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NORTH CAROLINA
Environmental Quality

DAQ-08-007.2 Standard Operating Procedure (SOP)

Reactive Oxides of Nitrogen (NO_y) Monitoring System

Operator Responsibilities

Revision 0.0

May 15, 2023

NORTH CAROLINA
Department of Environmental Quality

Contents

SOP Acronym Glossary

ADQ – Audit of data quality
ARM - Envista Air Resources Manager
cc/min – cubic centimeters per minute
CFR – Code of Federal Regulations
Chief – Ambient Monitoring Section Chief
CO – Carbon Monoxide
DAQ – North Carolina Division of Air Quality
DAS – Data acquisition system
° C – Degrees Celsius
DEQ – North Carolina Department of Environmental Quality
Director – Division of Air Quality Director
DIT – North Carolina Department of Information Technology
ECB – Electronics and Calibration Branch
e-log – electronic logbook
EPA – United States Environmental Protection Agency
FEM – Federal equivalent method
FRM – Federal reference method
HOBO – HOBO
IBEAM – Internet-Based Enterprise Application Management
IDL – Instrument detection limit
In-Hg A – inches mercury actual
LED – light emitting diode
LMS – North Carolina Learning Management System
LSASD – Laboratory Services and Applied Science Department
MDL – Method detection limit
mV – millivolts
NAAMS – National Ambient Air Monitoring Strategy
NAAQS – National ambient air quality standards
NC DOT – North Carolina Department of Transportation
NCore – National Core
NIST – National Institute of Standards and Technology
NO – Nitrogen
NO_2– Nitrogen Dioxide
NO_y– Reactive Oxides of Nitrogen
NPAP – National Performance Audit Program
O3 or O_3 - ozone
OAQPS – Office of Air Quality Planning and Standards
Pb - Lead
PC – personal computer
Pdf – portable document format
PFA – Perfluoroalkoxy
PM – Particulate Matter
PMT – photomultiplier tube
ppb – Parts per billion
PPB – Projects and Procedures Branch
ppm – Parts per million
psig – Pounds per square inch gauge
PZS – Precision/zero/span
QA – Quality assurance
QA/QC – Quality assurance/quality control
QAPP – Quality assurance project plan
QC – Quality control
RAMC – Regional Ambient Monitoring Coordinator
RCO – Raleigh Central Office
RRO – Raleigh Regional Office
sccm – standard cubic centimeters per minute
SO_2 – Sulfur Dioxide
SOP – Standard Operating procedure
TSA – Technical systems audit
VIP – Valuing individual performance
ZPS – precision, zero, span
Main Menu Key (Monitor and Calibrator)
↵ Enter Key (Monitor and Calibrator)
▶ Run Key

1.0 Approval Sign-Off Sheet

I certify that I have read and approve the contents of the Reactive Oxides of Nitrogen (NO_y) Monitoring System, Section II, Standard Operating Procedure, Operator Responsibilities with an effective date of May 15, 2023.

Director, Air Quality Division
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This document, and any revisions hereto, is intended solely as a reference to assist operators in the setup, calibration, operation, and the collection of data related to the North Carolina Division of Air Quality's Ambient Monitoring Program. This document is intended as a supplement to, and not a substitute for, the education, training and experience required for the efficient operation of ambient air quality monitoring equipment and the collection of scientifically valid data, if an event affecting reactive oxides of nitrogen (NO_y) monitoring is outside the purview of this SOP, contact the Electronics and Calibration Branch and the Raleigh Central Office for guidance.

2.0 Scope and Purpose

The goals of the United States Environmental Protection Agency (EPA) National Ambient Air Monitoring Strategy (NAAMS) include improvement of scientific and technical competency of the nation's air monitoring networks and increased value in protecting public health and the environment. Monitoring data are used to characterize air quality and associated health and eco-system impacts, develop emissions strategies to reduce impacts, and account for progress over time. In that regard substantial improvements in ambient air quality have been achieved over the last three decades and as a result ambient concentrations of several of the criteria pollutants (such as Pb, CO, SO_2, NO_2, etc.) are now well below the applicable National Ambient Air Quality Standards (NAAQS).

While the obvious problems of widespread elevated concentrations have been largely solved for some of the criteria pollutants, problems related to particulate matter (PM), ozone (O_3) and toxic air pollutants still remain. Further it now has become clear that even very low air pollution levels can be associated with adverse environmental and human health effects. As a result, new approaches in air monitoring are required to measure these low levels and to incorporate these measurements with other related data into compressive assessments of human and environmental health.

One of the major areas of investment in the NAAMS is the use of highly sensitive commercial air pollutant monitors for the characterization of the precursor gases such as CO, SO_2 and total reactive oxides of nitrogen (NO_y) in the National Core (NCore) monitoring network. These high sensitivity monitors (such as CO, SO_2 and NO_y) are fundamentally the same as those designated as Federal Reference and Equivalent methods, but with modifications to improve sensitivity and accuracy and reduce interferences. The use of such precursor gas analyzers in the NCore network will not only allow determination of compliance with the NAAQS but will also provide measurements at much lower detection limits than achievable by current monitors. This capability of more accurate measurements at low concentrations will also support long-term epidemiological studies, reduce uncertainties in data for modeling of air pollution episodes, and support source apportionment and observational analysis.

NCore is both a repackaging and an enhancement of existing networks with emphasis on the term "Core" reflect a multi-faceted national network that can be complemented by more specific efforts, such as intensive field campaigns to understand atmospheric processes, or personal and indoor measurements to assess human exposure effects.

The precursor gases CO, SO_2 and NO_y play an important role in the formation of atmospheric ozone, air toxics and particulate matter on both local and regional scales. Measurements of ambient nitrogen oxides differ from measurement of CO and SO_2 in that the target air pollutant is not a single chemical but a group of chemicals of different properties. Nitrogen oxides released from emission sources are primarily nitric oxide (NO) with lesser amounts of nitrogen dioxide (NO_2), which collectively are termed as NO_x (i.e., $NO_x = NO + NO_2$). These primary emitted species are converted by atmospheric processes to numerous other inorganic and organic nitrogen oxides, which are collectively called NO_z. The total of all reactive gaseous nitrogen species present in ambient air is called NO_y (i.e., $NO_y = NOx + NO_z$)

The objectives of this document are to establish and deploy common site operations and instrument calibration procedures for the generation of quality NO_y data that may be compared and if needed, further extrapolated. Therefore, it is critical that the Site Operator follows the procedures as detailed in this SOP. Technical assistance is also available from the Electronics and Calibration Branch (ECB) technicians.

All original records (electronic logbook, site logbook, etc.) must be legible, complete, dated and signed or initialed by the operator and retained as a part of the permanent analyzer record. This includes both the electronic logbook (e-log) and the site logbook. The operator's name and /or initials presented on the e-log will certify that the activities indicated have been performed in accordance with this Standard Operating Procedure (SOP) and that the information contained on the form is accurate (see Appendix C for an example of an e-log). All records will be reviewed and verified by the Regional Ambient Monitoring Coordinator (RAMC) and audited by the responsible chemist at the North Carolina Division of Air Quality (DAQ) Raleigh Central Office (RCO).

3.0 Equipment Checks

In general, the NO_y analyzer system consists of the following components:

Pneumatic System: this portion of the analyzer consists of a sample inlet incorporating a heated converter, sample inlet line, particulate matter filter, gas phase titration calibration unit, ozone generator, pre-reactor, flow meter, and pump, all used to bring ambient air samples to the analyzer inlet.

Analytical System: This portion of the analyzer consists of the reaction chamber, photomultiplier, and bandpass filters.

Electronic Hardware: This portion of the analyzer consists of the electronic components that control the analyzer and process the signals.

The significant instrumentation and equipment at each DAQ NO_y monitoring site includes:

- Thermo Electron TEI Model 42*i* NO_y Analyzer
- Thermo Electon TEI Model 146*i* Gas Calibrator
- Teledyne Model 701 Zero Air Generator
- External Molybdenum Converter
- By-Pass Pump with Flowmeters
- Chamber (Vacuum/Sample) Pump
- Certified Protocol Nitric Oxide "NO" Gas Cylinder
- Data Management System (e.g., Envidas/Envista)
- Ethernet / Modem connectivity01
- Dedicated Windows compatible site personal computer (PC)

Also included are HOBO back-up temperature sensors (shelter temperature), air conditioners, heaters, and other minor components not specified.

3.1 Thermo Environmental Model 42*i* NO_y Analyzer Operational Check

Verify and record the (e-log, Logbook Tab) the 42*i*-instrument settings using the Main Menu key on the front of the instrument panel to display the list of instrument settings (Table 3.0). See Appendix D for typical installation diagram. Instrument settings should be:

Table 3.0: Thermo 42i Parameters

Parameter	Expected Value
Instrument Range / Concentration Units	200 parts per billion (ppb)
Reactor Chamber Pressure	200 – 450 mm Hg
NO and NO_y Sample Flow	0.75 – 2.0 Liters per minute (LPM)
PMT Cooler Temperature	-1 degrees Celsius (° C) to -20 ° C
External (EXT) Converter Temperature	300 – 350 ° C
Reaction Chamber Temperature	48 – 52 ° C
Alarm? (Y/N)	

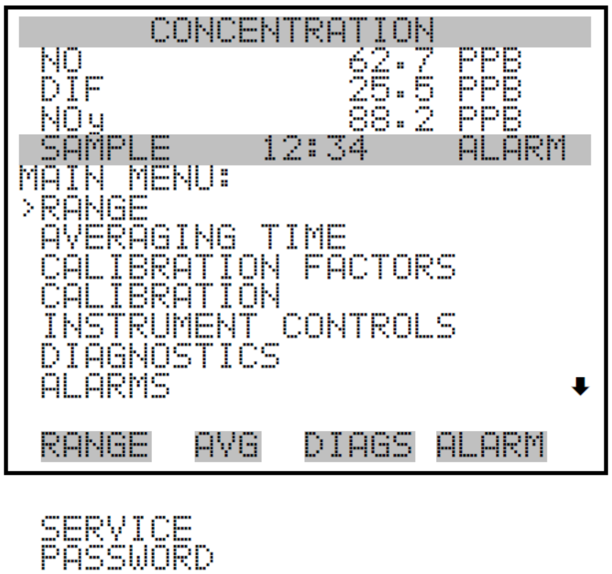


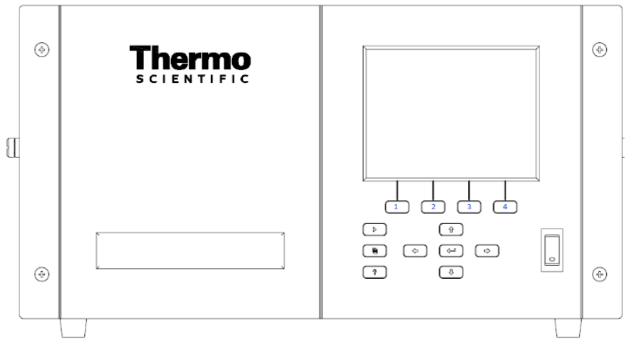
Figure 3.0: Main Menu Instrument Parameters Sub-Menu

3.2 THERMO 146*i* Dynamic Gas Calibrator Operational Check

The most common and/or serious instrument failures will result in a warning message being displayed on the front panel of the instrument.

Using the front panel or Run Screen of the instrument:

1. Press MENU and verify the calibrator is in the "REMOTE" mode, if not Press "STBY"
2. Check for "ALARM ON" presence using the ↑ or ↓ menu pushbuttons to display the **Alarm Submenus**, then press ↵
3. Use the ↑ or ↓ to select the parameter that is in Alarm Status
4. Determine the cause of the alarm. Consult with ECB if needed to discuss any alarm displayed.
5. Press MENU twice to return to the main menu screen or press the ▶ key
6. Verify the correct cylinder concentration has been entered into the calibrator by pressing MENU Gas Set-Up then scroll to display GASA – NOT, then press ↵ to confirm the cylinder concentration entered.



1 = OPERATION
2 = MODE
3 = DIAGNOSTICS
4 = ALARM
MENU Option Key
↵ Enter Key

Figure 3.1: THERMO 146i Main Screen

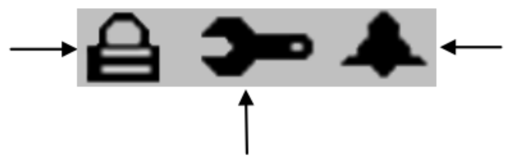


Figure 3.2: THERMO 146i Status Bar Icons

Verify that the calibrator certification is in date and document the expiration date in the e-log, Logbook Tab. Calibrator certification is valid for twelve months (365 days) and the certification and/or expiration date(s) should be indicated on a label located on the front panel of the instrument.

3.3 Calibration Gas Cylinder Check

Calibration gas cylinders of approximately 27.0 ppm NO are certified for three years from the original date of the manufacturer's certification. Verify that the calibration gas cylinder has not expired and document the expiration date in the e-log, Logbook Tab. If the calibration gas cylinder pressure is less than 500 psig, the ECB should be notified that a new cylinder is required. The delivery of a new gas calibration gas cylinder must be coordinated with the Region.

NOTE:. *The cylinder concentration value entered on the e-log and displayed on the calibrator panel should be the full precision concentration as stated on the "NO" calibration cylinder (i.e., 27.04 parts per million, or ppm).*

3.4 Model 701 Zero Air Generator Check

Verify that the delivery pressure is set to 30 ± 2 psig. If the delivery pressure is outside of the ± 2 psig range, adjust the regulator outlet pressure with the pressure adjustment knob (this is most accurately done while span gas is flowing). Document in the e-log, Logbook Tab. As the expiration date of the Model 701 Zero Air Generator approaches, contact the ECB to arrange for a Zero Air Generator that has been serviced (i.e., charged with fresh chemicals).

3.5 Site Visits and Checks

Operators are to visit the site at least once every 14 days. Upon arrival at the site, observe the outside of the shelter and the probe inlet, looking for vandalism or security breaches. Verify that the probe inlet and screen are in place and that the sample line is not blocked by insects or other debris. Document all observations and actions in the e-log, Logbook Tab.

If there is evidence of vandalism the operator should contact the local law enforcement department (generally this is the city police department if the monitor is within city limits or the County Sheriff's department if outside city limits) as well as the RAMC, the RCO and the ECB of DAQ. Unauthorized persons on the monitoring site should not be confronted by the site operator and the police should be contacted.

3.6 Shelter Temperature

The shelter temperature sensor (Comet Temperature Probe connected to the Site Computer and reported via Envidas Ultimate) must be compared to a National Institute of Standards and Technology (NIST) traceable thermometer, likewise the back-up temperature logger (HOBO) must be compared to the NIST traceable thermometer. If the NIST traceable thermometer was brought to the site, allow sufficient time for the reading to stabilize. The NIST traceable thermometer should be co-located with the Comet and the HOBO temperature data logger (backup).

Observe and record the internal temperature of the building in °C displayed by the Comet Temperature Probe and the HOBO. Compare each to the NIST traceable thermometer and record the values of all three in the e-log. If the shelter temperature sensor is reading greater than ± 2° C of the reference, contact ECB.

The site thermostat should be adjusted as needed to maintain the shelter temperature within the 20 to 30° C range. If the temperature cannot be stabilized and controlled within this range, notify the RAMC and the ECB that corrective action is required. Document in the e-log, Logbook Tab.

NOTE: Any data collected / reported must be invalidated when the temperature is out of the 20 - 30° C range.

3.7 HOBO Temperature Data

The HOBO temperature data will need to be exported at least once every 30 days from the logger; refer to RCO Guidance Documents under the Documents section on DAQ's Ambient Monitoring SharePoint page for instructions. The exported temperature data file name should include specific naming parameters such as site, parameter, and date. For example, "MQ 20220601to15 ST" would be Millbrook shelter temperature between 01 Jun and 15 Jun 2022.

The exported data are considered site files and kept in accordance with section 8.0 Quality Assurance & Data Handling of this SOP. HOBO temperature data may be imported to Envista Air Resources Manager (ARM) when needed as a backup; refer to RCO Guidance Documents under the Documents section on DAQ's Ambient Monitoring SharePoint page for instructions.

3.8 Electrical Power and Sample Line Check

Observe the analyzer, calibrator, computer, and data logger for indications of a power failure and if needed, correct the cause. If the analyzer or calibrator lost power, allow an equilibration period of at least 60 minutes for the instruments to stabilize after being powered up.

Visually inspect the tower and cable where the Molybdenum converter is located, checking for proper height (10 meters) of the converter box and for wear of the cable and pulleys. Ensure that the shelter air conditioner is not blowing on the sample line, as this can cause condensation to build up in the line. The ECB is required to replace the sample line every two years and will perform a sample line integrity check during their annual audit. (Reference SOP 2.17.1, Section I: ECB Responsibilities for details). Record all events and observations in the e-log, Logbook Tab.

3.9 Time and Date Checks and Adjustments

Record the times from the site computer, analyzer, HOBO temperature data logger and from NIST on the e-log created for the site visit.

The times for the site computer and the analyzer must be set to EASTERN STANDARD TIME (UTC-5h) for North Carolina. Additionally, they must have the same time and be synched to the NIST time. Time Synchronization on the analyzer and site computer is an automated process that occurs once per day and was programmed during Envidas installation on the site computer.

NOTE: The HOBO data logger time is set to the site computer's time whenever the device is launched. Launching is required after the battery replacement and should be performed at least once every 30 days to synch time with the site computer and to export and save the monthly HOBO logger data. Refer to RCO Guidance Documents under the Documents section on DAQ's Ambient Monitoring SharePoint page for instructions.

If the times for either the analyzer, HOBO temperature data logger or site computer are not within one minute of NIST time, call ECB and they will assist with correcting the issue.

Sources for getting NIST time:

- Call the ECB and ask for the NIST time
- Correct time Website: NIST time

3.10 Residence Time Check

During each Calibration, Calibration Verification or One-Point Quality Control Check the residence time of the sample line should be evaluated. Enter the sample flow rate into the e-log as well as the length of the sample line. The sample line length will be measured by ECB and recorded in the site logbook. If the residence time results in a failure in the e-log, download diagnostics from the monitor to determine when the sample flow rate dropped below the minimum sample flow rate requirements, all data must be invalidated back to that date and time. Contact the ECB in the event of a failed residence time check or for assistance in downloading diagnostic data from the monitor.

3.11 Computer Care

At least once every 30 days, the site computer should be restarted. This will ensure that network updates from the North Carolina Department of Information Technology (DIT) take effect without a prolonged interruption of service. Operators should also contact the ECB if the site computer behaves unusually or if a piece of computer equipment needs to be replaced such as a router, PC tower, computer mouse, etc.

NOTE: DIT will have to be contacted if unable to log onto the site computer.

3.12 Teflon (5 Micron) Particulate Filter

The particulate filter must be replaced at a minimum of every 30 days. It is recommended that when the filter is changed, handle the filter and the wetted surface of the filter housing as little as possible. When changing the particulate filter, one should use gloves or tweezers to avoid contamination of the sample filter assembly. The Teflon particulate matter filter should be conditioned after performing a QC check or sooner, if moist or excessively dirty. The procedure for Filter Change and Filter Conditioning are detailed in Section 5.4 of this SOP. Record Filter Change and Filter Conditioning in the e-log, Filter Tab. The Filter Conditioning procedure serves as a leak check.

4.0 Requirements

4.1 Manual Calibration (Section 5.1)

A manual calibration followed by a multi-point verification is required:

- When the monitor is initially installed during the site start-up
- When installation of a replacement monitor occurs
- When the system's operation is interrupted for 72-hours or longer (e.g., extended power outages caused by inclement weather)
- When the monitor undergoes major repairs or maintenance
- When the results of the automated nightly diagnostic Precision-Zero-Span (PZS) falls outside the warning limits for 2 or more consecutive days and results of a manually initiated One-Point Quality Control Check of the monitor are outside the range of acceptable criteria.
- When the Molybdenum Converter box is replaced or repaired
- When the monitor fails a multi-point verification
- Once every 365 days or once a calendar year regardless of monitor performance

A calibration IS NOT required after the replacement of any of the following components:

- ☒ the zero-air generator
- ☒ the calibrator
- ☒ the NO cylinder on site

NOTE: This note is applicable ONLY when the very next automated PZS is shown to be outside the acceptable limits (See Table 5.3). If the automated PZS fails, calibration of the monitor is required. It is imperative that the operator be aware of when components are changed so that the results of the next automated PZS can be reviewed. Therefore, arrangements with the ECB for delivery or replacement should be scheduled in advance. If a new monitor is placed into service at a site, allow for an equilibrium period, preferably overnight, before calibrating. The procedures to calibrate the monitor and perform a multi-point verification and acceptance criteria can be found in Sections 5.1 and 5.2 of this SOP.

4.2 Verification (Section 5.2)

The purpose of a verification is to correlate the output of the monitoring system with known traceable concentrations of NO-NO_2-NO_y to demonstrate the linearity of the monitor's response.

A multi-point verification is required:

- As part of any manual calibration procedure
- Within 182 days of the most recent calibration/verification, regardless of monitor performance.

Table 5.2 details the points run during a multi-point verification and acceptable limits.

4.3 One-Point Quality Control (QC) Check (Section 5.3)

The QC Check is to periodically verify that the monitor's calibration has not drifted out of the optimal range. The 1-Point QC checks are:

- Required at least every 14 days or less (40 CFR Part 58, Appendix A, Section 3.2.1)
- Must include a zero, spans (including titrations) and precision points (including titrations)
- Are reported to AQS (40 CFR Part 58, Appendix A, Section 3.2), specifically the precision point

NOTE: Regardless of which detailed procedure listed above is being completed, the status of the NOT-NO_2T-NO_yT channels should be set using the site computer so that no data is reported during the time the procedure is being completed. *(Refer to "Marking the Channels Up or Down" in the RCO Guidance Documents folder under the Documents section of DAQ's Ambien Monitoring SharePoint page for instructions.)*

Complete the required Equipment and Site Visit Checks (Section 3.0) as specified in this SOP prior to any Calibration / Calibration Verification / 1-Point QC Check.

5.0 Detailed Procedures

5.1 Manual (adjusted) Calibration

A manual (adjusted) calibration consists of

1) setting the **ZERO** using a source of zero air
2) setting the NO/NO_y **SPAN** using calibration gas with a concentration of nominally 80% of the monitor's range (i.e., 180 ppb NO/NO_y)
3) setting the NO_2 DIF concentration (as calculated in e-log IF >5%)
4) performing a multi-point verification

Mark the NOT-NO_2T-NO_yT channels down using Envidas VIEWER icon on the desktop of the site PC; refer to RCO Guidance Documents under the Documents section on DAQ's Ambient Monitoring SharePoint page for instructions. The channels can be marked down for a specific time period to allow for the completion of the manual calibration and multi-point verification if desired.

Using the Calibration Factors menu scroll to display and record the pre-calibration settings for:

- NO BKG
- NOy BKG
- PREREACTOR BKG
- NO COEFFICIENT
- NO_Y COEFFICIENT
- DIF COEFFICIENT

5.1.1 ZERO Calibration

Under the Operational Tab, using the NOTCAL Phase from Sequence menu

1. Select Phase **ZERO**.

2. Change the length of time to 1 hour and select **START**.
3. Using the MAIN MENU of the monitor, choose Calibration. Allow the monitor to sample zero air until NO and NO_y responses stabilize.
4. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow).
5. After the responses have stabilized (approximately 15-20 minutes), from the Main Menu of the monitor, choose Calibration>***CAL Prereactor Bkg*** then press ↵ then press ↵ to set the Prereactor Bkg to **ZERO**.
6. Press [▀▄] to return to the Calibration menu and repeat this procedure to set the NO and NO_y background to **ZERO**.
7. Allow the monitor to stabilize (approximately 15-20 minutes)
8. Using Envidas Reporter record the time and five stable 1-minute **ZERO** responses for NO and NO_y.
9. Abort **ZERO**.

NOTE: The measured zero for NO and NO_y must be less than ± 1.0 ppb.
The Background Correction for NO and NO_y must be less than 15 ppb – optimally less than 5 ppb.

5.1.2 SPAN Calibration

Using the NOTCAL Phase from Sequence menu

1. Select Phase **SPAN**
2. Change the length of time to 4 hours and select **START**.
3. Allow the monitor to sample the NO calibration gas until the NO and NOy readings have stabilized.
4. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow) on e-log to calculate the actual NO and NO_y concentration being generated.
5. When the responses stabilize (approximately 15 minutes), from the Main Menu of the monitor, choose Calibration> ***Cal NO Coefficient*** – the **NO** line of the Calibrate **NO** screen displays the current **NO** concentration. The **SPAN CONC** line of the display is where you enter the NO calibration gas concentration as calculated in the e-log (*Calibration & GPT Tab, cell G12*).
6. Using the ← or →to move the cursor left and right and use the ↑ or ↓ to increment and decrement the numeric character at the cursor.
7. Press ↵ to calculate and save the new **NO** coefficient based on the entered span concentration.
8. Press [▀▄] to return to the Calibration menu and choose ***Cal NO_y Coefficient***.
9. The **NO_y** line of the Calibrate **NO_y** screen displays the current **NO_y** concentration. The **SPAN CONC** line of the display is where you enter the **NO_y** calibration gas concentration as calculated in the e-log (*Calibration & GPT Tab, cell H12*).
10. Using the ← or →to move the cursor left and right and use the ↑ or ↓ to increment and decrement the numeric character at the cursor.
11. Press ↵ to calculate and save the new **NO_y** coefficient based on the entered span concentration.
12. Press ▶ to return to the Run screen.
13. Allow the monitor to stabilize, then using Envidas Reporter, record the time and five stable 1-minute SPAN responses for NO and NO_y.

NOTE: The measured NO and NO_y SPAN values should be within ± 2.0 ppb of the expected value.

NO/NO_y Span Coefficients stored in the monitor should be between 0.900 and 1.100 after adjustment of the span point.

5.1.3 Titration and Calibration of DIF (NO_2)

The following procedure uses gas phase titrations to calibrate the **DIF Coefficient** (NO_2 concentration).

5.1.3.1 GPT Original

1. While the calibrator is still in **SPAN** (180 ppb) and stabilized, from the Main Menu of the 146*i* calibrator, using the **OPER** key
2. Using the ↓ key scroll to OZONE OFF then using → or ← scroll until OZONE MAN or any Ozone channel where the % Ozone drive is set to 0 %, verify the % Ozone is set to 0.00% then press ↵ (Ozone lamp is shut OFF) and the SPAN flow is now going through the ozonator.
3. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow) on the e-log to calculate the actual NO and NO_y concentrations being generated.
4. Allow the monitor to stabilize then using Envidas Reporter, record the time and five 1-minute values for NO and NO_y averages (e-log, Calibration & GPT Tab, Gas Phase Titration Section).

5.1.3.2 GPT Remainder

1. Using the front panel of the calibrator, select OZONE MAN (if not selected previously) then press ↵ to edit the O_3 generator drive to a value that will reduce the NO concentration by approximately 150 ppb. It is recommended to start with the O_3 generator drive set to approximately 18 – 20% and adjust O_3 generator drive as needed, *while still producing the GPT original concentration of NO/NO_y generated in Section 5.1.3.1*. The DIF concentration should not exceed 90% of the $NO_{original}$ concentration.
2. Allow the monitor to stabilize then using Envidas Reporter, record the time and five 1-minute values for NO, NO_2 and NO_y.
3. The e-log will calculate the actual NO_2 concentration and NO_2 Converter Efficiency.

The calculation used to set the NO_2 calibration gas concentration generated by GPT:

$[NO2]_{CA} = [NO]_{ORIG} – [NO]_{REM} = [F_{NO}/(F_{NO} + F_{ZERO})] x [NO_{2IMP}]$

i.e. $[NO_2]CA$ = 180 ppb – 20 ppb + 0.7 ppb = 160.7 ppb

Where: $[NO_2]_{CA}$ = NO_2 concentration produced by the calibrator, ppb
$[NO]_{ORIGINAL}$ = Original NO concentration before titration with the O_3, ppb
$[NO]_{REM}$ = NO concentration after titration with O_3, ppb
$[NO_2]_{IMP}$ = NO2 impurity in cylinder
NO2 impurity in cylinder = NOy – NO values on the cylinder certification sheets
F_{NO} = NO flow rate, sccm
F_{ZERO} = Zero air flow rate, sccm
D = Dilution ration $F_{NO}/(F_{NO} + F_{ZERO})$

Additional information regarding the calculations can be found in Section 4 of the Manual.

NOTE: If the NO_2 calculated *(e-log, Calibration and GPT Tab, cell G35)* **and NO_2 measured** *(e-log, Calibration and GPT Tab, cell H44)* **are within 5%** *(e-log, Calibration and GPT Tab, cell H45)* **then no adjustment of the DIF channel is required.**

4. If the NO2 % DIF is less than 5 % turn OFF Ozone MAN (setting the O_3 generator to 0%)
5. Record the Calibration Factors for:
   - NO BKG
   - NO_y BKG
   - PREACTOR BKG
   - NO COEFFICIENT
   - NO_y COEFFICIENT
   - DIF COEFFICIENT
6. Abort **SPAN**
7. Proceed to the multi-point verification.

Table 5.1: Criteria for Calibration

	ZERO	SPAN (NOT)	SPAN (NO_yT)	SPAN GPT (NO_2T)
Concentration (ppb)	0	180	180	Approximately 150
Calibration Criteria (±)	1 ppb	3 %	3 %	5 % DIF

NOTE: If the NO_2 calculated and the NO_2 measured are > ± 5 %, the DIF *must* be calibrated as follows:

8. While the response is stable, from the Main Menu of the monitor, choose Calibration> ***Cal DIF Coefficient*** – the **DIF** (NO_2) line of the Calibrate DIF screen displays the current DIF concentration. The DIF CONC (NO_2) line of the display is where you enter the DIF (NO_2) gas concentration as calculated in the e-log (*Calibration & GPT Tab, cell G35*).
9. Using the ← or →to move the cursor left and right and right and use the ↑ or ↓ to increment and decrement the numeric character at the cursor.
10. Press ↵ to calculate and save the new DIF (NO_2) coefficient based on the entered span concentration.
11. Press ▶ to return to the Run screen

IF the DIF Coefficient was calibrated – Repeat Section 5.1.3.1 and 5.1.3.2 to confirm the NO2 % DIF is less than 5 % after adjustment and the Converter Efficiency is ≥ 96.0 – 104.1 percent.

12. Turn OFF O_3 generator (Ozone OFF)
13. Record the Calibration Factors for:
    - NO BKG
    - NO_y BKG
    - PREACTOR BKG
    - NO COEFFICIENT
    - NO_y COEFFICIENT
    - DIF COEFFICIENT
14. Abort **SPAN**.

5.2 Multi-Point Verification Procedure

The purpose of the multi-point verification procedure is to “verify or demonstrate” the linearity of the monitor at multiple concentrations. At an operator’s discretion, a multi-point verification can be performed to support weight of evidence.

A multi-point verification is required:

- Immediately after every calibration
- Every 6 months or within 182 days of the most recent calibration

To ensure that the adjustments made in a calibration are successful, each point of the multi-point verification should be checked. The multi-point verification consists of a multi-point sequence that should be run using the following steps:

1. Using Envidas Viewer module on the site computer, Under the “Operational” tab select [Sequence] then choose **NOTVER**.
2. Schedule the sequence to start at “0” minutes and click **START**.
3. The sequence will start at the top of the next minute timepoint. A countdown will appear in the dialog box.

NOTE: NOTVER consists of 5 phases or SPAN points and a purge, created and timed to produce a consistent repeatable result and is used to verify the monitor’s linearity after a calibration or at any other point in time when needed. The run time for the NOTVER sequence is approximately 1 hour and 25 minutes from beginning to end and includes a 5-minute purge.

The NOTVER SPAN points run for the multi-point verification should include:

- SPAN ZERO (0 ppb)
- SPAN (180 ppb NO/NO_y)
- SPAN 2 (100 ppb NO/NO_y)
- SPAN 3 (50 ppb NO/NO_y)
- SPAN 4 (25 ppb NO/NO_y)

4. When the NOTVER is complete, using Envidas Reporter, generate a minute data report that contains:
   - NO and NO_y minute average values during the time period the NOTVER sequence was run.
   - 146i calibrator flows (cubic centimeters per minute or cc/min) – 146i_gflow (gas flow) and 146i_zflow (dilution flow) reported in cubic centimeters per minute or cc/min.
5. Using the values from the minute data report generated, the last five 1-minute average values for each **SPAN** event will be used to complete the Verification worksheet to verify or demonstrate the linearity of the monitor.
6. The values entered int the verification worksheet are linked to the NO and NO_y Regression Tabs where the Point Difference and Percent Difference of best-fit line, slope and intercept are calculated for each.

The multi-point verification is complete when the five span points (including **ZERO**) have been run, and a linear regression calculation using the calculated NO and NO_y concentrations in ppb as ‘X’ verses the monitor responses as 'Y' has been performed. The linear regression line should meet the following specifications:

Table 5.2: Criteria for Multi-point Verification

	ZERO	SPAN	SPAN 2	SPAN 3	SPAN 4
		NO/NO_y	NO/NO_y	NO/NO_y	NO/NO_y
Concentration (ppb)	0	180	100	50	25
Verification Criteria (±)	All points < ± 2.1 % or ≤ ± 1.5 ppb difference of best-fit line, whichever is greater.				

If the linear regression(s) do not meet the acceptance criteria given in Table 5.2, the calibration and multi-point verification are unacceptable. The calibration verification must be re-run to identify and correct any problems. If a second attempt fails, contact the ECB for guidance.

If the multi-point verification is acceptable:

- Verify the monitor is in "Sample" mode and the Calibrator is in "Standby" mode
- Save the appropriate e-logs, graphs and minute data, and include in the e-log.
- Mark the NOT-NO_2T-NO_yT channels back up (Reset Flags to OK) after the completion of the calibration verification; refer to RCO Guidance Documents under the Documents section of DAQ's Ambient Monitoring SharePoint page for instructions if needed.
- Log OFF of Envidas/site computer prior to leaving the site.

5.3 One-Point QC Check (14-Day Check or PZS)

The purpose of the 14-Day check is to correlate the output of a monitoring system with known traceable concentrations of NO, and to periodically confirm that the monitor's calibration has not drifted outside the acceptable range. The EPA refers to calibration checks as "One Point QC Checks" (Reference 40 CFR Part 58, Appendix A, Section 3.2.1) and requires that 1-point QC check be performed at least once every 14-days. As part of a 1-point QC check, perform a precision check and one (1) titration check. Refer to Section 3.0 for equipment checks that need to be completed prior to starting a 1-point QC Check.

Mark the NOT-NO_2T-NO_yT channels down using Envidas VIEWER icon on the desktop of the site PC; refer to RCO Guidance Documents under the Documents section on DAQ's Ambient Monitoring SharePoint page for instructions.

5.3.1 SPAN ZERO (0 ppb)

1. Under the Operation Tab, using the NOTCAL Phase from Sequence menu, select Phase **ZERO,** change the length of time to 1 hour and select **START**
2. Create a Viewer Dynamic Chart to capture the **ZERO** point during the 1-point QC check
3. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow) flows on e-log to calculate the actual NO and NO_y concentrations being generated. Allow the monitor to sample **ZERO** until the NO and NO_y responses stabilize, approximately 15-20 minutes.
4. Using Envidas Reporter, record time and five stable 1-minute NO and NO_y zero air responses (e-log, QC Check & GPT Tab, ZERO Section).
5. Abort **ZERO**

5.3.2 SPAN 1 (36 ppb)

6. Under the Operation Tab, using the NOTCAL Phase from Sequence menu, select Phase **SPAN 1,** change the length of time to 1 hour and select **START**
7. Create a Viewer Dynamic Chart to capture the **SPAN 1** point during the 1-point QC check
8. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow) flows on e-log to calculate the actual NO and NO_y concentrations being generated. Allow the monitor to sample **SPAN 1** until the NO and NOy responses stabilize, approximately 15-20 minutes.
9. Using Envidas Reporter, record the time and five stable 1-minute NO and NOy **SPAN 1** responses for each (e-log, QC Check & GPT Tab, SPAN 1 Section).
10. Abort **SPAN 1**.

5.3.3 SPAN (180 ppb NO/NO_y)

1. Using the "Phase from Sequence" menu, select Phase **SPAN,** change the length of time to 4 hours and select **START.**
2. Create a Viewer Dynamic Chart to capture the **SPAN** point during the 1-point QC check
3. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow) flows on the e-log to calculate the actual NO and NO_y concentrations being generated. Allow the monitor to sample until the NO and NOy responses have stabilized, approximately 15-20 minutes.
4. Using Envidas Reporter record time and five stable 1-minute NO and NO_y **SPAN** responses for each (e-log, QC Check & GPT Tab, SPAN Section).

5.3.4 Titration of DIF (NO_2)

The following procedure uses gas phase titrations to check the **DIF** Coefficient (NO_2T concentration).

5.3.4.1 GPT Original

1. While the calibrator is still in **SPAN** (180 ppb) and stabilized, from the Main Menu of the 146*i* calibrator, press the **OPER** key on the touch screen.
2. Using the ↓ key scroll to OZONE OFF then using → or ← scroll until OZONE MAN or any Ozone channel where the % Ozone drive is set to 0 %, verify, the % Ozone is set to 0.00% then press ↵ (Ozone lamp is shut OFF) and the **SPAN** flow is now going through the ozonator.
3. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow) flows on the e-log to calculate the actual NO and NO_y concentrations being generated.
4. Allow the monitor to stabilize, approximately 15-20 minutes.
5. Using Envidas Reporter, record the time and five 1-minute values for NO and NO_y averages (e-log, QC Check & GPT Tab, Gas Phase Titration Section).

5.3.4.2 GPT Remainder

1. Using the front panel of the calibrator, while still in Ozone MAN (if not previously selected) then press ↵ to edit the O_3 generator drive to a value that will reduce the NO concentration by approximately 150 ppb. It is recommended to start with the O_3 generator set to 18 - 20% and adjust the O_3 generator drive as needed, *while still producing the original concentration of NO/NOy generated in Section 5.3.4.1*. The DIF concentration should not exceed 90% of the $NO_{ORIGINAL}$ concentration.

2. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow) flows on the e-log to calculate the actual NO and NO_y concentrations being generated.
3. Allow the monitor to stabilize, approximately 15-20 minutes.
4. Using Envidas Reporter, record the time and five 1-minute values for NO, NO_2 and NO_y.
5. The e-log will calculate the actual NO_2 concentration and NO_2 Converter Efficiency.

The calculation used to set the NO_2 calibration gas concentration generated by GPT:

$$[NO2]CA = [NO]_{ORIG} – [NO]_{REM} = [F_{NO}/(F_{NO} + F_{ZERO})]x\ [NO_2 IMP]$$

i.e. $[NO_2]CA$ = 180 ppb – 20 ppb + 0.7 ppb = 160.7 ppb

Where: $[NO_2]_{CA}$ = NO_2 concentration at the output manifold, ppb
$[NO]_{ORIGINAL}$ = Original NO concentration before titration with the O3, ppb
$[NO]_{REM}$ = NO concentration after titration with O3, ppb
$[NO_2]_{IMP}$ = NO2 impurity in cylinder
NO2 impurity in cylinder = NOy – NO values on the cylinder certification sheets
F_{NO} = NO flow rate, sccm
F_{ZERO} = Zero air flow rate, sccm
D = Dilution ration $F_{NO}/(F_{NO} + F_{ZERO})$

Additional information regarding the calculations can be found in Section 4 of the Manual.

If the NO_2 % DIF (cell H46) is less than 5 % turn OFF Ozone MAN (setting the O_3 generator to 0%). The values entered into the QC Check and GPT Worksheet tab will automatically populate the NO and NO_y values that will be reported to AQS as well as the converter efficiency of the molybdenum converter. The converter efficiency must be ≥ 96% to be acceptable. It is recommended the converter efficiency values be between 96% - 104.1%.

6. Confirm the NO_2 Converter Efficiency is ≥ 96.0% and less than 104.1%.
7. Abort **SPAN**

NOTE: The measured zero value must be less than ± 1.0 ppb.
The measured span values must be within 10% of the expected target concentrations.
The measured Precision point values must be within 10% of the expected target concentrations.

If any of the points are outside the 1-point QC check tolerance for the full-scale range, the QC check is unacceptable. If the QC check is unacceptable after two (2) attempts, contact ECB and/or conduct the required manual calibration followed by a verification.

Table 5.3: Criteria for 1-Point QC Check (PZS)

	Zero	Span (NO/NO_y)	Precision (NO/NOy)	Gas Phase Titration (NO_2)
Concentration (ppb)	0 ppb	180 ppb	36 ppb	Approximately 150 ppb
Warning Limit (±)	1.0 ppb	>10.1 % (% Diff)	>10.1 % (% Diff)	NO_2 % DIF <5 %
Control Limit (±)	≤ ± 1.0 ppb	<15 % (% Diff)	<15 % (% Diff)	Converter Efficiency ≥ 96.0 – 104.1 %

NOTE: The NO and NO_y Calibrator Calculated values in the e-log *(QC Check & GPT Tab, Cells G13 and H13, respectively)* during the Precision Point (SPAN 1) are reported as the Actual/Standard values to AQS using the AQ98 form. The NO and NOy values during the Precision check *(QC Check & GPT Tab, Cells G23 and H23, respectively)* are reported as the Indicated/Monitor values to AQS using the AQ98 form.

1. Change the Filter and Perform a Filter Conditioning (Leak Check) (See Section 5.4)
2. Mark the NOT-NO_2T-NO_yT channels back up after the completion of the 1-point QC check and filter change; refer to RCO Guidance Documents under the Documents section of DAQ's Ambient Monitoring SharePoint page for instructions.

Do not mark the channel up until the filter change and filter conditioning have been completed. If the channel was marked down using the "Force Status Time" option, the channels will return to "OK" status once the countdown is complete.

5.4 Filter Change and Leak Check Procedure

The particulate filter should be changed every 30 days or less. When the filter (5 µm PTFE Membrane 47 mm) is changed, handle it and the wetted surfaces of the filter housing as little as possible. It is recommended using gloves or tweezers to avoid contamination of the sample filter.

5.4.1 Filter Change and Filter Conditioning

1. Using filter wrenches provided by ECB, unscrew the filter holder.
2. Replace the old filter with a new one (provided by ECB).

5.4.1.1 Filter Conditioning and Leak Check SPAN ZERO

1. Under the Operation Tab, using the NOTCAL Phase from Sequence menu, select Phase **ZERO,** change the length of time to 25 minutes and select **START**
2. Create a Viewer Dynamic Chart to capture the **ZERO** point during the filter conditioning.
3. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow) flows on e-log to calculate the actual NO and NO_y concentrations being generated. Allow the monitor to sample **ZERO** until the NO and NO_y responses stabilize, approximately 15 minutes.
4. Using Envidas Reporter, record time and five stable 1-minute NO and NO_y **ZERO** responses in the e-log (Filter Tab)
5. ZERO values must be ± 2.0 ppb of the calculated zero value.
6. Abort **ZERO**

5.4.1.1 Filter Conditioning and Leak Check SPAN

7. Using the "Phase from Sequence" menu, select Phase **SPAN,** change the length of time to 25 minutes and select **START.**
8. Create a Viewer Dynamic Chart to capture the **SPAN** point during the filter conditioning.
9. Record the 146i_gflow (calibration gas flow) and 146i_zflow (dilution flow) flows on the on the e-log to calculate the actual NO and NO_y concentrations being generated. Allow the monitor to sample until the NO and NOy responses have stabilized, approximately 15 minutes.
10. Using Envidas Reporter, record time and five stable 1-minute NO and NO_y **SPAN** responses in the e-log (Filter Tab)
11. **SPAN** values must be ± 6% of the calculated SPAN value.

12. Abort **SPAN**

If both the **ZERO** and the **SPAN** pass the acceptance criteria the filter conditioning and leak check is considered a PASS. If the Filter Conditioning/Leak Check is acceptable:

- Verify the monitor is in "Sample" mode and the Calibrator is in "Standby" mode
- Save the appropriate e-logs, graphs and minute data, and include them in the e-log.
- Mark the NOT-NO_2T-NO_yT channels back up (Reset Flags to OK); refer to RCO Guidance Documents under the Documents section of DAQ's Ambient Monitoring SharePoint page for instructions if needed.
- Log OFF of Envidas/site computer prior to leaving the site.

6.0 Logbook Submittal and Data Retrieval

6.1 Logbook Submittal

The NOT-NO_2T-NO_yT e-log or electronic logbook, serves as the transfer record and document for evaluation of the success or failure of the operation of the NOT-NO_2T-NO_yT monitoring site and is the essential record for determining the quality of the NOT-NO_2T-NO_yT data reported from each site.

The **Site Operator** must complete the NOT-NO_2T-NO_yT e-log to document the purpose of every site visit, the observations and findings during the site visit, and the evaluation of the performance of the NOT-NO_2T-NO_yT monitoring system for each site visit. This includes any and all startups and shutdowns (including severe weather events, temperature extremes, and etc.).

The site operator must submit the NOT-NO_2T-NO_yT e-log to the Regional Ambient Monitoring Coordinator (RAMC) or designee for review and comment as soon as possible after the site visit and at a minimum by the end of each month. Additionally, a site logbook page should be annotated with any site visit (i.e., shutting down for approaching weather, start-ups, and shutdowns, and etc.) Each site visit should provide an e-log and an entry in the site logbook stating at a minimum, a purpose for the visit.

The **RAMC**, or designee must review site operator monthly submitted NOT-NO_2T-NO_yT e-logs for each site in their region and evaluate each e-log for completeness and operator adherence to operating procedures. Following the review, the **RAMC** must initial and submit each NOT-NO_2T-NO_yT logbook to the RCO chemist for review.

The **RCO Chemist** must review the logbooks submitted for completeness and adherence to operating procedures.

6.2 Data Retrieval and End Processing

Every business day, the RCO statistician initiated a data review for the previous day by providing a raw data report (in spreadsheet format) to each Regional Office (Reference DAQ-15-005.5 Data Verification and Validation for Continuous Gaseous Monitors, Revision 2.0, May 1, 2022). The RCO chemist may request the site operator to send additional data that is needed beyond what the RCO requires for verifying any missing data supplied by the site operator or regional office. This data can be retrieved from the "site monitor"; reference RCO Guidance Document under the Documents section on DAQ's Ambient Monitoring SharePoint page for instructions.

7.0 File Management

Site operators must have a PC (or laptop) to generate the e-log files from a Microsoft Excel template file. These e-logs are provided by the RCO and updated periodically. The file naming protocol is provided below. A formalized file naming convention has been established through consensus of the regions and the RCO and should be used for all e-logs.

7.1 Opening, Naming and Storing the Site Files

The e-log template file used at the site should be stored on the PC used for field operations by the field technicians (see Appendix C for an example of the e-log). E-logs can also be found in Laserfiche. To access this file, open the e-log template file using Excel. Every time a new e-log is filled out using the template it must be renamed and saved as a separate and complete workbook (all sheets or tabs) to preserve the record. *Do not* copy over a previously completed e-log.

NOTE: Refer to the logbook file naming convention "Policy Memorandum" dated January 1, 2011, located in the Laserfiche Ambient Monitoring module (summarized below).

Renaming and saving the e-log
1. Open the e-log workbook template file using Excel
2. Left click the "file" toolbar icon. Scroll down to "Save As" and left click
3. Under file name (highlighted) change workbook file name using the format: Site ID NOT-NO_2T-NO_yT Date Activity. For example, MQ NOY 20230116 AX.xls is a site visit at Millbrook on January 16, 2023
4. Change save location to operator's choice of folders
5. Left click "Save"
6. Find the tab needed for the task(s) involved. The first tab should be the Logbook tab. Fill in information as indicated.

8.0 Quality Assurance & Data Handling

All site files, e-logs or other supporting documents generated in the field will be stored on dedicated server space in the RO in a folder name for the official site operation files. These files should be transferred to the official file on a frequent and regular schedule as established by the RO. This is necessary to prevent the potential loss of such files from the field computer and to maintain a "paper trail" for providing defensible data. This also makes the data easily and readily available for review by the RAMC and transfer to the RCO group drive for review by the RCO. The files on the site or operator PC can be copied and transferred to the common hard drive via email or flash drive for storage in the official file folder.

The site files should be transferred every three business days and backed up monthly. This serves as a backup system in the event the official PC fails or is removed, or the site files are damaged. These files will be retained for a minimum of five years. When the need arises to review a file for data verification or site operations, the official folder is used, or a hardcopy is created from this file. For detail on data validation procedures, please reference DAQ-15-005.5 Data Verification and Validation for Continuous Gaseous Monitors, Revision 2.0, May 1, 2022). The following verification checks shall be completed every month:

- Providing proper null codes indicating calibrations, audits, etc.
- Providing missing valid data

- Documenting any invalid data as to reason with proper null code
- Identifying any data that may be associated with exceptional events

8.1 NOT-NO_2T-NO_yT Monthly Data Verification

Preliminary verification is completed by the site operator. The operator must account for and identify the reasons for missing or invalid data within Envista using proper flags and null codes while performing maintenance or shortly thereafter. The operator must review the previous month of data and add any flags or void codes to the status column as necessary. For each changed status, a comment must be entered with a description of why the status was changed.

The RAMC will perform the second level review of the month of data, adding any additional void codes and comments, and requesting additional information from the operator as necessary. If required, the RAMC can send data back to the site operator for additional comments or to correct any codes. When possible, the data will be validated within 20 calendar days from the end of the collection month.

The RCO chemist performs the final validation of the one-month period of data. Void codes and comments should all be added, and the RCO chemist can send the data back to the previous reviewer. Final validation of the data should be completed withing 40 calendar days of the end of the collection month. Once the data have been approved and have had the "final validation" label applied by the RCO chemist, they are automatically entered into a queue within Envista ARM. The database manager will send all approved data to AQS automatically on a regularly scheduled basis.

In some cases, "valid" data that are judged to be out of the ordinary are retained and an informational flag is added in AQS by the RCO. An example would be high concentration values resulting from an exceptional event. EPA has recently begun applying stricter standards for what it will accept as an exceptional event. In any case, where the site operator or regional office wishes data to be considered "exceptional," sufficient documentation to support the claim in accordance with a policy memorandum from the RCO dated June 29, 2007 should be submitted. Unusually high concentration values that may be the result of an exceptional event must be flagged in AQS by the RCO using the appropriate informational qualifier code. The fully validated file of data is then uploaded into AQS by the RCO.

A list of Null Codes that are routinely used during data verification on the AQS monthly summary report are listed in the following table.

Code	Meaning
AE	Shelter Temperature outside Limits
AN	Machine or Equipment Malfunction
AS	Poor Quality Assurance Results
AT	Calibration
AV	Power Failure
AZ	QC (ECB) Audit
BA	Maintenance and Routine Repairs (including filter change
BB	Unable to Reach Site
BC	Multi-point Calibration
BD	Auto Calibration
BF	Precision/Zero/Span

BJ	Operator Error
BK	Site Computer/ Data Logger Down
SA	Storm Approaching
QV	Multi-point Verification

9.0 Troubleshooting and Corrective Actions

Alarm	**Corrective Action**
Internal Temp	Check Fan Filter and operation, or clean fan foam filter
High Pressure Indicated:	Call ECB and request the pump and diaphragm and capillaries be checked or replaced.
External Conv. Temp	Check converter temp set point, call ECB
Ozonator Flow Low	Request ECB check ozone capillary for blockage
Monitor/Calibrator does not respond to any Phase Activation using Envidas Software	Check that Service Mode is OFF
Data Loss	Check all electrical connections, plugs, Uninterrupted Power Supplies (UPS), and confirm channels are reset
Zero or Span won't stabilize	Perform a leak test, check flow and pressure readings – Contact ECB
Poor Linearity	Verify Calibrator accuracy with an independent flow meter
Flow meter fluctuations	Check Teflon lines for clogs and request ECB check capillaries for blockages

10.0 Revision History

1. Complete revision of SOP 2.38.2 R5.5 – all sections and procedures.

11.0 References

1. Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, Part 1, Ambient Air Quality Monitoring Program, EPA-454/B-17-001, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Quality Assessment Division, Research Triangle Park, NC 27711. Link
2. Code of Federal Regulation: "Title 40: Protection of the Environment", U.S. Government, June 5, 2019. Link
3. QA Handbook Appendix D Validation Templates, U.S. Environmental Protection Agency, March 2017. Link
4. DAQ-15-005.5 Data Validation for Continuous Gaseous Monitors and Meteorological Data, Raleigh Central Office Responsibilities, Revision 2.0, May 1, 2022. Link
5. Envidas Ultimate, Continuous Emission, Air and Water Quality Monitoring System, Revision 1.3.17, March 2017 Link
6. Thermo Model 42*i* NOy Instruction Manual, Chemiluminescence NO-DIF-NOy Analyzer (Part Number 102975-00) 27 Sep 2016 Link

7. Thermo Addendum *i*Series Instruments (Part Number 104633-00) 25 Oct 2022 Link

12.0 Appendices

Appendix A: Envidas Phase from Sequence Settings
Appendix B: Common Continuous Monitoring Principles Applicable to the System
Appendix C: Example of e-log
Appendix D: Instrument Diagrams and Display Screens
Appendix E: Flow Chart of Menu-Driven Software
Appendix F: Glossary of Terms
Appendix G: Guidance for Useful Logbook Documentation

Appendix A: Envidas Phase from Sequence Settings during Verification

NOTVER Sequence Phase	Calibrator SPAN	Concentration NO/NOy (ppb)	Minutes to Complete
ZERO	ZERO	0	15
SPAN	Span 1	180	20
SPAN 2	Span 2	100	15
SPAN 3	Span 5	50	15
SPAN 4	Span 4	25	15

Appendix B: Common Continuous Monitoring Principles Applicable to the System

Calibration is required:

- At the initial start-up of a new site;
- When the monitor itself is replaced or undergoes major repairs;
- When the Molybdenum converter box is repaired or replaced;
- When the results of two valid PZS results exceed the warning limits;
- When the operation of the monitor is interrupted for more than 3 days without power (such as in the case with hurricanes or shelter repairs);
- Once every 365 days or once a calendar year regardless of monitor performance; and
- If a Multi-Point Verification fails.

A **Multi-Point Verification** is required:

- As part of any manual calibration procedure
- Within 182 days of the most recent calibration / calibration verification (regardless of monitor performance) per EPA guidance. See Section 5.2 of this SOP for details.

One-Point QC Check is required:

- Once every 14-days or less
- As a final check when a site is shutdown
- As a check after the operation is restored following a power outage lasting for 3 days or less.

The site Operator can, at his/her discretion, perform a manual performance check, multi-point verification, or calibration at any time he/she feels it is necessary to endure the collection of quality data.

The clock times of the components at the site are to be verified, and if necessary corrected, during each site visit.

During each site visit, the site is to be inspected for general maintenance issues such as condition of the shelter and sample lines as well as the residence time.

Operators are to visit the site once every 14 days

Residence time should be checked during each QC check, calibration verification or calibration.

Appendix C: Example of e-log

Example of Instructions Tab

NO_yT Logbook

DAQ -08-007.2 Rev 0.0 (01 May 2023)

1) This e-log is to be used for TEI 42i-Y NOy monitors

2) Information on "Log Book" Tab is linked to subsequent Tabs throught the workbook as needed.

3) CAL gas and DIL gas flows are obtained from the calibrator or DAS as LPM during manual checks and multi-point verifications. Actual calibrator values (ppb) should be recorded during any Calibration, Verification or Check for each corresponding minute value.

4) Cells containing formulas are locked

5) All cells requiring manual entry of information are

6) Back-up records after every site visit. Download from your laptop to a flash drive, a CD, the network or whatever is most relilable for you or your region. Let your supervisor/regional chemist know your method of back-up.

7) Prepare a NEW e-log for each visit and save with site identifier, pollutant identifier, date and activity.
(e.g. MQ NOY YYYYMMDD BC) Codes: BC Multi-Point Calibration
AX Precision/Zero/Span
QV Quality Control Multi-point Verification
BA Maintenance/Routine Repairs

8) Comments section of e-log should contain information detailing the following: Purpose, Appearance, Actions, Results and Response. Include any observed irregularities of the instruments / equipment as well as the site in general.

NOTES/COMMENTS:

Example of Logbook Tab

NO_yT Logbook

DAQ -08-007.2 Rev. 0.0 (01 May 2023)

Site: Time: Date: Operator:

Channel Down: Channel Up: ***Log Off Site Computer?***

Routine Site Inspection

Building Secure (Y/N)
Sampling Probe Intact (Y/N)
Building Power On (Y/N)
HoBo Battery > 1 bar?
Hobo Temperature Downloaded:
Date Range:

Building Temperature °c

NIST Thermometer Serial No: 47
Expiration Date: 03/14/24
NIST: (± 2 °C of NIST?)
Comet: *OK*
OK

Site Computer Restarted this Month?

Computer / Monitor Time

	Date (mm/dd/yy)	Time (hh:mm)
NIST:		
Analyzer:		
Site Computer:		

All must be within ± 1 min. of NIST)

Cylinder Number (>500 psig)
NO Cylinder Concentration (ppm)
NO_2 Impurity (ppm)
Cylinder Expiration Date
Cylinder Delivery Pressure (psig):
Cylinder Pressure (psig):
Days Remaining 0

TEI 146*i* Calibrator Serial No. / ID
Exp.Date
Internal Temp. (18.5 to 47°C)
Days Remaining 0
Alarms? (Y/N)

Teledyne 701 Zero Air Serial No. / ID
Delivery Air Pressure (psig):
Expiration Date:
Days Remaining 0

TEI Model 482i-Y NO-Diff-NOy Analyzer Serial No. / ID
Scale 200 ppm? (Y/N)
Alarms (Y/N)
Cooler (PMT) TMP °C
Reaction Chamber TMP °C

Average Sample Flow (lpm) 0
NO By-Pass Pump Rotameter (lpm)
NO_Y By-Pass Pump Rotameter (lpm)
Chamber Pressure 200 - 450 mm Hg

Analyzer Filter: Date Changed
Cooling Fan Filter Cleaned
EXT Converter

Sample Flow and Sample Line Residence Time Evaluation

Sample Line Length (meters)
(See site logbook for most recent sample line length)
Sample Line Residence Time (sec) #DIV/0!
Sample Line Residence Time (≤ 20 Sec) #DIV/0!

Operator Comments / Notes

Level 1 Signoff: Date:

Regional Chemist Comments

Level 2 Signoff: Date:

Central Office Chemist Comments

Level 2 Signoff: Date:

Example of QC Check and GPT Tab

NO_yT Manual Check

DAQ -08-007.2 Rev 0.0 (01 May 2023)

Site:	0	Time:	0:00	Date:	01/00/00	Operator:	0

NO Cylinder Concentration (ppm)	0.00
NO_2 Impurity (ppm)	0.00
NO_x Cylinder Concentration (ppm)	0.00

SPAN	(ppb)	146*i*_gflow	146*i*_zflow
ZERO	0		
SPAN 1	36		
SPAN	180		

SPAN ZERO	Calibrator NO (Calculated)	Calibrator NO_y (Calculated)
0 ppb	#DIV/0!	#DIV/0!

SPAN 1	Calibrator NO (Calculated)	Calibrator NO_y (Calculated)
36 ppb	#DIV/0!	#DIV/0!

SPAN	Calibrator NO (Calculated)	Calibrator NO_y (Calculated)
180 ppb	#DIV/0!	#DIV/0!

SPAN ZERO Time HH:mm	Analyzer NO	Analyzer NO_y
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
(warning limit)	[diff ± 1.0 ppb]	
Acceptable:	**#DIV/0!**	**#DIV/0!**

SPAN 1 Time HH:mm	Analyzer NO	Analyzer NO_y
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
% Diff	**#DIV/0!**	**#DIV/0!**
(warning limit)	[diff ± 10 %]	
Acceptable:	**#DIV/0!**	**#DIV/0!**

SPAN Time HH:mm	Analyzer NO	Analyzer NO_y
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
% Diff	**#DIV/0!**	**#DIV/0!**
(warning limit)	[diff ± 10 %]	
	#DIV/0!	**#DIV/0!**

Gas Phase Titration

SPAN	(ppb)	146*i*_gflow	146*i*_zflow
Originanl	180		
Remainder	180		

Original	NO	NO_y
180 ppb	#DIV/0!	#DIV/0!

Remainder O_3 Level	NO_2 (ppb) (Calculated)	NO_2 (ppb) (Converted)	NO_2 Converter Efficiency
	#DIV/0!	#DIV/0!	#DIV/0!

Original Time HH:mm	Analyzer NO	Analyzer NO_y
Avg ppb	#DIV/0!	#DIV/0!
% Diff	#DIV/0!	#DIV/0!

SPAN Time HH:mm	Analyzer NOT	Analyzer NO_2	Analyzer NO_y
Avg ppb	#DIV/0!	#DIV/0!	#DIV/0!
NO2 % DIF		**#DIV/0!**	

NO_2 % DIF Acceptable:	#DIV/0!	NO_2 % DIF Required:	< 5%

Comments:

Example of Minute Data Tab

NO_yT Minute Data										
DAQ -08-007.2 Rev 0.0 (01 May 2023)										

Example of Graphs Tab

NO_yT Graphs

DAQ -08-007.2 Rev 0.0 (01 May 2023)

Example of Filter Tab

Filter Conditioning

DAQ -08-007.2 Rev 0.0 (01 May 2023)

Site:	0	Time:	0:00	Date:	01/00/00	Operator:	0

NO Cylinder Concentration (ppm)	27.60
NO_2 Impurity (ppm)	0.20
NO_x Cylinder Concentration (ppm)	27.80

SPAN	(ppb)	CAL Gas	DIL Gas
ZERO	0		
SPAN	180		

SPAN ZERO	Calibrator NO (Calculated)	Calibrator NOy (Calculated)
0 ppb	#DIV/0!	#DIV/0!

SPAN 2 Time HH:mm	Analyzer NO	Analyzer NOy
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
	[diff ± 2.0 ppb]	
Acceptable:	**#DIV/0!**	**#DIV/0!**

SPAN	Calibrator NO (Calculated)	Calibrator NOy (Calculated)
180 ppb	#DIV/0!	#DIV/0!

SPAN Time HH:mm	Analyzer NO	Analyzer NOy
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
% Diff	**#DIV/0!**	**#DIV/0!**
(warning limit)	[diff ± 6 %]	
Acceptable:	**#DIV/0!**	**#DIV/0!**

Comments:

Example of Calibration and GPT Tab

NO_yT Calibration & GPT

DAQ -08-007.2 Rev 0.0 (01 May 2023)

Site: 0 | Time: 0:00 | Date: 01/00/00 | Operator: 0

NO Cylinder Concentration (ppm)	0.00
NO_2 Impurity (ppm)	0.00
NO_x Cylinder Concentration (ppm)	0.00

SPAN	(ppb)	146*i*_gflow	146*i*_zflow
ZERO	0		
SPAN	180		

SPAN ZERO	Calibrator NO (Calculated)	Calibrator NO_y (Calculated)
0 ppb	#DIV/0!	#DIV/0!

SPAN	Calibrator NO (Calculated)	Calibrator NO_y (Calculated)
180 ppb	#DIV/0!	#DIV/0!

Calibration Factors

	Pre-Cal	Post-Cal
NO Bkg		
NO_y Bkg		
Prereactor Bkg		
NO Coef		
DIF Coef		
NO_y Coef		

ZERO Time HH:mm	Analyzer NO	Analyzer NO_y
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!

SPAN Time HH:mm	Analyzer NO	Analyzer NOy
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
% Diff	**#DIV/0!**	**#DIV/0!**

	[diff ± 1.0 ppb]	
Acceptable:	**#DIV/0!**	**#DIV/0!**

	[diff ± 3 ppb]	
Acceptable:	**#DIV/0!**	**#DIV/0!**

Gas Phase Titration

SPAN	(ppb)	146*i*_gflow	146*i*_zflow
Originanl	180		
Remainder	180		

Original	NO	NO_y
180 ppb	#DIV/0!	#DIV/0!

Remainder O_3 Level	NO_2 (ppb) (Calculated)	NO_2 (ppb) (Converted)	NO_2 CE Converter Efficiency
	#DIV/0!	#DIV/0!	#DIV/0!

Original Time HH:mm	Analyzer NO	Analyzer NO_y
Avg ppb	#DIV/0!	#DIV/0!
% Diff	#DIV/0!	#DIV/0!

SPAN Time HH:mm	Analyzer NO	Analyzer NO_2	Analyzer NO_y
Avg ppb	#DIV/0!	#DIV/0!	#DIV/0!
NO2 % DIF		**#DIV/0!**	

NO_2 % DIF Acceptable: #DIV/0! | NO_2 % DIF: < 5%

Comments:

Example of Verification Tab

NO_yT Verification of Calibration

DAQ -08-007.2 Rev 0.0 (01 May 2023)

Site:	0	Time:	0:00	Date:	01/00/00	Operator:	0

NO Cylinder Concentration (ppm)	0.00
NO_2 Impurity (ppm)	0.00
NO_x Cylinder Concentration (ppm)	0.00

SPAN	(ppb)	146*i*_gflow	146*i*_zflow
ZERO	0		
SPAN	180		
SPAN 2	100		
SPAN 3	50		
SPAN 4	25		

SPAN ZERO	Calibrator NO (Calculated)	Calibrator NOy (Calculated)
0 ppb	#DIV/0!	#DIV/0!

SPAN ZERO Time HH:mm	Analyzer NO	Analyzer NOy
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!

Acceptance Criteria:	[diff ± 1.0 ppb]	
Point Difference:	**#DIV/0!**	**#DIV/0!**

SPAN	Calibrator NO (Calculated)	Calibrator NOy (Calculated)
180 ppb	#DIV/0!	#DIV/0!

SPAN Time HH:mm	Analyzer NO	Analyzer NOy
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
% Diff	**#DIV/0!**	**#DIV/0!**

Acceptance Criteria:	[diff ± 1.5 ppb or 2%]	
Point Difference:	**#DIV/0!**	**#DIV/0!**
Percent Difference:	**#DIV/0!**	**#DIV/0!**
	#DIV/0!	**#DIV/0!**

SPAN 2	Calibrator NO (Calculated)	Calibrator NOy (Calculated)
100 ppb	#DIV/0!	#DIV/0!

SPAN 2 Time HH:mm	Analyzer NO	Analyzer NOy
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
% Diff	**#DIV/0!**	**#DIV/0!**

Acceptance Criteria:	[diff ± 1.5 ppb or 2%]	
Point Difference:	**#DIV/0!**	**#DIV/0!**
Percent Difference:	**#DIV/0!**	**#DIV/0!**
	#DIV/0!	**#DIV/0!**

SPAN 3	Calibrator NO (Calculated)	Calibrator NOy (Calculated)
50 ppb	#DIV/0!	#DIV/0!

SPAN 3 Time HH:mm	Analyzer NO	Analyzer NOy
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
% Diff	**#DIV/0!**	**#DIV/0!**

Acceptance Criteria:	[diff ± 1.5 ppb or 2%]	
Point Difference:	**#DIV/0!**	**#DIV/0!**
Percent Difference:	**#DIV/0!**	**#DIV/0!**
	#DIV/0!	**#DIV/0!**

SPAN 4	Calibrator NO (Calculated)	Calibrator NOy (Calculated)
25 ppb	#DIV/0!	#DIV/0!

SPAN 4 Time HH:mm	Analyzer NO	Analyzer NOy
Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!	#DIV/0!
% Diff	**#DIV/0!**	**#DIV/0!**

Acceptance Criteria:	[diff ± 1.5 ppb or 2%]	
Point Difference:	**#DIV/0!**	**#DIV/0!**
Percent Difference:	**#DIV/0!**	**#DIV/0!**
	#DIV/0!	**#DIV/0!**

Comments:

NOTE: *Either the Point Difference (± 1.5 ppb)* ***OR*** *the Percent Difference (± 2 %) must be met for the verification to PASS, but not both.*

Example of NO Regression Tab

NO Regression

DAQ -08-007.2 Rev 0.0 (01 May 2023)

Acceptance Criteria: all points within D8% of best fit straight line

What percentage is acceptable?	2%
Calibration Scale	180
Point Difference Acceptance Value	1.5
Slope Acceptance Criteria	0.95 - 1.05

Only values on sheet that can be changed are in gray, above

Instructions

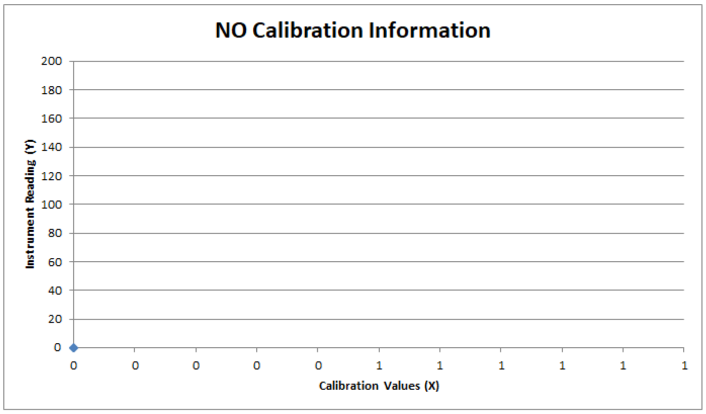
1) Place in the acceptable percentage (2% is current validation criteria) in D8
2) Select the calibration scale. This does not need to be the FEM approved scale of the instrument (e.g., 500 ppb or 1000 ppb) in D9. It should be the high cal value. The point difference acceptance value in field D8 will be calculated for the values entered in D8 and D9
3) Calibration values (X) in Row 21 are linked to the Calibrator minute values entered on the Calibration Verification Tab
4) Instrument values (Y) are linked to the Analyzer minute values entered on the Calibration Verification Tab.
5) The remainder of the worksheet should automatically calculate the results.
6) Any **point result >** the point difference acceptance criteria in D10 will turn the boxes and font in rows 30 red. Any **percent difference >** the value in D8 will turn the boxes and font in rows 31 red.
7) The percent difference estimates are measured using the best fit conc. values (row 29) and the average of the instrument avg. values (row 27) for each concentration.

	Zero Concentration 1	SPAN (~180 ppb) Concentration 2	SPAN 2 (~100 ppb) Concentration 3	SPAN 3 (~50 ppb) Concentration 4	SPAN 4 (~25 ppb) Concentration 5
Calibrator Value (X)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Instrument Value (Y)	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Average	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Best Fit Concentration	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Point Difference (Best fit - Average) absolute value	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Percent Difference (Best fit Conc vs. Avg Y values)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

r	slope (m_i)	intcpt (I_i)	lin reg
#DIV/0!	#DIV/0!	#DIV/0!	#VALUE!

(Calibrator) X	(Monitor) Y
#DIV/0!	0.00
#DIV/0!	0.00
#DIV/0!	0.00
#DIV/0!	0.00
#DIV/0!	0.00



Example of NO_y Regression Tab

NO_y Regression

DAQ -08-007.2 Rev 0.0 (01 May 2023)

Acceptance Criteria: all points within D8% of best fit straight line

What percentage is acceptable?	2%
Calibration Scale	180
Point Difference Acceptance Value	1.5
Slope Acceptance Criteria	0.95 - 1.05

Only values on sheet that can be changed are in gray, above

Instructions
1) Place in the acceptable percentage (2% is current validation criteria) in D8
2) Select the calibration scale. This does not need to be the FEM approved scale of the instrument (e.g., 500 ppb or 1000 ppb) in D9.
It should be the high cal value. The point difference acceptance value in field D8 will be calculated for the values entered in D8 and D9

3) Calibration values (X) in Row 21 are linked to the Calibrator minute values entered on the Calibration Verification Tab
4) Instrument values (Y) are linked to the Analyzer minute values entered on the Calibration Verification Tab.
5) The remainder of the worksheet should automatically calculate the results.

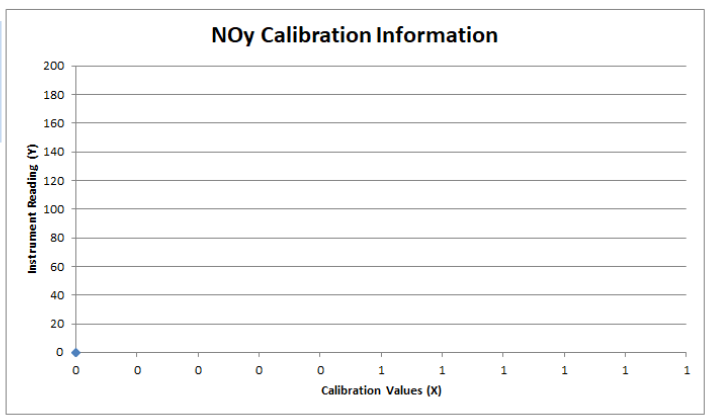
6) Any **point result >** the point difference acceptance criteria in D10 will turn the boxes and font in rows 30 red.
Any **percent difference >** the value in D8 will turn the boxes and font in rows 31 red.
7) The percent difference estimates are measured using the best fit conc. values (row 29)
and the average of the instrument avg. values (row 27) for each concentration.

	Zero Concentration 1	SPAN (~180 ppb) Concentration 2	SPAN 2 (~100 ppb) Concentration 3	SPAN 3 (~50 ppb) Concentration 4	SPAN4 (~25 ppb) Concentration 5
Calibrator Value (X)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Instrument Value (Y)	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Average	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

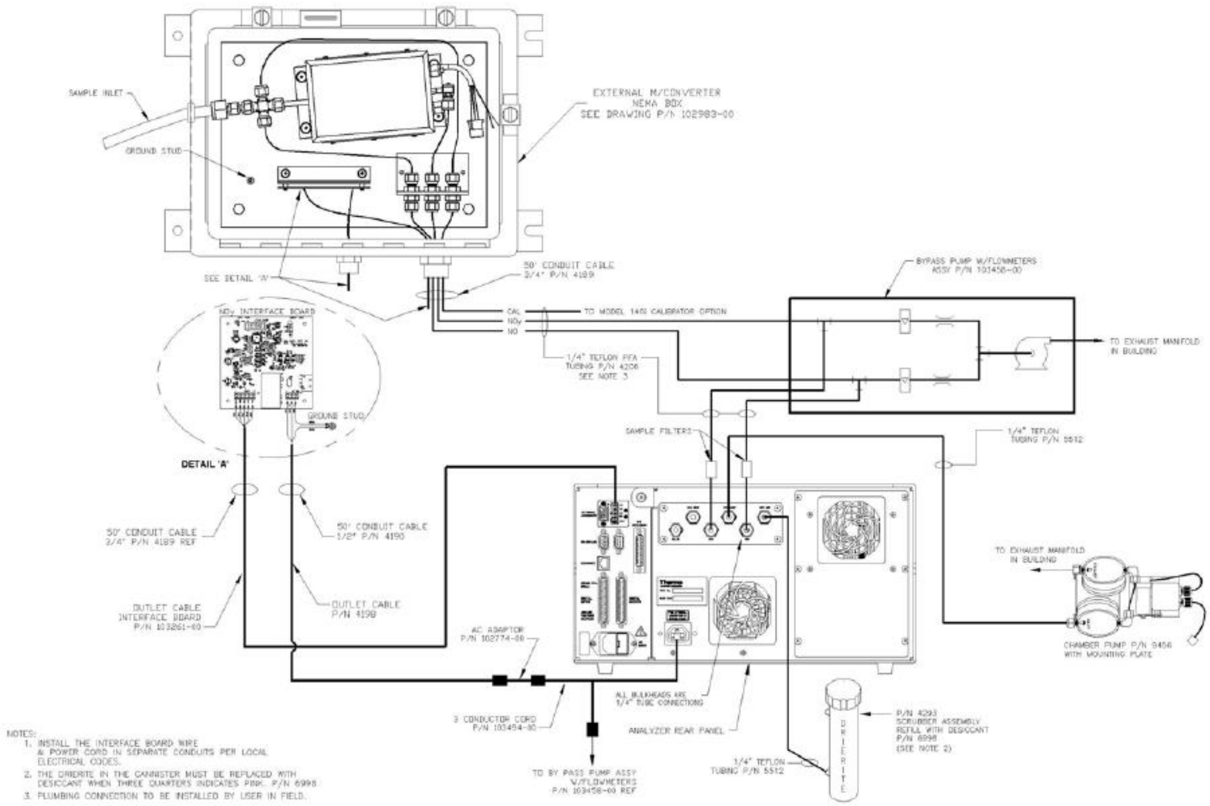
Best Fit Concentration	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Point Difference (Best fit - Average) absolute value	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Percent Difference (Best fit Conc vs. Avg Y values)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

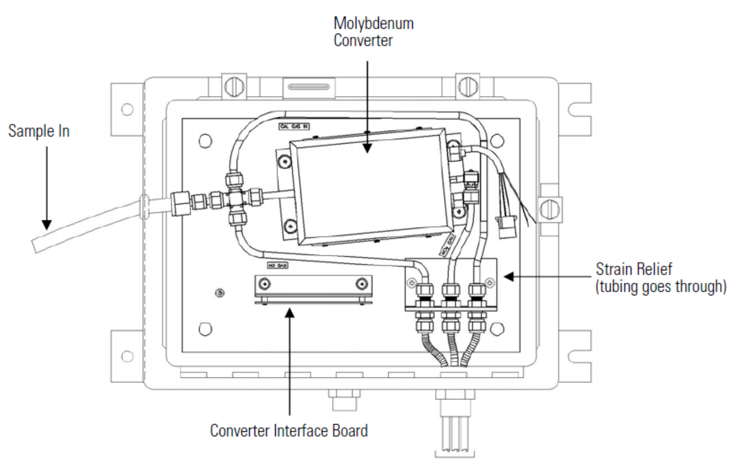
r	slope (m_i)	intcpt (I_i)	lin reg
#DIV/0!	#DIV/0!	#DIV/0!	#VALUE!

(Calibrator) X	(Monitor) Y
#DIV/0!	0.00
#DIV/0!	0.00
#DIV/0!	0.00
#DIV/0!	0.00
#DIV/0!	0.00



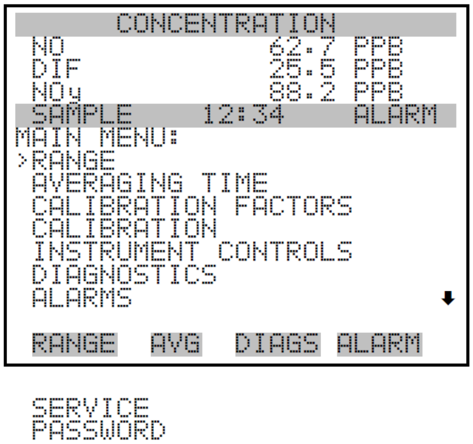
Appendix D: Instrument Diagrams and Display Screens



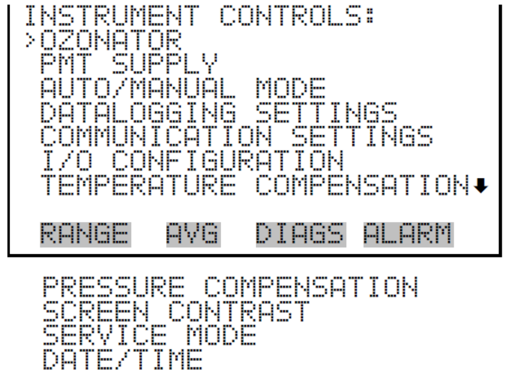


Model 42i-Y NOy Typical Installation Diagram and Molybdenum Converter Detail

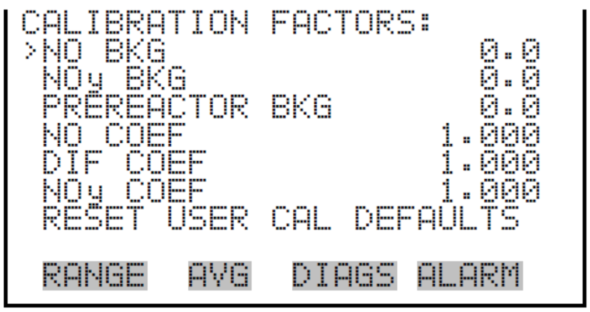
NOTE: The 42i has an internal perma pure dryer (no external dryer) and the port for dry air is capped.



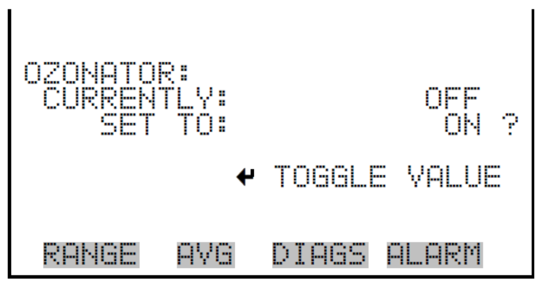
Main Menu



Main Menu – Instrument Controls

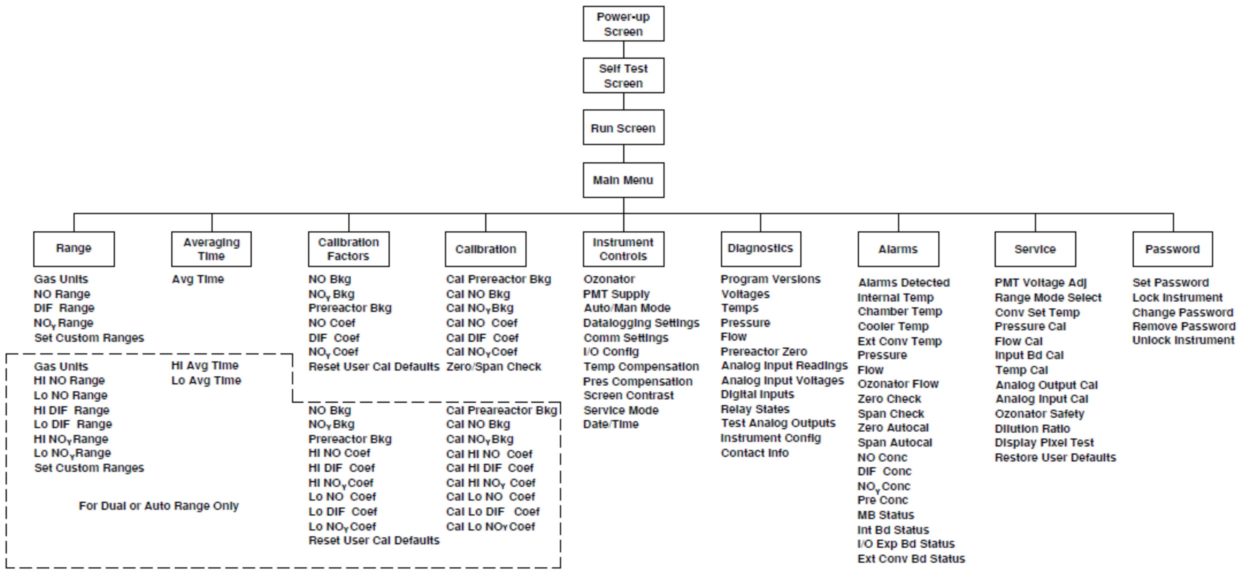


Main Menu – Calibration Factors



Main Menu – Instrument Controls – Ozonator

Appendix E: Flow Chart of Menu-Driven Software



Appendix F: Glossary of Terms

Acceptance criteria – is the pollutant-specific criteria that must be met to collect valid data specified by the United States Environmental Protection Agency in their validation templates, included as Appendix D to the United States Environmental Protection Agency Quality Assurance Handbook.

Calibration – is the act of changing or setting values in a monitor.

- *Gaseous Monitor Calibration* – is the act of setting response values stored in a monitor while running a series of challenge concentrations. A calibration for a monitor is accomplished by pressing a button to change the values stored in the monitor for each challenge concentration. For carbon monoxide a calibration involves running three upscale points to set or reset the coefficients. For all other gaseous monitors, the challenge concentrations include zero and at least one span point.
- *Particulate Matter Calibration* - For low volume particulate matter monitors a calibration is the changing or resetting of the span and offset using three flow points bracketing the desired flow point. For PM monitors the temperature and pressure calibration is changing or resetting a slope using a one-point measurement. The temperature and pressure calibration must be completed before the flow calibration.

Calibration Criteria – are pollutant-specific limits established by the Division of Air Quality that a calibration must meet to pass and be used to collect valid data. The calibration criteria may be equal to or more stringent than the EPA acceptance criteria.

Control Limits – are limits established by the United States Environmental Protection Agency and published in the Code of Federal Regulations at 40 CFR Part 58 Appendix A. These limits may not be exceeded. They are listed as acceptance criteria in the Environmental Protection Agency validation tables in Appendix D to the United States Environmental Protection Agency Quality Assurance Handbook and North Carolina Division of Air Quality validation tables in the North Carolina Division of Air Quality, Quality Assurance Project Plans. The precision, zero and span for gaseous monitors or flow rate verification for particulate matter monitors must be within the control limits for the collected data to be valid. Data collected when the precision, zero and span or flow rate verifications are outside of the control limits will be invalidated and replaced with a null code.

Electronics and Calibration Branch Performance Evaluation – is a check performed by the Electronics and Calibration Branch electronics technicians to confirm the correct operation of an instrument. At a minimum it involves challenging the instrument with a zero and three upscale points. One of the upscale points must be at the detection limit of the instrument. Another upscale point is either at the level of the national ambient air quality standard or at the level of the highest measured values. The Electronics and Calibration Branch electronics technicians must perform an Electronics and Calibration Branch performance evaluation on each instrument at least once every 365 days and at least once every calendar year.

Flowrate Audit - is a measurement of flow, ambient pressure and ambient temperature to ensure correct operation of the monitor, performed by someone other than the operator using a certified flow standard different from that used to calibrate or verify the monitor.

Flowrate Verification – is a measurement of flow, ambient pressure and ambient temperature by the operator to ensure correct operation of the monitor.

Functionality Test – is a test of the monitor, calibrator, cylinder, or zero air supply conducted by an ECB electronics technician, either remotely or on site, to evaluate whether the system is performing as expected. It may include running a zero and span or multiple points. Since functionality tests involving the running of points do not necessarily run the points long enough for them to stabilize and are not necessarily recorded in an e-log, results of functionality tests are not reported to AQS. Functionality tests, alone, cannot be used as weight of evidence to demonstrate that the monitor is functioning properly.

Installation – is when a monitor is both taken to a site and plugged in. A leak check followed by a calibration is required on installation and before data reporting.

Manual Performance Checks – are any performance checks completed by the regional operator to evaluate the instrument and its performance. A manual performance check could be a precision, zero, span or just a zero and a span or just a one-point quality control check. It could be performed remotely or on-site. It includes manual 14-day one-point quality control checks performed at the site.

Moving – for a gaseous monitor, is removing the monitor from the monitoring shelter.

Multi-point Verification – is the check that the operator performs after completing a calibration on a gaseous monitor. It includes running a zero, span and two (for sulfur dioxide) or three intermediate, equally spaced concentrations to verify the linearity of the calibration and assess the overall success of the calibration. A multi-point verification may be used instead of a calibration for carbon monoxide and other pollutants, when allowed by an SOP, for the calibration required once every 365 days or when calibrators and cylinders are replaced.

National Performance Audit Program Performance Evaluation – is a performance check completed by United States Environmental Protection Agency contractors to confirm the correct operation of an instrument. It involves challenging the instrument with a zero and several upscale points.

One-Point Quality Control Check – is a check performed at least once every two weeks on each gaseous monitor. It must fall within the range of 0.5 to 5 parts per million for carbon monoxide and 5 to 80 ppb for all other gaseous pollutants. Any check that meets the requirements of a one-point quality control check must be reported to the Air Quality System.

Precision, zero, span or PZS – is the automated scheduled check that runs each night to measure drift in the zero, span and one-point-quality control check also known as the precision point.

- *Failed PZS* – is a check where all of the calibration equipment worked properly to provide the desired gas at the desired concentration, but the instrument failed to read the concentration within the EPA-established control limits. [Note that the action or warning limits are stricter than the control limits.] For SO_2 and O_3 the data for a failed PZS are reported to AQS. The data are invalidated back to the last passing PZS. The operator is required to take corrective action. Valid data cannot be reported until the problem is corrected, or the instrument is recalibrated.

- *Invalid PZS* – is a check where one or more components of the calibration system (solenoid, zero air generator, gas cylinder, ozone generator, mass flow controllers, etc.) used to produce the challenge concentration failed for some reason. As a result, the system failed to provide the desired gas at the desired concentration. The operator is required to take action within two working days to identify and document the cause of an invalid PZS. The invalid PZS for ozone and sulfur dioxide is reported to the Air Quality System with a null code that describes the reason the PZS failed. Because the PZS is invalid, no data are invalidated as long as the calibration system is fixed and a passed PZS runs within 14 days. If the operator fails to act within the prescribed timeframe, the data may be flagged with a "6" for not following the standard operating procedure.
- *Passed PZS* – is a check where all of the calibration equipment worked properly to provide the desired gas at the desired concentration and the instrument successfully measured the concentration within the EPA-established control limits. For sulfur dioxide and ozone, the data for a passed PZS are reported to AQS. The operator is only required to take corrective action if the check is outside of the EPA Region 4 recommended warning limits for two consecutive days.
- *Valid PZS* – is a check where all of the calibration equipment (solenoid, zero air generator, gas cylinder, ozone generator, mass flow controllers, etc.) used to produce the challenge concentration worked properly to provide the desired gas at the desired concentration. A valid PZS is necessary to have either a passed PZS or a failed PZS. A valid PZS refers only to the status of the equipment used to produce the challenge concentration and not the monitor that measures the challenge concentration.

Shut down – is when the monitor is no longer collecting reportable data.

Start-up – is when the monitor is now collecting reportable data.

Systems Test – is a test of the monitor, calibrator, cylinder, zero air supply, or other support equipment conducted by an operator, either remotely or on site, to evaluate whether the system is performing as expected. It may include, but is not limited to, running a zero and span or multiple points. Since systems tests involving the running of points do not necessarily run the points long enough for them to stabilize, results of systems tests are not reported to AQS. Systems tests must be recorded in an e-log and, alone, cannot be used as weight of evidence to demonstrate that the monitor is functioning properly.

Warning Limits – are limits recommended by the United States Environmental Protection Agency Region 4 and adopted by the North Carolina Division of Air Quality, which are stricter or tighter than the United States Environmental Protection Agency established control limits. The North Carolina Division of Air Quality has put them into place to minimize data loss. When the precision, zero and span for gaseous monitors or flow rate verification for particulate matter monitors are outside of the warning limits, the operator must take corrective action to identify the cause. If the cause is normal drift, the operator will recalibrate the instrument. If the cause is more serious, the instrument may be replaced or repaired and then recalibrated. Action must be taken but the data remain valid as long as the precision, zero and span or flow rate verification remains within the control limits. Data may be flagged with a "6" for not following the standard operating procedure if the operator fails to act within the timeframe prescribed by the standard operating procedure.

Weight of evidence – is documentation and verifiable proof that the monitor or calibration system was either working properly or failed in some manner. To demonstrate the system was working properly, the weight of evidence should thoroughly document that whatever occurred at the time had no effect on the data or did not compromise the quality or validity of the data collected. To be acceptable for use as weight of evidence, any points ran must be run by the regional office staff, must be documented in an e-log, and must at a minimum include a precision point, zero point and span point. Whenever points are run to provide weight of evidence that the monitor is functioning properly, they must be reported to AQS.

Appendix G: Guidance for Useful Logbook Documentation

EPA has been providing guidance on record keeping requirements for QA/QC programs. In particular, EPA has discussed the role that logbooks play in providing proof that QAPPs and SOPs are being followed. According to EPA, logbooks should, at a minimum, provide the following to be a useful tool for documenting the operations conducted at a monitoring site:

1. Purpose – Define the purpose of this site visit. Tell why you are there. Is it to replace a filter? Did you note something in the previous data download that is indicating a problem? Are you experiencing data drops and want to see if anything is wrong? In a couple of sentences, tell what you intend to do. Don't say routine maintenance, say instead: "noted fluctuations in flow while reviewing the 5-minute average data". Be specific.

2. Appearance – Tell how you found the site. If the site was secure, say so. If you noted a problem, or a changed condition, then document it in a couple of sentences: "construction has taken place in the vacant lot next to the site since my last visit".

3. Action – Tell what you did. In a few short sentences describe the actions you took at the site: "cleaned the PM10 head and replaced one of the two gaskets". In particular, you might want to document any site computer updates that were run. Just things like that.

4. Results – Were you successful? Did you accomplish your goals? If so, then say so: "completed the monthly and quarterly maintenance and returned the monitor to "Wait" mode". If not, then say so: "failed as-left leak check, contacted ECB".

5. Response – Is the equipment operating within specifications set in SOP? If so, then great, note that fact in the logbook and you are done. If not, then what did you do? If something is wrong then reach out for help and document it: "contacted Scott at ECB, he will be here presently with a new FRM."

6. Reviewers should add their comments: "reviewed above, approved operator action." Or: "upon review noted deviation from SOP".