CALIFORNIA
AIR RESOURCES BOARD

STANDARD OPERATING PROCEDURES FOR TELEDYNE ADVANCE POLLUTION INSTRUMENTS MODEL T703U PHOTOMETRIC OZONE CALIBRATOR

AQSB SOP 707

First Edition

MONITORING AND LABORATORY DIVISION

April 2022

CALIFORNIA AIR RESOURCES BOARD

Approval of Standard Operating Procedures

Title:	Teledyne Advanced Pollution Instruments (TAPI) Model T703U Photometric Ozone Calibrator
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Edition	Release Data	Changes
First	April 2022	New Document

LIST OF ACRONYMS.

AMNS - Air Monitoring North Section
AMSS - Air Monitoring North Section
APICOM - Interface utility by TAPI to access internal instrument data
AQSB - Air Quality Surveillance Branch
CARB - California Air Resources Board
CFR - Code of Federal Regulations
CPU - Central Processing Unit
DAS - Data Acquisition System
DMS - Data Management System
DFU - Dry Filter Unit
FEM - Federal Equivalent Method
FRM - Federal Reference Method
GPT - Gas Phase Titration
iDAS - Internal Data Acquisition System (TAPI), previously referred to as DAS
LPM - Liters per Minute
MFC - Mass Flow Controller
MFM - Mass Flow Meter
MLD - Monitoring and Laboratory Division
NLB - Northern Laboratory Branch
ODSS - Operations and Data Support Section
NIST - National Institute of Standards and Technology
NO - Nitric oxide
NO_X - Nitrogen oxides, used here as the sum of NO and NO_2
NO_2 - Nitrogen dioxide
O3 – Ozone
PMT - Photo Multiplier Tube
ppb - parts per billion
ppm – parts per million
PQAO - Primary Quality Assurance Organization.
PST – Pacific Standard Time
QA – Quality Assurance
QAS – Quality Assurance Section
QA/QC - Quality Control/Quality Assurance
QMB - Quality Management Branch
SLPM - Standard Liters per Minute, gas flow at standard temperature and pressure
SOP - Standard Operating Procedure.
TAPI - Teledyne Advanced Pollution Instrumentation
Thermo – Thermo Electron Scientific
U.S.EPA – United States Environmental Protection Agency
UV – Ultraviolet
LIST OF ACRONYMS Continued.
VARS – Teledyne Variable Menu Option

1.0 GENERAL INFORMATION

1.1 Introduction:

This Standard Operating Procedure (SOP) describes procedures used by the California Air Resources Board (CARB) Air Quality Surveillance Branch (AQSB) to operate, maintain, and calibrate the Teledyne Advanced Pollution Instrument (TAPI) Model T703U Photometric Ozone (O_3) Calibrator (T703U). This SOP maybe applicable to the T703 model although this document focuses on the T703U operation. These procedures supplement the "Models T703 and T703U Photometric O_3 Calibrators with NumaView Software" manual (operating manual) by describing hardware and/or operating procedures as implemented by CARB for calibrating ambient air monitoring criteria gaseous samplers. The TAPI T703U manual contains a significant source of information pertinent to the operation, maintenance, and understanding of this instrument and therefore CARB highly recommends a thorough review of the manufacturer's operation manual.

1.2 Principle of Operation:

The Model T703U is a microprocessor-controlled ozone calibrator for calibration of precision ambient ozone instruments. The T703U features an internal ozone photometer that provides a very accurate closed loop feedback control of the ozone concentration. The T703U will generate ozone in the fractional mode for ultra-low ozone production.

As many as 50 independent calibration sequences may be programmed into the T703U, covering time periods of up to one year. The setup of sequences is simple and intuitive. These sequences 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 T703U is designed for fast response time, repeatability, overall accuracy, and ease of operation. The T703 can utilize the zero-air pump (purchase option), or it can be combined with an external zero air pump to provide precise ozone output levels.

Summarized features of the T703U include:

- Advanced T-Series electronics
- LCD Graphical User interface with capacitive touch screen
- Bi-directional RS-232 and 10/100Base-T Ethernet, optional USB and RS-485, ports for remote operation

- Front panel USB ports for peripheral devices
- 12 independent timers for sequences
- Nested sequences (up to 5 levels)
- Internal ozone generator and photometer allows use as primary or transfer standard
- UV Lamp Feedback modes
- Lightweight for transportability
- Produces low ozone levels down to 3ppb

For a complete description of all the options for the T703U refer to the T703U operator manual.

1.3 Photometer Operation:

The calibrator's photometer determines the concentration of O_3 in sample gas drawn through it. Sample and calibration gasses must be supplied at ambient atmospheric pressure in order to establish a stable gas flow through the absorption tube where the gas's ability to absorb the ultraviolet (UV) radiation of a certain wavelength (in this case 254 nm) is measured.

Gas bearing O_3 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 O_3 present are made and recorded.

Calibration of the photometer is performed in software and does not require physical adjustments. Two internal variables, a slope and offset, are used to adjust the calibration of the photometer.

The CPU uses these calibration values, the UV absorption measurements made on sample gas in the absorption tube, along with data regarding the current temperature and pressure of the gas to calculate a final O_3 concentration.

1.4 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 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:

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

I_0 = intensity of the light if there was no observation
I = intensity with absorption
L = absorption path or distance the light travels as it is being absorbed
C = concentration of the absorption gas - O3 in the case of the T703U
α = absorption coefficient for how well O3 absorbs light in the specific wavelength of interest

To solve this equation for C, the concentration of the absorption Gas (in this case O_3), the application of a little algebra is required to rearrange the equation as follows:

$$C = \ln\left(\frac{I_0}{I}\right) \times \left(\frac{I}{\alpha L}\right) \text{ at STP}$$

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

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

$$C = \ln\left(\frac{I_0}{I}\right) \times \left(\frac{I}{\alpha L}\right) \times \left(\frac{T}{273\text{ K}} \times \frac{29.92\text{ in Hg}}{P}\right) \text{ at STP}$$

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:

$$C = \ln\left(\frac{I_0}{I}\right) \times \left(\frac{10^9}{\alpha L}\right) \times \left(\frac{T}{273\text{ K}} \times \frac{29.92\text{ in Hg}}{P}\right) \text{ at STP}$$

The photometer:

- Measures each of the above variables: ambient temperature; ambient gas pressure; the intensity of the UV light beam with and without O_3 present.
- Inserts known values for the length of the absorption path and the absorption coefficient, and:
- Calculates the concentration of O_3 present in the sample gas.

1.5 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 O_3 is present and when it is not. A valve called the measure/reference (M/R) valve, physically located on front-left corner of the O_3 generator assembly (see figure) alternates the gas stream flowing to the photometer between zero air (diluent gas) and the O_3 output from the O_3 generator. This cycle takes about 6 seconds.

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_0**) during this period.
CYCLE REPEAT EVERY 6 SECONDS	

Table 1: Table of Measure/Reference Timing

Photolytic O_3 Generation:

The primary principles of O_3 generation are UV-light and corona discharge. The T703U calibrator utilizes the UV-light method to produce low concentrations of ozone. An ultra-violet lamp inside the generator emits a wavelength of UV Light (185 nm). Ambient air is passed over the lamp, splitting some of the air's molecular oxygen (O_2) into individual oxygen atoms (O) that attach to other remaining oxygen molecules (O_2), forming ozone (O_3).

Dry Air In (internal air source):

The typical CARB monitoring station T703U air source configuration will be utilizing the internal zero-air pump. If utilizing the internal T703U zero air system, a source of dry air is imperative and requires use of a desiccant cartridge. **Operating the T703U without a desiccant cartridge connected to the port labeled "Dry Air In" on the rear panel can cause permanent damage to the instrument**. This input air (station room air) should be at atmospheric pressure. The supplied air through the desiccant should have a dew point of –20 °C or less. TAPI supplies an optional desiccant cartridge that can be used to supply dry air to the T703U.

Zero Air In (external air source):

The T703U can also be configured to operate utilizing an external air source such as a TAPI model 751 zero air generator. The external air source must deliver pressurized, dry air directly to the T703U. The external air source is directly connected to the "Zero Air" port located on the rear panel. This is the standard configuration when a zero-air pump is not installed in the T703 or as an option during station calibration. The external zero air must be O3 free and have a dew point of -20 °C or less. The pressure of the zero air should be regulated to 20-35 psig (CARB setpoint is 30 psig). **When connecting an external zero air source to the T703U, the zero-air pump should be disabled (Setup>Vars>ZA Pump Enable, Edit and set to OFF)**.

Sample Flow:

Gas flow rates are set by various flow control assemblies in the gas stream(s); each of the assemblies includes a critical flow orifice to regulate the flow.

Photometer Critical Flow Orifice:

Critical flow orifices operate without moving parts by utilizing the laws of fluid dynamics. By restricting the flow of gas though the orifice, a pressure differential is created. This pressure differential combined with the action of the T703U pump draws the gas through the orifice. As the pressure on the downstream side of the orifice (the pump side) continues to drop, the gas flow 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 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.

Internal Gas Pressure:

The T703U has two pressure sensors; one for the regulator and one for the photometer. A 100 psig pressure sensor monitors the downstream regulator pressure, and a 0-15 psia (absolute pressure) range sensor measures the pressure of gas in the photometer's absorption tube. The data are used by the CPU when calculating the O_3 concentration inside the absorption tube.

Software:

The T703U's core module is a high performance, Vortex 86SX-based microcomputer running Windows CE. Inside Windows CE, TAPI-developed software 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. The T703U interface software is NumaView.

1.6 Safety Precautions:

Prior to cleaning the analyzer or performing any maintenance on the instrument, place the Main power switch to the OFF position, and unplug the power cord. Avoid the use of chemical agents that might damage components or interface with the analytical method used by the analyzer.

Always use a three-prong, grounded plug on this analyzer. Adhere to general safety precautions when using compressed gas cylinders (e.g., secure cylinders, vent exhaust flows).

1.7 Personnel Qualifications:

Staff should be trained and familiar with basic air monitoring principles and procedures prior to operating any air monitoring equipment. Staff should complete any required safety training before operating any air monitoring equipment and working in the field. Staff should review this SOP, the operating manual, and complete any instrument related and air monitoring operations training required by their section manager prior to operating this analyzer.

2.0 INSTALLATION PROCEDURE

2.1 General Information:

The instrument is designed to operate at a temperature range between 5° and 40°C. However, good monitoring practices state that the instrument should be installed in a stable temperature controlled environment between 20°C to 30°C (ideal temperature setpoint is 25°C). Care should be taken to install the instrument in a standard 19" instrument rack such that it can be accessed for maintenance, repair work, troubleshooting etc. The standard 19" instrument rack should be bolted to the floor and properly grounded.

2.2 Physical Inspection:

Upon receiving the instrument, confirm that the instrument is in good working order and inspect for damage. If any damage is observed, photograph and document the damage and contact your supervisor. Prior to installing the instrument, check the following:

1. All items and options are received.
2. Verify that there is no shipping damage.
3. Check that all connections are fully inserted.
4. Check that all mechanical connections are tight.
5. Open and remove the internal shipping screws on the pump and the internal foam blocks.

2.3 Installation/Setup:

After receipt, physical inspection, and installation of the T703U in the station rack, perform the following steps (refer to Figures 1 and 2 below):

1. Desiccant cartridge: Install the supplied desiccant cartridge (with fresh desiccant) to the "Dry Air" port on the rear panel. **Failure to install a desiccant cartridge prior to powering on the T703U can permanently damage the T703U**. In Figure 2 below, the "Dry Air" connection appears as the only clear tube with the black tube fastener.
2. Photometer Gas Connectors: "PHOTO ZERO IN" to "PHOTO ZERO OUT" (connected this way from factory)
3. O3 Outlet to Photometer: "PHOTO IN" to "PHOTO OUT" (connected this way from factory)
4. Exhaust: Connect a ¼" tubing from the T703U back panel "EXHAUST" to an exhaust manifold or outside the station – do not leave directly open to the inside of station.

5. Cal Gas Out: Connect a 1/4" inch tubing from the T703U "CAL GAS OUT" to the station manifold or connect a 3/8" inch tubing from the "CAL GAS OUT" to the station's gaseous glass manifold.
6. Cap the "VENT" port.
7. Connect an Ethernet cable from the T703U back panel "ETHERNET" to the station Ethernet switch for CARBLogger connection.

NOTE 1: Inlet for External Zero Air Source is only used if the T703U internal zero air pump is not used (i.e., T703U operating simply as a photometer to measure external O3 concentrations). See T703U operating manual Section 2.3.26 "Setup for Operation as an O3 Photometer".

NOTE 2: When connecting an external source of zero air to a T703U with an internal zero air pump installed, the zero air pump must be disabled. The "ZA_PUMP_ENABLE" VAR must be set to "OFF".

Figure 1: Picture of Configured T703U Back Panel

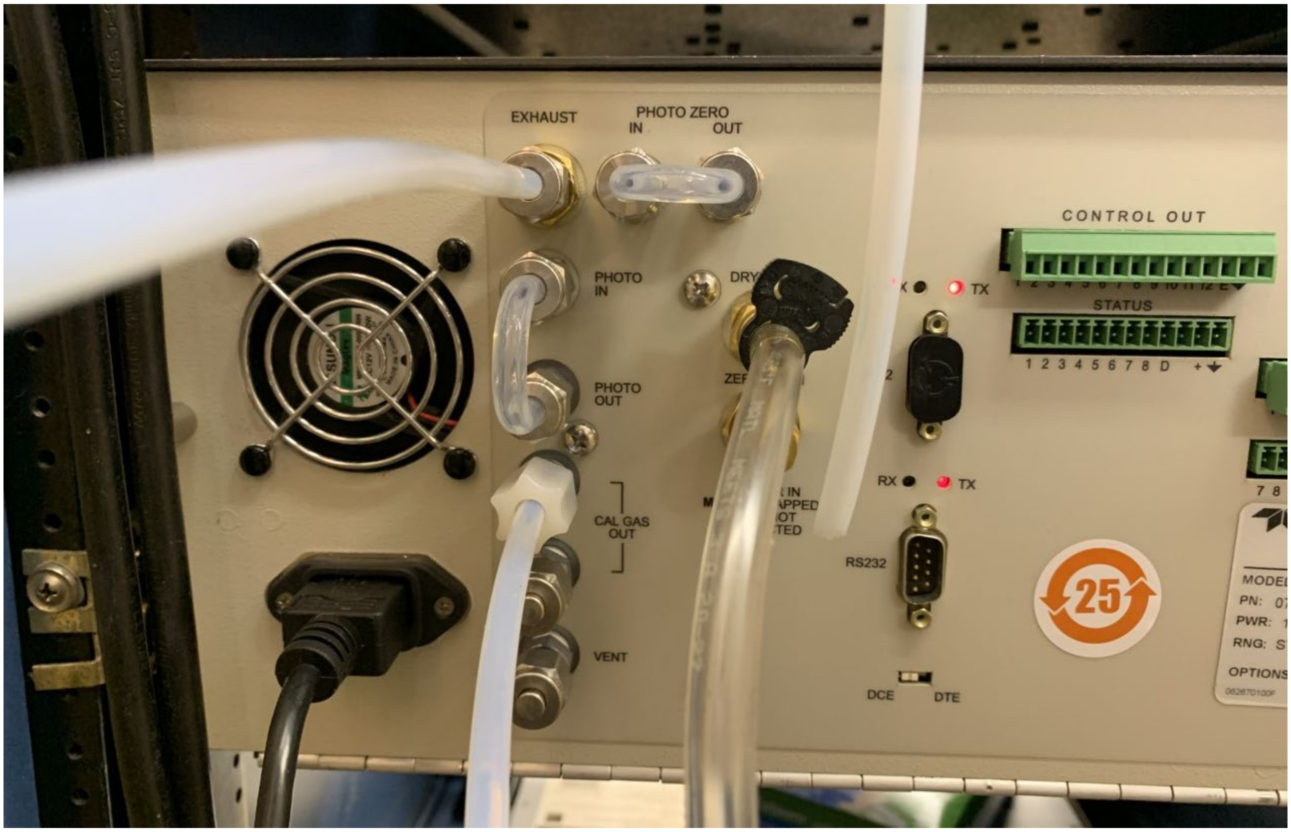

Figure 2: Closeup Picture of T703U Tubing Connections

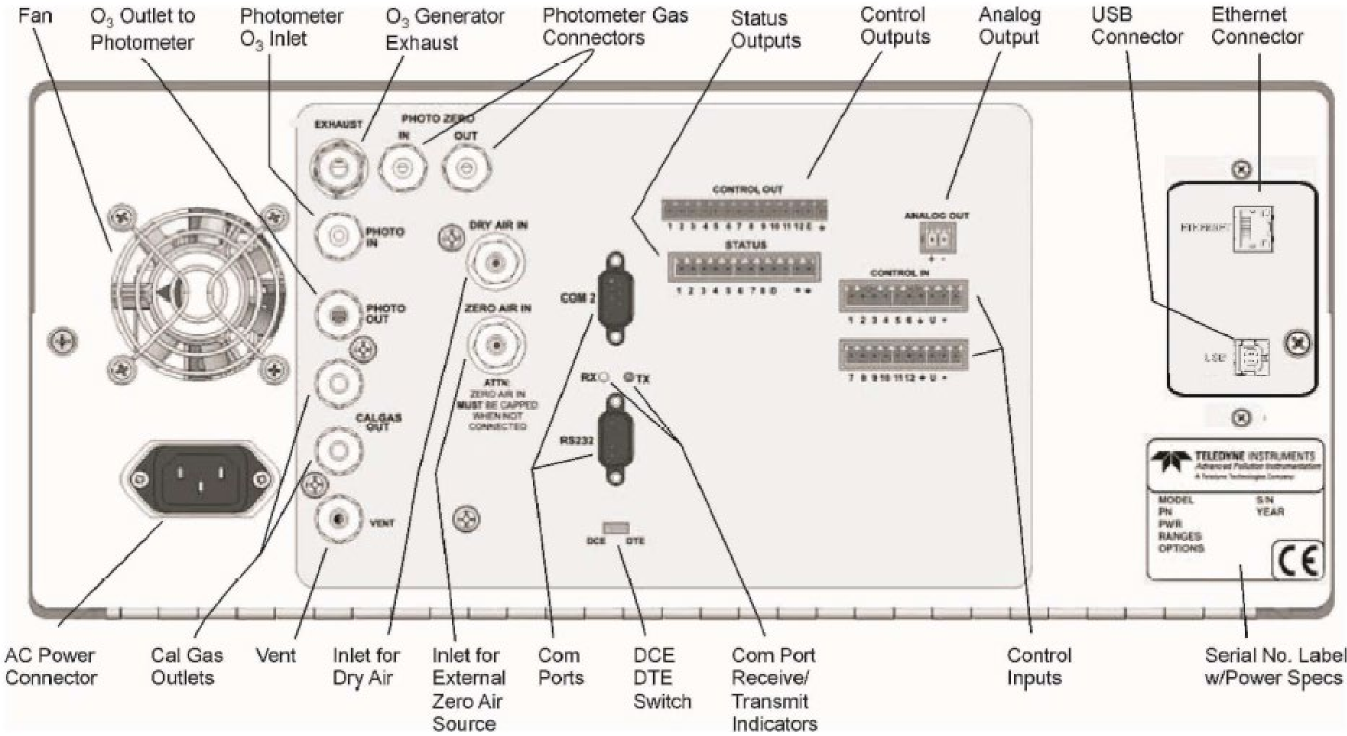

Figure 3: T703U Rear Panel Connection Schematic

8. Verify standard AQSB VARS settings per the table below:

VARS Parameter	Factory Default Value	CARB Configuration
Background Periodic Report Upload	True	False
Daylight Savings Enable	Enable	Disable
DL Time Format	12 hr	24 hr
Gas STD Pressure	29.92 inHg	No change
Gas STD Temperature	0 deg. C	25 deg. C
Periodic Check for Updates	True	False
System Time Format	12 hr	24 hr
Upload service report to Cloud	True	False

Table 2: T703U VARS Settings

9. Verify DAS Configuration for Hi-resolution data.
    a. NAME: 1-min data
    b. Max Records: Set ~ 10 million
    c. Log Tags: Select all available records except flags and funding

d. Trigger Type: Periodic

Note: The file named "HIRES" is the default name set by the manufacturer. Although this file name can be changed by the operator, it is recommended to leave the file name as the default "HIRES".

10. Generate a concentration of zero air to note pump operation and any diagnostic flags or warnings.

2.4 Connecting the T703U to the Station Inlet Probe "Candy Kane":

Connecting through the station probe, make the following connections to the ports on the back of the T703U, see Figure 3:

a. Uncap the Dry Air In port.

b. Connect one end of a Teflon tubing of an appropriate length and diameter to the Vent port labeled "To Station" (bottom port on the back of the transfer standard). This will be the line to the station's probe inlet.

c. Connect a separate piece of Teflon tubing to the Exhaust port and direct the other end outside the building if possible.

d. Leave the Cal Gas Out port labeled "Vent" capped.

Figure 4: Example Tubing Configuration for Station Manifold Connection - 3/8" OD Tubing with Vent Port Capped

2.5 Connecting the T703U to the Station "Manifold":

For presentation to the station's sample manifold or to the back of the station's ozone analyzer, make the following connections to the ports on the back of the transfer standard, see Figure 2:

a. Uncap the Dry Air In port.

b. Connect one end of Teflon tubing of an appropriate length and diameter to the Vent port labeled "To Station" (bottom port on the back of the transfer standard). This will be the presentation line to the station's manifold or ozone analyzer.

c. Connect a separate piece of Teflon tubing to the Exhaust port and direct the other end outside the building if possible.

d. Connect a third piece of Teflon tubing to the Cal Gas Out port labeled "Vent" and direct the other end outside the building if possible. (If sufficient bypass will be vented from the station manifold or the connection to the station's analyzer, the vent tubing connection is not necessary, and the port may remain capped.)

WARNING: Incorrect venting of bypass flow will affect the total flow presented to the station and may introduce ambient air into the test path when the final connection to the station is made.

Figure 5: Example Tubing Configuration for Station Manifold Connection - ¼" OD Tubing to Station Manifold and Second ¼" Tubing for Venting

2.6 Operational Verification:

After proper connections have been configured, turn on the power switch. Allow approximately one hour for the instrument to stabilize before performing any further operations.

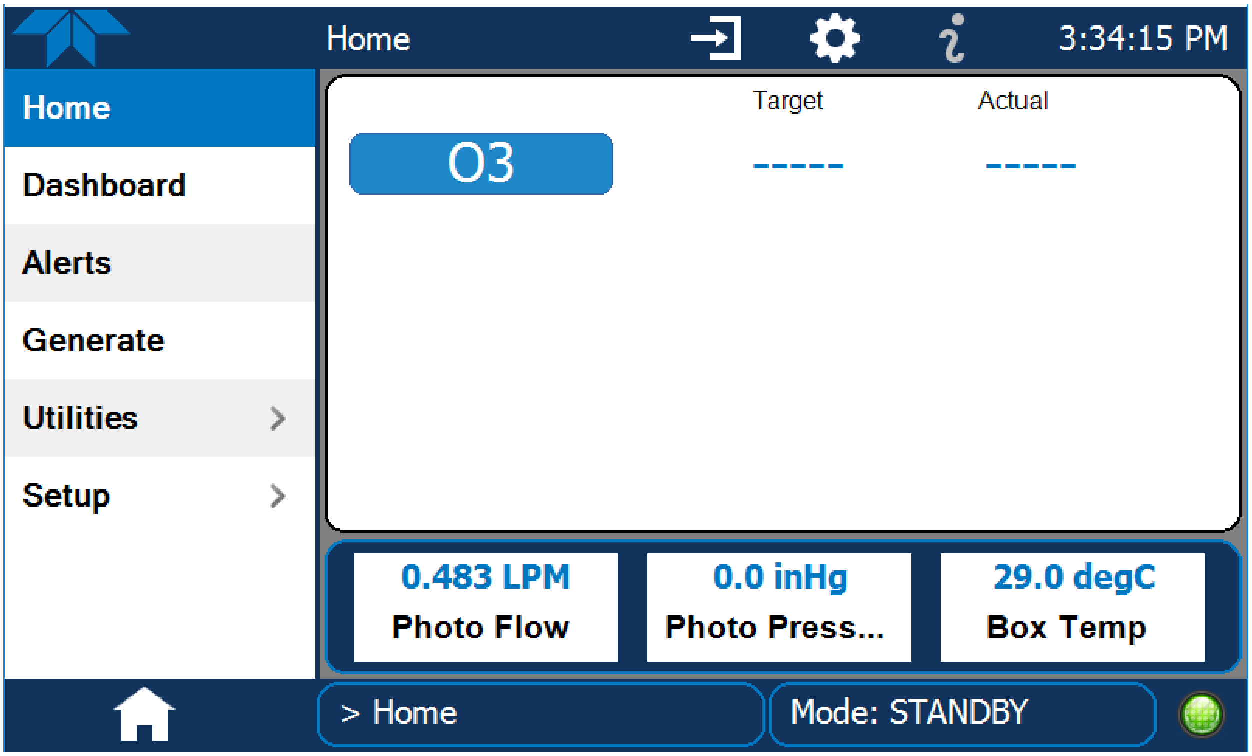

Figure 6: Typical Home Page Prior to Configuration

NumaView displays diagnostic values via the dashboard menu. Compare these values to those listed on the factory's final checkout sheet.

Note: The factory settings change based on acceptance testing.

If warning messages persist after the warmup period is over, investigate their causes using the troubleshooting guidelines provided in the operation manual.

T703U O3_Pressure and Reg_Pressure Verification/Adjustment:

If O3_Pressure (O3_PRES) and Reg_Pressure (REG_PRES) must be verified. The T703U must be in generate mode to verify. To activate, generate a zero, precision, or span gas. The O3_Pres and Reg_Pres reading should be 8 +/- 1 psi and 15 +/- 2 psi respectively.

If the O3_PRES or REG_PRES readings are outside of the above limits, an adjustment is required. As the two pressures are associated, the single adjustment process will affect both pressures at the same time. To adjust the O3_Pres and Reg_Pres within criteria, perform the following steps:

1. Open the front panel by releasing the two snap-in fasteners at the top of the front panel (refer to the figure below).

2. Pull out the regulator knob and adjust the regulator until the desired pressure is achieved.

3. Push the pressure regulator knob back in to lock. Close the front panel.

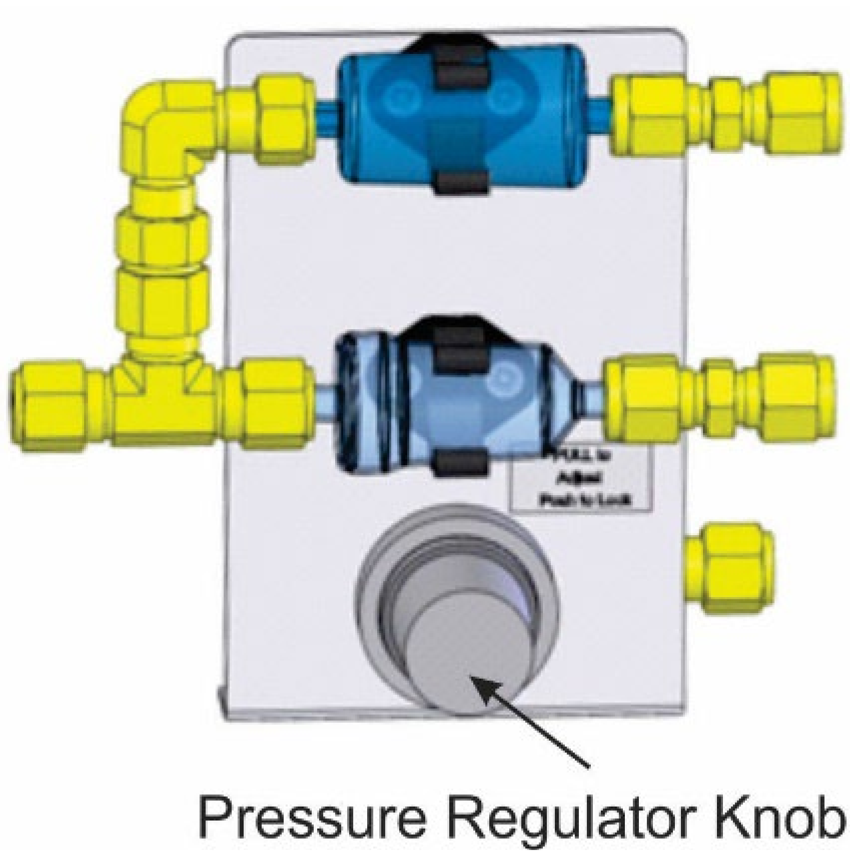

Figure 7: Output Pressure Regulator Assembly

Back Pressure Compensation:

After calibrating a gas pressure sensor, after initial installation at a monitoring station, and after making any pneumatic configuration changes (whether to the instrument locally or to the system), there are potential effects to the internal measure/reference pressure. To compensate for this, a back pressure compensation calibration should be performed. The T703U must be in "Standby Mode" to perform the automated Back Pressure Compensation.

To perform a back pressure compensation, go to:
<Utilities><Diagnostics><Back Pressure Calibration>. Select calibrate.

This process takes approximately 5 minutes. Once complete, the instrument will read "PASSED" and the back pressure compensation value will be displayed. Record this gain value.

If the back pressure compensation calibration fails, perform the adjustment again. The initial adjustment may fail if never performed prior or if there is a significant pressure change since the last adjustment.

When operating normally, the photometer pressure (Photo Pressure) should not vary by more than 0.1" to 0.2" (inches) every 3 seconds (measure/reference cycles). If greater, then a back pressure compensation should be performed. Back pressure compensation will not be able to correct for a pressure difference more than 2".

O3 Generator Calibration:

Calibrating the O3 Generator is a software driven process. Results (drive voltages) of this calibration are stored in an internal calibration table. This table determines the initial O3 output when the T703U generates precision and span levels. The O3 Generator Calibration should be performed when:

- The T703U photometer is calibrated.
- A change has been made to any O_3 generator tower.
- After running a Back Pressure Compensation.

To perform an O_3 Generator Calibration:

1. Navigate to Utilities>Diagnostics and press O_3 Gen Cal.

Fractionation Calibration:

One unique aspect to the T703U is the ability of the ozone generator to operate in a high range or a low range. High range is similar to the standard T703. Low range produces lower levels of ozone (viewable in the Dashboard with theO3GenFraction tag). The T703U low range operation is automatically invoked based on the O3 concentration demand and the total flow specified. Additional information and procedures are not well documented in T703U manual. A Fractionation Calibration should be performed after the initial install/setup.

The current fraction setting can be viewed in the VARS menu. To view, go to <Set-up>, <VARS>, 929, scroll to Low Range Threshold (displayed in ppb).

To calibrate, go to <Utilities>, <Diagnostics>, 929 scroll to <Fraction Cal> select calibrate (displayed in ppm).

3.0 CONFIGURATION

3.1 CARBLogger Connection:

CARB utilizes an Ethernet connection from the T703U to the CARBLogger.

Equipment Needed:

- Ethernet cable(s)
- Network Switch
- Ethernet-enabled instrument

The procedures below detail the procedure for configuring the CARBLogger, DMS and the respective instrument for data acquisition and calibration flagging.

CARBLogger Site Network Configuration:

a. CARBLogger network changes are not necessary if a new CARBLogger is being installed along with the Ethernet-enabled instrument. **If the instrument is being added to an active field CARBLogger, contact ODSS for assistance in verifying/modifying the network configuration prior to installation.** The instrument will not be able to communicate with the CARBLogger via Ethernet without the correct network configuration. While the network configuration is outlined below, ODSS staff assist with necessary changes.

b. Configure the second Ethernet port of the CARBLogger for static IP. Modify the file on Debian installation and the file on a CENTOS installation, with the following configuration:

   IP address: 172.16.0.1
   Netmask: 255.255.255.0

c. Deactivate the Network Manager application. The Network Manager application interferes with the static IP assignment on the second port. Change “managed=true” to “managed=false” in the file of both Debian and CENTOS installations.

d. If the operating system is Debian, configure /etc/ntp.conf to act as a time server by adding the following line to the appropriate section:

Restrict 172.16.0.0 mask 255.255.0.0

Add the rule below to UFW to allow the instrument to use the CARBLogger as an NTP server. CENTOS servers already have a firewall rule to allow NTP syncing.

Ufw allow from 172.16.0.0/24 to any port 123

e. If the operating system is Debian and a Thermo 42i/42iQ/43iTLE/43iQTL is being installed, copy the modpoll binary into the /usr/local/bin file. This file can be transferred from any CENTOS installation in the /home/agdms/installs folder.

f. If a network switch was issued, install the switch within 10 feet of both the instrument and CARBLogger. Connect the CARBLogger's second Ethernet port (a small "2" is stamped alongside the correct port) to the switch with the provided Ethernet cable. Confirm that another green light appears on the switch port. If there is no network switch, and only one instrument uses Ethernet communications, connect the instrument's Ethernet port directly to the second port on the CARBLogger. A switch is required if more than one instrument uses Ethernet communications.

3.2 Instrument Configuration for T703U:

1. The T703U uses Ethernet for communication with CARBLogger instead of RS-232. Verify the network configuration of the T703U, from the instrument's Home screen, navigate from Setup>Comm>Network Settings. The network settings should match the table below. If the configuration is incorrect, enter the correct values or contact ODSS for support. If any changes are made, reboot the analyzer to initialize the new network configuration.

Field	Configuration
Address Type	Static
IP Address	172.16.0.7
Subnet Mask	255.255.255.0

Field	Configuration
Gateway	172.16.0.1

Table 3: T703U Ethernet Settings

2. Install the T703U driver via the CARBLogger "Add Instrument" menu. The driver name is "APIT703_drv". The "Channel Name" can be changed but leave all other driver settings at the default values.

3. If replacing a T400w/IZS ozone analyzer.

    a. For NumaView operating instruments from the home screen on the analyzer, go the SETUP>ACAL. Change any ACAL sequences from "Enabled" too "Disabled".
    b. For Legacy operating instruments, select SETUP >ACAL. Disable the ACAL routine.

4. The TAPI IZS driver will conflict with the T703 driver and must be replaced with the TAPI non-IZS driver. Record the value of the serial port, delete the IZS driver via the CARBLogger "Delete Instrument" menu.

5. Install the TAPI non-IZS driver for the appropriate analyzer (API400E_drv or APIT400_drv) via the CARBLogger "Add instrument" menu. Configure the driver with serial port recorded in step 4.

6. Once the CARBLogger has reinitiated all drivers, choose option 6, "Display Channels" from CARBLogger main menu. Data values should appear in the T703 and API 400 parameters and the parameters should be in black text. If data is not recorded, check all the connections and wait two more minutes. Contact ODSS for support if there is still no data on the CARBLogger display.

7. Two changes are required in the dms.cfg to ensure proper calibration flagging. The span and precision steps in the T703 run in the opposite order of the IZS system. This requires a change in the ozone step definition. A recovery step must also be added or modified in the dms.cfg file. The recovery step will allow CARBLogger to flag the equilibration period and the recovery period at the end of the calibration cycle. Contact ODSS for assistance if you are unfamiliar with the dms.cfg formatting. Errors in the file will and can result in incorrect flagging and /or data loss. The correct

definitions are as follows:

O3 = O3 11 13 12 0 1
RECOV = RECOV 66 ---- 0 1

3.3 T703U Data Flagging Configuration:

The T703 driver initiates the daily calibration checks by requesting preprogrammed "levels" stored in the system. There are no scheduled sequences in theT703 scheduler. Like the Sabio driver, the T703 driver flags equilibration time and starts each step of the calibration sequence. Since the equilibration and recovery steps are flagged in CARBLogger, sites operating a T703 **MUST** be removed from the DMS calibration flagging routine. Contact ODSS immediately after the installation of the T703 and ODSS staff will update DMS calibration flagging routine. The change must be made **on the same day** of the installation to avoid erroneously flagged calibration data.

Staff should also update DMS true values table for their specific site to reflect new precision and span ozone true values.

3.4 DMS Configuration:

After installing a new instrument, update the "Select Instruments" setting in DMS to reflect the instrument changes, and verify the parameter settings for correctness on the "Select Parameters" setting. Refer to AQSB SOP 606 or the DMS homepage for this part of the configuration.

Ensure other instrument parameters (AutoQC checks, True Values, POC codes, Method code etc.) are correct in DMS.

4.0 CALIBRATOR OVERVIEW

4.1 Calibration Introduction:

To ensure the quality of the data collected within CARB's air monitoring network, **ALL** instruments used in the network must be calibrated:

1. During initial field installation and every six months thereafter
2. Following physical relocation
3. Before any scheduled major maintenance or repair
4. After any unscheduled major maintenance or repair
5. Prior or immediately after an instrument drifts outside acceptable QC limits
6. When terminating sampling of the pollutant

Multi-point instrument calibrations at all stations within the ARB network shall be performed in a consistent manner, so that all network monitoring stations in all areas of the State are calibrated in a similar fashion. **Instruments must be calibrated in accordance with this AQSB SOP and/or appropriate instruction manual.**

The T703U calibrator is a computer-controlled calibrator with a dynamic menu interface for easy, yet powerful, and flexible operation. All major operations are controlled from the front panel touch screen control.

To assist in navigating the system's software, a series of menu trees can be found in Appendix A of the T703U TAPI manual.

The menu flowcharts in this SOP depict the manner in which the front panel touchscreen is used to operate the T703U Photometric Calibrator. Please refer to figure 4-1 for an illustration of how the menu flowcharts correlate to the actual front panel.

The menu flowcharts depict typical representation of the display during the various operations being described; they are not intended to be exact and may differ slightly from the actual display your system.

4.2 Calibration Overview:

The T703 calibrator software has a variety of operating modes. Most commonly, the calibrator will be operating in STANDBY mode. In this mode, the calibrator and all of its subsystems are inactive although TEST function and WARNING messages are still updated and can be examined via the front panel display.

The second most important operating mode is SETUP mode. This mode is used for performing certain configuration operations, such as programming the concentration of source gases, setting up automatic calibration sequences and configuring the analog/digital inputs and outputs. The SET UP mode is also used for accessing various diagnostic tests and functions during troubleshooting.

The Mode Field of the front panel display indicates to the user which operating mode the unit is currently running.

The four (4) T703U modes are:

MODE	MEANING
DIAG	One of the calibrator's diagnostic modes is being utilized. When those diagnostic functions that have the greatest potential to conflict with generating concentrations are active, the instrument is automatically placed into Standby mode.
GENERATE	In this mode, the instrument is engaged in producing calibration gas.
SETUP[1]	**SETUP** mode is being used to configure the calibrator.
STANDBY	The calibrator is not actively generating gas.
[1] The revision of the Teledyne API software installed in this calibrator will be displayed following the word **SETUP**. E.g. "**SETUP B.4**"	

Table 4: T703U Operating Modes

4.3 Standby Mode:

When the T703U is in standby mode, it is resting.

Some functions under the SETUP > MORE > DIAG > submenu, those which conflict with accurate creation of calibration gas mixtures (e.g. ANALOG OUPUT STEP TEST) automatically place the calibrator into STANDBY mode when activated.

NOTE: The T703U calibrator should always be placed in STANDBY mode when calibration gas is not needed.

This can be done manually by pressing the STBY button that appears when the calibrator's display is showing the top-level menu (see Figure 4-1)

4.4 General Information About the Generate Mode:

The GENERATE mode is the mode of operation where the T703U is actively producing calibration gas, either zero or some specified concentration of ozone. In the GENERATE mode the Zero Air Pump (if enabled) and Photometer Pump are turned on.

4.5 Generate > Auto: Basic Generation of Calibration Gas

This is the simplest procedure for generating calibration gas mixtures. To generate calibration gas, press this menu.

4.6 Automatic Calibration Sequences:

The T703U calibrator can be set up to perform automatic calibration sequences of multiple steps. These sequences can perform all the calibration operations available for manual operation and can be set up to be triggered by using the front panel touch screen buttons, the internal timer, the external digital control inputs, the RS-232 interface, the Ethernet interface or even as sub-processes in another sequence.

4.7 Setup Programming Calibration Sequence:

A sequence is a database of single or multiple steps where each single step is an instruction that causes the instrument to perform an operation. These steps are grouped under a user-defined SEQUENCE NAME.

For each sequence, seven attributes must be programmed; the attributes are presented in the table below.

ATTRIBUTE NAME	DESCRIPTION
NAME	Allows the user to create a text string of up to 10 characters identifying the sequence.
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.
CC INPUT	Specifies which of the Digital Control Inputs will initiate the sequence.
CC OUTPUT	Specifies which of the Digital Control Outputs will be set when the sequence is active.
TIMER ENABLE	Enables or disables an internal automatic timer that can initiate sequences using the calibrator's built in clock.
STEPS	A series of submenus for programming the activities and instructions that make up the calibration sequence.
PROGRESS MODE	Allows the user to select the reporting style the calibrator uses to report the progress of the sequences , on the front panels display, as it runs

Table 5: Automatic Calibration Sequence Setup Attributes

The types of instruction steps available for creating calibration sequences are presented in the table below:

INSTRUCTION NAME	DESCRIPTION
GENERATE	Puts the instrument into **GENERATE** mode. Similar in operation and effect to the **GENERATE > AUTO** function used at the front panel.
DURATION	Adds a period of time between the previous instruction and the next
EXECSEQ	Calls another sequence to be executed at this time. The calling sequence will resume running when the called sequence is completed. Up to 5 levels of nested sequences can be programmed.
SETCCOUTPUT	Allows the sequence to activate the digital control outputs. Similar to the CC OUPUT attribute, but can be set and reset by individual steps.

Table 6: Calibration Sequence Setup Instruction

It is recommended that each calibration sequence end with an instruction to return the instrument to STANDBY mode.

To create a sequence, use the instructions in Operating the Calibrator located in section 4.5 in the Teledyne API T703U Calibrator Operation Manual.

4.8 Calibration at Altitude:

Calibrating the T703U at altitude requires a backpressure compensation calibration which should be performed at any elevation once the instrument is installed and configured.

Prior to calibration, verify the operation of the internal temperature and pressure sensors in the instrument by recording the values of temperature and pressure from the instrument and from a certified temperature/pressure standard for one point check.

<u>DAS vs. T703U O3 Display reading</u>:

The CARB air monitoring station's data acquisition system (DAS) is used for primary data recording, therefore the station's DAS data values should be used for calibration calculations in lieu of the analyzer display readings.

4.9 Calibration Scale:

Calibration Scale indicates the concentration range that an instrument is typically calibrated. CARB recommends that ozone and other gaseous used in ambient air monitoring network be calibrated over a range that represents concentrations likely to be found in the network while still being protective of concentrations exceeding the NAAQS. Hence, the instrument does not necessarily need to be calibrated or verified at concentration levels not normally measured by the monitor. The idea is that a monitoring organization select a calibration scale that provides more calibration points at the lower concentrations to establish a better test of linearity at the routine concentration ranges. The calibration scale minimally should cover the “controlling” NAAQS standard especially if the monitor is used for regulatory purpose (comparison to the NAAQS).

5.0 VERIFICATION (AS-IS)

5.1 Verification Overview:

AS-IS instrument verification should be performed prior to any analyzer repairs or adjustments.

Prior to beginning AS-IS verification, disable the appropriate DAS channels on the station data logger and record instruments diagnostic parameters.

5.2 Gas Flow Calibration:

The T703U has two gas flow characteristics that affect its performance: The flow of the gas through the sample chamber of the instrument's photometer (Photo Flow) and the total gas flow being output (Output Flow). While both are stored in the calibrator's memory and used to compensate the final concentration calculations for the changes in atmospheric pressure, they are calculated quite differently: The Photo Flow rate is calculated by applying the slope factor from the previous Photo Flow calibration to the reading measured by the flow sensor located on the pressure/flow sensor PCA, whereas the Output Flow rate is calculated by applying a separate slope factor to an interpolated value. Both can be viewed in the Dashboard (if not shown, use the Setup>Dashboard menu).

Perform the Photo Flow Cal (Section 6.4.2.1) and then the Output Flow Cal (Section 6.4.2.2) per the T703/T703U manual.

5.3 Verification Procedures (As-Is):

An "as-is" verification is performed initially to evaluate an instrument's performance. No adjustments, modifications or repairs are made to the instrument prior to the "as-is" verification. A verification confirms instrument performance for the recently generated data, usually back to the previous calibration or verification. An "as-is" verification can also assist to determine the T703U and T400 operational status. If one or both instruments do not meet the "as-is" criteria, the calibrator should determine the cause (i.e. maintenance, repair, or an adjustment needed).

Whenever the T703 photometer is verified or calibrated, an external zero air source is utilized.

Prior to beginning the verification:

1) Disable the appropriate DAS channels on the station data logger.
2) Record the T703U diagnostic parameters on the calibration worksheet.
3) Make appropriate entries in the site logbook and instrument maintenance sheet, such as transfer standard identification and certification dates.

The air monitoring station DAS is used for primary data reporting, therefore the displayed CARBLogger data values should be used for calibration calculations in lieu of the analyzer display readings.

To perform an “as-is” calibration:

1. Set-up the calibration apparatus:
    a. The T703 “Cal Gas Out” should already be connected to the station manifold (1/4 inch Teflon tubing).

    b. Connect the O3 transfer standard to the station manifold (1/4 inch Teflon tubing).

    c. Disable the T703U internal dry air pump in the VARS menu (the “ZA_PUMP_ENABLE” VAR should be set to OFF).

    d. Connect a Zero Air Source to theT703 “ZERO AIR IN” port and the transfer standard’s zero air input port (split the zero air source output with a tee and connect one to the T703U and the other to the transfer standard). It is important to utilize the same zero air for both the T703U and transfer standard. Therefore, an external zero air source must be utilized and the T703U internal zero air pump must be turned off.

    e. Ensure the T703U “VENT” port is capped. During routine T703U operation, the “VENT” port should already be capped.

    f. DO NOT CAP T703U “EXHAUST” PORT – this port is left as-is (exiting exhaust gas outdoors of the station).

    Set the T703U O3 Gen control mode to CNST by placing the T703U in Standby Mode (set via the Home page Generate menu); then in the Setup >Vars menu edit O3 Gen Mode.

2. In the standby mode, complete the back pressure compensation calibration step to compensate for any meas/ref pressure differences. The back pressure compensation should be performed any time the tubing

configuration or flow rate changes.

3. Allow the transfer standard and the T703U to warm up for at least one hour. All instrument covers should be securely attached as the verification is dependent upon the internal temperature of the analyzer. The transfer standard diagnostic values should be stable; showing no upward or downward trend when operating temperature has been reached.

4. Ensure the T703U is in CNST Mode via the VARS screen.

5. Record the station information, analyzer identification numbers, analyzer settings, calibration equipment information, and all other pertinent information on the calibration data sheet (Appendix B). Confirm that the slope and offset values have not changed since the most recent verification/calibration. If either the slope or offset have changed, investigate when, why and determine whether retroactive data review is required.

6. Energize the zero-air source and configure the transfer standard for zero air to flow though the calibration assembly. Perform this by entering the generate button, enter Auto mode, select 0 ppb O3 and press the enter button. Calculate an appropriate T703U flow rate needed to supply the transfer standard ozone photometer, the T703U photometer and the T400 ozone monitor and add a minimum of 0.5 lpm. Test this by uncapping the "VENT" port and measuring the flow – should be a minimum of 0.5 lpm but not more than 2 lpm.

7. Utilizing the T703U as the air and ozone source, generate zero ppb O3, four O3 levels followed by another zero ppb O3 (post-zero).

8. There are four (4) O3 calibration levels plus a pre and post zero: 0, 320 (span), 150, 70, 30 and followed by another 0.

9. From HOME: <Generate> Set instrument mode <AUTO> Select gas window. Chose <O3> and enter desired O3 conc. Press the generate button to initiate.

10. Once the ozone display value stabilizes, (photometer stability < 0.5 ppb), record T703U ACT= value and transfer standard reading.

11. If verifying the O3 generator at the same time, record O3 set point and O3 lamp voltage values.

12. Set the T703U to produce a zero ppb O3 concentration. After T703U and transfer standard equilibrate, record their respective O3 display values.

13. Set the transfer standard to produce an ozone concentration at the upper end of the calibration scale. Typically, this value is 320 ppb.

14. Repeat the step above for each of the next output levels (160, 70, and 30 ppb and post-zero) and record the results.

15. Although the calibration worksheet will automatically calculate averages for each set of values, it is important that the calibrator reviews and understands the equations and results for each cell in the sheet.

16. The average pre-zero and average post-zero results for the transfer standard and the T703U should not deviate more than 3 ppb from each other. If these results are greater than 3 ppb, then the one or both instruments were not completely equilibrated and the verification should be performed again. DO NOT USE ZERO RESULTS TO CORRECT O3 LEVEL RESULTS.

17. If the as-is verification "% Deviation" results are greater than ± 2 percent, then an adjustment and final verification is required.

6.0 Final Verification (T703U Photometer Calibration and Final Verification):

A "final" verification is essentially a two part process; a zero/span adjustment and a final verification to ensure accuracy and linearity. A final verification is typically performed after the instrument has undergone an in-depth maintenance procedure, a repair, a relocation, an ozone photometer calibration and/or when the as-is verification exceeds acceptable criteria (> 2%).

6.1 Photometer Calibration:

The photometer calibration is a two-part process; the photometer zero calibration (zero) and the photometer span calibration (span). The configuration for these two calibration steps should be performed in the same manner as the as-is verification configuration (as described in the above section 5.2). Always perform the zero calibration first, followed by the span calibration (API T703U sections 5.4.3.1 and 5.4.3.2 respectively).

1. Photometer Zero Calibration: This procedure adjusts the T703U memory for the zero point offset and slope. Most often, the T703U verification/calibration simultaneously includes the T400 analyzer verification/calibration. The procedure described below will therefore describe the External Zero Air procedure where the T703U's internal zero air is turned off and an external zero air source is utilized. Refer to section 5.4.1 "SETUP FOR VERIFYING AND CALIBRATING THE O3 PHOTOMETER" in the manual for more information.

    a. Perform the step in section 5.3 (subpart 1, steps a-f).
    b. Ensure the calibrator is in Standby mode and navigate to the Utilities>Diagnostics>Bench Cal menu.
    c. Select the Calibration Type: The Zero button is for internal zero calibration and the XZero button is for external zero calibration.
    d. Allow Zero air to enter the PHOTO ZERO IN port of the calibrator's rear panel.
       Press the Calibrate button. Pressing "Yes" in the Confirm Calibration windows changes the Offset and Flow values for the O3 measurement, where "No" aborts the calibration.

2. Photometer Span Calibration: This procedure adjusts the T703U memory for the span point slope.

    a. As described directly above, the setup for this procedure mirrors the Photometer Zero Calibration. Configure the T703U as performed in section 5.3 (subpart 1, steps a-f).

b. In standby mode, navigate to the Utilities>Diagnostics>Bench Cal menu.
c. Select the Calibration Type: The Span button is for internal span calibration and the XSpan button is for external span calibration. Press the Span button.
d. Set the T703U Gen Target window to deliver a span concentration of O3 (~400 ppb). Once stable, enter corrected transfer standard concentration value (true O3) value in the 703U actual window. Select calibrate.

6.2 Final Verification:

A final calibration is conducted when an as-is verification exceeds criteria and/or after a major repair or maintenance. A final verification is performed after all necessary maintenance, adjustments, or instrument repairs have been conducted.

The final verification process is identical to the as-is verification process. Follow the steps as described in Section 5.3 above.

If the final verification results fall outside acceptable criteria, then a photometer zero/span calibration must be performed again or troubleshooting to identify any potential issues such as leaks or maintenance needs.

6.3 Calibrating the O3 Generator:

The T703U calibrator's software includes a routine for automatically calibrating the O3 generator. A calibration table of drive voltages stored in the calibrator's memory is the basis for this calibration. This table is utilized by the T703U to set initial O3 generator drive settings and should be used only under the following circumstances:

1. After completing a photometer calibration and final verification.
2. When there has been a change to a component of the ozone generator tower.
3. Only after:
   a. Performing a pressure leak check (Section 6.5.1), followed by
   b. Running a Back Pressure Compensation (Section 5.1).

To perform an automated O3 generator calibration program:

1. Connect a Cal Gas Out port to the station manifold (in the same configuration as the T703U will be utilized daily).
2. From Home screen, navigate to <Utilities><Diagnostics><O3 Gen Cal>

3. The automatic process takes approximately an hour. The T703U must be manually placed back into standby mode following the completion of the automated O_3 generator calibration.

6.4 Pressure Sensor Calibration Set Up:

Attach the independent, calibration pressure meter/monitor at the location shown in the Figure 5 for the T703U.

6.5 Back Pressure Compensation:

After calibrating a gas pressure sensor (and after making any pneumatic configuration change, whether to the instrument locally or to the system), there is risk of impacting the internal measure/reference pressure. To compensate for this, a back pressure compensation calibration should be performed. To do this, ensure that the calibrator is in Standby Mode (under Generate menu), then navigate to the Utilities>Diagnostics>Back Pressure Compensation menu, and press the Calibration button; the operation will take a few minutes.

Another occasion to run a Back Pressure Compensation is if there is a fluctuating difference of more than 0.2 in Hg in the Photo Pressure parameter while ozone is being generated. This would be where the Meas/Ref valve is cycling (about six seconds per full cycle), and the Photo Pressure reading changes by more than 0.2 as the valve switches approximately every three seconds.

6.6 Gas Flow Calibration:

The T703U has two gas flow characteristics that affect its performance: The flow of the gas through the sample chamber of the instrument's photometer (Photo Flow) and the total gas flow being output (Output Flow). While both are stored in the calibrator's memory and used to compensate the final concentration calculations for the changes in atmospheric pressure, they are calculated quite differently: The Photo Flow rate is calculated by applying the slope factor from the previous Photo Flow calibration to the reading measured by the flow sensor located on the pressure/flow sensor PCA, whereas the Output Flow rate is calculated by applying a separate slope factor to an interpolated value. Both can be viewed in the Dashboard (if not shown, use the Setup>Dashboard menu).

Perform the Photo Flow Cal (Section 6.4.2.1) and then the Output Flow Cal (Section 6.4.2.2) per the T703/T703U manual.

6.7 <u>Calibrating the Photometer's Sample Gas Flow (Photo Flow Cal)</u>:

Note: The procedure described in this Section requires an independent, calibrated gas flow meter/monitor be connected to the T703U's rear panel EXHAUST fitting.

1. Connect an independent, calibrated external flow meter/monitor per the preceding Note.
2. Navigate to the Utilities>Diagnostics>Photo Flow Cal menu (Figurer 5.8)
3. Press the Enable button to start the flow.
4. Adjust the Actual Flow as measured by the external flow meter and press ENTER button.
5. Press the Calibration button.
6. A confirmation window will pop up: pressing the No button aborts the calibration, pressing Yes button starts the calibration.
7. The Status field will display "Success" when completed.

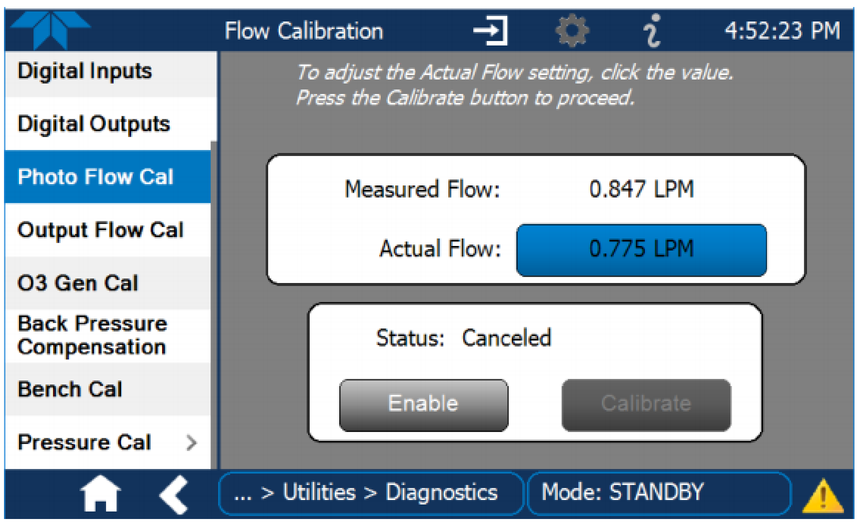

Figure 8: Photo Flow Calibration Menu

6.8 <u>Calibrating the Photometer's Sample Gas Flow (Photo Flow Cal)</u>:

Note: The procedure described in this Section requires that an independent, calibrated external gas flow meter/monitor be connected to one CAL GAS OUT port capped.

1. Connect an independent, calibrated external flow meter/monitor per preceding Note. Figure 5-9 and Figure 5-10 show the flow paths for T703U.
2. Navigate to the Utilities>Diagnostics>Output Flow Cal menu (Figure 5-8).

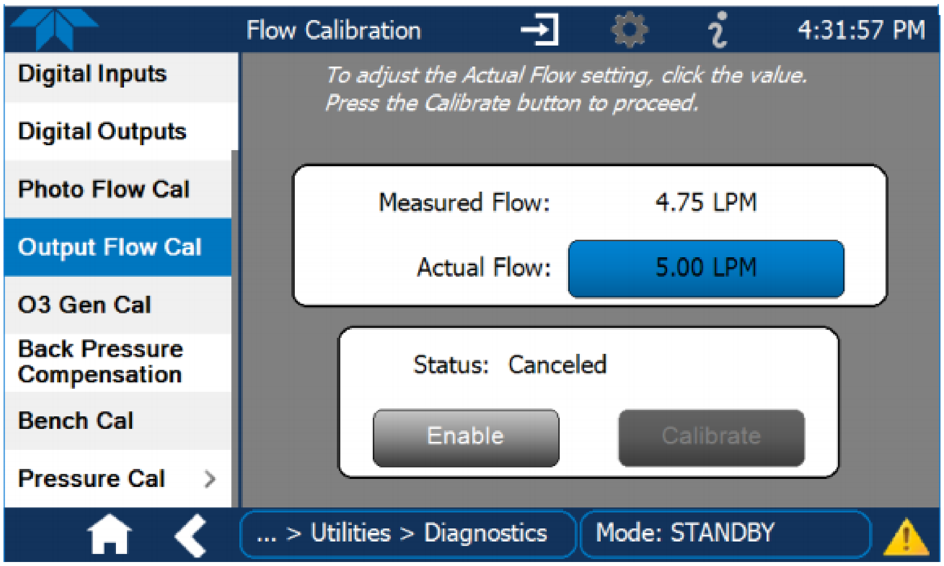

Figure 9: Output Flow Calibration Menu

3. Press the Enable button to start the flow.
4. Adjust the Actual Flow as measured by the external flow meter and press the ENTER button.
5. Press the Calibration button.
6. A confirmation window will pop up: pressing the No button aborts the calibration; pressing Yes button starts the calibration.
7. The Status field will display "Success" when completed.
8. Now run a leak check Run a (refer to Section 7.2 in the TAPI manual) prior to moving on to verifying and calibrating the bench.

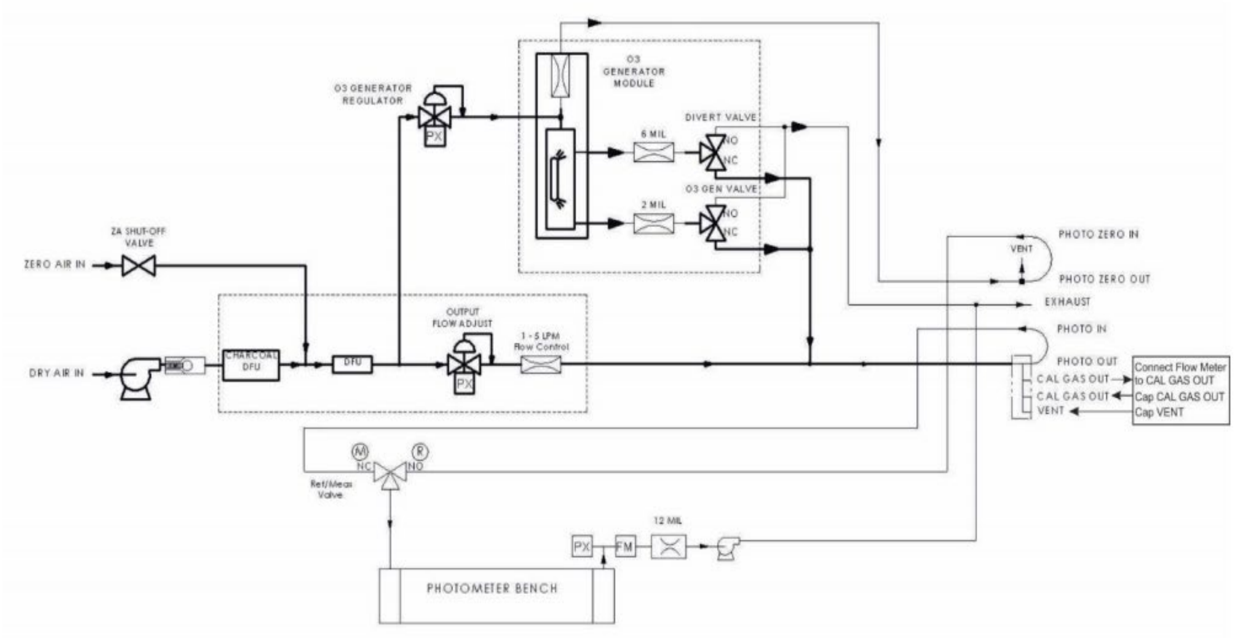

Figure 10: T703U Output Calibration Flow Schematic

7.0 OPERATIONAL AND ROUTINE SERVICE CHECKS

7.1 General Information:

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.

Table 7 displays a typical maintenance schedule for the calibrator. The actual frequency of performing these procedures can vary depending on the operating environment. Please note that in certain environments (i.e. dusty, very high ambient pollutant levels) some maintenance procedures may need to be performed more often than shown. The Monthly Quality Control Check Sheet (See References) should be completed weekly and submitted in the station's monthly data submittal package. The station operator must keep a copy of the Monthly QC Check Sheet in the air monitoring station. Detailed routine maintenance procedures can be found in Chapter 6 of the operating manual.

Follow the maintenance schedule provided in this section.

Item	Action	Freq	Cal Check Req'd.	Manual Section	Date Performed									
Verify Test Functions	Record and analyze	Weekly or after any Maintenance or Repair	No	3.4.4										
Photometer Pump Diaphragm	No Replacement Required. Under Normal Circumstances the Pumps Will Last the Lifetime of the Instrument.													
Dry Air Pump Diaphragm	Replace	Annually	Yes	7.4										
Absorption Tube	Inspect - - - Clean	As Needed	Yes after cleaning	7.3	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 T703 Calibrator									
Perform Leak Check	Verify Leak Tight	Annually or after any Maintenance or Repair	N0	7.2.1										
Pneumatic lines	Examine and clean	As needed	Yes if cleaned	- - -										

Table 7: Maintenance Schedule

7.2 Daily Checks:

Daily (or each site visit) review instrument diagnostic and concentration data, automated calibration values and chart records (if used) for any indication of analyzer malfunction. Review auto QC checks for values being flagged invalid. Check the instruments for any error messages.

7.3 Weekly Checks:

Once a week, review the daily zero/precision/span results. Per the QC check sheet, the "Output Flow", "Reg Press", "O3 Press" and "Photo Flow" values can be acquired via daily CARBLogger emails each week or the operator will be required to generate zero air at the station to read and record the results.

7.4 Monthly Checks:

Check desiccant on a monthly basis and complete and submit the AQSB Form 704 (API T703U) in the station's monthly data packet.

7.5 Semiannual Checks:

Perform instrument multi-point calibration using the calibration sheet. Submit the calibration form in the station's monthly data packet.

7.6 Annual Checks:

Replace dry air desiccant
Replace dry air pump diaphragm
Replace DFU filter and Charcoal scrubber
Perform leak check (or after repair)

NOTE: A leak check should also be performed after any maintenance or repair to the analyzer has occurred.

7.7 As Required Checks:

Clean optical chamber, absorption tube, and adjust phot lamp when 03 reference value is less than 2500 mV. If this needs to be done, the instrument may require recalibration. Complete an ozone generator calibration upon completion of instrument calibration and flow adjustments, pump changes or photometer and ozone lamp replacements. Record the date of any as required checks on the maintenance check list from attached to the instrument.

8.0 MAINTENANCE PROCEDURES

8.1 General Information:

The instrument is designed to operate unattended for long periods of time. Other than the routine service checks outlined in section 6.0 of this SOP, the T703U need very little maintenance. However, preventative maintenance requirements may vary from instrument to instrument, thus operators should refer to the instrument instruction manual to become familiar with maintenance requirements.

If station operators cannot repair an instrument using procedures stated in the instruction manual, contact the Operation Data Support Section Instrument Shop for assistance.

9.0 TROUBLESHOOTING

9.1 General Information:

The T703U is designed to rapidly detect possible problems and allow for their quick evaluation and repair. During operation, the analyzer continuously performs self-test diagnostics and provides the ability to monitor the key operating parameters of the instrument without disturbing monitoring operations. As the T703U is being run with CARBLogger, any diagnostic parameters which drift outside of the acceptable range will cause and alert to be emailed to the site operator.

The table below lists common errors and possible solutions. If the issue or solution is not listed in the table, operators should refer to Section 8, "General Troubleshooting and Service" in the T703/703U instruction manual. Operators can also contact ODSS instrument laboratory staff for additional assistance.

Problem	Solution
Low flow warning	Perform a leak check and verify only one in-line filter is in filter holder. If no leak found, rebuild or replace pump. Verify analyzer flow reading with an external flow meter.
Lamp or photometer reference warning	Check lamp voltage test function. Adjust or replace lamp. Lamp voltage should be between 2500 – 4900 mVDC.
Minute not matching CARBLogger error	Adjust analyzer clock to match time on CARBLogger.
Automated calibrations drift out of acceptable criteria (± 7.1%)	Verify with certified standard, perform leak check, and replace Sample/Reference valve.

Table 8: Common Troubleshooting Issues

10.0 QUALITY CONTROL AND ASSURANCE

10.1 General Information:

CARB monitoring stations have been configured for automated QC checks. These checks are performed using the station gas dilution system.

10.2 Quality Control:

Station operators will monitor the automated QC checks on a daily basis using the guidelines below. Nightly zero checks are considered acceptable if the zero drift is < ± 3.1 ppb (24hr) or < ±5.1 ppb (> 24 hr-14 day). Precision and span checks are considered acceptable when the percent difference from true is < ± 5%. The "warning" level is reached when the precision check is > ± 5%. The operator should observe the analyzer performance closely and if necessary, take corrective action prior to the analyzer exceeding ±7.1% from true.

The acceptable precision and span levels are exceeded when the automated QC checks response for ozone varies by ± 7.1% from true. When this level is reached, the station operator must take corrective actions. Corrective action means that calibration staff (staff independent from the site operator, if possible) using independent certified transfer standards, verify that QC check results are valid and are not simply caused by a problem with the calibration system (i.e., faulty O_3 generator or zero air supply etc.) If it is determined that an instrument has malfunctioned or drift has occurred causing the instrument to read outside of acceptable criteria, staff should determine the cause of the problem, perform necessary maintenance or repairs, and document the investigation. All corrective actions should be documented on QC maintenance sheets, recorded in station logbooks, and optionally electronically documented in the data management system (DMS).

Any data collected when the analyzer exceeded the ± 7.1% should be invalidated unless there is compelling evidence or reasons for not doing so. If the data is to remain valid, the data should be flagged with an appropriate AQS qualifier code. Refer to AQSB SOP 610, Data Review and Validation, for additional guidance on data review and validation.

NOTE: Like air monitoring instruments, QC systems may fail, yielding invalid QC results. For this reason, ambient data should not be invalidated based solely on QC data. Reviewers must check all other available information to determine if any data should be invalidated.

10.3 Quality Assurance:

CARB monitoring sites conform to the quality assurance procedures found in the CARB Quality Assurance Program Plan for Gaseous Pollutant Air Monitoring Program (QAPP). Please refer to the QAPP for additional information.

REFERENCES

- Primary Quality Assurance Organization (PQAO) website (link to PQAO website)
- CARB QAPP for Gaseous Pollutant Air Monitoring Program
- AQSB 605 SOP CARBLogger
- AQSB 606 SOP Data Management System
- AQSB 610 SOP Data Review and Validation
- Teledyne API instrument Manual T703/703U Rev F
- Teledyne API instrument Manual T703/703U w/NumaView Software

CALIFORNIA AIR RESOURCES BOARD
MONTHLY QUALITY MAINTENANCE CHECK SHEET
TAPI MODEL T703U OZONE CALIBRATOR

Location: ____________________ Month/Year: ____________________
Station Number: ____________________ Operator: ____________________
Property Number: ____________________ Agency: ____________________

Test Parameters		Readings				
DATE	Current Date					
TIME (PST)	Current Time (HH:MM)					
**OUTPUT FLOW*	3 – 5.5 LPM					
**REG PRESS*	15 ± 2 PSIG @ 5 LPM					
**O3 PRESS*	8 ± 1 PSIG					
BOX TEMP	20 - 35 °C					
PHOTO PRESS	Ambient Pressure ± 2 inHg					
O3 LAMP TEMP	48 ± 1°C					
O3 MEAS	2500 - 4700 mV					
**PHOTO FLOW*	0.720 – 0.880 LPM					
PHOTO LAMP TEMP	58 ± 1°C					
PHOTO SLOPE	1.0 ± 0.15 – No Changes					
PHOTO OFFSET	0 ± 10 ppb – No Changes					

These parameters should be recorded from CL daily 1-min records e-mail once per week.

OPERATOR INSTRUCTIONS:

1. Daily checks: Review daily calibration results.
2. Weekly Checks: Record test parameters.
3. Monthly Check Check desiccant
4. Semi-Annual: Calibrate instrument: Date last performed:____________
5. Annual: Replace dry air desiccant Date last performed:____________
   Replace dry air pump diaphragm Date last performed:____________
   Replace DFU filter & Charcoal scrubber Date last performed:____________
   Perform leak check (or after repair) Date last performed:____________
6. As Required: Inspect/Clean absorption tube
   Examine/Clean pneumatic lines
   Back Pressure Compensation
   O3 Generator Calibration

Date	Comments or Maintenance Performed:

Reviewed by: ______________ Date: ______________

AQSB QC Form 707 (API T703U) (02/22) Page 1 of 1

APPENDIX A: AQSB MONTHLY MAINTENANCE QUALITY CONTROL FORM 707

Calibration Report:

ID Information: **Instrument:** **Calibration:**

Station Name:	Placerville	Make:	API	"As Is"	X
AQS Site #:	09-690	Model #:	T700U	"Final"	
Station Address:	Gold Strike Road	Property #:	B017348	Calib. Date	10/20/2020
Agency:	CARB	Serial #:	235	Report Date	10/20/2020

Flow Transfer Standard I.D.:

Make & Model:	AliCat 3in1
Prop. #:	20163839
Cert. Date:	6/18/2020
Cert. Exp.:	6/18/2021

Meteorology:

Temp. (Deg. C):	25.1
Press. (mm Hg):	708.0
Elevation (Ft.):	2008
ACF:	0.9273

Flow Transfer Standard Equatio

	m:	x:		b:	
Air Flow =	1.0000	*Avg. Display	+/-	0.0000	SLPM

Calibration Results:

Pollutant		Ozone
Instrument Range, ppb:		0 -500
	Slope:	1.0233
Best Fit Line	Intercept	-0.0005
	Correlation:	1.0000
"As Is" Percent Deviation from True:		2.0%
% Diff. from Prev. Cal. (04/14/2020):		0.3%
Zero Air Verification		0.0

Diagnostic Parameters:

Time:	10:14	hh:ss
Range:	500	(ppb)
Stabil:	0.32	
O3 Meas.:	3482	(mV)
O3 Ref.:	3482	(mV)
Flow Std. Display:	0.800	(LPM)
O3 Flow Disp.:	744.0	(cc/m)
O3 True flow :	800.0	(cc/m)
Alt. Cor. Inst. Flow:	862.7	(cc/m)
Pres.:	27.1	(" Hg)
Sample Flow:	744	(cc/m)
Sample Temp:	40.5	(°C)
Photo Lamp	58.0	(°C)
Box Temp.:	31.3	(°C)
Slope:	0.972	
Offset :	1.2	(ppb)
*O3 Gen temp:	48.0	(°C)
*O3 Gen:	0.0	(mV)
*O3 Drive:	0.0	(mV)

(* apply to IZS enabled instruments)

Zero Air Source:

Make:	TAPI
Model:	751H
Barcode:	B017172
Serial No:	246

Ultrapure Air Cylinder:

Make & Model:	Praxair UP
Cylinder Number:	CC702627
Certification Date:	11/2/2018
Cylinder Press. (psi):	500
Outlet Press. (psi):	30

Data Acquisition System (DAS):

Make:	CARBLogger
Model:	2.1.3
Barcode:	20131069
Serial No:	3HB5CZ1

OzoneTransfer Standard I.D.:

Make & Model:	TAPI T750U	O3 Lamp Temp (°C):	NA
Property No.:	B0107159	O3 Flow (LPM):	NA
Serial No.:	150	O3 Press (mmHg):	NA
Air Flow Setting:	1.5	Photometer Temp	33.3
Air Flow (slpm):	1.5	Photo Lamp Temp	58.0
Cert. Date:	8/11/2020	Photometer Flow	0.79
Cert. Exp.:	2/12/2021	Photometer Press	27.3

APPENDIX B: AQSB CALIBRATION REPORT 707 (PAGE 1)

Ozone Transfer Standard Correction Equations:

	m:	x:		b:	
True Ozone =	0.9976	*Avg. Display	+/-	0.0001	ppm Ozone
True Air Flow=	0.9980	*Avg. Display	+/-	0.0060	LPM

Calibration Data:

Zero Air Verification:

	Air Cylinder	Air Generator
Inst. Zero (ppb)	3.0	3.0
Difference (ppb)	0.0	

Difference must be less than +/- 3.0 ppb to use zero air generator

Calibration Data (Transfer Standard):

Number	Pre-Zero	1st Point	2nd Point	3rd Point	4th Point	Post-Zero
Lamp Intensity (%)		320	150	70	30	
1	-0.001	0.310	0.143	0.065	0.026	-0.001
2	-0.001	0.310	0.143	0.065	0.026	-0.001
3	-0.001	0.310	0.143	0.065	0.026	-0.001
Average Display:	-0.001	0.310	0.143	0.065	0.026	-0.001
Corr. Ave. (ppm):		0.310	0.144	0.066	0.027	

Calibration Data (Analyzer):

Number	Pre-Zero	1st Point	2nd Point	3rd Point	4th Point	Post-Zero
1	0.003	0.320	0.150	0.070	0.030	0.003
2	0.003	0.320	0.150	0.070	0.030	0.003
3	0.003	0.320	0.150	0.070	0.030	0.003
DAS Display:	0.003	0.320	0.150	0.070	0.030	0.003
Analyzer (ppm):	0.003	0.320	0.150	0.070	0.030	0.003
Strip Chart Rec.:						
Corr. Ave. (ppm):		0.317	0.147	0.067	0.027	

Linear Regression Equ.:

Analyz. Resp.= Tr. O3*x + b (ppm)	
x :	1.0233
b :	-0.0005
r^2	1.0000
Previous Cal. Slope:	1.0207

Deviation from True:

Sum of Corr. TS Ave's. (S1):	
S1:	0.547
Sum of Corr. DAS Ave's. (S2):	
S2:	0.558
% Deviation:	2.0%

Comments:	
Calibrated by:	

Reviewed by

APPENDIX C: AQSB CALIBRATION REPORT 707 (PAGE 2)