FORSYTH COUNTY OFFICE OF ENVIRONMENTAL ASSISTANCE AND PROTECTION

STANDARD OPERATING PROCEDURE (SOP)

Nitrogen Dioxide (NO_2)

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
1.1	3/8/18	Section 2.4.1.3 – Added the option to run an Auto-cal ahead of a calibration instead of having to perform a full 14 day ZSP check. The auto cal can be scheduled to run ~6:00 am and be complete so the cal can be started ~ 8:00 am to allow a full day for a quality calibration.
2	1/22/21	Changed Agilaire EDAS procedures to Agilaire AirVision procedures. Updated figures as necessary. Added hyperlinks to all referenced sections and figures. Added table of figures. Added T200U manual to References.
2.1	9/17/21	Updated NO2 QC check acceptance criteria from 10% to 15%.

STANDARD OPERATING PROCEDURES NITROGEN DIOXIDE (NO_2)

Forsyth County Office of Environmental Assistance and Protection

2.0 Introduction

All equipment, chemicals, field operating procedures, and laboratory operating procedures for the continuous measurement of NO-NO_x-NO_2 in the atmosphere using the chemiluminescence method are selected and performed according to 40 CFR 50, Appendix F. The following procedure manual is to be used as a supplement to the Federal Register and the Code of Federal Regulations (CFR) for the measurement of NO-NO_x-NO_2 in the atmosphere. Siting and various quality assurance (QA) procedures are followed in accordance with the EPA-454/R-98-004 - Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II.

This "Standard Operating Procedure" will provide guidance for the monitoring of NO-NO_x-NO_2 using the Teledyne API 200 Series Nitrogen Oxide Analyzer (Automated Reference Method: RFNA-1194-099), Teledyne API 700 Series Dynamic Dilution Calibrator and a Teledyne API 701 Series Zero Air Generator.

2.1 Procurement of Calibration Standards, Zero Gases, and Monitoring Instrumentation

2.1.1 General Information

2.1.1.1 Calibration standards include known concentrations of nitric oxides (NO/NO_x) used for calibrations, audits, precision checks, and span checks.

2.1.1.2 All calibration, audit, precision, and gas standards must be traceable to National Institute of Standards and Technology (NIST) Standard Reference Materials (SRM) or NIST/EPA approved commercially available certified Reference Materials (CRM); using EPA approved traceability Protocols. A "Certificate of Analysis" must accompany each gas certified to EPA Protocols. A copy of these certificates should be kept in the office by the QA staff member who oversees gas cylinder renewals. The API 700 Series calibrator's Mass Flow Controllers (MFCs) must have their flow certified every 6 months and when necessary, calibrated to match a NIST traceable flow device. The flow certification process is covered in the Calibrator Operation SOP found in Section 12.

2.1.1.3 Zero gases are not certified to NIST standards but must meet specific requirements (see section 2.1.2.5).

2.1.1.4 Monitoring instrumentation must be an EPA reference or equivalent method meeting the requirements specified in 40 CFR Part 53 and 40 CFR Part 50 Appendix F.

2.1.2 Specifications for Calibration Standards, Zero Gases, and Monitoring Instrumentation

2.1.2.1 Calibration gases will contain NO in nitrogen in the range of 6 - 60 ppm. Gases will be analyzed for NO and NOx and certified as described in section 2.1.1.2. Cylinder gases will be diluted to the appropriate concentrations using a dynamic gas dilution system incorporating gas phase titration with ozone for the production of NO2. See Figure 1.

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Part Number:	E03NI99E15AC2M5	Reference Number:	163-400952465-1
Cylinder Number:	CC281065	Cylinder Volume:	144.3 CF
Laboratory:	124 - Pasadena (SG06) - TX	Cylinder Pressure:	2015 PSIG
PGVP Number:	A32017	Valve Outlet:	660
Gas Code:	CO,NO,NOX,BALN	Certification Date:	Aug 01, 2017

Expiration Date: Aug 01, 2020

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
NOX	16.50 PPM	16.39 PPM	G1	+/- 1.4% NIST Traceable	07/21/2017, 08/01/2017
CARBON MONOXIDE	16.50 PPM	16.38 PPM	G1	+/- 0.9% NIST Traceable	07/21/2017
NITRIC OXIDE	16.50 PPM	16.30 PPM	G1	+/- 1.4% NIST Traceable	07/21/2017, 08/01/2017
NITROGEN	Balance			-	

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	100809	AAL073282	25.54 PPM CARBON MONOXIDE/NITROGEN	+/-0.70%	Apr 13, 2022
NTRM	150610	CC442707	18.12 PPM NITRIC OXIDE/NITROGEN	+/-1.21%	Nov 11, 2018
NTRM	150610	CC442707-NOX	18.13 PPM NOx/NITROGEN	1.21	Nov 11, 2018
NTRM	150610	CC442707-NOX	18.13 PPM NOx/NITROGEN	+/-1.21%	Nov 11, 2018

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Thermo Low CO 48iTLE	NDIR	Jun 27, 2017
NO-CAL ANAL MODEL 600 A12001	CHEMI	Jul 12, 2017
NOX-CAL ANAL MODEL 600 A12001	CHEMI	Jul 12, 2017

Triad Data Available Upon Request

PERMANENT NOTES:FRONTERA-DE-L01

Signature on file
Approved for Release

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Figure 1: Certificate of Analysis for Gas Cylinders

2.1.2.2 NO/NO_x and NO_2 concentrations used for multi-point calibrations are produced by a gas dilution system and should be in the following ranges:

- Point 1: 0 ppb NO/NOx (Zero)
- Point 2: 225 ppb NO/NOx (Span)
- Point 3: 160 ppb NO/NOx (Midpoint)
- Point 4: 70 ppb NO/NOx (Precision)
- Point 5: 40 ppb NO/NOx (Low-point)

Point 1: 0 ppb NO2 (Zero)
Point 2: 190 ppb NO2 (Span)
Point 3: 160 ppb NO2 (Midpoint)
Point 4: 70 ppb NO2 (Precision)
Point 5: 40 ppb NO2 (Low-point)

2.1.2.3 Audit concentrations must be produced by a system independent of the routine calibration system. A minimum of zero and three upscale points should be chosen to bracket 80% of the ambient data if at all possible. The points chosen must be in the following ranges, contained within the calibration range that the FCEAP uses, which is 0-250 ppb. For FCEAP, three of the points chosen must be in the required levels in the following ranges. Additional points can be added and run in any other level.

- **Level 1: 0.3-2.9 ppb NO_2 (Required)**
- Level 2: 3.0-4.9 ppb NO_2
- Level 3: 5.0-7.9 ppb NO_2
- Level 4: 8.0-19.9 ppb NO_2
- **Level 5: 20.0-49.9 ppb NO_2 (Required)**
- Level 6: 50.0-99.9 ppb NO_2
- **Level 7: 100.0-299.9 ppb NO_2 (Required)**
- Level 8: 300.0-499.9 ppb NO_2 (Over FCEAP range)
- Level 9: 500.0-799.9 ppb NO_2 (Over FCEAP range)
- Level 10: 800.0-1000.0 ppb NO_2 (Over FCEAP range)

Audit standards must be independent of the standards used for calibrations/verifications.

2.1.2.4 NO_2 concentrations used to perform zero/span/precision checks are produced by a gas dilution system and must be in the range of:

- Zero: 0.0 ppb NO_2
- Span: 170 - 250 ppb NO_2
- Precision: 60 - 80 ppb NO_2

2.1.2.5 Zero air to be used for calibrations, 90-day verifications, bi-weekly Zero/Span/Precision (ZSP) checks, and audits must be free of contaminates, which will cause a detectable response on the NO2 analyzer. The zero air should contain < 1.0 ppb of NO_2. A series of drierite columns or similar containers loaded with purafil, silica gel, charcoal, hopcalite, and molecular sieve is used to scrub compressed air. The compressed air is routed through a 5 μm Teflon filter.

Audit zero air is provided by a pump (diaphragm or oil-less piston) moving air through a series of scrubbers. The audit zero air is dried with silica gel, then scrubbed through purafil and charcoal. The audit zero air is finally filtered through a 5 μm particulate filter.

2.1.3 Gas Standard and Initial Instrument Checks

2.1.3.1 Upon receipt of gases, check to insure that the certificate of analysis is included with each cylinder.

2.1.3.2 Check the concentration on the cylinder label against the concentration on the certificate for each cylinder.

2.1.3.3 Thoroughly check each gas cylinder to ensure that all specifications have been met by running a ZSP check on an up to date, calibrated, analyzer. Reject any gases that do not pass specifications and return them to the supplier.

2.1.3.4 Upon receipt of cylinder gas standards the following information must be clearly marked on the cylinder by affixing a tag to the cylinder:

a. ID Reference Number
b. Cylinder contents
c. Cylinder concentrations
d. Expiration date
e. Cylinder usage (i.e., cal, span, precision, etc.)

Cylinder standards must not be used after the expiration date until recertified.

2.1.3.5 NO_2 instrumentation must meet the requirements of the Technical Assistance Document for Precursor Gas Measurements (EPA -454/R-05-003, September 2005) or be an equivalent method as described in 40 CFR, Part 53. A list of EPA designated reference and equivalent methods is available from EPA.

a. An EPA designation sticker must be affixed to the instrument.
b. A factory manual must accompany the instrument.

c. A brief record or log (hardcopy) of all maintenance done to the analyzer must be kept in the pocket on top of the analyzer. Update the more detailed digital copy in the Analysis-Monitoring\Equipment\Repair Supplies and Logs directory in Microsoft Teams.
d. Instrument must be tested and performance documented in the FCEAP master Excel spreadsheet (see Figure 2) containing all check records for network equipment. This document is located in the Analysis-Monitoring\Equipment\Repair Supplies and Logs\In-lab Instruments checks folder and is called NO2 Analyzer In-Lab checks.xls. Below is the layout:

NO2 Analyzer check

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

Date 7/13/2016 **Initials** LGA

Comments

Another check after receiving instrument.

	Instrument	SN
Generating	T700U	128
Reading	T200U	214
Gas Cylinder		

Non GPT

	zero			span			mid			prec			low			low			low		
	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx
generate	0.0	0.0	0.0	225.0	0.0	225.0	175.0	0.0	175.0	90.0	0.0	90.0	40.0	0.0	40.0	15.0	0.0	15.0	7.0	0.0	7.0
gen. lpm																					
read	-1.2	-0.1	-1.3	231.1	-0.6	230.6	179.9	-0.1	179.3	91.4	0.0	91.0	39.6	-0.6	39.0	13.1	-0.6	12.5	4.5	-0.7	3.8
stability		0.1																			
ppb diff	-1.20	-0.12	-1.30	6.13	-0.55	5.64	4.86	-0.06	4.30	1.38	-0.04	1.00	-0.44	-0.60	-1.03	-1.91	-0.56	-2.49	-2.48	-0.71	-3.19
% diff	na	na	na	-2.65	na	-2.45	-2.7	na	-2.4	-1.51	na	-1.1	1.11	na	2.64	14.59	na	19.9	54.87	na	83.73
				OK		OK	OK		OK	OK		OK	OK		OK	FAILED		FAILED	FAILED		FAILED

GPT

	zero			span			mid			prec			low			low			low		
	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx	NO	NO2	NOx
generate	225.0	0.0	225.0	35.0	190.0	225.0	155.0	70.0	225.0	185.0	40.0	225.0	210.0	15.0	225.0	218.0	7.0	225.0	220.0	5.0	225.0
gen. lpm																					
read	232.3	0.7	231.6	27.1	205.4	231.6	160.5	71.1	231.6	193.1	38.2	231.3	215.4	14.6	230.1	224.8	4.9	229.7	226.6	3.2	229.8
stability																					
ppb diff	8.04	0.73	6.58	197.47	15.39	6.60	76.61	1.09	6.60	46.30	-1.76	6.30	20.05	-0.39	5.05	11.65	-2.15	4.66	9.77	-1.78	4.77
% diff	3.47	na	-2.84	85.26	-7.49	-2.85	33.08	-1.53	-2.85	20.02	4.6	-2.72	8.72	2.67	-2.2	5.07	44.33	-2.03	4.25	55.28	-2.08
	OK		OK	FAILED	OK	OK	FAILED	OK	OK	FAILED	OK	OK	OK	OK	OK	OK	FAILED	OK	OK	FAILED	OK

Comments

Figure 2: Instrument Checks Form

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

2.2 Initial Monitor Setup

2.2.1 Site Requirements

To ensure the uniform collection of air quality data, various siting criteria must be followed. 40 CFR 58 Appendix E outlines these criteria. The criteria are summarized below for middle, neighborhood, and urban spatial scales. The FCEAP NO_2 analyzer operates on the neighborhood scale.

2.2.1.1 The sample probe inlet must be located 2-15 m above ground and at a distance from the supporting structure >1 m.

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

2.2.1.3 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.

2.2.1.4 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, NC area the primary wind direction is SW.

2.2.1.5 The sample line should be as short as practical and should be constructed of borosilicate glass, FEP Teflon, or their equivalent.

2.2.1.6 If the above siting criteria cannot be followed, it must be thoroughly documented and a waiver requested from EPA Region 4. 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.

2.2.2 Monitor Installation - Teledyne API 200 Series Nitrogen Oxide Analyzer

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

2.2.2.2 The table or rack should be as vibration free as possible.

2.2.2.3 The analyzer must operate within an internal site temperature range of 5 - 40°C. FCEAP will maintain shelter temperatures ranging from 20 - 30°C.

2.2.2.4 A verified thermometer should be installed near the analyzer to observe temperature readings to ensure that internal site 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. The thermometer will be verified semi-annually to ensure proper function (see Figure 3).

Figure 3: Site Temperature Device

2.2.2.5 Connect ambient air to be measured to the bulkhead connector labeled "SAMPLE" on the rear panel of the instrument. Care should be taken to see that dirty, wet, or incompatible materials in the sample lines do not contaminate the sample. Teflon tubing with an outside diameter (OD) of 1/4" and a minimum inside diameter (ID) of 1/8" is required for all sample lines. The length of the tubing should be held to a minimum. Connect the rear panel bulkhead labeled 'EXHAUST' to a suitable charcoal scrubber and vacuum pump. The exhaust stream will contain significant concentrations of ozone and oxides of nitrogen. The exhaust should be vented to the outside of the building.

2.2.2.6 Confirm that a 1-µm Teflon particulate filter is installed in the filter holder and the holder is connected to the sample line before the sample port.

2.2.2.7 Plug in analyzer.

2.2.2.8 Turn on power switch.

2.2.2.9 Check that the instrument is booting the firmware. Let it warm up for at least 1 hour. Use the menu on the front panel to check the instruments diagnostics. If the sample flow is outside its ranges, check for blockages, pump condition, and/or leaks.

2.2.2.10 Connect the calibration standard gas produced from the calibrator to the NO/NO_2 solenoid (see Figure 4) valve that feeds NO/NO_2 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 NO/NO_2 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 NO/NO_2 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.

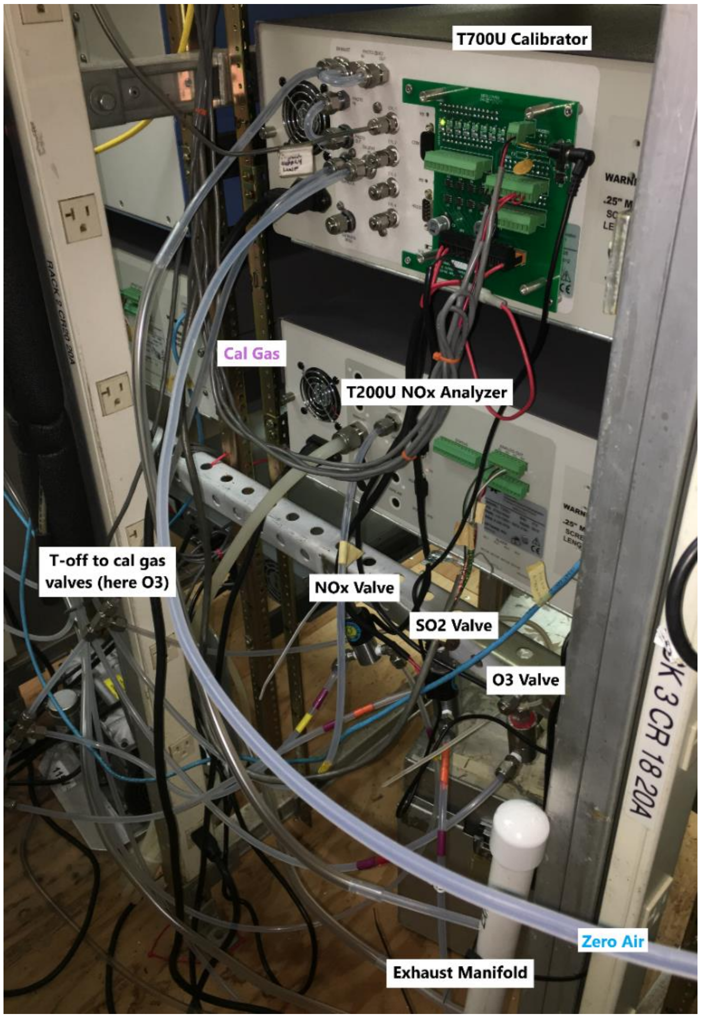


Figure 4: Plumbing Behind the Calibrator

2.2.2.11 An ESC 8832 Datalogger is used as the Datalogger. The TAPI NO2 Analyzer is connected to the 8832 through an analog and/or Modbus connection. Configurations for individual channels are programmed into the central AirVision server. From there, the channel configurations are uploaded to the 8832 Datalogger and mirrored on the site computer if AV-Trend is installed. Site workstations running AirVision client will not have a mirrored configuration because there is no local database. Refer to Section 11 Datalogger 8832 SOP for more information. Check that the Datalogger channel has been properly initialized as follows:

2.2.2.11.1 To Login into the 8832, open AirVision or AV-Trend on the site PC. Login to the central server located at the Government Center with your credentials. Navigate the Utilities menu and click Link To Logger. Select your desired site from the dropdown then uncheck Server Connection. Now click the Connect button and you should see a login screen in the terminal window. Press L to login, type the password, then press Enter.

Alternatively, open "HyperTerminal" on the PC and connect to the 8832 by using the correct IP address. Typically there are pre-programmed files that enter the login screen when opened. These should be used, if available.

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.

2.2.2.11.2 Check the channel configuration entries (Figures 5,6, and 7) to ensure that they correspond to the entries listed below:

```
ESC 8832 v3.02   ID:HA          Standard Channel Config.          01/21/21 16:31:13

     Instrument Name                :  NO
     Analog Input Number            :  02
     Report Channel Number          :  03
     Volts Full Scale               :  1
     High Input                     :  1 V
     Low Input                      :  0 V
     High Output (E.U.s)            :  248.2
     Low Output (E.U.s)             :  0.2615
     Units                          :  ppb
     Base Avg. Interval, Storage :  1m  , 3d 50m
     Average #1 Interval, Storage:  15m , 0s
     Average #2 Interval, Storage:  1h  , 14d 9h

     Use Time-on-line Valid (Y/N):  N
     FINISHED (Configure Now)      01/31/19 13:07:21




   CTRL-V=Edit Validation, CTRL-D=Config. Channel Options
```

Figure 5: NO Channel Configuration

```
ESC 8832 v3.02   ID:HA          Standard Channel Config.          01/21/21 16:31:45

     Instrument Name                :  NO2
     Analog Input Number            :  03
     Report Channel Number          :  04
     Volts Full Scale               :  1
     High Input                     :  1 V
     Low Input                      :  0 V
     High Output (E.U.s)            :  245.7
     Low Output (E.U.s)             :  0
     Units                          :  ppb
     Base Avg. Interval, Storage :  1m  , 3d 50m
     Average #1 Interval, Storage:  15m , 0s
     Average #2 Interval, Storage:  1h  , 14d 9h

     Use Time-on-line Valid (Y/N):  N
     FINISHED (Configure Now)      01/31/19 13:08:05




   CTRL-V=Edit Validation, CTRL-D=Config. Channel Options
```

Figure 6: NO_2 Channel Configuration

```
ESC 8832 v3.02   ID:HA        Standard Channel Config.         01/21/21 16:32:16

     Instrument Name              :  NOX
     Analog Input Number          :  04
     Report Channel Number        :  05
     Volts Full Scale             :  1
     High Input                   :  1 V
     Low Input                    :  0 V
     High Output (E.U.s)          :  248.6
     Low Output (E.U.s)           :  0.0885
     Units                        :  ppb
     Base Avg. Interval, Storage :  1m  , 3d 50m
     Average #1 Interval, Storage:  15m , 0s
     Average #2 Interval, Storage:  1h  , 14d 9h

     Use Time-on-line Valid (Y/N):  N
     FINISHED (Configure Now)      01/31/19 13:07:39


   CTRL-V=Edit Validation, CTRL-D=Config. Channel Options
```

Figure 7: NO_x Channel Configuration

2.2.2.12 The internal memory on the analyzer is used a back up data logger. The site computer utilizing AV-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 to maintain a local copy on site. Using the slope and intercept from the 200EU/T200U records calculation we can recover lost hourly data from the minute data on the 8832.

2.2.3 Initial Analyzer Checks and Adjustment of the Teledyne API 200 Series Nitrogen Oxide Analyzer

2.2.3.1 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.

2.2.3.2 To set the time and date press 'Setup, Clk, Time (EST) or Date' on the instrument and adjust using the corresponding buttons, press 'Enter' to save your settings and 'Exit' back out to the main screen. To set the ambient pressure, go into the 'Diagnostics' menu press 'Next' button to get to PRES in-Hg-A and press 'Enter', set the pressure and press 'Enter' to save.

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

2.2.3.4 Using the 'Test' button on the front panel (see Figure 8), check the following diagnostics:

Figure 8: Front Panel of a T200U

- Sample flow 1000 ±50 cm^3 (> 700 cm^3)
- Ozone flow 80 ±10 cm^3
- RC temp 40 ±1°C
- Box temp 8 – 48°C
- PMT temp 5 ±1°C
- MF temp 8 – 48°C
- CNV temp 315 ±5°C
- RC press < 10 in-Hg-A
- SM press 25 – 34 in-Hg-A (~1" < Ambient)

If any of these diagnostic values are not met, perform troubleshooting and necessary repairs/maintenance (see chapter 2.7).

2.2.3.5 Check the HVPS value on the front display (use the 'Test' buttons). The HVPS has to be between 450-900V. If it is outside this range, a PMT Adjustment is necessary, refer to Teledyne API Service Note 13-002 'Performing a PMT Adjustment on a NO/NO_x Analyzer'.

2.2.3.6 Calculate the Moly Converter Efficiency. To ensure accurate operation of the 200 Series Nitrogen Oxide Analyzer, it is important to check the NO_2 converter efficiency (CE) during 90-day verification checks. For the analyzer to function correctly, the CE must be between 0.960 and 1.020 (96-102%). If the CE is outside these limits, the NO_2 converter should be replaced. Refer to Teledyne API Service Note 04-001 RevC (17-May-2010) "How to calculate moly converter efficiencies."

A prepared table is in the instrument logbook (see Figure 9).

			Moly Test Data Sheet				
Date:	3/6/2014						
Section 1:	Converter Out-gassing/Eating Test						
Leak Check when HOT			Yes/No				
NOx Response when Moly is bypassed					*225 NO/NOx short path		
NOx Response when Moly back in-line					*225 NO/NOx short path		
Outgassing/eating results				0	(>-5, <5 PPB)		
Section 2:	CE adjustment						
NOx Original		225, 190, 4 LPM GPTz		223.5			
NOx Remaining		225, 190, 4 LPM GPT		224			
			NOx Loss:	-0.5	(<4% of NOx Original)		
NO Original		225, 190, 4 LPM GPTz		222.68			
NO Remaining		225, 190, 4 LPM GPT		31.319			
			NO2:	191.361			
Efficency Loss Equation:							
	NOx Loss	/	NO2	* 100	=	CE Loss	
	-0.5	/	191.361	* 100	=	-0.2613	
Total CE in %:							
	100%	-	CE Loss	=	New CE		
	100	-	-0.2613	=	100.2613	(>96%,<102%)	

Figure 9: Molybdenum Converter Efficiency Calculation Worksheet

2.3 Teledyne API 200 Series Nitrogen Oxide Analyzer Instrument Description

The 200EU/T200U analyzer is a microprocessor controlled instrument that determines the concentration of NO, total NO_x (sum of NO and NO_2) and NO_2 in a sample gas drawn through the instrument.

It requires that sample and calibration gases be supplied at ambient pressure in order to establish a constant gas flow through the reaction cell where the sample gas is exposed to O_3, where one NO molecule will chemically react with one O_3 molecule, producing O_3 and excited NO*2. The excited NO*2 condition is unstable, forcing it to release energy to return to a stable NO_2 state, hereby giving off a quantum of light (hv) with a peak at 1200nm.

The instrument measures the amount of chemiluminescence to determine the amount of NO in the sample gas. A catalytic-reactive converter converts NO_2 in the sample gas to NO which, along with the NO present in the sample gas, is reported as NO_x. The NO_2 is calculated as the difference between NO_x and NO.

2.4 Multi-point Calibration of the Teledyne API 200 Series Nitrogen Oxide Analyzer

NO-NO_2-NO_x analyzers are to be calibrated upon receipt, when installed, if moved from current location, 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.

Before the actual initial calibration is performed, the moly converter efficiency should be calculated. See section 2.2.3.6. This ensures accurate operation of the 200 Series Nitrogen Oxide Analyzer.

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 sample collections for a site, and/or when a biweekly ZSP check or 90-day verification fails. However, the operator must contact the Program Manager before proceeding directly to a calibration if QC checks fail. The resulting slope and intercept values calculated from the calibration are automatically stored in the instrument's 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 can reset the Bi-weekly Zero/Span/Precision (ZSP) schedule.

2.4.1 Adjusted Multi-point Calibration

2.4.1.1 Typically the only time a Calibration is performed will be at the beginning of the analyzer's field operation or after certain maintenance or repairs.

A 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 or the Span check >± 15% of expected value, 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.

2.4.1.2 Allow sufficient time for the NO_2 analyzer and the calibration standard to warm up (~1 hour) as necessary, if they are not already on.

2.4.1.3 Always, if no major malfunctions have occurred and the monitor has been in normal operation, perform either a bi-weekly zero/span/precision (ZSP) check or an overnight auto-cal prior to a calibration. If necessary, after the ZSP or autocal check, install a clean 1-µm particulate filter in the monitor filter holder in the probe line box on the roof of the site. Perform a system leak check (refer to TAPI 200 Series manual) after replacing the filter and saturate the probe system with NO-NO_x by running a NO-NO_x span point (225 ppb) for 15 minutes. Record all information in the logbook.

2.4.1.4 An Adjusted Calibration procedure consists of four major steps:

- Short Path (no O_3) (2.4.2)
- Ozone Presets (on the Calibrator) (2.4.3)
- Gas Phase Titration (GPT; O_3 introduced) (2.4.5)
- ESC 8832 data logger Update (2.4.2 & 2.4.5)

2.4.1.5 Login into the ESC 8832 data logger using AirVision, AV-Trend, or HyperTerminal on the PC. See section 2.2.2.11.1 for details.

Press L (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 NO-NO_2-NO_x, then press Enter for each to disable the all three channels.

2.4.1.6 Prepare a calibration worksheet in the instrument logbook containing the following entries:

- Date/Time
- Operator
- Site/AQS ID
- Datalogger check
- Analyzer and Calibrator Make/Model/Serial Number/Diagnostics
- Operational checks
- NO-NO2-NOx Readings

The following example of the electronic data sheet (see Figure 10) will be used to document checks. All information fields listed above must be included.

2.4.1.7 In the ESC 8832 skip back to the Main Menu (use Esc). Press D (Real-Time Display), V (Display Raw Readings).

2.4.1.8 Make sure the 700 Series Calibrator is connected to a source of zero air (i.e. a Teledyne API T701H) which is reading a pressure of 25-30 psig. Check the regulator pressure on the 700 Series Calibrator to make sure it is at 7-10 psig. Check a source of calibration gas (Gas cylinder) is connected to the 700 Series Calibrator with a regulator pressure of 20-25 psig.

2.4.1.9 Check that the 700 Series Calibrator 'Cal Gas Out' is connected to the 200 Series Nitrogen Oxide Analyzer 'Sample Inlet'. Make sure the flow of calibration gas is routed through the analyzer particulate filter. The test atmosphere must pass through all filters, conditioners, other components used during normal ambient sampling, and as much of the ambient air inlet system as is practicable.

2.4.1.10 Calculate the moly converter efficiency (see chapter 2.2.3.5).

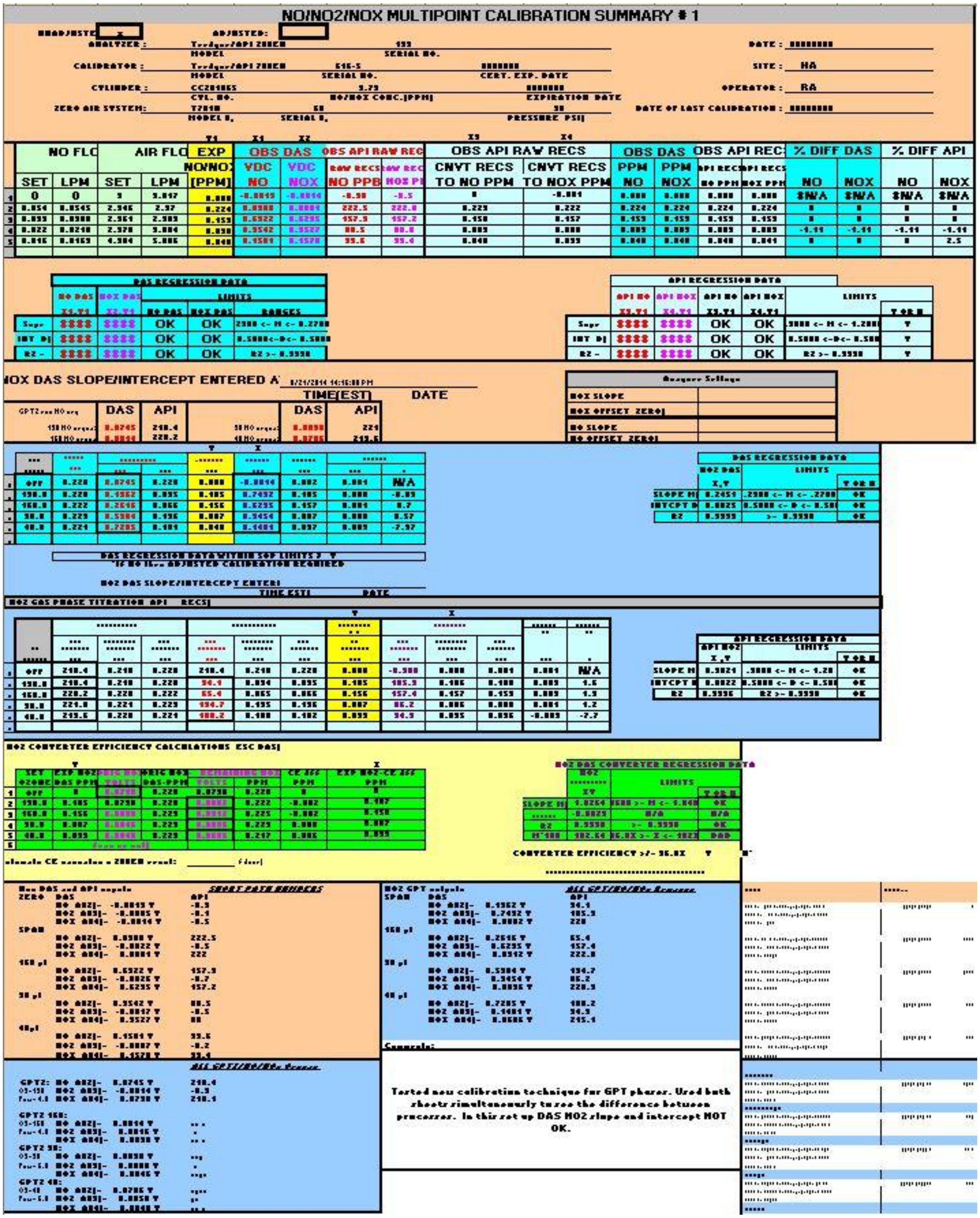


Figure 10: NO2 Calibration Worksheet

2.4.2 NO-NO_x Short Path Procedure

During the Short Path part of the calibration, no ozone is introduced and only the NO-NO_x values are recorded. The only NO_2 value used is the zero point NO_2 observed 8832 and 200 Series reading.

2.4.2.1 On the 700 Series calibrator press SEQ (see Figure 11), use the arrow keys to reach NOxZERO, press Enter to start the sequence.

Figure 11: Calibrator Sequence Program

2.4.2.2 Check the instrument functions by pressing the Test button. Check the analyzer temperatures, pressure, flow, and intensities. Any issues shall be addressed before completing the calibration using the manufacturer's manual.

2.4.2.3 Allow the analyzer to sample zero air for at least 30 minutes until stability < 0.2 is obtained. If 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) and let the analyzer stabilize. The analyzer should now read zero, if not inform the 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. Check the AirVision charts to assist with this.

2.4.2.4 Allow the instrument to stabilize (~30 minutes). Observe the analyzer and the calibration standard. The difference for the zero point should meet the following specification:

$\leq \pm 5$ ppb at stability of < 0.5

2.4.2.5 Record (highlight, right click ‘copy’) the raw voltage reading (see Figure 12) from the ESC 8832 (in AirVision or Hyperterminal) and download the instrument’s 1-minute readings using the APICom software. Open APICom 5, select the 200 Series analyzer of choice and click the ‘power plug’ button to open a front display window (see Figure 13).

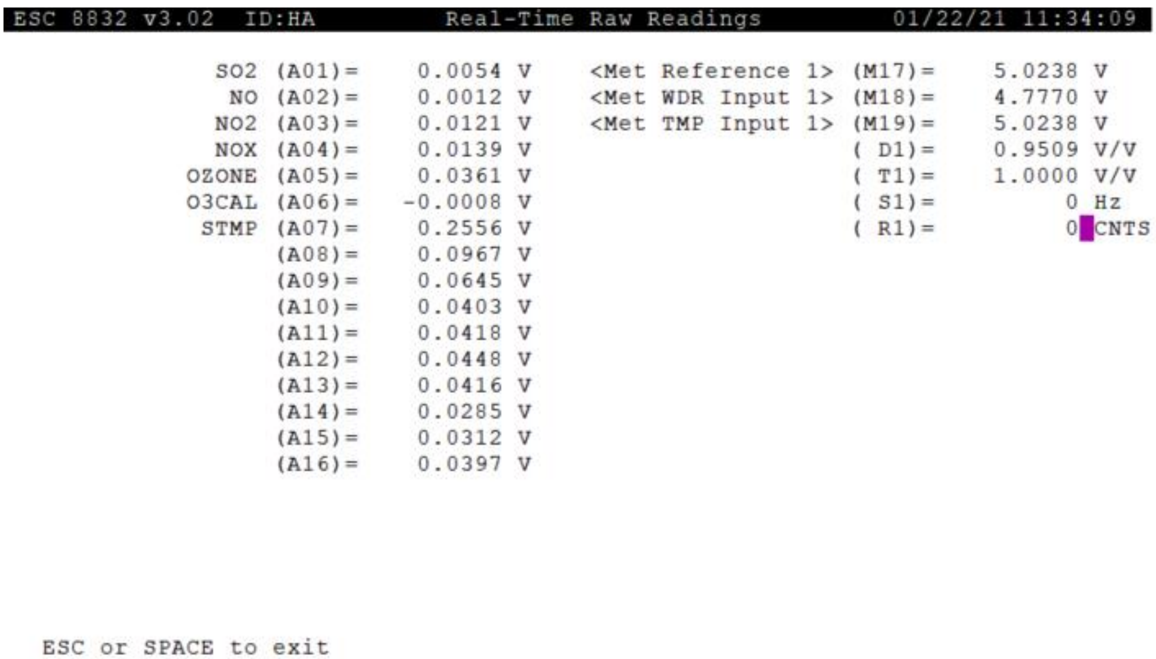


Figure 12: ESC 8832 Raw Voltage Reading

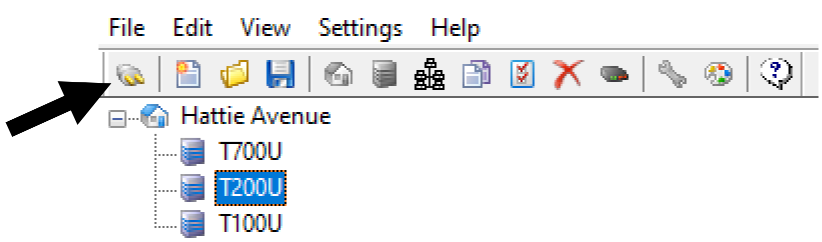


Figure 13: APICom 5 Home

Click the 'iDAS' button (see Figure 14).

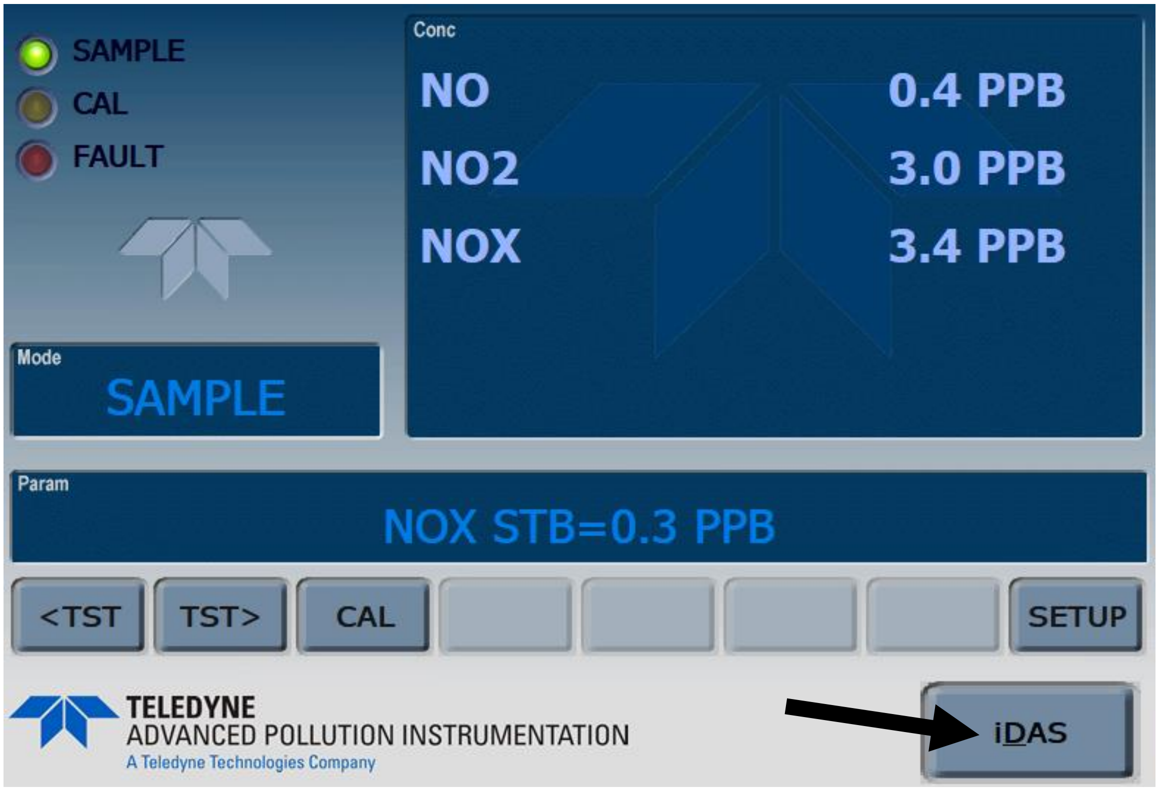


Figure 14: APICom 5 Analyzer Screen

In the opening window, mark the NONOX_MIN box, click the 'Get Data' button, choose 'most recent on record' to download the 1-minute readings from the 200 Series analyzer. Click 'Save Data' (to a .csv file) and choose 'Append' when asked (see Figure 15).

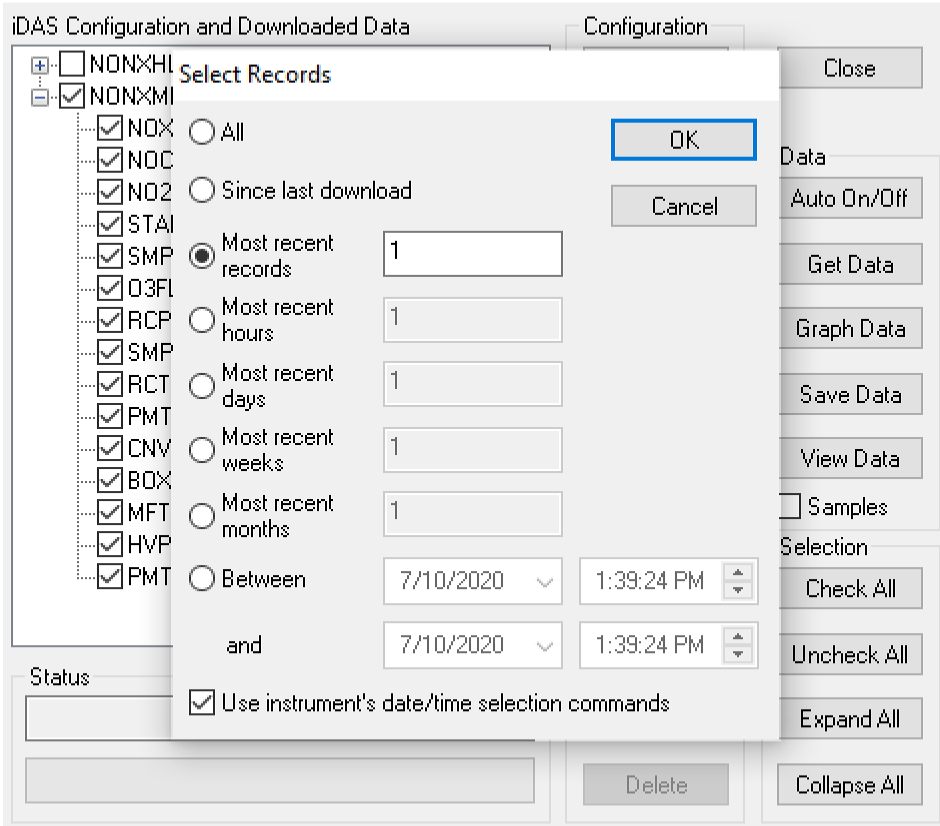


Figure 15: APICom 5 iDAS Home Screen

Copy and paste both the data logger (ESC) and APICom min data readings into the instrument's logbook (see Figure 10). The following observed DAS and API NO and NOx readings have to be manually copied into OBS DAS VDC NO; DAS VDC NOx and OBS API Raw Recs NO; OBS API Raw Recs NOx cells (see Appendix: 'NOx Calibration worksheet' for assistance).

2.4.2.6 While the zero point is still running, on the 700 Series Calibrator check the NO Flow and Air Flow settings and actual flows. Copy these readings to the NO FLOW Set/Lpm and AIR FLOW Set/Lpm in the worksheet. Check the expected NO/NOx values and copy it to the EXP NO/NOx [PPB] in the worksheet.

2.4.2.7 Press SEQ on the 700 Series Calibrator, use the arrow keys to reach NOx225, press Enter to start the Span point.

2.4.2.8 Perform the following steps until no further adjustments are necessary. Record results after all adjustments are complete.

2.4.2.9 Allow the analyzer to sample 225 ppb (Span) gas for about 15 minutes until stability < 0.2 is obtained. If the analyzer needs to be adjusted to read 225 ppb, press the CAL button and choose SPAN, press Enter. Return to the main screen (press Exit) and let the analyzer stabilize. The analyzer should now read 225 ppb, 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. Check the AirVision charts to assist with this.

2.4.2.10 Allow the instrument to stabilize (15-30 minutes). Observe the analyzer and the calibration standard. The difference for the span point should meet the following specification:

≤ ± 2 ppb at stability of < 0.5

2.4.2.11 Record the raw voltage reading from the ESC 8832 and download the instrument's 1-minute reading using APICom (see 2.4.2.5). Paste (ESC) and copy/paste (APICom) both readings into the instruments logbook (see Figure 10). The following observed DAS and API NO and NOx readings have to be manually copied into OBS DAS VDC NO; DAS VDC NOx and OBS API Raw Recs NO; API Raw Recs NOx cells (see Appendix: 'NOx Calibration worksheet' for assistance).

2.4.2.12 While the span point is still running, on the 700 Series Calibrator check the NO FLOW Set/Lpm and AIR FLOW Set/Lpm settings. Check the EXP NO/NOx [PPM] values.

2.4.2.13 After the 0.0 ppb (Zero) and 225 ppb (Span) NO-NOx points have been run satisfactorily and data recorded, start the sequences on the 700 Series Calibrator to run the points for NOx 160 ppb, NOx 90 ppb, and NOx 40 ppb. Press SEQ on the 700 Series Calibrator, use arrow keys to reach the desired NO-NOx concentration, press Enter.

Do NOT adjust the analyzer while running any of the midpoints.

Record the results for each concentration based on stable readings (stability <0.5) from the ESC 8832 Raw Readings and 1-minute APICom (see 2.4.2.5) in the instrument logbook (see Figure 10) and manually copy them into the corresponding OBS DAS VDC NO; OBS DAS VDC NOx and OBS API Raw Recs NO; OBS API Raw Recs NOx cells. The difference for each point should meet the following specification:

≤ ± 2% difference

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

Check the NO FLOW Set/Lpm and AIR FLOW Set/Lpm settings. Check the EXP NO/NOx [PPM] values.

2.4.2.14 Review the linear regression results for NO/NO_x calculated in the calibration worksheet between the expected NO/NO_x and the observed NO/NO_x from the 8832. The linear regression line should meet the following specifications in order to be valid for reporting ambient air data: $245 \leq m \leq 255$, $-0.500 \leq b \leq 0.500$ and $r^2 \geq 0.9990$ (the logger slope and intercept translates the raw voltage into engineering units for the data logger). If the line does not meet these specifications inform the Program Manager. If specifications are met, enter the new slope and intercept into the NO/NO_x channel configuration in the 8832.

2.4.2.15 Review the linear regression results for NO/NO_x calculated in the calibration worksheet between the expected NO/NO_x and the observed NO/NO_x from the 200 Series analyzer. The linear regression line should meet the following specifications in order to be valid for reducing ambient air data: $0.9800 < \text{slope} < 1.0200$, $-2.0 < \text{intercept} < 2.0$, and $r^2 \geq 0.9990$ (the analyzer slope and intercept adjusts a ppb value to a corrected ppb value based on a best fit line across the five points). If the line does not meet these specifications inform the Program Manager. If specifications are met, the new slope and intercept can be applied to any value stored in the internal datalogger in the analyzer if data is lost from the 8832.

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

2.4.3 Ozone Presets (GPTPS)

2.4.3.1 Before continuing the calibration procedure for NO_2 with the Gas Phase Titration (GPT) part, presets have to be run on the 700 Series Calibrator. Press SEQ on the 700 Series Calibrator, use arrow keys to reach GPTPS, press Enter.

The preset mimics the 700 Series Calibrator set up for running the following GPT without mixing any O_3 with calibration gas. Instead, the internal photometer measures the actual ozone concentration and adjusts the ozone drive voltage on the ozone generator, to receive a most accurate NO_2 reading later during the GPT.

The preset will run approximately 15-20 min and no records have to be taken during the preset, as this only prepares the 700 Series Calibrator for the following GPT. Observe the ‘Active’ and ‘Auto’ lights on the front panel (see Figure 16).

Figure 16: T700U Active/Auto Lights

While both lights are blinking the calibrator is adjusting the ozone drive voltage. When the ‘Active’ light is steady lit, it’s setting a reference point. There will be a total of 8 steps to complete the presets sequence.

Once the 700 Series Calibrator is back in Standby mode, proceed with the Gas Phase Titration Zero (GPTZ) procedure.

2.4.4 NO-NO_x GPTZ Explanation

During the GPTZ, ozone is not introduced to the calibration gas mixture but the flow paths and amounts follow the GPT settings for a given desired result. The GPTZ steps will produce the NOorig and NOxorig (original) values used along with NOrem and NOxrem (remaining) collected during the GPT steps to calculate expected NO_2 levels.

2.4.4.1 On the calibrator press SEQ, use the arrows to reach GPTZ, press Enter. This will start the zero point for the GPT run. This GPTZ point will mimic the flow settings for the 190 ppb NO_2 GPT point but will serve as the zero point for NO_2. During the GPTZ 160, GPTZ 90 and GPTZ 40 the NOOrig and NOxOrig are obtained to get more accurate NORem and NO2Rem calculations. On the 700 Series Calibrator press SEQ, use the arrow keys to reach the desired GPTZ point. The results can be used as the NOorig and NOxorig.

2.4.4.2 Allow the instrument to stabilize (15-30 minutes). Observe the analyzer and the calibration standard. The % error for the GPTZ points should meet the following specification:

$\leq \pm$ 15% ppb of 225 ppb at stability of < 0.5

*Note: Each GPT point that will be run will have a GPTZ point executed right before it with the same flow and desired ozone level targets as the GPT.

No adjustments of the NO-NO_x-NO_2 values during the entire GPTZ or GPT phases are necessary!

2.4.4.3 Copy the raw voltage readings from the ESC 8832 and download the instrument's 1-minute reading using APICom (see 2.4.2.5). Copy both readings into the instrument's logbook (see Figure 10). The following observed DAS and API NO, NO_x and NO_2 readings have to be manually copied into DAS NORem VDC; DAS NO2Obs VDC; DAS NOxOrig Volts and API NOOrig Raw Records; API NO2Obs Raw Records cells. Also enter the NOOrig DAS and API in 'GPTZ run NO orig / 190 NO original' (see Appendix: 'NO_x Calibration worksheet' for assistance).

2.4.5 NO_2 GPT

2.4.5.1 On the 700 Series Calibrator press SEQ, use the arrows to reach NO_2 190 (Span point), press Enter. This step actually mixed ozone into the NO/NO_x gas to produce a given NO_2 point.

2.4.5.2 Allow the instrument to stabilize (15-30 minutes). Observe the analyzer and the calibration standard. The difference for all NO_2 points should meet the following specification:

$\leq \pm$ 15% difference of the calculated expected ppb for NO_2 at stability of < 0.5

2.4.5.3 Copy the raw voltage reading from the ESC 8832 and download the instrument's 1-minute reading using APICom (see 2.4.2.5). Copy both readings into the instrument's logbook (see Figure 10). The following observed DAS and API NO, NO_x and NO_2 readings have to be manually copied into DAS NORem VDC; DAS NO2Obs VDC; DAS NOxRem Volts and API NORem Raw Records; API NO2Obs Raw Records cells (see Appendix: 'NOx Calibration worksheet' for assistance).

2.4.5.4 After the 0.0 ppb (Zero) and 190 ppb (Span) GPT points have been run satisfactorily and recorded, start the sequences on the 700 Series Calibrator to run points for GPT NO2 160, GPT NO2 90 ppb and GPT NO2 40 ppb.

*Before each of the following GPT points are to be run, a GPTZ point has to be run with the same target ozone and total flow to be used for each of the GPT points. See 2.4.4.

2.4.5.5 After the GPTZ point, press SEQ on the 700 Series calibrator, use arrow keys to reach the desired GPT NO_2 concentration, press Enter.

Record the results for each concentration based on stable readings on the analyzer (stability <0.5) and using the AirVision chart. Copy the raw voltage readings from the ESC 8832 and the instrument's 1-minute reading using APICom (see 2.4.2.5) in the instrument logbook (see Figure 10) and manually copy into the corresponding into DAS NORem VDC; DAS NO2Obs VDC; DAS NOxOrig Volts; DAS NOxRem Volts and API NORem raw records; API NO2Obs raw records cells. From each associated GPTZ manually copy the API NOOrig and DAS NOxOrig VDC values (see Appendix: 'NO_x Calibration worksheet' for assistance).

2.4.5.6 Review the linear regression results for NO_2 calculated in the calibration worksheet between the expected NO_2 and the observed NO_2 from the 8832. The linear regression line should meet the following specifications in order to be valid for reporting ambient air data: $245 \le m \le 255$, $-2.0 \le b \le 2.0$, and $r^2 \ge 0.9990$ (the logger slope and intercept translates the raw voltage into engineering units for the data logger). If the line does not meet these specifications inform the Program Manager. If specifications are met, enter the new slope and intercept into the NO_2 channel configuration in the 8832.

2.4.5.7 Review the linear regression results for NO_2 calculated in the calibration worksheet between the expected NO_2 and the observed NO_2 from the 200 Series Analyzer. The linear regression line should meet the following specifications in order to be valid for reducing ambient air data: $0.9800 < \text{slope} < 1.0200$, $-2.0 < \text{intercept} < 2.0$, and $r^2 \ge 0.9990$ (the analyzer slope and intercept adjusts a ppb value to a corrected ppb value based on a best fit line across the five points). If the line does not meet these specifications inform the Program Manager. If specifications are met, the new slope and intercept can be applied to any value stored in the internal datalogger in the analyzer if data is lost from the 8832.

If not, inform the Program Manager.

2.4.5.8 Close all APICom windows to disconnect from the NO_2 Analyzer.

2.4.5.9 On the 700 Series Calibrator press the STBY button to bring it back in standby mode. Check the analyzer for it to return to reading ambient NO-NO_x-NO_2 values.

2.4.5.10 The newly calculated slope and intercept values for NO_2 in the NO_x calibration worksheet have to be entered into the ESC 8832 and the worksheet for the upcoming Zero/Span/Precision check.

2.4.5.11 Refer to Section 11, Data logger 8832 SOP.

In the ESC 8832 return to the Main Menu (use the Esc button). Press C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration). Use arrows to skip to NO, press Enter. Use arrow keys to skip to 'Slope=High output (E.U.s)' and enter the 'DAS Regression Data NO DAS Slope X1Y1' from the instrument logbook calibration worksheet (see Figure 10). Use arrow keys to skip to 'Intercept=Low output (E.U.s)' and enter the 'DAS Regression Data NO DAS Intercept X1Y1' from the instrument logbook calibration worksheet (see Appendix: 'NOx Calibration worksheet' for assistance). Use the arrow keys to skip to 'Finished (Config. Now)' and press Enter to save changes.

Repeat this procedure for the NOx channel using the 'DAS Regression Data NOx DAS Slope/Intercept X2Y1' values.

Repeat this procedure for the NO2 channel using the 'DAS Regression Data NO2 DAS Slope/Intercept XY' values.

These new slopes and intercepts will apply to all future NO-NOx data until the next adjusted calibration. Note time and date new slope and intercept were entered into the datalogger on logbook calibration worksheet.

2.4.5.12 In the instrument logbook, create a ZSP worksheet (see Figure 22) and enter the new 'DAS Regression Data NO DAS Slope/Intercept X1Y1'; 'DAS Regression Data NOx DAS Slope/Intercept X2Y1'; 'DAS Regression Data NO2 DAS Slope/Intercept XY' and 'API Regression Data NO DAS Slope/Intercept X1Y1'; 'API Regression Data NOx DAS Slope/Intercept X2Y1'; 'API Regression Data NO2 DAS Slope/Intercept XY' from the calibration worksheet into the ZSP worksheet (see Figure 22). This will have a new ZSP worksheet ready for the next check due 14 days after the completion of the calibration.

2.4.5.13 In the ESC 8832 skip back to the Main Menu (use Esc). Press C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration). Press E (Enable/Mark Channel Online). Use arrows to skip to NO-NO_2-NO_x, then press Enter for each to enable the all three channels.

Refer to Section 11, Data logger 8832 SOP.

2.4.5.14 Record a note in the AirVision electronic logbook and AirVision minute data graph. Be sure to apply the minute data annotation to all three data sets (NO, NO_2, and NO_x).

2.4.5.15 Verify the sample line is connected to the NO_x solenoid, which leads to the sample port of the NOx analyzer.

2.4.5.16 Close all APICom windows to disconnect from the NO_2 Analyzer.

2.4.6 NO/NO_2/NO_x 90-day Verification

The 90-day Verification procedure is similar to the Adjusted Multi-point Calibration procedure (see section 2.4), with the exception of no adjustments are made to any equipment and engineering units are used from the 8832 instead of voltages. Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the calibrator's front panel actual concentration. The procedure is also divided, as in the Adjusted Multi-point calibration, into Short Path (no ozone introduction) with only the NO-NO_x values recorded, Presets and the Gas Phase Titration (GPT) during which ozone is introduced to the calibration gas to record NO-NO_x-NO_2 values. A 15% difference is also used as the acceptable limit in the verification instead the 2% difference used in the calibration. The NO_2 90-day worksheet (see Figure 17) is to be used for the verification. The converter efficiency (CE) is also verified to check the moly converter's operation. The CE needs to be .9600 >= CE <= 1.0200. If not, inform the Program Manager.

NO/NO2/NOX 90-DAY WORKSHEET

ANALYZER:	Teledyne/API 200EU (MODEL)	133 (SERIAL NO)		DATE:	05/14/2015
CALIBRATOR:	Teledyne/API 700EU (MODEL)	616-S (SERIAL NO)	8/28/2015 (CERT. EXP. DATE)	SITE:	HA
CYLINDER:	CC281065 (CYL. NO)	9.79 (NO/NOX CONC [PPM])	1/15/2015 (EXPIRATION DATE)	OPERATOR:	RA
ZERO AIR SYSTEM:	T701H (MODEL)	60 (SERIAL NO)	30 (PRESSURE (PSI))	DATE OF LAST CALIBRATION	2/27/2015
				NEXT VERIFICATION/CALIBRATION DUE	5/28/2015

NO/NOx

	NO FLOW		AIR FLOW		EXP	OBS DAS		OBS API RECS		Corrected API RECS		% DIFF DAS		% DIFF API	
					NO/NOX	DAS	DAS	API	API	API RECS	API RECS				
	SET	LPM	SET	LPM	[PPB]	NO	NOX	NO PPB	NOX PPB	NO PPB	NOX PPB	NO	NOX	NO	NOX
1	0	0	3	3	0.0	0.1	0.2	-0.10	0.1	-0.1	0.1	#N/A	#N/A	#N/A	#N/A
2	0.0544	0.0545	2.946	2.953	224.0	224.4	224.9	224.1	224.3	224.4	224.5	0.18	0.4	0.17	0.2
3	0.0387	0.0388	2.961	2.971	160.0	159.3	159.7	158.9	159.6	159.1	159.7	-0.44	-0.19	-0.56	-0.18
4	0.0218	0.0218	2.978	2.989	90.0	89.1	89.5	89.7	90.2	89.8	90.3	-1	-0.56	-0.2	0.29
5	0.0161	0.0162	4.984	4.988	40.0	39.7	39.9	40.1	40.4	40.2	40.4	-0.75	-0.25	0.38	1.07

API Analyzer Settings	
NOX SLOPE	0.74
NOX OFFSET (ZERO)	1.3
NO SLOPE	0.726
NO OFFSET (ZERO)	0.8

	NO DAS OK?	NOX DAS OK?	NO API OK?	NOx API OK?
Zero	YES	YES	YES	YES
Span	YES	YES	YES	YES
Mid	YES	YES	YES	YES
Prec	YES	YES	YES	YES
Low	YES	YES	YES	YES

API Correction Factors	NO Current	NOX Current
Slope	1.0013	1.0007
INT (B)	0.0001	-0.0002

NO2 — DAS 8832

SET OZONE	NO ORIG PPB	NO REM VDC	EXP NO2 PPB	OBS NO2 VDC	NO2 DIFF PPB	NO2 DIFF %
OFF	224.2	224.2	0.0	0.2	0.2	N/A
190.0	224.1	35.9	188.2	189.1	0.9	0.48
160.0	224.3	67.0	157.3	158.2	0.9	0.57
90.0	224.3	135.4	88.9	89.4	0.5	0.56
40.0	223.8	184.6	39.2	40.0	0.8	2.04

API

O3 OFFSET	API NO ORIGINAL RAW RECORDS PPB	API NO ORIGINAL OBS RECORDS PPB	API NO REMAINING RAW RECORDS PPB	API NO REMAINING OBS RECORDS PPB	EXPECTED NO2 API RECORDS PPB	OBS API NO2 RAW RECORDS PPB	OBS API NO2 OBS RECORDS PPB	NO2 DIFF API PPM	NO2 DIFF API %
OFF	224.0	224.3	224.0	224.3	0.0	0.3	0.3	0.3	N/A
190.0	224.2	224.5	34.9	34.9	189.5	188.7	188.8	-0.7	-0.4
160.0	224.1	224.4	67.5	67.6	156.8	156.2	156.3	-0.5	-0.3
90.0	224.1	224.4	134.9	135.1	89.3	88.9	89.0	-0.4	-0.4
40.0	224.0	224.3	184.7	184.9	39.4	39.1	39.1	-0.2	-0.6

	NO2 DAS OK?	NO2 API OK?
Zero	YES	YES
Span	YES	YES
Mid	YES	YES
Prec	YES	YES
Low	YES	YES

NO2 CONVERTER EFFICIENCY CALCULATIONS (ESC DAS)

	SET OZONE	EXP NO2 DAS PPB (Y)	ORIG NOX PPB	REM NOX PPB	CE diff PPB	EXP NO2-CE diff PPB
1	OFF	0.0	225.1	225.1	0	0.0
2	190.0	188.2	225.1	225.2	-0.100	188.3
3	160.0	157.3	224.7	225.3	-0.600	157.9
4	90.0	88.9	225.1	224.9	0.200	88.7
5	40.0	39.2	224.8	224.9	-0.100	39.3

NO2 DAS CONVERTER REGRESSION DATA

	NO2 CONVERTER XY	LIMITS	Y OR N
SLOPE(M)	1.0017	.9600 >= M <= 1.0400	OK
INTCPT(B)	0.0000	N/A	N/A
R2	1.0000	>= 0.9990	OK
M*100	100.17	96.0% >= % <= 102%	OK

CONVERTER EFFICIENCY >/= 96.0% Y N*

Figure 17: 90-day Verification Data Worksheet

2.5 Teledyne API 700 Series Dynamic Dilution Calibrator

In ambient air monitoring applications, precise gas mixture concentrations are required for the calibration of NO_2 analyzers. Gas cylinder standards must be certified and used before the certification expires. The Mass Flow Controllers (MFC) must also be certified and if need be, calibrated every 6 months. Pressure transducers must also be verified and if need be, adjusted every 6 months.

A Teledyne API 700 Series Dynamic Dilution Calibrator is used to generate ozone to produce calibration gas for NO_2 calibrations in the network. This calibrator is also used to calibrate an Ozone analyzer located at the same site so it must be kept as a true level 3 transfer standard. Normally the NO_2 alone does not require the calibrator's photometer to be certified. A Teledyne API T750U Dynamic Dilution Calibrator is used to audit the T-API 200 Series NO-NO_x-NO_2 analyzer in the network. Currently our network utilizes two level 2 transfer standards: a Teledyne API T703 Photometric Ozone Analyzer (bench primary standard) and a Teledyne API T750U Dynamic Dilution Calibrator (transfer primary standard). Both calibrators are verified annually against a standard reference photometer (EPA Region 4 SRP#10) and all previous verifications (up to 6, if available) are used to calculate verification equations. The calibrators are verified by USEPA Region 4 annually, in accordance with USEPA Region 4 procedure.

For verification and maintenance procedures of the Teledyne API 700 Series Dynamic Dilution Calibrator, refer to Section 12 Standard Operating Procedure (SOP) Calibrators.

2.6 Teledyne API 701 Series 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.

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

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

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

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

2.6.5 After the annual maintenance is completed, attach the zero air to a flow certified calibrator.

2.6.6 Prepare to run a zero point with the calibrator to an analyzer.

2.6.7 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.

For maintenance procedures, refer to Section 13 Standard Operating Procedure (SOP) Zero Air Supplies.

2.7 Teledyne API 200 Series Nitrogen Oxide Analyzer Maintenance

On a regular schedule (yearly), the analyzer should be inspected to assure proper functionality. If the instrument is malfunctioning or breaks down, immediate checks and repairs are to be performed. Perform yearly inspections and filter changes AFTER a QC check passes.

Record all maintenance in the logbook, as well as the briefing maintenance sheet on the cover of the analyzer. Also, fill out the repair log Excel spreadsheet in Microsoft Teams to illustrate an extensive and detailed history of the maintenance log of the analyzer.

Before turning the instrument off, check the diagnostics by using the test button on the front panel display. If there are any discrepancies to the manufacturer's specifications, they should be addressed first. Refer to the Teledyne API 200 Series Nitrogen Oxide Analyzer Manual for details.

2.7.1 Clean the sample line annually or as necessary. If the sample line becomes extremely dirty replace the line.

2.7.2 Replace the 1 µm Teflon particulate filter at least monthly (see Figure 18).

Figure 18: Sample Box Filter Housing

A good habit is to replace it after every other bi-weekly ZSP check. The filter may be replaced more often if necessary. Refer to Teledyne API 200 Series Nitrogen Oxide Analyzer Manual for more details.

2.7.3 Replace the Ozone Dryer Particulate filter. Refer to Teledyne API 200 Series Nitrogen Oxide Analyzer Manual for more details.

2.7.4 Clean the Reaction Cell. Refer to Teledyne API 200 Series Nitrogen Oxide Analyzer Manual for more details.

2.7.5 Inspect and clean the Thermoelectric Cooler Fins. The cooler fins on the PMT Cooler should be inspected and cleaned at six-month intervals. This assures optimal performance of the cooler.

2.7.6 Perform a sample vacuum leak and pump check. If the leak check fails, perform necessary maintenance. To rebuild the external sample pump, refer to Teledyne API 200 Series Nitrogen Oxide Analyzer Manual for more details.

2.7.7 Verify the sample flow is at 1000 ± 50 cm^3 and the Ozone flow is at 80 ± 10 cm^3. If either flow is bad, rebuild the faulty critical flow orifice. Refer to Teledyne API 200 Series Nitrogen Oxide Analyzer Manual for more details.

2.7.8 Check the HVPS value on the front display (use the test buttons). The HVPS has to be between 400-900V. If it is outside this range, a PMT Adjustment is necessary, refer to Teledyne API Service Note 13-002 ‘Performing a PMT Adjustment on a NO/NOx Analyzer’.

2.7.9 Perform a Moly Converter Calculation (see section 2.2.3.6). If necessary replace the Moly Converter, refer to Teledyne API 200 Series Nitrogen Oxide Analyzer Manual for more details.

2.7.10 Record all maintenance performed on the instrument in the preventive maintenance logbook located in Microsoft Teams (see Figure 19).

Preventive Maintenance Log for a 200EU [redacted]	Maintenance Performed and completed		
Site: Serial #: [redacted]	Date	By	Notes
Check all electrical connections			
Check all pneumatic connections			
Clean PMT cooling fins			
Check vacuum pump and repair			
Replace sintered filter and "O" rings and clean critical orifice			
Clean Reaction Cell			
Turn unit ON and allow it to warm up (~30m)			
perform leak check			
Calibrate flow			
Calibrate pressure			
Calculate Moly Converter Efficiency			
Adjust Analog Outputs			
Run test points from calibrator to test NOx readings			

Figure 19: Preventive Maintenance Logbook for a TAPI 200 Series NO2 Analyzer

2.8 Routine site visits

The purpose of the routine site visit is to ensure the site is safe, sampling is undisturbed and the 200 Series analyzer and ESC 8832 data logger are operating properly. Routine site visits should be conducted at least weekly and more frequently if necessary.

2.8.1 Upon arrival, visually inspect the site for safety hazards and cleanliness. Ensure the 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.

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

2.8.3 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. Check electrical connections for proper seating.

2.8.4 Check to see that the computer and the ESC 8832 data logger are set to eastern standard time. If times are off more than 1 minute, adjust to correct time, make a note in the logbook and alert program manager.

2.8.5 Record the site visit in the Agilaire AirVision logbook (see Figure 20).

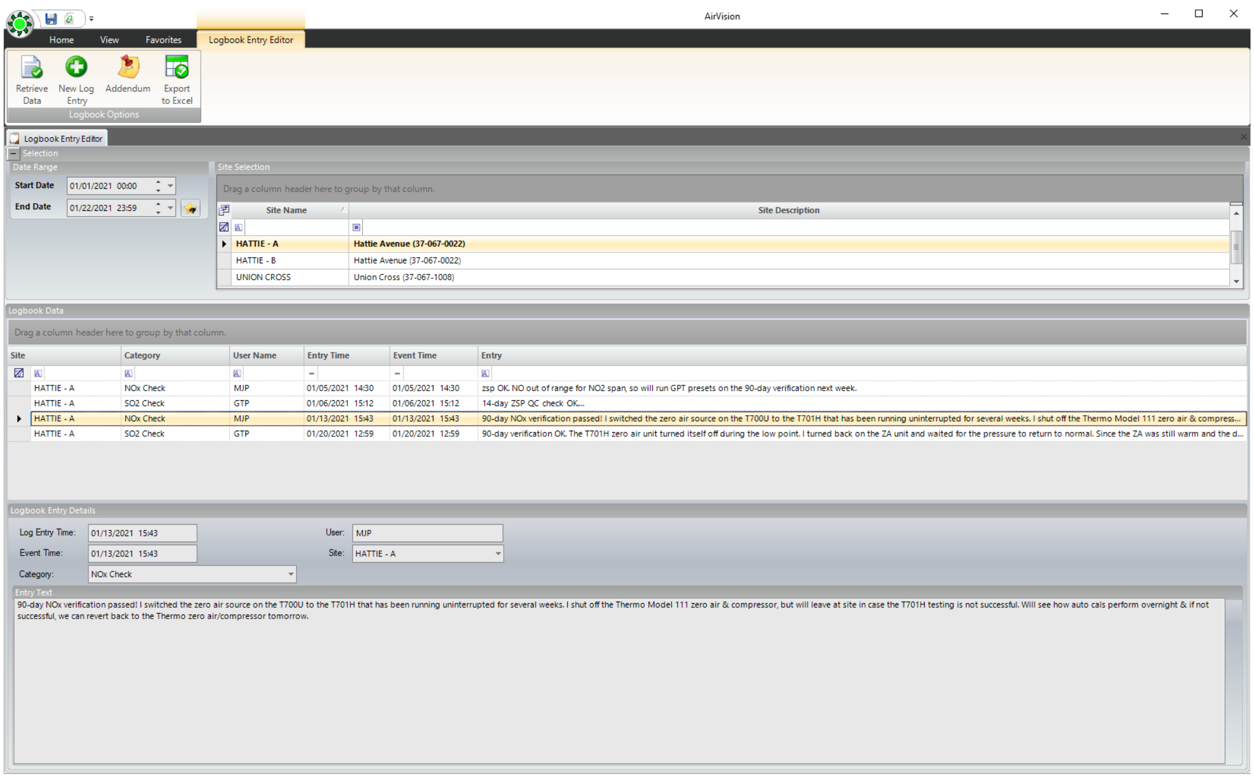


Figure 20: Agilaire AirVision Logbook Entry

2.8.6 In AirVision, examine the entire 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.

2.8.7 Check the frequencies, pressure, and temperature (see 2.2.3.4) on the instrument. Ensure that the hourly data is typical and that the previous day's auto-calibration cycle is ok. Corrective action should be taken if the zero is > ± 5 ppb $NO-NO_x-NO_2$ or the span or precision is > ± 8 ppb $NO-NO_x-NO_2$ from the expected value. Corrective action must be taken if the zero is > ± 8 ppb $NO-NO_x-NO_2$ or the span or precision is > ± 10 ppb $NO-NO_x-NO_2$ from the expected value. Corrective actions that may be performed are:

- Inform Program Manager
- Repair/Maintenance
- Repeat the auto-calibration
- Perform a Bi-weekly Zero/Span/Precision (ZSP) check (2.9.5).
- Perform an Adjusted Multi-point Calibration

2.8.8 Any possible abnormalities should be investigated to ensure continuous uninterrupted quality controlled data collection. If any problems are found the operator is to notify the program manager and do whatever is necessary to permanently correct the problem. If the operator is not absolutely sure the problem encountered is permanently rectified, he should revisit the site later on that day or the next working day to check the problem. The operator is to keep the supervisor informed on a daily basis as to the status of the problem. Detailed records of all corrective actions are to be maintained in the AirVision electronic logbook, graph, and site pollutant Excel logbook.

2.9 Quality Assurance/Quality Control checks

Quality Assurance (QA)/Quality Control (QC) procedures include performance audits, 90-day verification checks, zero-span-precision (ZSP) 14-day checks, and calibration checks.

Analyzer accuracy audits are to be performed once for each quarter of the year and 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. The audit should be conducted using a gas dilution system, certified NIST EPA protocol cylinder gas and zero air system that are independent of the normal calibration system.

2.9.1 Audit Short Path Procedure

Audits are to be performed quarterly at a frequency $\leq$ 90 days apart. Analyzer accuracy audits are to be performed by an individual other than the analyst who performed the calibration. The audit should be conducted using a gas dilution system, certified NIST EPA protocol cylinder gas, and zero air system that are independent of the normal calibration system. The following procedure should be followed when conducting audits.

2.9.1.1 The analyzer audit is conducted by challenging the measurement system with a series of known concentrations of calibration gas. The audit field procedure is similar to the 90-day verification procedure except that different points can be run. The NO-NO_x points of the audit must be the following 5 points: a zero, 225 ppb, 160 ppb, 70 ppb, and 40 ppb.

The NO_2 portion of the audit must include zero and at least one point taken from three of the ten ranges:

- **Level 1: 0.3-2.9 ppb NO_2 (Required)**
- Level 2: 3.0-4.9 ppb NO_2
- Level 3: 5.0-7.9 ppb NO_2
- Level 4: 8.0-19.9 ppb NO_2
- **Level 5: 20.0-49.9 ppb NO_2 (Required)**
- Level 6: 50.0-99.9 ppb NO_2
- **Level 7: 100.0-299.9 ppb NO_2 (Required)**
- Level 8: 300.0-499.9 ppb NO_2 (Over FCEAP range)
- Level 9: 500.0-799.9 ppb NO_2 (Over FCEAP range)
- Level 10: 800.0-1000.0 ppb NO_2 (Over FCEAP range)

2.9.1.2 The audit is to be recorded in the audit section of the analyzer logbook. Figure 21 should be used for a template of data that must be recorded in the logbook. Record the information but do not alter the analyzer settings in any way.

DATE:	09/05/2013	NITROGEN DIOXIDES PERFORMANCE AUDIT DATA SHEET	PG 2 OF 2

COMMENT(S):

ANALYZER DATA:

MOST RECENT CALIBRATION SLOPES AND INTERCEPTS:	DAS			API 200A RECORDS		
	NO	NO2	NOX	NO	NO2	NOX
SLOPE	0.2505	0.2495	0.2517	1.0023	0.9971	1.0058
INT	-0.0002	-0.0012	-0.0003	-0.0003	-0.0016	-0.0001

TELEDYNE API [illegible] INTERNAL ANALYZER RECORDS SLOPE AND INTERCEPT	NO	NOX
OFFSET	2.40 MV	4.50 MV
SLOPE	1.181	1.192

DATE OF LAST MULTIPOINT CALIBRATION :	10/23/2013
DATE OF LAST PERFORMANCE AUDIT:	09/05/2013

AUDIT DATA:

AUDIT POINTS	ZERO AIR SETTING	ZERO AIR LPM	GAS CHAN A SETTING	GAS CHAN A LPM	Y1 EXP PPM NO	Y2 EXP PPM NOX	X1 OBS DAS VDC NO	X2 OBS DAS VDC NOX	OBSERVED DAS PPM NO	OBSERVED DAS PPM NOX
# 1	3.000	3.000	OFF	0	0.000	0.000	0.0007	0.0010	0.000	0.000
# 2	2.987	3.001	0.0130	0.0130	0.225	0.225	0.8805	0.8788	0.221	0.221
# 3	2.991	3.004	0.0092	0.0093	0.160	0.160	0.6281	0.6276	0.157	0.158
# 4	2.995	3.009	0.0052	0.0052	0.090	0.090	0.3538	0.3533	0.089	0.089
# 5	2.996	3.009	0.0040	0.0041	0.070	0.070	0.2721	0.2723	0.068	0.068
# 6	2.998	3.012	2.3000	2.3000	0.040	0.040	0.1514	0.1531	0.038	0.038

AUDIT POINTS	OBSERVED RAW API RECORDS RAW RECS NO	OBSERVED RAW API RECORDS RAW RECS NOX	X3 OBS API RAW RECS CNVT RECS TO NO PPM	X4 OBS API RAW RECS CNVT RECS TO NOX PPM	OBS API RECS ARE CALCULATED FROM THE LATEST MULTIPOINT CAL API RECS NO PPM	API RECS NOX PPM	% DIFF DAS NO	% DIFF DAS NOX	% DIFF API NO	% DIFF API NOX	NO DAS CONTROL LIMITS OK?	NOX DAS CONTROL LIMITS OK?	NO API CONTROL LIMITS OK?	NOX API CONTROL LIMITS OK?
# 1	0.10	0.30	0	0	0.000	0.000	#N/A	#N/A	#N/A	#N/A	YES	YES	YES	YES
# 2	220.00	219.60	0.220	0.22	0.220	0.221	-1.91	-1.64	-2.22	-1.78	YES	YES	YES	YES
# 3	157.00	157.00	0.157	0.157	0.157	0.158	-1.69	-1.19	-1.88	-1.25	YES	YES	YES	YES
# 4	88.60	88.30	0.089	0.088	0.089	0.088	-1.67	-1.18	-1.11	-2.22	YES	YES	YES	YES
# 5	68.10	68.20	0.068	0.068	0.068	0.068	-2.79	-2.37	-2.86	-2.86	YES	YES	YES	YES
# 6	37.80	38.00	0.038	0.038	0.038	0.038	-5.60	-4.45	-5.00	-5.00	YES	YES	YES	YES

AUDIT SLOPES AND INTERCEPTS:	DAS	DAS	API 200A RECORD	
	NO	NOX	NO	NOX
	X1Y1	X2Y2	X3Y1	X4Y2
SLOPE	0.2548	0.2555	1.0191	1.0193
INT	0.0004	0.0001	0.0004	0.0005
RSQRD	0.9999	1.0000	0.9999	1.0000

NO2 GAS PHASE TITRATION:

NO2 DAS AUDIT SET OZONE	THESE REMAINING NO VALUES ARE CALCULATED USING THE NEWLY GENERATED AUDIT SLOPE AND NO ORIG PPM	NO ORIG VDC	NO REMAINING VDC	NO REMAINING PPM	Y5 EXP NO2 PPM	X5 OBS NO2 PPM	NO2 DIFF PPM	NO2 DIFF %	NO2 DAS CONTROL LIMITS OK?
OFF	0.227	0.8890	0.8890	0.227	0.000	-0.001	0.001	N/A	YES
208.0	0.227	0.8890	0.0611	0.016	0.211	0.208	0.003	-1.63	YES
65.0	0.227	0.8890	0.6456	0.165	0.062	0.062	0.000	-0.01	YES
37.0	0.227	0.8890	0.7513	0.192	0.035	0.035	0.000	-0.39	YES
6.0	0.227	0.8890	0.8338	0.213	0.014	0.013	0.001	-7.57	YES

Figure 21: Audit Data Worksheet

2.9.1.3 Transport an audit dynamic calibration system (i.e., Teledyne API T750U Dynamic Dilution Calibrator), an audit gas certified by EPA traceable to NIST standards, and an independent zero air system to the site to be audited. The audit calibrator may be transported to the site the day before the audit if feasible. The audit calibrator should warm up at least one hour prior to the performance of the audit. The audit calibrator's mass flow controllers must be calibrated against authoritative standards such as an NIST traceable bubble meter, a wet test meter or a calibrated BIOS Drycal prior to use and should be recertified semi-annually. The calibration slope and intercept prepared when calibrating the audit calibrator will be used to determine calibrator flows.

2.9.1.4 Use a pump (oil-less diaphragm or oil-less piston type) to supply a source of audit zero air. The pump should be capable of supplying at least 20 psig at 10 lpm. The audit zero air should be dried with silica gel or drierite, passed through canisters containing purafil and charcoal and filtered through a 5 µm particulate filter prior to entering the audit calibrator.

2.9.1.5 Connect 1/4" O. FEP Teflon tubing from the audit zero air system to the audit calibrator zero air in port.

2.9.1.6 Login into the ESC 8832 data logger using AirVision, AV-Trend, or HyperTerminal on the PC. See section 2.2.2.11.1 for details.

Press L (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 NO-NO2-NOx, then press Enter for each to disable the all three channels.

2.9.1.7 Connect the audit calibrator output with 1/4" Teflon tubing to the analyzer sample line inlet. The length of the tubing should be kept to a minimum. An atmospheric vent should be utilized. The normal sample setup is through an ambient solenoid and particulate filter so the audit should be set up similarly.

2.9.1.8 Attach a two-stage regulator to the audit NO cylinder. Quickly open and close the cylinder valve on the NO audit cylinder and adjust the 1st stage regulator valve to 24 psig. Open the second stage valve and allow the regulator to empty. Close the second stage valve. Repeat this process 5 times to evacuate residual gases in the regulator. The regulator evacuation should be performed in a well ventilated area. After the evacuation procedure fill the regulator with gas leaving the second stage valve closed. Connect the NO regulator to the audit calibrator with the appropriate tubing (stainless steel) and fitting (stainless steel). Open the second stage regulator valve to the maximum. Adjust the second stage pressure to 24 psig. Check the fittings for leaks with Snoop®. Record the cylinder pressure.

2.9.1.9 Switch on the audit zero air pump. Set the audit calibrator for an output of 0.000 ppm NO-NO_x-NO_2 by pressing SEQ and toggle to ZERO and press enter.

*During the Short Path part of the audit, no ozone is introduced and only the NO-NO_x values are recorded. The only NO_2 value used is the zero point NO_2 observed 8832 and the analyzer's reading.

2.9.1.10 Check the instrument functions by pressing the Test button. Check the analyzer temperatures, pressure, flow, and intensities.

2.9.1.11 Allow the instrument to stabilize (~30 minutes). Observe the analyzer and the calibration standard. The difference for the zero point should meet the following specification:

$\leq \pm 5$ ppb at a stability of < 0.5

2.9.1.12 Record (highlight, right click ‘copy’) the ppb reading from the ESC 8832 (in AirVision or HyperTerminal) and download the instrument’s 1-minute readings using the APICom software. Paste both, the data logger (ESC) and copy/paste APICom min data, readings into the audit data worksheet (see Figure 21) in the correct cells. Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the audit calibrator’s front panel actual concentration.

2.9.1.13 While the zero point is still running, on the calibrator check the NO Flow and Air Flow settings and actual flows. Type these readings to the NO FLOW Set/Lpm and AIR FLOW Set/Lpm in the worksheet. Check the expected NO/NO_x values and type it into the EXP NO/NO_x [PPB] in the worksheet.

2.9.1.14 Press SEQ on the calibrator, use the arrow keys to reach NOx225, press Enter to start the Span point.

2.9.1.15 Allow the instrument to stabilize (15-30 minutes). Observe the analyzer and the calibration standard. The difference for the span point should meet the following specification:

$\leq \pm$ 15% difference at a stability of < 0.5

2.9.1.16 Record (highlight, right click ‘copy’) the ppb reading from the ESC 8832 and download the instrument’s 1-minute reading using APICom. Paste (ESC) and copy/paste (APICom) both readings into the audit data worksheet (see Figure 21). Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the audit calibrator’s front panel actual concentration.

2.9.1.17 While the span point is still running on the calibrator, check the NO FLOW Set/Lpm and AIR FLOW Set/Lpm settings and the EXP NO/NO_x [PPB] values and type them into the correct cells in the audit data worksheet (see Figure 21).

2.9.1.18 After the 0.0 ppb (Zero) and 225 ppb (Span) NO-NO_x points have been run satisfactorily and data recorded, start the sequences on the calibrator to run the points for NO_x 160 ppb, NO_x 90 ppb, and NO_x 40 ppb. Press SEQ on the calibrator, use arrow keys to reach the desired NO-NO_x concentration, press Enter.

Record the results for each concentration based on stable readings (stability <0.5) from the ESC 8832 ppb readings and 1-minute APICom (see 2.4.2.5) in the audit data worksheet (see Figure 21) and manually copy them into the correct cells. Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the audit calibrator’s front panel actual concentration.

The difference for each point should meet the following specification:

$\leq \pm$ 15% difference

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

Document the NO FLOW Set/Lpm and AIR FLOW Set/Lpm setting and the EXP NO/NO_x [PPB] values in the audit data worksheet (see Figure 21).

2.9.2 Ozone Presets for Audits (GPTPS)

2.9.2.1 Before continuing the audit procedure for NO_2 with the Gas Phase Titration (GPT) part, presets have to be run on the audit calibrator. Press SEQ on the calibrator, use arrow keys to reach GPTPS, press Enter.

The preset mimics the calibrator set up for running the following GPT without mixing any O_3 with calibration gas. Instead, the internal photometer measures the actual ozone concentration and adjusts the ozone drive voltage on the ozone generator, to receive a most accurate NO_2 reading later during the GPT.

The preset will run approximately 15-20 min and no records have to be taken during the preset, as this only prepares the calibrator for the following GPT. Observe the ‘Active’ and ‘Auto’ lights on the front panel. While both lights are blinking the calibrator is adjusting the ozone drive voltage. When the ‘Active’ light is steady lit, it’s setting a reference point. There will be a total of 8 steps to complete the presets sequence.

Once the calibrator is back in Standby mode, proceed with the Gas Phase Titration Zero (GPTZ) procedure.

2.9.3 NO-NO_x GPTZ for Audits Explanation

During the GPTZ, ozone is not introduced to the calibration gas mixture but the flow paths and amounts follow the GPT settings for a given desired result. The GPTZ steps will produce the NOorig and NOxorig (original) values used along with NOrem and NOxrem (remaining) collected during the GPT steps to calculate expected NO_2 levels.

2.9.3.1 On the calibrator press SEQ, use the arrows to reach GPTZ, press Enter. This will start the zero point for the GPT run. This GPTZ point will mimic the flow settings for the 190 ppb NO_2 GPT point but will serve as the zero point for NO_2. The results can be used as the NOorig and NOxorig.

2.9.3.2 Allow the instrument to stabilize (15-30 minutes). Observe the analyzer and the calibration standard. The % error for the GPTZ points should meet the following specification:

$\leq \pm$ 15% difference of 225 ppb at stability of < 0.5

*Note: Each GPT point that will be run will have a GPTZ point executed right before it with the same flow and desired ozone level targets as the GPT.

2.9.3.3 Copy the ppb readings from the ESC 8832 and download the instrument's 1-minute reading using APICom (see 2.4.2.5). Copy both readings into the audit data worksheet (see Figure 21). The following observed DAS and API NO, NO_x and NO_2 readings have to be manually copied into the correct cells. Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the audit calibrator's front panel actual concentration.

2.9.4 NO2 GPT for Audits

2.9.4.1 On the calibrator press SEQ, use the arrows to reach NO_2 190 (Span point), press Enter.

2.9.4.2 Allow the instrument to stabilize (15-30 minutes). Observe the analyzer and the calibration standard. The difference for all NO_2 points should meet the following specification:

$\leq \pm$ 15% difference of the calculated expected ppb for NO_2 at stability of < 0.5

2.9.4.3 Copy the ppb reading from the ESC 8832 and download the instrument's 1-minute reading using APICom (see 2.4.2.5). Copy both readings into the audit data worksheet (see Figure 21). The following observed DAS and API NO, NO_x and NO_2 readings have to be manually copied into the correct cells of the audit data worksheet (see Figure 21). Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the audit calibrator's front panel actual concentration.

2.9.4.4 After the 0.00 ppb (Zero) and 190 ppb (Span) GPT points have been run satisfactorily and recorded, start the sequences on the calibrator to run points for GPT NO_2 160, GPT NO_2 70 ppb and GPT NO_2 40 ppb.

*Before each of the following GPT points are to be run, a GPTZ point has to be run with the same target ozone and total flow to be used for each of the GPT points. During the GPTZ 160, GPTZ 70 and GPTZ 40 the NOOrig and NOxOrig are obtained to get more accurate NORem and NO2Rem calculations. On the calibrator press SEQ, use the arrow keys to reach the desired GPTZ point. See section 2.9.3.

2.9.4.5 Record the results for each concentration based on stable readings on the analyzer (stability <0.5) and using the AirVision chart. Copy the ppb readings from the ESC 8832 and the instrument's 1-minute reading using APICom (see 2.4.2.5) in the audit data worksheet (see Figure 21) and manually copy into the corresponding correct cells. From each associated GPTZ run, manually copy the API NOOrig and DAS NOxOrig values into the correct cells. Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the audit calibrator's front panel actual concentration.

2.9.4.6 After all NO_2 points are done verify that each result has a difference <= 15%. If not, inform the Program Manager. The converter efficiency (CE) is also verified to check the moly converter's operation. The CE needs to be .9600 >= CE <= 1.0200. If not, inform the Program Manager.

2.9.4.7 Close all APICom windows to disconnect from the NO_2 Analyzer.

2.9.4.8 If the sample line was disconnected, reconnect the sample line to the sample port of the analyzer.

2.9.4.9 On the calibrator press the STBY button to bring it back in standby mode. Check the analyzer for it to return to reading ambient NO-NO_x-NO_2 values.

2.9.4.10 In the ESC 8832 skip back to the Main Menu (use Esc). Press C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration). Press E (Enable/Mark Channel Online). Use arrows to skip to NO-NO2-NOx, then press Enter for each to enable the all three channels.

Refer to Section 11, Data logger 8832 SOP.

2.9.4.11 Record a note in the AirVision logbook and the real time trending graph where the audit was performed.

2.9.5 Bi-weekly Zero/Span/Precision Checks (ZSP)

Zero/Span/Precision checks (ZSP) must be performed every 14 days. The ZSP procedure is divided into two parts: Short Path, during which no ozone is introduced and only the NO-NO_x values are recorded, and Gas Phase Titration (GPT) during which ozone is introduced to the calibration gas to record NO-NO_x-NO_2 values. Concentrations for the Short Path points are 0.0 ppb NO_x (Zero), 225 ppb NO_x (Span) and 70 ppb NO_x (Precision). Concentrations for the GPT points are 0.0 ppb NO_2 (Zero), 190 ppb NO_2 (Span) and 70 ppb NO_2 (Precision) respectively. The ZSP check must be performed with a currently certified gas dilution system (for example, a

Teledyne API T700U Dynamic Dilution Calibrator) and a NIST cylinder gas, which is currently certified according to EPA protocol.

2.9.5.1 Make sure the 700 Series Calibrator is connected to a source of zero air producing 25-30 psig pressure. Check the regulator pressure on the 700 Series Calibrator to make sure it is set to 7-10 psig.

2.9.5.2 Check that the 700 Series Calibrator is connected to the NO-NO_x-NO_2 analyzer. Make sure the calibration gas passes through all filters, conditioners, and other components used during normal ambient sampling and as much of the ambient air inlet system as is practicable.

2.9.5.3 Login into the ESC 8832 data logger using AirVision, AV-Trend, or HyperTerminal on the PC. See section 2.2.2.11.1 for details.

Press L (Login), type password, press Enter. D (Real-time Display Menu), O (Display all Digital Outputs). Use arrows to skip to NO-NO_x-NO_2 Bad Stat, press Enter to disable the NO-NO_x-NO_2 channel.

2.9.5.4 Using the APICom software download one instrument's 1-minute reading (see 2.4.2.5) and copy it into the instrument's logbook (200EU Diag., top right) (see Figure 22).

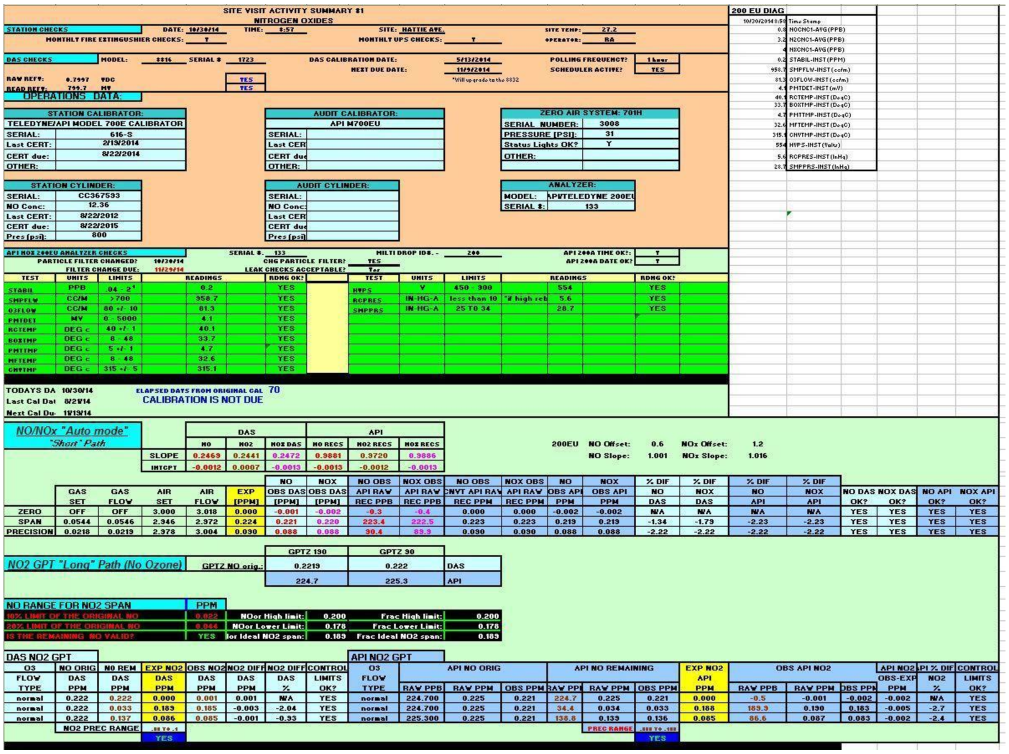


Figure 22: Instrument Logbook, Zero/Span/Precision Worksheet

2.9.5.5 In the ESC 8832 skip back to the Main Menu (use Esc). Press D (Real-Time Display), F (Display Readings w/Flags).

2.9.5.6 Short Path Procedure

2.9.5.6.1 Start the zero point by pressing SEQ on the 700 Series Calibrator, toggle to NOxZERO and press Enter. Let the point run for at least 10 minutes until stability reaches < 0.5.

2.9.5.6.2 Use Esc to skip back to the Main Menu. Press D (Real-Time Display), F (Display Readings w/Flags). Copy (highlight, right click 'copy') the ppb readings from the ESC 8832 (see Figure 23). Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the calibrator's front panel actual concentration.

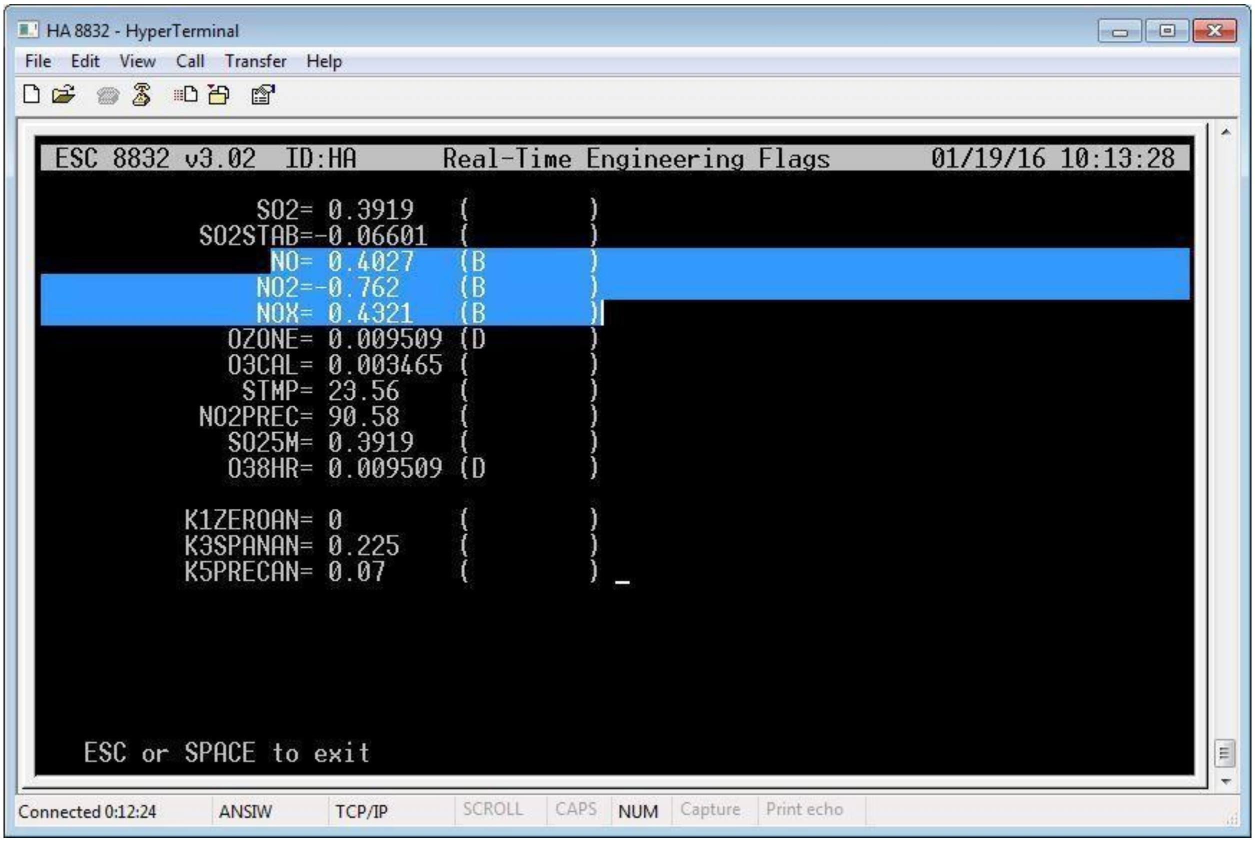


Figure 23: ESC 8832 NO/NO_2/NO_x ppb Readings

2.9.5.6.3 Download the instrument's 1-minute readings using APICom (see 2.4.2.5). Paste both readings into the appropriate sections of DAS input (Raw Readings) and TAPI inputs (1-minute reading) in the instrument's logbook (see Figure 22). The observed and downloaded NO-NO_x, not NO_2, readings have to be manually copied into 'NO/NO_x "Auto Mode" Short Path' section NOObs/NOxObs DAS and NOObs/NOxObs API Raw Rec. The NO_2 reading has to be entered into OBS NO2 DAS in the DAS NO2 GPT section (see Appendix C 'NO_x Zero/Span/Precision worksheet, data input and handling' for assistance).

2.9.5.6.4 While the zero point is still running, on the 700 Series Calibrator, check the NO Flow and Air Flow settings and actual flows. Type these readings to the NO FLOW Set/Lpm and AIR FLOW Set/Lpm in the worksheet. Also check the expected NO/NO_x values and type it to the EXP NO/NOx [PPB] in the worksheet.

2.9.5.6.5 Start the span point by pressing SEQ, then NOx225 on the 700 Series Calibrator. Let the point run for at least 10 minutes until stability reaches < 0.5.

2.9.5.6.6 Copy the Reading from the ESC 8832. Download the instrument's 1-minute reading using APICom (see 2.4.2.5). Paste both readings into the appropriate sections of DAS input (Raw Readings) and TAPI inputs (1-minute reading) in the instrument's logbook (see Figure 22). The following observed NO-NO_x, not NO_2, readings have to be manually copied into 'NO/NO_x "Auto Mode" Short Path' section NOObs/NOxObs DAS and NOObs/NOxObs API Raw Rec. The NO_2 reading does not have to be manually copied (see Appendix 'NO_x Zero/Span/Precision worksheet, data input and handling' for assistance). Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the calibrator's front panel actual concentration.

From the 700 Series Calibrator, type the NO FLOW Set/Lpm, AIR FLOW Set/Lpm, and EXP NO/NOx [PPB] readings.

2.9.5.6.7 Start the precision point by pressing SEQ, then NOx90 on the 700 Series Calibrator. Let the point run for at least 10 minutes until stability reaches < 0.5.

2.9.5.6.8 Copy the reading from the ESC 8832. Download the instrument's 1-minute reading using APICom (see 2.4.2.5). Paste both readings into the appropriate sections of DAS input (Raw Readings) and TAPI inputs (1-minute reading) in the instrument's logbook (see Figure 22). The observed and downloaded NO-NO_x, not NO_2, readings have to be manually copied into 'NO/NOx "Auto Mode" Short Path' section NOObs/NOxObs DAS and NOObs/NOxObs API Raw Rec. The NO_2 reading does not have to be manually copied (see Appendix 'NO_x Zero/Span/Precision worksheet, data input and handling' for assistance). Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the calibrator's front panel actual concentration.

From the 700 Series Calibrator, type the NO FLOW Set/Lpm, AIR FLOW Set/Lpm, and EXP NO/NOx [PPB] readings.

2.9.5.6.9 The difference for each point should meet the following specification:

$\leq \pm$ 15% difference

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

2.9.5.7 Before continuing with the (GPT) procedure, a preset run can be executed on the 700 Series Calibrator. It is only required if the NO_2 values from previous ZSP checks show an increase in error, i.e. drift. The preset mimics the 700 Series Calibrator set up for running the following GPT points without introducing NO to the calibration gas. Instead, the internal photometer measures the actual ozone concentration and adjusts the ozone drive voltage on the ozone generator, to receive a most accurate NO_2 reading during the GPT afterwards. Typically the presets should be run about every two months.

To start the preset, press SEQ on the 700 Series Calibrator, use arrow keys to reach PSZSP, press Enter.

The preset will run approximately 12-15 min and no records have to be taken.

Once the 700 Series Calibrator is back in Standby mode, proceed with the GPT procedure.

2.9.5.7.1 GPTZ Procedure

2.9.5.7.2 Start the GPT zero point by pressing SEQ, then GPTZ on the 700 Series Calibrator. Let the point run for at least 10 minutes until stability reaches < 0.5.

2.9.5.7.3 Copy (highlight, right click 'copy') the ppb reading from the ESC 8832. Download the instrument's 1-minute reading using APICom (see 2.4.2.5). Paste both readings into the appropriate sections of DAS input (ppb) and TAPI inputs (1-minute reading) in the instrument's logbook (see Figure 22). The following observed NO, not NO_x or NO_2, readings have to be manually entered into NO Rem DAS in the DAS NO2 GPT section and API NO Rem. The NO_2 readings have to be manually copied into Obs API NO2 in the DAS NO2 GPT section (see Appendix 'NO_x Zero/Span/Precision worksheet, data input and handling' for assistance). Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the calibrator's front panel actual concentration.

Also manually copy the DAS and API NO value into "NO2 GPT "Long Path" (No Ozone) GPTZ190.

2.9.5.7.4 Check the Moly Converter Check Original NO_x.

2.9.5.7.5 Start the GPT span point by pressing SEQ, then NO_2 190 on the 700 Series Calibrator. Let the point run for at least 10 minutes until stability reaches < 0.5.

2.9.5.7.6 Copy the Reading from the ESC 8832. Download the instrument's 1-minute reading using APICom (see 2.4.2.5). Paste both readings into the appropriate sections of DAS input (ppb) and TAPI inputs (1-minute reading) in the instrument's logbook (see Figure 22). The following observed NO and NO_2, not NO_x, readings have to be manually copied into NO Rem DAS and Obs NO2 DAS and API NO Rem Raw and Obs API NO2 in the DAS NO2 GPT section (see Appendix C 'NOx Zero/Span/Precision worksheet, data input and handling' for assistance). Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the calibrator's front panel actual concentration.

2.9.5.7.7 Start the GPT precision point by pressing SEQ, then NO2_90 on the 700 Series Calibrator. Let the point run for at least 10 minutes until stability reaches < 0.5.

2.9.5.7.8. Copy the Reading from the ESC 8832. Download the instrument's 1-minute reading using APICom (see 2.4.2.5). Paste both readings into the appropriate sections of DAS input (ppb) and TAPI inputs (1-minute reading) in the instruments logbook (see Figure 22). The following observed NO and NO_2, not NO_x, readings have to be manually copied into NO Rem DAS and Obs NO2 DAS and API NO Rem Raw and Obs API NO2 Raw in the DAS NO2 GPT section (see Appendix C 'NOx Zero/Span/Precision worksheet, data input and handling' for assistance). Never use the concentration on the front panel of the analyzer. For the expected concentration from the calibrator, use the calibrator's front panel actual concentration.

2.9.5.8 Check that Zero/Span/Precision Differences are within a 15% difference.

If the biweekly check does not meet the above criteria, check the instrument line set up. If there are no issues in the set up, inform the Program Manager.

2.9.5.9 When finished, press the STBY button on the 700 Series Calibrator to set into Standby mode. Make sure the front of the analyzer is showing it is in 'Sample' mode; observe the NO-NO_x-NO_2 values and stability to make sure it is returning to ambient values.

2.9.5.10 Once a month the 1 µm filter has to be changed. This has to be done after the Biweekly Zero/Span/Precision Check was performed. Always handle particulate filters with tweezers.

2.9.5.11 After every Biweekly Zero/Span/Precision Check a record of all hourly data of the past 14 days has to be downloaded. In APICom click the 'Get data' button, choose ' since last download (15 days)' to download the hourly data from the analyzer and 'Save' to the NOx hourly data folder (see 2.4.2.5). Close all APICom windows to disconnect from the analyzer.

2.9.5.12 Go to the ESC 8832 data logger and enable the NO-NO_x-NO_2 channel.

Refer to Section 11 Data logger 8832 SOP

Using ‘Esc’ skip back to Main Menu. Press D Real-time Display Menu, O Display all Digital Outputs. Use arrows to skip to NO-NO_x-NO_2 Bad Stat, press Enter to enable the NO-NO_x-NO_2 channel. Skip back to the Main Menu (Esc), press O Log Out/Exit to exit out of the ESC 8832.

2.9.5.13 Record a note in the AirVision electrnoic logbook and graph of the performed check.

2.9.6 Teledyne 200 Series 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 marked 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. Auto cal results have to meet the 15% difference. If it does not meet this then corrective action is required. Some troubleshooting may be needed if results are greater than 12% so data loss can be avoided. 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).

2.10 Data Handling - Documentation, Reduction, Analysis, and Reporting.

See Section 10, Data Handling and Reporting SOP

REFERENCES

Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, Part 1, Ambient Air Quality Monitoring Program Quality System Development 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, Office of Air Quality Planning and Standards, Research Triangle Park, N.C. 27711.

Guideline on the Meaning and Use of Precision and Accuracy Data Required by 40 CFR 58, Appendices A and B, U. S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Research Triangle Park, N.C. 27711.

Manual Addendum, Ultra Sensitivity Model T200U NO/NO_2/NO_x (Addendum to T200 Manual, PN 06858), Teledyne Advanced Pollution Instrumentation, 9970 Carroll Canyon Road, San Diego, CA 92131-1106.

Title 40 Code of Federal Regulations Part 50, Appendix F- Measurement Principal and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere, 1993.

Title 40 Code of Federal Regulations Part 58- Ambient Air Quality Surveillance, 1993.

Technical Manual, Nitrogen Oxide Analyzer 200EU, Teledyne Instruments Advanced Pollution Instrumentation Division, 9480 Carroll Park Drive, San Diego, CA 92121-5201.

User Manual, Models T200 and T200U NO/NO_2/NO_x Analyzers with NumaView™ software, Teledyne Advanced Pollution Instrumentation, 9970 Carroll Canyon Road, San Diego, CA 92131-1106.

APPENDIX A

Moly Converter Test Data Sheet

Date: 2/27/2015 Time 8:40 AM Site HA Operator: RA/JRB

Section 1: Converter Out-gassing/Eating Test

Leak Check when HOT	Yes/No		
NOx Response when Moly is bypassed			*225 NO/NOx short path
NOx Response when Moly back in-line			*225 NO/NOx short path
Outgassing/eating results		0	(>-5, <5 PPB)

Use 8832 values for calculations. Also run cal gas straight into the analyzer to bypass probe box and shorten cal gas path. Open rear vent on Calibrator.
Run the back pressure compensation procedurebefore and after CE calculation.

Section 2: CE adjustment

NOx Original	225, 190, 4 LPM GPTz	225.6	
NOx Remaining	225, 190, 4 LPM GPT	224.9	
	NOx Loss:	0.7	(<4% of NOx Original)
NO Original	225, 190, 4 LPM GPTz	225.2	
NO Remaining	225, 190, 4 LPM GPT	28	
	NO2:	197.2	

NOx Original	225, 160, 4 LPM GPTz	226.2	
NOx Remaining	225, 160, 4 LPM GPT	226.1	
	NOx Loss:	0.1	(<4% of NOx Original)
NO Original	225, 160, 4 LPM GPTz	224.6	
NO Remaining	225, 160, 4 LPM GPT	58.5	
	NO2:	166.1	

NOx Original	225, 90, 4 LPM GPTz	230.7	
NOx Remaining	225, 90, 4 LPM GPT	230	
	NOx Loss:	0.7	(<4% of NOx Original)
NO Original	225, 90, 4 LPM GPTz	229.8	
NO Remaining	225, 90, 4 LPM GPT	139.1	
	NO2:	90.7	

Section 3: Efficiency Loss Equation:

	NOx Loss	/	NO2	* 100	=	CE Loss
	0.7	/	197.2	* 100	=	0.3550
AVG	0.5		151.333333	* 100		0.3304

Total CE in %:

	100%	-	CE Loss	=	New CE	
	100	-	0.3550	=	99.6450	(>96%,<102%)
AVG	100	-	0.3304	=	99.6696	

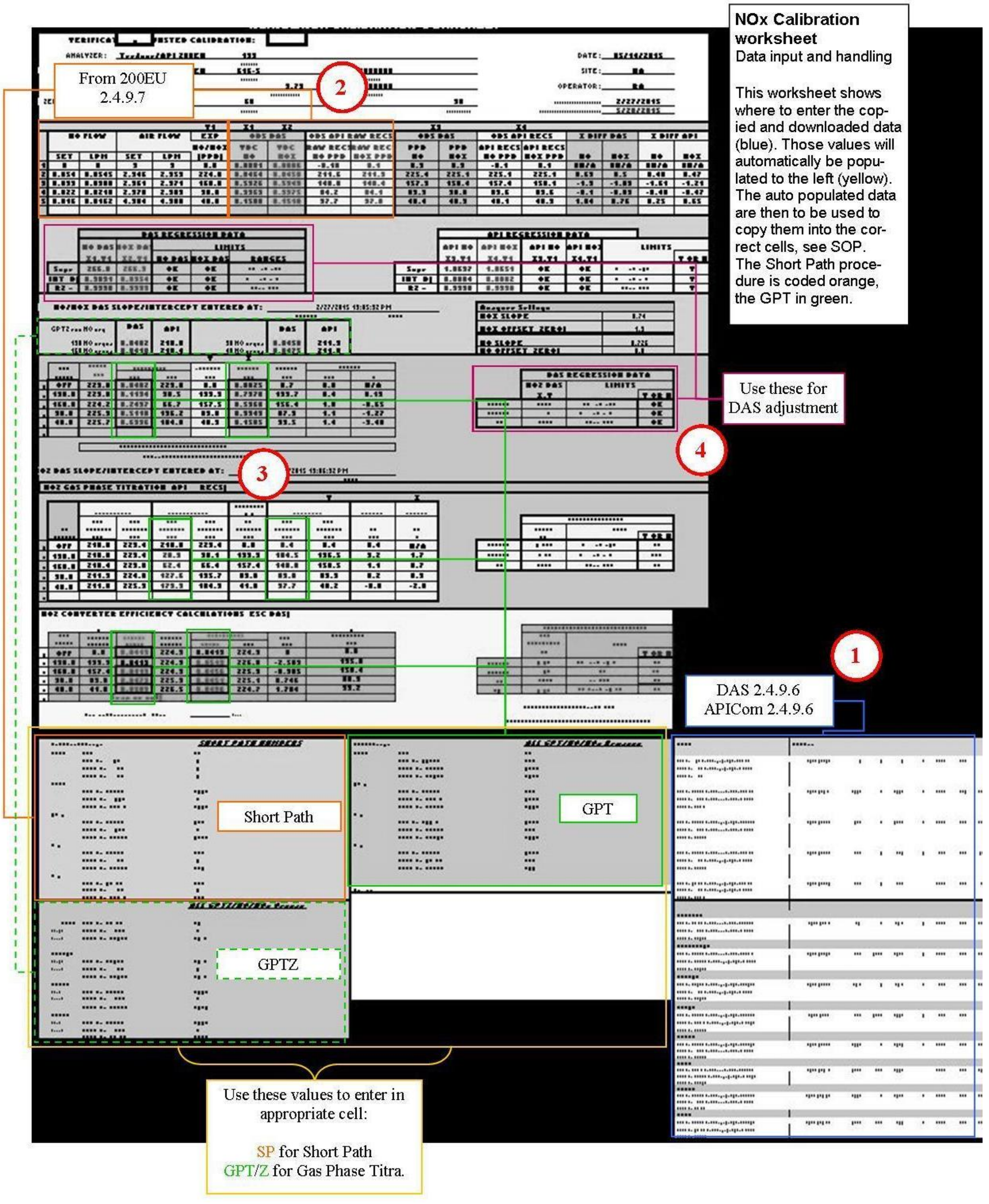
NO2 X axis	NO2-NOx loss Y axis
197.2	196.5
166.1	166
90.7	90

Slope: 0.9985 (>96%,<102%)

Graph NO2 on the X axis and NO2-NOx Loss on the Y axis. Calculate slope to verify CE is between 96% and 102%.

	Time Stamp	NOCNC1-	N2CNC1-A	NXCNC1-/	STABIL	SMPFLW	O3FLOW-IN:	PMTDET-	RCTEMP-	BOXTMP-I	PMTTMP-	MFTI	CNVTMP-	HVPS-INST	RCPRES-	SMPPRS-INST (InHg
GPTz 190	2/27/2015 8:45	225.2	0.4	225.6	0.4	953.2	82.3	453.5	39.9	31.8	4.8	30.8	316.3	553.7	5.8	29.1
GPT 190	2/27/2015 8:53	28	197	224.9	0.2	953.3	82.3	434.2	39.9	31.4	4.8	30.8	317.4	554.1	5.9	29.1
GPTz 160	2/27/2015 9:00	224.6	1.5	226.2	0.3	952.8	82.3	453	40	31.1	4.8	30.6	317.5	554.1	5.9	29.1
GPT 160	2/27/2015 9:08	58.5	167.6	226.1	0.3	951.3	82.3	329.6	40	30.8	4.8	30.4	315.7	554	5.9	29.1
GPTz 90	2/27/2015 9:24	229.8	0.8	230.7	0.1	953.2	82.2	467.5	39.9	32.2	4.7	31.1	315.4	554.2	5.7	29.1
GPT 90	2/27/2015 9:31	139.1	90.9	230	0.2	952.1	82.1	276.6	40.1	32.6	4.7	31.5	314.3	554.1	5.7	29.1

APPENDIX B


NOx Calibration worksheet
Data input and handling
This worksheet shows where to enter the copied and downloaded data (blue). Those values will automatically be populated to the left (yellow). The auto populated data are then to be used to copy them into the correct cells, see SOP.
The Short Path procedure is coded orange, the GPT in green.
From 200EU 2.4.9.7
2
Use these for DAS adjustment
4
3
1
DAS 2.4.9.6
APICom 2.4.9.6
Short Path
GPT
GPTZ
Use these values to enter in appropriate cell:
SP for Short Path
GPT/Z for Gas Phase Titra.

APPENDIX C

NOx Zero/Span/Precision worksheet Data input and handling

This worksheet shows where to enter the copied and downloaded data (blue). Those values will automatically be populated to the left (yellow). The auto populated data are then to be used to copy them into the correct cells corresponding this the SOP. The Short Path procedure is coded orange, the GPT in green.
Text box numbers correspond to chapter number in SOP.