FORSYTH COUNTY OFFICE OF ENVIRONMENTAL ASSISTANCE AND PROTECTION

STANDARD OPERATING PROCEDURE (SOP)

Calibrators

Signature Page

By the signatures below, the Forsyth County Office of Environmental Assistance and Protection (FCEAP) certifies that the information contained in the following Standard Operating Procedure (SOP) is complete and fully implemented as the official guidance for our Office. However, due to circumstances that may arise during the sampling year, some practices may change. If a change occurs, a notification of change and a request for approval will be submitted to EPA Region 4 at that time.

Name: Cary Gentry Signature: Date: 8/19/16

Title: FCEAP QA Specialist

Name: Jason Bodenhamer Signature: Date: 8/19/16

Title: FCEAP Program Manager

Name: Minor Barnette Signature: Date: 8/19/16

Title: FCEAP Director

Name: ____________________ Signature: ______________________ Date: ________

Title: ____________________

Name: ____________________ Signature: ______________________ Date: ________

Title: ____________________

REVISIONS

REVISION	DATE	CHANGES TO SOP
1.1	10/17/2016	Additional Flow Certification Equipment Section added for Alicat MBS Precision Mass Flow Meter units.
2	07/20/2021	Performed a pass through the entire document, ensuring that all current models and serial numbers are up to date.
2.1	06/23/2022	Updated calibrator models and serial numbers. Updated the mass flow controller certification process to match the current procedure. Removed Figure 4 and all procedures related to BIOS DryCals. Added a new Figure 5 that shows the slope/intercept calculation for the CAL 1 MFC certification procedure.

TABLE OF CONTENTS

12.1 General Overview 6

12.2 Verification of Level 2 and Level 3 Transfer Standards 7

12.2.1 Transfer Standards Traceability 7

12.2.2 Regulatory Requirements 8

12.3 Ozone Photometer Performance Verification, Calibration and Recertification 8

12.3.1 Ozone Photometer Tracking 8

12.3.2 Ozone Photometer Verifications 8

12.3.3 Ozone Photometer Calibrations 10

12.4 Verification and Calibration of Ozone Generators 12

12.4.1 Teledyne API 700EU Ozone Generator Verification and Calibration 12

12.4.2 Teledyne API T700U Generator Verification and Calibration 13

12.4.3 Teledyne API T750 Generator Verification and Calibration 13

12.4.4 Teledyne API 703E Generator Verification and Calibration 13

12.4.5 Teledyne API T703 Generator Verification and Calibration 13

12.5 Mass Flow Controller Calibration 13

12.5.1 Teledyne API 700EU MFC Calibration using an Alicat MBS flow meter 14

12.5.2 Teledyne API T700U MFC Calibration 16

12.5.3 Teledyne API T750 MFC Calibration 17

12.6 Maintenance 18

12.6.1 Teledyne API 700EU Dynamic Dilution Calibrator 18

12.6.2 Teledyne API T700U Dynamic Dilution Calibrator 19

12.6.3 Teledyne API T750 Dynamic Dilution Calibrator 19

12.6.4 Teledyne API 703E Photometric Ozone Calibrator 20

12.6.5 Documentation 21

12.7 O3 Photometer Backpressure Compensation........ 22

12.7.1 - Backpressure Compensation Procedure........ 22

APPENDIX A 23

REFERENCES 24

TABLE OF FIGURES

Figure 1: Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone........ 7

Figure 2: In-lab checks worksheet 9

Figure 3: Alicat MBS Precision Gas Mass Flow Meter 14

Figure 4: MFC Calibration Worksheet 15

Figure 5: Slope/Intercept Calculation ....**Error! Bookmark not defined.**

STANDARD OPERATING PROCEDURES FOR CALIBRATORS

Forsyth County Office of Environmental Assistance and Protection

12.1 General Overview

Calibrators are used to generate gas mix concentrations needed to calibrate instruments analyzing ambient air for different gases ($NO/NO_x/NO_2$, SO_2, or O_3) to a known gas concentration. In the Forsyth County Air Quality network (FCAQ) various different Calibrators are used:

At the Hattie Avenue site a Teledyne API T700U Dynamic Dilution Calibrator is used for $NO/NO_x/NO_2$, SO_2 and O_3 calibrations.

At the Clemmons Middle and Union Cross sites Teledyne API T703 Photometric Ozone Calibrators are used to calibrate O_3 analyzers.

For audit purposes in the FCEAP a Teledyne API T750 Dynamic Dilution Calibrator (SN 123) (travel/audit standard) is used, which is recertified against an EPA standard reference photometer annually.

For backup purposes a Teledyne API 700EU Dynamic Dilution Calibrator and a Teledyne API 703E Photometric Ozone Calibrator are kept at the FCAQ office.

A Teledyne API T703 remains in the Forsyth County Government Center permanently and serves as a bench standard. It is recertified against an EPA standard reference photometer annually.

To supply the calibrators with clean air, Zero Air Generators are connected to the zero air input of the calibrators. The typical Zero Air Generator configuration is a compressor connected to a drying and filtering system, followed by an activated charcoal and Purafil system (see Section 13 Zero Air Generator SOP). The filtered air, now zero air, is used to mix with calibration gas, which is introduced to the analyzer to be calibrated.

In the FCAQ, Teledyne API 701H and T701H High Performance Zero Air Generators are used at the monitoring sites. For audits, an independent two-part zero air system is used that consists of a pump and drier/purifier box.

12.2 Verification of Level 2 and Level 3 Transfer Standards

12.2.1 Transfer Standards Traceability

In ambient air monitoring applications, precise ozone concentrations called standards are required for the calibration of ozone analyzers. Gaseous ozone standards cannot be stored for any practical length of time due to the reactivity and instability of the gas. Therefore, ozone concentrations must be generated and ‘verified’ on site. When the monitor to be calibrated is located at a remote monitoring site, it is necessary to use a transfer standard that is traceable to a more authoritative standard. According to the International Standards Organization (ISO)-International Vocabulary of Basic Terms in Meteorology: Traceability is the ‘property of a measurement result whereby the result can be related to a stated reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty’.

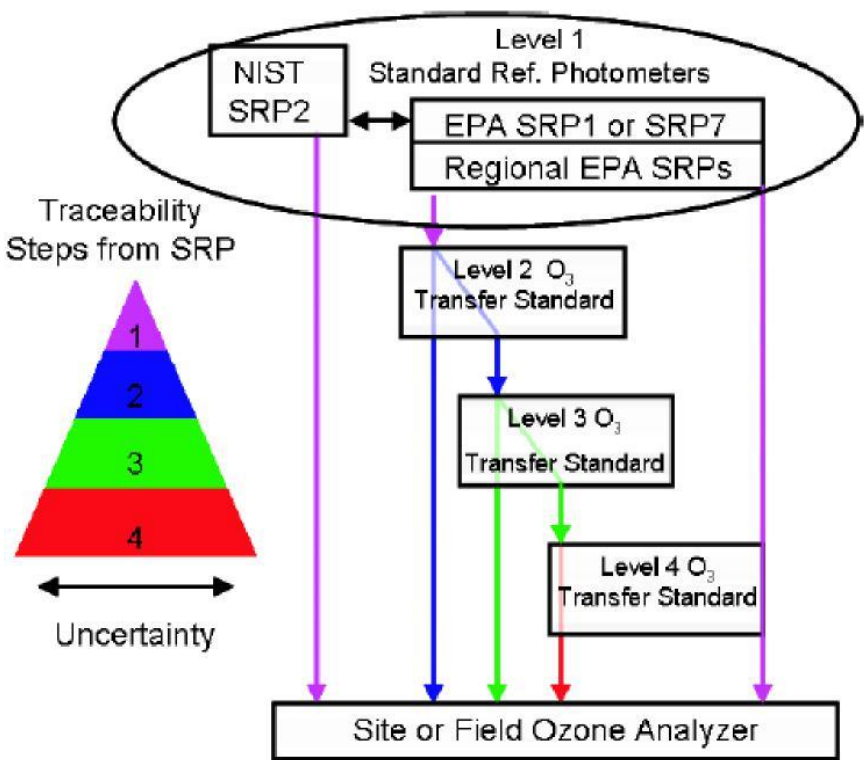

Figure 1: Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone

At least one Level 2 Transfer Standard Photometer has to remain in a stable laboratory environment and is designated as the laboratory primary standard. Currently FCAQ utilizes two level 2 transfer standards. A Teledyne API T703 Photometric Ozone Analyzer (SN 610) (laboratory primary/bench standard) and a Teledyne API T750 Dynamic Dilution Calibrator (SN 78) (trip/audit standard). **The T703 SN 610 and T750 SN 78 should be verified annually against a standard reference photometer (EPA Region 4**

SRP#10) and all previous verifications (up to 6, if available) are used to calculate the T703 SN 610 and T750 SN 78 verification equation. The T703 SN 610 and T750 SN 78 are verified by USEPA Region 4 annually, in accordance with USEPA Region 4 procedures.

All other photometers (Teledyne API 703E Photometric Ozone Calibrators, Teledyne API T703 Photometric Ozone Calibrators, Teledyne API 700EU and T700U Dynamic Dilution Calibrators) operated by FCAQ are referenced directly with the T703 (SN 610) lab/bench standard. Quality assurance checks (audits) of ozone instrumentation are compared to the T750 in the field.

12.2.2 Regulatory Requirements

12.2.2.1 40 CFR Appendix D to Part 50 - Measurement Principle and Calibration Procedure for the Measurement of Ozone in the Atmosphere - This regulation describes the calibration procedure of reference methods for measuring ozone in the atmosphere.

12.2.2.2 U.S. EPA, Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program (EPA-454/B-08-003) - The handbook describes the Ambient Air Quality Surveillance Program and the data collection activities inherent to that program.

12.2.2.3 U.S. EPA, Transfer Standards, For the Calibration of Ambient Air Monitoring Analyzers for Ozone, Technical Assistance Document (EPA-454/B-10-001) - This guidance defines, specifies, and formalizes the verification of ozone transfer standards for calibrating ambient ozone analyzers.

12.3 Ozone Photometer Performance Verification, Calibration and Recertification

12.3.1 Ozone Photometer Tracking

12.3.1.1 All calibrators capable of Ozone generating are equipped with an Ozone photometer. The accuracy of the photometer is critical to ensure accurate calibration gas mixtures where O_3 is involved. Therefore, regular photometer verifications should be performed.

12.3.1.2 If the photometer verification shows more than 4% difference, calibration against an EPA certified photometer should be performed. See section 12.3.3 Ozone Photometer Calibrations.

12.3.1.3 Two Ozone Calibrators used by the FCAQ (Teledyne API T703 (SN 610) and Teledyne API T750 (SN 78)) are verified, if needed calibrated, and recertified yearly against the EPA Region 4 SRP #10 Level 1 Standard Reference Photometer. See section 12.4 Verification of Level 2 and Level 3 Transfer Standards.

12.3.2 Ozone Photometer Verifications

12.3.2.1 Teledyne API 700EU Ozone Photometer Verification

Refer to Teledyne 700EU Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 8.3.1 and Chapter 8.3.2

12.3.2.1.1 Connect the 700EU CAL 1 port to a recently calibrated and accurate O3 Analyzer sample inlet port (i.e. API Model 400E).

Alternatively you can connect the 700EU CAL 1 port to the PHOTO IN port of an level 2 transfer standard (i.e., T703 SN 610) which is generating 0 ppb ozone at 3 lpm. This is the same set up as for the ozone photometer calibration. See section 12.3.3.

12.3.2.1.2 Generate a 225 ppb (span) air concentration with the 700EU Calibrator and allow the T400 Analyzer to sample the test atmosphere for at least 30 minutes. Record the verification point in the 700EU T703 O3 Calibrator In-Lab checks.xls (Fig. 2) file.

O3 Calibrator check

In lab checks only (these checks does NOT replace z/s/p checks, calibrations or audits!)
These checks are only to verify that the instrument is approximately reading what it is supposed to read.
Use after maintenance and repairs or to test a new instrument when receiving.

Date 3/8/2016 **Initials** RA

Reason for check

Maintenance

	Instrument	SN
Generating	700EU	616-S
Reading	703E	59
Gas Cylinder		

	zero	span	mid	prec	low
generate	0	225	150	70	40
read	0	226	151	71	41
stability					
ppb diff	0.00	1.00	1.00	1.00	1.00
% diff	na	0.44	0.66	1.41	2.44
		OK	OK	OK	OK

Observations

Figure 2: In-lab Checks Worksheet

12.3.2.1.3 Repeat the data recording procedure used above generating different O_3 concentrations (i.e. 0 ppb, 150 ppb, 70 ppb, 40 ppb) and record the appropriate data.

12.3.2.1.4 A successful O3 photometer verification is achieved if all recorded concentrations are within 4% of the generated concentrations.

12.3.2.2 Teledyne API T700U Ozone Photometer Verification

Photometer verification of the T700U O3 Photometer is the same as the 700EU procedure. See section 12.3.2.1.1.

12.3.2.3 Teledyne API T750 Ozone Photometer Verification

Photometer verification of the T750 O3 Photometer is the same as the 700EU procedure. See section 12.3.2.1.1.

Note: Verification of the T750 (SN 78 trip/audit standard) O3 Photometer is performed annually against EPA Region 4 SRP #10 Level 1 Standard Reference Photometer.

12.3.2.4 Teledyne API 703E Ozone Photometer Verification

Photometer verification of the 703E O3 Photometer is the same as the 700EU procedure. See section 12.3.2.1.1.

Photometer verification of the T703 O3 Photometer is the same as the 700EU procedure. See section 12.2.3.1.1.

Note: Verification of the T703 (SN 610 laboratory primary/bench standard) O3 Photometer is performed annually against EPA Region 4 SRP #10 Level 1 Standard Reference Photometer.

12.3.3 Ozone Photometer Calibrations

An ozone photometer has to be calibrated after the photometer bench was disassembled for maintenance or repairs and if verification of the ozone photometer shows a difference of more than 4% from the level 2 transfer standard. See section 12.6 for maintenance of the photometer bench.

Two Ozone Calibrators used by the FCEAP (Teledyne API T703 (SN 610) and Teledyne API T750 (SN 78)) are verified, if needed calibrated, and recertified yearly against the EPA Region 4 SRP #10 Level 1 Standard Reference Photometer.

12.3.3.1 Teledyne API 700EU Ozone Photometer Calibration

Refer to Teledyne API 700EU Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 8.3.3

12.3.3.1.1 Connect a zero air system (i.e., T701H) to the level 2 bench transfer standard (i.e., T703 SN 610). The level 2 transfer standard should be supplied with >25 psig at >6-8 lpm flow. Connect the same zero air system to the 700EU Calibrator (level 3 transfer standard). The level 2 transfer standard and the level 3 transfer standard should utilize a common zero air source.

Verify that the internal regulators of the level 2 transfer standard and the 700EU Calibrator internal regulators are displaying approximately 10 psig. Verify that there is excess flow at the manifold vent port at the rear of both the level 2 transfer standard and the 700EU Calibrator by feeling for positive pressure coming out of the vent with your finger.

12.3.3.1.2 Connect the CAL OUT port of the level 2 transfer standard directly to the PHOTOMETER IN port of the 700EU Calibrator with a length of clean 1/4" OD Teflon tubing. **Verify that the level 2 transfer standard vent is open. Make sure the 700EU Calibrator vent is capped.**

12.3.3.1.3 Set the 700EU Calibrator to generate a 0 ppb O_3 concentration at 3 lpm. In the main menu press GEN, AUTO, adjust to 0 O_3, press ENTER, adjust to 3 lpm, press ENTER. Generate a zero air concentration with the level 2 transfer standard and allow the 700EU Calibrator to sample the test atmosphere for at least 30 minutes.

12.3.3.1.4 Record the test variables information from the 700EU Calibrator into the logbook. Also log the ozone reading from the photometer from the level 2 transfer standard and the level 3 calibrator to compare results.

12.3.3.1.5 Generate a 225 ppb O_3 (span) air concentration with the level 2 transfer standard calibrator and allow the 700EU Calibrator to sample the test atmosphere for at least 30 minutes.

12.3.3.1.6 Repeat the data recording procedure used above in section 12.3.3.1.4 and record the appropriate data.

12.3.3.1.7 Repeat step 12.3.3.1.3 generating zero air. When the 700EU has reached a stable zero reading, follow the instructions in the Teledyne API 700EU Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 8.3.4.1, to calibrate the zero point on the 700EU Calibrator. Once you see a stable O_3 reading with less than 1 ppb change in 5 minutes on the 700EU, press the CAL button and choose ZERO, press Enter. Return to the main screen (press Exit). The 700EU should now read zero, if not, repeat the adjustment steps above and inform the program manager.

It is recommended to wait for a good stability (less than 1 ppb change in 5 minutes) before calibrating the point instead of calibrating the point consecutively until the point becomes stable.

12.3.3.1.8 Repeat step 12.3.2.1.5 generating O_3 span gas. When the 700EU has reached a stable zero reading, follow the instructions in the Teledyne API 700EU Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 8.3.4.2, to calibrate the span point on the 700EU Calibrator. Once you see a stable O_3 reading with less than 1 ppb change in 5 minutes on the 700EU, press the CAL button and choose SPAN, press Enter. Return to the main screen (press Exit). The 700EU should now read span, if not, repeat the adjustment steps above or contact the program manager.

It is recommended to wait for a good stability (less than 1 ppb change in 5 minutes) before calibrating the point instead of calibrating the point consecutively until the point becomes stable.

12.3.3.1.9 Press ‘Stby’ on the 700EU Calibrator and level 2 transfer standard to bring both units back in Standby mode. Turn off the zero air generator.

12.3.3.2 Teledyne API T700U Ozone Photometer Calibration

Photometer verification and calibration of the T700U O3 Photometer is the same as the 700EU procedure. See section 12.3.2.1.

12.3.3.3 Teledyne API T750 Ozone Photometer Calibration

Photometer calibration of the T750 O3 Photometer is the same as the 700EU procedure. See section 12.3.3.1.

Note: Verification of the T750 (SN 78, trip/audit standard) O3 Photometer is performed annually against EPA Region 4 SRP #10 Level 1 Standard Reference Photometer. If the Verification shows more than 4% difference, the photometer is out of certification, and a calibration is performed against the EPA Region 4 SRP #10 Level 1 Standard Reference Photometer.

12.3.3.4 Teledyne API 703E Ozone Photometer Calibration

Photometer calibration of the 703E O3 Photometer is the same as the 700EU procedure. See section 12.3.3.1.

12.3.3.5 Teledyne API T703 Ozone Photometer Calibration

Photometer calibration of the T703 O3 Photometer is the same as the 700EU procedure. See section 12.3.3.1.

Note: Verification of the T703 (SN 610, laboratory primary/bench standard) O3 Photometer is performed annually against EPA Region 4 SRP #10 Level 1 Standard Reference Photometer. If the Verification shows more than 4% difference, the photometer is out of certification, and a calibration is performed against the EPA Region 4 SRP #10 Level 1 Standard Reference Photometer.

12.4 Verification and Calibration of Ozone Generators

Verification and Calibration of an Ozone Generator is an automated process stored in the instrument's internal storage. Refer to Teledyne API Calibrator Manual to perform the Ozone Generator calibration.

12.4.1 Teledyne API 700EU Ozone Generator Verification and Calibration

12.4.1.1 Verifying the Teledyne API 700EU Ozone Generator

Connect a zero air system to the 700EU Calibrator which should supply the calibrator with >25 psig at >6-8 lpm flow. Connect the 700EU Calibrator to a level 2 transfer standard (i.e., T703 SN 610) as a reference photometer.

12.4.1.1.1 With the 700EU calibrator generate a 225 ppb O_3 concentration at 3-4 lpm. Observe the reference photometer. The observed O_3 concentration must be within ± 1%, if not the O_3 Generator has to be calibrated by running the automated process on the calibrator.

12.4.1.2 Calibrating the Teledyne API 700EU Calibrator O_3 Generator

Refer to Teledyne API 700EU Dynamic Dilution Calibrator Manual, Section 8.4.3.

The O_3 Generator of the 700EU Calibrator has to be calibrated after the generator is disassembled for maintenance or repairs and routinely at least once a year. See section 12.4.1 for maintenance of the O_3 Generator.

Record the performed O_3 Generator Calibration in the instrument log book.

12.4.2 Teledyne API T700U Generator Verification and Calibration

Verification and Calibration of a T700U O3 Generator is the same procedure as for a 700EU, see section 12.4.1

12.4.3 Teledyne API T750 Generator Verification and Calibration

Verification and Calibration of a T750 O3 Generator is the same procedure as for a 700EU, see section 12.4.1.

12.4.4 Teledyne API 703E Generator Verification and Calibration

Verification and Calibration of a 703E O3 Generator is the same procedure as for a 700EU, see section 12.4.1.

12.4.5 Teledyne API T703 Generator Verification and Calibration

Verification and Calibration of a T703 O3 Generator is the same procedure as for a 700EU, see section 12.4.1.

12.5 Mass Flow Controller Calibration

Applicable for Teledyne API 700EU, T700U and T750 Dynamic Dilution Calibrators

A separate flow measuring device (i.e., Alicat MBS Precision Gas Mass Flow Meter, Fig. 3 is needed for this calibration procedure. The Diluent (DIL) Mass Flow Controller (MFC) and all Calibration Gas (CAL1 & CAL2) MFC's have to be calibrated electronically every 6 months. A total of 20 flow points have to be adjusted for each MFC (see Fig. 4).

Figure 3: Alicat MBS Precision Gas Mass Flow Meter

The instruments MFC flows can be calibrated by either adjusting the Drive Voltage to receive a most accurate actual/desired flow or by input of the observed flow at certain Drive Voltage settings. FCOEAP leaves each point in the table at its preset flow and adjusts the drive voltage to achieve the desired flow on the certified flow standard (i.e., Alicat MBS).

12.5.1 Teledyne API 700EU MFC Calibration using an Alicat MBS flow meter

12.5.1.1 Start with the DIL1 MFC which regulates flow of 0-10 lpm. Choose the correct Alicat MBS unit (Fig. 3) for the flow to be measured.

12.5.1.2 Connect the Alicat MBS inlet port directly to the 700EU MFC DIL1 outlet port facing the front side of the 700EU (flow direction is MFC → Alicat MBS). Make sure the 700EU is connected to a source of zero air producing 30 psig. The Zero Air Supply has to able to produce up to 40 psig needed for higher DIL1 flows.

12.5.1.3 Follow the procedure in the Teledyne API 700EU Dynamic Dilution Calibrator Manual, Chapter 8.2.

- Make sure the MFC flow set points are set to the original manufacturer settings (see Fig. 4).

- Make sure the Alicat MBS unit is appropriate for the flow to be observed.

- Make sure there is gas flow present at the outlet of the MFC.

12.5.1.4 Observe the Alicat MBS flow reading, once you have a stable flow reading, enter the Alicat MBS flow reading into the *700EU Recert mm-dd-yy.xlsx* file (Fig. 4), column “Flow As Found [SLPM]”. Enter the current Drive Voltage setting into the “Drive Volts As Found [mV]” column.

Figure 4: MFC Calibration Worksheet

12.5.1.4.1 Next adjust the Drive Voltage up or down to raise or lower the flow, respectively. Usually only small adjustments on the order of 10-20 mV are necessary. Continue making Drive Voltage adjustments until the Alicat MBS is reading the ideal flow for that point.

12.5.1.4.2 Enter the adjusted Drive Voltage into the “Drive Volts Adjusted [mV]” column. Enter the new flow reading into the “Flow After Adjustment [SLPM]” column. Ideally, the adjusted flow will equal the ideal flow and the “Flow After Adjustment [SLPM] % Diff.” column should be all zeroes.

12.5.1.4.3 Repeat this procedure for all 20 points for the diluent MFC. To run higher flows (7-10 lpm, points 14 to 20) increase the pressure on the zero air supply to 38-40 psig by turning the pressure adjustment knob on the Zero Air Supply.

12.5.1.4.4 Once all points have been entered, press ENTER. The 700EU will ask if the changes should be saved, press YES.

12.5.1.5 Connect the appropriate Alicat MBS unit to the CAL1 MFC in the 700EU (0-100 sccm). Repeat steps 12.5.1.4-12.5.1.4.4 to calibrate the CAL1 MFC (0-100 sccm).The T700U and T750 CAL1 MFCs have a larger flow range than a 700EU. To avoid using two Alicats and thereby creating a jump point within the MFC table, only use one Alicat MBS. See section 12.5.2 for the T700U procedure and section 12.5.3 for the T750 procedure for CAL1.

12.5.1.6 Connect the appropriate Alicat MBS to the CAL2 MFC in the 700EU (0-50 sccm). Repeat steps 12.5.1.4-12.5.1.4.4 to calibrate the CAL2 MFC (0-50 sccm).

12.5.1.7 After calibrating all three MFCs, disconnect the Alicat MBS from the last 700EU MFC.

12.5.1.8 Record a note in the AirVision logbook, graph and instrument logbook of the performed MFC Calibration.

12.5.2 Teledyne API T700U MFC Calibration

12.5.2.1 MFC Calibration on a Teledyne API T700U Dynamic Dilution Calibrator is nearly the same procedure as on a Teledyne API 700EU Dynamic Dilution Calibrator. The T700U has a wider range CAL1 MFC which would require two Alicat MBS units. This would create a breakpoint within the MFC table which is undesirable. In order to avoid this, only one Alicat unit will be used over points 0-10. Drive voltages will be calculated for points 11-20.

12.5.2.2 Follow the procedure outlined in sections 12.5.1.4 – 12.5.1.4.2 for points 0 through 10.

12.5.2.3 In the Excel spreadsheet, enter the “Drive Volts Adjusted [mV]” values into the “Adjusted mV” column on the left hand side of the spreadsheet for points 2 through 9 (Figure 5).

Point	Adjusted mV	Adjusted LPM
2	459	0.020
3	691	0.030
4	923	0.040
5	1156	0.050
6	1389	0.060
7	1623	0.070
8	1855	0.080
9	2089	0.090
	slope	0.0000429
	intercept	0.0003344

Figure 5: Slope/Intercept Calculation

12.5.2.4 Also in the Excel spreadsheet, enter the "Flow after Adjustment [SLPM]" values into the "Adjusted LPM" column on the left hand side of the spreadsheet for points 2 through 9 (Figure 5).

12.5.2.5 A slope and intercept will be calculated. The Excel spreadsheet should already be configured to use the ideal flow and this slope and intercept relationship to calculate an adjusted Drive Voltage.

12.5.2.6 Enter the values from the "Drive Volts Adjusted [mV]" column into the calibrator's MFC table for points 11-20. While entering these numbers, please make sure to note the original Drive Voltage setting in the "Drive Volts As Found [mV]" column before making any edits if you have not already done so.

12.5.2.7 Once all values have been entered into the calibrator, exit out of the menu and when prompted by the calibrator to save changes, press yes.

12.5.3 Teledyne API T750 MFC Calibration

MFC Calibration on a Teledyne API T750 Dynamic Dilution Calibrator is nearly the same procedure as on a Teledyne API 700EU Dynamic Dilution Calibrator. The T750 has a wider range CAL1 MFC which would require two Alicat MBS units. This would create a breakpoint within the MFC table which is undesirable. In order to avoid this, only one Alicat unit will be used over points 0-10. Drive voltages will be calculated for points 11-20. Follow the steps in sections 12.5.2.2 – 12.5.2.7 as the T700U and T750 have an identical procedure for the Cal 1 MFC.

12.6 Maintenance

12.6.1 Teledyne API 700EU Dynamic Dilution Calibrator

Once a year the Calibrator should be cleaned and checked for proper function. Before turning off the instrument, check the instruments diagnostics by using the ‘Test’ button on the front panel display. If there are any discrepancies to the manufacturer’s specifications they should be addressed directly during maintenance. Refer to the respective Teledyne API 700x Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 10.2.

12.6.1.1 Open the instrument and clean the inside.

12.6.1.2 Check all pneumatic connections for tightness and all electrical connectors for proper seating.

12.6.1.3 Inspect the photometer bench (remove bench cover) and UV lamp seating.

12.6.1.4 Connect a zero air source to the instrument, turn the instrument on and let it warm up for at least 30 minutes.

12.6.1.5 Perform an auto leak check. Refer to Teledyne API Service Note 10-017A. Remember that the provided pressure is between 25-35 psi, if not, the leak check will fail! Refer to Teledyne API 700x Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 8.5 and 10.2.5.

12.6.1.6 Calibrate the regulator and ambient pressure sensors. Remember that the provided pressure is between 25-35 psi, if not, the leak check will fail! Refer to Teledyne API 700x Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 8.5.

12.6.1.7 Calibrate the photometer flow and output flow; refer to Teledyne API 700x Dynamic Dilution Calibrator Manual, Chapter 8.3.6. The instructions for the flow calibration in the manual are not fully correct! Use appendix A1. for a correct flow calibration!

12.6.1.8 Adjust the UV lamp output to 4400-4600 mV. Refer to Teledyne API 700x Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 10.2.3.

12.6.1.8.1 Check the UV lamp temperature reading for a stable reading at 58ºC. Loosen the UV lamp and turn it to a maximum mV output. Tighten UV lamp. (The manual might say turn UV lamp to minimum mV, this is incorrect! Contacting Teledyne API reconfirmed that a maximum mV output is desired for the UV lamp adjustment.)

12.6.1.8.2 On the other end of the photometer bench locate the gain adjustment pot under the small cap and adjust to 4400-4600 mV. Turn the pot very slowly and in small increments. Let the mV settle before continuing turning the pot.

12.6.1.9 Place the cover back on the instrument and perform a photometer dark calibration (this is an automated process). Refer to Teledyne API 700x Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 8.3.5.

12.6.1.9 Adjust the O3 generator UV lamp output to approximately 2500 mV. Refer to Teledyne API 700x Dynamic Dilution Calibrator Manual, Rev. B4 July 2009, Chapter 10.2.5.

12.6.1.10 Verify the 700x O3 Photometer Performance (see section 12.3.2).

12.6.1.11 Verify the 700x O3 Generator Performance (see section 12.4).

12.6.2 Teledyne API T700U Dynamic Dilution Calibrator

Maintenance procedures for a T700U Dynamic Dilution Calibrator are the same as for 700EU Dynamic Dilution Calibrator. See section 12.6.1.

12.6.3 Teledyne API T750 Dynamic Dilution Calibrator

Once a year, before Ozone season starts, every Ozone Calibrator should be cleaned and checked for proper function. Before turning the instrument off, check the diagnostics by using the test button on the front panel display. If there are any discrepancies to the manufacturer’s specifications they should be addressed and the program manager informed of the issues. Refer to Teledyne API T750 Dynamic Dilution Calibrator Manual, Feb 2015, Chapter 8.2.

12.6.3.1 Open the instrument and clean the inside.

12.6.3.2 Check all pneumatic connections for tightness and all electrical connectors for proper seating.

12.6.3.3 Inspect the photometer bench (remove bench cover) and UV lamp seating.

12.6.3.4 Connect a zero air source to the instrument, turn the instrument on and let it warm up for at least 30 minutes.

12.6.3.5 Calibrate diluent, cal gas, regulator and ambient/sample gas pressure sensors. Refer to Teledyne

API T750 Dynamic Dilution Calibrator Manual, Feb 2015, Chapter 7.5.

12.6.3.6 Perform an auto leak check. Refer to Teledyne API T750 Dynamic Dilution Calibrator Manual, Chapter 8.2.1. Remember that the provided pressure is between 25-35 psi, if not, the leak check will fail!

12.6.3.7 Calibrate the photometer flow and output flow; refer to Teledyne API T750 Dynamic Dilution Calibrator Manual, Feb 2015, Chapter 7.3.6. The instructions for the flow calibration in the manual are not fully correct! Use appendix A1. for a correct flow calibration.

12.6.3.8 Adjust the UV lamp output to 4400-4600 mV. Refer to Teledyne API T750 Dynamic Dilution Calibrator Manual, Feb 2015, Chapter 8.2.4.

12.6.3.8.1 Loosen the UV lamp and turn it to a maximum mV output. Tighten UV lamp. (The manual might say turn UV lamp to minimum mV, this is incorrect! Contacting Teledyne API reconfirmed that a maximum mV output is desired for the UV lamp adjustment.)

12.6.3.8.2 On the other end of the photometer bench locate the gain adjustment pot under the small cap and adjust to 4400-4600 mV. Turn the pot very slowly and in small increments. Let the mV settle before continuing turning the pot.

12.6.3.9 Place the cover back on the instrument and perform a photometer dark calibration (this is an automated process). Refer to Teledyne API T750 Dynamic Dilution Calibrator Manual, Feb 2015, Chapter 7.3.5.

12.6.3.10 Adjust the O3 generator UV lamp output to approximately 2500 mV. Refer to Teledyne API T750 Dynamic Dilution Calibrator Manual, Feb 2015, Chapter 8.2.5.

12.6.3.11 Verify the T750 O3 Photometer Performance (see section 12.3.2).

12.6.3.12 Verify the T750 O3 Generator Performance (see section 12.4.).

12.6.4 Teledyne API 703E Photometric Ozone Calibrator

Once a year, before Ozone season starts, every Ozone Calibrator should be cleaned and checked for proper function. Before turning the instrument off, check the diagnostics by using the test button on the front panel display. If there are any discrepancies to the manufacturer’s specifications they should be addressed and the program manager informed of the issues. Refer to Teledyne API 703E Photometric Ozone Calibrator Manual, May 2011, Chapter 8.3.

12.6.4.1 Open the instrument and clean the inside.

12.6.4.2 Check the Dry Air Pump. If needed, repair the pump; refer to Teledyne API 703E Photometric

Ozone Calibrator Manual, May 2011, Chapter 10.4

12.6.4.3 Check all pneumatic connections for tightness and all electrical connectors for proper seating.

12.6.4.4 Inspect the photometer bench (remove bench cover) and UV lamp seating.

12.6.4.5 Connect a zero air source to the instrument, turn the instrument on and let it warm up for at least 30 minutes.

12.6.4.6 Calibrate the regulator and ambient pressure sensors; refer to Teledyne API 703E Photometric Ozone Calibrator Manual, May 2011, Chapter 8.3.

12.6.4.7 Calibrate the photometer flow and output flow; refer to Teledyne API 703E Photometric Ozone Calibrator Manual, Chapter 8.4.1-8.4.2. The instructions for the flow calibration in the manual are not fully correct! Use appendix A1. for a correct flow calibration.

12.6.4.8 Adjust the UV lamp in output to 4400-4600 mV. Refer to Teledyne API 703E Photometric Ozone Calibrator Manual, May 2011, Chapter 10.5.

12.6.4.8.1 Check the UV lamp temperature reading for a stable reading at 58ºC. Loosen the UV lamp and turn it to a maximum mV output. Tighten UV lamp. (The manual might say turn UV lamp to minimum mV, this is incorrect! Contacting Teledyne API reconfirmed that a maximum mV output is desired for the UV lamp adjustment.)

12.6.4.8.2 On the other end of the photometer bench locate the gain adjustment pot and adjust to 4400-4600 mV. Turn the pot very slowly and in small increments. Let the mV settle before continuing turning the pot.

12.6.4.9 Adjust the O3 generator UV lamp output to approximately 2500 mV. Refer to Teledyne API 703E Photometric Ozone Calibrator Manual, May 2011, Chapter 10.7.

12.6.4.10 Place the cover back on the instrument and perform a photometer dark calibration (this is an automated process). Refer to Teledyne API 703E Photometric Ozone Calibrator Manual, May 2011, Chapter 8.1.4.

12.6.4.11 Verify the 703E O3 Photometer Performance (see section 12.3.2).

12.6.4.12 Verify the 703E O3 Generator Performance (see section 12.4.).

12.6.5 Documentation

Document all problems, maintenance, test results, and verifications completed on the calibrators using other calibrators and/or analyzers to track the quality of the calibrators performance. All results should be logged in the Microsoft Teams ► \Analysis-Monitoring\Equipment\Repair Supplies and Logs folder under the Ambient Equipment Repair Log CAL.xls file. Find the corresponding tab for each unit based on serial number within the excel sheet and add documentation to track the equipment's history.

12.7 O3 Photometer Backpressure Compensation

At initial set up and any time the pneumatic configuration is changed (i.e. new line installed, change of line length, repositioning of vent…), the internal measure/reference pressure can be impacted and result in incorrect Ozone readings. Therefore the backpressure compensation should be performed.

12.7.1 - Backpressure Compensation Procedure

The backpressure compensation is an automated process, refer to the respective Teledyne API Dynamic Dilution/Photometric Ozone Calibrator Manual.

12.7.1.1 Make sure to bypass any solenoids incorporated in the line (usually in the Cal Gas line leading to the sample inlet at the probe box) to ensure a continuous air flow is possible.

12.7.1.2 For a more accurate backpressure compensation, detach the sample line on the back of any API T400 Ozone Analyzer that may be connected. The vacuum produced by the analyzer has a destabilizing effect on the backpressure compensation procedure.

12.7.1.3 After a successful backpressure compensation, reattach the sample line to the back of the analyzer and remove the solenoid bypass installed in step 12.7.1.1.

APPENDIX A

A1. Photometer and output flow calibration 703E/700EU

Photometer and output flow calibration 703 EU

As the instructions for the flow calibration in the 703 EU manual are not correct, useful, halfway complete…, FCEAP talked to API.

Following is the correct procedure as described by a technician who guided staff through the process while FCEAP performed the flow calibration.

Feed Zero air into the 703 EU.

The internal Zero Air pump has to be turned off during this procedure.

First adjust Sample and Regulator pressure on the 703 EU. See manual.

<u>To calibrate Photometer Gas Flow:</u>

Connect BiosDry Cal to the inlet port of the photometer bench, on the detector side. Flow will go from the Bios to the photometer bench, check for correct setup. All Output ports have to be plugged (Vent; Exhaust; Cal2). Keep only **Cal 1 open**.

Now refer to the 703 EU manual "Calibrating the photometer's sample gas flow".

Wait for flow and run the BiosDry Cal.

When prompted with the **Actual photo flow: 1.000 LPM**, do not hit Enter, instead **Exit out** up to the sub menu!

Note the flow value from the BioDry Cal.

Remove the BiosDry Cal from the photometer bench and put everything back to "normal".

Restart the "Calibrating the photometer's sample gas flow" from the manual and when prompted with the Actual photo flow: 1.000 LPM, enter the **BiosDry Cal value** you just noted. Push Enter to save.

<u>To calibrate the Output Gas Flow:</u>

Now connect the BiosDry Cal to the **CAL 1 port** on the back of the 703 EU. Flow will go from the 703 EU Cal 1 port to the BiosDry Cal.

Now refer to the 703 EU manual "Performing an output gas flow calibration".

Exit out from the Actual photo flow and wait for the **Actual outputflow: 1.000 LPM**.

Run the BiosDry Cal and enter the observed flow. Hit enter to save.

REFERENCES

Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone, Technical Assistance Document. EPA-600/4-79-056. United States Environmental Protection Agency, September 1979.

Technical Assistance Document for the Calibration of Ambient Ozone Monitors. EPA-600/4-79-057. United States Environmental Protection Agency, September 1979.

Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone. Technical Assistance Document. EPA-454/B-10-001. United States Environmental Protection Agency, October, 2013.

Operators Manual, Photometric Ozone Analyzer 703E, May 2011, Teledyne Instruments Advanced Pollution Instrumentation Division, 9480 Carroll Park Drive, San Diego, CA 92121-5201.

Technical Manual, Dynamic Dilution Calibrator 700EU, Rev. B4 July 2009,, Teledyne Instruments Advanced Pollution Instrumentation Division, 9480 Carroll Park Drive, San Diego, CA 92121-5201.

Technical Manual, Dynamic Dilution Calibrator T700U May 2012, Teledyne Instruments Advanced Pollution Instrumentation Division, 9480 Carroll Park Drive, San Diego, CA 92121-5201.

User Manual, Models T703 and T703U Photometric O_3 Calibrators with NumaView™ Software, January 2020, Teledyne Advanced Pollution Instrumentation, 9970 Carroll Canyon Road, San Diego, CA 92131-1106.

Technical Manual, Dynamic Dilution Calibrator T750, Feb 2015, Teledyne Instruments Advanced Pollution Instrumentation Division, 9480 Carroll Park Drive, San Diego, CA 92121-5201.