FORSYTH COUNTY OFFICE OF ENVIRONMENTAL ASSISTANCE AND PROTECTION

STANDARD OPERATING PROCEDURE (SOP)

OZONE

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.

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REVISION	DATE	CHANGES TO SOP

STANDARD OPERATING PROCEDURES FOR OZONE

Forsyth County Office of Environmental Assistance and Protection

1.0 Introduction

All equipment, chemicals, field operating procedures, and laboratory operating procedures used during the continuous measurement of ozone in the atmosphere will satisfy the ultra-violet photometric method (equivalent method) EQOA-0992-087 requirements. The following procedure manual is to be used as a supplement to the Code of Federal Regulations (CFR). Siting and various quality assurance (QA) procedures are followed in accordance with the Code of Federal Regulation Title 40 Part 50, Part 58 and EPA-454/B-13-003: Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II Ambient Air Quality Monitoring Program.

This “Standard Operating Procedure” (SOP) will provide guidance for the monitoring of ozone using the ESC 8832 datalogger, Teledyne API 400E Ozone Analyzer (Equivalent Method Number: EQOA-0992-087), Teledyne API 703E Photometric Ozone Calibrator, Teledyne API 700EU Dynamic Dilution Calibrator and a Teledyne API 701H Zero Air Generator.

1.1 Procurement of Calibration Standards, Zero Air, and Monitoring Instrumentation

1.1.1 General Information

1.1.1.1 Calibration standards produce known concentrations of ozone using a calibrated and verified level 2 ozone calibrator transfer standard and level 3 ozone calibrator transfer standard. Zero air is produced by a process of drying and purifying ambient air.

1.1.1.2 All calibrations, audits, and quality control checks must establish traceability to a level 2 or 3 ozone calibrator transfer standard that has been verified as traceable by comparison to an EPA level 1 standard reference photometer. Two calibrator instruments are taken down to Region 4 in Athens each year for certification or, if needed, calibration. One serves as our level 2 bench standard and the other is our level 2 transfer standard.

1.1.1.3 Zero air supplies are not certified to NIST standards but must meet specific requirements (See section 1.1.2.6) and operate in good working order.

1.1.2 Specifications for Calibration Standards, Zero Air and Monitoring Instrumentation

1.1.2.1 Calibration gases are produced using a UV photometric ozone calibrator and a zero air generator. The level 2 bench standard calibrator is a Teledyne API 703E Ozone Calibrator (SN 59) (stationary in laboratory) and the level 2 transfer standard is a Teledyne API T700U Dynamic Dilution Calibrator, which is used as the quality assurance (audit) standard. The field calibration standards (level 3 transfer standards) are Teledyne API 703E Photometric Ozone Calibrators and a Teledyne API 700EU Dynamic Dilution Calibrator. Teledyne API 701 H Zero Air Generators are used as zero air supplies. Calibration gases are produced by exposure of zero air to a UV light source (185 nm) within the transfer standard calibrator. The concentration of ozone in the gas stream is determined by measuring the attenuation of light due to the ozone in the absorption tube. Varying the flow of air through the system or varying the voltage applied to the UV lamp in the ozone chamber produces various concentrations of ozone.

1.1.2.2 Ozone concentrations used for multi-point verifications/calibrations are produced by a verified calibration standard calibrator. Multi-point calibrations consist of a zero and 4 upscale points, the highest being a concentration of 80%-90% of the calibration scale range of the analyzer (0 - 0.250 ppm). The points are listed below.

Point 1: 0 ppm O3 (Zero)

Point 2: 0.225 ppm O3 (Span)

Point 3: 0.150 ppm O3 (Mid-point)

Point 4: 0.070 ppm O3 (Precision)

Point 5: 0.040 ppm O3 (Low Point)

1.1.2.3 Audit concentrations must be produced by a system independent of the routine calibration system. A minimum of a zero point and three upscale points should be chosen to bracket 80% of the ambient data in Forsyth County. 80% of ambient data ranges from 0.030-0.075 ppm. For FCEAP, three of the points chosen must be in the three required levels in the following ranges. Additional points can be added and run in any other level.

Level 1: 0.004 - 0.0059 ppm O3

Level 2: 0.006 - 0.019 ppm O3 (required)

Level 3: 0.020 - 0.039 ppm O3

Level 4: 0.040 - 0.069 ppm O3

Level 5: 0.070 - 0.089 ppm O3 (required)

Level 6: 0.090 - 0.119 ppm O3

Level 7: 0.120 - 0.139 ppm O3

Level 8: 0.140 - 0.169 ppm O3

Level 9: 0.170 - 0.189 ppm O3

Level 10: 0.190 - 0.259 ppm O3 (required)

1.1.2.4 Ozone concentrations used to perform precision checks are produced by a level 3 transfer standard calibrator and should target 0.070 ppm O3.

1.1.2.5 Ozone concentrations used for span checks are produced by a level 3 transfer standard calibrator and should target 0.225 ppm O3.

1.1.2.6 Zero air to be used for Verifications, Calibrations, Zero, Bi-weekly (Precision) Checks, and audits must be free of contaminates which will cause a detectable response on the O3 analyzer. The zero air should contain < 0.002 ppm O3. Air from a zero air generator or a pump (oil-less piston or diaphragm) may be used. Zero air from a pump must be scrubbed in some manner (i.e.-silica gel, charcoal, and molecular sieve) and routed through a particulate filter.

1.1.3 Initial Monitor Checks

1.1.3.1 Ozone instrumentation must meet the requirements of the CFR for reference or equivalent methods as described in 40 CFR Part 53. A list of EPA designated reference and equivalent methods are available from EPA.

1.1.3.2 Upon receipt of monitoring instrumentation, check the following:

a. An EPA designation sticker must be affixed to the instrument.

b. A factory manual must accompany the instrument.

c. All circuit boards should be in position and nothing obviously broken.

d. Instrument must be tested and performance documented in the FCEAP master Excel spreadsheet containing all check records for network equipment. This document is located in the S:\A&M\Repair Supplies and Logs\Instruments checks folder and is called 400E O3 Analyzer In-Lab checks.xls. Below is the layout:

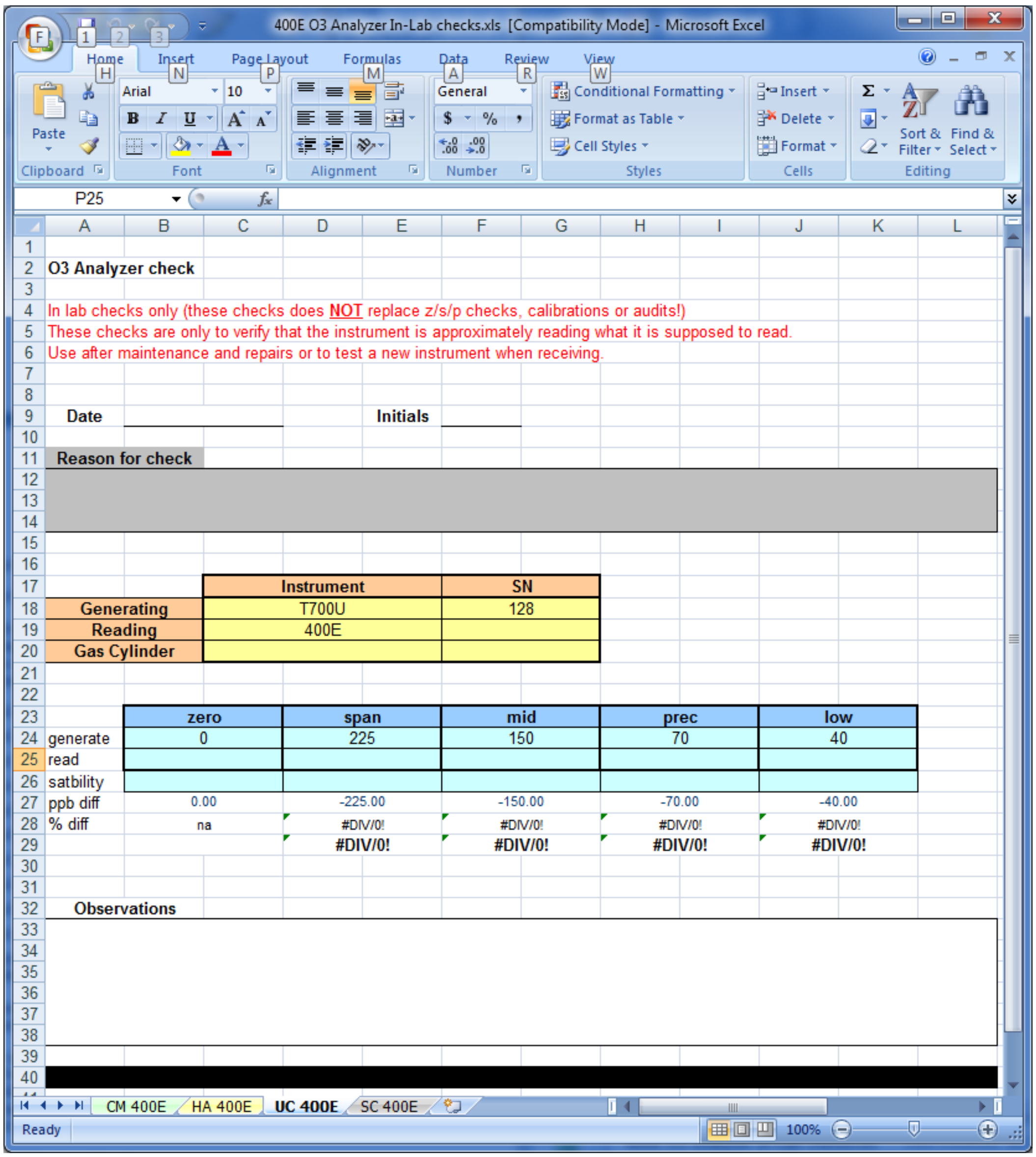

Figure 1: Instrument In-Lab Checks Worksheet

After calibration, if 2% error tolerances are not met, inform the Program Manager and contact the manufacturer.

1.2 Initial Monitor Setup

1.2.1 Site Requirements

To insure the uniform collection of air quality data, various siting criteria must be followed. 40 CFR 58 Appendix E outline these criteria. The criteria are summarized below for neighborhood scale site for ozone.

1.2.1.1 The sample inlet must be located 2-5 m above ground and a distance from the supporting structure > 1 m.

1.2.1.2 The probe inlet must be > 10 meters from the drip line of trees that are located between the urban city core and along the predominant summer daytime wind direction.

1.2.1.3 The distance from the probe inlet to any obstacles such as buildings must be at least twice the height the obstacle protrudes above the probe inlet.

1.2.1.4 There must be unrestricted airflow 270° around the inlet probe, or 180° if the probe is on the side of a building. The 270° arc must include the predominant wind direction for the season of greatest pollutant concentration. In the Winston-Salem area, greatest ozone concentrations exist from May until September. The primary wind direction during this period is SW.

1.2.1.5 The sample line should be as short as practical and should be constructed of FEP Teflon.

1.2.1.6 If the above siting criteria cannot be followed, it must be thoroughly documented and a waiver requested from the Air, Pesticides and Toxics Management Division (APTMD) of the USEPA. A complete site evaluation including all dimensions, pictures, maps, and the monitoring objective should be prepared as the site is being set up. This documentation should be maintained in the annual monitoring network plan.

1.2.2 Monitor Installation – Teledyne API 400E Ozone Analyzer

1.2.2.1 The analyzer should be placed on a sturdy table or in an appropriately sized instrument rack.

1.2.2.2 The table or rack should be as vibration-free as possible.

1.2.2.3 The analyzer must operate within 5-40 °C, but FCEAP will operate within the temperature range of 20 - 30 °C (68 -86 °F).

1.2.2.4 A verified thermometer should be installed near the analyzer to observe temperature fluctuations to insure that temperature criteria are met. It is polled and checked along with other data to make sure it falls within limits. Identify and correct problem if it is not within limits.

1.2.2.5 Confirm that a 5-µm Teflon particulate filter is installed in the analyzer filter holder, which is located on the inside of the instrument front panel.

1.2.2.6 Plug in analyzer.

1.2.2.7 Turn on power switch.

1.2.2.8 Check that the instrument is booting the firmware. Clear the ‘System Reset’ warning message and let it warm up for at least 1 hour. Use the ‘Test’ buttons to check the instruments diagnostics. If the sample flow is outside its ranges, check for blockages, pump condition, and/or leaks.

1.2.2.9 Connect ambient air to be measured to the bulkhead connector labeled ‘Sample’ on the rear panel of the instrument. Care should be taken so that dirty, wet, or incompatible materials in the sample lines do not contaminate the sample. Teflon (FEP) or borosilicate glass with an OD of 1/4" and a minimum ID of 1/8" is required for all sample lines. The length of the tubing should be held to a minimum.

1.2.2.10 Connect the calibration standard ozone bulkhead fitting to the ozone solenoid valve that feeds ozone calibrator concentrations to the sample probe box outside the building via a Teflon (FEP)line with OD of 1/4” and a minimum ID of 1/8”. The transfer standard will send ozone concentrations up the cal gas line into the probe box to a “tee”. The tee is also connected to the short inlet line that goes to the inlet funnel and the sample feed going to the analyzer. In ambient operation the analyzer pulls ambient air from the inlet line and the cal gas line is sealed by the solenoid. In calibration operation the transfer standard supplies ozone concentrations through the solenoid and cal gas line up to the probe box. The analyzer pulls what it needs through the sample line and the inlet line becomes the vent for the excess cal feed. The entire sample path except the short inlet line (less than 12”) is used during all reportable QC/QA checks.

1.2.2.11 An ESC 8832 Datalogger is used as the Datalogger. The Teledyne API 400E Ozone Analyzer is connected to the 8832 through an analog connection. Configurations for individual channels are programmed into the 8832 Datalogger, site computer, and Office polling computer. Refer to Section 11 Datalogger 8832 SOP for more information. Check that the Datalogger channel has been properly initialized as follows:

1.2.2.11.1 To Login into the 8832, open ‘HyperTerminal’ on the PC and connect to the 8832 through the appropriate COM port or by using the correct IP address.

Type Esc ‘site ID’ AQM to enter Login screen.

Site ID in the Forsyth County Network:

Clemmons Middle (CM)

Hattie Avenue A (HA)

Hattie Avenue B (HB)

Peter's Creek (PC)

Shiloh Church (SC)

Union Cross (UC)

Press L (Login), type password, press Enter. Then press C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration). Press Enter to see the channel configurations.

1.2.2.11.2 Check the channel configuration entries to ensure that they correspond to the entries listed below:

ESC 8832 v3.02 ID:CM Standard Channel Config. 11/04/14 14:13:38

Instrument Name	: OZONE
Analog Input Number	: 01
Report Channel Number	: 01
Volts Full Scale	: 1
High Input	: 1 V
Low Input	: 0 V
High Output (E.U.s)	: 0.2462 (Can be different but should be close to 0.250)
Low Output (E.U.s)	: 0.0105 (Can be different but should be close to zero)
Units	: PPM
Base Avg. Interval, Storage	: 1m, 16d 1h 15m (Needs to be at least 14 days)
Average #1 Interval, Storage	: 15m, 0s
Average #2 Interval, Storage	: 1h, 14d 9h (Needs to be at least 14 days)
Use Time-on-line Valid (Y/N)	: N
FINISHED (Configure Now)	: 11/04/14 10:06:51

1.2.2.12 The site computer utilizing E-DAS Digi-Trend software is also used to backup the hourly data from the Datalogger. The local computer polls the minute and calibration data from the 8832 Datalogger each hour to maintain a local copy on site. Using the slope and intercept from the 400E records calculation we can recover lost hourly data from the minute data on the 8832.

1.2.3 Initial Analyzer Checks and Adjustment of the Teledyne API 400E Ozone Analyzer

1.2.3.1 Turn the instrument's power switch to ON. The instrument will display various 'Loading' screens while it is warming up and conducting self-tests. After loading has finished, press 'Clr' button on the instrument to clear the 'System Reset' warning message.

1.2.3.2 To set the time and date press 'Setup, Clk, Time or Date', adjust using the corresponding buttons, press Enter to save settings and 'Exit back out to the main screen. Time on all instruments should be set to and kept on Eastern Standard Time (EST). To set the ambient pressure, press 'Test' button to reach PRES in-Hg-A and press 'Enter'.

1.2.3.3 Allow the instrument to warm up for at least 1 hour.

1.3 Multi-point Calibrations of a Teledyne API 400E Ozone Analyzer

Ozone analyzers are to be calibrated upon receipt, when installed, if moved from current location, at the start of the ozone season, and when certain repairs are made. An adjusted calibration may be necessary if an analyzer malfunctions and is repaired, or if power is lost for more than 24 continuous hours at a site.

An Adjusted Calibration, during which the lowest point (Zero) and the highest point (Span) are adjusted on the analyzer itself, is used at the start of every ozone season and/or when a biweekly ZSP check or 90 day verification fails. The resulting slope and intercept values are automatically stored in the instruments memory. In addition, a new slope and intercept will be calculated comparing the analog voltage (from the instrument) and the engineering units output from the 8832 datalogger in the Excel site logbook. This updated slope and intercept will be entered into the 8832. The adjusted calibration resets the performance check (Bi-weekly Zero/Span/Precision) schedule, starting with the performance date of the Adjusted Calibration.

During a 90 day verification (multipoint check - 4 points plus a zero) the results are recorded in "as found" condition. The 90 day verification does not reset the Bi-weekly Zero/Span/Precision (ZSP) schedule. The (ZSP) will remain on its previous schedule.

1.3.1 Adjusted Multi-point Calibration

1.3.1.1 Typically the only time an Adjusted Calibration is performed will be at the beginning of the ozone season. It can also be called the "Initial Calibration". Adjusted calibrations are not required for pump replacement or source lamp replacement. The initial calibration should be done at least 4 days before the start of the ozone season so auto-cal results can be monitored.

An adjusted calibration must be performed if a 90 day verification or bi-weekly zero/span/precision (ZSP) check fails and the instrument is in good working order. Normally if either of these checks fail there is some problem within the monitoring system that needs addressing. If the Zero check is outside >± 0.005 ppm of known 0.000, Span check >± 7% of expected value, or if the optical bench has been completely disassembled, then an adjusted calibration will be done AFTER equipment failure is diagnosed, repaired, and instrument cleared for normal operation. If a typical slow drift causes the check to fail, no maintenance may be necessary but check with the program manager before proceeding.

1.3.1.2 Allow sufficient time for the ozone analyzer and the calibration standard to warm up (~1 hour) as necessary, if they are not already on.

1.3.1.3 Always, if no major malfunctions have occurred and the monitor has been in normal operation, perform a bi-weekly zero/span/precision (ZSP) check (section 1.8.2) prior to a calibration. If necessary, after the ZSP check, install a clean 5-μm particulate filter in the monitor filter holder in the probe line box on the roof of the site. Perform a system leak check after replacing the filter (section 1.6.1.4) and saturate the probe system with ozone by running an O3 purge point (0.500 ppm). This is done by running an upscale point and comparing analyzer and level 3 transfer standard results. Perform maintenance as required in section 1.6. Record all information in the logbook.

1.3.1.4 Login to the 8832 using HyperTerminal.

Refer to Section 11 Datalogger 8832 SOP for more information.

Type Esc (two letter site ID) AQM Enter, to enter Login screen.

ESC 8832 v3.02 ID:CM Home Menu 11/06/14 14:01:50

H Help Screen

L Login / Set User Level

O Log Out / Exit

Press L to Login, type password, press Enter. C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration). Press M (Disable/Mark Channel Offline). Use arrows to skip to Ozone, then press Enter to disable the Ozone channel.

1.3.1.5 Prepare a calibration worksheet (Fig. 2) in the instrument logbook containing the following entries:

Date/Time; Operator; Site/AQS ID; Datalogger check; Analyzer and Calibrator Make/Model/Serial Number/Diagnostics; Ozone Operational checks and Ozone Readings

The following example of the electronic data sheet (Fig. 2) will be used to document checks. All information fields listed above must be included.

Ozone Calibration Worksheet

SITE:	UC	DATE:	3/25/15	OPERATOR:	CDG	DATE OF LAST CAL/VER.:	3/25/15
						Next verification due:	**6/23/15**
ANALYZER:		400E	2219	CALIBRATOR:	703E	294	
		MODEL #	SERIAL #		MODEL #	SERIAL #	

API Ozone Analyzer 400E Diagnostics:			API Ozone Calibrator 700EU/703E Diagnostics:	
SERIAL NUMBER:	M400E-2218		SERIAL NUMBER:	
Time Stamp	3/25/2015 9:15		OUTPUT FLOW (L/min)	3.8
CONC1-AVG (PPB)	0.037		REG PRESSURE (PSI)	10.7
STABIL-AVG (PPB)	0.008		BOX TEMP (°C)	25.9
PHMEAS-AVG (mV)	4523.9	OK	O3LAMP TEMP (°C)	48.0
PHREF-AVG (mV)	4525.4	OK	PHOTO MEASURE (mV)	4310.0
SMPPRS-AVG (InHg)	29	OK	PHOTO REFerence (mV)	4310.0
SMPFLW-AVG (cc/m)	763	OK	PHOTO LAMP TEMP (°C)	58.0
SMPTMP-AVG (DegC)	39.9	OK	PHOTO SPRESS (in Hg)	29.1
PHTEMP-AVG (DegC)	58	OK	PHOTO STEMP (°C)	37.0
BOXTMP-AVG (DegC)	26.4	OK		

	PRIMARY STD POINTS DISPLAY NET O3 PPM (Y)		OBSERVED DAS VDC *X1*	OBSERVED 400E *X3*	Adjusted DAS [PPM]	Adjusted 400E [PPM]	PERCENT DIFFERENCE DAS	PERCENT DIFFERENCE 400E
1	0.000		0.0009	0.0021	**0.000**	**0.000**	N / A	N / A
2	0.225		0.9012	0.2259	**0.225**	**0.225**	**0**	0
3	0.150		0.6017	0.1521	**0.150**	**0.151**	**0**	0.67
4	0.070		0.2825	0.0712	**0.070**	**0.070**	**0**	0
5	0.040		0.1633	0.0413	**0.040**	**0.040**	**0**	0

400E:	**SLOPE:**	1.020	OK	**OFFSET:**	0.24 OK

DAS 8832			400E Records		
NEW SLOPE:	0.250	(.245 <= M <= .255)	NEW SLOPE:	1.0	(0.9800 <= M <= 1.020)
NEW INTERCEPT:	-0.0006	(-2 <= B <= 2)	NEW INTERCEPT:	-0.0018	(-0.300 <= B <= +0.300)
R2:	1.0000	(R^2 >= 0.9990)	R2:	1.0000	(R^2 >= 0.9990)

ALL LINEAR REGRESSION VALUES WITHIN SOP LIMITS?	YES			
*DAS SLOPE/INTERCEPT ENTERED INTO 8832 AT:	10:45	3/25/15		
Comments:	Time	Date		

8832 Ozone Readings	
Zero	0.0009 V
Span	0.9012 V
Midpoint	0.6017 V
Precision	0.2825 V
Lowpoint	0.1633 V

	Diag.	Zero	Span	Midpoint	Precision	Lowpoint
Time Stamp	3/25/2015 9:15	3/25/2015 9:38	3/25/2015 9:54	3/25/2015 10:05	3/25/2015 10:17	3/25/2015 10:31
CONC1-AVG (PPB)	0.037	0.0021	0.2259	0.1521	0.0712	0.0413
STABIL-AVG (PPB)	0.008	0.003	0.003	0.004	0.002	0.004
PHMEAS-AVG (mV)	4523.9	4528.1	4517.7	4521.3	4525	4526.2
PHREF-AVG (mV)	4525.4	4527.8	4528.1	4528.4	4528.4	4528.4
SMPPRS-AVG (InHg)	29	29.6	29.3	29.4	29.5	29.5
SMPFLW-AVG (cc/m)	763	774	776	775	776	775
SMPTMP-AVG (DegC)	39.9	39.6	39.5	39.4	39.4	39.5
PHTEMP-AVG (DegC)	58	58	58	58	58	58
BOXTMP-AVG (DegC)	26.4	26.2	26	26	26.1	26.2
SLOPE1-AVG	1.072	1.072	1.062	1.061	1.061	1.061
OFSET1-AVG (PPB)	-3.6	-3.6	-5.7	-5.7	-5.7	-5.7

Figure 2: Instrument Logbook, Calibration worksheet

1.3.1.6 Using APICom software, download the instrument's 1-minute reading (see 1.3.1.15.1) and copy it into the instruments logbook ('400E Diagnostics'). Record the 'pre' calibration level 3 transfer standard (700EU/703E) diagnostics/test variables as required by Fig. 2. Use the Test button on the calibrator to cycle through the diagnostics/test variables.

1.3.1.7 Make sure the verified level 3 ozone transfer standard calibrator is connected to a source of zero air and the pressure is reading 25-30 psig. Check the regulator pressure on the level 3 transfer standard calibrator to make sure it reads 7-13 psig.

1.3.1.8 Check that the level 3 transfer standard calibrator is connected to the sample line feeding the O3 analyzer. Make sure the flow of calibration gas is routed through the analyzer particulate filter and as much of the sample line as possible. See 1.2.2.10. The test atmosphere must pass through all filters, scrubbers, conditioners and other components used during normal ambient sampling and as much of the ambient air inlet system as is practicable.

1.3.1.9 In the 8832 return to the Main Menu (use Esc). Press D (Real-Time Display), V (Display Raw Readings), which are voltages.

1.3.1.10 On the level 3 transfer standard calibrator press SEQ, use the arrows to reach ZERO, press Enter. This will start the Zero point by allowing pressurized zero air to pass through the calibrator, into the probe system, and into the analyzer. The sequences programmed into the level 3 transfer standard calibrator help run desired points without having to remove/move fittings or lines in the back of the equipment. The programming guidance for the calibrators can be found in the instrument manuals.

1.3.1.11 Check the instrument functions by going to the Test button. Check the analyzer temperatures, pressure, flow and intensities. Any issues shall be addressed using the manufacturer's manual.

1.3.1.12 Perform the following steps (1.3.1.13-1.3.1.14) until no further adjustments are necessary. Record results after all adjustments are complete.

1.3.1.13 Allow the analyzer to sample zero air for at least 15 minutes and until stability <0.5 is obtained. When stable, the analyzer needs to be adjusted to read zero, press the CAL button and choose ZERO, press Enter. Return to the main screen (press Exit). The analyzer should now read zero, if not repeat the adjustment steps above or contact program manager.

It is recommended to wait for a very low stability and calibrate the point once instead of calibrating the point consecutively until the point becomes stable. Digitrend charts can assist this.

1.3.1.14 After the instrument has stabilized (normally 15-30 minutes), check the EDAS minute graph to verify a stable trace for the point. Observe the analyzer and the calibration standard. The difference for the zero point should meet the following specification:

$\leq \pm$ 0.002 ppm at stability of < 0.5 ppb (stability is reported in ppb in the 400E)

1.3.1.15 Record the Raw Voltage Reading from the 8832 and download the instrument's 1-minute reading using APICom.

1.3.1.15.1 Open APICom 4.0.1 exe. Select the 400E (see figure 3) and click the 'green arrow' to open a 400E front display window (see figure 4).

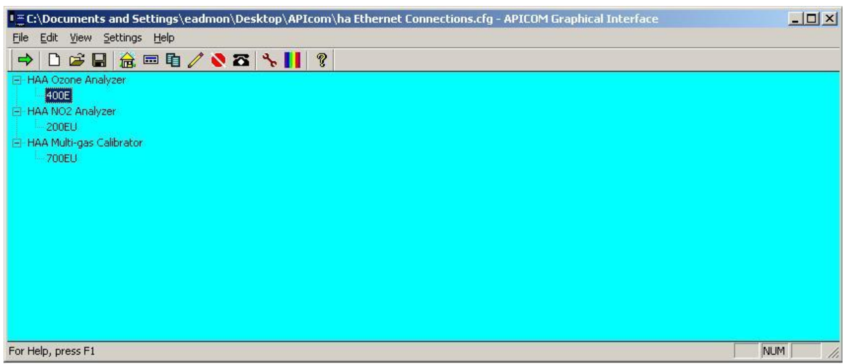

Figure 3: APIcom home screen

Click the 'iDAS Panel' button.

Figure 4: APIcom instrument panel screen

In the opening window (See figure 5) select "O3mindata" and click the 'Get data' button. O3Hlydata is used for collecting hourly data from the 400E's internal datalogger. Choose 'most recent on record' to download the 1-minute readings from the 400E. Click 'Save Data' and select the running 400E diagnostics/test variables file. Choose 'Append' so the newest record from the 400E is added to the running list in the Excel file.

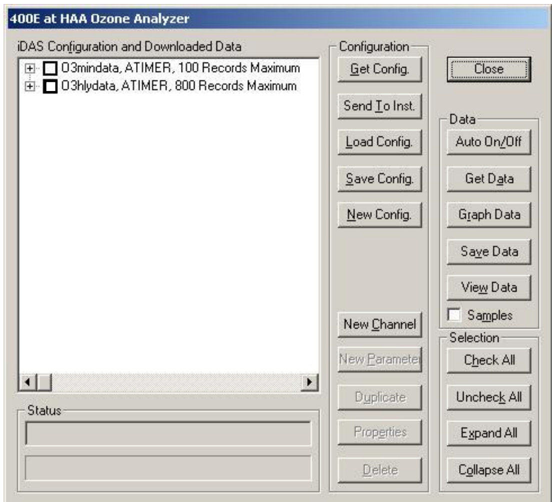

Figure 5: APIcom instrument iDAS screen

Copy both readings (8832 and APICom) into the instruments logbook (Fig. 2). The observed and entered Ozone readings have to be manually copied into Observed DAS VDC x1 and Observed 400E x3 cells.

1.3.1.16 Press SEQ on the level 3 transfer standard calibrator, use arrow keys to reach O3 225, press Enter. This will start the SPAN point by turning on the internal photometer pump and mixing pressurized zero air with ozone generator fed air into the bench. This air is sent from the calibrator, into the probe system, and into the analyzer.

1.3.1.17 Allow the analyzer to sample 0.225 (Span) gas for about 15 minutes and until stability < 0.5 is obtained. When stable, the analyzer needs to be adjusted to read 0.225, press the CAL button and choose SPAN, press Enter. Selecting the CONC allows you to adjust the set point for the SPAN if the calibrator is sending out a value other than 0.225. Return to the main screen (press Exit) and let the analyzer stabilize. The analyzer should now read 0.225, if not repeat the adjustment steps above.

It is recommended to wait for a very low stability and calibrate the point once instead of calibrating the point consecutively until the point becomes stable.

1.3.1.18 Allow the instrument to stabilize (15-30 minutes). Check the EDAS minute graph to verify a stable trace for the point. Observe the analyzer and the calibration standard. The difference for the span point should meet the following specification:

$\leq \pm$ 2% difference at stability of < 0.5

1.3.1.19 Record the Raw Reading from the 8832 and download the instrument’s 1-minute reading using APICom (see 1.3.1.15.1). Copy both readings into the instruments logbook (Fig. 2). The observed and entered Ozone readings have to be manually copied into ‘Observed DAS VDC x1’ and ‘Observed 400E x3’ cells.

1.3.1.20 After the 0.000 ppm (Zero) and 0.225 ppm (Span) Ozone points have been run satisfactorily and recorded, start the sequence on the level 3 transfer standard calibrator to run points for 0.150 ppm, 0.070 ppm, and 0.040 ppm. Press SEQ on the level 3 transfer standard calibrator, use arrow keys to reach the desired concentration and press Enter. Check the EDAS minute graph to verify a stable trace for each of the points.

Do not adjust the analyzer while running any of these points!

Record the results for each concentration based on stable readings (stability <0.5) from the 8832 Raw Readings and 1-minute APICom in the instrument logbook (Fig. 2) and manually copy them into the corresponding Observed DAS VDC x1 and Observed 400E x3 cells. The difference for each point should meet the following specification:

$\leq \pm$ 2% difference.

If it is not within the % difference for each point inform the Program Manager.

1.3.1.21 Set the level 3 transfer standard calibrator back in standby mode by pressing STBY.

1.3.1.22 Verify that the calculated slope (m), intercept (b), and the correlation coefficient (r2) in the instruments logbook meet the following specifications in order to be valid for reporting ambient air data:

8832: $.245 \leq m \leq .255$, $-2 \leq b \leq 2$, and $r2 \geq 0.9990$ (the logger slope and intercept translates the raw voltage into engineering units for the data logger)

400E: $0.9800 \leq m \leq 1.020$, $-0.300 \leq b \leq 0.300$ and $r2 \geq 0.9990$ (the analyzer slope and intercept adjusts a ppm value to a corrected ppm value based on a best fit line across the five points)

If these specifications are not met, corrective action should be taken and another calibration should be performed after problem is identified and corrected.

1.3.1.23 If the sample line was disconnected, reconnect the sample line to the sample port of the analyzer and the line from the O3 port of the level 3 transfer standard calibrator to the O3 port of the analyzer.

1.3.1.24 Close all APICOM windows to disconnect from the 400E Ozone Analyzer.

1.3.1.25 In the 8832 return back to the Main Menu (use Esc). Press C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration). Use arrows to skip to Ozone, press Enter. Use arrow keys to skip to Slope=High output (E.U.s) and enter the DAS Slope from the instrument logbook calibration worksheet (Fig. 2). Use arrow keys to skip to Intercept=Low output

(E.U.s) and enter the DAS Intercept from the instrument logbook calibration worksheet. Use the arrow keys to skip to ‘Finished (Config. Now)’ and press Enter to save changes. These new slopes and intercepts will apply to all future ozone data until the next adjusted calibration. Note time and date new slope and intercept were entered into the datalogger on logbook calibration worksheet.

1.3.2 Ozone 90-day Verification

1.3.2.1 An ozone 90-day verification check must be done once every 90 days. Run the following points: 0 (Zero), 0.225 (Span), 0.150, 0.070, and 0.040 ppm and verify results are all within 7% difference. This is to verify everything is running properly in an “as found” state.

1.3.2.2 To perform a 90-day verification check, login onto the 8832 datalogger and disable the channel.

Refer to Section 11. Datalogger 8832 SOP

Open HyperTerminal and type Esc ‘site ID’ AQM press Enter, to enter Login screen. Press L Login, type password, press Enter. C (Configuration Menu), D (Configure (Data) Channels), M (Disable/Mark Channel Offline). Use arrows to skip to Ozone, press Enter to disable the Ozone channel.

1.3.2.3 Using the APICom software download one instrument’s 1-minute reading (see 1.3.1.15.1) and copy into the instruments logbook (400E Diagnostics) (Fig. 6).

1.3.2.4 The ZSP check may be performed by manually activating the appropriate sequences in the level 3 transfer standard.

1.3.2.5 To run a 90-day verification, check that the level 3 transfer standard is connected to a zero air generator, which is producing 20-30 psig.

1.3.2.6 The level 3 transfer standard is connected to the analyzer through a cal out supply line. Make sure the cal out line goes to the ozone solenoid behind the calibrator and that it opens when starting the sequence.

1.3.2.7 Start the zero point by pressing SEQ, then ZERO on the level 3 transfer standard. Let the point run for at least 10 minutes and until stability reaches at least < 0.5.

1.3.2.8 Record the reading from the datalogger. Use Esc to skip back to the Main Menu. Enter D (Real-Time Display), F (Display Readings w/Flags). Download the instrument’s 1-minute reading using APICom (see 1.3.1.15.1). Copy both readings into the instrument’s logbook (Fig. 6). The observed and downloaded Ozone readings have to be manually copied into the observed 8832 and 400E (green cells) section.

Ozone 90 Day Verification Worksheet

SITE:	UC	DATE:	6/23/15	OPERATOR:	CDG	DATE OF LAST CAL/VER.:	3/25/15
						Next verification due:	6/23/15
ANALYZER:		400E	2219	CALIBRATOR:	703E	294	
		MODEL #	SERIAL #		MODEL #	SERIAL #	

API Ozone Analyzer 400E Diagnostics:			API Ozone Calibrator 700EU/703E Diagnostics:	
SERIAL NUMBER:	M400E-2218		SERIAL NUMBER:	
Time Stamp	6/23/2015 8:40		OUTPUT FLOW (L/min)	2.6
CONC1-AVG (PPM)	0		REG PRESSURE (PSI)	5.8
STABIL-AVG (PPM)	0.003		BOX TEMP (°C)	27.9
PHMEAS-AVG (mV)	4101	OK	O3LAMP TEMP (°C)	47.9
PHREF-AVG (mV)	4101	OK	PHOTO MEASURE (mV)	3668.0
SMPPRS-AVG (InHg)	27	OK	PHOTO REFerence (mV)	3685.9
SMPFLW-AVG (cc/m)	735	OK	PHOTO LAMP TEMP (°C)	58.0
SMPTMP-AVG (DegC)	38	OK	PHOTO SPRESS (in Hg)	28.4
PHTEMP-AVG (DegC)	58	OK	PHOTO STEMP (°C)	38.6
BOXTMP-AVG (DegC)	29	OK		

OZONE OPERATIONAL CHECKS:

	PRIMARY STD POINTS DISPLAY NET O3 PPM (Y)		OBSERVED 8832 PPM X1	OBSERVED 400E PPM X3	Adjusted DAS [PPM]	Adjusted 400E [PPM]	PERCENT DIFFERENCE DAS	PERCENT DIFFERENCE 400E	Verification OK? DAS	Verification OK? 400E
1	0		0.0010	0.0000	0.001	0.000	N / A	N / A	OK	OK
2	0.225		0.2240	0.2228	0.225	0.225	0	0	OK	OK
3	0.150		0.1493	0.1492	0.150	0.150	0	0	OK	OK
4	0.070		0.0699	0.0697	0.070	0.070	0	0	OK	OK
5	0.040		0.0398	0.0396	0.040	0.040	0	0	OK	OK

400E: SLOPE: 1.02 OK OFFSET: 0.24 OK

Current 8832 E.U. outputs		8832 results		400E Records		Current 400E factors:	
SLOPE:	0.2531	1.0	(0.9800 <= M <= 1.020)	1.0091	(0.9800 <= M <= 1.020)	1.0091	SLOPE
INTERCEPT:	-0.00074	-0.0005	(-0.300 <= B <= +0.300)	-0.0001	(-0.300 <= B <= +0.300)	0.0002	INTERCEPT
R2:	1.0000	1.0000	(R^2 >= 0.9990)	1.0000	(R^2 >= 0.9990)	1.0000	R2

ALL LINEAR REGRESSION VALUES WITHIN SOP LIMITS? YES

*DAS SLOPE/INTERCEPT ENTERED INTO 8832 AT 10:21 (Time) 6/23/2015 (Date)

8832 Ozone Readings with Flags	
Zero	OZONE=-0.001043 (D)
Span	OZONE= 0.224 (D)
Midpoint	OZONE= 0.1493 (D)
Precision	OZONE= 0.06991 (D)
Lowpoint	OZONE= 0.03978 (D)

	Diag.	Zero	Span	Midpoint	Precision	Lowpoint
Time Stamp	6/23/2015 8:40	6/23/2015 8:59	6/23/2015 9:18	6/23/2015 9:32	6/23/2015 9:44	6/23/2015 9:59
CONC1-AVG (PPM)	0	0.1	0.2228	0.1492	0.0697	0.0396
STABIL-AVG (PPM)	0.003	0.002	0.003	0.003	0.004	0.004
PHMEAS-AVG (mV)	4101	4101	4092	4095	4098	4099
PHREF-AVG (mV)	4101	4101	4101	4101	4101	4101
SMPPRS-AVG (InHg)	27	27	27	27	27	26
SMPFLW-AVG (cc/m)	735	736	734	735	735	735
SMPTMP-AVG (DegC)	38	38	38	39	39	39
PHTEMP-AVG (DegC)	58	58	58	58	58	58
BOXTMP-AVG (DegC)	29	29	29	29	29	29
SLOPE1-AVG	1.02	1.02	1.02	1.02	1.02	1.02
OFSET1-AVG (PPB)	0.24	0.24	0.24	0.24	0.24	0.24

Figure 6: Instrument Logbook, 90-day Verification worksheet

1.3.2.9 Record the following level 3 transfer standard diagnostics by skipping through the Test options while the zero point is running:

Output flow (L/min)
Regulator Pressure (PSI)
Box Temperature (°C)
Ozone Lamp Temperature (°C)
Photometer Measure Voltage (mV)
Photometer Reference Voltage (mV)
Photometer Lamp Temperature (°C)
Photometer Pressure (inHg)
Photometer Temperature (°C)

1.3.2.10 Start the Span point by pressing SEQ, then press arrow to find O3 225 on the levels 3 transfer standard. Let the point run for at least 10 minutes and until stability reaches at least < 0.5. Record the reading from the datalogger (F Display with Flags) and download the instrument’s 1-minute reading using APICom (see 1.3.1.15.1). Copy both readings into the instrument’s logbook (Fig. 6). The observed and downloaded ozone readings have to be manually copied into the “Observed 400E PPM” section.

1.3.2.11 Now start the Mid-point by pressing SEQ, then press arrow to find O3 150 on the levels 3 transfer standard. Let the point run for at least 10 minutes and until stability reaches at least < 0.5. Record the reading from the datalogger (F Display with Flags) and download the instrument’s 1-minute reading using APICom (see 1.3.1.15.1). Copy both readings into the instrument’s logbook (Fig. 6). The observed and downloaded ozone readings have to be manually copied into the “Observed 400E PPM” section.

1.3.2.12 Now start the Precision point by pressing SEQ, then press arrow to find O3 70 on the levels 3 transfer standard. Let the point run for at least 10 minutes and until stability reaches at least < 0.5. Record the reading from the datalogger (F Display with Flags) and download the instrument’s 1-minute reading using APICom (see 1.3.1.15.1). Copy both readings into the instrument’s logbook (Fig. 6). The observed and downloaded ozone readings have to be manually copied into the “Observed 400E PPM” section.

1.3.2.13 Now start the Low-point by pressing SEQ, then press arrow to find O3 40 on the levels 3 transfer standard. Let the point run for at least 10 minutes and until stability reaches at least < 0.5. Record the reading from the datalogger (F Display with Flags) and download the instrument’s 1-minute reading using APICom (see 1.3.1.15.1). Copy both readings into the instrument’s logbook (Fig. 6). The observed and downloaded ozone readings have to be manually copied into the “Observed 400E PPM” section.

1.3.2.14 When the 90-day verification is complete, run a ZERO point again to flush system and lines ensure there was no drift from the previous ZERO result. Press the STBY button on the level 3 transfer standard to set into “Stand By” mode. Make sure the front of the analyzer is showing it is in “Sample” mode; observe the ozone value and stability to make sure it is returning to ambient values.

1.3.2.15 Check the 90 day verification worksheet (Fig. 5), to verify that all entered data and manually copied values are correct. Also check the new slopes and intercepts and make sure they satisfy their limits as well. **These are NOT to be entered into the 8832.**

1.3.2.16 Check that verification differences are OK and within their limits:

Zero ≤± 0.005 ppm
All other points ≤± 7%

If the above criteria are met, proceed to 1.3.2.17. If the verification does NOT meet the above criteria, inform the program manager. Maintenance and/or troubleshooting may be required before calibration can be done. An adjusted calibration must be performed before channel is enabled.

1.3.2.17 Log on onto the datalogger and enable the ozone channel.

Refer to Section 11 Datalogger 8832 SOP

Use ESC to skip back to Main Menu. Press C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration), E (Enable/Mark Channel Online). Use arrows to skip to ozone, press Enter to enable the ozone channel. Skip back to the Main Menu (ESC), press O Log Out/Exit to exit out of the datalogger.

1.3.3 Ozone End of Season Verification

1.3.3.1 Ozone season ends November 1, 12:00 A.M. To close the season, a manual 90 day verification should be performed. Run the following points: 0 (Zero), 0.225 (Span), 0.150, 0.070, and 0.040 ppm and verify results are all within 7% difference. If so, the data is good and the ozone equipment can be turned OFF. If not, check for problems with the equipment or lines or contact the division program manager to discuss how far back data must be flagged, i.e. last good auto cal/last good bi-weekly check, last good audit.

1.4 Certification of Level 2 Transfer Standards (Teledyne API 703E Photometric Ozone Calibrator and Teledyne API T700U Dynamic Dilution Calibrator)

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 Metrology: 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'.

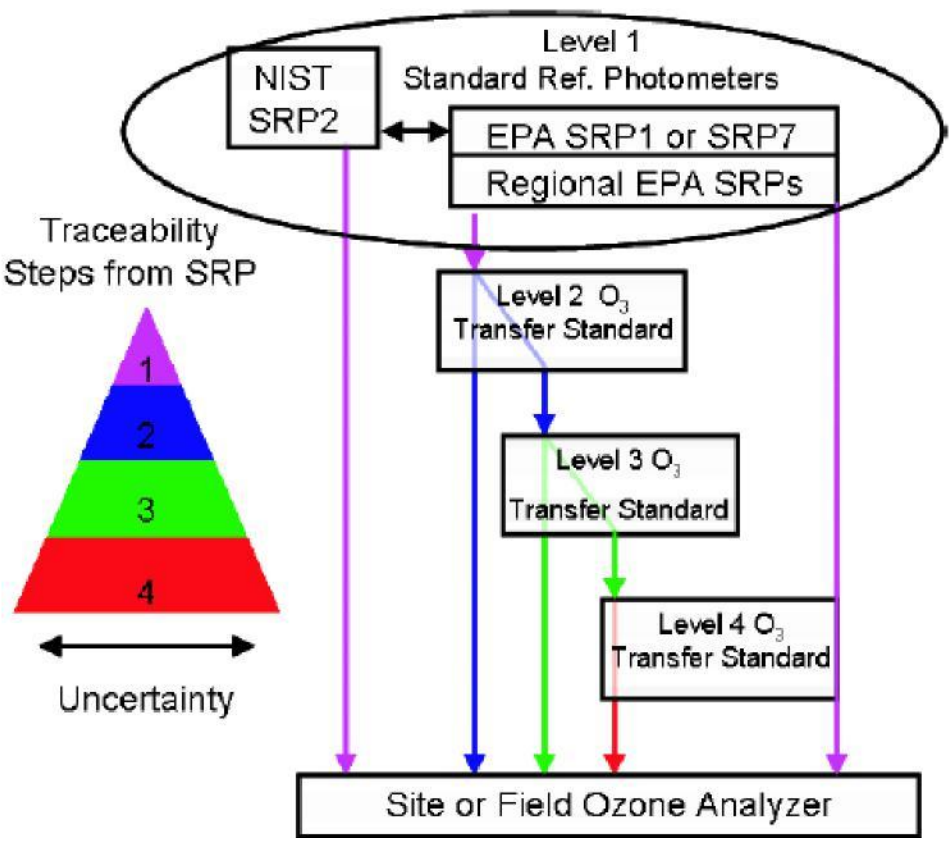

Figure 7: The relationships among the family of ozone transfer standards

A Teledyne API 703E Photometric Ozone Calibrator and the Teledyne API 700EU Dynamic Dilution Calibrator are used to calibrate ozone monitors in the Forsyth County Air Quality network (FCAQ). The Teledyne API T700U Dynamic Dilution Calibrator is used to certify and audit the ozone analyzers in the FCAQ while the API 703E serves as our bench standard because it remains stationary in our office's monitoring workshop. Currently FCAQ utilizes two level 2 transfer standards. A Teledyne API 703E Photometric Ozone Analyzer (SN 59) (laboratory bench standard) and a Teledyne API T700U Dynamic Dilution Calibrator (SN 128) (transfer standard). **The SN 59 and T700U should be verified annually against a standard reference photometer (most of the time it is the EPA Region 4 SRP#10).** The SN 59 and T700U are verified or calibrated, based on performance, by USEPA Region 4 annually, in accordance with USEPA Region 4 procedures.

All other photometers operated by FCEAP are referenced to the T700U transfer standard or directly with the SN 59. **Level 3 transfer standards used for field calibration of ozone instrumentation are verified every 12 months by direct comparison to the SN 59 in the laboratory. Quality assurance checks (audits) of ozone instrumentation are compared to the T700U in the field**. The procedures for verification follow:

1.4.1 Teledyne API 700EU Dynamic Dilution Calibrator (Level 3 Transfer Standard)

For verification and maintenance procedures of the Teledyne API 700EU Dynamic Dilution Calibrator, refer to Section 12, Standard Operating Procedure (SOP) for Calibrators. Also perform preventive maintenance and performance checks on the level 3 transfer standard calibrators and level 2 transfer standard calibrators as needed or at least annually (every 365 days). See section 1.6.

1.4.1.1 Mass Flow Controller (MFC) Calibration

To achieve a correct calibration gas blending for SO2, NO2, and CO, it is important to verify and calibrate the output flow of each individual MFC every 6 months.

1.4.1.2 O_3 Generator Calibration

For a most accurate O_3 output, the internal generator should be calibrated annually during the maintenance season (ideally two months before ozone season starts).

1.4.1.3 O_3 Photometer Calibration/Verification

The accuracy of calibration gas mixtures depend on the accuracy of the internal photometer. Verifications of the photometer are to be performed once a year and if the zero and/or span points need adjustment (See 1.4.1.3.5) then the verification becomes a calibration. Calibrations of the photometer adjust the offset and/or slope of the reading calibrator (level 3 transfer standard). For more information see the SOP for calibrators in section 12.

1.4.1.3.1 Refer to Teledyne API 700 series Dynamic Dilution Calibrator Manual (version 06873B DNC 6388), Chapter 7.

1.4.1.3.2 Connect the zero air system to the level 2 transfer standard calibrator. The level 2 transfer standard calibrator should be supplied with >20 psig at >6-8 lpm flow. Connect the zero air system to the Teledyne API 700EU Photometric Ozone Calibrator (level 3 transfer standard). The level 2 transfer standard calibrator and the level 3 transfer standard calibrator should utilize a common zero air source.

1.4.1.3.3 Verify that the internal regulator of the level 2 transfer standard calibrator is displaying approximately 10 psig and the site level 3 transfer standard calibrator internal regulator is 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 calibrator and the level 3 transfer standard calibrator. Connect the ozone outlet of the level 2 transfer standard calibrator to the ozone inlet of the level 3 transfer standard calibrator with a length of clean 1/4" OD Teflon tubing. Verify that the level 2 transfer standard calibrator vent is open. Make sure the level 3 transfer standard calibrator vent is capped.

1.4.1.3.4 After performing a backpressure compensation process (See Section 12 for the Calibrator SOP) on the level 2 transfer standard calibrator generate a zero air concentration with the level 2 transfer standard calibrator and allow the level 3 transfer standard calibrator to sample the test atmosphere for at least 30 minutes.

1.4.1.3.5 Record the ‘test variables’ information from both transfer standard calibrators into the equipment logbook. This information should be recorded prior to the calibration. If all information recorded above is within manufacturer specifications proceed with the verification, if not, perform maintenance as outlined in sections 1.6. Zero results should be +- .003 ppm and have a difference between the two calibrators less than .003 ppm. If so proceed to the span point. If not change the offset of the Level 3 transfer standard so it matches the Level 2 transfer standard and run another zero point to verify new results satisfy the above criteria. Adjustments to either the offset or the slope (after span point) change this process from a verification to a calibration. If no adjustments are needed then this process serves as a verification.

1.4.1.3.6 Generate a 0.225 ppm (span) air concentration with the level 2 transfer standard calibrator and allow the level 3 transfer standard calibrator to sample the test atmosphere for at least 30 minutes.

1.4.1.3.7 Record the ‘test variables’ information from both transfer standard calibrators into the equipment logbook. This information should be recorded prior to the calibration. If all information recorded above is within manufacturer specifications proceed with the verification, if not, perform maintenance as outlined in sections 1.6. Span results should be +- 3% and have a difference between the two calibrators less than 3%. If so proceed to the next point. If not change the slope of the Level 3 transfer standard so it matches the Level 2 transfer standard and run another span point to verify new results satisfy the above criteria.

1.4.1.3.8 Correct all level 3 transfer standard calibration readouts using the EPA verification formula and record the results in the logbook as level 3 transfer standard calibrator. A copy of the EPA verification equation should be referenced in the level 3 transfer standard calibrator verification logbook. The equation is computed as follows:

$$x=1/m(y-b)$$

where:
x = certified ozone concentration (ppm)
m = slope from level 2 transfer standard verification
y = photometer read out
b = intercept of level 2 transfer standard verification (ppm)

1.4.1.3.9 Perform a linear regression analysis- level 2 transfer standard calibrator correct (X) versus the level 3 transfer standard calibrator (Y). Perform the analysis in units of ppm.

1.4.1.3.10 Record the slope (m). The slope must be within 0.9700 - 1.0300. Record the intercept (b). The intercept must be within -3.0000 - 3.0000. Record the correlation coefficient (r). The correlation coefficient must be >0.9990.

1.4.1.3.11 If the calculated slope and intercept fail to meet these criteria further adjustments may be needed to the level 3 transfer standard calibrator. After an adjustment is made run the zero and span values again and calculate new slope and intercept. Once the slope and intercept meet the criteria, run three more of the following points without adjustment and record the results in the ozone certification logbook:

Level 10: 0.225 ppm O3 (this is the span point, no need to run again)
Level 9: 0.180 ppm O3
Level 8: 0.150 ppm O3
Level 7: 0.130 ppm O3
Level 6: 0.090 ppm O3
Level 5: 0.070 ppm O3
Level 4: 0.050 ppm O3
Level 3: 0.030 ppm O3
Level 2: 0.015 ppm O3
Level 1: 0.005 ppm O3

1.4.2 Teledyne API 703E Photometric Ozone Calibrator (Level 3 Transfer Standard)

For verification and maintenance procedures of the Teledyne API 703E Dynamic Dilution Calibrator, refer to Section 12, Standard Operating Procedure (SOP) for Calibrators. Perform preventive maintenance and performance checks on the level 3 transfer standard calibrators and level 2 transfer standard calibrators as needed and at least annually (every 365 days). See sections 1.6.

1.4.2.1 Flow Sensor Calibration

To achieve a correct calibration gas flow, it is important to verify and calibrate the output flow of the API 703E every 12 months.

1.4.2.2 O_3 Generator Calibration

For a most accurate O_3 output, the internal generator should be calibrated annually during the maintenance season (ideally two months before ozone season starts).

1.4.2.3 O_3 Photometer Calibration

The accuracy of calibration gas mixtures depend on the accuracy of the internal photometer. Calibrations/Verifications of the photometer are to be performed once a year.

1.4.2.3.1 Refer to Teledyne API 700 series Dynamic Dilution Calibrator Manual (version 06873B DNC 6388), Chapter 7.

1.4.2.3.2 Connect the zero air system to the level 2 transfer standard calibrator. The level 2 transfer standard calibrator should be supplied with >20 psig at >6-8 lpm flow. Connect the zero air system to the Teledyne API 700EU Photometric Ozone Calibrator (level 3 transfer standard). <u>The level 2 transfer standard calibrator and the level 3 transfer standard calibrator should utilize a common zero air source.</u>

1.4.2.3.3 Verify that the internal regulator of the level 2 transfer standard calibrator is displaying approximately 10 psig and the site level 3 transfer standard calibrator internal regulator is 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 calibrator and the level 3 transfer standard calibrator. Connect the ozone outlet of the level 2 transfer standard calibrator to the ozone inlet of the level 3 transfer standard calibrator with a length of clean 1/4" OD Teflon tubing. Verify that the level 2 transfer standard calibrator vent is open. Make sure the level 3 transfer standard calibrator vent is capped.

1.4.2.3.4 After performing a backpressure compensation process (See Section 12 for the Calibrator SOP) on the level 2 transfer standard calibrator generate a zero air concentration with the level 2 transfer standard calibrator and allow the level 3 transfer standard calibrator to sample the test atmosphere for at least 30 minutes.

1.4.2.3.5 Record the ‘test variables’ information from both transfer standard calibrators into the equipment logbook. This information should be recorded prior to the calibration. If all information recorded above is within manufacturer specifications proceed with the verification, if not, perform maintenance as outlined in sections 1.6. Zero results should be +- .003 ppm and have a difference between the two calibrators less than .003 ppm. If so proceed to the span point.

If not change the offset of the Level 3 transfer standard so it matches the Level 2 transfer standard and run another zero point to verify new results satisfy the above criteria. Adjustments to either the offset or the slope (after span point) change this process from a verification to a calibration. If no adjustments are needed then this process serves as a verification.

1.4.2.3.6 Generate a 0.225 ppm (span) air concentration with the level 2 transfer standard calibrator and allow the level 3 transfer standard calibrator to sample the test atmosphere for at least 30 minutes.

1.4.2.3.7 Record the 'test variables' information from both transfer standard calibrators into the equipment logbook. This information should be recorded prior to the calibration. If all information recorded above is within manufacturer specifications proceed with the verification, if not, perform maintenance as outlined in sections 1.6. Span results should be +- 3% and have a difference between the two calibrators less than 3%. If so proceed to the next point. If not change the slope of the Level 3 transfer standard so it matches the Level 2 transfer standard and run another span point to verify new results satisfy the above criteria.

1.4.2.3.8 Correct all level 3 transfer standard calibration readouts using the EPA verification formula and record the results in the logbook as level 3 transfer standard calibrator. A copy of the EPA verification equation should be referenced in the level 3 transfer standard calibrator verification logbook. The equation is computed as follows:

$$x=1/m(y-b)$$

where:
x = certified ozone concentration (ppm)
m = slope from level 2 transfer standard verification
y = photometer read out
b = intercept of level 2 transfer standard verification (ppm)

1.4.2.3.9 Perform a linear regression analysis- level 2 transfer standard calibrator correct (X) versus the level 3 transfer standard calibrator (Y). Perform the analysis in units of ppm.

1.4.2.3.10 Record the slope (m). The slope must be within 0.9700 - 1.0300. Record the intercept (b). The intercept must be within -3.0000 - 3.0000. Record the correlation coefficient (r). The correlation coefficient must be >0.9990.

1.4.2.3.11 If the calculated slope and intercept fail to meet these criteria further adjustments may be needed to the level 3 transfer standard calibrator. After an adjustment is made run the zero and span values again and calculate new slope and intercept. Once the slope and intercept meet the criteria, run three more of the following points without adjustment and record the results in the ozone certification logbook:

Level 10: 0.225 ppm O3 (this is the span point, no need to run again)
Level 9: 0.180 ppm O3

Level 8: 0.150 ppm O3
Level 7: 0.130 ppm O3
Level 6: 0.090 ppm O3
Level 5: 0.070 ppm O3
Level 4: 0.050 ppm O3
Level 3: 0.030 ppm O3
Level 2: 0.015 ppm O3
Level 1: 0.005 ppm O3

1.4.2.4 Verifying the O3 Photometer Performance (Once a year or when photometer related maintenance is done) is very similar to the calibration but no adjustments are made to the level 3 calibrator at any point.

Refer to Teledyne API 700EU Dynamic Dilution Calibrator Manual (version 06873B DNC 6388), Chapter 7.

1.4.2.4.1 Calculate a new slope and intercept comparing all expected ozone values produced by the generating calibrator to and of the observed ozone values read by the reading calibrator. As before, record the slope (m). The slope must be within 0.9800 - 1.0200. Record the intercept (b). The intercept must be within -3.0000 - 3.0000. Record the correlation coefficient (r). The correlation coefficient must be >0.9990.

1.4.2.4.2 Repeat the data recording procedure used above and record the appropriate results. If % difference is greater than 3 maintenance and/or repairs are needed and program manager must be notified.

1.5 Teledyne API 701 Zero Air Generator, Teledyne API T701H Zero Air Generator

A zero air system to be used in the field should be constructed as follows: a zero air generator, a valve connected to the output that is connected to two drying columns filled with fresh silica gel followed by a column of activated charcoal containing a layer of Purafil, the air is then passed through a 5 µm teflon filter to remove particulate.

1.5.1 A check of the zero air system should be performed annually.

1.5.2 Annually, the entire zero air system, including the zero air generator and drying columns, should be brought back to the laboratory.

1.5.3 At this time, replenish the drying column with fresh silica gel, activated charcoal, and fresh Purafil. Replace the filter at this time.

1.5.4 Replace the filter on rear of zero air generator. Check the canisters for leaks before re-installing them into the generator.

1.5.5 After the annual maintenance is completed, attach the laboratory zero air system to a level 2 transfer standard. Then connect a line between the ozone port of the level 2 transfer standard and the sample port of an ozone analyzer.

1.5.6 Turn the level 2 transfer standard on to run a zero point.

1.5.7 Let the analyzer stabilize and observe the ozone value which should read ± .002 ppm of zero. If not, contact the Program Manager for how to proceed.

1.6 Analyzer Maintenance Checks and Annual Preventive Maintenance

On a regular schedule, all instruments should be inspected to assure proper functionality. If the instrument is malfunctioning or breaks down, immediate checks and repairs must be performed.

During ozone season, monitor maintenance and repairs should not be performed between the hours of 10 am and 8 pm unless absolutely essential or weather permitting, i.e. 100% overcast or rain at the site during the check. Data recovery during this period must exceed 75%.

1.6.1 Teledyne API 400E Ozone Analyzer Routine Checks

1.6.1.1 Prior to the start of the ozone season the optical bench should be inspected and cleaned. During the monitoring season occasional cleaning may be necessary. If the absorption tubes are extremely dirty the entire optical bench should be inspected (see 1.6.2.2.)

1.6.1.2 Check that the UV-Lamp shows a Photo_DET of 4400-4600 mV. Adjustment or replacement is necessary when the following conditions indicate the need to examine the lamp for proper operation (see 1.6.2.11):

1. No light output.
2. Photo_DET not in 4400-4600 mV range
3. Noisy output signal, which is traced to an unstable lamp. Replacing the lamp does not affect the calibration.

1.6.1.3 Verify sample flow is 720-880 cc/m, if not, see 1.6.2.10. If the actual flow is below 720cc/m, check sample pump and if necessary rebuild sample flow orifice assembly (see 1.6.2.5 and 1.6.2.6).

1.6.1.4 Perform a system leak check. While in the sample mode, plug the sample port of the analyzer using as much of the sample line as possible. Telfon cap should be place on the ambient side of the "T" union in the sample probe box on top of the site. Let the instrument run and wait for SAMP FL and SAMP PRES to stabilize. The observed SAMP FL should be < 10 cc/m (there are no leaks in the analyzer) and SAMP PRESS < 10 in Hg-A (the sample pump diaphragm is in good condition). If leak check fails contact the Program Manager.

1.6.1.5 Inspect the sample line quarterly. If the sample line becomes dirty and/or has visible moisture, replace the line. If a filter is placed at the beginning of the sample line inlet, the sample line only needs to be replaced as necessary, but still inspected quarterly.

1.6.1.6 Replace the 5-µm Teflon sample filter when system pressure is 20 mm Hg lower than ambient pressure, or at least every 30 days. The filter may be replaced more often if necessary. Always handle particulate filters with tweezers. Perform a leak check on the system after filter replacement (see 1.6.1.4).

1.6.1.7 Record all maintenance in the instrument and site logbooks.

1.6.2 Teledyne API 400E Ozone Analyzer Annual Preventive Maintenance

To avoid instrument failures during the ozone season, following preventive maintenance should be done during off-season in the laboratory. (see Fig. 8)

1.6.2.1 Clean the instrument's interior and the bench interior. Check tubes and cables for wear or cracks.

1.6.2.2 Inspect the photometer glass tube. Do not disassemble photometer absorption tube! If absorption tube has to be cleaned, refer to Teledyne API 400E Ozone Analyzer Manual, Chapter 12.3.6.

1.6.2.3 Check all electrical connectors and make sure they are seated properly.

1.6.2.4 Replace ozone scrubber with a new one. Label the new scrubber with the installation date (at least each 2 years when operating on the April 1-October 31 sampling schedule).

1.6.2.5 Rebuild sample pump with new flappers and diaphragm. Disconnect tubes on pump head. Undo four head cap screws and remove head assembly and clean it. Replace flapper between head plate and intermediate plate. Undo clamping disc screw on piston head, replace diaphragm and tighten down with cleaned clamping disc screw. Place head back on pump (check alignment markings!) and tighten down four head cap screws. Reattach tubes to pump head. Refer to Teledyne API 400E Ozone Analyzer Manual, Chapter 12.3.2.

1.6.2.6 Rebuild sample flow orifice assembly. Remove sample flow orifice assembly from tubing. Disassemble flow orifice assembly, keep parts in correct order. Replace two o-rings (to each side of orifice), sintered filter and spring. After cleaning orifice with deionized water and pressurized air, reassemble flow orifice assembly (red colored sapphire jewel of orifice is facing downstream!). Place sample flow orifice assembly back between tubes. Refer to Teledyne API 400E Ozone Analyzer Manual, Chapter 13.10.1.

1.6.2.7 Replace sample particulate filter in front panel. Clean housing while it is open. Always handle particulate filters with tweezers.

1.6.2.8 After all mechanical work has been performed check all tubing for tightness and electrical connections for proper seating.

1.6.2.9 Turn on instrument and let warm up for at least 30 min. Perform a leak check by capping sample inlet port. Verify that sample flow is < 10 cc/m and pressure is < 10 in Hg-A. Use instrument's test buttons to check instruments diagnostics.

1.6.2.10 Adjust the ozone photometer gas flow. Attach a flow meter directly to the sample inlet port. Observe the observed actual flow and adjust the flow in the instrument's diagnostics/flow calibration sub menu. Refer to Teledyne API 400E Ozone Analyzer Manual, Chapter 9.5.2. **The instructions for the flow calibration in the manual are not fully correct! Use appendix A1. for a correct flow calibration.**

1.6.2.11 To adjust UV-lamp mV output, loosen UV-lamp in photometer bench and turn until maximum Photo_DET mV is observed (instruments signal I/O/Photo_DET sub menu). Tighten UV-lamp and adjust detector gain adjust potentiometer to Photo_DET 4400-4600 mV. If UV-lamp is not adjustable to desired mV, replace UV-lamp. Refer to Teledyne API 400E Ozone Analyzer Manual, Chapter 12.3.6.2.-12.3.6.3.

1.6.2.12 Return instrument back to monitoring site and verify ambient pressure and ambient temperature.

1.6.2.13 Adjust analog outputs. Refer to Teledyne API 400E Ozone Analyzer Manual, Chapter 7.4.2.3.

1.6.2.14 Record all preventive maintenance in the instrument's log (Fig. 8) and place a copy in the instrument's label holder located on top of the instrument.

Preventive Maintenance Log for a 400E	Maintenance Performed and completed		
Site: Serial #:	Date	By	Notes
Check all electrical connections			
Check all pneumatic connections			
Inspect Photometer tube			
Replace pump diaphragm and flapper			
Replace sintered filter and "O" rings and clean critical orifice			
Replace ozone scrubber			
Turn unit ON and allow it to warm up (~30m)			
perform leak check			
Calibrate flow			
Calibrate pressure			
Adjust UV lamp position to **MAXimize** reading			
Adjust UV detector pot to get Ref to 4400-4600 mV			
Perform the "Dark Calibration"			
Adjust Analog Outputs			
Run test points from calibrator to test Ozone readings			

Figure 8: Preventive maintenance log for a 400E

1.6.3 Teledyne API 400E Ozone Analyzer Nightly Auto-Calibrations

Each night an auto-calibration is triggered by the datalogger and controlled by the calibrator to further test and confirm the equipment's operational status. This program starts at a selected time when ambient readings for a specific pollutant are at their lowest point in a typical diurnal pattern. The datalogger triggers the auto-cal to start but then hands over control to the calibrator. The timing of the check for both the datalogger and calibrator are in sync so the datalogger can capture expected results from the calibrator and the analyzer at the right moment. These records are flagged by the datalogger as calibrations and the results are reported to AQS as QC checks. All auto-cals run at least a zero point and a precision point (a point near the current standard) but could include additional points if needed. Most auto-cals are also programmed so reportable hours are not lost in the process. Operators and staff review the results of the auto-cals every workday since all values show up on a daily report (see Data Handling and Reporting SOP section 10).

1.7 Routine site visits

The purpose of the routine site visit is to ensure the analyzer, datalogger, zero air generator, and level 3 transfer standard are operating properly. Routine site visits should be conducted at least biweekly and more frequently if necessary. During ozone season, monitor maintenance should not be performed between the hours of 10 am and 8 pm unless absolutely essential or weather permitting, i.e. 100% overcast or rain at the site during the check. Data recovery during this period should exceed 75%.

1.7.1 Upon arrival, visually inspect the site for safety hazards and cleanliness. Ensure sample line and probe box are intact, and that there are no problems such as tree branches or other greenery growing too close to the sample inlet, etc. Check the fire extinguisher and initial label once a month. If there are any problems contact the Program Manager.

1.7.2 Inspect the building interior for cleanliness of instruments, PC, desk, and floor. Clean if needed. Check the AC and heater systems for proper function and make sure there are no safety hazards.

1.7.3 Check and ensure that the sample line is connected to the back of the analyzer and that it is not contaminated by dirt or moisture. If it has contaminates contact the Program Manager and clean the sample line. Check cable connections for proper seating.

1.7.4 Check to see if the computer, analyzer, level 3 transfer standard, and datalogger are set to the proper time. If times are off more than 1 minute, adjust to correct time, make a note in the logbook and alert supervisor.

1.7.5 Record the site visit in the site EDAS logbook.

1.7.6 Examine the EDAS minute data graph day by day since the last visit and check for atypical data. Record any discrepancies on the graph and in the logbook if necessary. Complete data edit sheets upon returning to the office. Document any discrepancies as soon as possible and maintain the documentation in the proper files.

1.7.7 Check the frequencies, pressure, and temperature. Ensure that all previous auto-calibration cycles since the last check are typical and that the hourly data is typical. Fill in the daily section of the logbook. **(Corrective action should be taken if the auto-calibration zero is > ± .002 ppm O3 or the span is > ± 7% from the expected value.)**

1.7.8 If you have taken the channel offline, enable the channel.

1.7.9 Any possible abnormalities should be investigated to insure continuous uninterrupted quality controlled data collection. If any problems are found the operator is to notify the program manager immediately and document any actions taken to correct the problems. If the operator is not absolutely sure the problem encountered is permanently rectified, he should visit the site later on that day or the next working day to check the status of the problem and perform additional corrective action as necessary. The operator is to keep the program manager informed on a daily basis as to the status of the problem. Detailed records of all corrective actions are to be maintained in the EDAS logbook and on the minute graph.

1.8 Quality Assurance / Quality Control Checks

Quality assurance / quality control procedures include performance audits, 14 day manual ZSP checks, 90 day verification checks, and calibrations.

Audits are to be performed quarterly at a frequency <90 days apart. Analyzer accuracy audits are to be performed by an individual other than the operator who performed the calibration. The QA staff performing the audit should also inspect the site's overall condition and report any issues to the Program Manager. Issues can include but not be limited to: safety hazards, operator oversights, EPA site requirements being met, building condition, overall neatness, and up-to-date documentation of the site's activities. During ozone season monitor maintenance should not be performed between the hours of 10 am and 8 pm unless absolutely essential or weather permitting, i.e. 100% overcast or rain at the site during the check. Data recovery during this period should exceed 75%. The following procedure should be followed when conducting audits:

The analyzer audit is conducted by challenging the measurement system with a series of known concentrations of calibration gas using only audit equipment. No site equipment can be used during the audit except the analyzer that is being audited. The audit field procedure is similar to the calibration procedure except that no analyzer adjustments are made. The audit must include zero and at least one point taken from three of the ten ranges:

Level 1: 0.004 - 0.0059 ppm O_3
Level 2: 0.006 - 0.019 ppm O_3
Level 3: 0.020 - 0.039 ppm O_3
Level 4: 0.040 - 0.069 ppm O_3
Level 5: 0.070 - 0.089 ppm O_3
Level 6: 0.090 - 0.119 ppm O_3
Level 7: 0.120 - 0.139 ppm O_3
Level 8: 0.140 - 0.169 ppm O_3
Level 9: 0.170 - 0.189 ppm O_3
Level 10: 0.190 - 0.259 ppm O_3

The audit photometer must meet all the traceability requirements defined in section 1.4 of this SOP.

OZONE QUARTERLY AUDIT WORKSHEET

Site:	UC	DATE:	05/27/2015
Site #:	37- 0067- 1008	AUDITOR:	LGA
Site analyzer:	TAPI 400E SN:2219	SITE TEMP:	25.2
Site Calibrator Standard:	TAPI 703 E SN: 294	AUDIT STANDARD	API T700U SN: 128
Cert. Due:	4/23/16	Cert Due:	2/12/16

DIAGNOSTICS:

400E STATION ANALYZER DIAGNOSTICS:	
SERIAL NUMBER:	2219
O3 MEASURE (Mv)	4422.1
O3 REFERENCE (Mv)	4421.9
PRESSURE IN-HG-A	29.7
SAMPLE FLOW (CC/M)	773.0
SAMPLE TEMP (DEG. C)	43.9
PHOTO LAMP (DEG. C)	58.0
BOX TEMP (DEG. C)	32.0
SLOPE	1.0095
OFF SET	-0.2839
TEST (Mv)	383.9
RANGE	250.0
STABILITY	0.4
DATE OF LAST VER/CAL:	4/27/15
DATE OF LAST AUDIT:	4/27/15

T700U AUDIT STD DIAGNOSTICS:	
SERIAL NUMBER:	128
TOTAL FLOW (LPM)	3.0
REG PRESSURE (PSIG)	8.1
BOX TEMP (DEG.C)	33.7
O3 GEN REF (Mv)	1.0
O3 GEN DRIVE (Mv)	0.0
O3 LAMP TEMP (DEG. C)	48.0
PHOTO MEASURE (MV)	4527.5
PHOTO REF (MV)	4526.1
PHOTO FLOW (LPM)	0.8264
PHOTO LAMP TEMP (DEG. C)	58.0
PHOTO S PRESS (IN HG)	28.7
PHOTO STEMP (DEG. C)	43.0
PHOTO SLOPE	0.9780
PHOTO OFFSET (PPB)	1.4000
TEST	6.9
DIL PRESSURE (PSIG)	24.6
A-DIL (LPM)	3.0570
T-DIL (LPM)	2.9750

ZERO AIR SYSTEM:	
Zero Air Model:	API 701H
Serial Number:	
Pressure (PSI):	28
Last Serviced:	
Comments:	

Site Calibrator 703E/700EU		
SLOPE	1.0151	Good
OFFSET	-0.6324	Good

COMMENTS:

ANALYZER/8832 DATA:

	CURRENT SLOPES AND INTERCEPTS	
	DAS	API RAW SREC
SLOPE	0.2478	1.0019
INT	0.0001	-0.0001

AUDIT RESULTS:

Audit Target	AUDIT STD. Generating PPM	8832 OBS DAS PPM	API 400E RAW PPB	API 400E OBS PPM	8832 % DIFF PPM	API % DIFF PPM	8832 Audit Point OK?	API Audit Point OK?
ZERO	0.000	0.0011	0.1	0.0000	#N/A	#N/A	OK	OK
0.225	0.2249	0.2238	225.6	0.2259	-0.49	0.46	OK	OK
0.180	0.1801	0.1793	181.0	0.1812	-0.44	0.63	OK	OK
0.150	0.1499	0.1496	151.1	0.1513	-0.20	0.92	OK	OK
0.130	0.1298	0.1289	130.7	0.1308	-0.69	0.80	OK	OK
0.090	0.0899	0.0891	90.5	0.0906	-0.89	0.74	OK	OK
0.070	0.0701	0.0689	70.4	0.0704	-1.71	0.47	OK	OK
0.050	0.0502	0.0492	50.2	0.0502	-1.99	-0.01	OK	OK
0.030	0.0251	0.0252	25.0	0.0249	0.40	-0.61	OK	OK
0.015	0.0099	0.0101	10.0	0.0099	2.02	0.19	OK	OK
0.005	0.0049	0.0051	5.1	0.0050	4.08	2.19	OK	OK

8832 Readings	API Minute Averages Time Stamp	CONC1-AVG	STABIL-AVG	PHMEAS-AVG	PHREF-AVG	SMPPRS-AVG	SMPFLW-AVG	SMPTMP-AVG	PHTEMP-AVG	BOXTMP-AVG	SLOPE1-AV(	OFSET1-AVG
OZONE= .0011 (D)	5/27/2015 7:22	0.1	0.1	4298	4298	27	771	38	58	25	1.0095	-2.8391
OZONE= .2238 (D)	5/27/2015 7:49	225.6	0.4	4288	4298	27	768	38	58	25	1.0095	-2.8391
OZONE= .1793 (D)	5/27/2015 7:58	181	0.3	4290	4298	27	764	38	58	26	1.0095	-2.8391
OZONE= .1496 (D)	5/27/2015 8:09	151.1	0.4	4291	4298	27	766	38	58	26	1.0095	-2.8391
OZONE= .1289 (D)	5/27/2015 8:19	130.7	0.5	4292	4298	27	766	38	58	26	1.0095	-2.8391
OZONE= .0891 (D)	5/27/2015 8:35	90.5	0.5	4293	4297	27	767	38	58	26	1.0095	-2.8391
OZONE= .0689 (D)	5/27/2015 8:35	70.4	0.5	4293	4297	27	767	38	58	26	1.0095	-2.8391
OZONE= .0492 (D)	5/27/2015 8:59	50.2	0.4	4293	4296	27	767	38	58	27	1.0095	-2.8391
OZONE= .0252 (D)	5/27/2015 9:07	25	0.4	4294	4296	27	762	39	58	27	1.0095	-2.8391
OZONE= .0101 (D)	5/27/2015 9:18	10	0.4	4295	4295	27	761	39	58	27	1.0095	-2.8391
OZONE= .0051 (D)	5/27/2015 9:39	5.1	0.4	4295	4295	27	761	39	58	27	1.0095	-2.8391

O3 DAS REGRESSION RESULTS AND CRITERIA (X,Y)					
✓ EXCELLENT		EXCELLENT		EXCELLENT	
SLOPE (M)	1.0063	INTERCEPT (B)	-0.0001	RSQR	1.0000
EXCELLENT (0.98 = < M< = 1.02)	✓	EXCELLENT (-0.002=<B< = 0.002)	✓	EXCELLENT (> =0.9999)	✓
SATISFACTORY(0.90=<M<=1.10)		SATISFACTORY (-0.010 = < B <=0.010)		SATISFACTORY (> =0.9990)	
UNSATISFACTORY(M<0.90,M>1.10)		UNSATISFACTORY(B<-0.010, B>0.010)		UNSATISFACTORY(<0.9990)	

Figure 9: Ozone Audit Data worksheet

1.8.1 Audit Procedure using the Teledyne API T700U Dynamic Dilution Calibrator

1.8.1.1 Part of each audit is a routine site check. See 1.7 of this SOP.

1.8.1.2 The audit is to be recorded in the audit section of the analyzer logbook. The Ozone Audit Data Sheet (Fig. 9) must be used to document the completion of the audit. Record the information but do not alter the analyzer settings in any way.

1.8.1.3 Transport an audit photometer (T-API T700U, level 2 transfer standard) to the site to be audited. The photometer may be transported to the site the day before the audit if feasible. The audit photometer should warm up at least one hour prior to the performance of the audit.

1.8.1.4 Login to the datalogger using HyperTerminal.

Refer to Section 11. Datalogger 8832 SOP

Disable the appropriate channel. Type Esc ‘site ID’(CM) AQM Enter, to enter Login screen. Hit L Login, type password, press Enter. C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration), M (Disable/Mark Channel Offline). Use arrows to skip to Ozone, press Enter to disable the Ozone channel.

1.8.1.5 Upon arrival at the site on the day the audit is to be performed connect the audit photometer output (from the level 2 transfer standard) with 1/4" Teflon tubing to the calibration line that feeds cal gas to the sample probe box. This way the audit gas will follow the same path as the cal gas takes to get to the sample line for the analyzer.

1.8.1.6 Connect the zero air supply line to the zero air inlet port of the audit standard. Check to ensure that the zero air system is operating at approximately 20-30 psig. Check to ensure that the level 2 transfer standard internal pressure regulator is reading 15 psig. If these settings are not obtained contact the program manager for corrective procedures. Set the level 2 transfer standard calibrator to generate ZERO air by pressing the SEQuence, A, Zero.

1.8.1.7 Allow the analyzer to sample the ZERO air for 15 minutes. After 15 minutes, check the stability of the analyzer. If it is less than 0.5 ppb record the results from the 8832 and the API 400E in the logbook. Calculate the corrected ozone concentrations from the API 400E based on the applicable verification equation from the last 90-day verification.

1.8.1.8 Using the front panel touch buttons, generate 0.225 ppm on the audit photometer. Allow the analyzer to sample the 0.225 ppm ozone concentration from the calibrator for 15 minutes. After 15 minutes, check the stability of the analyzer. If it is less than 0.5 ppb record the results from the 8832 and the API 400E in the logbook. Calculate the corrected photometer ozone concentrations from the API 400E based on the applicable verification equation from the last 90-day verification.

1.8.1.9 Repeat step 1.8.1.8 for the remaining audit points. After running the last point, run a ZERO point again to flush system and lines ensure there was no drift from the previous ZERO result. Then place the audit calibrator back in stand by mode by pressing STBY.

1.8.1.10 Calculate the percent difference of the datalogger response and the corrected photometer O3 output using the following equation.

[(a-b)/b]*100=% Difference

where:
a = Datalogger response
b = Corrected photometer output

The differences should be ± 7% for all points. If not, contact the Program Manager and relay results.

Any differences outside of the ranges listed above must be brought to the attention of the program manager. Corrective action should be discussed and applied.

1.8.1.11 If the audit passes, record the audit completion on the EDAS minute graph and logbook. Also inspect site condition for QA requirements, safety concerns, documentation completeness, and overall neatness and order. Document findings in logbook and report them to the program manager.

1.8.1.12 Disconnect the audit photometer (audit standard) and reconnect the sample line to the level 3 transfer standard gas on/off switch.

1.8.1.13 Enable the ozone channel.

Refer to Section 11. Datalogger 8832 SOP

In the datalogger, skip back to the Main Menu (use Esc). Press C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration), E (Enable/Mark Channel Online). Use arrows to skip to Ozone, press Enter to enable the Ozone channel. Skip back to the Main Menu (Esc), hit O Log Out/Exit to exit out of the datalogger.

1.8.2 Biweekly Zero/Span/Precision (ZSP) Checks

Biweekly zero/span/precision (ZSP) checks must be performed every 14 days or less. Concentrations for these points are 0.000 ppm, .225 ppm, and .070 ppm. The ZSP check must be performed with a currently certified ozone calibration standard. ZSP checks may be performed manually as outlined below or automatically during the scheduled auto-calibration sequence. Checks performed as part of the automatic calibration sequence are to be reviewed and recorded daily in the site Excel logbook

(.xls file, ZSP worksheet). ZSP check data resulting from automatic calibration sequences must meet the following requirements:

The zero point should be within ≤ ± 5 ppb for manually run zeros and when part of an automatic calibration. The precision point should be within ≤ ± 7 %. The span point should be within ≤ ± 7 %.

1.8.2.1 To perform a manual ZSP check, login onto the datalogger and disable the channel.

Refer to Section 11. Datalogger 8832 SOP

Open HyperTerminal and type Esc ‘site ID’ AQM press Enter, to enter Login screen. Press L Login, type password, press Enter. C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration), M (Disable/Mark Channel Offline). Use arrows to skip to Ozone, press Enter to disable the Ozone channel.

1.8.2.2 Using the APICom software download one instrument’s 1-minute reading (see 1.3.1.15.1) and copy into the instrument’s logbook (400E Diagnostics) (Fig. 10)

OZONE ZSP

DATE: 6/18/2015		**TIME:** 8:30 **EST**		**OPERATOR:** CDG		**SITE:** UC	

DATA LOGGER CHECKS:

MODEL:	8832	SERIAL #: A4303K	Last 8832 Cal Done: 5/4/15
8832 Date Correct?	y		Next 8832 Cal. Due: 11/2/15
8832 time within 15 s?	y		CPU Date Correct? y
Time/Date of last 8832 poll by the CPU?	8:05		CPU Time Correct? y

API Ozone Analyzer 400E Diagnostics:				**API Ozone Calibrator 700EU/703E Diagnostics:**	
SERIAL NUMBER:	M400E-2218	**OK?**		SERIAL NUMBER:	M700E-59
Date and Time:	6/18/2015 8:31	Yes	within 15 s?	OUTPUT FLOW (L/min)	2.6
PHMEAS-AVG (mV)	4101	OK		REG PRESSURE (PSI)	5.8
PHREF-AVG (mV)	4101	OK		BOX TEMP (°C)	27.9
SMPPRS-AVG (InHg)	27	OK		O3LAMP TEMP (°C)	47.9
SMPFLW-AVG (cc/m)	736	OK		PHOTO MEASURE (mV)	3668.0
SMPTMP-AVG (DegC)	38	OK		PHOTO REFerence (mV)	3685.9
PHTEMP-AVG (DegC)	58	OK		PHOTO LAMP TEMP (°C)	58.0
BOXTMP-AVG (DegC)	29	OK		PHOTO SPRESS (in Hg)	28.4
SLOPE1-AVG	1.02			PHOTO STEMP (°C)	38.6
OFSET1-AVG (PPB)	0.24				

OZONE OPERATIONAL CHECKS:

LAST CAL DATE:	3/25/14	
NEXT CAL DUE:	**6/23/14**	
	DAS	**400E**
SLOPE	0.2531	1
INT	-0.00074	0.00024

POINTS	Cal Actual PPM	Stability	OBS DAS [PPM]	Obs 400E [PPM]	Raw 400E [PPM]	% DIFF DAS	% DIFF SREC
ZERO	**0.000**	**0.0**	**-0.1433**	**0.0140**	**0.0**	**n/a**	**n/a**
SPAN	**0.225**	**0.0**	**0.2241**	**0.2248**	**0.2**	**-0.4**	**0.02**
PRECISION	**0.070**	**0.0**	**0.0690**	**0.0698**	**0.1**	**-1.43**	**0.06**

OZONE CONTROL LIMITS (DAS):	
ZERO DIFFERENCE < = ± 0.005 PPM?	**OK**
SPAN DIFFERENCE < = ± 7 % ?	**OK**
PRECISION DIFFERENCE < = ± 7 %?	**OK**

8832 Ozone Readings	
ZERO	OZONE=-0..1433 (D)
SPAN	OZONE= .2241 (D)
PRECISION	OZONE= .0690 (D)

Entered Logbook Comments:	y	
Entered Memo on Digital Chart:	y	
Loaded records from 400E:	y	
UPS Check:	y	
Fire Extinguisher Check:	y	
Filter Change and Leak Check:	y	
Probe box/inlet check:	y	
Site temperature:	25	degC
Zero Air Supply Pressure:	30	PSI

Comments:

400E Diagnostics		Zero	Span	Precision
Time Stamp	6/18/2015 8:31	6/18/2015 8:45	6/18/2015 8:55	6/18/2015 9:08
CONC1-AVG (PPB)	0.014	0.0003	0.2248	0.0698
STABIL-AVG (PPB)	0.002	0.002	0.002	0.002
PHMEAS-AVG (mV)	4101	4101	4101	4101
PHREF-AVG (mV)	4101	4101	4101	4101
SMPPRS-AVG (InHg)	27	27	27	27
SMPFLW-AVG (cc/m)	736	736	736	736
SMPTMP-AVG (DegC)	38	38	38	38
PHTEMP-AVG (DegC)	58	58	58	58
BOXTMP-AVG (DegC)	29	29	29	29
SLOPE1-AVG	1.02	1.02	1.02	1.02
OFSET1-AVG (PPB)	0.24	0.24	0.24	0.24

Figure 10: Instrument Logbook, Zero/Span/Precision (ZSP) worksheet

1.8.2.3 The ZSP check may be performed by manually activating the appropriate sequences in the level 3 transfer standard.

1.8.2.4 To run a manual ZSP check, check that the level 3 transfer standard is connected to a zero air generator, which is producing 20-30 psig.

1.8.2.4 If the level 3 transfer standard is connected to the analyzer through the sample line, make sure the solenoid opens when starting the sequence.

1.8.2.5 Start the zero point by pressing SEQ, then ZERO on the level 3 transfer standard. Let the point run for at least 10 minutes and until stability reaches at least < 0.5.

1.8.2.6 Record the reading from the datalogger. Use Esc to skip back to the Main Menu. Enter D (Real-Time Display), F (Display Readings w/Flags). Download the instrument's 1-minute reading using APICom (see 1.3.1.15.1). Copy both readings into the instrument's logbook (Fig. 10). The observed and downloaded Ozone readings have to be manually copied into the 'Ozone Operational Checks' section.

1.8.2.7 Record the following level 3 transfer standard diagnostics by skipping through the Test options while the zero point is running:

Output flow (L/min)
Regulator Pressure (PSI)
Box Temperature (°C)
Ozone Lamp Temperature (°C)
Photometer Measure Voltage (mV)
Photometer Reference Voltage (mV)
Photometer Lamp Temperature (°C)
Photometer Pressure (inHg)
Photometer Temperature (°C)

1.8.2.8 Start the Span point by pressing SEQ, then press arrow to find O3 225 on the levels 3 transfer standard. Let the point run for at least 10 minutes and until stability reaches at least < 0.5. Record the reading from the datalogger (F Display with Flags) and download the instrument's 1-minute reading using APICom (see 1.3.1.15.1). Copy both readings into the instrument's logbook (Fig. 10). The observed and downloaded ozone readings have to be manually copied into the 'Ozone Operational Checks' section.

1.8.2.9 Now start the Precision point by pressing SEQ, then press arrow to find O3 70 on the levels 3 transfer standard. Let the point run for at least 10 minutes and until stability reaches at least < 0.5. Record the reading from the datalogger (F Display with Flags) and download the instrument's 1-minute reading using APICom (see 1.3.1.15.1). Copy both readings into the instrument's logbook (Fig. 10). The observed and downloaded ozone readings have to be manually copied into the 'Ozone Operational Checks' section.

1.8.2.10 When the ZSP check is complete, press the STBY button on the level 3 transfer standard to set into "Stand By" mode. Make sure the front of the analyzer is showing it is in "Sample" mode; observe the ozone value and stability to make sure it is returning to ambient values.

1.8.2.11 Check the Zero/Span/Precision worksheet (Fig. 10), to verify that all entered data and manually copied values are correct.

1.8.2.12 Check that Zero/Span/Precision Differences are within their limits:

Zero ≤± 0.005 ppm
Span ≤± 7%
Precision ≤± 7%

If the ZSP check does not meet the above criteria, inform the program manager. An adjusted calibration must be performed before channel is enabled. Maintenance and/or troubleshooting may be required before calibration can be done.

1.8.2.13 Once a month, the 5 µm filter has to be changed. This has to be done after the ZSP check is performed. Always handle particulate filters with tweezers.

1.8.2.14 In APICom 4.0.1exe. click the 'Get data' button, choose 'since last download (15 days)' to download the hourly data from the 400E and 'Save' to the ozone hourly data folder. Close all APICom windows to disconnect from 400E.

1.8.2.15 Log on onto the datalogger and enable the ozone channel.

Refer to Section 11. Datalogger 8832 SOP

Use ESC to skip back to Main Menu. Press C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration), E (Enable/Mark Channel Online). Use arrows to skip to ozone, press Enter to enable the ozone channel. Skip back to the Main Menu (ESC), press O Log Out/Exit to exit out of the datalogger.

1.8.2.16 Review ALL minute data since the last check using the EAS minute graphs and look for questionable data. Make a note of all said data and investigate potential quality concerns. Notify program manager of potential data flagging needed. Record a note in the EDAS logbook and minute graph of the performed check. Confirm EDAS scheduler is ON.

1.9 Data Handling - Documentation, Analysis, Editing, and Reporting

See the Data Handling and Processing SOP, which is Section 10.

APPENDIX

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

As the instructions for the flow calibration in the 703 EU manual are not correct, useful, halfway complete…, I spoke with API. Following is the correct procedure as described by a technician who guided me through the process while I 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.

To calibrate Photometer Gas Flow:

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

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II- Ambient Air Specific Methods, EPA-454/B-13-003 (2013), U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Research Triangle Park, N.C. 27711.

Title 50 Code of Federal Regulations Part 50, Appendix D- Measurement Principal and Calibration Procedure for the Measurement of Ozone in the Atmosphere, 1993.

Title 50 Code of Federal Regulations Part 58- Ambient Air Quality Surveillance. 1993.

Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone, Technical Assistance Document. EPA-454/B-13-004. United States Environmental Protection Agency, October 2013.

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, November, 2010.

Technical Manual, Ozone Analyzer 400E, Teledyne Instruments Advanced Pollution Instrumentation Division, 9480 Carroll Park Drive, San Diego, CA 92121-5201.

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

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

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