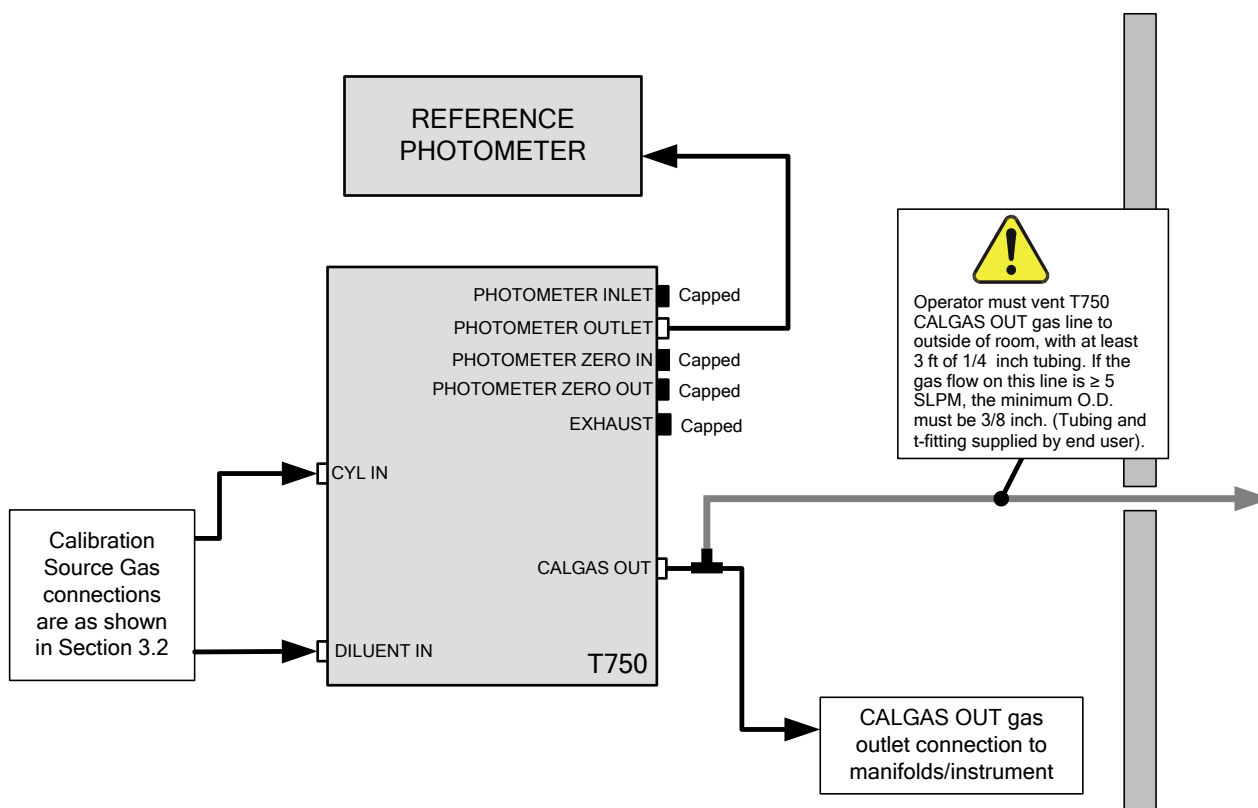


Figure 6-10. O₃ Generator Calibration Setup

1. Power off the instrument, configure the connections as illustrated, and power back on.
2. In the Generate menu, place the calibrator in Standby mode and select the Auto function.
3. Set the Gas to O₃, and set the concentration, units, and Total Flow.
4. Navigate to the **Utilities>Diagnostics>O₃ Gen Cal** menu and press Calibrate.

6.4. CALIBRATING GAS PRESSURE SENSORS

Note The calibration procedures presented in this section require an independent, calibrated pressure meter/monitor.

The portable calibrator has several sensors that monitor the pressure of the gases flowing through the instrument. The data collected by these sensors are used to compensate the final concentration calculations for changes in atmospheric pressure and are stored in the CPU's memory.

6.4.1. PRESSURE SENSOR SETUP

Refer to Table 6-2, Figure 6-11, and Figure 6-12 for setup information. Procedures are given in Sections 6.4.2 and 6.4.3.

Table 6-2. Pressure Sensor Calibration Setup

| MENU | SENSOR | UNITS | PRESSURE MONITOR MEASUREMENT POINT |
|---|--|----------------|---|
| Cal Gas Press Cal | Cal Gas Pressure Sensor | PSIG | Insert monitor just before the inlet port of the cal gas MFC |
| Diluent Press Cal | Diluent Pressure Sensor | PSIG | Insert monitor just before the inlet port of the diluent MFC |
| O₃ Press Cal | O ₃ Regulator Pressure Sensor (with optional O ₃ Generator) | PSIG | Insert monitor in line between the regulator and the O ₃ gas pressure sensor located on the O ₃ generator / photometer pressure / flow sensor PCA |
| * Photo Press Cal * (Section 6.4.3) | Sample Gas Pressure Sensor (with optional O ₃ Photometer) | IN-HG-A | Use monitor to measure ambient atmospheric pressure at the calibrator's location. |

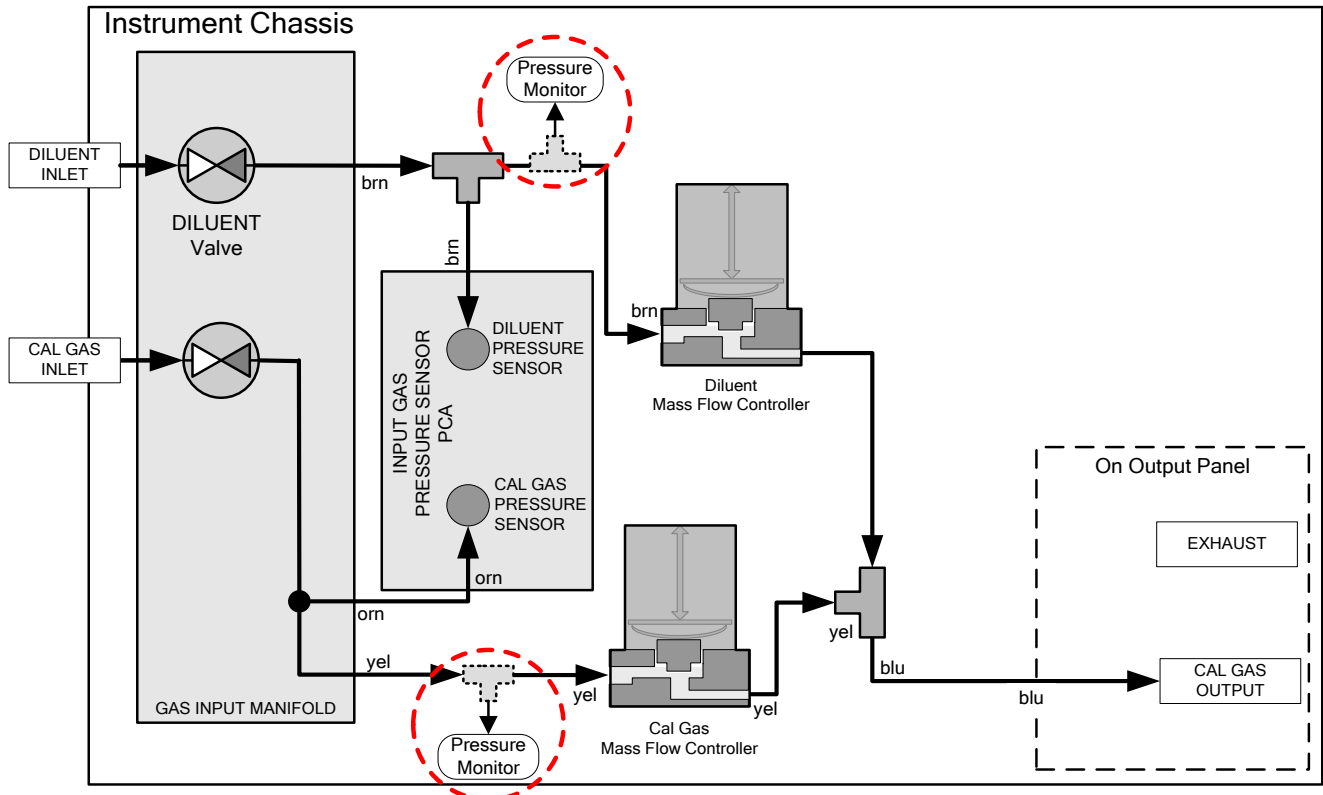


Figure 6-11. Pressure Monitor Points, T750 Basic Unit

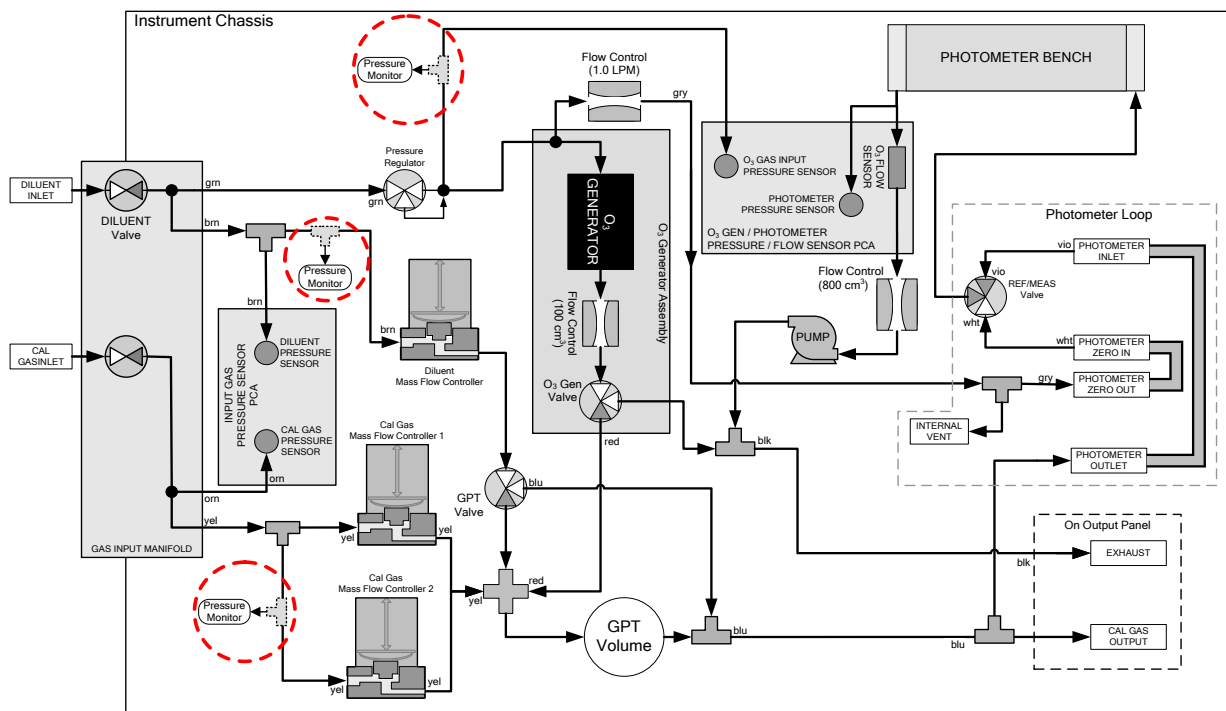


Figure 6-12. Pressure Monitor Points, T750 with O3 Options and Multiple Cal MFCs Installed

6.4.2. CALIBRATING THE DILUENT, CAL GAS, AND O₃ GENERATOR OPTION PRESSURE SENSORS

Note

The procedures for setting up the O₃ Photometer option for its pressure sensor calibration differ slightly and are presented in Section 6.4.3. (It does still require the independent, calibrated pressure meter/monitor).

1. Turn off the calibrator and open its panels.
2. For the sensor being calibrated, insert a “T” pneumatic connector with the prescribed monitor at the location described in the preceding Pressure Sensor Setup section.
3. Turn on the calibrator
4. Navigate to the **Utilities>Diagnostics>Pressure Cal** menu.

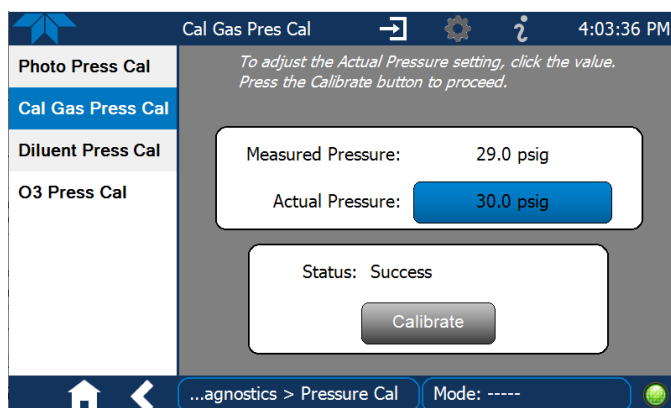


Figure 6-13. PSIG Pressure Ca

5. Select the pressure to be calibrated, and in the Actual Pressure field input the value obtained from the corresponding external pressure meter.
6. Once entered, press the Calibrate button and confirm in the next window to proceed with the pressure calibration.
7. Wait for the Status field to show “Success” and then turn off the calibrator.
8. Remove the pressure monitor and restore the pneumatic lines to their proper connections. For the remaining pressure sensors (except for the O₃ Photometer option), repeat the procedure beginning at Step 2.
9. Close the calibrator’s panels.

6.4.3. CALIBRATING THE O₃ PHOTOMETER OPTION PRESSURE SENSOR

Note

This calibration must be performed when the pressure of the photometer sample gas is equal to ambient atmospheric pressure.

1. Turn off the calibrator and open its panels.
2. Disconnect power to the photometer’s internal pump.
3. Measure the ambient atmospheric pressure of the calibrator’s location in In-Hg-A.
4. Turn on the calibrator and allow it to warm up.

5. Navigate to the **Utilities>Diagnostics>Pressure Cal** menu and select **Photo Press Cal**.

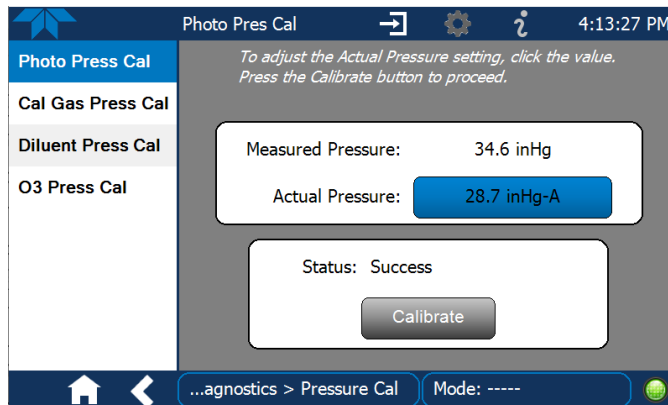


Figure 6-14. In-Hg Pressure Cal for O₃ Photometer Option

6. In the Actual Pressure field input the value obtained in Step 3.
7. Once entered, press the Calibrate button and confirm in the next window to proceed with the pressure calibration.
8. Wait for the Status field to show “Success” and then turn off the calibrator.
9. Reconnect power to the internal pump
10. Close the calibrator’s panels.

6.5. ANALOG INPUTS CALIBRATION

Note This calibration is typically only necessary after a major repair.

The **Utilities>Diagnostics>Analog Inputs** menu is used to calibrate the instrument’s A-to-D conversion circuitry. such as replacement of CPU, motherboard or power supplies.

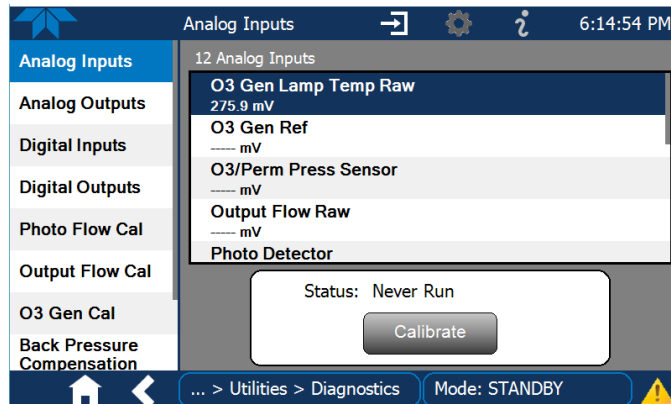


Figure 6-15. Analog Inputs Calibration Page



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7. MAINTENANCE AND SERVICE

Predictive diagnostic functions including failure warnings and alarms built into the calibrator's firmware allow the user to determine when repairs are necessary without performing painstaking preventative maintenance procedures.

For the most part, the calibrator is maintenance free; there are, however, a minimal number of simple procedures that when performed regularly will ensure that the photometer continues to operate accurately and reliably over its lifetime.

Troubleshooting and service are covered in Section 8 of this manual.

7.1. MAINTENANCE SCHEDULE

Table 7-1 below shows the recommended maintenance schedule for the calibrator. Please note that in certain environments (i.e. dusty, very high ambient pollutant levels, temperatures, or humidity) some maintenance procedures may need to be performed more often than shown.

Note

A Span and Zero Calibration Check must be performed following maintenance procedures specified (see CAL CHECK REQ'D Column of Table 7-1).

WARNING – ELECTRICAL SHOCK HAZARD



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



CAUTION – TECHNICIAN REQUIRED

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



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Table 7-1. Maintenance Schedule

| ITEM | ACTION | FREQ | CAL CHECK REQ'D. | MANUAL SECTION | DATE PERFORMED | | | | | | | |
|----------------------------|--|--|------------------------|-------------------|--|--|--|--|--|--|--|--|
| | | | | | | | | | | | | |
| Verify Dashboard Functions | Record and analyze | Weekly or after any Maintenance or Repair | No | 2.5.2 | | | | | | | | |
| Photometer Pump Diaphragm | No Replacement Required. Under Normal Circumstances the Pumps Will Last the Lifetime of the Instrument. | | | | | | | | | | | |
| Absorption Tube | Inspect --- Clean | As Needed | Yes after cleaning | 7.5 | Cleaning of the Photometer Absorption Tube Should Not Be Required as long as ONLY CLEAN, DRY, PARTICULATE FREE Zero Air (Diluent Gas) is used with the calibrator | | | | | | | |
| Perform Flow Check | Verify Flow of MFCs | Annually or any time the T750's internal DAC is recalibrated | No | 6.1 | | | | | | | | |
| Perform Leak Check | Verify Leak Tight | Annually or after any Maintenance or Repair | No | 7.4 | | | | | | | | |
| Pneumatic lines | Examine and clean | As needed | Yes if cleaned | --- | | | | | | | | |

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7.2. OPERATIONAL HEALTH CHECKS

Navigate to the **Utilities>USB Utilities>Report** menu (Figure 7-1) to download a report on the basic operations of the instrument. The report is generated every 24 hours to the Internet (the “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.

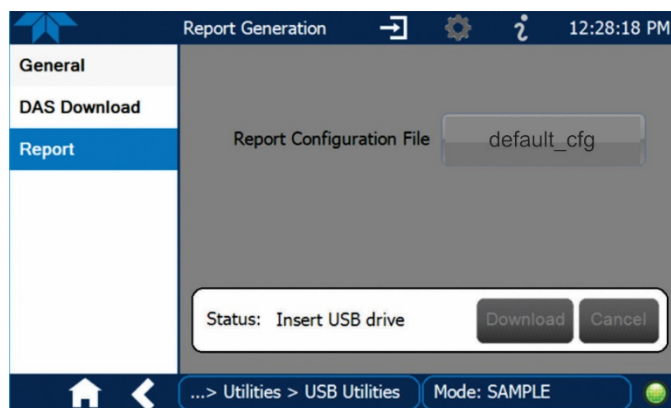


Figure 7-1. Report Generation Page

7.3. SOFTWARE/FIRMWARE UPDATES

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

7.3.1. REMOTE UPDATES

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

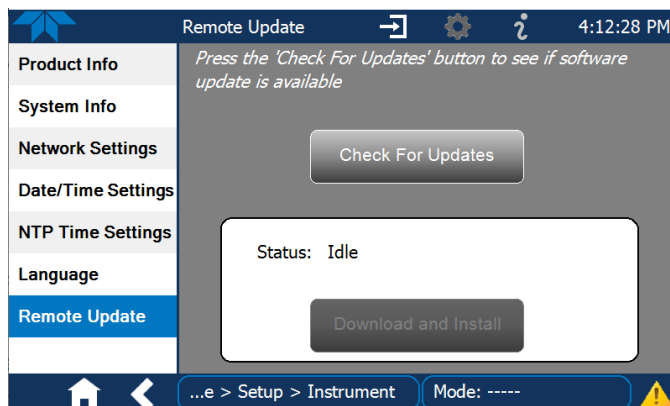


Figure 7-2. Remote Update Page

7.3.2. MANUAL RELOAD/UPDATE PROCEDURES

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

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

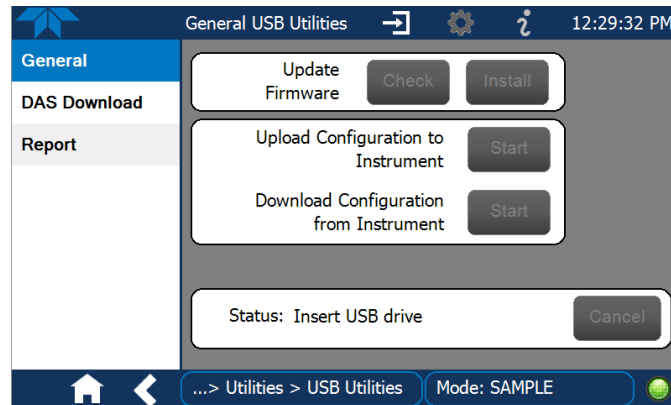


Figure 7-3. Manual Update Page (and other utilities)

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.

7.4. PERFORMING THE AUTO LEAK CHECK

7.4.1. LEAK CHECK EQUIPMENT AND CALIBRATOR SETUP

Make sure to have ready:

- One 1/4" pneumatic cap for the CAL GAS OUT fitting on T750 basic configuration,

Or, for T750 models with the O₃ generator with photometer installed:

- Two (2) 1/4" Pneumatic caps (for EXHAUST and CAL GAS OUT ports)
- One (1) 1/8" Pneumatic Cap (for internal vent)
- Two (2) pneumatic tube clamps, KIT000322Setup for Auto Leak Check

Refer to Figure 7-4 and Figure 7-5 for the setup instructions, and to Figure 7-6 and Figure 7-7 for illustrations of pneumatic flow in the basic model and with the optional photometer, respectively):

1. Power off the instrument.
2. Use the 1/4" caps to cover the EXHAUST and CALGAS OUT ports on the communications and output panel (Figure 2-3).

Note

If a bottle of source gas is connected to the CYL IN port, close the gas outlet of the bottle first, and then disconnect the gas line from the CYL IN port.

3. Connect a gas line from the zero air gas source to the DILUENT IN port on the control/display and input panel (Figure 2-1).
4. Open the calibrator's panels.

For instruments without the O₃ photometer installed, skip the next two steps and jump to Step 6.

5. On instruments with the O₃ photometer installed, clamp off the input to the photometer flow sensor and clamp off the pump output (refer to Figure 7-4):

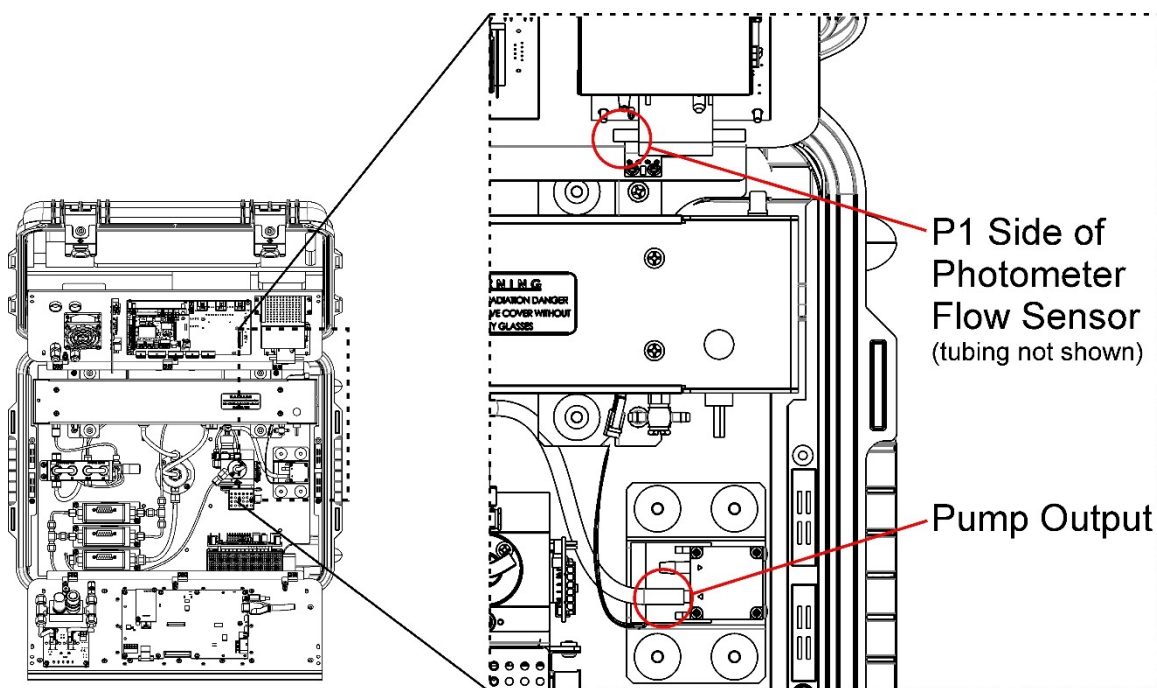


Figure 7-4. Clamping the Photometer Sensor Input and Pump Output

6. Use the 1/8" cap to securely cover the outlet of the internal vent (Figure 7-5).
7. Once the setup procedure is complete, power on the instrument and navigate to the **Utilities>Diagnostics>Auto Leak Check** to press the "Check" button.

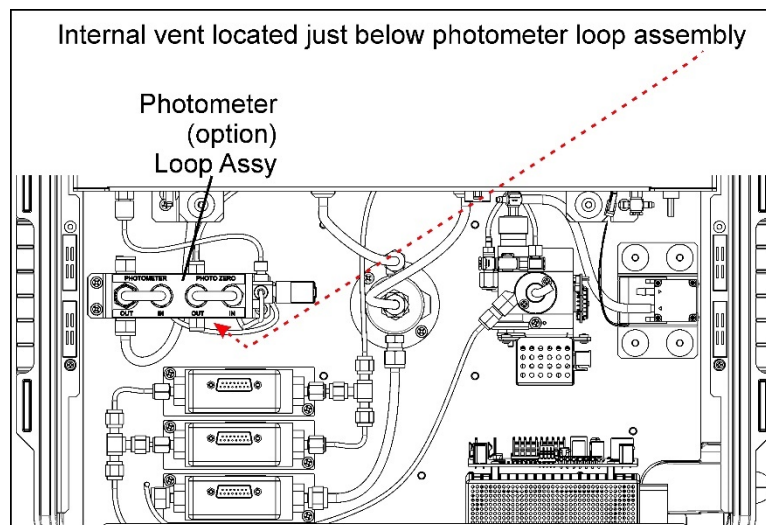


Figure 7-5. Internal Vent Location

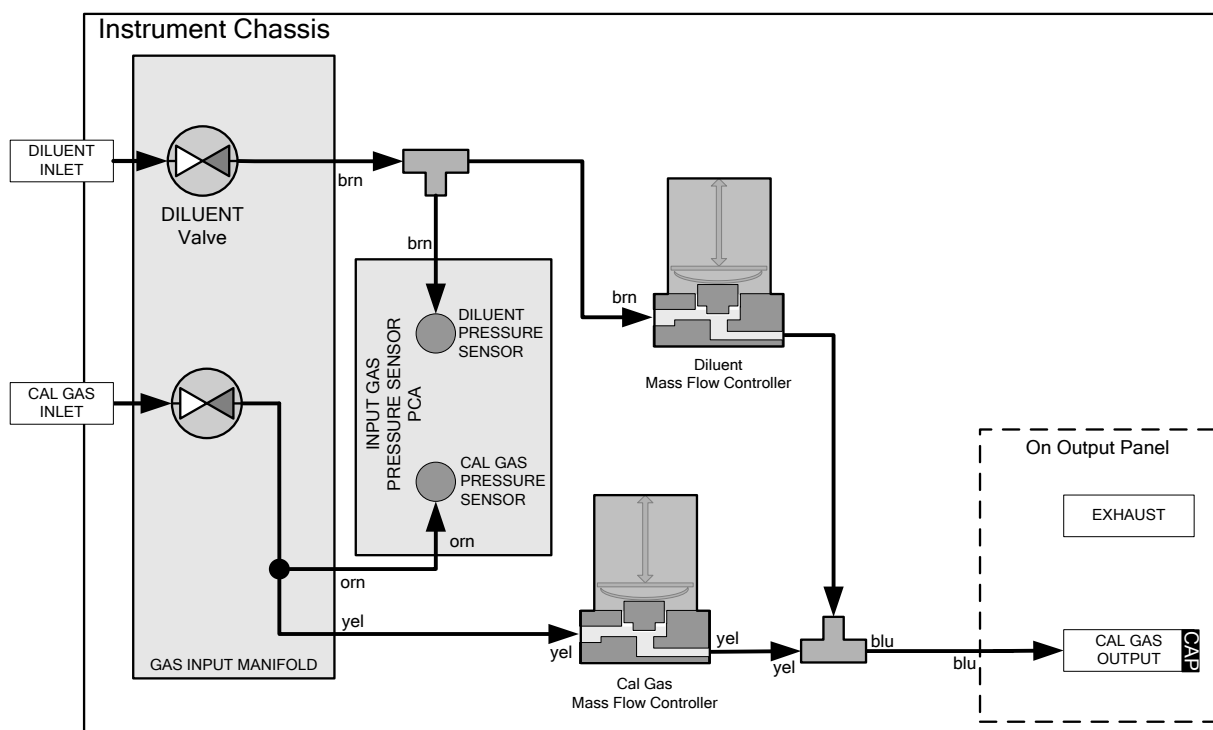


Figure 7-6. Gas Flow for Auto-Leak Check Procedure of Base Model T750 (no Photometer)

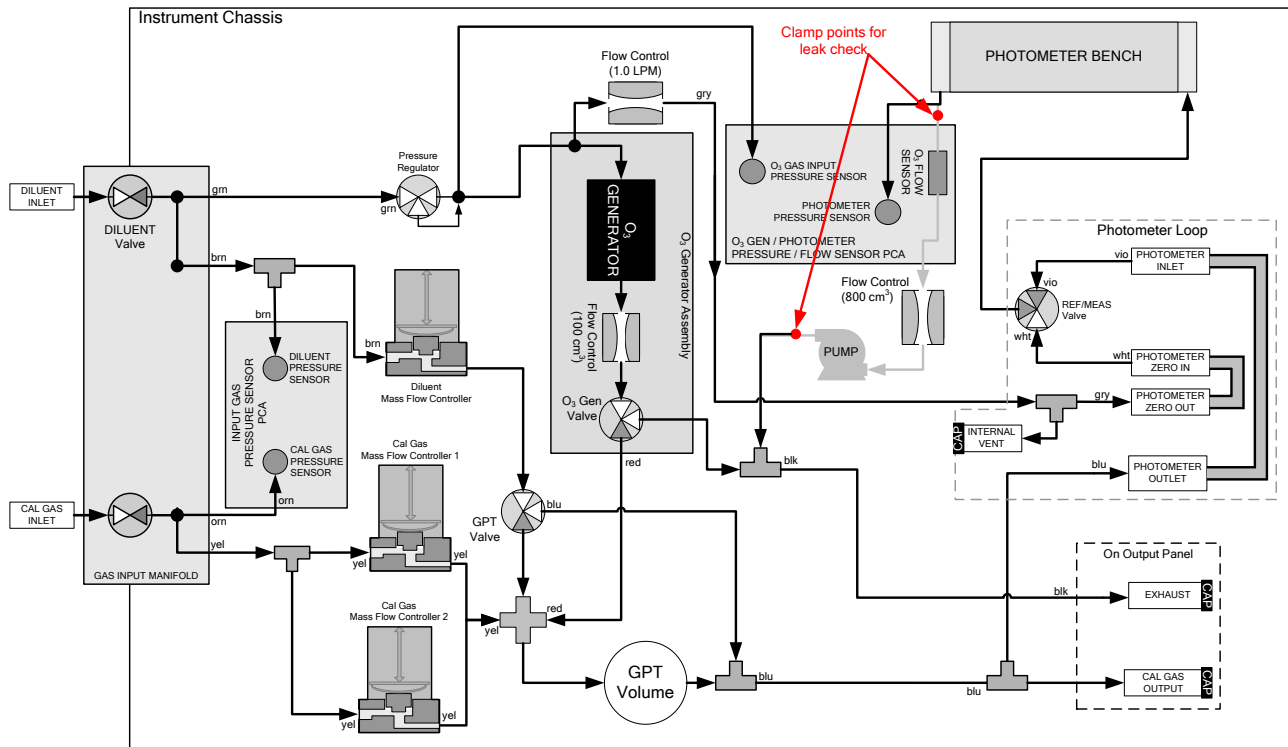


Figure 7-7. Gas Flow for Auto-Leak Check Procedure of Calibrator with Photometer

7.4.2. RETURNING THE CALIBRATOR TO SERVICE AFTER AUTO LEAK CHECK

1. Remove all of the caps from the EXHAUST, the CALGAS OUT, and the internal vent.
2. On instruments with an optional O3 photometer, remove the clamps that were installed in Step 5 of the setup procedures in Section [7.4.1](#).
3. Remove the tee from the DILUENT IN and CYL 1.
4. Reconnect the zero air source to DILUENT IN.
5. Reconnect the cal gas bottle to CYL 1 and open the bottle's outlet port.
6. Close the calibrator's panels.
7. The calibrator is now ready to be used.



7.5. CLEANING OR REPLACING THE ABSORPTION TUBE

Note

Although this procedure should never be needed as long as the user is careful only to supply the photometer with clean, dry and particulate free zero air, it is included here for those rare occasions when cleaning or replacing the absorption tube may be required.

1. Remove the center cover from the optical bench.
2. Unclip the sample thermistor from the tube.
3. Loosen the two screws on the round tube retainers at either end of the tube.
4. Using both hands, carefully rotate the tube to free it.
5. Slide the tube towards the lamp housing.
 - The front of the tube can now be slid past the detector block and out of the instrument.



CAUTION – Avoid Damage to the Instrument

Do not cause or allow the tube to bind against the metal housings. The tube may break and cause serious injury.

6. Clean the tube with Distilled or de-ionized water by running a swab from end-to-end.
7. Air-dry the tube.
8. Check the cleaning job by looking down the bore of the tube.
 - It should be free from dirt and lint.
9. Inspect the o-rings that seal the ends of the optical tube (these o-rings may stay seated in the manifolds when the tube is removed.)
 - If there is any noticeable damage to these o-rings, they should be replaced.
10. Re-assemble the tube into the lamp housing and perform a leak check (Section 7.4) on the instrument.

Note

For correct optical alignment, ensure that the tube is pushed all the way to the front of the optical bench when it is reassembled prior to gently retightening the tube retainer screws, so that the tube is snug against the stop inside the detector manifold

7.6. ADJUSTING THE PHOTOMETER OPTION'S UV SOURCE LAMP

This procedure details the steps for adjustment of the UV source lamp in the optical bench assembly. This procedure should be done whenever the **PHOTO REFERENCE** value drops below 3000 mV.

1. Make sure the instrument is warmed-up and has been running in Standby mode for at least 30 minutes before proceeding.
2. Open the instrument panels.
3. Locate the Photometer.
4. Locate the UV detector gain adjust pot on the photometer assembly (see Figure 7-8).
5. Navigate to the **Utilities>Diagnostics>Analog Inputs** menu and select Photo Detector.
6. Using an insulated pot adjustment tool, Turn the UV detector gain adjustment pot until the value of Photo Detector is as close as possible to 4600.0 MV.
 - Additional adjustment can be made by physically rotating the lamp in its housing. To do this, slightly loosen the UV lamp setscrew and slowly rotate the lamp up to ¼ turn in either direction while watching the **Photo Detector** signal.
 - Once the optimum lamp position is determined, re-tighten the lamp setscrew.

Note

If a minimum reading of 3500.0 mV cannot be reached, the lamp must be replaced.

7. Replace the cover on the instrument.

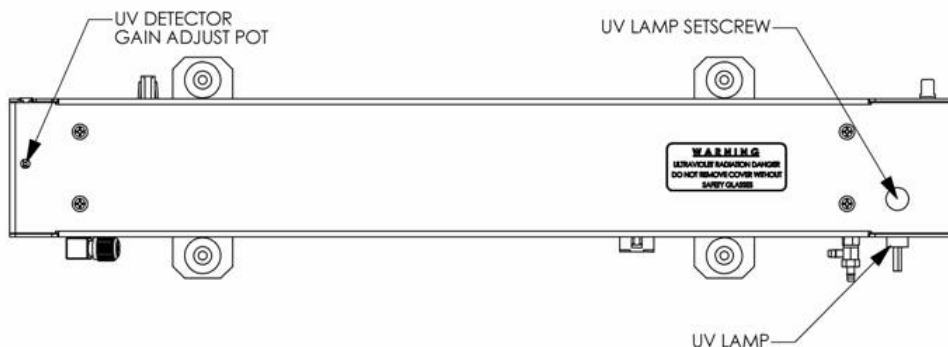


Figure 7-8. Photometer – Location of UV Detector Gain Adjustment & UV Lamp Set Screw



7.7. REPLACING THE PHOTOMETER OPTION'S UV SOURCE LAMP

This procedure details the steps for replacement of the UV source lamp in the optical bench assembly. This procedure should be done whenever the lamp can no longer be adjusted as described in Section 7.6.

1. Turn the instrument off.
2. Open the calibrator's panels.
3. Locate the Photometer Bench Assembly (Figure 2-4).
4. Locate the UV lamp at the rear of the bench assembly (Figure 7-8)
5. Unplug the lamp cable from the power supply connector on the side of the optical bench.
6. Slightly loosen (do not remove) the UV lamp setscrew and pull the lamp from its housing.

Note

The UV lamp contains mercury (Hg), considered hazardous waste. The lamp should be disposed of in accordance with local regulations regarding waste containing mercury.

7. Install the new lamp in the housing, pushing it all the way in. Leave the UV lamp setscrew loose for now.
8. Turn the instrument back on and allow it to warm up for at least 15 minutes.
9. Turn the UV detector gain adjustment pot (see Figure 7-8) clockwise to its minimum value. The pot may click softly when the limit is reached.
10. Perform the UV Lamp Adjustment procedure described in Section 7.6, with the following exceptions:
 - a) Slowly rotate the lamp in its housing (up to $\frac{1}{4}$ turn in either direction) until a **maximum** value (or 4600 mVDC) is observed.
 - Make sure the lamp is pushed all the way into the housing while performing this rotation.
 - If the Photo Detector will not drop below 5000 mV while performing this rotation, contact TAPI Technical Support for assistance.
 - b) Once a lamp position is found that corresponds to a maximum observed value for Photo Detector, tighten the lamp setscrew at the approximate maximum value observed.
 - c) Adjust the Photo Detector to within the range of 4400 – 4600 mV.
11. Close the instrument panels.

7.8. ADJUSTING OR REPLACING THE OZONE GENERATOR UV LAMP

This procedure details the steps for replacement and initial adjustment of the ozone generator lamp. If you are adjusting an existing lamp, skip to Step 8.

1. Turn off the calibrator.
2. Open the calibrator's panels.
3. Locate the O₃ generator assembly (Figure 2-4).

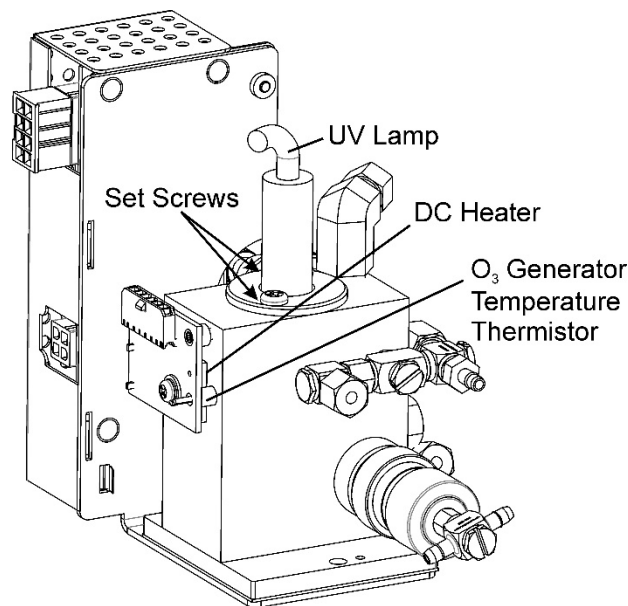


Figure 7-9. O₃ Generator UV Lamp Assembly

4. Remove the two setscrews that hold the UV lamp in place and gently pull out the old lamp.
5. Inspect the o-ring beneath the UV lamp retaining ring and replace if damaged.
6. Install the new lamp in the O₃ generator housing
The lamp should be able to be rotated in the assembly by grasping the lamp cable.
Ensure that it is fully seated in the O₃ generator housing.
7. Tighten the two set screws.
8. Turn on instrument and allow it to stabilize for at least 30 minutes.
9. Run an Auto Leak check (Section 7.4).
10. Run an Ozone Generator calibration (see Section 6.3).



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8. GENERAL TROUBLESHOOTING & SERVICE

This section contains a variety of methods for identifying and solving performance problems with the calibrator.



CAUTION – TECHNICIAN REQUIRED

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



WARNING – ELECTRICAL SHOCK HAZARD

- Risk of electrical shock. Some operations need to be carried out with the instrument open and running.
- Exercise caution to avoid electrical shocks and electrostatic or mechanical damage to the calibrator.
- Do not drop tools into the calibrator or leave those after your procedures.
- Do not short out or touch electric connections with metallic tools while operating inside the calibrator.
- Use common sense when operating inside a running calibrator.

8.1. GENERAL TROUBLESHOOTING

The calibrator 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 warning messages in the Alerts page and take corrective action as necessary.
2. Examine the values of functions 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 power distribution board. (The calibrator's DC power wiring is color-coded and these colors match the color of the corresponding test points on the power distribution board).
4. Suspect a leak first!
 - Technical Support data indicate that the majority of all problems are eventually traced to leaks in the internal pneumatics of the calibrator 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, a damaged / malfunctioning pumps, etc.
5. Refer to the Dashboard to confirm that the calibrator's vital functions are working properly.



8.1.1. FAULT DIAGNOSIS WITH MESSAGES IN THE ALERTS PAGE

The most common and/or serious instrument failures will result in a warning message being displayed in the Alerts page. Table 8-1 lists possible Alerts, along with their meaning and recommended corrective action.

It should be noted that more than two or three warning messages occurring at the same time is often an indication that some fundamental sub-system (power supply, power distribution board, motherboard) has failed rather than an indication of the specific failures referenced by the warnings. In this case, it is recommended that proper operation of power supplies (see Section 8.4.3), the power distribution board (see Section 9.4.3), and the motherboard (see Section 8.4.9) be confirmed before addressing the specific warning messages.

Table 8-1. Possible Alerts

| MESSAGE | FAULT CONDITION | POSSIBLE CAUSES |
|---|--|--|
| Config Initialized | Configuration and Calibration data reset to original Factory state. | <ul style="list-style-type: none"> - Failed Disk on Chip - User has erased configuration data |
| Data Initialized | Data Storage in DAS was erased. | <ul style="list-style-type: none"> - Failed Disk-on-Module. - User cleared data. |
| Lamp Driver Warning | The CPU is unable to communicate with either the O ₃ generator or photometer lamp I ² C driver chip. | <ul style="list-style-type: none"> - I²C has failed |
| MFC Communication Warning | Firmware is unable to communicate with any MFC. | <ul style="list-style-type: none"> - I²C has failed - One of the MFCs has failed - Cabling loose or broken between MFC and Motherboard |
| MFC Pressure Warning | One of the calibrator's mass flow controllers internal gas pressure is <15 PSIG or >36 PSIG | <ul style="list-style-type: none"> - Zero or source air supply is incorrectly set up or improperly vented. - Leak or blockage exists in the T750's internal pneumatics - Failed CAL GAS or DILUENT pressure sensor |
| O₃ Gen Lamp Temp Warning | IZS Ozone Generator Temp is outside of control range of 48°C ± 3°C. | <ul style="list-style-type: none"> - No IZS option installed, instrument improperly configured - O₃ generator heater - O₃ generator temperature sensor - Relay controlling the O₃ generator heater - Entire Power distribution board - I²C Bus |
| O₃ Pump Warning¹ | The photometer pump failed to turn on within the specified timeout period (default = 30 sec.). | <ul style="list-style-type: none"> - Failed Pump - Problem with Power distribution board - 12 VDC power supply problem |
| Photo Lamp Temp Warning | The photometer lamp temp is outside range limits. | Possible failure of: <ul style="list-style-type: none"> - Bench lamp heater - Bench lamp temperature sensor - Relay controlling the bench heater - Entire Power distribution board - I²C Bus - Hot Lamp |
| Photo Lamp Stability Warning | Value output during the Photometer's reference cycle changes from measurement to measurement more than 25% of the time. | <ul style="list-style-type: none"> - Faulty UV source lamp - Noisy UV detector - Faulty UV lamp power supply - Faulty ± 15 VDC power supply |

| MESSAGE | FAULT CONDITION | POSSIBLE CAUSES |
|-----------------------------------|---|--|
| Photo Reference Warning | Occurs when Ref is <2500 mVDC or >4950 mVDC. | Possible failure of: <ul style="list-style-type: none"> - UV Lamp - UV Photo-Detector Preamp |
| Rear Board Not Det | Motherboard not detected on power up. | <ul style="list-style-type: none"> - THIS WARNING only appears on Serial I/O COM Port(s) Input and Control Panel Display will be frozen, blank or will not respond. - Failure of Motherboard |
| Regulator Pressure Warning | Regulator pressure is <15 PSIG or >25 PSIG | <ul style="list-style-type: none"> - Zero or source air supply is incorrectly set up or improperly vented. - Incorrectly adjusted O₃ zero air pressure regulator - Leak or blockage exists in the T750's internal pneumatics - Failed O₃ Generator Input pressure sensor |
| Relay Board Warning | The CPU cannot communicate with the Relay Board (power distribution board). | <ul style="list-style-type: none"> - I²C Bus failure - Failed power distribution board - Loose connectors/wiring |
| System Reset | The computer has rebooted. | <ul style="list-style-type: none"> - This message occurs at power on. - If it is confirmed that power has not been interrupted: - Failed +5 VDC power - Fatal error caused software to restart - Loose connector/wiring |

8.1.2. FAULT DIAGNOSIS WITH DASHBOARD FUNCTIONS

In addition to being useful predictive diagnostic tools, the functions viewable from the Dashboard menu can be used to isolate and identify many operational problems when combined with a thorough understanding of the calibrator's Theory of Operation (see Section 9).

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

Table 8-2 contains some of the more common causes for these values to be out of range.

Table 8-2. Dashboard Functions (Tags) - Indicated Failures

| FUNCTION | DIAGNOSTIC RELEVANCE AND CAUSES OF FAULT CONDITIONS. |
|------------------------------------|---|
| Output Flow | Gas flow problems directly affect the concentration accuracy of the O ₃ calibration gases. This number is computed using data from the calibrator's <ul style="list-style-type: none"> - Check for Gas Flow problems. - Check the pressure regulator |
| O₃ Gen Drive | Check the O ₃ generator heater and temperature sensors Possible causes of faults are the same as O ₃ GEN LAMP TEMP WARNING from Table 8-1 |
| O₃ Gen Lamp Temp | Incorrect Lamp temperature can affect the efficiency and durability of the O ₃ generators UV lamp. Possible causes of faults are the same as O ₃ GEN LAMP TEMP WARNING from Table 8-1 |
| Regulator Pressure | Same as REGULATOR PRESSURE WARNING from Table 8-1 |

| FUNCTION | DIAGNOSTIC RELEVANCE AND CAUSES OF FAULT CONDITIONS. |
|-----------------------------|---|
| Box Temp | <p>If the Box Temperature is out of range (Box Temperature typically runs ~7°C warmer than ambient temperature), make sure that:</p> <ul style="list-style-type: none"> - The Exhaust-Fan is running. - There is sufficient open space to the side and rear of instrument to allow adequate ventilation. |
| O3 Meas & O3 Ref | <p>If the value displayed is too high the UV Source has become brighter. Adjust the variable gain potentiometer on the UV Preamp Board in the optical bench.</p> <p>If the value displayed is too low:</p> <ul style="list-style-type: none"> - < 100mV – Bad UV lamp or UV lamp power supply. - < 2000mV – Lamp output has dropped, adjust UV Preamp Board or replace lamp. <p>If the value displayed is constantly changing:</p> <ul style="list-style-type: none"> - Bad UV lamp. - Defective UV lamp power supply. - Failed I²C Bus. <p>If the O3 Ref value changes by more than 10mV between zero and span gas:</p> <ul style="list-style-type: none"> - Defective/leaking switching valve. |
| Photo Flow | <p>Gas flow problems directly affect the accuracy of the photometer measurements and therefore the concentration accuracy of cal gas mixtures.</p> <ul style="list-style-type: none"> - Check for Gas Flow problems. |
| Photo Lamp Temp | <p>Poor photometer temp control can cause instrument noise, instability and drift. Temperatures outside of the specified range or oscillating temperatures are cause for concern.</p> <p>Possible causes of faults are the same as PHOTO LAMP TEMP WARNING from Table 8-1</p> |
| O3 Press | <p>The pressure of the gas in the photometer's sample chamber is used to calculate the concentration of O₃ in the gas stream. Incorrect sample pressure can cause inaccurate readings.</p> <ul style="list-style-type: none"> - Check for Gas Flow problems. |
| Sample Temp | <p>The temperature of the gas in the photometer's sample chamber is used to calculate the concentration of O₃ in the gas stream. Incorrect sample temperature can cause inaccurate readings.</p> <p>Possible causes of faults are:</p> <ul style="list-style-type: none"> - Bad bench lamp heater - Failed sample temperature sensor - Failed relay controlling the bench heater - Failed Power distribution board - I²C Bus malfunction - Hot Lamp |
| O3 Slope | <p>Values outside range indicate:</p> <p>Contamination of the Zero Air or Span Gas supply.</p> <p>Instrument is miss-calibrated.</p> <p>Blocked Gas Flow.</p> <p>Faulty Sample Pressure Sensor or circuitry.</p> <p>Bad/incorrect Span Gas concentration.</p> |
| O3 Offset | <p>Values outside range indicate:</p> <p>Contamination of the Zero Air supply.</p> |

8.1.3. USING THE DIAGNOSTIC ANALOG INPUTS FUNCTION

The Analog Inputs found under the **Utilities>Diagnostics** menu combined with a thorough understanding of the instrument's Theory of Operation (Section 9) are useful for troubleshooting in that the technician can view the raw, unprocessed signal level, and control some, of the calibrator's critical inputs and outputs. Ensure that the instrument is in Standby mode (under **Home>Generate**).

8.2. USING THE SIGNAL OUTPUTS FOR DIAGNOSTICS

The signals available for output over the Analog Output channel can also be used as diagnostic tools. See Section 3.3.9 for instruction on activating the analog output and selecting a function.

Table 8-3. Signal Outputs as Diagnostic Tools

| FUNCTION | DESCRIPTION | ZERO | FULL SCALE | CAUSES OF EXTREMELY HIGH / LOW READINGS |
|-------------------------|---|------------------------|------------|---|
| O3 Meas | The raw output of the photometer during its measure cycle | 0 mV | 5000 mV | <p>If the value displayed is:</p> <ul style="list-style-type: none"> - >5000 mV: The UV source has become brighter. Adjust the UV Detector Gain potentiometer. - < 100mV – Bad UV lamp or UV lamp power supply. - < 2000mV – Lamp output has dropped, adjust UV Preamp Board or replace lamp. <p>If the value displayed is constantly changing:</p> <ul style="list-style-type: none"> - Bad UV lamp. - Defective UV lamp power supply. - Failed I²C Bus. |
| O3 Ref | The raw output of the photometer during its reference cycle | 0 mV | 5000 mV | <p>If the O3 Ref value changes by more than 10mV between zero and span gas:</p> <ul style="list-style-type: none"> - Defective/leaking M/R switching valve. |
| Photo Press | The pressure of gas in the photometer absorption tube | 0 In-Hg-A | 40 In-Hg-A | Check for Gas Flow problems. |
| Photo Flow | The gas flow rate through the photometer | 0 cm ³ /min | 1000 cc/m | Check for Gas Flow problems. |
| Photo Samp Temp | The temperature of gas in the photometer absorption tube | 0 °C | 70 °C | Possible causes of faults are the same as Sample TempTEMP from Table 8-2 |
| Photo Lamp Temp | The temperature of the photometer UV lamp | 0 °C | 70 °C | <p>Possible failure of:</p> <ul style="list-style-type: none"> - Bench lamp heater - Bench lamp temperature sensor - Relay controlling the bench heater - Entire Power distribution board - I²C Bus - Hot" Lamp |
| O3 Gen Lamp Temp | The temperature of the O ₃ generator's UV lamp | 0 mV | 5000 mV | Same as PHOTO LAMP TEMP WARNING from Table 8-1 |
| Box Temp | The temperature inside the chassis | 0 °C | 70 °C | <p>If the Box Temperature is out of range (Box Temperature typically runs ~7°C warmer than ambient temperature), make sure that:</p> <ul style="list-style-type: none"> - the Exhaust-Fan is running. - there is sufficient open space to the side and rear of instrument to allow adequate ventilation. |
| O3 Actual | The current concentration of O ₃ being measured by the photometer. | --- | | <ul style="list-style-type: none"> - I²C Bus malfunction - Gas flow problem through the photometer. - Electronic failure of the photometer subsystems - Failure or pressure / temperature sensors associated with the photometer - Bad/incorrect Span Gas concentration - Contamination of the Zero Air supply. - Malfunction of the O₃ generator. - Internal A/D converter problem |



8.3. USING THE INTERNAL ELECTRONIC STATUS LEDs

Several LEDs are located inside the instrument to assist in determining if the calibrators CPU, I²C bus and Power distribution board are functioning properly.

8.3.1. CPU STATUS INDICATOR

DS5, a red LED, that is located on upper portion of the motherboard, just to the right of the CPU board, flashes when the CPU is running the main program loop. After power-up, approximately 30 – 60 seconds, DS5 should flash on and off. If characters are written to the Input and Control Panel display but DS5 does not flash then the program files have become corrupted, contact Technical Support because it may be possible to recover operation of the calibrator. If after 30 – 60 seconds neither DS5 is flashing and nothing has been written to the Input and Control Panel display then the CPU is bad and must be replaced.

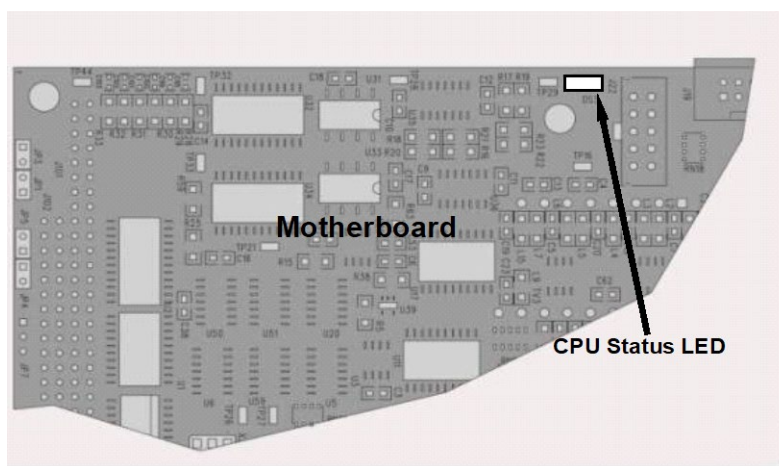


Figure 8-1. CPU Status Indicator

8.3.2. POWER DISTRIBUTION BOARD STATUS LEDs

There are sixteen status LEDs on the power distribution board, Described in Table 8-4 and Table 8-5, and depicted in Figure 8-2. Not all are used on this model.

8.3.2.1. I²C Bus Watchdog Status LEDs

The most important is D1 (see Figure 8-2), which indicates the health of the I²C bus.

Table 8-4. Power Distribution Board Watchdog LED Failure Indications

| LED | Function | Fault Status | Indicated Failure(s) |
|-------------|---|---|---|
| D1 (Red) | I ² C bus Health (Watchdog Circuit) | Continuously ON or Continuously OFF | Failed/Halted CPU Faulty Motherboard or Power distribution board Faulty Connectors/Wiring between Motherboard or Power distribution board Failed/Faulty +5 VDC Power Supply (PS1) |

If D1 is blinking, then the other LEDs can be used in conjunction with the **Utilities>Diagnostics>Analog Inputs** menu to identify hardware failures of the relays and switches on the board.

8.3.2.2. Troubleshooting with Power Distribution Board Status LEDs

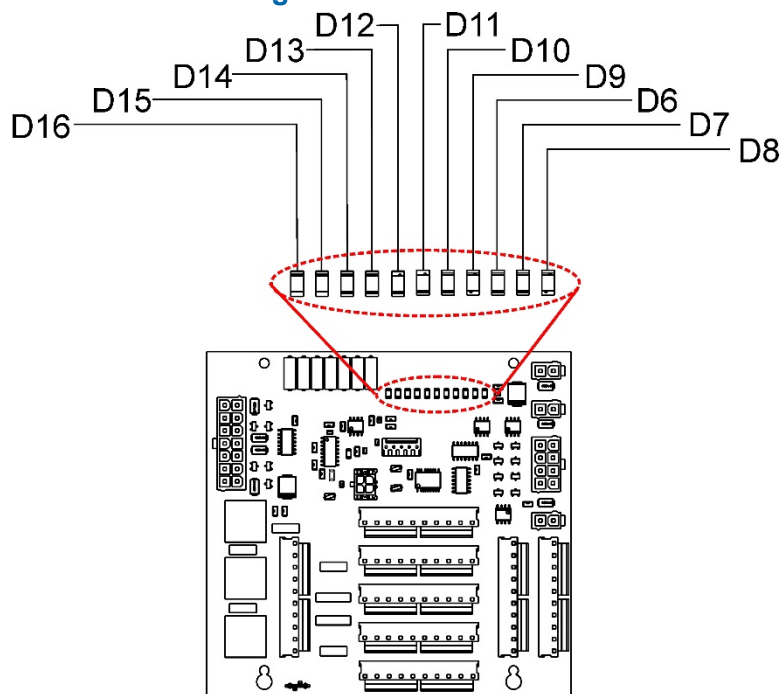


Figure 8-2. Power Distribution Board Status LEDs Used for Troubleshooting

Table 8-5. Power Distribution Board Status LED Failure Indications

| LED | INDICATES | ACTIVATED BY DIGITAL OUTPUT | DIAGNOSTIC TECHNIQUE |
|--------------|--|-----------------------------|--|
| D6 | GPT Valve Status | GPT_VALVE | Valve should audibly change states. If not: <ul style="list-style-type: none"> • Failed Valve • Failed Relay Drive IC on Relay PCA • Failed Relay PCA • Faulty +12 VDC Supply (PS2) Faulty Connectors/Wiring |
| D7 | Photometer Meas/Ref Valve | Photo Ref Valve | |
| D8 | O ₃ Generator Valve Status | O3 Gen Valve | |
| D10 | Cal Gas Status | Cylinder Valve | |
| D13 | Diluent Valve Status | Input Valve | |
| D9 | O ₃ Photometer Pump Status | O3 Pump On | Pump should start /stop. If not: <ul style="list-style-type: none"> • Failed pump • Failed Drive IC on Power distribution board • Failed Power distribution board • Faulty +12 VDC Supply • Faulty Connectors/Wiring |
| D15 Green | Photometer Heater Status | Photo Lamp Heater | Voltage displayed should change. If not: <ul style="list-style-type: none"> • Failed Heater • Faulty Temperature Sensor • Failed AC Relay • Faulty Connectors/Wiring |
| D16 Green | O ₃ Generator Heater Status | O3 Gen Lamp Heater | |

D1 = Watchdog; D2 thru D5, D11, D12, D14 = Spares

8.4. SUBSYSTEM CHECKOUT

The preceding sections of this manual discussed a variety of methods for identifying possible sources of failures or performance problems within the calibrator. In most cases, this includes a list of possible components or subsystems that might be the source of the problem. This section describes how to check individual components or subsystems to determine if which is actually the cause of the problem being investigated.

8.4.1. VERIFY SUBSYSTEM CALIBRATION

A good first step when troubleshooting the operation of the calibrator is to verify that its major subsystems are properly calibrated. These are:

- Mass flow controllers (see Section 6.1).
- Analog Inputs, Digital to Analog conversion (see Section 8.4.9.1).
- Gas pressure calibration (see Section 6.4).
- Photometer calibration (see Section 6.2).
- O₃ generator calibration (see Section 6.3).

8.4.2. AC MAIN POWER

The calibrator'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 Input and Control Panel display.

- Internally, the status LEDs located on the Power distribution board, 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 instruments Input and Control Panel

WARNING – Electrical Shock Hazard



Should the AC power circuit breaker trip, investigate and correct the condition causing this situation before powering on the calibrator again.

8.4.3. DC POWER SUPPLY

If you have determined that the calibrator's AC main 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. The supplies can have two faults, namely no DC output, and noisy output.

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 power distribution board follow a standard color-coding scheme as defined in the following table.

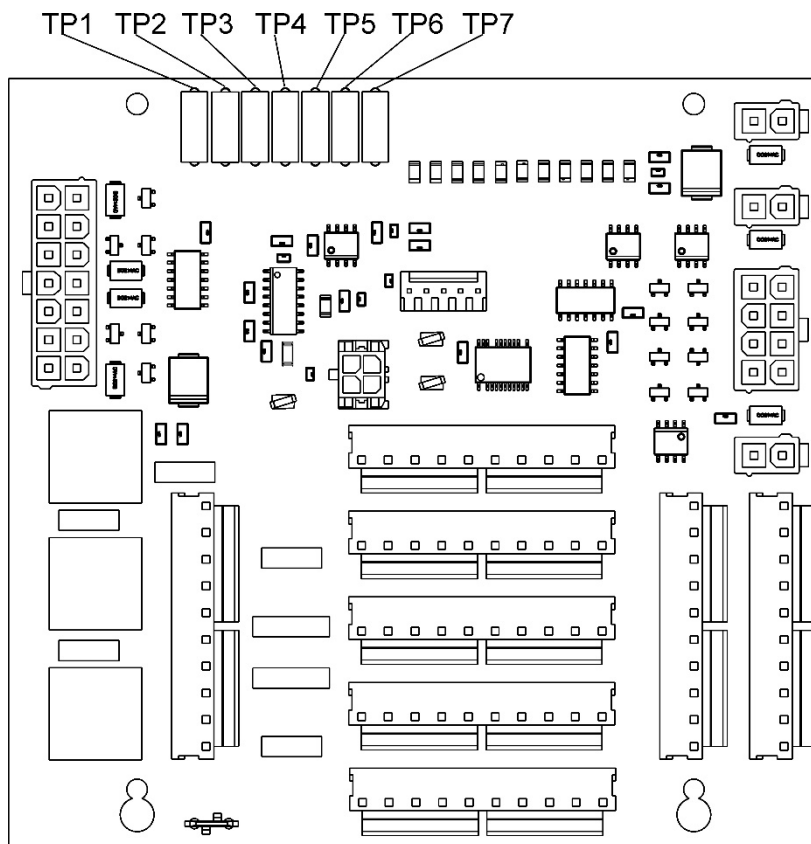


Figure 8-3. Location of DC Power Test Points on Power distribution board

Table 8-6. DC Power Test Point and Wiring Color Codes

| NAME | TEST POINT# | TP AND WIRE COLOR |
|------|-------------|-------------------|
| Dgnd | 1 | Black |
| +5V | 2 | Red |
| Agnd | 3 | Green |
| +15V | 4 | Blue |
| -15V | 5 | Yellow |
| +12R | 6 | Purple |
| +12V | 7 | Orange |

A voltmeter should be used to verify that the DC voltages are correct per the values in the table below, and an oscilloscope, in AC mode, with band limiting turned on, can be used to evaluate if the supplies are producing excessive noise (> 100 mV p-p).

Table 8-7. DC Power Supply Acceptable Levels

| POWER SUPPLY ASSY | VOLTAGE | CHECK POWER DISTRIBUTION BOARD TEST POINTS | | | | MIN V | MAX V |
|-------------------------|---------|---|---|---------------|-----|-------|-------|
| | | FROM TEST POINT | | TO TEST POINT | | | |
| | | NAME | # | NAME | # | | |
| PS1 | +5 | Dgnd | 1 | +5 | 2 | 4.8 | 5.25 |
| PS1 | +15 | Agnd | 3 | +15 | 4 | 13.5 | 16V |
| PS1 | -15 | Agnd | 3 | -15V | 5 | -14V | -16V |
| 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 | 11.75 | 12.5 |
| PS2 | Dgnd | +12V Ret | 6 | Dgnd | 1 | -0.05 | 0.05 |

8.4.4. I²C Bus

Operation of the I²C bus can be verified by observing the behavior of D1 on the power distribution board & D2 on the Valve Driver PCA. Assuming that the DC power supplies are operating properly, the I²C bus is operating properly if D1 on the power distribution board and D2 of the Valve Driver PCA are flashing

There is a problem with the I²C bus if both D1 on the power distribution board and D2 of the Valve Driver PCA are ON/OFF constantly.

8.4.5. TOUCHSCREEN INTERFACE

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

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

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

8.4.6. POWER DISTRIBUTION BOARD

The Power distribution board can be most easily checked by observing the condition of the status LEDs located along its upper edge (see Section 8.3.2 and Figure 8-2), and observing the **Utilities>Diagnostics>Analog Inputs** menu (see Section 8.1.3) while toggling each LED **ON** or **OFF**.

If D1 on the Power distribution board is flashing and the status indicator for the output in question (Pump power, Heater power, Valve Drive, etc.) toggles properly using the Analog Inputs function, then the associated control device on the Power distribution board is bad. Several of the control devices are in sockets and can be easily replaced. The table below lists the control device associated with a particular function.

Table 8-8. Power Distribution Board Control Devices

| FUNCTION | CONTROL DEVICE | IN SOCKET |
|---------------------------|----------------|-----------|
| UV Lamp Heater | Q2 | No |
| O ₃ Gen Heater | Q3 | No |
| All Valves | U5 | Yes |

8.4.7. INPUT GAS PRESSURE/FLOW SENSOR ASSEMBLY

The input gas pressure/flow sensor PCA (on Input Gas Pressure Sensor Assy, Figure 2-4) can be checked with a voltmeter. The following procedure assumes that the wiring is intact and that the motherboard and the power supplies are operating properly:

BASIC PCA OPERATION

1. Measure the voltage across C1; it should be 5 VDC \pm 0.25 VDC.
 - If not, then the board is bad.

CAL GAS PRESSURE SENSOR

1. Measure the pressure on the inlet side of S1 with an external pressure meter.
2. Measure the voltage across TP4 and TP1. The expected value for this signal should be:

$$\text{Expected mVDC} = \left(\frac{\text{Pressure}}{34.18_{\text{psig}}} \times 4250_{\text{mVDC}} \right) + 750_{\text{mVDC}} \quad \pm 10\%_{\text{rdg}}$$

EXAMPLE: If the measured pressure is 25 PSIG, the expected voltage level between TP4 and TP1 would be between 3470 mVDC and 4245 mVDC.

EXAMPLE: If the measured pressure is 30 PSIG, the expected voltage level between TP4 and TP1 would be between 4030 mVDC and 4930 mVDC.

- If this voltage is out of range, then either pressure transducer S1 is bad, the board is bad, or there is a pneumatic failure preventing the pressure transducer from sensing the absorption cell pressure properly.

DILUENT PRESSURE SENSOR:

1. Measure the pressure on the inlet side of S2 with an external pressure meter.
2. Measure the voltage across TP5 and TP1.
3. Evaluate the reading in the same manner as for the Cal Gas Pressure Sensor.

8.4.8. PHOTOMETER O₃ GENERATOR PRESSURE /FLOW SENSOR ASSEMBLY

This assembly is present in calibrators with the O₃ generator and/or photometer installed. The pressure sensor/flow sensor PCA, located on the inside of the outputs panel next to the Motherboard, can be checked with a voltmeter. The following procedure assumes that the wiring is intact and that the motherboard and the power supplies are operating properly:

BASIC PCA OPERATION:

1. Measure the voltage across C1; it should be 5 VDC \pm 0.25 VDC.
 - If not then the board is bad.
2. Measure the voltage between TP2 and TP1 C1; it should be 10 VDC \pm 0.25 VDC.
 - If not then the board is bad.

PHOTOMETER PRESSURE SENSOR (ABSOLUTE PRESSURE):

1. Measure the pressure on the inlet side of S1 with an external pressure meter.
2. Measure the voltage across TP4 and TP1. The expected value for this signal should be:

$$\text{Expected mVDC} = \left(\frac{\text{Pressure}}{30.0_{\text{In-Hg-A}}} \times 4660_{\text{mVDC}} \right) + 250_{\text{mVDC}} \quad \pm 10\%_{\text{rdg}}$$

EXAMPLE: If the measured pressure is 20 Hg-in-A, the expected voltage level between TP4 and TP1 would be between 2870 mVDC and 3510 mVDC.

EXAMPLE: If the measured pressure is 25 Hg-in-A, the expected voltage level between TP4 and TP1 would be between 3533 mVDC and 4318 mVDC.

- If this voltage is out of range, then either pressure transducer S1 is bad, the board is bad or there is a pneumatic failure preventing the pressure transducer from sensing the absorption cell pressure properly.

O₃ GENERATOR PRESSURE SENSOR (GAUGE PRESSURE):

1. Measure the pressure on the inlet side of S2 with an external pressure meter.
2. Measure the voltage across TP5 and TP1.
 - Evaluate the reading in the same manner as for the Cal Gas Pressure Sensor.

PHOTOMETER FLOW SENSOR:

1. Measure the voltage across TP3 and TP1.
 - With proper flow (800 cc³/min through the photometer), this should be approximately 4.5V (this voltage will vary with altitude).
 - With flow stopped (photometer inlet disconnected or pump turned OFF) the voltage should be approximately 1V.
 - If the voltage is incorrect, the flow sensor S3 is bad, the board is bad or there is a leak upstream of the sensor.

8.4.9. MOTHERBOARD

8.4.9.1. A/D Functions

The simplest method to check the operation of the A-to-D converter on the motherboard is to use the Analog Inputs page in the **Utilities>Diagnostics** menu to check the two A/D reference voltages and input signals that can be easily measured with a voltmeter.

1. Use the Analog Inputs function to view the value of Ref 4096mV and Ref Ground.
 - If both are within 3 mV of nominal (4096 and 0), and are stable, ± 0.5 mV then the basic A/D is functioning properly. I
 - If not, then the motherboard is bad.
2. Choose an Analog Inputs function such as Diluent Pressure or Sample Flow, and compare these voltages at their origin (see Interconnect drawing in Appendix B) with the voltage displayed through the **Utilities>Diagnostics>Analog Inputs** menu.
 - If the wiring is intact but there is a large difference between the measured and displayed voltage (± 10 mV) then the motherboard is bad.

8.4.9.2. Analog Outputs Voltage

To verify that the analog output is working properly, connect a voltmeter to the analog output in question and perform an analog output step test as follows:

1. Navigate to the **Utilities>Diagnostics>Analog Outputs** page

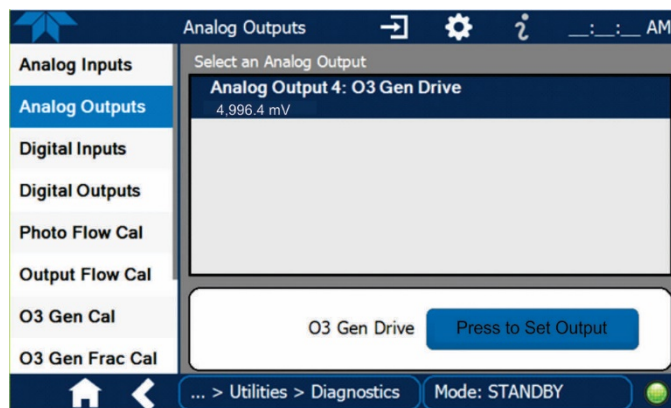


Figure 8-4. Analog Outputs Page

2. Use the Press to Set Output button to set the desired percent of the signal output in the numeric keypad that pops up, and press Enter.
3. Compare the value displayed in the Analog Output field to the voltmeter.

For each percentage set, the output should be within 1% of the nominal value. Use the table below as an example. Ensure to take into account any offset that may have been programmed into the analog output channel.

Table 8-9. Analog Output Test Function - Nominal Values Voltage Outputs

| | FULL SCALE OUTPUT OF VOLTAGE RANGE | | | |
|-------------|------------------------------------|-----|----|-----|
| | 100MV | 1V | 5V | 10V |
| SIGNAL % | NOMINAL OUTPUT VOLTAGE | | | |
| 0 | 0 | 0 | 0 | 0 |
| 20 | 20 mV | 0.2 | 1 | 2 |
| 40 | 40 mV | 0.4 | 2 | 4 |
| 60 | 60 mV | 0.6 | 3 | 6 |
| 80 | 80 mV | 0.8 | 4 | 8 |
| 100 | 100 mV | 1.0 | 5 | 10 |

If one or more of the readings fails to be within range, it is likely that there has been a failure of the either or both of the DACs and their associated circuitry on the motherboard.

8.4.9.3. Status Outputs (Digital Output Pins 1 – 8)

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 (see table below).
4. Under the **Utilities>Diagnostics** menu scroll 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.

8.4.9.4. Digital Control Inputs

Table 8-10. Digital Control Input Pin Assignments and Corresponding Functions

| INPUT | CORRESPONDING I/O SIGNAL |
|-------|--------------------------|
| 1 | CONTROL_IN_1 |
| 2 | CONTROL_IN_2 |
| 3 | CONTROL_IN_3 |
| 4 | CONTROL_IN_4 |
| 5 | CONTROL_IN_5 |
| 6 | CONTROL_IN_6 |
| 7 | CONTROL_IN_7 |
| 8 | CONTROL_IN_8 |
| 9 | CONTROL_IN_9 |
| 10 | CONTROL_IN_10 |
| 11 | CONTROL_IN_11 |
| 12 | CONTROL_IN_12 |

The control input bits can be tested by applying a trigger voltage to an input and watching changes in the status of the associated function under the **Utilities>Diagnostics** menu:

EXAMPLE: to test the “1” control input:

1. Under the Utilities>Diagnostics menu scroll to the input for CONTROL_IN_1.
2. Connect a jumper from the “+” pin on the appropriate connector to the “U” on the same connector.
3. Connect a second jumper from the “▽” pin on the connector to the “A” pin.
 - The status of CONTROL_IN_1 should change to read “ON”.

8.4.9.5. Control Outputs (Digital Output Pins 1 – 12)

Table 8-11. Control Outputs Pin Assignments and Corresponding Functions Check

| PIN (RIGHT TO LEFT) | STATUS |
|---------------------|----------------|
| 1 | CONTROL_OUT_1 |
| 2 | CONTROL_OUT_2 |
| 3 | CONTROL_OUT_3 |
| 4 | CONTROL_OUT_4 |
| 5 | CONTROL_OUT_5 |
| 6 | CONTROL_OUT_6 |
| 7 | CONTROL_OUT_7 |
| 8 | CONTROL_OUT_8 |
| 9 | CONTROL_OUT_9 |
| 10 | CONTROL_OUT_10 |
| 11 | CONTROL_OUT_11 |
| 12 | CONTROL_OUT_12 |

To test the Control Output electronics:

1. Connect a jumper between the “E” 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 (see Table 8-11).
4. Under **Utilities>Diagnostics>Digital Outputs**, scroll 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.

8.4.10. 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 instrument stops during initialization (triggering an Alert), it is likely that the DOM, the firmware or the configuration and data files have been corrupted.

8.4.11. RS-232 COMMUNICATIONS, GENERAL TROUBLESHOOTING

Teledyne API calibrators use the RS-232 communications protocol to allow the instrument to be connected to a variety of computer-based equipment. RS-232 has been used for many years and as equipment has become more advanced, connections between various types of hardware have become increasingly difficult. Generally, every manufacturer observes the signal and timing requirements of the protocol very carefully.

Problems with RS-232 connections usually center around four general areas:

- Incorrect cabling and connectors (see RS-232 Com Port Connector Pin-outs in Section 2.4.1.6).
- The BAUD rate and protocol are incorrectly configured (see RS-232 Com Port Default Settings in Section 2.4.1.6).
- Incorrect setting of the DTE – DCE Switch (see Section 5.1.1).
- Verify that the cable that connects the serial COM ports of the CPU to J12 of the motherboard is properly seated

8.4.12. TEMPERATURE PROBLEMS

Individual control loops are used to maintain the set point of the UV lamp and ozone generator. If any of these temperatures are out of range or are poorly controlled, the calibrator will perform poorly.

8.4.12.1. Box / Chassis Temperature

The box temperature sensor is mounted to the motherboard and cannot be disconnected to check its resistance. Rather check the **BOX TEMP** signal in the Dashboard. This parameter will vary with ambient temperature, but at ~30°C (6-7° above room temperature) the signal should be ~1450 mV.

8.4.12.2. Photometer Sample Chamber Temperature

The temperature of the gas in the photometer sample chamber should read approximately 5.0°C higher than the box temperature.

8.4.12.3. UV Lamp Temperature

There are three possible causes for the UV Lamp temperature to have failed.

- The UV Lamp heater has failed. Check the resistance between pins 5 and 6 on the six-pin connector adjacent to the UV Lamp on the Optical Bench.
- It should be approximately 30 Ohms.



T750, T750U

- Assuming that the I²C bus is working and that there is no other failure with the Power distribution board, the FET Driver on the Power distribution board may have failed.
 - Using the PHOTO_LAMP HEATER parameter in the **Utilities>Diagnostics** menu, as described above, turn on and off the UV Lamp Heater (D15 on the power distribution board should illuminate as the heater is turned on).
 - Check the DC voltage present between pin 1 and 2 on J13 of the Power distribution board.
 - If the FET Driver has failed, there will be no change in the voltage across pins 1 and 2.
- If the FET Driver Q2 checks out OK, the thermistor temperature sensor in the lamp assembly may have failed.
 - Unplug the connector to the UV Lamp Heater/Thermistor PCB, and measure the resistance of the thermistor between pins 5 and 6 of the 6-pin connector.
 - The resistance near the 58°C set point is ~8.1k ohms.

8.4.12.4. Ozone Generator Temperature

There are three possible causes for the Ozone Generator temperature to have failed.

- The O₃ generator heater has failed. Check the resistance between pins 5 and 6 on the 6-pin connector adjacent to the UV Lamp on the O₃ Generator. It should be approximately 5 Ohms.
- Assuming that the I²C bus is working and that there is no other failure with the Power distribution board, the FET Driver on the Power distribution board may have failed. Using the O3_GEN_HEATER parameter in the **Utilities>Diagnostics** menu, as described above, turn on and off the UV Lamp Heater. Check the DC voltage present between pin 1 and 2 on J14 of the Power distribution board.

If the FET Driver has failed, there should be no change in the voltage across pins 1 and 2.

- If the FET Driver checks out OK, the thermistor temperature sensor in the lamp assembly may have failed. Unplug the connector to the Ozone Generator Heater/Thermistor PCB, and measure the resistance of the thermistor between pins 5 and 6 of the 6-pin connector.

8.5. TROUBLESHOOTING THE O₃ PHOTOMETER

8.5.1. DYNAMIC PROBLEMS WITH THE O₃ PHOTOMETER

Dynamic problems only manifest when the photometer is measuring O₃ concentration gas mixtures. These can be the most difficult and time-consuming to isolate and resolve.

Since many photometer behaviors that appear to be a dynamic in nature are often a symptom of a seemingly unrelated static problems, it is recommended that dynamic problems not be addressed until all static problems, warning conditions and subsystems have been checked and any problems found are resolved.

Once this has been accomplished, the following most common dynamic problems should be checked.



8.5.1.1. Noisy or Unstable O₃ Readings at Zero

- Check for leaks in the pneumatic system as described in Section 7.2
- Confirm that the Zero gas is free of Ozone.
- Confirm that the Source Lamp is fully inserted and that the lamp hold-down thumb- screw is tight.
- Check for a dirty Absorption Cell and/or pneumatic lines. Clean as necessary as described in Section 7.2
- Disconnect the exhaust line from the optical bench (the pneumatic line at the lamp end of the bench) and plug the port in the bench. If readings remain noisy, the problem is in one of the electronic sections of the instrument. If readings become quiet, the problem is in the instrument's pneumatics.

8.5.1.2. Noisy, Unstable, or Non-Linear Span O₃ Readings

- Check for leaks in the pneumatic systems as described in Section 7.2.
- Check for proper operation of the meas/ref switching valve as described in Section 8.5.2.
- Check for dirty absorption cell and clean or replace as necessary as described in Section 7.2
- Check for operation of the A/D circuitry on the motherboard. See Section 8.4.9.1.
- Confirm the Sample Temperature, Sample Pressure and Sample Flow readings are correct. Check and adjust as required.

8.5.1.3. Slow Response to Changes in Concentration

- Check for dirty absorption cell and clean or replace as necessary as described in Section 7.2
- Check for pneumatic leaks as described in Section 7.2
- The photometer needs 800 cc³/min of gas flow. Make sure that this is accounted for when calculating total required output flow for the calibrator (see Section 2.5.5).

8.5.1.4. The Analog Output Signal Level Does Not Agree With Display Readings

- Confirm that the recorder offset (see Section 3.3.9.2) is set to zero.
- Perform an Analog Output calibration (see Section 3.3.9.3).

8.5.1.5. Cannot Zero

- Check for leaks in the pneumatic system as described in Section 7.2.
- Confirm that the Zero gas is free of Ozone.
- The photometer needs 800 cc³/min of gas flow. Make sure that this is accounted for when calculating total required output flow for the calibrator (see Section 2.5.5).



8.5.1.6. Cannot Span

- Check for leaks in the pneumatic systems as described in Section 7.2.
- Check for proper operation of the meas/ref switching valve as described in Section 8.5.2.
- Check for dirty absorption cell and clean or replace as necessary as described in Section 7.2
- Check for operation of the A/D circuitry on the motherboard. See Section 8.4.9.1.
- Confirm the Sample Temperature, Sample Pressure and Sample Flow readings are correct. Check and adjust as required.
- The photometer needs 800 cc³/min of gas flow. Make sure that this is accounted for when calculating total required output flow for the calibrator (see Section 2.5.5).

8.5.2. CHECKING MEASURE / REFERENCE VALVE

To check the function of the photometer's measure / reference valve:

1. Set the Dashboard display to show the photometer reference parameter, O3 Ref.
2. Ensure the calibrator is set up as required to produce ozone.
3. In the Generate menu press AUTO and set the gas to O3 and the concentration to 0.0.
4. Press the Generate button.
5. While generating, navigate to the Dashboard and record the O3 Ref value.
6. Return to the Generate menu, press the Standby button and change the concentration to 400 PPB.
7. Press the Generate button.
8. Return to the Dashboard, allow time to stabilize, and observe the O3 Ref value.

If the O3 Ref value has decreased by more than 2.0 mV from the value noted in Step 5 above, then there is a cross-port leak in the measure/reference valve, and it needs to be replaced.

8.6. TROUBLESHOOTING THE O₃ GENERATOR



WARNING – ELECTRICAL SHOCK HAZARD

Hazardous voltage present - use caution.

The only significant components of the O₃ generator that might reasonable malfunction is the power supply assembly for the UV source lamp and the lamp itself.

1. Make sure the calibrator is idling in **STANDBY** mode.
2. Unplug the cable connector at P1 on the Lamp Power Supply and confirm that +15VDC is present between Pins 1 and 2 on the cable connector.
 - If this voltage is incorrect, check the DC test points on the power distribution board as described in Section 8.4.3.
3. Remove the cover of the photometer and check for the presence of the following voltages on the UV lamp power supply PCA:
 - +800 mVDC \pm 10 mVDC between TP1 and TP4 (grnd)
 - If this voltage is incorrect, either the UV lamp power supply PCA is faulty or the I²C bus is not communicating with the UV lamp power supply PCA.
 - +5VDC between TP3 and TP4 (grnd)
 - If this voltages is less than 4.8 or greater than 5.25, either the 5 VDC power supply or the UV lamp power supply PCA are faulty.

If the above voltages check out, it is more likely that a problem is due to the UV Lamp than due to the Lamp Power Supply. Replace the UV Lamp and if the problem persists, replace the Lamp Power Supply.

8.7. SERVICE PROCEDURES

8.7.1. DISK-ON-MODULE REPLACEMENT PROCEDURE

Replacing the Disk-on-Module (DOM) will cause loss of all DAS data; it also may 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 instrument 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 instrument parameters that may have been changed, such as range, auto-cal, analog output, serial port and other settings before replacing the DOM. (You will need this information to re-enter at the end of this procedure).
2. Turn off power to the instrument, fold down the communications and output panel by loosening the mounting screws.
3. When looking at the electronic circuits from the back of the instrument, locate the Disk-on-Module in the right most socket of the CPU board.

The DOM should carry a label with firmware revision, date and initials of the programmer.

4. Remove the nylon fastener that mounts the DOM over the CPU board, and lift the DOM off the CPU. Do not bend the connector pins.
5. Install the new Disk-on-Module, making sure the notch at the end of the chip matches the notch in the socket.

It may be necessary to straighten the pins somewhat to fit them into the socket. Press the DOM all the way in and reinsert the offset clip.

6. Close the communications and output panel and turn on power to the machine.
7. If the replacement DOM carries a firmware revision, re-enter all of the setup information.
8. Recalibrate A/D converter, and conduct a Zero and Span calibration as well.

8.8. TECHNICAL ASSISTANCE

If this manual and its trouble-shooting / service sections do not solve your problems, technical assistance may be obtained from

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

Toll-free Phone: +1 800-324-5190
Phone: +1 858-657-9800
Fax: +1 858-657-9816
Email: api-techsupport@teledyne.com
Website: <http://www.teledyne-api.com/>

Before contacting Technical Support, please complete the problem report available online for electronic submission at <http://www.teledyne-api.com/forms/>.



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9. PRINCIPLES OF OPERATION

This section provides information about the scientific principles based on which this instrument operates.

9.1. BASIC PRINCIPLES OF DYNAMIC DILUTION CALIBRATION

The portable calibrator generates calibration gas mixtures by mixing bottled source gases of known concentrations with a diluent gas (zero air). Using several Mass Flow Controllers (MFCs) the T750 calibrator creates exact ratios of diluent and source gas by controlling the relative rates of flow of the various gases, under conditions where the temperature and pressure of the gases being mixed is known (and therefore the density of the gases).

The CPU calculates both the required source gas and diluent gas flow rates and controls the corresponding mass flow controllers by the following equation.

Equation 9-1

$$C_f = C_i \times \frac{GAS_{flow}}{Totalflow}$$

WHERE:

C_f = final concentration of diluted gas

C_i = source gas concentration

GAS_{flow} = source gas flow rate

$Totalflow$ = the total gas flow through the calibrator

Totalflow is determined as:

$$TOTALFLOW = GAS_{flow} + Diluent_{flow}$$

WHERE:

GAS_{flow} = source gas flow rate

$Diluent_{flow}$ = zero air flow rate

For instruments with multiple source gas MFCs, Totalflow is determined as:

$$TOTALFLOW = GAS_{flow\ MFC1} + GAS_{flow\ MFC2} + GAS_{flow\ MFCn} + Diluent_{flow\ rate}$$

This dilution process is dynamic. The T750's CPU not only keeps track of the temperature and pressure of the various gases, but also receives data on actual flow rates of the various MFCs in real time so the flow rate control can be constantly adjusted to maintain a stable output concentration.

The calibrator's level of control is so precise that bottles of mixed gases can be used as source gas. Once the exact concentrations of all of the gases in the bottle are programmed into the calibrator, it will create an exact output concentration of any of the gases in the bottle.

9.2. GAS PHASE TITRATION MIXTURES FOR O₃ AND NO₂

Because ozone is a very reactive and therefore under normal ambient conditions a short-lived gas, it cannot be reliably bottled, however, an optional O₃ generator can be included in the portable calibrator, which allows the instrument to be used to create calibration mixtures that include O₃.

This ability to generate O₃ internally also allows the T750 Portable Calibrator to be used to create calibration mixture containing NO₂ using a gas phase titration process (GPT) by precisely mixing bottled NO of a known concentration with O₃ of a known concentration and diluent gas (zero air).

The principle of GPT is based on the rapid gas phase reaction between NO and O₃ that produces quantities of NO₂ as according to the following equation:

Equation 9-2



Under controlled circumstances, the NO-O₃ reaction is very efficient (<1% residual O₃), therefore the concentration of NO₂ resulting from the mixing of NO and O₃ can be accurately predicted and controlled as long as the following conditions are met:

- The amount of O₃ used in the mixture is known.
- The amount of NO used in the mixture is **AT LEAST** 10% greater than the amount O₃ in the mixture.
- The volume of the mixing chamber is known.
- The NO and O₃ flow rates (from which the time the two gases are in the mixing chamber) are low enough to give a residence time of the reactants in the mixing chamber of >2.75 ppm min.

Given the above conditions, the amount of NO₂ being output by the T750 will be equal to (at a 1:1 ratio) the amount of O₃ added.

Since:

- The O₃ flow rate of the T750's O₃ generator is a fixed value (typically about 0.105 SLPM);
- The GPT chamber's volume is known,
- The source concentration of NO is a fixed value,

Once the **TOTALFLOW** is determined and entered into the T750's memory and target concentration for the O₃ generator are entered into the calibrator's software, the T750 adjusts the NO flow rate and diluent (zero air) flow rate to precisely create the appropriate NO₂ concentration at the output.

In this case, **Totalflow** is calculated as:

Equation 9-3

$$DIL_{flow} = Totalflow - NO\ GAS_{flow} - O_3_{flow}$$

WHERE:

$NOGAS_{flow}$ = NO source gas flow rate (For calibrator's with multiple source gas MFC, $NOGAS_{flow}$ is the sum of the flow rate for all of the active cal gas MFCs)

$Totalflow$ = total gas flow requirements of the system.

O_3_{flow} = the flow rate set for the O_3 generator.

DIL_{flow} = required diluent gas flow

Again, this is a dynamic process. An optional photometer can be added the calibrator that allows the CPU to track the chemiluminescent reaction created when the NO and O_3 interact to measure the decrease in NO concentration as NO_2 is produced. This information, along with the other data (gas temperature and pressure, actual flow rates, etc.) is used by the CPU to establish a very accurate NO_2 calibration mixture.

9.3. PNEUMATIC OPERATION

The portable calibrator's pneumatic system is comprised of the precision dilution system and valve manifold consisting of one gas port valve and one diluent valve. These valves open and close off gas flow from the zero air and bottles upstream of the MFCs.

9.3.1. GAS FLOW CONTROL

The precision of gas flow through the T750 Portable Calibrator is centrally critical to its ability to mix calibration gases accurately. This control is established in several ways.

9.3.1.1. Diluent and Source Gas Flow Control

Diluent and source gas flow in the calibrator is directly and dynamically controlled by using highly accurate Mass Flow Controllers. These MFCs include internal sensors that determine the actual flow of gas through each and feedback control circuitry that uses this data to adjust the flow as required. The MFCs consist of a shunt, a sensor, a solenoid valve and the electronic circuitry required to operate them.

The shunt divides the gas flow such that the flow through the sensor is a precise percentage of the flow through the valve. The flow through the sensor is always laminar.

The MFC's internal sensor operates on a unique thermal-electric principle. A metallic capillary tube is heated uniformly by a resistance winding attached to the midpoint of the capillary. Thermocouples are welded at equal distances from the midpoint of the tube. At zero air flow the temperature of both thermocouples will be the same. When flow occurs through the tubing, heat is transferred from the tube to the gas on the inlet side and from the gas back to the tube on the outlet side creating an asymmetrical temperature distribution. The thermocouples sense this decrease, increase of temperature in the capillary tube, and produce a mVDC output signal proportional to that change that is proportional to the rate of flow through the MFCs valve.

The electronic circuitry reads the signal output by the thermal flow sensor measured through a capillary tube. This signal is amplified so that it varies between 0.00 VDC and



5.00 VDC. A separate 0 to 5 VDC command voltage is also generated that is proportional to the target flow rate requested by the calibrator's CPU. The 0-5VDC command signal is electronically subtracted from the 0-5VDC flow signal. The amount and direction of the movement is dependent upon the value and the sign of the differential signal.

The MFC valve is an automatic metering solenoid type; its height off the seat is controlled by the voltage in its coil. The controller's circuitry amplifies the differential signal obtained by comparing the control voltage to the flow sensor output and uses it to drive the solenoid valve.

The entire control loop is set up so that as solenoid valve opens and closes to vary the flow of gas through the shunt, valve and sensor in an attempt to minimize the differential between the control voltage for the target flow rate and the flow sensor output voltage generated by the actual flow rate of gas through the controller.

This process is heavily dependent on the capacity of the gas to heat and cool. Since the heat capacity of many gases is relatively constant over wide ranges of temperature and pressure, the flow meter is calibrated directly in molar mass units for known gases (molar mass was discussed in Section 2.5.3). Changes in gas composition usually only require application of a simple multiplier to the air calibration to account for the difference in heat capacity and thus the flow meter is capable of measuring a wide variety of gases.

9.3.1.2. Flow Control Assemblies for O₃ Components

Whereas the gas flow rates for the final mixing of gases is controlled directly by the calibrator's MFCs, under direction of the CPU, other gas flow rates in the calibrator are set by various flow control assemblies located in the gas stream(s). These orifices are not adjusted but maintain precise volumetric control as long as a critical pressure ratio is maintained between the upstream and the downstream orifice. The most important component of the flow control assemblies is the critical flow orifice.

9.3.1.3. Critical Flow Orifices

Critical flow orifices regulate stable gas flow rates. They operate without moving parts by taking advantage of the laws of fluid dynamics: restrict the flow of gas through the orifice to create a pressure differential. This pressure differential combined with the action of the calibrator'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.

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.



9.3.2. INTERNAL GAS PRESSURE SENSORS

The T750 portable calibrator includes a single pressure regulator. Depending upon how many and which options are installed, there are between two and four pressure sensors installed as well.

In the basic unit a printed circuit, assembly located near the front of the calibrator near the MFCs includes sensors that measure the pressure of the diluent gas and the source gas currently selected to flow into the calibrator. The calibrator monitors these sensors.

- Should the pressure of one of them fall below 15 PSIG or rise above 36 PSIG a warning is issued.

In units with the O₃ generator (option in the T750) installed, a second PCA located at the rear of the calibrator just behind the generator assembly includes a sensor that measures the gas pressure of the zero air flowing into the generator. A regulator is also located on the gas input to the O₃ generator that maintains the pressure differential needed for the critical flow orifice to operate correctly.

- Should the pressure of one of this sensor fall below 15 PSIG or rise above 25 PSIG a warning is issued.

In calibrators with O₃ photometers installed, a second pressure located on the rear PCA measures the pressure of gas in the photometer's absorption tube. This data is used by the CPU when calculating the O₃ concentration inside the absorption tube.

9.4. ELECTRONIC OPERATION

9.4.1. OVERVIEW

Figure 9-1 shows an electronic block diagram of the portable calibrator.

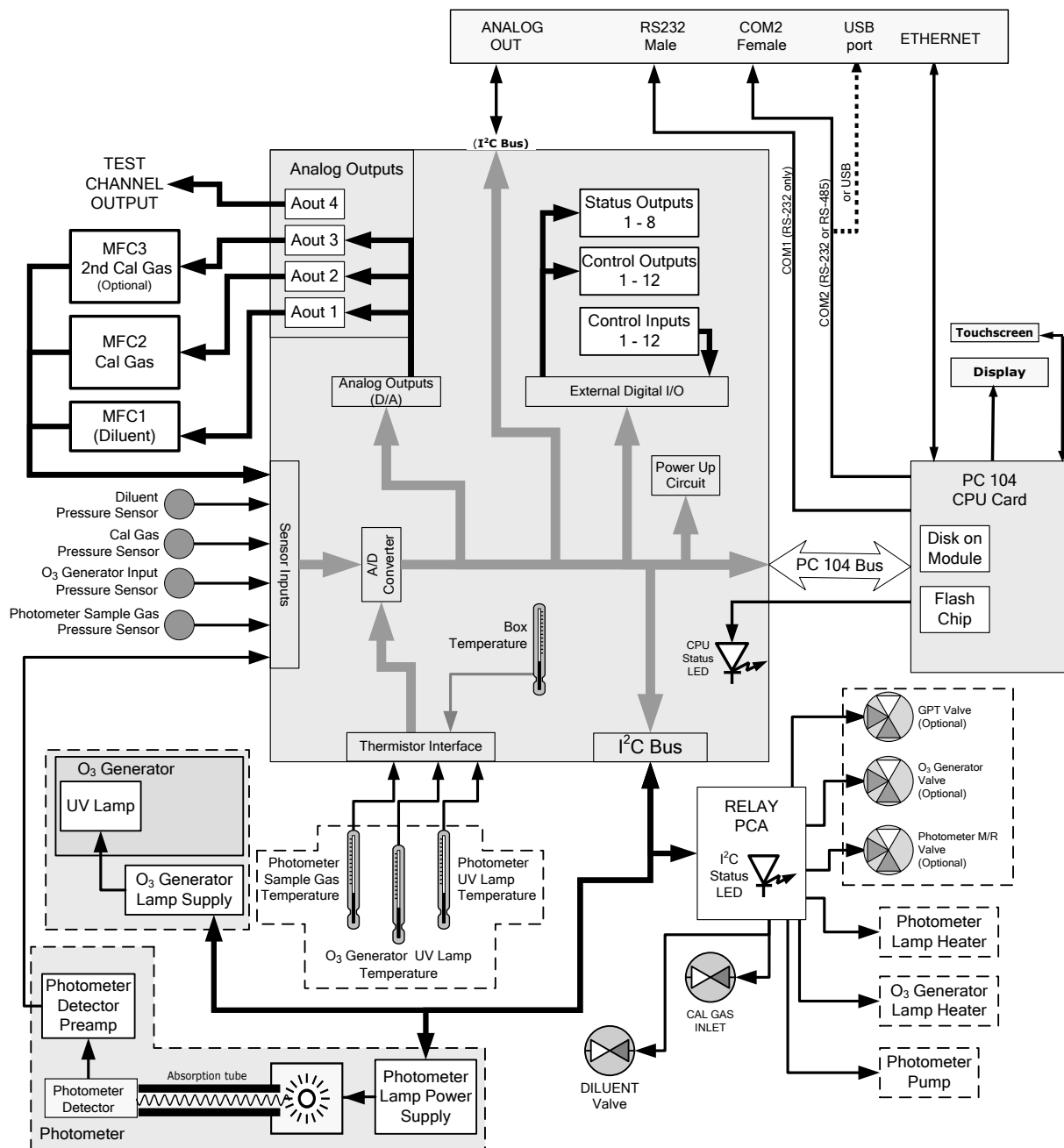


Figure 9-1. Electronic Block Diagram

The core of the calibrator is a microcomputer (referred to as the 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 called the motherboard.

The motherboard is directly mounted to the inside communications and output panel and collects data, performs signal conditioning duties and routes incoming and outgoing signals between the CPU and the calibrator's other major components.

Data are generated by the various subcomponents of the T750 (e.g. flow data from the MFCs, O₃ concentration from the optional photometer). Analog signals are converted into digital data by a unipolar, analog-to-digital converter, located on the motherboard.

A variety of sensors report the physical and operational status of the calibrator's major components, again through the signal processing capabilities of the motherboard. These status reports are used as data for the concentration calculations and as trigger events for certain control commands issued by the CPU. They are stored in memory by the CPU and in most cases can be viewed but the user via the LCD touchscreen.

The CPU communicates with the user and the outside world in a variety of manners:

- Through the calibrator's LCD touchscreen interface;
- RS 232 and RS485 serial I/O channels;
- Via Ethernet;
- Various digital and analog outputs, and
- A set of digital control input channels.

Finally, the CPU issues commands via a series of relays and switches (also over the I²C bus) located on a separate printed circuit assembly to control the function of key electromechanical devices such as heaters, motors and valves.

9.4.2. CENTRAL PROCESSING UNIT (CPU)

The unit's CPU card is installed on the motherboard located inside the communications and output panel. It is a low power (5 VDC, 720mA max), high performance, Vortex 86SX-based microcomputer running Windows CE. Its operation and assembly conform to the PC-104 specification.

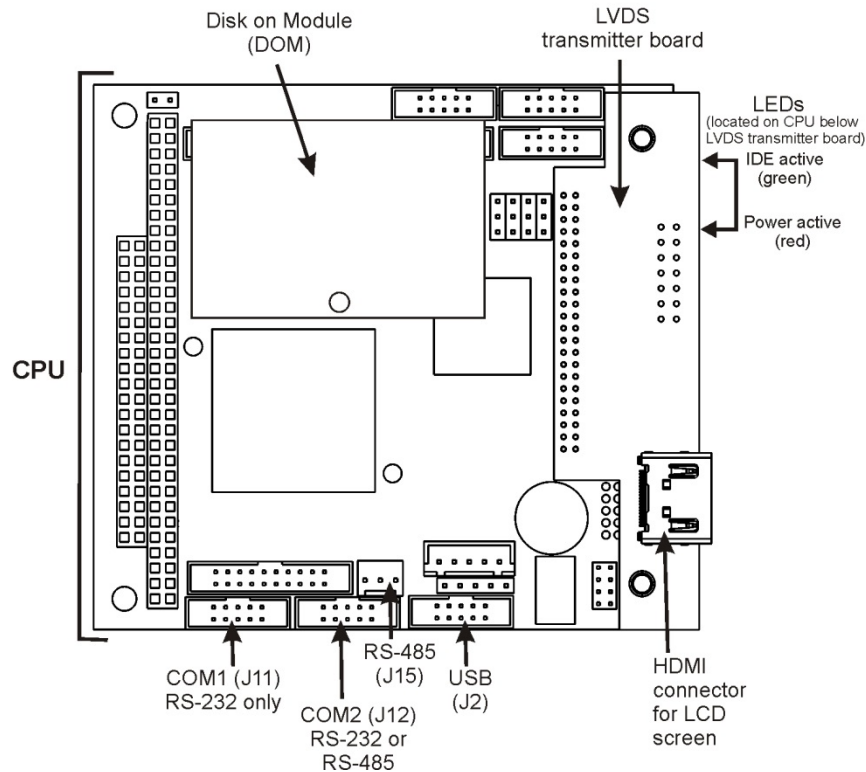


Figure 9-2. CPU Board Annotated

The CPU includes two types of non-volatile data storage: a Disk on Module (DOM) and an embedded flash chip.

9.4.2.1. Disk On Module (DOM)

The DOM is a 44-pin IDE flash chip with a storage capacity up to 256 MB. It is used to store the computer's operating system, the Teledyne API firmware, and most of the operational data.

9.4.2.2. Flash Chip

This non-volatile, embedded flash chip includes 2MB of storage for calibration data as well as a backup of the calibrator's configuration. Storing these key data onto a less frequently accessed chip significantly decreases the chance of data corruption.

In the unlikely event that the flash chip should fail, the calibrator will continue to operate with just the DOM. However, all configuration information will be lost, requiring the unit to be recalibrated.



9.4.3. POWER DISTRIBUTION BOARD (RELAY PCA)

The power distribution board (Relay PCA), Figure 9-3, is one of the central switching and power distribution units of the calibrator (see Figure 9-4 for its location). It contains power relays, valve drivers and status LEDs for all heated zones and valves, as well as thermocouple amplifiers, power distribution connectors and the two switching power supplies of the calibrator. This board communicates with the motherboard over the I²C bus. Its status indicators and components can be used for troubleshooting power problems and valve or heater functionality.

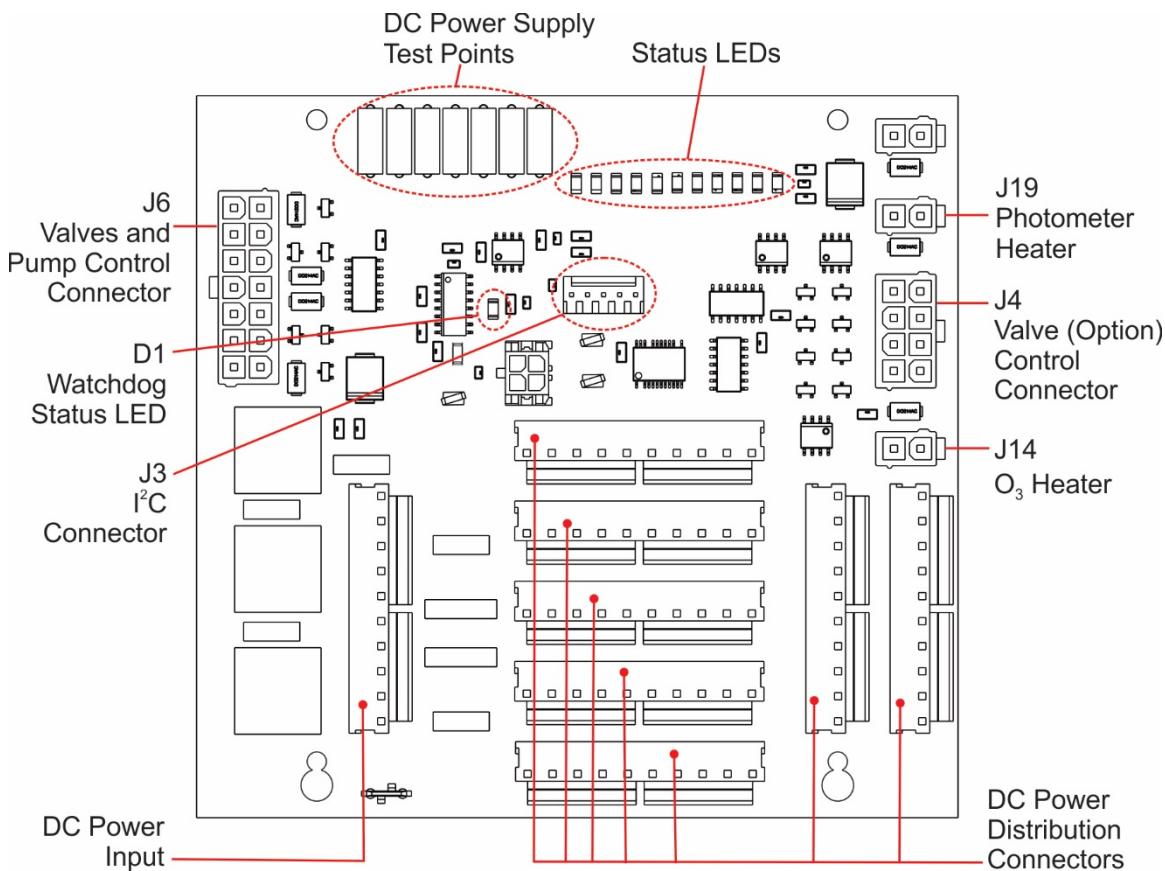


Figure 9-3. Power Distribution Board (Relay PCA)



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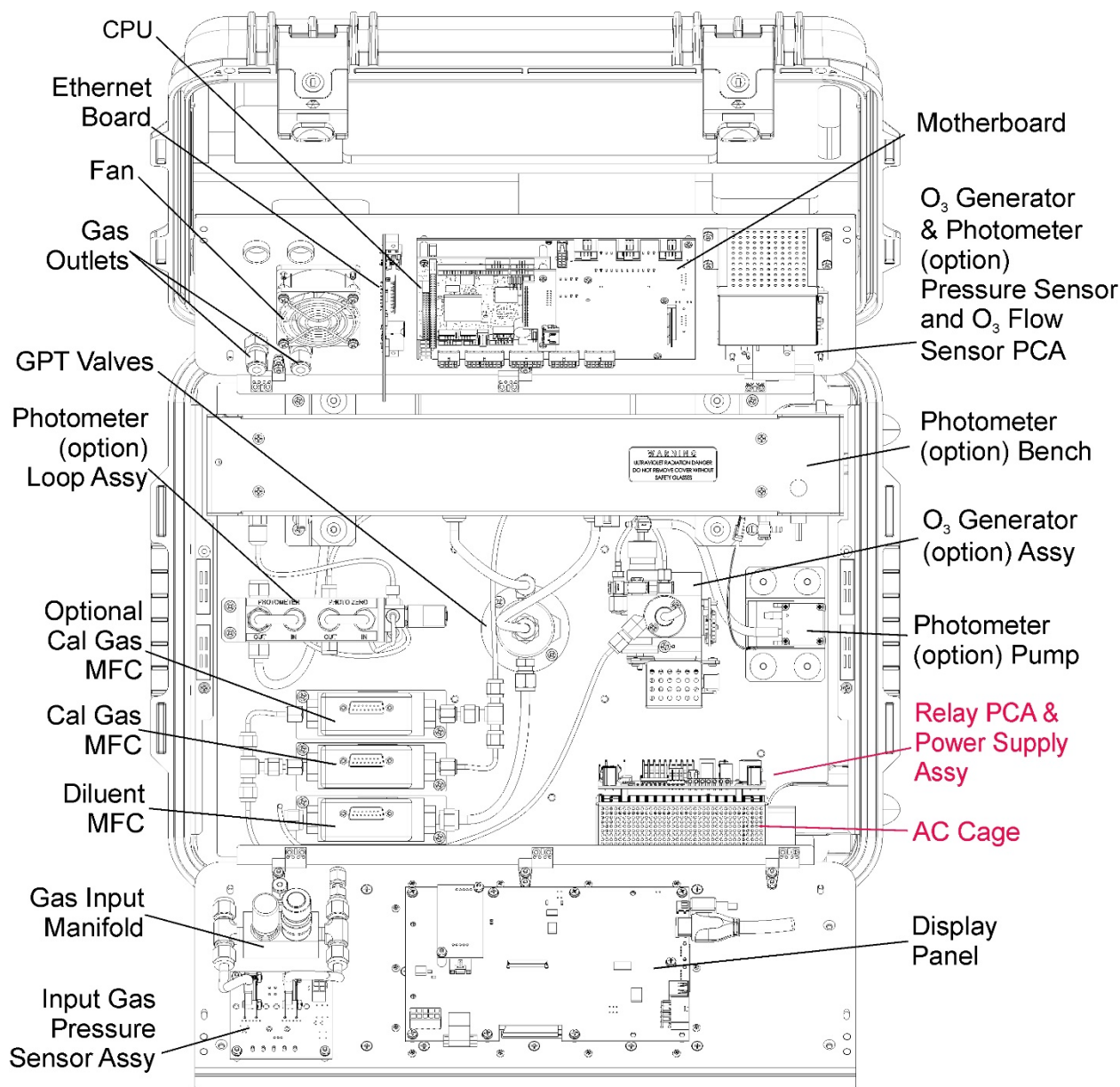


Figure 9-4. Relay PCA Location

WARNING – ELECTRICAL SHOCK HAZARD



Never remove the AC Cage, which is a safety shield, while the instrument is plugged in and turned on. The contacts of the AC relay sockets beneath the shield carry high AC voltages even when no relays are present.

9.4.3.1. Valve Control

The power distribution board/Relay PCA also hosts two valve driver chips, each of which can drive up four valves. The board controls all the valves related to source gas and diluent gas flow. It also controls those associated with the O₃ generator and photometer options.

9.4.3.2. Heater Control

The power distribution board controls the DC heaters related to the O₃ generator and photometer.

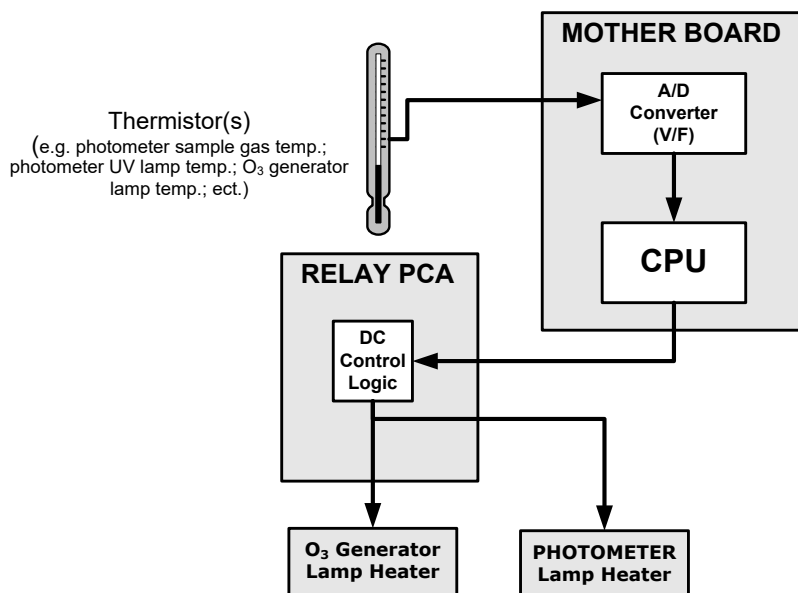


Figure 9-5. Heater Control Loop Block Diagram.

9.4.3.3. Power Distribution Board Status LEDs and Watch Dog Circuitry

LEDs located on the calibrator's power distribution board (Figure 9-6) indicate the status of the calibrator's heating zones and some of its valves; included is a general operating watchdog indicator. Table 9-1 shows the states of these LEDs and their respective functionality. Not all LEDs are used.

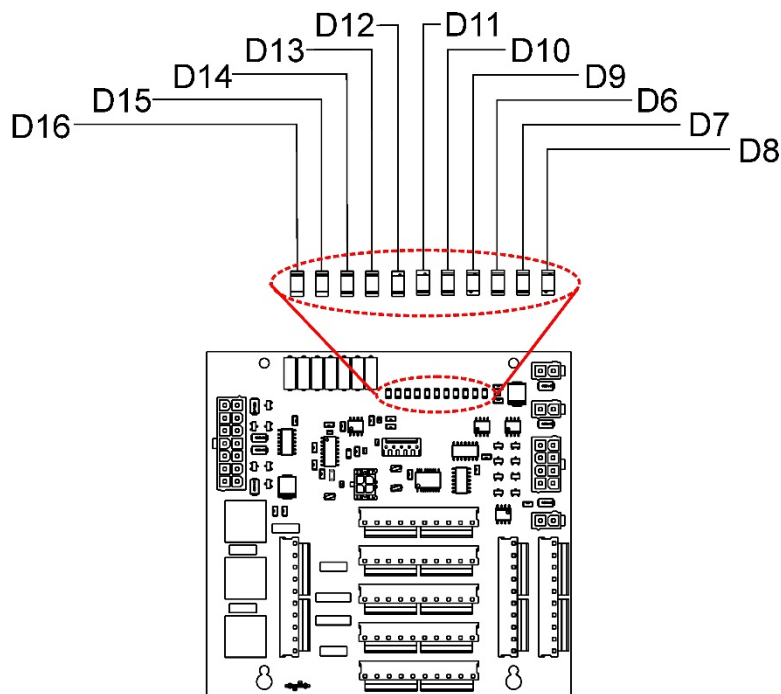


Figure 9-6. Status LED Locations – Power Distribution Board

Table 9-1. Power Distribution Board Status LEDs

| LED | DESCRIPTION | FUNCTION |
|-------------------|---|---|
| D1 | Watchdog Circuit; I ² C bus operation. | Blinks when I ² C bus is operating properly |
| D2-5 | SPARE | |
| D7 ¹ | Photometer Meas/Ref Valve | When lit, the valve opens the REFERENCE gas path |
| D8 ² | O ₃ Generator Valve status | When lit, the valve open to O ₃ generator gas path |
| D9 | Photometer Pump status | When lit, the pump is turned on. |
| D6 ^{1,2} | GPT Valve status | When lit, the valve opens the GPT Chamber |
| D13 | Diluent Gas Valve status | When lit, the valve is open. |
| D10 | Cal Gas Valve status | When lit, the valve is open. |
| D11 - 14 | SPARE | |
| D15 ¹ | Photometer Heater Status | When lit, the photometer UV lamp heater is on |
| D16 ² | O ₃ Generator Heater Status | When lit, the O ₃ generator UV lamp heater is on |

¹ On T750, only applies when photometer option installed.

² On T750, only applies when O₃ generator option installed.

9.4.3.4. Watchdog Indicator (D1)

The most important of the status LEDs on the power distribution board/Relay board is the red I²C Bus watchdog LED. It is controlled directly by the calibrator's CPU over the I²C bus. Special circuitry on the power distribution board watches the status of D1. Should this LED ever stay ON or OFF for 30 seconds (indicating that the CPU or I²C bus has stopped functioning) this Watchdog Circuit automatically shuts all valves and turns off all heaters and lamps.

9.4.4. MOTHERBOARD

This is the largest electronic assembly in the calibrator and is mounted to the communications and output panel as the base for the CPU board and all I/O connectors. This printed circuit assembly provides a multitude of functions including A/D conversion, digital input/output, PC-104 to I²C translation, temperature sensor signal processing and is a pass through for the RS-232 and RS-485 signals.

9.4.5. POWER SUPPLY AND CIRCUIT BREAKER

The calibrator operates in two main AC power ranges as presented in the specifications table. A 5-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 calibrator.

Note

The calibrator is equipped with a universal power supply that allows it to accept any AC power configuration, within the limits listed in the specifications table.

WARNING – Electrical Shock Hazard



Should the AC power circuit breaker trip, investigate and correct the condition causing this situation before powering on the calibrator again.

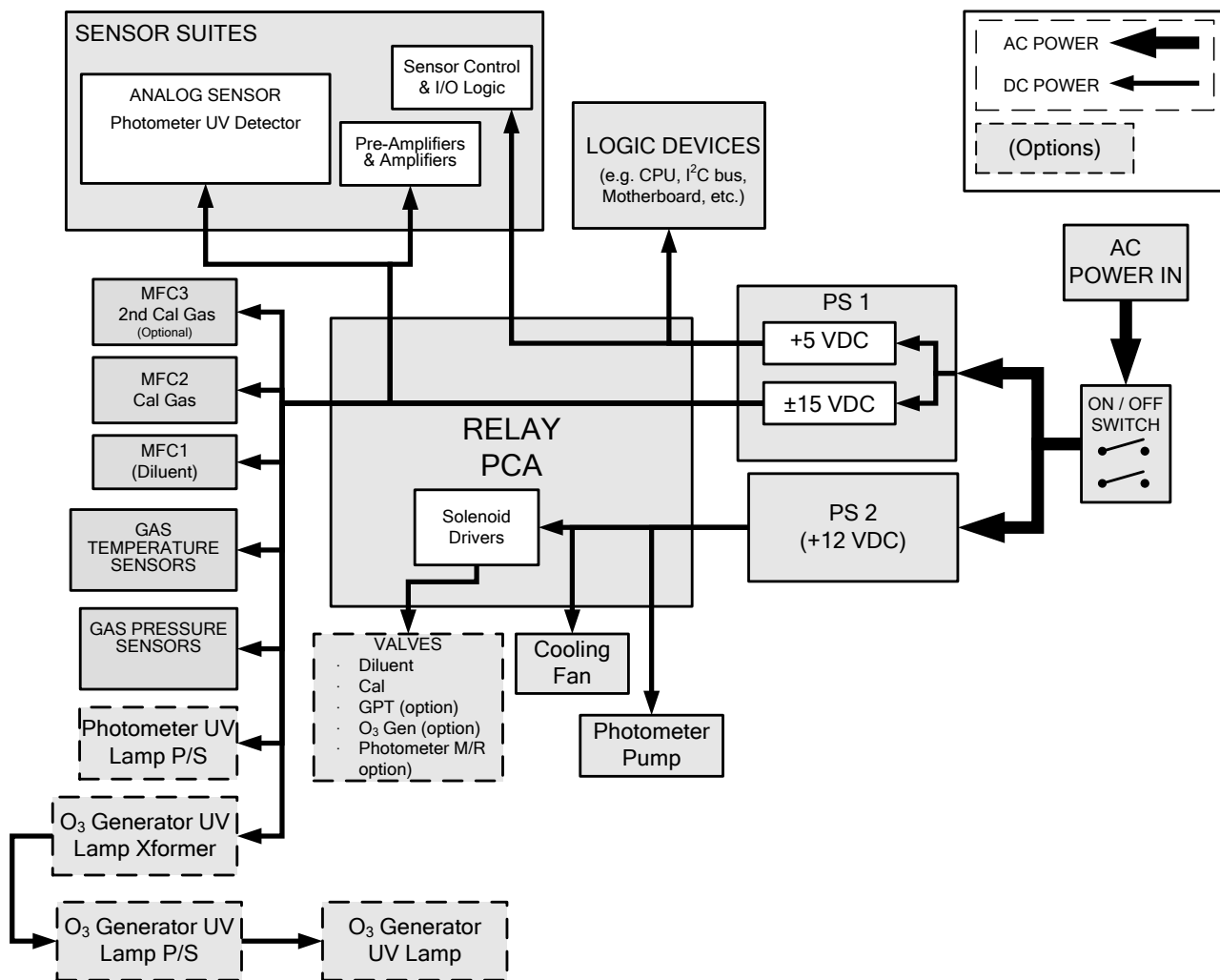


Figure 9-7. Power Distribution Block diagram

9.5. INPUT AND CONTROL PANEL TOUCHSCREEN/DISPLAY INTERFACE

The most commonly used method for communicating with the T753U Portable Calibrator is via the instrument's Input and Control Panel LCD 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.

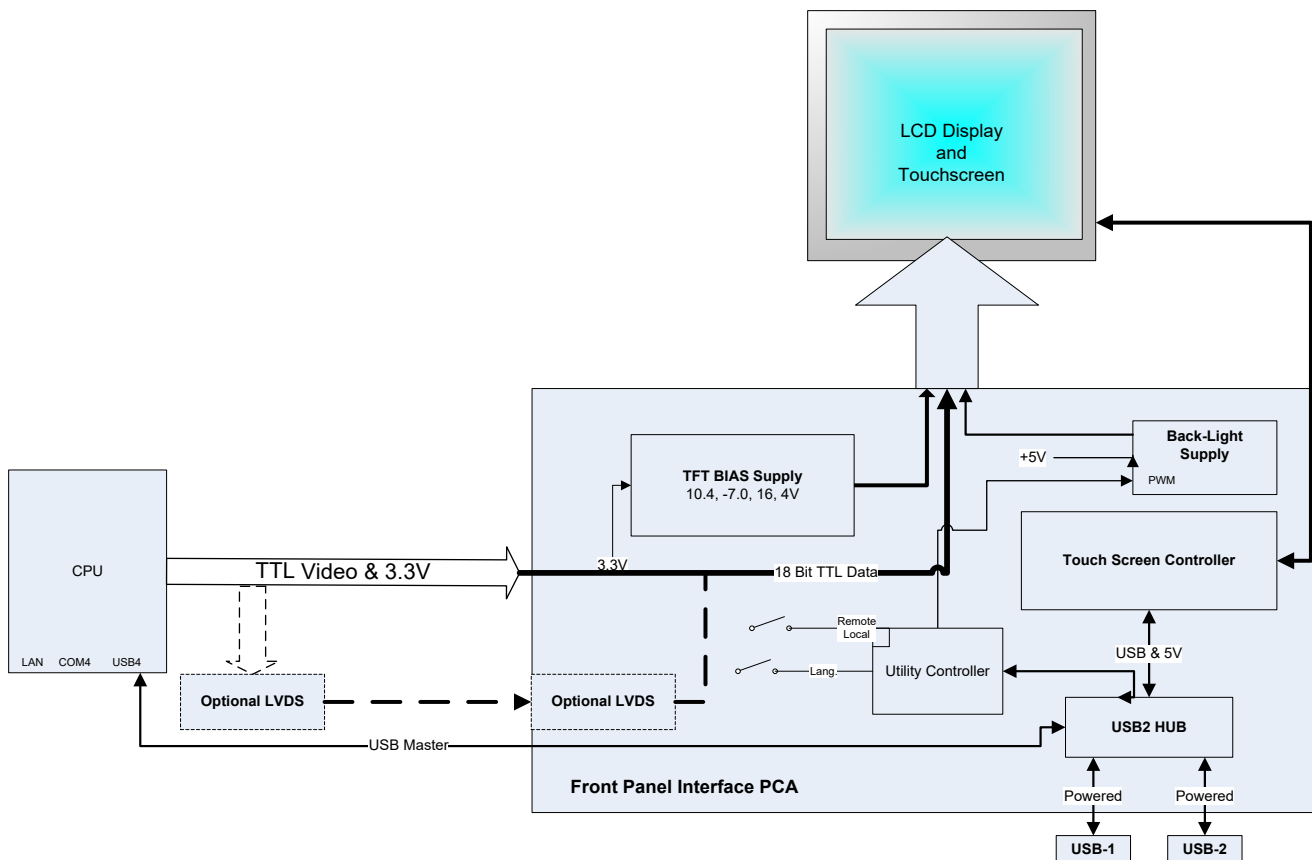


Figure 9-8. Input and Control Panel Layout

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.

9.5.1. INPUT AND CONTROL PANEL INTERFACE PCA

The Input and Control Panel interface PCA controls the various functions of the display and touchscreen, and 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 that is used for communications with the touchscreen controller and the two Input and Control Panel USB device ports
- circuitry for powering the display backlight

9.6. SOFTWARE OPERATION

The calibrator's core module is a high performance, Vortex 86SX-based microcomputer running Windows CE. Inside Windows CE, special software developed by Teledyne API interprets user commands from the various interfaces, performs procedures and tasks, stores data in the CPU's various memory devices, and calculates the concentration of the gas being sampled.

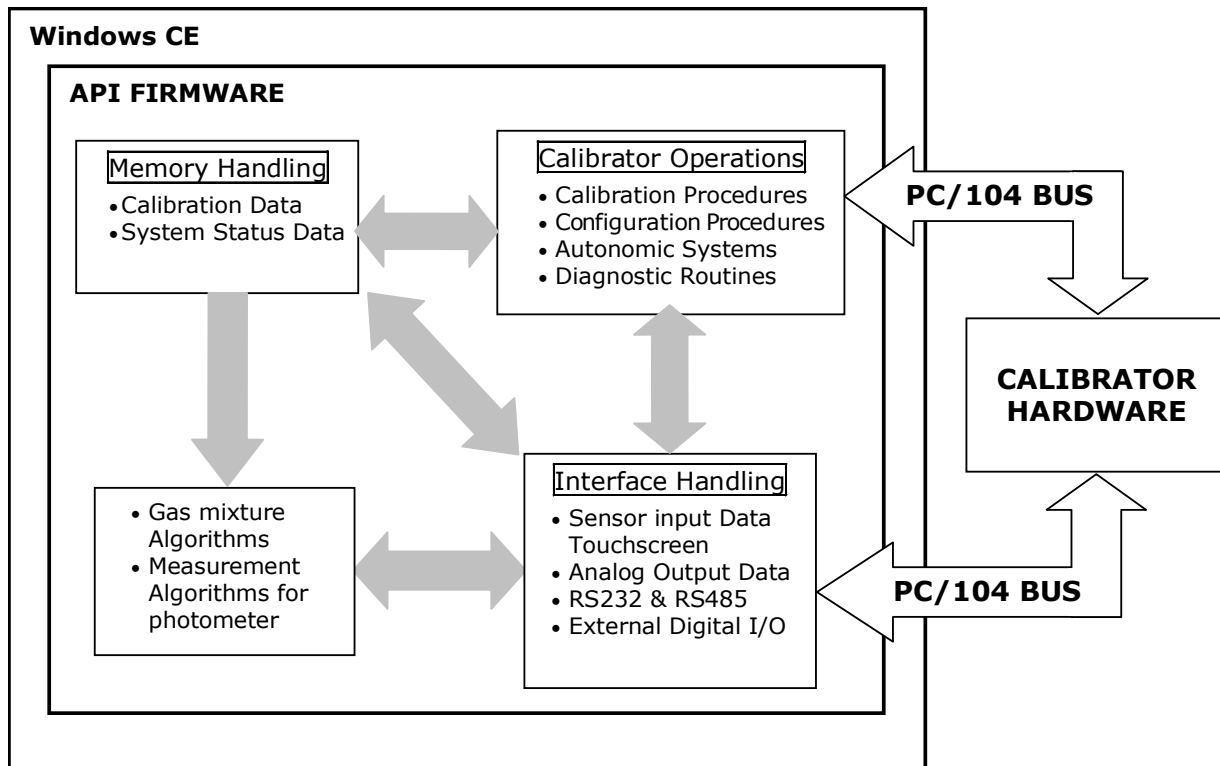


Figure 9-9. Schematic of Basic Software Operation

9.7. O₃ GENERATOR OPERATION

9.7.1. PRINCIPLE OF PHOTOLYTIC O₃ GENERATION

Ozone is a naturally occurring substance made up of three atoms of oxygen (O₃). Because of its relatively short half-life, ozone cannot be bottled and stored for later use and therefore must always be generated on-site by an ozone generator. The two main principles of ozone generation are Ultraviolet (UV) light and corona discharge. While the corona-discharge method is most common because of its ability to generate very high concentrations (up to 50%), the UV-light method is most feasible in calibration applications where low, accurate concentrations of ozone are desired. The UV-light method mimics the radiation method that occurs naturally from the sun in the upper atmosphere producing the ozone layer. A UV lamp inside the generator emits a precise wavelength of UV light (185 nm). Ambient air is passed over the UV lamp, which splits some of the molecular oxygen (O₂) in the gas into separate atoms which attach to other existing O₂ molecules, thus forming ozone (O₃).

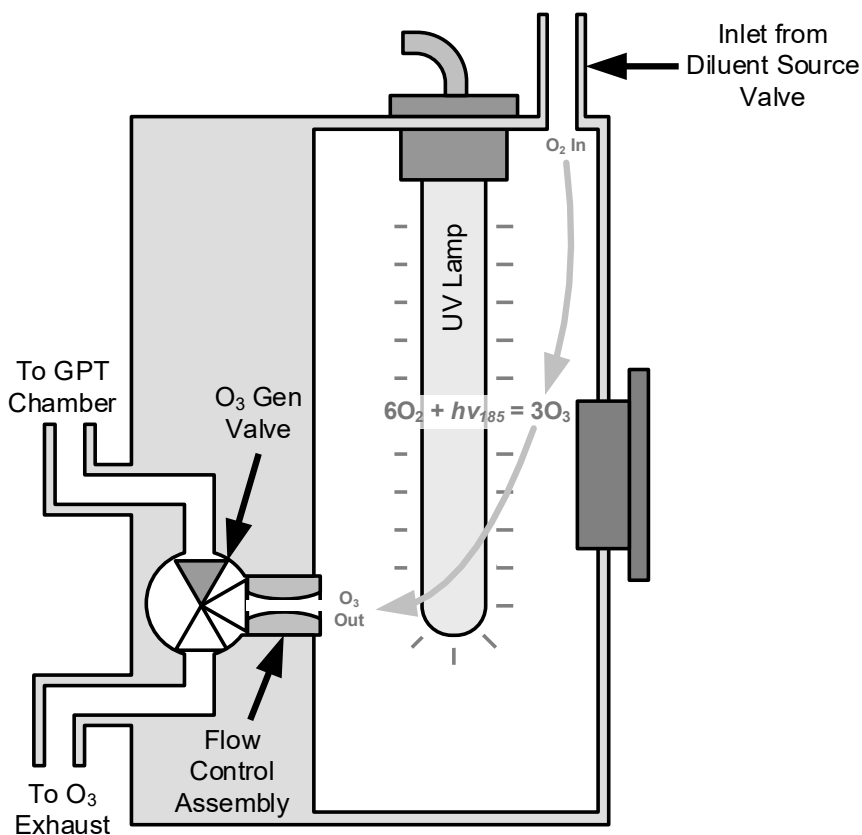


Figure 9-10. O₃ Generator Internal Pneumatics



9.7.2. O₃ GENERATOR PNEUMATIC OPERATION

Pneumatic flow through the O₃ generator is created by supplying zero air (diluent) to it under pressure. The zero air source must be capable of maintaining a continuous flow rate of at least 100 cm³/min unless the photometer (option in the T750) is also installed, in which case the minimum continuous flow rate must be at least 1.1 SLPM.

Input and output gas flow is directed by two valves, both of which must be open:

- The diluent inlet valve: This valve is located on the display/control and input panel and allows diluent / zero air into the calibrator.
- The O₃ generation valve: This valve is located on the body of the O₃ generator downstream from the generator chamber itself and directs the output of the generator to either the GPT mixing chamber or the EXHAUST port of the calibrator.

The rate of flow through the O₃ generator is controlled by a 100 cm³/min flow control assembly positioned between the O₃ generation chamber and the O₃ generation valve. A self-adjusting pressure regulator on the zero air (diluent) supply gas line maintains the pressure across the critical flow orifice of the flow control assembly

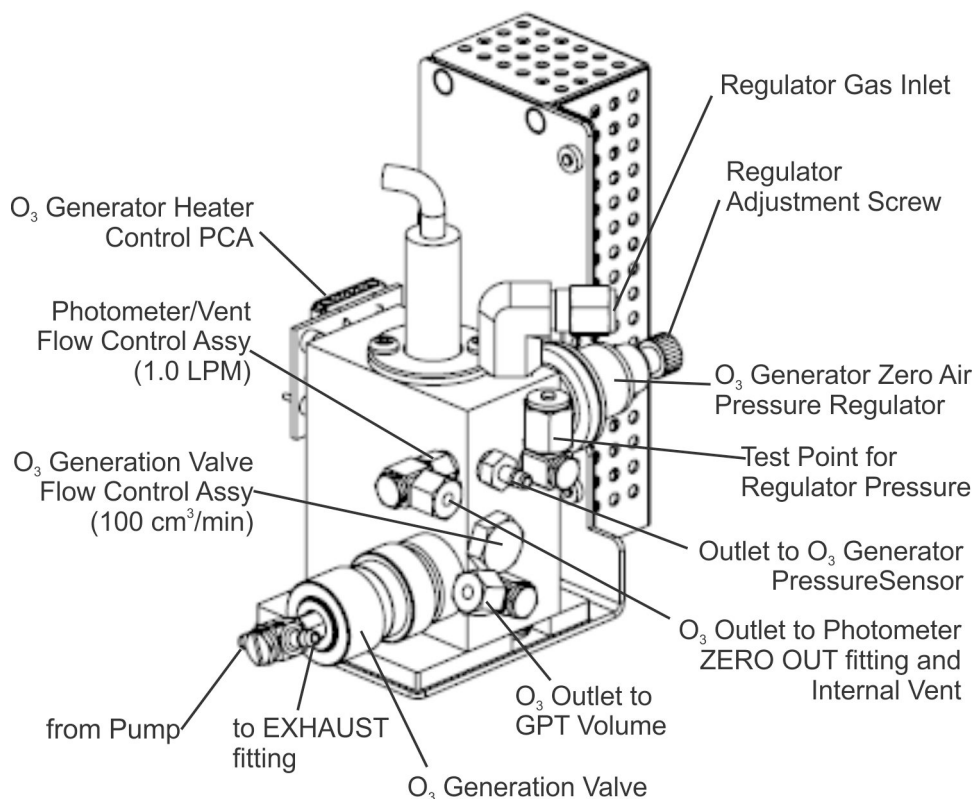


Figure 9-11. O₃ Generator Valve and Gas Fixture Locations

9.7.3. O₃ GENERATOR ELECTRONIC OPERATION

Electronically the O₃ generator and its subcomponents act as peripheral devices operated by the CPU via the motherboard. Sensor signals, such as from the UV lamp thermistor, are routed to the motherboard where they are digitized. Digital data are sent by the motherboard to the calibrator's CPU and, where required, are stored in either flash memory or on the CPU's Disk-on-Module. Commands from the CPU are sent to the motherboard and forwarded to the various devices via the calibrator's I²C bus.

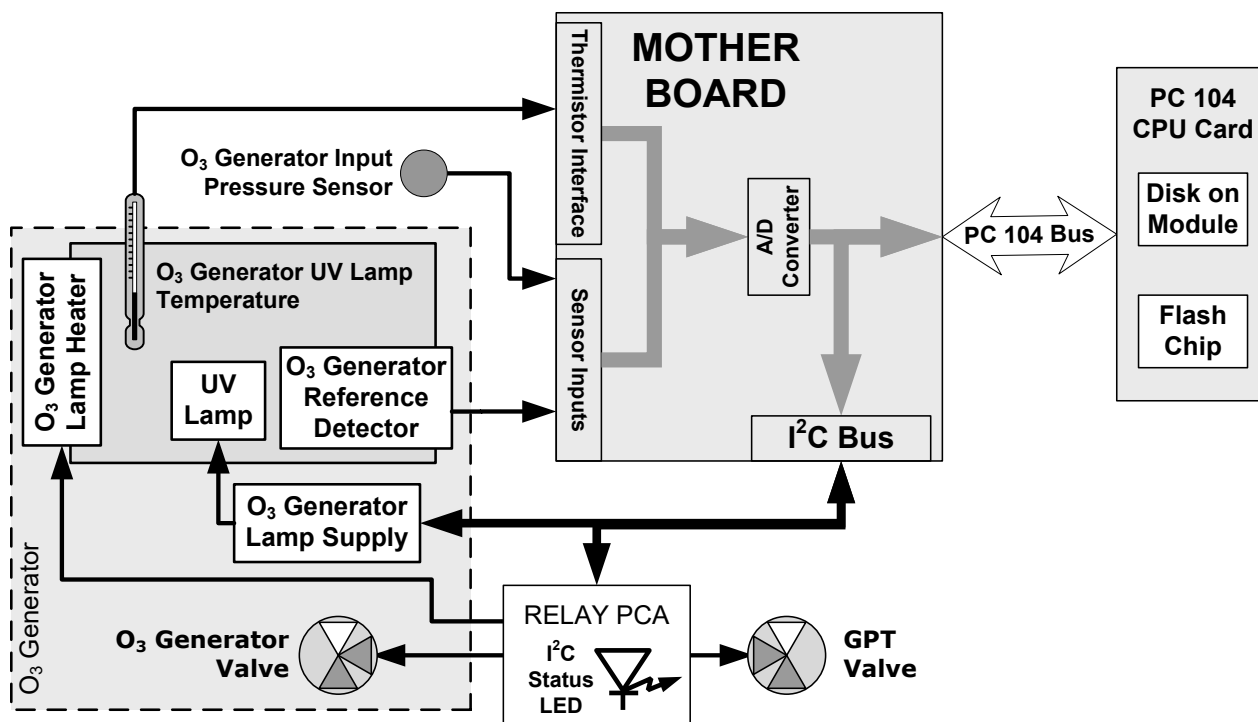


Figure 9-12. O₃ Generator Electronic Block Diagram

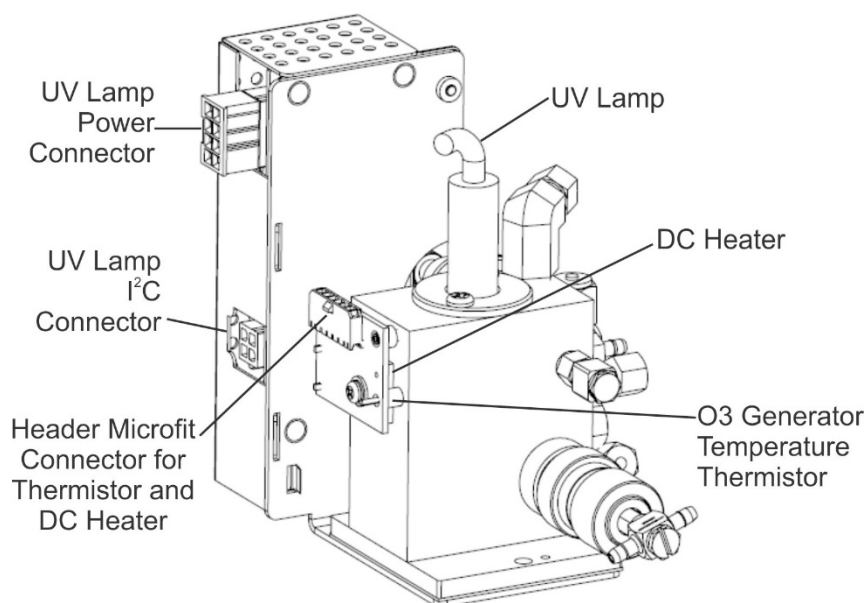


Figure 9-13. O₃ Generator Electronic Components Location

9.7.3.1. O₃ Generator Temperature Control

In order to operate at peak efficiency the UV lamp of the O₃ generator is maintained at a constant 48°C. If the lamp temperature falls below 43°C or rises above 53°C, an Alert is issued by the CPU.

This temperature is controlled as described in section 9.4.3.2. The location of the thermistor and heater associated with the O₃ generator is shown below:

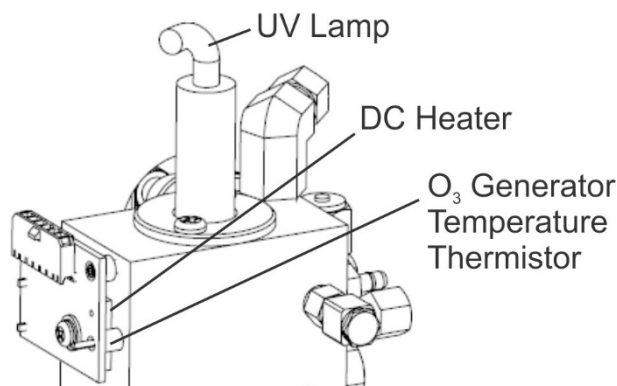


Figure 9-14. O₃ Generator Temperature Thermistor and DC Heater Locations

9.7.3.2. O₃ Generator Pneumatic Sensor

A pressure sensor, located on the O₃ generator and photometer, pressure/flow sensor PCA, monitors the output gas pressure of the regulator on the O₃ generator's zero air supply. The regulator is adjusted at the factory to maintain a pressure of 20 PSIG on this line. If the pressure drops below 15 PSIG or rises above 25 PSIG, an Alert is issued.

9.8. PHOTOMETER OPERATION

The calibrator's photometer determines the concentration of Ozone (O₃) in a sample gas drawn through it. Sample and calibration gases must be supplied at ambient atmospheric pressure in order to establish a stable gas flow through the absorption tube where the gas' ability to absorb ultraviolet (UV) radiation of a certain wavelength (in this case 254 nm) is measured.

Gas bearing O₃ and zero air are alternately routed through the photometer's absorption tube. Measurements of the UV light passing through the sample gas with and without O₃ present are made and recorded.

Calibration of the photometer is performed in software and does not require physical adjustments. During calibration, the CPU's microprocessor measures the current state of the UV Sensor output and various other physical parameters of the calibrator and stores them in memory. The CPU uses these calibration values, the UV absorption measurements made on the sample gas in the absorption tube, and data regarding the current temperature and pressure of the gas to calculate a final O₃ concentration.



9.8.1. MEASUREMENT METHOD

9.8.1.1. Calculating O₃ Concentration

The basic principle by which photometer works is called Beer's Law (also referred to as the Beer-Lambert equation). It defines the how light of a specific wavelength is absorbed by a particular gas molecule over a certain distance at a given temperature and pressure. The mathematical relationship between these three parameters for gasses at Standard Temperature and Pressure (STP) is:

Equation 9-5

$$I = I_0 e^{-\alpha LC} \quad \text{at STP}$$

Where:

***I*₀** is the intensity of the light if there was no absorption.

I is the intensity with absorption.

L is the absorption path, or the distance the light travels as it is being absorbed.

C is the concentration of the absorbing gas. In the case of the Model T753U, Ozone (O₃).

α is the absorption coefficient that tells how well O₃ absorbs light at the specific wavelength of interest.

To solve this equation for ***C***, the concentration of the absorbing Gas (in this case O₃), the application of a little algebra is required to rearrange the equation as follows:

Equation 9-6

$$C = \ln \frac{I_0}{I} \times \frac{1}{\alpha L} \quad \text{at STP}$$

Unfortunately, both ambient temperature and pressure influence the density of the sample gas and therefore the number of ozone molecules present in the absorption tube thus changing the amount of light absorbed.

In order to account for this effect the following addition is made to the equation:

Equation 9-7

$$C = \ln \frac{I_0}{I} \times \frac{1}{\alpha L} \times \frac{T}{273^\circ K} \times \frac{29.92 \text{ inHg}}{P}$$

Where:

T = sample ambient temperature in degrees Kelvin

P = ambient pressure in inches of mercury

Finally, to convert the result into Parts per Billion (PPB), the following change is made:

Equation 9-8

$$C = \ln \frac{I_o}{I} \times \frac{10^9}{\alpha L} \times \frac{T}{273^\circ K} \times \frac{29.92 \text{ inHg}}{P}$$

In summary, the photometer:

- Measures each of the above variables: ambient temperature; ambient gas pressure; the intensity of the UV light beam with and without O₃ present;
- Inserts known values for the length of the absorption path and the absorption coefficient, and:
- Calculates the concentration of O₃ present in the sample gas.

9.8.1.2. The Measurement / Reference Cycle

In order to solve the Beer-Lambert equation it is necessary to know the intensity of the light passing through the absorption path both when O₃ is present and when it is not. A valve called the measure/reference valve (see Figure 2-4 for the location) and alternates the gas stream flowing to the photometer between zero air (diluent gas) and the O₃ output from the O₃ generator (see Figure 9-15 and Figure 9-16. This cycle takes about 6 seconds.

Table 9-2. Photometer Measurement / Reference Cycle

| TIME INDEX | STATUS |
|-------------------------------------|--|
| 0 sec. | Measure/Reference Valve Opens to the Measure Path. |
| 0 – 2 sec. | Wait Period. Ensures that the Absorption tube has been adequately flushed of any previously present gasses. |
| 2 – 3 sec. | Analyzer measures the average UV light intensity of O ₃ bearing Sample Gas (I) during this period. |
| 3 sec. | Measure/Reference Valve Opens to the Reference Path. |
| 3 – 5 sec. | Wait Period. Ensures that the Absorption tube has been adequately flushed of O ₃ bearing gas. |
| 5 – 6 sec. | Analyzer measures the average UV light intensity of Non-O ₃ bearing Sample Gas (I_o) during this period. |
| CYCLE REPEAT EVERY 6 SECONDS | |

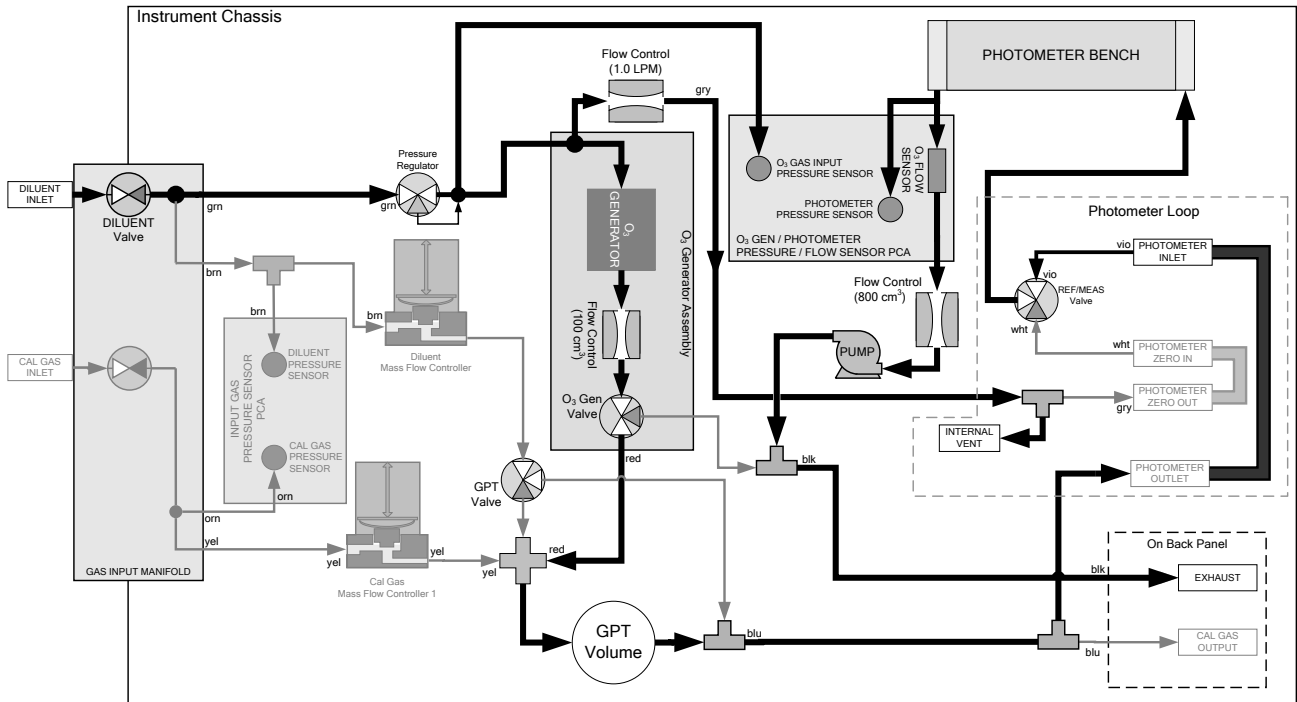


Figure 9-15. O₃ Photometer Gas Flow – Measure Cycle

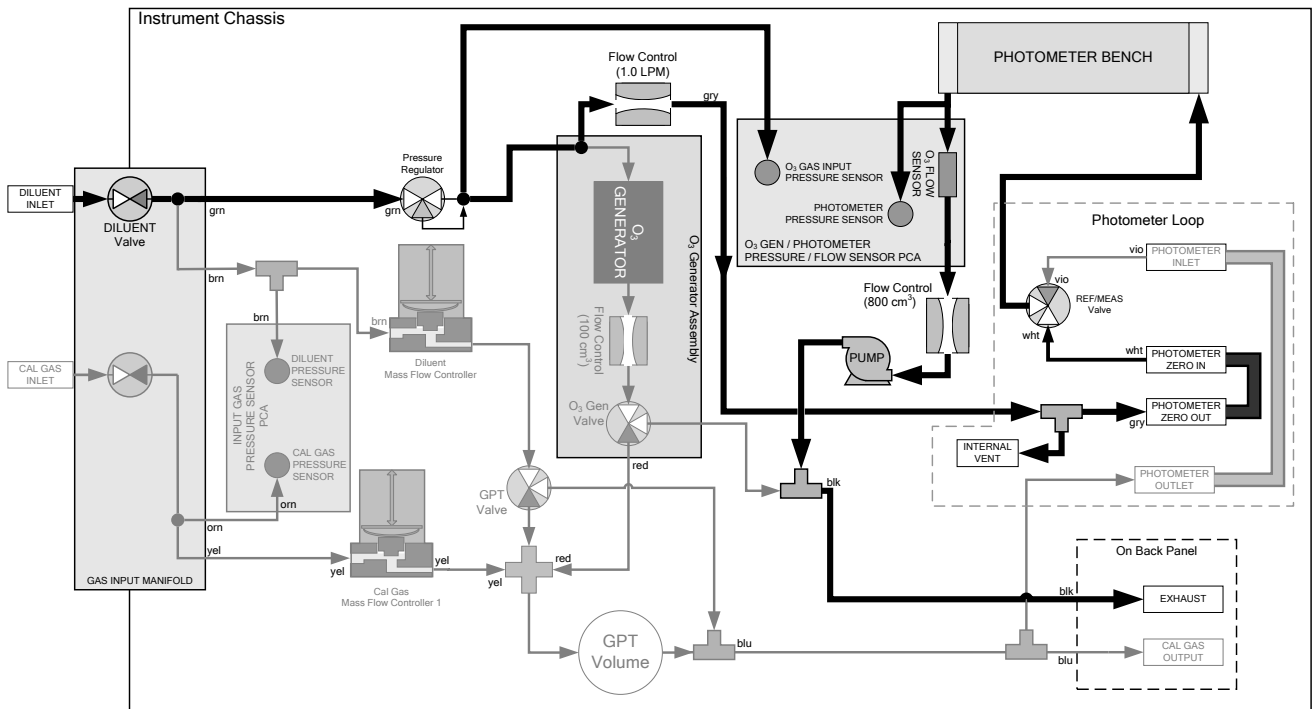


Figure 9-16. O₃ Photometer Gas Flow – Reference Cycle

9.8.1.3. The Absorption Path

In the most basic terms, the photometer uses a high energy, mercury vapor lamp to generate a beam of UV light. This beam passes through a window of material specifically chosen to be both non-reactive to O₃ and transparent to UV radiation at 254nm and into an absorption tube filled with sample gas.

Because ozone is a very efficient absorber of UV radiation the absorption path length required to create a measurable decrease in UV intensity is short enough (approximately 42 cm) that the light beam is only required to make one pass through the Absorption Tube. Therefore, no complex mirror system is needed to lengthen the effective path by bouncing the beam back and forth.

Finally, the UV passes through a similar window at the other end of the absorption tube and is detected by a specially designed vacuum diode that only detects radiation at or very near a wavelength of 254nm. The specificity of the detector is high enough that no extra optical filtering of the UV light is needed.

The detector reacts to the UV light and outputs a current signal that varies in direct relationship with the intensity of the light shining on it. This current signal is amplified and converted to a 0 to 5 VDC voltage analog signal sent to the instrument's motherboard where it is digitized. The CPU uses this digital data in computing the concentration of O₃ in the absorption tube.

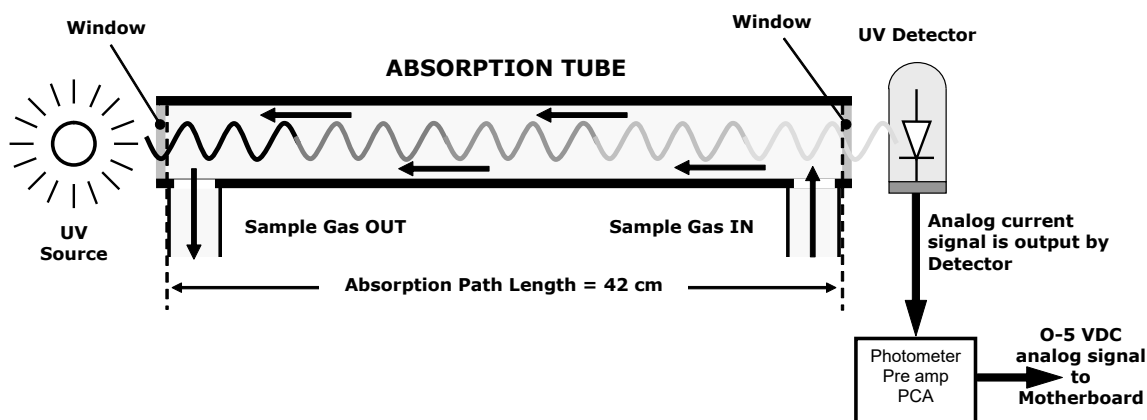


Figure 9-17. O₃ Photometer Absorption Path

9.8.1.4. Interferent Rejection

It should be noted that the UV absorption method for detecting ozone is subject to interference from a number of sources. The photometer has been successfully tested for its ability to reject interference from sulfur dioxide, nitrogen dioxide, nitric oxide, water, and meta-xylene.

While the photometer rejects interference from the aromatic hydrocarbon meta-xylene, it should be noted that there are a very large number of other volatile aromatic hydrocarbons that could potentially interfere with ozone detection. If the calibrator is installed in an environment where high aromatic hydrocarbon concentrations are suspected, specific tests should be conducted to reveal the amount of interference these compounds may be causing.

9.8.2. PHOTOMETER LAYOUT

The Photometer is where the absorption of UV light by ozone is measured and converted into a voltage. It consists of several sub-assemblies:

- A mercury-vapor UV lamp. This lamp is coated in a material that optically screens the UV radiation output to remove the O_3 producing 185nm radiation. Only light at 254nm is emitted.
- An AC power supply that supplies the current for starting and maintaining the plasma arc of the mercury vapor lamp.
- A thermistor and DC heater attached to the UV Lamp to maintain the Lamp at an optimum operating temperature.
- 42 cm long quartz absorption tube.
- A thermistor attached to the quartz tube for measuring sample gas temperature.
- Gas inlet and outlet mounting blocks that rout sample gas into and out of the photometer.
- The vacuum diode, UV detector that converts UV light to a DC current.
- A preamplifier assembly, which converts the detector's current output into a DC Voltage then amplifies it to a level readable by the A to D converter circuitry of the instrument's motherboard.

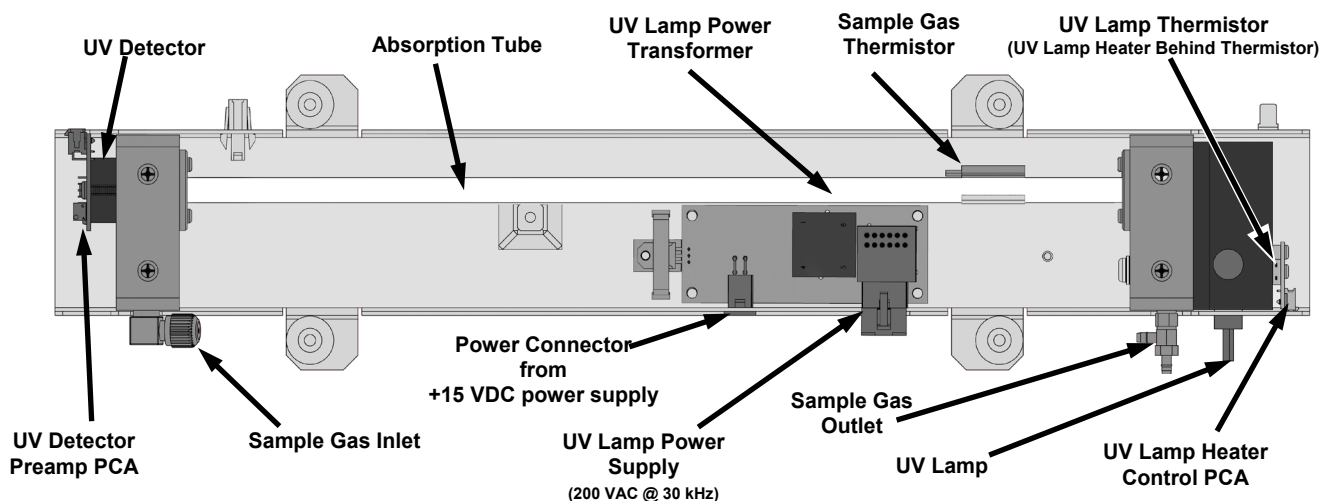


Figure 9-18. O_3 Photometer Layout – Top Cover Removed

9.8.3. PHOTOMETER PNEUMATIC OPERATION

The flow of gas through the photometer is created by an internal pump that pulls air through the instrument. There are several advantages to this “pull through” configuration. Placing the pump downstream from the absorption tube avoids problems caused by the pumping process heating and compressing the sample.

In order to measure accurately the presences of low concentrations of O_3 in the sample air it is necessary to establish and maintain a relatively constant and stable volumetric flow of sample gas through the photometer. The simplest way to accomplish this is by placing a

flow control assembly containing a critical flow orifice directly upstream of the pump but downstream from the absorption tube.

The critical flow orifice installed in the pump supply line is tuned to create a gas flow of 800 cm³/min. A pressure sensor and a flow sensor, located on the O₃ generator / photometer pressure flow sensor PCA, monitor the pressure and flow rate of the gas passing through the photometers absorption tube.

See Figure 9-17 for depictions of the gas flow related to the photometer.

9.8.4. PHOTOMETER ELECTRONIC OPERATION

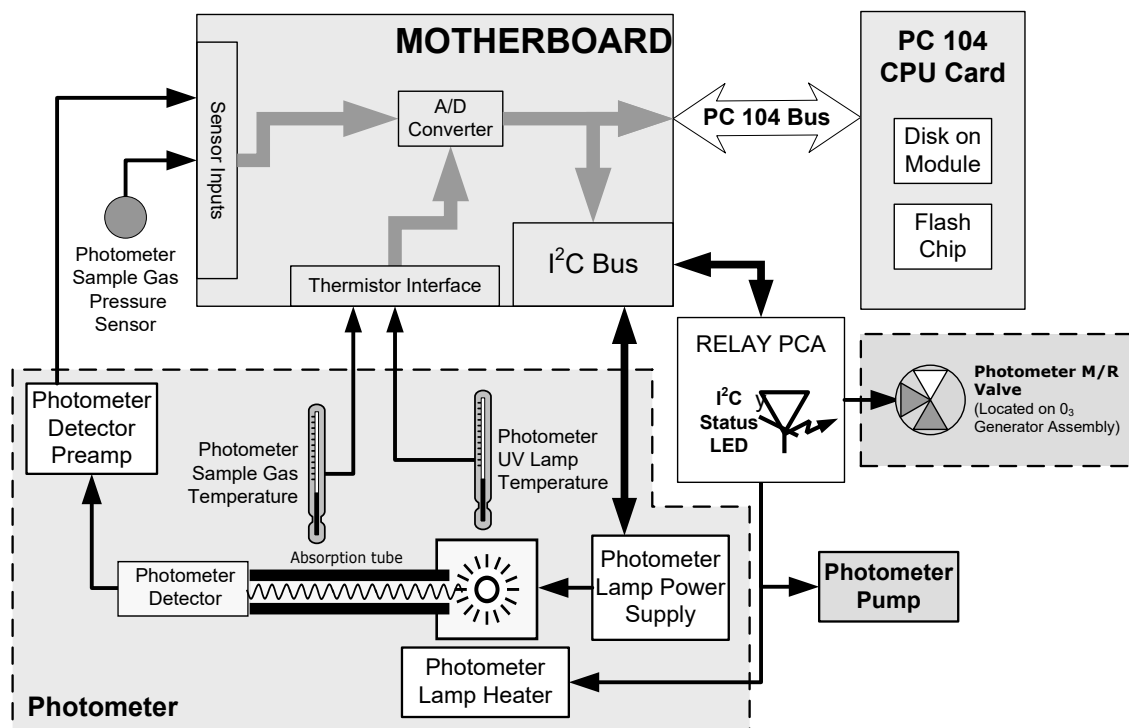


Figure 9-19. O₃ Photometer Electronic Block Diagram

Like the O₃ generator, the O₃ photometer and its subcomponents act as peripheral devices operated by the CPU via the motherboard. Communications to and from the CPU are handled by the motherboard.

Outgoing commands for the various devices such as the photometer pump, the UV lamp power supply the UV Lamp heater are issued via the I²C bus to circuitry on the power distribution board which turns them ON/OFF. The CPU also issues commands over the I²C bus that cause the power distribution board to cycle the measure/reference valve back and forth.

Incoming data from the UV light detector is amplified locally then converted to digital information by the motherboard. Output from the photometer's temperature sensors is also amplified and converted to digital data by the motherboard. The O₃ concentration of the sample gas is computed by the CPU using this data along with gas pressure and flow data received from the pressure sensors.



9.8.4.1. O₃ Photometer Temperature Control

In order to operate at peak efficiency, the UV lamp of the O₃ photometer is maintained at a constant 58°C. This is intentionally set at a temperature higher than the ambient temperature of the operating environment to make sure that local changes in temperature do not affect the UV Lamp. If the lamp temperature falls below 56°C or rises above 61°C anAlert is issued by the calibrator's CPU.

This temperature is controlled as described in the section on the power distribution board (Section 9.4.3.2).

The Photo Lamp Temp and the Photo Sample Temp, viewable in the Dashboard display when configured to show them, report the UV lamp temperature and the Sample gas in the absorption tube, respectively, in °C.

9.8.4.2. Pneumatic Sensors for the O₃ Photometer

The sensors located on the pneumatic sensor just to the left rear of the O₃ generator assembly measure the absolute pressure and the flow rate of gas inside the photometer's absorption tube. This information is used by the CPU to calculate the O₃ concentration of the sample gas. Both of these measurements are made downstream from the absorption tube but upstream of the pump. A critical flow orifice located between the flow sensor and the pump maintains the gas flow through the photometer at 800 cm³/min.

Viewable in the Dashboard display when configured to show them, the Photo Flow shows the flow rate of gas through the photometer, measured in SLPM, and Photo Sample Press shows the pressure of the gas inside the absorption in inches of mercury absolute (in-Hg-A), which is referenced to a vacuum (zero absolute pressure), and is not the same as PSIG.

GLOSSARY

Some terms in this glossary may not occur elsewhere in this manual.

| 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) |
| 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 light energy that is actually converted into electricity |
| CEM | <i>Continuous Emission Monitoring</i> |
| Chemical formulas that may be included in this document: | |
| CO ₂ | carbon dioxide |
| C ₃ H ₈ | propane |
| CH ₄ | methane |
| H ₂ O | water vapor |
| HC | general abbreviation for hydrocarbon |
| HNO ₃ | nitric acid |
| H ₂ S | hydrogen sulfide |
| NO | nitric oxide |
| NO ₂ | nitrogen dioxide |
| NO _x | nitrogen oxides, here defined as the sum of NO and NO ₂ |
| NO _y | nitrogen oxides, often called odd nitrogen: the sum of NO _x plus other compounds such as HNO ₃ (definitions vary widely and may include nitrate (NO ₃), PAN, N ₂ O and other compounds as well) |
| NH ₃ | ammonia |
| O ₂ | molecular oxygen |
| O ₃ | ozone |
| SO ₂ | sulfur dioxide |
| cm ³ | metric abbreviation for <i>cubic centimeter</i> (replaces the obsolete abbreviation "cc") |
| CPU | <i>Central Processing Unit</i> |
| DAC | <i>Digital-to-Analog Converter</i> |
| DAS | <i>Data Acquisition System</i> |
| DCE | <i>Data Communication Equipment</i> |
| DFU | <i>Dry 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 |
| DIAG | <i>Diagnostics</i> , the diagnostic settings of the instrument. |



T750, T750U

| TERM | DESCRIPTION/DEFINITION |
|----------------------|--|
| 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> |
| 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> ® |
| 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 ² C bus | a clocked, bi-directional, serial bus for communication between individual instrument 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> |
| M/R | <i>Measure/Reference</i> |
| MOLAR MASS | 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. 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. Atomic weights can be found on any Periodic Table of Elements. |
| NDIR | <i>Non-Dispersive Infrared</i> |
| NIST-SRM | <i>National Institute of Standards and Technology - Standard Reference Material</i> |
| PC | <i>Personal Computer</i> |
| PCA | <i>Printed Circuit Assembly</i> , the PCB with electronic components, ready to use |
| PC/AT | <i>Personal Computer / Advanced Technology</i> |
| PCB | <i>Printed Circuit Board</i> , the bare board without electronic component |
| PFA | <i>Per-Fluoro-Alkoxy</i> , an inert polymer; one of the polymers that <i>Du Pont</i> markets as <i>Teflon</i> ® |
| PLC | <i>Programmable Logic Controller</i> , a device that is used to control instruments based on a logic level signal coming from the instrument |



T750, T750U

| TERM | DESCRIPTION/DEFINITION |
|-------------|---|
| PLD | <i>Programmable Logic Device</i> |
| PLL | <i>Phase Lock Loop</i> |
| PMT | <i>Photo Multiplier Tube</i> , a vacuum tube of electrodes that multiply electrons collected and charged to create a detectable current signal |
| P/N (or PN) | <i>Part Number</i> |
| PSD | <i>Prevention of Significant Deterioration</i> |
| PTFE | <i>Poly-Tetra-Fluoro-Ethylene</i> , a very inert polymer material used to handle gases that may react on other surfaces; one of the polymers that <i>Du Pont</i> markets as <i>Teflon</i> ® |
| PVC | <i>Poly Vinyl Chloride</i> , a polymer used for downstream tubing |
| Rdg | Reading |
| RS-232 | specification and standard describing a serial communication method between DTE (Data Terminal Equipment) and DCE (Data Circuit-terminating Equipment) devices, using a maximum cable-length of 50 feet |
| RS-485 | specification and standard describing a binary serial communication method among multiple devices at a data rate faster than RS-232 with a much longer distance between the host and the furthest device |
| SAROAD | <i>Storage and Retrieval of Aerometric Data</i> |
| SLAMS | <i>State and Local Air Monitoring Network Plan</i> |
| SLPM | <i>Standard Liters Per Minute</i> of a gas at standard temperature and pressure |
| STP | <i>Standard Temperature and Pressure</i> |
| TCP/IP | <i>Transfer Control Protocol / Internet Protocol</i> , the standard communications protocol for Ethernet devices |
| TEC | <i>Thermal Electric Cooler</i> |
| TPC | <i>Temperature/Pressure Compensation</i> |
| USB | <i>Universal Serial Bus</i> : a standard connection method to establish communication between peripheral devices and a host controller, such as a mouse and/or keyboard and a personal computer or laptop |
| VARS | <i>Variables</i> , the variable settings of the instrument |
| V-F | <i>Voltage-to-Frequency</i> |
| Z/S | <i>Zero / Span</i> |

