California Environmental Protection Agency

AIR RESOURCES BOARD

AIR QUALITY SURVEILLANCE BRANCH

STANDARD OPERATING PROCEDURES

FOR

TELEDYNE/ADVANCED POLLUTION INSTRUMENTS (API) MODEL 400A OZONE ANALYZER

AQSB SOP 001

First Edition

MONITORING AND LABORATORY DIVISION

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California Environmental Protection Agency
AIR RESOURCES BOARD

Approval of Standard Operating Procedures (SOP)

Title:	TELEDYNE/ADVANCED POLLUTION INSTRUMENTS (API) MODEL 400A OZONE ANALYZER
SOP:	AQSB SOP 001, First Edition
Section:	Operation Support Section
Branch:	Air Quality Surveillance Branch (AQSB)
Division:	Monitoring and Laboratory Division (MLD)
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1.0 GENERAL INFORMATION

1.1 Introduction:

This Standard Operating Procedure (SOP) describes procedures used by the Air Resources Board (ARB) Air Quality Surveillance Branch (AQSB) to operate the Teledyne/Advanced Pollution Instruments Model 400A Ozone Analyzer (API 400A) to measure ozone levels in ambient air. This procedure is designed to supplement the instruction manual by describing modifications in the hardware or operating procedures, if any, implemented by the AQSB. It is not the intent of this SOP to duplicate the instruction manual. This SOP was written referencing the manual for the API 400 AMX firmware. Operators with other versions of firmware should reference the instrument manual for their specific instrument. A separate document is available for the analyzers acceptance test procedures.

1.2 Principle of Operation:

The API 400A detects ozone by measuring the absorption of 254nm UV light emitted by a mercury lamp. The light passes through a glass tube that is alternately filled with sample gas and gas that has been scrubbed to remove ozone. The ratio of the light intensity forms the basis of the calculation of ozone concentration. A detailed discussion of the analyzer's measurement principle is contained in the manufacturer's instruction manual

1.3 Safety Precautions:

Prior to cleaning the analyzer or performing any maintenance on the API 400A, place the MAIN power switch to the OFF position, and unplug the power cord. Avoid the use of chemical agents which might damage components.

Always use a three-prong, grounded plug on this analyzer.

Adhere to general safety precautions when using compressed gas cylinders (e.g., secure cylinders, vent exhaust flows).

2.0 INSTALLATION PROCEDURE

2.1 General Information:

The API 400A is designed to be installed in an environmentally controlled environment. Normally the instrument should be rack mounted in a standard 19" instrument rack.

2.2 Physical Inspection:

The Model 400 is shipped with the following standard equipment

1. Power cord
2. Instruction manual
3. Side rails

Upon receiving the API Model 400A confirm that the instrument is in good working order and check for damage. If any damage is observed, contact your immediate supervisor. Prior to installation of the API 400A check the following:

1. Verify no apparent shipping damage
2. Check that all connectors are fully inserted
3. Check that all mechanical connections are tight
4. Connect sample inlet line to sample port on rear panel
5. Connect the pump exhaust to a suitable vent outside the analyzer area
6. Connect IZS inlet input (if installed) to a clean, dry air supply
7. Connect a recording device to the terminal strip connections on the rear panel see Figure 1.2, "REAR PANEL ELECTRICAL CONNECTIONS" in the instruction manual.
8. Connect power cord to an appropriate power outlet

3.3 Siting:

The API 400A should be sited accordance with the United States Environmental Protection Agency (U.S. EPA) Title 40, Code of Federal Regulations Part 58 (40 C.F.R. 58).

3.4 Data Logger Connection:

The API 400A has a six-pin output connector strip on the rear panel (see Figure 1, page 20). The middle two pins (Output #2) are the ozone concentration output for the data acquisition system. The pins are marked plus and minus and must be connected accordingly.

3.5 Strip Chart Connection:

The API 400A has a six-pin output connector strip on the rear panel (see Figure 1, page 20). The first two pins (Output #1) are the ozone concentration output for chart recorder. The pins are marked plus and minus and must be connected accordingly.

3.6 Operation Verification:

NOTE: Prior to operation of the API Model 400A analyzer, operators are encouraged to read the instrument manual to familiarize themselves with the operation of the instrument.

1. After connecting sample lines, exhaust lines and data acquisition connections, turn on the power switch located on the lower right corner of the front panel. The display should turn on and the green sample LED should begin blinking indicating that the instrument has entered the HOLD-OFF mode. Sample mode can be entered immediately by pressing the EXIT button on the front panel. The red “fault” LED may also be on until the flows, temperatures and voltages are within operating limits. Clear any fault messages.

2. Allow 60 minutes for the temperatures to assume their respective set points then scroll through the TEST values. Compare these values to those listed on the factory final checkout sheet in the instrument manual or those listed on the Operation Support Sections Instrument Laboratory Data Sheet. Verify that the test parameters are within the limits prescribed by Table 1, API 400A Standard Configuration Table.

3.0 CONFIGURATION

3.1 Instrument Configuration

The API 400A is usually configured by the ARB's Operation Support Sections Instrument Laboratory and requires no field configuration. However, field staff are strongly encouraged to verify that their instrument is properly configured.

TEST PARAMETER	NOMINAL	RANGE
Time	Current PST time	+/- 2 minutes
Range (ppb)	500	0 to 1000
Stabil (Standard Deviation of O3 Readings)	0.1	< 1 ppb w. zero air
O3 Meas (Current V/F conv MV, measured channel)	4400	4200 to 4700
O3 Ref (Current V/F conv MV, reference channel)	4400	4200 to 4700
O3 Gen (IZS ref channel feedback)	+/- 10% demand	80-5000 MV
O3 Drive (Drive voltage for O3 Gen Lamp)	+/- 10% demand	0-5000 MV
Vacuum (in-Hg-A)	11 inHg	< ½ Ambient Pressure
Pressure (Absolute Pressure, inHg)	Ambient Press.	29 to 31
Sample Temp (°C)	Ambient Temp	Ambient +/- 10°
Sample Fl (Sample Flow through Analyzer, c/min)	800	800 +/- 10%
Photo LMP (Photometer Lamp Housing Temp, °C)	58	58 +/- 2
O3 Gen Temp (O3 Generator Housing Temp, °C)	48 C	+/- 1°
Box Temp (Internal Box Temp, °C)	Ambient Temp	Ambient +/- 10°
DCPS (DC Power Supply, mV)	2500	2450 to 2550
Slope (Internal Formula, Slope)	1.00	0.9 to 1.1
Offset (Internal Formula, Offset)	0.0	-5.0 to 5.0

TABLE 1, Standard AQSB API 400A Configuration Table

3.2 Datalogger Configuration

Datalogger channel configuration for the API 400A is covered in the AQSB SOP for the datalogger model you are using. The datalogger channel (channel one) for the ozone analyzer must be configured for a 0 to 1 volt signal equaling 0 to 500 PPB assuming the range of the API 400A is set to 500 ppb.

3.3 Strip Chart Configuration

Strip chart channel configuration for the API 400A is covered in the AQSB SOP 604. The strip chart channel (channel one) for the ozone analyzer must be configured for a 0 to +1 voltage output range, with units from 0 – 500 ppb. The strip chart recorder color should be set to light green.

4.0 CALIBRATION INFORMATION

4.1 Calibration Introduction:

A calibration is a procedure for aligning or checking the output of an instrument to a known "true" standard. An "AS-IS" calibration is performed initially to quantify the instruments accuracy. The "AS-IS" calibration verifies the accuracy of the recently generated data, usually back to the previous calibration. A "Final" calibration is performed just after an instrument has been aligned to a "true" standard or instrument replacement. Typically, an "AS-IS" calibration is performed, then an alignment, and followed by a "Final" calibration. To ensure the quality of the data provided by the API 400A, the analyzer must be calibrated prior to use, after any major maintenance and recalibrated every six months thereafter. This section of the SOP provides a list of the necessary equipment and the correct procedures to accurately calibrate the analyzer.

4.2 Calibration Overview:

Test concentrations for ozone must be obtained in accordance with UV photometric calibration procedures listed in 40 CFR 50 Appendix D (Measurement Principle and Calibration Procedure for the Measurement of Ozone in the Atmosphere) or by means of a certified ozone transfer standard. The transfer standard must be traceable to a primary ultraviolet photometer and recertified on a quarterly basis.

The test concentration for ozone generated using an ozone transfer standard should be delivered directly to the API 400A via the inline particulate filter "hockey puck".

4.3 Calibration Apparatus for the API 400A:

1. Certified Ozone/Gas Transfer Standard.

2. One-quarter inch Teflon tubing for air flow connections.

3. Zero air source

4. Calibrated laminar flow device for measuring air flow (mass flow meter).

5. Calibration report forms (Appendix B).

6. Simulated calibration line if using calibrator for ozone source.

5.0 CALIBRATION PROCEDURE

5.1 Calibration at Altitude

Calibrating the API 400A analyzer at altitude requires no special adjustments because the analyzer compensates for changes in temperature and pressure. At the time of calibration, verify the operation of the transducers in the analyzer by recording the values of temperature and pressure from the analyzer and from a certified transfer standard for one point.

NOTE: The data acquisition system (DAS) is used for primary data recording, therefore the DAS data reading should be used for calibration calculations in lieu of the analyzer display readings.

5.2 AS-IS Calibration:

AS-IS instrument calibrations should be made prior to making any analyzer repairs or adjustments. The ozone scrubber and solenoid valve should not be replaced with out first performing an AS-IS calibration. It is acceptable to perform routine service checks prior to an AS-IS calibration. Prior to beginning AS-IS calibration "mark down" appropriate DAS channels on the station datalogger.

1. When setting up the certified ozone/gas transfer standard to generate the test concentrations for ozone, configure the transfer standard so that the ozone generated is measured by the transfer standards UV photometer. Using one-quarter inch (1/4" O.D.) Teflon tube, connect a zero air source and exhaust lines to the transfer standard. Connect a 1/4" O.D. Teflon line from the transfer standard's sample port to the API 400A "hockey puck".

   Energize the zero air system and configure the transfer standard so that zero air is flowing through the calibration assembly.

2. Allow both the transfer standard and the analyzer being calibrated to warm-up for at least one hour. All instrument covers should be on during the calibration, as the calibration is dependent upon the internal temperature of the analyzer. The transfer standard diagnostic values should be stable; showing no upward or downward trend when operating temperature has been reached.

3. Record the station information, analyzer identification numbers, analyzer settings, calibration equipment information and any other pertinent information on the calibration data sheet (Appendix B).

4. Obtain the instrument internal slope and offset from the API 400A front

display following the steps in the instruction manual. Record the AS-IS slope and offset on the calibration data sheet. Confirm that the values are the same as at the end of the previous calibration. If not, investigate when and why these values have changed before beginning calibration.

5. Adjust the sample air flow rate of the transfer standard to 5.0 SLPM as measured by the calibrated laminar flow device. Measure and record the AS-IS sample air flow rate of the API 400A. Connect an 18 inch long Teflon line (1/4" O.D.) to the vent port of the transfer standard and measure the vent flow. The vent flow should be greater than 0.5 LPM.

6. Allow the analyzer and transfer standard to sample zero air. When a stable zero reading is reached and the stability test function (a measure of the standard deviation taken from the last ten data points) is less than 1 ppb, record 10 consecutive DAS display values in the respective columns labeled "pre-zero" on the calibration data sheet. Record the average strip chart and API 400A zero reading in the space provided.

7. Set the transfer standard to produce a Span ozone concentration of approximately 80% of full scale (400 ppb) of the analyzer being calibrated as read by the transfer standard.

8. When the stability test function is less than 1 ppb, record ten consecutive digital values in the columns labeled "1st pt" for each analyzer. Calculate the sum and average of the ten numbers and record the value on the calibration data sheet in the appropriate blocks. Record the average strip chart recorder and API 400A span readings in the appropriate space.

9. Record data for the "2nd Pt", "3rd Pt", and 4th Pt": after adjusting the ozone transfer standard output to approximately 0.25, 0.090, and 0.05 PPM, respectively and stability readings are less than 1 ppb. Calculate and record the sum and average readings.

10. Repeat step 6 and record the value on the column marked "post- zero". Average the "pre-zero" and "post-zero" readings and use this value as the zero correction.

11. Calculate corrected averages for the transfer standard analyzer using the formula:

    Corrected Average (Transfer Standard) = (Average Reading - Zero Correction) x True Ozone Correction Factor

12. Calculate the summation of corrected averages for the transfer standard (S1)

by adding the corrected averages for points 1, 2, 3, and 4.

13. Calculate the corrected averages of the analyzer being calibrated using the formula:

Corrected Average = Average Reading - Zero Correction

14. These values, in PPM, should correspond to the analyzer's DAS display. If not, check the calibration of the recording device before making adjustments to the analyzer.

15. Calculate the summation of corrected averages for the analyzer being calibrated (S2) by adding the corrected averages for points 1, 2, 3, and 4.

16. Calculate the average percent difference from true ozone:

$$Overall\%\,Accuracy = \left(\frac{S2 - S1}{S1}\right) * 100$$

17. Using a best fit linear regression, calculate the slope (m) and intercept (b) equation of the calibration line:

Where x = true concentration, in PPM
y = analyzer response, in PPM

18. Calculate the percent change from the previous calibration:

Percent change from the previous calibration =
New Slope - Old Slope x 100 Old Slope

19. Record the calibration data on the Calibration Report (Appendix B).

5.3 Final Calibration:

If the percent difference reported in Section 5.2, step 16 is greater than ± 3%, or if the ozone scrubber is replaced, the analyzer must undergo a final calibration. Perform the final calibration as follows:

1. Challenge the API 400A with zero air until the reading stabilizes (not more than +/-2% over a 5 minute time period).

   NOTE: IF THE ANALYZER FAILS TO STABILIZE WHILE SAMPLING ZERO AIR AT, IT WILL BE IMPOSSIBLE TO ENTER ZERO AND IT WILL BE NECESSARY TO REFER TO THE TROUBLESHOOTING SECTION OF THE INSTRUMENT MANUAL.

2. Perform a zero alignment on the API 400A by following the steps in the instrument manual section 3.3 “Dynamic zero/span adjustment”. The API 400A should now zeroed, but the blinking cal light and words "HOLD OFF" indicate that data are not being sent out. This status will last approximately 5 minutes.

3. Record 10 display updates on zero air for pre-zero and record them on the calibration sheet.

4. Challenge the API 400A with a span level of ozone. This level should be approximately 80% of full scale (400 ppb) as measured by the UV photometer. Allow the API 400A to sample until a stable reading is achieved.

5. When the span level is stable, SPAN the API 400A by performing the steps in section 3.3 “Dynamic zero/span adjustment” of the instruction manual.

6. Obtain the instrument internal slope and offset from the API front display following the steps in the instruction manual.

7. Record the final slope and offset on the Calibration Data Sheet (Appendix B).

8. Record on the Calibration Data Sheet 10 display updates at this span level for high point.

9. Return to Section 5.2 (AS-IS Calibration) step 6 to complete the remaining steps of the final calibration. If the analyzer cannot be properly calibrated, refer to the API Instruction Manual for assistance in troubleshooting and repairing the analyzer.

5.4 IZS Calibration:

The IZS calibration is used to adjust the internal ozone generator to match its photometer value. The M400A measures the IZS reference signal and ozone concentration at five different lamp voltages: 0.25 V, 1.0 V, 2.0 V, 3.0 V, and 5.0 V. Each step takes approximately 10 minutes. During the calibration process the screen will display the percent completed, taking approximately 50 minutes to complete.

AQSB standard configuration indicates that the low span should be set for 90 PPB and the high span should be set for 400 ppb. Refer to section 6.3 “Internal Zero / Span (IZS) option” to set the IZS calibration parameters. Also, ensure that units running the IZS feedback option have their feedback mode set to *Ref*.

At a minimum the IZS calibration should be performed following an alteration to the sample pump, adjustment of the flow rate, replacement of the ozone lamp, or after conducting an as-is or final calibration.

1. From the front panel of the instrument, choose *setup*, *more*, followed by *diag*.
2. Ensure that the password reads *818,* and choose *enter*.
3. Choose the *next* entry until obtaining the *ozone generator calibrator* menu item.
4. Choose enter and wait for approximately fifty minutes. After completion, choose *exit* several times until arriving back at the main menu.

Immediately following the IZS calibration, the next auto IZS calibration sequence will determine the new baseline for zero, precision, and span values. These will become the new source values for use in AQDAS II.

5.5 Automatic Zero/Span Check:

The API 400A with IZS option is capable of conducting automatic calibrations on regular intervals. After conducting IZS calibration, daily calibration checks should be scheduled. Detailed procedures can be found in the Instruction Manual, section 6.4 “Auto calibration set-up to Support IZS and Z/S valve option”. AQSB standard configuration uses the parameters detailed in the following table:

Parameter	**Value**
Mode	Zero-Lo-Hi
Starting Date	The day following the IZS calibration.
Starting Time	0350 Hours
Delta Days	1
Delta Time	0
Duration	20

TABLE 2: AQSB IZS Configuration Parameters

6.0 ROUTINE SERVICE CHECKS

6.1 General Information:

The following routine service checks are to be performed in accordance with the maintenance schedule (Table 3). Perform the routine service checks at least at the prescribed intervals or more often in necessary. The AQSB Monthly Quality Control Check Sheet (AQSB QC Form 001) should be completed weekly and submitted monthly to the station operator's supervisor. The station operator must keep a copy of the Monthly Quality Control Check Sheet in the air monitoring station. Detailed routine maintenance procedures can be found in Chapter 11 of the Instruction Manual.

6.2 Daily Checks:

Review instrument data and check chart recorders for any indication of analyzer malfunction. Check instrument front panel for any error messages.

6.3 Weekly Checks:

Record test parameters on the AQSB QC Form 001. Change the inline particulate filter.

6.4 Monthly Checks:

Complete AQSB QC Form 001 and submit to immediate supervisor.

6.5 As Required Checks:

Clean optical chamber and adjust photo lamp when O3 reference value is less than 2500 mV.

Complete an IZS calibration upon completion of instrument calibrations, flow adjustments, or lamp replacements.

6.6 Semiannual Checks:

Perform instrument calibration.

	Value	Daily	Weekly	Monthly	Semi-Annual	As Req
Power On	On	X				
Error Flags	None	X				
Check Chart Recorder	None	X				
Record Test Parameters	Record		X			
Change Inlet filter	Clean		X			
Complete AQSB QC Form	None			X		
Perform field calibration	6 months				X	
Adjust photo lamp	< 2500 mV					X
IZS Calibration	None					X

Table 3, API 400A Prescribed Routine Maintenance Table

7.0 MAINTENANCE AND PROCEDURES

7.1 General Information:

The API 400A is designed to operate unattended for long periods of time and other than routine checks required in section 6.0 of this SOP required little maintenance. However, maintenance requirements vary from instrument to instrument, thus operators should refer to the instrument operating manual to become familiar with maintenance requirements.

Corrective maintenance is any unscheduled maintenance activity that becomes necessary due to system malfunctions. Examples are pump replacement, orifice cleaning and photometer lamp replacement.

If station operators can not repair an instrument using procedures stated in the instrument manual, contact the Operations Support Sections Instrument Laboratory.

8.0 TROUBLESHOOTING

8.1 General Information:

The API 400A has been designed to rapidly detect possible problems and allow for their quick evaluation and repair. During operation, the analyzer continuously performs self-test diagnostics and provides the ability to monitor the key operating parameters of the instrument without disturbing monitoring operations.

Should instrument malfunctions occur and troubleshooting is required to determine the problem, operators should refer to Chapter 10, “Troubleshooting” in the instrument manual.

FIGURES

Figure 1 – API 400A connection from the REC DAS port.

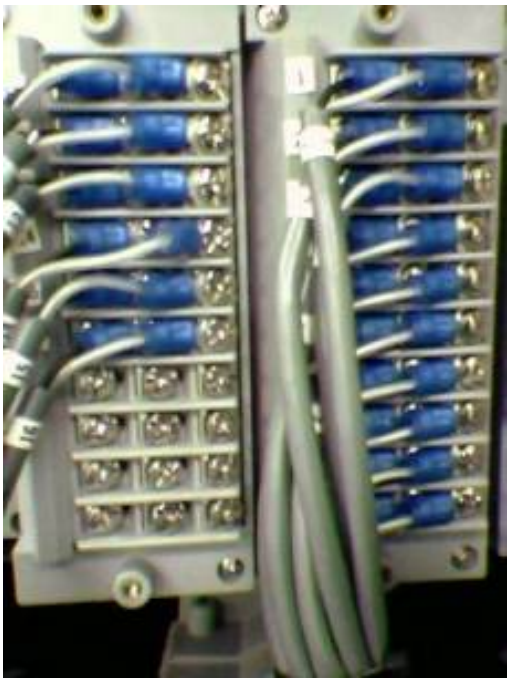

Figure 2 – Strip chart recorder rear-panel, channel one input from the API 400A.

AQSB MONTHLY QUALITY CONTROL MAINTENANCE CHECK SHEET 001
API Model 400 A Ozone Analyzer

Location: _____ Month/Year: _____
Station Number: _____ Technician: _____
Property Number: _____ Agency: _____

Test Parameters		Readings			
	DATE:				
TIME	Current time of day (HH:MM:SS)				
O3 MEAS	Current V/F conv mV, measure channel				
O3 REF	Current V/F conv mV, reference channel				
PRES	Absolute Pressure – inHg				
SAMPLE FL	Sample flow through Analyzer (cc/min)				
SAMPLE TEMP	Temperature of the sample				
ANA LMP TMP	Analyzer Lamp Housing Temp. (°C)				
BOX TEMP	Internal Box Temp. (°C)				
DCPS	DC Power Supply (mV)				

OPERATOR INSTRUCTIONS:

1. Daily checks: Review data and strip charts.

2. Weekly Checks: Record test parameters.
   Change inline particulate filter: Date_____/_____/_____/_____/

3. As Required: Clean optical chamber and adjust photo lamp when O3 ref < 2500 mV

4. Semi-Annual: Calibrate analyzer. Date last calibrated:_____.

Date	Comments or Maintenance Performed:

Reviewed by: _____ Date: _____

Appendix A
AQSB OZONE CALIBRATION REPORT 001
Teledyne/Advanced Pollution Instruments 400A

	Calibration Report:					
ID Information:		Instrument:			Calibration:	
Station Name:		Make:			"As Is"	
Site #:		Model #:			"Final	
Station Address:		Property #:			Calibration Date:	
Agency:		Serial #:			Report Date:	
		Log #:			Previous Calib.:	
Flow Transfer Standard I.D.:						
Make & Model:			Temp. (deg C):			
Property #:			Atm. Press. (mmHg):			
Cert. Date:			Elevation:			
Cert. Exp.:			ACF:			
Flow Transfer Standard Equation:		m (slope)			b (intercept)	
0 to 3 LPM MFC:	Air Flow =		* Avg. Display	+/-		SLPM
Calibration Results:				Analyzer Parameters:		
Pollutant:		Ozone		Press. (inHg):		
Instrument Range (ppm):				O3 Meas. (mv):		
Initial Internal Offset:				O3 Ref. (mv):		
Initial Internal Slope:				Flow Std. Display:		
Air Flow Rate, SLPM:				True Flow (ccm):		
Air Flow Display:				Flow Disp. (ccm):		
	Slope:			DCPS (mv):		
Best Fit Line	Intercept:			Sample Temp. (C):		
	Correlation:			Box Temp (C):		
"As Is" Percent Deviation From True:						
Percent Difference from Prev. Cal.:						
Final Internal Offset:						
Final Internal Slope:						
==========						
	Calibration Data:					
Ozone Transfer Standard ID:						
Make & Model:		Span Dial #:				
Property Number:		P/T Comp.:				
Serial Number:		P/T Correction:				
Gas Press. (mmHg):		Air Flow (volts):				
Gas Temp. (C):		Gas Flow (volts):				
Air Flow (lpm):		Cert. Date:				
Air Flow Setting:		Cert. Exp. Date:				
True Ozone Correction Factor (TOCF):						
	Slope (m)			Intercept (b)		
True Ozone =		*Avg. Display	+/-		ppm Ozone	

Appendix B

Calibration Data (Transfer Standard):						
Number	Pre-Zero	1st Point	2nd Point	3rd Point	4th Point	Post-Zero
O3 Gen. Setting:						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Average Display:						
Corrected Avg.(ppm):						

Calibration Data (Analyzer):						
Number	Pre-Zero	1st Point	2nd Point	3rd Point	4th Point	Post-Zero
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Average Display:						
Strip Chart Reading:						
Corrected Avg. (ppm):						

Linear Regression Equation:	
Analyzer Response = True O3*x+b(ppm)	
Slope (x):	
Intercept (m):	
Prev. Cal. Slope:	

Deviation From True:	
Sum of Corrected TS Averages (S1):	
S1:	
Sum of Corrected DAS Averages (S2):	
S2:	
Percent Deviation:	

"As Is" vs Previous Cal. Slope:	
Percent Difference:	

Comments:						
Calibrated By:					Reviewed By:	