STATEWIDE
STANDARD OPERATING PROCEDURE

FOR

THERMO FISHER SCIENTIFIC

MODEL 42i – NO_2-NO-NO_X ANALYZER

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL PROTECTION

OFFICE OF AIR MONITORING

Prepared by: Florida PQAO Date: February 2023

Approved by: Daisy Anderson Digitally signed by Daisy Anderson Date: 2023.04.14 13:48:57 -04'00' Date: April 14, 2023

Quality Assurance Manager

Approved by: _____ Date: _____

EPA Region IV Approval Officer

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0	April 2017	FAMAC	Initial Release
1	February 2023	PQAO	Updated SOP and Forms

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1.0 PURPOSE

This document has been prepared for Field Technicians to use during routine, periodic and calibration visits to ambient air monitoring sites in the Florida air monitoring network utilizing a Thermo Scientific (TEI) Model 42*i* NO-NO_2-NO_X Analyzer. This document is not designed to cover all the technical details that are included in the TEI Model 42i Analyzer Manual (published 7/25/2015), or quality assurance information in 40 Code of Federal Regulations (CFR) Parts 50, 53, and 58; EPA Technical Assistance Documents (TAD's), and related reference materials. Adherence to this manual will enable the site Field Technician to know and follow state-wide quality control/quality assurance (QA/QC) requirements. Site Field Technicians should also be knowledgeable of and refer to the references noted in this Standard Operating Procedure (SOP). In this SOP, the TEI Model 42i will primarily be referred to as the analyzer. Both the instruction manual and this SOP are to be kept at the shelter. Agencies may elect to keep digital versions of these files on a computer or network drive.

2.0 SCOPE AND APPLICABILITY

The Florida Department of Environmental Protection and Florida Local Air Monitoring Agencies utilizes the Thermo Scientific (TEI) Model 42*i* NO-NO_2-NO_X analyzer to quantify NO_2 concentrations in the ambient air. The TEI 42i nitrogen oxide analyzer uses chemiluminescence technology to measure the amount of nitrogen oxides in the air. The analyzer is designated as an equivalent reference method (Number RFNA-1289-074) for NO_2 measurements, as defined in 40 CFR Part 53. It is operated, calibrated and maintained in accordance with 40CFR Part 50, Appendix F: Measurement Principles of Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere, the Quality Assurance Project Plan for the State of Florida Ambient Air Quality Monitoring Program (FDEP QAPP-002) and the EPA Quality Assurance Handbook, Volume II.

The procedures are intended for use by the operator during routine operations at the monitoring site. Additional detailed technical information may be found in the manufacturer's manual. Refer to the manufacturer's manual for schematics and diagrams.

The Model 42i meets EPA designation requirements when operated as follows:

Table 2-1. Operation Requirements for EPA Designation

Range	50 to 1000 ppb
Averaging Time	10 to 300 seconds
Temperature Range	15 to 35 °C
Line Voltage	90 to 110 Vac @50/60 Hertz 105 to 125 Vac @50/60 Hertz 210 to 250 Vac @50/60 Hertz
Pressure Compensation	ON or OFF
Temperature Compensation	ON or OFF
Flow Rate	0.5 to 1.0 LPM

3.0 SUMMARY OF METHOD

The Model 42i operates on the principle that nitric oxide (NO) and ozone (O3) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to lower energy states.

Specifically:

$$NO + O_3 \rightarrow NO_2 + O_2 + h\nu$$
$h\nu$ = emitted photon energy

Nitrogen dioxide (NO_2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a molybdenum NO_2-to-NO converter heated to about 325 °C (the optional stainless steel converter is heated to 625 °C).

The ambient air sample is drawn into the analyzer through the sample bulkhead, as shown in Figure 3-1. The sample flows through a capillary, and then to the mode solenoid valve. The solenoid valve routes the sample either straight to the reaction chamber (NO mode) or through the NO_2-to-NO converter and then to the reaction chamber (NO_x mode). A flow sensor to the reaction chamber measures the sample flow.

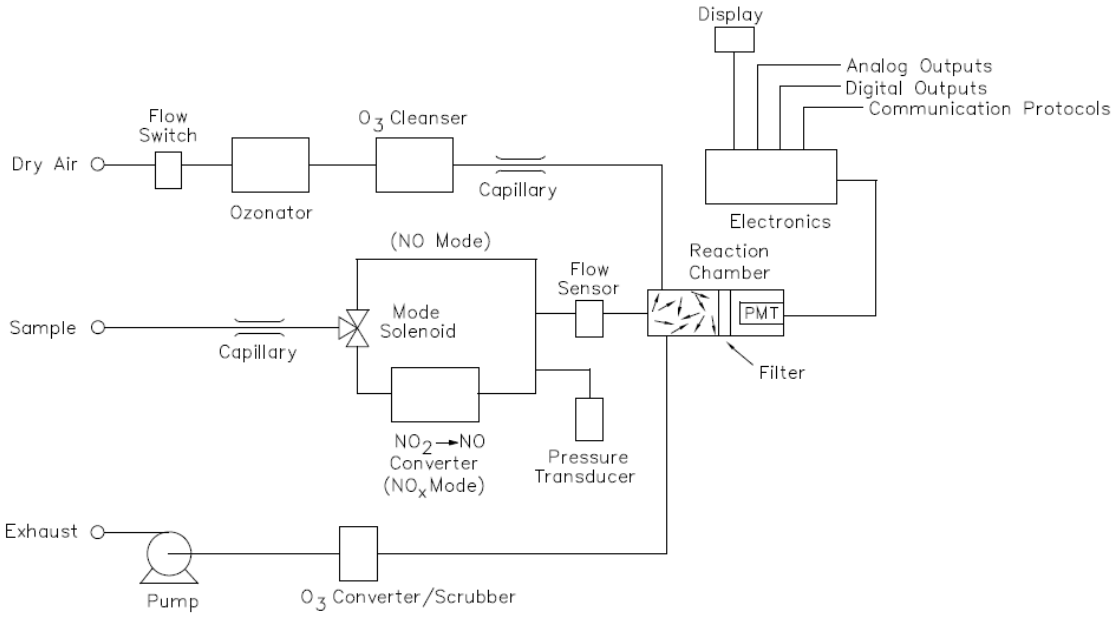


Figure 3-1. Model 42i Flow Schematic

Dry air enters the analyzer through the dry air bulkhead, passes through a flow switch, and then through a silent discharge ozonator. The ozonator generates the ozone needed for the chemiluminescent reaction. At the reaction chamber, the ozone reacts with the NO in the sample to produce excited NO_2 molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the luminescence generated during this reaction. From the reaction chamber, the exhaust travels through the ozone (O_3) converter to the pump and is released through the vent.

The NO and NO_X concentrations calculated in the NO and NO_X modes are stored in memory. The difference between the concentrations is used to calculate the NO_2 concentration. The analyzer outputs NO, NO_2, and NO_X concentrations to the front panel display, the analog outputs, and also makes the data available over the serial or Ethernet connection.

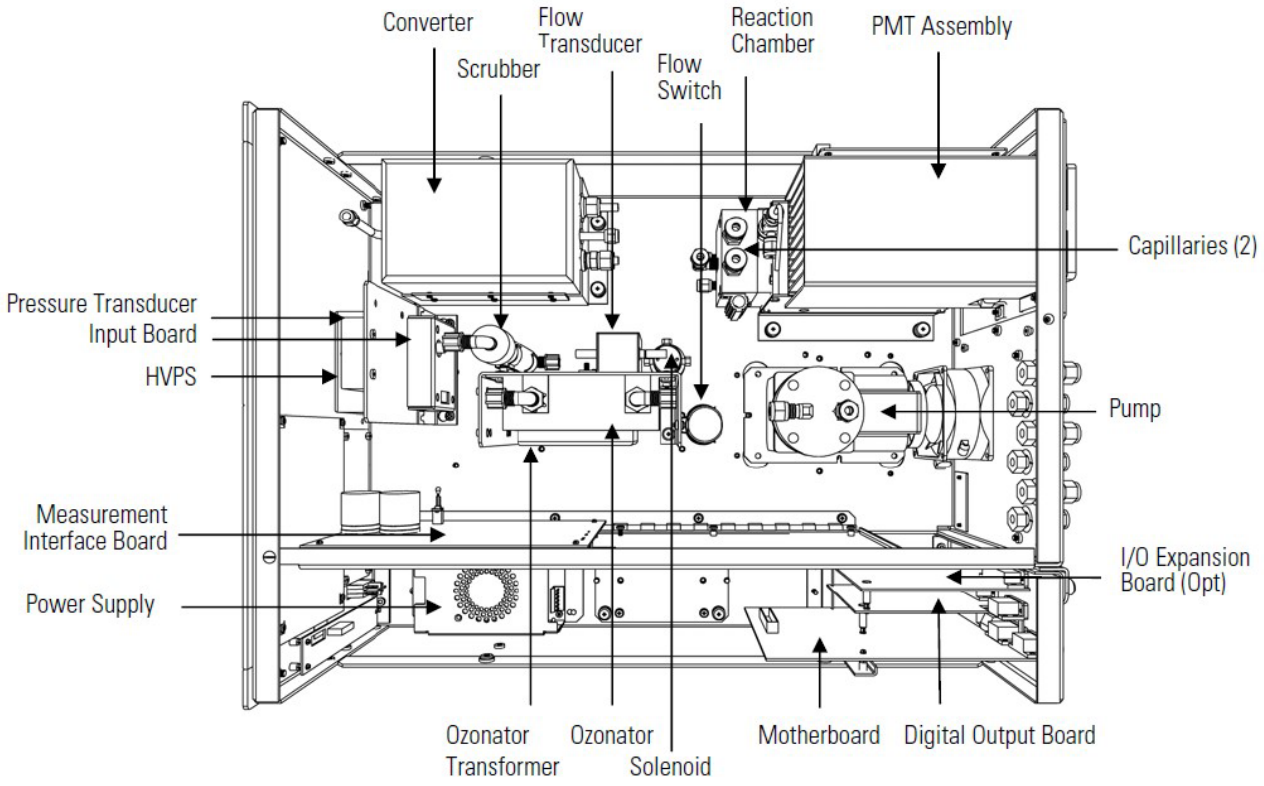


Figure 3-2: Component Layout

4.0 DEFINITIONS AND CONVERSION FACTORS

Technical terms in this SOP are defined as they are introduced so that their meaning is made clear in context. This section explains some general terminology.

Table 4-1. General Terms and Definitions

Term	Definition
Calibration (adjusted)	A calibration where the instrument is adjusted and the coefficient, slope and offset are changed. This adjusted calibration involves adjusting the zero and/or span and verifying values at three other upscale concentrations between the zero and the span value.
Flow Calibrator	Equipment used to mix zero air with a sample gas to furnish the desired concentration at the required flow.
Interference	Physical or chemical entities that cause NO_2 measurements to be higher (positive) or lower (negative) than would be without the entity.
Stability	Stability is defined as 10 one minute averages of ±3 ppb with no upward or downward trend
Output Manifold	The external manifold between NO_2 analyzer and the gas phase titration (GPT) calibrator. The manifold receives NO, NO_X, and NO_2 calibration gasses from the GPT calibrator and allows the analyzer to sample these calibration gasses at atmospheric pressure.
Quality Assurance (QA)	Refers to the planned or systematic activities used to provide confidence that the requirements for quality are fulfilled. An independent audit is an example of a QA activity. QA protocols determine whether the QC procedures are adequate.
Quality Control (QC)	Refers to the operational techniques and activities used to fulfill the requirements for quality. QC Checks referenced in this SOP, refer to quality control activities performed by the operator including zero/span/precision checks and multipoint calibration checks conducted immediately prior to and after instrument maintenance and calibration adjustments.
Sample Line Integrity Check (SLIC)	The quarterly check done to verify the integrity of the sample line and ensure that the sample line is not having a negative effect on the concentration values read by the analyzer. It is typically made from a piece of ¼" Teflon tubing with a Teflon "T" in the middle for a vent. One end is connected to the output of the flow calibrator and the other end to the input of the analyzer.
Span Gas	Span gas is defined as a gas specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired measurement range. Typically, this is 80-90 % of the measurement range of the application of the instrument.
Validation	Determining whether the system complies with requirements, performs the functions for which it is intended, and meets the organization's goals and user needs. It is a determination of correctness of the data and is usually performed only periodically (e.g., quarterly) or at the end of a project.
Verification (unadjusted)	Also referred to as a calibration check, the instrument is not adjusted and the coefficient, slope and offset remains the same. This check is performed at zero, span, and three upscale concentrations.

Term	Definition
Zero Gas	Zero gas or zero calibration gas is defined as a gas that is similar in chemical composition to the measured medium but without the gas to be measured by the analyzer. See EPA QA Handbook Vol 2 Section 11.1.2 and Appendix K for further information on zero gas requirements.
Zero, Span and Precision Check (ZSPs)	The analytical check done to verify that the analyzer is operating satisfactorily. It is done at a minimum frequency of every 14 days.
Verification (unadjusted)	Also referred to as a calibration check. The instrument calibration coefficients are not adjusted. This check is performed at zero, span, and three upscale concentrations.

5.0 HEALTH AND SAFETY PRECAUTIONS

To prevent personal injury, or damage to the NO-NO_2-NO_X analyzer, the following health and safety points should be followed while working with the analyzer:

A. Health Precautions
   1. Nitrogen oxide gasses are poisonous. Even low levels of nitrogen oxides can irritate your eyes, nose, throat, and lungs, possibly causing you to cough and experience shortness of breath, tiredness, and nausea. Vent any nitrogen oxide or calibration span gas to the atmosphere rather than into the shelter or sampling area. If the operator experiences lightheadedness, headache, or dizziness, he or she should leave the area immediately.
   2. It is possible (and practical) to purchase multi-blend cylinders containing pollutant gases in addition to NO. If this is done, it is recommended that Material Safety Data Sheets (MSDS) for all cylinder gas components be made available to all staff members who use and handle the cylinders.
   3. Always use a third ground wire on all instruments.
   4. Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap should be worn while handling any internal component. For more information about appropriate safety precautions, see the "Servicing" chapter in the TEI Model 42i Instruction Manual.

B. Safety Precautions
   1. When lifting the instrument, use procedure appropriate to lifting a heavy object, such as, bending at the knees while keeping your back straight and upright. Grasp the instrument at the bottom in the front and at the rear of the unit. Although one person can lift the unit, it is desirable to have two persons lifting, one by grasping the bottom in the front and the other by grasping the bottom in the rear. Do not attempt to lift the instrument by the cover or other external fittings.
   2. Keep the interior of the analyzer clean.
   3. Inspect the system regularly for structural integrity.
   4. To prevent problems with leaks, make sure that all sampling lines are reconnected after required checks and before leaving the site.
   5. Inspect tubing for cracks and leaks.
   6. It is recommended that the analyzer be leak-checked after replacement of any pneumatic parts. If cylinders are used in tandem with Mass Flow Control (MFC) calibrators, their use and transport is a major concern. Gas cylinders may have interior pressures as high as 2000 pounds per square inch (psi). Handling of cylinders must be done in a safe manner. If a cylinder is accidentally dropped and its valve breaks off, the cylinder can become explosive or a projectile.
   7. Transportation of cylinders is regulated by the Department of Transportation (DOT). It is strongly recommended that all agencies contact the DOT or the Highway Patrol to learn the most recent regulations concerning transport of cylinders. Shipping of cylinders is governed by the DOT. Contact the DOT or your local courier about the proper procedures and materials needed to ship high pressure cylinders.
   8. Gas cylinders must be properly secured to the interior walls of the shelter with the appropriate straps before use.

6.0 INTERFERENCES

The chemiluminescence method for detecting NO-NO_2-NOx is subject to interference from a number of sources including certain hydrocarbons, water vapor (H_2O), and ammonia (NH_3). Depending on the converter temperature, the converter may convert a small amount of ammonia (NH_3) to NO, resulting in increased NO readings. However, under normal circumstances NH_3 concentrations are low compared to NO and this positive interference is negligible. Nonetheless, care should be taken when siting the monitor to be sure that it is not located near significant NH_3 sources which could cause elevated NH_3 concentrations (e.g., concentrated animal feeding operations).

7.0 PERSONNEL QUALIFICATIONS

A basic understanding of the principles governing ambient air sampling is necessary. All field operations personnel should be familiar with environmental field measurement techniques. Those who service the analyzer in the field must be very conscientious and attentive to detail in order to report complete and high-quality environmental data. Installation, operation, maintenance, repair and calibration of the instrument and all support equipment should only be performed by properly trained personnel. The training will be provided by in house personnel, state or federal agencies when available. The training documentation will be maintained by the state or local agency where the personnel operate. Persons qualified to perform measurements of ambient NO_2 concentrations should be able to:

a) Operate the Thermo 42i analyzer
b) Calibrate, audit, troubleshoot and perform preventative maintenance
c) Operate the dilution calibrator and dilution (zero air) system.

Operators are also required to read the manufacturer's instruction manuals supplied with the analyzer and supporting calibration equipment to become familiar with the various controls and components prior to attempting any operation described in this procedure. The manufacturer's manuals contain useful operation, maintenance, and diagnostic information that may not be contained in this SOP.

8.0 EQUIPMENT AND SUPPLIES

A. **TEI 42i Analyzer** - The NO_2 analyzer must be designated by EPA as an official equivalent method and bear the designation sticker on the front of the instrument. The analyzer must meet factory specifications and be set up and operated per the manufacturer's operations manual and this SOP (see section 9.0 for startup/set up procedures).

B. **Zero Air (Dilution Air) System** - Zero air must be free of contaminants, which will cause analyzer response or react with NO, O_3, or NO_2 during the gas phase titration reaction. For example, the TEI 111 or the Teledyne T701 zero air unit are both currently being used by agencies in the State of Florida. Zero Air systems typically consist of a desiccant, Purafil Scrubber, Charcoal Scrubber, pressure adjustment control and a compressor. The zero-air system must be equipped with a pressure regulator capable of maintaining a stable output pressure. Refer to the SOP for the applicable instrument/equipment for maintenance intervals.

C. **Calibration System** - the system must have an accurate mass flow-controlled gas dilution system and be capable of producing ozone for converting NO to NO_2. The air flow controller should be capable of maintaining constant air flows within ±2% of the required flow rate, as verified by a NIST traceable flow standard. Calibrators used within the State of Florida PQAO must be designed to meet all EPA requirements for evaluating NO_2 instruments. Calibrators with photometers must be certified by FDEP prior to being used for any procedures. The operator should consult any applicable SOPs for the calibrator prior to use.

D. **NO Standard Gas Cylinder** - Needed to supply NO to the calibration system. Cylinder must be certified according to a valid an EPA Protocol Gas as specified in EPA – 600/R97/12, and typically contains NO in N_2 with less than 1 ppm NO_2. The cylinder must not be used past certification expiration date. The cylinder should not be used below 200 psig as indicated on the regulator gauge unless a higher value is specified by the manufacturer.

E. **Pressure regulator** for gas cylinder - Must have non-reactive internal parts (those coming into contact with the NO standard) as well as a non-reactive diaphragm. Must have sufficient delivery pressure (approximately 20-30 psig). Connecting line from the regulator must be 1/8 " FEP Teflon and should be less than 24" in length.

F. **Output Manifold (optional)** - This is the external manifold between NO_2 analyzer and the GPT calibrator. The manifold receives NO, NO_X, and NO_2 calibration gasses from the GPT calibrator and allows the analyzer to sample these calibration gasses at atmospheric pressure. The output manifold must be made of a non-reactive material. The manifold must be vented to ensure conditions in the manifold are at atmospheric pressure and designed so room air does not enter the manifold. A minimum of 10% excess flow must exhaust through the manifold vent when calibration gasses are being run.

G. **Particulate Filter** - Teflon, two inch (47 mm), five-micron pore size enclosed in a Teflon filter holder utilizing Teflon fittings and components.

H. **Sample Line Integrity Check (SLIC) tubing assembly** - This is required during all multi-point calibrations and consists of a dedicated sample tube with an attached "T" or appropriate atmospheric dump for ventilation.

I. **Data Acquisition System (DAS)** - A data acquisition system (DAS) is necessary for storage of ambient and ancillary data collected by the analyzer. Agencies within the State of Florida PQAO may utilize differing DAS for all data collection. Operators should check the manual and SOPs specific to the DAS used within their agency for performing the general steps described in this document. Before beginning any procedures that disrupt the analyzer's ambient air sampling, ensure that the appropriate channel(s) on the DAS are marked in a way that causes the DAS to disregard the data and not average it with ambient concentrations throughout the duration of the procedure. The corresponding analyzer channel(s) should be marked "offline" prior to conducting any of the following procedures: ZSPs, Multipoint Verifications, Analyzer Maintenance, and Calibrations. Channels may also be marked "offline" when the ambient air data is deemed to be compromised.

J. **Computer and Electronic Logbook** - Used to communicate with the DAS, document procedures with PQAO forms, and store and transmit the various records used for calibrations, ZSPs, maintenance, etc.

K. **Reference Thermometer** - Used to calibrate the internal analyzer temperature probe. Graduated in 1° C increments (minimum). Calibrated against an NIST traceable thermometer and accurate to ± 1° C.

L. **Reference Barometer** – Used to calibrate the internal analyzer pressure sensor probe. Reads to increments of 1 mmHG (minimum). Calibrated against a NIST traceable barometer accurate to ±1 mmHg.

M. **Instrument Shelter** - A shelter is required to protect the analyzer from precipitation and adverse weather conditions, maintain operating temperature within the analyzer's temperature range requirements, and provide security and electrical power. The allowable shelter temperature range for the instrument is 15-35°C according to the Automated Reference Method; RFNA-1289-074.

N. **Shelter Temperature Probe** - Used to document the internal sample shelter temperature stays within specifications. Calibrated initially and then annually against a NIST traceable primary or secondary temperature standard. Continuous readout. Accurate to + 0.1° C.

O. **Wiring, Tubing and Fittings** - All tubing and fittings must be made of a non-reactive material. Teflon™ Brand FEP tubing, PTFE, or equivalent FEP Tubing should be used exclusively throughout the intake system. All fittings and ferrules should be made of Teflon™ Brand FEP tubing, PTFE, or equivalent FEP Tubing or stainless steel. Do not mix materials (e.g. stainless threaded onto a Teflon fitting) or mix fittings of different manufacturers. Connection wiring to the DAS should be shielded two strand wire, RS-232 or CAT 5 or 6 network cables for digital connections.

9.0 INSTALLATION, START-UP, AND REMOVAL INSTRUCTIONS

Operator(s) are required to read the manufacturer's manual and become thoroughly familiar with the various controls and components of the analyzer prior to beginning operation.

9.1 Analyzer Siting Recommendations

All ambient air oxides of nitrogen analyzers must meet the location and siting criteria referenced in the Code of Federal Regulations (CFR), Part 58, Appendix E, Sections 2.0-2.6 for NO_2 Siting Criteria.

The probe will be positioned at least 1 meter vertically or horizontally away from any supporting structure or walls and should be 3 - 15 meters above ground level.

The ambient air inlet probe will have unrestricted airflow and be located away from obstacles so that the distance from the probe or monitoring path is at least twice the height that the obstacle protrudes above the probe or monitoring path. The probe will have unrestricted airflow in an arc of at least 270 degrees (180 degrees if protruding horizontally away from the shelter wall) around the inlet probe.

Trees provide surfaces for O_3, and NO_2 adsorption or reactions and can obstruct wind flow. To reduce these possible interferences, the site NO_x sampling probe will be 10 meters or more from the drip line of any trees.

9.2 Inspecting New and/or Returned Equipment

When shipment of the monitor is received, verify that the package contents are complete as ordered. Inspect the instrument for external physical damage due to shipping, such as scratched or dented panel surfaces and broken knobs or connectors.

Remove the instrument cover and all interior foam packing and save (in case future shipments of the instrumentation are needed). Make note of how the foam packing was installed.

Inspect the interior of the instrument for damage, such as broken components or loose circuit boards. Make sure that all the circuit boards are completely secured. Loose boards could short out the motherboard. If no damage is evident, the monitor is ready for calibration, installation and operation. If any damage due to shipping is observed contact the manufacturer for instructions on how to proceed.

If you discover that the instrument was damaged during shipping and it becomes necessary to return it to the manufacturer, repack it in the same way it was delivered and contact the manufacturer for further instructions.

9.3 Installation

A. Prior to installation and startup of the analyzer, the operator should read the Model 42i factory instruction manual.

B. Set the analyzer on a table or bench, which will allow access to both the front and rear of the instrument.

C. Remove the cover and inspect the inside of the instrument for possible damage. Make sure all circuit boards and plugs are tightly inserted in their connectors. Extract any packaging foam if present.

D. Connect a ¼-inch outer diameter Teflon line to the analyzer's exhaust vent. An optional charcoal scrubber can be installed in the exhaust line if the operator and the agency chooses to do so. Run the end of the exhaust line so it vents to the outdoors. The exhaust line should be 10' or less.

E. Open the rear panel filter holder and install a 5-micron Teflon filter.

F. If the analyzer is being set up in the field, connect the sample line. Use a new piece of ¼-inch outer diameter Teflon tubing to connect one end of the sample line to the analyzer sample inlet and filter holder assembly. Connect the other end of the sample line to the laminar flow duct or funnel system. Be sure the tip of the sample line inlet within the laminar flow duct extends to the middle of the duct. Keep the overall length of the sample line as short as possible to ensure compliance with residency time requirements.

G. If the instrument is not installed with a permeation dryer, fill the desiccant canister (supplied with the instrument) with fresh Drierite or silica gel desiccant and connect the canister with a short piece of Teflon tubing to the "Dry Air" inlet located on the rear of the analyzer. A particulate filter should be installed between the dryer canister and the analyzer.

H. Check the internal option switches on the left front corner of the motherboard. Set the switches as follows:

Switch #	Position
1	OFF
2	OFF
3	OFF
4	OFF
5	OFF
6	ON
7	OFF
8	OFF

I. Connect the instrument to the DAS via analog wires or ethernet for a digital connection. The data logger must be initialized and calibrated before official data collection begins. Refer to the appropriate SOP for specific data logger operation.

J. Connect the power cord to the rear of the analyzer and plug in to a grounded 110 120 VAC outlet.

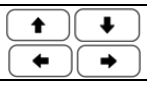
9.3.2 Front Panel Controls

A. Description of Controls

The operation of the analyzer is based on menu-driven software. Main menu selections on the NO_2 analyzer contain lists of submenu items such as operational parameters, functions, and controls. See the manufacturer's manual for more details and pictorials of this section, as necessary.

B. Push Keys and Switches

Table 9-1. Operational Push Keys and Switches

Name	Key	Description
Power Switch		Main power control for the analyzer. Rock it to the ON or OFF position.
RUN		Use to display the current concentrations on the run screen and exit menu and submenu options
MENU		Use to display the Main Menu operation selections and submenu screens.
ENTER		Use to select a menu item, save an entry, or toggle on/off functions.
ARROW		Use to move the cursor, navigate between options, or increase/decrease numerical values as needed.
HELP		Press to see additional information about the screen being displayed
SOFT		Located directly under the display screen, these keys provide customizable shortcuts to the functions listed on the bottom of the display.

9.4 Start-Up Procedures

9.4.1 Initiating Start-Up

A. Turn the analyzer's power switch on. If the analyzer is operating properly, the operator should note the following: the sound of the pump, and the RUN screen should be displayed.

B. Allow a minimum of 24 hours warm up time prior to initial analyzer calibration.

9.4.2 Configure Operation and Communication Settings

To set the instrument's operating parameters:

A. Press [MENU]  from the run screen to access the Main Menu.

B. To change any of the settings listed in the following procedures, move your cursor to the desired function in the menu and press [ENTER] ↵. Use the up ↑ and down ↓ arrow buttons to toggle through the setting options or increase/decrease numerical values, then press [ENTER] ↵ to save the selection.

C. Setting the Range

1. Place the instrument in service mode, which will allow the operator to access the service menu. From the Main Menu, select *SERVICE*, then select *RANGE MODE*. Select *SINGLE RANGE* and press [ENTER] ↵ to save the selection. Press Menu ■ to return to the Main Menu screen.

2. From the Main Menu, select RANGE and press [ENTER] ↵. Follow the prompts to set NO_2, NO and NO_X to the same range, **300 PPB**.

D. Instrument Control Settings

1. From the Main Menu ■, select *INSTRUMENT CONTROLS* and press [ENTER] ↵. Check the following Instrument Control functions to ensure they are configured to the proper setting:

   a. PMT (photo multiplier tube) is **ON**.

   b. Ozonator is **ON**.

   c. Temperature Correction is **ENABLED**.

   d. Pressure Correction is **ENABLED**.

E. Date/Time Settings

The internal clock of the analyzer must also be set to within ± 1 minute of the site data acquisition system (DAS).

1. From Instrument Controls ■, use the up ↑ and down ↓ arrow buttons to select DATE/TIME. Press [ENTER] ↵.

2. Use the [ENTER] ↵ button to edit the date and time. Use the up ↑ and down ↓ arrow buttons to adjust the values, and again press the [ENTER] ↵ button to save the entries.

3. Ensure that the analyzer time is within ±1 minute of the site DAS and a NIST time standard.

F. Alarm Settings

1. From the Main Menu, select *ALARMS* and press [ENTER].

2. Use the table below to set minimum and maximum values for the listed parameters:

Table 9-2. Alarm Settings

Parameter	Minimum	Maximum	Unit
Internal Temp	15.0	35.0	Deg. C
Chamber Temp	47.0	51.0	Deg. C
Cooler Temp	-5.0	-1.0	Deg. C
Converter Temp	300	350	Deg. C
Pressure	150.0	300.0	mmHg
Sample Flow Rate	0.400	1.0	Liters/min
Ozonator Flow Rate	0.050	0.150	Liters/min

WARNING: If the ozonator flow drops below 0.050 liters/min the ozonator will overheat, potentially causing permanent damage.

G. Setting Instrument Averaging Time

1. From the Main Menu, select *AVERAGING TIME* and press [ENTER].

2. Set averaging time to sixty seconds (60s).

H. Internal Data Back Up

The analyzer has the ability to retain data records (short and long records) for back up and diagnostic purposes. The Thermo iPort software installed on the site computer/laptop will allow access to the analyzer by serial cable or Ethernet connection with the IP of the analyzer. For additional information refer to the iPort instruction manual and the analyzer operations manual.

iPort is the proprietary software provided by ThermoFisher Scientific that can also be used for remote diagnostics and instrument functionality.

The data logger data should lineup and match the data in the analyzer. Make sure the recorded parameters in the analyzer and the data logger are identical to ensure the correct data will be available in the event that data recovery is needed.

If available, backup data from the analyzer may be used in the event the data logging and communication system fails. Refer to the analyzer instruction manual for instructions on downloading backup records and contact the appropriate staff for instructions on how to restore data from the backup records.

I. Communications Setup

The TEI 42i analyzer can communicate with the data logger or computer via network connections. Network connections are unique to the agency's IT protocols. Consult the

appropriate staff and/or IT personnel for the correct communication setting configuration. To configure communication settings, access the INSTRUMENT CONTROLS menu, navigate to COMMUNICATION SETTINGS and push [ENTER] ↵. As communication setting information will differ by agency, consult the appropriate personnel for a reference of applicable codes, Device IDs, and communications settings.

J. Internal Temperature and Pressure Probe Calibration

See section 11.3G and 11.3H for full procedures to calibrate the instrument's internal temperature and pressure probe.

K. Instrument Calibration

Prior to ambient air monitoring, see section 10.0 for instrument calibration procedures.

L. Leak Check

Ensure there are no internal leaks within the analyzer by checking all fittings and internal tubing. Tighten fittings and/or replace fittings and tubing if necessary.

10.0 INSTRUMENT CALIBRATION

The purpose of the calibration is to determine the NO, NO_2 and NO_X relationship between the analyzer and the true NO and NO_2 concentrations. This procedure involves the gas phase titration (GPT) of a NO standard with O_3 to produce NO_2. This method is based upon the rapid gas phase reaction between NO and O_3 to produce stoichiometric quantities of NO_2.

$$NO + O_3 \rightarrow NO_2 + O_2$$

The calibration procedure is used to document the relationship between the gas concentration measurements made by the analyzer and known concentrations. FDEP PQAO relies upon this documented relationship to establish the legal traceability of the ambient NO_2 measurements subsequently made by the analyzer.

Using linear regression, a calibration relationship is determined using the indicated values of the analyzer and the actual values from the calibrator. The calibration data is saved for use as a point of reference for subsequent calibrations.

In this procedure, the Field Technician uses a calibrator and zero air system to provide the analyzer with zero air and the four concentrations of NO, NO_X, and NO_2 over the analyzer's measurement range. Whether adjusted or unadjusted, during calibration the analyzer will be tested at the following concentrations:

Table 10-1. Calibration and Multipoint Verification Check Levels

Event	**NO/NOx Linearity**	**NO_2 Linearity (GPT)**	
	NO/NOx Levels (ppb)	NO Levels (ppb)	NO_2 Levels (ppb)
Zero event	0	0	0
Span event	270	270	240
Upscale Point 1	175		175
Upscale Point 2	100		100
Precision	80		34

All calibration gas must pass through the entire sample line used during normal operation. The analyzer's response to each concentration is recorded and, if necessary, the analyzer is adjusted to accurately measure the NO/NO_x and NO_2 gas concentrations. Multiple gas concentrations are used to allow the analyzer's linearity to be assessed. The procedure requires the Field Technician to use the front panel of the calibrator to set the zero and several known concentrations to challenge the analyzer.

Multi-Point Verifications are QC checks performed using the concentration levels and procedures similar to adjusted calibrations. The exception is no adjustments are made to the analyzer background and span coefficients Frequency

10.1 Frequency

The analyzer is required to be verified prior to its use in collecting ambient $NO/NO_2/NO_x$ data that may be reported to FDEP's air quality database. The analyzer must be calibrated under the following conditions:

A. Prior to the resumption of ambient data collection following any repairs or service that might affect its calibration.

B. At least every 90 days,

C. Following a biweekly zero response which exceeds ±5 ppb, a bi-weekly span response that exceeds 10% relative difference for NO or NO_2, or precision response that exceeds 15% relative difference for NO or NO_2 (strongly encouraged if exceeds the warning limits of 12% relative difference).

D. Following any multipoint QC check where the span, upscale and precision audit points exceed ± 2% of the calibration curve, best-fit straight line. The calibration assessment is between the analyzer response and the best fit concentration determined by the linear regression line.

E. Upon any indication of analyzer malfunction or change in calibration.

This includes exceedance of the control limits during bi-weekly checks.

F. After major repair, maintenance or adjustment, or physical relocation.

G. Following an interruption in operation of more than 72 consecutive hours.

10.2 Documentation of Calibration

To ensure the accuracy of the calibration record, the operator must systematically document the calibration process using only approved calibration forms and procedures. All relevant observations or other information must be recorded immediately. The calibration form (DEP 09-2-B must be completed in its entirety, including the heading. Calibration forms may be printed and filled out or filled out electronically. Some information that is unlikely to change from year to year may be added to an agency's template of the form. Examples include the site name and AQS number, the instrument serial number, and the calibration gas cylinder information. However, it is the operator's responsibility to ensure that any pre-printed information contained on any form is correct. In the event any of the pre-printed information changes (e.g., temporary use of replacement equipment), the operator should use standard initialed strikethrough(s) to correct the information.

All primary records (e.g. records documenting observations, or other relevant information, that cannot be obtained from another more direct or reliable source) must be dated and signed

by the operator and retained as part of the permanent analyzer calibration record. The operator's signature on the calibration form certifies that the calibration has been performed in accordance with this SOP and that the information contained on the form, including any pre-printed entry, is accurate. Calibration records must be reviewed and initialed by the agency QA Coordinator, QA staff, or another knowledgeable authority to verify that they are legible and complete. Electronic signatures are acceptable if they are secured by a unique password.

The current year calibration records should be kept at the site, or be accessible from the site, in electronic format or at the site in hard copy form.

10.3 Calibration Procedures

10.3.1 Pre-Calibration

A. Ensure the analyzer has warmed up at least 24 hours and is on normal auto sampling mode.

B. If the instrument has been officially collecting ambient data, perform a ZSP check (see section 12.1.2 of this SOP.) Otherwise, proceed with the calibration procedure.

C. Set up equipment as follows:

1. **Nitric Oxide (NO) Cylinder Pressure Regulator** - Install a pressure gauge on the NO tank. Purge the tank by opening the valves. Allow the cylinder gas to vent out by either using an exhaust line or opening the doors to the shelter. The suggested amount of time to leave the valves open is about 10-20 seconds. After the cylinder has been purged, close the regulator valves, and restore the pneumatic connection between the gas cylinder and the dilution calibrator. Reopen the valves and make sure there are no leaks.

2. **NO Standard Connection** – The NO gas cylinder regulator is connected to the calibrator output port with stainless steel fittings and 1/8" tubing. Keep the tubing as short as possible. Check the certification date to ensure the cylinder was certified according to a valid EPA protocol. Do not use the tank if not properly certified or if the cylinder pressure is less than 200 psig.

   Gas Phase Titration (GPT) Calibrator and **Output Manifold** - If the calibration unit has not been in operation, turn on the power and allow at least 30 minutes for the calibrator to warm up. Connect a clean line of tubing from the calibrator output port to the output manifold or the primary standard line that forms a T connection with the sample line. For more detail regarding the calibrator settings, please refer to the SOP and operations manual relevant to the calibrator model available at the site.

3. **Dilution Air System** - Check to ensure the dilution air system is properly maintained (silica gel is blue or orange, filter and scrubber materials replaced within prescribed maintenance intervals, etc.). Maintain if necessary. Connect the air coming from the

zero-air system to the zero-air inlet on the back of the calibrator. Make sure the pressure meets operational requirements for the calibrator model to ensure proper operation and avoid damage to the calibrator's mass flow controllers.

D. Record operational information (flow rates, chamber & cooler temperature, and pressure) on the daily check form (see section 12.1.1). Set calibrator to supply zero air.

E. Prepare the calibration form DEP 09-2-B. The form must be filled electronically for the calculations to be performed automatically. Record the following information into the calibration form DEP 09-02-B:

1. Identification Block

    a. **Date, site name** and **AQS ID number,** Operator's **name**. For **Procedure,** select *Calibration/Verification* from the drop down menu.

    b. **Instrument (analyzer)** manufacturer ("Thermo"), model ("42i"), serial number, and date last calibrated (if not applicable, record N/A)

    c. **Data Logger** manufacturer, model, serial number, and last certification date

    d. **Calibrator** manufacturer**,** model, serial number, and last calibration date

    e. **Zero Air System** manufacturer, model, serial number, scrubber service date

2. Standards Block

    a. **Nitric Oxide (NO) Gas Cylinder** serial number, NO concentration, date certified, initial tank pressure reading, NO_X concentration, and expiration date. These NO and NOx values are very important and are used in multiple calculations throughout DEP-09-02-B. Record tank concentrations in parts per million (ppm).

F. Pre-Calibration Setup

1. Using the data logger, "disable" the data logger channels for NO, NO_2, and NO_X (see standard operating procedures for the relevant data logging system) and enter the "Channel Off-Line" time on the calibration form. Set the data logger/computer for real time, continuous display of one-minute averages for NO, NO_2, and NO_X.

Note: The operator may consider beginning the procedure after 45 minutes from the top of the hour to capture a valid ambient hourly reading as a best practice.

2. Ensure the calibrator output is connected to the analyzer sampling system. Adjust the calibrator to supply dilute (zero) air.

3. Allow the analyzer to sample zero air for at least ten minutes to ensure a stable response.

NOTE: For calibration and linearity checks, stability is defined to be at least 10 consecutive points of one-minute averages within ±3 ppb, with no clear upward or downward trend. The zero calibration must be within ±2 ppb.

Maintenance NOTE: The SLIC should be performed ***before*** the NO/NO_x linearity check or ***after*** all linearity checks are complete so as not to interrupt the check for the linearity of the analyzer's response curve. See 10.4.7 for SLIC procedure.

10.3.2 NO/NOx Multipoint Calibration

NOTE: If performing an unadjusted multi-point QC check, skip to step 10.4.2G below.

A. Adjusted Zero Calibration

NOTE: If performing an unadjusted multi-point QC check, skip to step 10.3.2D below.

1. Calibrate NO Background

    a. From the Main Menu ▪ of the analyzer, select CALIBRATION, and then select CAL NO BACKGROUND.

    b. Press enter ↵ to set the NO reading to zero and store the new background offset.

    c. Press the menu key ▪ to return to the Calibration menu.

2. Calibrate NO_X Background

    a. From the CALIBRATION menu, select CAL NOX BACKGROUND.

    b. Press enter ↵ to set the NOX reading to zero and store the new background offset.

    c. Press the run key ▸ to return to the run screen.

3. Continue to run the zero point until the readings have stabilized. The analyzer NO, NO_2, and NO_X readings should be zero ± 2 ppb with no upward or downward trend. If not, recalibrate NO and NOx background.

4. Observe the readings for at least 10 minutes to ensure the zero calibration is satisfactory and stable.

B. Adjusted NO/NO_X Span Calibration

Ensure that the calibrator is connected to the input port of the calibrator, and is receiving flowing gas from the NO tank, per the instructions provided in the applicable calibrator SOP.

1. Calibrate NO Span Coefficient

    a. Set the calibrator to adjust NO flow from the standard NO cylinder and multi-gas calibrator to generate a NO concentration of about 270ppb, 90% of the current full scale desired for the calibration (do not exceed 270 ppb)

    b. Allow the analyzer to sample the span NO calibration gas until the NO, NO_2, and NO_X readings on the data logger have stabilized. Note: NO_2 should be stabilizing around zero ± 2 ppb.

    c. Record the calibrator's gas and zero air flows (cc/min) on the calibration form under the NO Calibration block, next to the Span point. Calculate the NO concentration being delivered by the calibrator using Equation 10-1.

NOTE: These values will be automatically calculated throughout the calibration when using the Microsoft Excel version of Form No. DEP-09-02-B. Otherwise, the operator will have to complete this calculation manually and enter the results in the hardcopy version of DEP Form 09-02-B:

Equation 10-1. NO Gas Concentration from Calibrator

$$NO\ Output\ = \frac{Fg}{Fg + Fz} \times Cg$$

Where:
Fg = Actual NO gas flow (l/min)
Fz = Actual Zero Air flow (l/min)
Cg = NO gas concentration in cylinder (ppb)

    d. From the Main Menu [▪] of the analyzer, select *CALIBRATION*, and then select *CAL NO COEFFICIENT*.

    e. The *NO* line of the Calibrate NO screen displays the current NO concentration. Enter the calculated NO span concentration (from Equation 10-1 above) next to the *SPAN CONC* line of the display. Use the left and right arrow keys [←] [→] to move the cursor and use the up and down arrow keys [↑] [↓] to increase and decrease the numeric character at the cursor.

    f. Press [ENTER] [↵] to store the calibrated NO span concentration.

    g. Press [MENU] [▪] to return to the Calibration menu.

2. Calibrate NO_X Span Coefficient

a. Continue sampling of NO span gas.

b. From the Calibration menu, select *CAL NOX COEFFICIENT*.

c. Form DEP 09-2-B calculates the NO_X calculation being delivered by the calibrator using Equation 10-2 below.

Equation 10-2. NO_X Gas Concentration from Calibrator

$$NOx\ Output\ = \frac{Fg}{Fg + Fz} \times Cg$$

Where;
Fg = NO_X gas flow (l/min)
Fz = Zero Air flow (l/min)
Cg = NO_X gas concentration in cylinder (ppb)

d. The **NO_X** line of the Calibrate NO_X screen displays the current NO_X concentration. Enter the known NO_X calibration gas concentration next to the **SPAN CONC** line of the display.

e. Press [ENTER] ↵ to store the calibrated NO_X span concentration.

f. Press the run key ▸ to return to the run screen.

g. Continue to run the span point. Allow time for 10 stable one-minute average readings, as displayed from the data logger. The readings should be with 2% of the known concentration of the calibration gas. Record 10 one-minute readings on the calibration form, which will calculate the average (09-2-B).

C. Review Calibration

1. Re-initiate the zero event to review any drift caused by the NO/NOx calibration. Although the acceptable level of zero drift within 24 hours of calibrating the zero offset is < ± 3.1 ppb, the zero response is typically within ± 1.0 ppb during this review.

2. If necessary, adjust the calibration coefficients by repeating the NO and NOx span coefficient calibration steps above, until satisfied that the calibration will achieve the best linearity of the calibration curve. When satisfied with the calibration, the technician will begin recording the multipoint calibration check on the calibration form, DEP 09-02-B.

   NOTE: Do not attempt to calibrate the analyzer at the precision points or upscale points. The analyzer is only calibrated at the zero and span points. All other points are run to check the linearity of the analyzer.

D. NO/NOx Linearity Checks

Once the NO/NOx background and coefficient adjustments are set (or unadjusted if performing a Multipoint Verification), proceed with the NO/NOx Linearity Checks.

1. Initial Zero Check (0 ppb)

    a. Configure the calibrator to supply dilution (zero) air to the analyzer.

    b. On DEP Form 09-2-A&B, under the NO calibration block, record the calibration's Dilution air flow (cc/min or LPM) for the Zero event (gas flow should be 0 during this event).

    c. Allow the analyzer NO/NO_X responses to stabilize. Record 10 consecutive 1-minute averages of Observed NO and Observed NOx on the Calibration Form Data Entry Sheet in the NO/NOx Calibration boxes in the Zero column.

2. Span Check (270 ppb)

    a. Set the calibrator to adjust NO flow from the standard NO cylinder and multi-gas calibrator to generate a NO concentration of about 90% of the current full scale desired for the calibration (do not exceed 270 ppb)

    b. Record the calibrator's gas and zero air flows (cc/min or LPM) on the calibration form under the NO Calibration block, next to the Span event.

    c. Allow the analyzer to sample the span NO calibration gas until the NO, NO_2, and NO_X readings on the data logger have stabilized.

    d. Allow the analyzer NO/NO_X responses to stabilize. Record 10 consecutive 1-minute averages of Observed NO and Observed NOx on the Calibration Form Data Entry Sheet in the NO/NOx Calibration boxes in the **Span** column.

3. Upscale 1 Check (175 ppb)

    a. Adjust the calibrator to generate a NO concentration of approximately 175 ppb for the analyzer to sample. Record the calibrator's gas and zero air flows (cc/min or LPM) on the calibration form under the NO Calibration block, next to the **Upscale 1** event.

    b. Allow the analyzer NO/NO_X responses to stabilize. Record 10 consecutive 1-minute averages of Observed NO and Observed NOx on the Calibration Form Data Entry Sheet in the NO/NOx Calibration boxes in the **Upscale 1** column.

4. Upscale 2 Check (100 ppb)

    a. Adjust the calibrator to generate a NO concentration of approximately 100 ppb for the analyzer to sample. Record the calibrator's gas and zero air flows (cc/min or LPM) on the calibration form under the NO Calibration block, next to the **Upscale 2** event.

b. Allow the analyzer NO/NO_X responses to stabilize. Record 10 consecutive 1-minute averages of Observed NO and Observed NOx on the Calibration Form Data Entry Sheet in the NO/NOx Calibration boxes in the **Upscale 2** column.

5. Precision Check (80 ppb)

   a. Adjust the calibrator to generate a NO concentration of approximately 80 ppb for the analyzer to sample. Record the calibrator's gas and zero air flows (cc/min or LPM) on the calibration form under the NO Calibration block, next to the **Precision** event.

   b. Allow the analyzer NO/NO_X responses to stabilize. Record 10 consecutive 1-minute averages of Observed NO and Observed NOx on the Calibration Form Data Entry Sheet in the NO/NOx Calibration boxes in the **Precision** column.

10.3.3 NO_2 Span Calibration - Gas Phase Titration

NOTE: It is recommended that the same calibrator flows for gas and zero air be used for all the NO_2 (GPT) calibrations. If this is done, the same impurity concentration can also be used for the calibrations. The calibrator's ozonator level will determine the amount of NO_2 that will be converted and subsequently measured by the analyzer. If the NO and NO_X values of the gas cylinder are the same, it is assumed that there are no impurities.

A. Adjust the calibrator to re-establish an NO Span concentration of no more than 270 ppb (90% full scale), delivered to the analyzer. Record the calibrator's gas and air flows on the Calibration form under the Gas Phase Titration box, next to **NO Orig Calculation.** Sample this concentration until the analyzer's NO and NO_X responses have stabilized. The Calibration form will automatically generate a calculated NO orig using **Equation 10-1**.

B. Adjust the ozone generator in the calibrator to provide sufficient ozone to produce generate an NO_2 concentration of approximately 240ppb (approximately 30ppb of NO remaining). Sample this concentration until the responses have stabilized. After the analyzer responses stabilize, average 10 minutes of NO, NO_X, and NO_2 values. Determine the corrected NO remaining and known NO_2 concentration using the following equations:

Equation 10-3. Calculated NO_2

$$NO_2 = NO_{ORIG} - NO_{REM} + NO_{2\,IMP}$$

Where:

NO_{ORIG} = NO concentration before ozone generation, as calculated using **Equation 10-1**.

NO_{REM} = Observed NO concentration remaining: read from the stabilized response after GPT of not less than 10% of the NO_{ORIG} value.

$NO_{2\ IMP}$ = NO_2 impurities in the NO cylinder. This is the ppb value of NO_2 impurities diluted by the calibrator's gas and zero air flows during gas phase titration. (If NO=NOX in the cylinder, there are no impurities in the cylinder).

C. Calibrate NO_2 Span Coefficient

NOTE: If performing an unadjusted Multipoint Verification, skip to step 10.3.3D below.

1. From the Calibration menu on the analyzer, select [**CAL NO2 COEFFICIENT]**.

2. The **NO2** line of the Calibrate NO_2 screen displays the current NO_2 concentration. Enter the known NO_2 calibration gas concentration next to the **SPAN CONC** line of the display.

3. Press enter ↵ to store the calibrated NO_2 span concentration.

4. Press run key ▸ to return to the run screen

5. Continue to run the NO_2 span point. The NO_2 readings should be with 2% of the known NO_2 concentration of the calibration gas; if not, recalibrate.

D. NO_2 Linearity Checks

1. NO_2 Span (240 ppb)

   a. Adjust the calibrator's ozone generator to generate approximately 240 ppb of NO_2 for the analyzer to sample

   b. Record the target O_3 concentration for the NO_2 span event on the Calibration Form in the NO_2 Check table, next to the Span event in the O_3 column.

   c. Allow the analyzer responses to stabilize. Record 10 consecutive one-minute averages, as displayed from the data logger, on the Data Entry Worksheet in the Gas Phrase Titration cells in the Span columns for each respective channel (NO, NO_2, NOx). The form will calculate impurities and calculated NO_2 concentration using Equation 10-3.

2. Upscale 1 Check (175 ppb)

   a. Adjust the calibrator's ozone generator to generate approximately 175 ppb of NO_2 for the analyzer to sample.

   b. Record the target O_3 concentration for the NO_2 Upscale 1 event on the Calibration Form in the NO_2 Check table, next to the Upscale 1 event in the O_3 column.

c. Allow the analyzer responses to stabilize. Record 10 consecutive one-minute averages, as displayed from the data logger, on the Data Entry Worksheet in the Gas Phrase Titration cells in the Upscale 1 column for each respective channel (NO, NO_2, NOx). The form will calculate impurities and calculated NO_2 concentration using Equation 10-3.

3. Upscale Pt. 2 (100 ppb)

   a. Adjust the calibrator's ozone generator to generate approximately 100 ppb of NO_2 for the analyzer to sample.

   b. Record the target O_3 concentration for the NO_2 Upscale 2 event on the Calibration Form in the NO_2 Check table, next to the Upscale 2 event in the O_3 column.

   c. Allow the analyzer responses to stabilize. Record 10 consecutive one-minute averages, as displayed from the data logger, on the Data Entry Worksheet in the Gas Phrase Titration cells in the Upscale 2 column for each respective channel (NO, NO_2, NOx). The form will calculate impurities and calculated NO_2 concentration using Equation 10-3.

4. NO_2 Precision Point (34 ppb)

   a. Adjust the calibrator's ozone generator to generate approximately 34 ppb of NO_2 for the analyzer to sample.

   b. Record the target O_3 concentration for the NO_2 Precision event on the Calibration Form in the NO_2 Check table, next to the Precision event in the O_3 column.

   c. Allow the analyzer responses to stabilize. Record 10 consecutive one-minute averages, as displayed from the data logger, on the Data Entry Worksheet in the Gas Phrase Titration cells in the Precision column for each respective channel (NO, NO_2, NOx). The form will calculate impurities and calculated NO_2 concentration using Equation 10-3.

10.3.4 Post-Calibration: Ending Zero

A. Allow the calibrator to supply zero air to the system until the analyzer reads 0.3 ppb or less for all parameters NO_X, NO, and NO_2. Ensure the NO gas cylinder is no longer supplying gas to the calibrator.

B. Record 10 consecutive one-minute averages, as displayed from the data logger, on the Data Entry Worksheet in the Gas Phrase Titration cells in the Zero column for each respective channel (NO, NO_2, NOx).

C. Adjust the calibrator and/or sampling system to allow the analyzer to sample ambient air.

D. Put the NO, NO_2, and NO_x channels on the DAS back to ambient mode by enabling the channels and record the time of the Channel On-line in the Data Logger Status block of the calibration form.

E. Record the analyzer's post-adjustment calibration factors (if applicable) on the Calibration Form in the comments.

F. Complete the calibration form by adding any pertinent comments. Then sign and date the form and submit it to the QA staff for review.

10.3.5 Sample Line Integrity Check

In this procedure, the Field Technician must determine if contamination of the sample line is adversely affecting ambient NO_2 measurements made by the analyzer. This check is required to be performed once per quarter and whenever visible moisture is observed in the sample line or sample line filter. It may also be performed at any time the Field Technician suspects the sample line has become contaminated. If the sample lines are contaminated, the entire sample line must be cleaned or changed.

The Field Technician performs a SLIC after all maintenance and adjustments to the analyzer are complete. It must be followed by a QC check, either ZSP or a multipoint linearity check, prior to resuming ambient air data collection. Therefore, the SLIC may be performed before the multipoint linearity check so as not to interrupt the check for the linearity of the analyzer's response curve. However, if the SLIC is performed after the multipoint linearity check, the technician must complete a post-maintenance ZSP check, after the SLIC tubing has been removed and the sample line has been placed back into configuration.

Some agencies have safety protocols in place that determine how field technicians decide whether to leave the span gas running during the line changes, or to turn off gas generation and/or flow from the calibrator so that only dilution (zero) air is running during the configuration transitions. Consult with your QA coordinator to identify the SLIC approach (Zero/Span/Zero or Span Only) used within your network.

Equation 10-4 below will calculate the relative percent difference between the data logger response through its normal sample line and through the clean SLIC line:

Equation 10-4. SLIC Relative Percent Difference

$$\%\ Diff = \frac{Response\ (ppb)\ through\ sample\ line - Response\ (ppb)\ through\ SLIC\ line}{Response\ (ppb)\ through\ SLIC\ line} \times 100$$

If the calculated difference is ≤ ±2%, the analyzer's sample line is approved for further use without additional effort.

If the calculated difference is greater than ± 2%, the analyzer's sample line must be cleaned or replaced before resuming ambient data collection. Replace/recheck the sample line until the calculated results are within 2%. Record whether a "span only" or "zero-span-zero" procedure was performed in the "Comments" section of the calibration form.

A. Zero-Span-Zero SLIC Procedure

1. While the analyzer is sampling zero air from the calibrator, disconnect the sample line between the analyzer and multi-gas calibrator and replace it with the SLIC tubing assembly. The SLIC tubing will connect the "Output" fitting of the multi-gas calibrator and the "Sample" fitting of the analyzer. The vent located on the SLIC line "TEE" can be vented to any external vent that is available.

2. Adjust the ozone generator on the calibrator to supply 240 ppb of NO_2. Record the calibrator gas flow, dilution flow, and ozone values on the Calibration form in the SLIC block, next to the SLIC event.

3. Allow the analyzer responses to stabilize. Record 10 stable one-minute average readings, as displayed from the data logger on the Data Worksheet in the SLIC Worksheet box, in the SLIC column.

4. When finished, turn off ozone generation and gas flow and set the calibrator to supply zero air to the system, then disconnect the SLIC line from the calibrator, analyzer, and vent. Re-install the original sample line in the same configuration as before the SLIC.

5. Adjust the calibrator to the same settings used in generating the NO_2 span concentration, as done in step 2. Record the calibrator gas flow, dilution flow, and ozone values on the Calibration form, next to the SPAN event.

6. Allow the analyzer responses to stabilize. Record 10 stable one-minute average readings, as displayed from the data logger on the Data Worksheet in the SLIC Worksheet box, in the SPAN column.

7. When finished, set the calibrator to supply zero air to the system, and then calculate the SLIC percent difference (performed automatically by the form). The form will indicate whether the result is satisfactory with a "PASS" or unsatisfactory with a "FAIL."

B. Span Only SLIC Procedure

1. Disconnect the sample line between the analyzer and multi-gas calibrator and replace it with the SLIC tubing assembly. The SLIC tubing will connect the "Output" fitting of the multi-gas calibrator and the "Sample" fitting of the analyzer. The vent located on the SLIC line "TEE" can be vented to any external vent that is available.

2. Adjust the ozone generator on the calibrator to supply 240 ppb of NO_2. Record the calibrator gas flow, dilution flow, and ozone values on the Calibration form in the SLIC block, next to the SLIC event.

3. Allow the analyzer responses to stabilize. Record 10 stable one-minute average readings, as displayed from the data logger on the Data Worksheet in the SLIC Worksheet box, in the SLIC column.

4. When finished, disconnect the SLIC line from the calibrator, analyzer, and vent. Re-install the original sample line in the same configuration as before the SLIC.

5. Record the calibrator gas flow, dilution flow, and ozone values on the Calibration form, next to the SPAN event.

6. Allow the analyzer responses to stabilize. Record 10 stable one-minute average readings, as displayed from the data logger on the Data Worksheet in the SLIC Worksheet box, in the SPAN column.

7. When finished set the calibrator to supply zero air to the system, and then calculate the SLIC percent difference (performed automatically by the form). The form will indicate whether the result is satisfactory with a “PASS” or unsatisfactory with a “FAIL.”.

11.0 INSTRUMENT MAINTENANCE

Maintenance must not bias the data in any way, therefore any maintenance, which could cause the analyzer to respond differently, is to be done after a ZSP check and before an adjusted calibration. Major part replacements, such as pumps, lamps, etc, should be recorded on the Historical Maintenance record (DEP 09-02-E).

Maintenance which wouldn't affect analyzer readout, such as a sample filter change, generally should be done after a ZSP check is performed and should be followed by a post-maintenance ZSP check to ensure normal operation before returning to ambient air sampling. Both ZSP checks must be thoroughly documented on separate forms.

$$Percent\ Difference = \frac{AR - BR}{BR} \times 100\%$$

Where:

AR = "After" maintenance span response
BR = "Before" maintenance span response

"Before" and "after" span responses for sample line maintenance such as filter change, line cleaning or replacement, etc., must differ no more than ± 2%. A multi-point calibration of an analyzer is necessary after major maintenance that causes a response change exceeding ± 2%.

11.1 Scheduled Maintenance

Regular preventive maintenance is essential to ensure data quality and to reduce equipment failure and down time. See table below for the schedule of preventive maintenance tasks:

Table 11-1. Schedule of Preventive Maintenance

Preventive Maintenance Task	Frequency (at minimum)	SOP Section
Zero, span, and precision checks	Every 14 days	12.1.2
Inspect/Change Desiccant (if applicable)	Every 14 days	11.3A
Check converter efficiency	Every 14 days	12.1.3
Change external sample line filter	Every 90 days (more frequent if necessary)	11.3B
Multi-Point Calibration/Verification	Every 90 days	10.0
Clean fins and fan	Semi-Annually	11.3D
Change Ozone Cleanser	Semi-Annually	11.3E
Clean or replace the sample line	Annually (more frequent if necessary)	11.3F
Calibrate Temperature Sensor	Annually	11.3G
Calibrate Pressure Sensor	Annually	11.3H
Inspect and/or clean capillaries and O-rings	Annually	11.3I

11.2 Documentation of Maintenance

Record all scheduled maintenance on the Analyzer Maintenance Schedule (DEP 09-2-C) and on the Equipment Status Report (DEP 09-2-A). Record major parts replacements, pumps, sensors, etc, on the Historical Maintenance record (DEP 09-02-E).

11.3 Specific Maintenance Procedures

A. Change Desiccant in Ozonator Inlet Air Dryer

NOTE: Perform this maintenance if a Permeation Dryer is not installed in the analyzer.

1. Desiccant (Drierite or silica gel) should be inspected during each site visit check and replaced more often if necessary.

2. Replace before the blue or orange color of the desiccant is gone. If the desiccant needs to be changed, change at the beginning of the zero event of a ZSP check or before a calibration.

B. Teflon Sample Inlet Filter

The sample line air filter contains a Teflon element which should be replaced every 3 months (90 days), or more frequently if necessary. Perform a ZSP check prior to the change, followed by a GPT Span check and a final zero check before resuming ambient air sampling.

Replace the filter as follows:

1. Loosen the clamping device, open the filter assembly, and remove the Teflon element.

2. Install the new filter element, close the assembly, and tighten the clamping device.

3. Reinstall the sample air filter assembly in the sample line ensuring that the INLET side is toward the manifold.

C. Sample Pump

It is essential that a constant vacuum be maintained on the analyzer by the sample pump. The pump is to be inspected by checking internal diaphragms, valves, etc. Rebuild or replace if the pump cannot provide an adequate measured flow or vacuum. Refer to the instrument manual for rebuilding or replacing the pump.

D. Thermoelectric Cooling Fans and Analyzer's Internal Components

1. With a container of compressed air, spray off the cooling fins.

2. Use a brush or cloth to remove any remaining dust or debris.

E. Sample Line

Clean or replace the entire sample line annually. Perform ZSP checks before and after sample line maintenance, in addition to a SLIC check prior to the post maintenance ZSP. Refer to program QA coordinator for agency procedures for cleaning or replacing sample lines.

F. Temperature Transducer Calibration

Follow steps below to check the temperature of the temperature transducer which measures the internal case temperature. Perform this procedure between a pre-maintenance ZSP check and a post-maintenance ZSP or an adjusted calibration.

1. Enter site, analyzer, and thermometer information on the Sensor Data form.
2. If necessary, allow the analyzer to warm up. Remove the analyzer top cover.
3. Place the tip of a NIST-traceable thermometer probe near the thermistor on the motherboard assembly.
4. Display the analyzer temperatures screen.
5. After the digital thermometer reading has stabilized, record the thermometer reading and internal temperature readings on the form in the unadjusted readings column.
6. If the analyzer reading does not agree with the digital thermometer reading, ± 2 degrees Celsius, perform an adjustment:
7. From the Main Menu, select Instrument Controls, then Service Mode. Press enter to turn Service Mode on.
8. From the Main Menu select Service, then scroll to Temperature Calibration and press enter.
9. At the Temperature Calibration Screen enter the known temperature value on the line, press enter and recheck stabilized reading.
10. Record the adjusted thermometer temperature & analyzer readings on the form as the adjusted readings.
11. When complete, remove the thermometer probe and replace the analyzer cover. Sign and date the Sensor Data form.

G. Pressure Transducer Calibration

1. Remove the analyzer cover and disconnect the tubing to the transducer box (located at the front of the analyzer). Allow a few minutes for readings to stabilize.

2. Display the analyzer pressure screen. Record the barometer and analyzer pressure readings on the form, in the unadjusted readings column, after they stabilize.

3. If the analyzer reading is not within ± 2 mm Hg of the barometer, perform adjusted calibration:

4. Disconnect the tubing from the transducer assembly.

5. From the Main Menu, select Instrument Controls, then Service Mode. Press enter to turn Service Mode on.

6. From the Main Menu select Service, then scroll to Pressure Calibration and press enter. At the Pressure Sensor Cal Screen select Span.

7. Wait for the pressure reading to stabilize, then enter the known ambient pressure value on the line and press Enter.

8. Recheck the stabilized reading. Document on the form as adjusted readings.

9. Reconnect the transducer tubing and replace cover. Sign and date the Sensor Calibration form.

H. Capillaries and Associated 'O' Rings

1. This operation should be done between a z/s/p check and a calibration. Follow below for this maintenance procedure.

2. Turn the power off to the analyzer

3. Remove the instrument cover and locate the capillary holders.

4. Remove fittings from the reaction chamber block. A 5/16-inch wrench may be required.

5. Remove the glass capillaries and 'O' rings. Inspect for cuts, abrasions. Replace the 'O' ring(s) if necessary.

6. Inspect the inside of the capillaries for dirt or deposits. Clean or replace as necessary.

7. Replace the capillary in the reaction chamber block, making sure the 'O' ring is around the capillary before inserting it into the block.

8. Reassemble all components, replace the instrument cover, and turn the power back on.

12.0 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance is a system of management and operational activities designed to ensure that the data produced by the operation of the analyzer will be of the type and quality needed and expected by the data user. Quality control defines the procedures implemented to assure that acceptable precision, bias, completeness, representativeness, and comparability are obtained and maintained in the generated data set. Quality control procedures, when properly executed, provide data that meet or exceed the minimally acceptable quality criteria established to assist management in making confident decisions. It is the policy of the department to implement a QA program and QC procedures to assure that data of known and acceptable precision, bias, completeness, comparability, and representativeness are collected from all monitoring projects. The following procedures and their associated intervals are used to manage the quality of data generated by the analyzer:

Table 12-1. QA/QC Schedule

Parameter/Description	Acceptance Criteria	Frequency
One Point QC Precision Check	±15.1% or ± 1.5ppb whichever is greater(corrective action when ±10.1% warning limit exceeded)	Minimum every 14 days
Zero/Span check	± 3.1 ppb 24hr ± 5.1 ppb for zero check (>24hr-14day) ± 10.1% for span check	Minimum every 14 days
Converter Efficiency	≥ 96%	During calibrations, span check, and performance audit Minimum every 14 days
Sample Line Integrity Check	± 2.1%	Upon installation, sample line maintenance, or repair, minimum every 90 days
Multi-Point Calibration	Zero within ±1.5ppb, All points ±2.1% or ±1.5ppb difference of best fit straight line whichever is greater and slope of 1 ± .05	Upon initial installation; minimum every 90 days
Pressure Sensor - Check the analyzer pressure sensor reading against a NIST traceable standard	± 2.1 mmHg	Annually
Temperature Sensor - Check the analyzer bench temperature sensor of the analyzer against a NIST traceable standard	± 2.1°C	Annually

Parameter/Description	Acceptance Criteria	Frequency
Time Clock - Check analyzer time clock against the DAS/chronometer standard	± 1 min	Annually
DEP Performance Audit	Comparison of the analyzer response to a Florida DEP Transfer Standard	Annually

12.1 Quality Control Checks

This section covers zero checks, span checks, precision checks, and a number of other checks necessary to assure proper instrument operation and data validity.

Upon arrival at the site, prior to all operational procedures, visually inspect the site to ensure the sample line/probe inlet manifold is intact. Make sure there are no problems with trees beginning to grow too close the sample inlet. Inspect the sample shelter to make sure the building is in good condition. Finally, inspect the immediate area to make sure no conditions exist, which would cause biased samples. Note any problems in the logbook comments section. Should any problems be suspected with the analyzer, perform a ZSP check before investigating in order to determine the accuracy of the data.

12.1.1 Equipment Operations Check

An Equipment Status Report (DEP 09-02-A) is completed prior to any QC check, instrument maintenance, or calibration. It is used to document the shelter environmental conditions and diagnostic parameters of the analyzer. Once complete, the operator will sign, date, and submit the form to QA Staff for review and document retention in the agency Document Management System. The form is available by itself and as a sheet in form DEP 09-02-A&B.

A. Record the date, site information, manufacturer, model, serial numbers and calibration dates for the instrument, calibrator, and data logger in the Identification block.

B. Record the manufacturer, model, and serial number of the NIST Time standard.

C. If one or more operating parameters of the analyzer are outside their prescribed limits, an alarm (bell) icon will show on the Run screen in the bottom right-hand corner of the analyzer display. If present, access the Main Menu [▪], scroll to Alarms, and press enter [↵]. On the Equipment Status Report, record an asterisk (*) under Alarms Status and record the actions taken in the “Comments” section of the log. If no alarm is present, record “OK” in the Alarms Status column.

D. From the Main Menu [▪], select Diagnostics and press enter [↵]. Record the following values:

E. Temperatures: Record the internal, chamber and cooler temperatures (in degrees Celsius).

F. Pressure: Record the reaction chamber pressure reading (in mmHg). Normal Pressure approximately 150-300 mmHg. Values outside this range may indicate pump or capillary problems.

G. Record the sample flow rate. The sample should be 0.5 to 1.0 lpm and the ozonator should indicate OK. Values outside these ranges may indicate pump or capillary problems.

H. Navigate back to the Main Menu ( ), scroll to Calibration Factors and press enter ( ). Record the background and coefficient calibration factors.

I. Check the Analyzer Maintenance Schedule (DEP 09-2-C) for tasks due or that will be due before the next site visit. Checkmark the box when complete, or if no maintenance was needed.

12.1.2 Routine QC Checks: Zero, Span, Precision

Manual ZSP checks must be performed at least every 14 days (bi-weekly) if automated z/s/p checks are not performed. However, if the DAS/calibrator is configured for automated nightly z/s/p checks, then the routine manual QC checks may be performed every 30 days (monthly).

More frequent checks are permitted for diagnostic purposes or confirming instrument repairs.

All precision data is to be documented and reported to the FAMAS database. This specifically includes the "unadjusted" zero, span, and precision performed prior to a calibration. ZSP checks must also be performed under the following conditions (unless prevented by analyzer malfunction):

1. Immediately prior to a multipoint calibration of the analyzer unless prevented by its malfunction.

   NOTE: No checks are required prior to the calibration performed following the analyzer's initial installation (or re-installation) at the monitoring site.

2. Immediately prior to an intentional analyzer shutdown (e.g. hurricane, end of site operations etc.) that is likely to last longer than four (4) hours, unless prevented by its malfunction.

3. Immediately prior to performing any of the "major" maintenance procedures for analyzer described in the manufacturer's manual and/or addendum, unless prevented by its malfunction.

4. Prior to any other operation which is likely to affect the response of the analyzer (e.g., sample line cleaning or drying, sample filter replacement, voltage adjustment), unless prevented by its malfunction.

To perform the routine manual ZSP checks, the operator will follow the procedures below. All ZSP checks are documented on the 42i ZSP, Calibration and Verification Form (DEP 09-02-A&B). When complete, the operator will sign, date, and submit the calibration form to QA Staff for review and document retention in the agency Document Management System.

A. Pre-check Procedures

1. Before performing zero, span, or precision procedures, perform routine site and equipment operations checks.

2. Prepare the calibration form DEP 09-2-A&B. The form must be filled electronically for the calculations to be performed automatically. Fill out the requested information in the Identification and Standards blocks of Calibration Form DEP 09-02-A&B. For **Procedure,** select Z/S/P check from the drop-down menu.

3. Using the data logger, "disable" the data logger channels for NO, NO_2, and NO_X (see standard operating procedures for the relevant data acquisition and logging system) and enter the "Channel Off-Line" time on the calibration form. Set the data logger/computer for real time, continuous display of one-minute averages for NO, NO_2, and NO_X.

Note: The operator may consider beginning the procedure after 45 minutes from the top of the hour to capture a valid ambient hourly reading as a best practice.

4. Connect the calibrator output to the primary standard line. Adjust the calibrator to supply dilute (zero) air.

5. Allow the analyzer to sample zero air for at least ten minutes to ensure a stable response.

NOTE: For QC checks, stability is defined to be at least 10 consecutive one minute averages within ±3 ppb, with no clear upward or downward trend.

B. Zero Check (0 ppb)

1. Ensure the calibrator is supplying dilution (zero) air to the analyzer.

2. On DEP Form 09-2-A&B, under the NO calibration block, record the calibration's Dilution air flow (cc/min or LPM) for the Zero event (gas flow should be 0 during this event).

3. Allow the analyzer NO/NO_X responses to stabilize. Record 10 consecutive 1-minute averages of Observed NO and Observed NOx, as displayed from the data logger, on the Calibration Form Data Entry Sheet in the NO/NOx Calibration boxes in the Zero column.

C. NO/NOx Span Check (270 ppb)

1. Set the calibrator to generate a NO concentration of about 270 ppb, 90% of the current full scale desired for the calibration (do not exceed 270 ppb)

2. Allow the analyzer to sample the span NO calibration gas until the NO, NO_2, and NO_X readings on the data logger have stabilized.

3. Record the calibrator's gas and zero air flows (cc/min or LPM) on the calibration form under the NO Calibration block, next to the Span event .

4. Record 10 consecutive 1-minute averages of Observed NO and Observed NOx, as displayed from the data logger, on the Calibration Form Data Entry Sheet in the NO/NOx Calibration boxes in the Span column. .

D. NO/NOx Precision (80 ppb)

1. Adjust the calibrator to generate a NO concentration of approximately 80 ppb for the analyzer to sample. Record the calibrator's gas and zero air flows (cc/min or LPM) on the calibration form under the NO Calibration block, next to the **Precision** event.

2. Allow the analyzer NO/NO_X responses to stabilize. Record 10 consecutive 1-minute averages of Observed NO and Observed NOx on the Calibration Form Data Entry Sheet in the NO/NOx Calibration boxes in the **Precision** column.

E. Initiate Gas Phase Titration

NOTE: It is recommended that the same calibrator flows for gas and zero air be used for all the NO_2 (GPT) calibrations. If this is done, the same impurity concentration can also be used for the calibrations. The calibrator's ozonator level will determine the amount of NO_2 that will be converted and subsequently measured by the analyzer. If the NO and NO_X values of the gas cylinder are the same, it is assumed that there are no impurities.

1. Adjust the calibrator to re-establish an NO Span concentration of no more than 270 ppb (90% full scale), delivered to the analyzer. Record the calibrator's gas and air flows on the Calibration form under the Gas Phase Titration box, next to **NO Orig Calculation.** Sample this concentration until the analyzer's NO and NO_X responses have stabilized. The Calibration form will automatically generate a calculated NO_{ORIG} using **Equation 10-1**.

2. Adjust the ozone generator in the calibrator to provide sufficient ozone to produce generate an NO_2 concentration of approximately 240ppb (approximately 30ppb of NO remaining). Sample this concentration until the responses have stabilized. After the analyzer responses stabilize, average 10 minutes of NO, NO_X, and NO_2 values.

F. NO_2 Span (240 ppb)

1. Record the calibrator's ozone generator to generate approximately 240 ppb of NO_2 for the analyzer to sample .

2. Record the target O_3 concentration for the NO_2 span event on the Calibration Form in the NO_2 Check table, next to the Span event in the O_3 column.

3. Allow the analyzer responses to stabilize. Record 10 consecutive one-minute averages, as displayed from the data logger, on the Data Entry Worksheet in the Gas Phrase Titration cells in the Span columns for each respective channel (NO, NO_2, NOx). The form will calculate impurities and calculated NO_2 concentration using Equation 10-3.

G. NO_2 Precision Point (34 ppb)

1. Adjust the calibrator's ozone generator to generate approximately 34 ppb of NO_2 for the analyzer to sample.

2. Record the target O_3 concentration for the NO_2 Precision event on the Calibration Form in the NO_2 Check table, next to the Precision event in the O_3 column .

3. Allow the analyzer responses to stabilize. Record 10 consecutive one-minute averages, as displayed from the data logger, on the Data Entry Worksheet in the Gas Phrase Titration cells in the Precision column for each respective channel (NO, NO_2, NOx). The form will calculate impurities and calculated NO_2 concentration using Equation 10-3.

H. Final Zero

1. Allow the calibrator to supply zero air to the system until the analyzer reads 0.3 ppb or less for all parameters NO_X, NO, and NO_2. Ensure the NO gas cylinder is no longer supplying gas to the calibrator.

2. Record 10 consecutive one-minute averages, as displayed from the data logger, on the Data Entry Worksheet in the Gas Phrase Titration cells in the Zero column for each respective channel (NO, NO_2, NOx).

I. Adjust the calibrator and/or sampling system to allow the analyzer to sample ambient air for 5-10 minutes.

J. Put the NO, NO_2, and NOx channels on the DAS back to ambient mode by enabling the channels and record the time of the Channel On-line in the Data Logger Status block of the calibration form.

K. Complete the calibration form by adding any pertinent comments. Record "N/A" in any unused editable fields. Then sign and date the form and submit it to the QA staff for review.

12.1.3 Converter Efficiency

A. The converter efficiency check is calculated as part of the multi-point calibration, the span check and/or audit. Converter efficiency must be greater than 96%, if it is not, service or replace the converter.

B. On each calibration and QC check form, the spreadsheet normally calculates the converter efficiency. If needed, follow the calculation below:

C. On the Converter Efficiency Calculator (Appendix C), note the $NO_{2\ OUT}$ (refer to the NO_2 Gas Phase Titration section of the calibration or QC check form) for each of the points. This is the NO_2 concentration generated for each adjusted calibration point during GPT.

Figure 12-1. Converter Efficiency Calculator

Converter Efficiency Calculator

Calibration/ Verification Event	[NO2]out (Corrected NO2) (X)	[NOx]orig (Before O3)	[NOx]rem (After O3)	[NO2]conv (Y)
Zero Set Point	0	270	270	0.000
Span	240	270	260	230.000
Pt. 1	175	270	265	170.000
Pt. 2	100	270	270	100.000
Precision	34	270	265	29.000

Slope (b)= **0.968**
Converter Efficiency = **96.8%**
[NO2]conv = [NO2]out - ([NOx]orig - [NOx]rem)

D. Record $NO_{X\ ORIG}$. This is the NO_X span concentration prior to turning on the ozone lamp. This value is the same for all four entries. This value was calculated by linear regression.

E. Record the $NO_{X\ REM}$ concentration recorded during each NO_2 point. This value was also derived from linear regression.

F. Calculate $NO_{2\ CONV}$ for each event with the equation:

$NO_{2\ CONV} = (NO_{2\ OUT} - (NO_{X\ ORIG} - NO_{X\ REM}))$

G. Using a calculator, compute a slope by entering the $NO_{2\ OUT}$ values as X and the $NO_{2\ CONV}$ values as Y. Record the slope on the converter efficiency form.

H. Multiply the slope by 100. This is the converter efficiency. Record this value on the converter efficiency form. The converter efficiency must be greater than 96%. If it is not, the analyzer must be serviced and an entire adjusted calibration must be performed.

13.0 DATA ACQUISITION AND RECORDS MANAGEMENT

13.1 Data Acquisition System

Data acquisition is accomplished using a wireless modem at the site, connected either directly to the analyzer or through an Ethernet switch interfaced with the site data logger. The central polling computer uses AirVision (or equivalent) software to poll the data wirelessly from the site, typically every hour. Refer to specific SOPs for data loggers (8832, 8872 etc.), AirVision or equivalent software, and data validation for specific details regarding data acquisition.

The DAS is configured to record pressures, temperatures, and flow channels from the instrument registers. The operator must consult the instrument and DAS manuals for channel configuration. The following variables may be captured to aid the operator in diagnosing problems and maintain quality control of the data generated:

NO_X Flow, NO_X Pressure, NO_X Reactor (Temperature), NO_X Cooler (Temperature), NO_X Converter (Temperature)

13.2 Records Management

Records Management is the process to manage, store, back-up, and protect all the documents associated with operation, quality assurance, and the data associated with the Thermo 42i nitrogen dioxide monitoring instrument. All records must be backed up, stored securely, and retained for a minimum of 5 years. State law dictates retention schedules for various records. Refer to the specific SOPs that delineate this process.

Documentation of the quality control activities such as, bi-weekly QC checks, quarterly verifications and audits, and annual calibrations are documented on hardcopy or electronic forms and then submitted by the operator for data verification and validation processes.

All QA/QC records must contain the following items at a minimum:

A. Date QA\QC operation was performed and the name of the operator or auditor;
B. Station name or AQS ID#;
C. Instrument manufacturer, model, a unique ID# (e.g. serial no. or property asset no.), and date it was last calibrated;
D. Each reference standard must include the manufacturer, model, and unique ID#;
E. Each QA/QC operation must include the actual measurement, indicated measurement, and the result of the check, verification, or calibration;
F. A signature and date block for the operator or auditor;
G. A signature and date block for the QA reviewer.
H. The forms and reports included in the appendices of this SOP were developed in an electronic spreadsheet format and therefore contain embedded formulas for performing calculations and data validity checks. The reporting agency may retain these records in hardcopy or in electronic format.

14.0 REFERENCES

Quality Assurance Project Plan for the State of Florida Ambient Air Quality Monitoring Program, FDEP QAPP-002, Revision 1, April 2016, Florida Department of Environmental Protection, Tallahassee, FL.

Quality Assurance Project Plan for the State of Florida Ambient Air Quality Monitoring Program, FDEP Gaseous QAPP Revision 2, April 2022, Florida Department of Environmental Protection, Tallahassee, FL.

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II (EPA-454/B-08-003, 5/2013).

Thermo Fisher Scientific Inc. Model 42i Instruction Manual, Part number 101350-00, 2015.

Thermo Fisher Scientific In. i-Port Instruction Manual, Part number 102606-00, April 2014.

Standard Operating Procedure for Data Handling and Data Validation, DEP 18-27, Revision No. 1, June 2016, Florida Department of Environmental Protection, Tallahassee, FL.

15.0 APPENDICIES

Appendix A: Forms

Form DEP 09-02-A, TEI 42i Equipment Status Report
Form DEP 09-02-B, TEI 42i Calibration Form
Form DEP 09-02-C, TEI 42i Analyzer Maintenance Form
Form DEP 09-02-D, Annual Calibration Form (Flow Rate, Pressure, and Temperature Sensors)
Form DEP 09-02-E, Historical Maintenance Record

Appendix B: Schedule of QA/QC and Preventive Maintenance Tasks

Appendix C: Converter Efficiency Calculator

Appendix D: Glossary

Form No. DEP 09-02-A **TEI 42i Equipment Status Report** **Effective: February 2023**

Identification Block							
Date Performed:		Site Name:		AQS #:		Procedure:	
Instrument Mfr:		Model:		Serial #:		Date Calibrated:	
Calibrator Mfr:		Model:		Serial #:		Date Calibrated:	
Data Logger Mfr:		Model:		Serial #:		Date Certified:	

Standards Block							
Time Standard Mfg:		Model:		Serial #:		Date Certified:	

Analyzer Checks			
Parameter	Limits	Value	If Out of Limits
System Alarm	On/Off		Record alarm in comments, troubleshoot
DAS NO Channel #	-		
DAS NOx Channel #	-		
DAS NO2 Channel #	-		
Range (ppb)	0 - 300	300	
Avg. Time (sec)	10 - 300	60	
Internal Temp (°C)	15 - 35		Check Temp. Sensor
Chamber Temp (°C)	47 - 51		Check Rxn Chamber
Cooler Temp (°C)	~ -3.0		Check PMT Cooler and Fan Guards
Conv Temp (°C)	300 - 350		Check NO_2->NO Conv.
Chamber Press (mm Hg)	150 - 300		Check pump and press. sensor
Sample Flow (LPM)	0.4 - 1.0		Check Pump
Ozonator Flow (LPM)	> 0.050		Check Conv. Temp. and Pump
Cal. Factors: NO Bkg.			
NOx Bkg			
NO Coef.			
NO2 Coef.			
NOx Coef.			

Maintenance Checks		
Sample Lines	Maint. Action	NOT DUE
Particulate Filter	Maint. Action	NOT DUE

Concurrency Checks					
Concurrency	Instrument	Data Logger	Difference	Limits	RESULT
Time Display				± 2 minutes	
Concentration Display				± 0.5 ppb	

Operator Comments:

Performed by: Date:

QA Comments:

Verified by: Date:

Form DEP 09-2-A, TEI 42i Equipment Status Report: Instructions

This Equipment Status Form is a Microsoft Excel spreadsheet that is populated during the site visit. Complete the form by entering the information in the selected block and cell of the work sheet.

Identification Block: Enter the requested site and analyzer identification information. For the ***Procedure*** field, select the correct procedure from the drop down. Available procedures include Zero/Span/Precision, multi-point check, calibration or maintenance.

Standards Block: Enter the information for the time standard.

Analyzer Check Block: Scroll through the instrument diagnostics and instrument controls menu and log each value.

Maintenance Check: Document the maintenance that is being performed for this visit. If no maintenance is performed, select "*NOT DUE*" from the dropdown.

Concurrency Check: Document the time and concentration displayed on the analyzer and the data logger in the required cell. Note that they must meet the limits as required. If the reading is satisfactory the result will indicate pass. If it is not, it will indicate calibrate. Calibrate if required.

Operator's Comments: Enter any observations while at the site. Enter your name and the date after completing the data entry into the form.

QA Comments: The QA personnel will enter comments after they have reviewed the spreadsheet. The QA personnel will sign and date the form after review.

Form No. DEP 09-02-B | **TEI 42i NO-NO2-NOx Analyzer ZSP, Calibration and Verification Form** | **Effective: February 2023**

Identification Block				
Date Performed:		Site Name:	AQS #:	Procedure:
Instrument Mfr:		Model:	Serial #:	Date Calibrated:
Primary Recorder Mfr:		Model:	Serial #:	Date Calibrated:
Dilution Calibrator Mfr:		Model:	Serial #:	Date Calibrated:
Zero Air System Mfr:		Model:	Serial #:	Date Serviced:
Monitoring Objective:	NAAQS			

Standards Block			
Gas Cylinder #:		NO (ppm):	Date Certified:
Tank Pressure (psig):		NOx (ppm):	Expiration Date:

NO Calibration Curve	slope (m)	intcpt (b)
Previous Cal:		
New Cal:	N/A	N/A

Primary Recorder Status	Time (hh:mm)
Channel Off-line:	
Channel On-line:	

Converter Efficiency Check	%CE	Result	Limit
Converter Eff:	#DIV/0!	#DIV/0!	96% - 104%

Impurity Calculation	
NO @ NO orig:	
NOx @ NO orig:	
Impurity (ppb):	

SLIC

Calibration Point	Gas Flow (cc/min)	Dil Flow (cc/min)	O_3 (%, ppb)	Calc. NOx	Obs NO2	% Diff	Limits	RESULT
SLIC (≤90% scale)				N/A	N/A	N/A	± 2%	N/A
Span (≤90% scale)				N/A	N/A			

Gas Flow Conversion: 1000 cc/min = 1 LPM . Units must be the same for all flows

NO Calibration

Calibration Point	Gas Flow (cc/min)	Dil Flow (cc/min)	Calc. NO	Calc. NOx	Obs NO	Obs NOx	NO % Diff	Limits	RESULT
Zero (Initial)	0		0.00	0.00			N/A	± 5.0 ppb	
Span (≤90% scale; 270)							N/A	10%	
Upscale 1 (175)			N/A		N/A	N/A	N/A	15%	N/A
Upscale 2 (100)					N/A	N/A	N/A	15%	N/A
Precision (80)			N/A		N/A	N/A	N/A	15%	N/A

Gas Phase Titration

	Gas Flow (cc/min)	Dil Flow (cc/min)	Obs NO_{ORIG}	Corr NO_{ORIG}
NO_{ORIG} Calculation				

NO2 Check

Calibration Point	O_3 (%, ppb)	Corr NO_{ORIG}	Corr NO_{REM}	Impurities	Calc. NO2	Obs NO2	% Diff	Limits	RESULT
Span (≤80% scale; 240)							N/A	10%	
Upscale 1 (175)			N/A		N/A	N/A	N/A	15%	N/A
Upscale 2 (100)			N/A		N/A	N/A	N/A	15%	N/A
Precision (34)			N/A		N/A	N/A	N/A	15%	N/A
Zero (Final)	0						N/A	± 5.0 ppb	

Calibration Assessment

	ZERO	PRECISION	UPSCALE 2	UPSCALE 1	SPAN	
Calibrator Value (X)	-	-	-	-	-	
Instrument Value (Y)	-	-	-	-	-	
Best Fit Concentration	-	-	-	-	-	
% Diff (Best fit Conc vs. Y values)	-	-	-	-	-	
	RESULT:	-	-	-	-	(≤ ± 2.1%)
Straight Diff (Best fit Conc vs. Y values)	-	-	-	-	-	
	RESULT:	-	-	-	-	(≤ ± 1.5 ppb)

slope (m)	intcpt (I)
-	-

Operator Comments:

Performed by: Date:

QA Comments:

Verified by: Date:

Form DEP 09-2-B, TEI 42i Calibration Form: Instructions

This Calibration Form is a Microsoft Excel form that is populated during calibration, Zero/Span/Precision or multi-point QC checks. Complete the Calibration form tab by entering the information in the selected block and cells of the work sheet.

Identification Block: Enter the requested site and analyzer identification information. For the ***Procedure*** field, select the correct procedure from the drop down. Available procedures include Zero/Span/Precision, multipoint check or calibration. The limits for the form will change based on the selection from this cell.

Standards Block: Enter the information for the NO gas cylinder.

Data Logger Status: Enter the time the channels were taken offline. Also, at the end of the procedure, enter the time when the channels were brought back online.

SLIC, NO Calibration Block and Gas Phase Titration Blocks: These average values are entered into the spreadsheet during the NO calibration, Gas phase titration, and SLIC procedure. The values are read from the data logger. The individual values used to calculate the stable average may be recorded on the Data Worksheet tab of the spreadsheet.

Operator's Comments: Enter any observations while at the site. Enter your name and the date after completing the data entry into the form.

QA Comments: The QA personnel will enter comments after they have reviewed the spreadsheet. The QA personnel will sign and date the form after review.

Form No. DEP 09-02-C **42i Maintenance Log** **Effective: February 2023**

Identification Block			
Year:	Site Name:		AQS #:
Instrument Mfr:	Model:	42i	Serial #:

Minimum Maintenance Frequency:		Quarterly			Semi-Annual		Annual					
Date	Operator	Change Sample Line Filter	SLIC	Multipoint Calibration/Verification	Change Ozone Scrubber (cleanser)	Clean Cooler Fins & Fan Guards	Inspect/Replace Permeation Dryer	Inspect/Clean Capillaries & O-Rings	Internal Sensor Calibrations/Verifications	Clean/Change Sample Lines	QA Verification	QA Date
ENTER DATE LAST PERFORMED:												
	Due Dates:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
	Warnings:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Operator Comments:

QA Comments:

Form DEP 09-2-C, TEI 42i Analyzer Maintenance Schedule: Instructions

This Analyzer Maintenance Schedule is a Microsoft Excel form that is populated during maintenance processes. Complete the form by entering the information in the selected block and cells of the work sheet.

Identification Block: Enter the requested information for the year, site name, AQS number and identifying information for each piece of equipment.

Maintenance Activity:

For each maintenance activity as performed:

Under Date Performed, enter the date the maintenance was performed.

Under Performed By, enter the initials of operator who performed the maintenance

Under “Date Due” or “Next Date Due”, record the date the maintenance will next be due for easy reference.

The QA reviewer shall sign in the designated cell after the sheet has been reviewed.

Form No. DEP 09-02-D **TEI 42i Annual Calibration Form** **Effective February 2023**

Identification Block			
Date Performed:	Site Name:	AQS #:	Parameter:
Instrument Mfr:	Model:	Serial #:	Date Calibrated:
Data Logger Mfr:	Model:	Serial #:	Date Calibrated:
Calibrator Mfr:	Model:	Serial #:	Date Certified:

Standards Block			
Flow Standard Mfg:	Model:	ID/Serial #:	Date Certified:
Temp. Standard Mfg:	Model:	ID/Serial #:	Date Certified:
BP Standard Mfg:	Model:	ID/Serial #:	Date Certified:

Annual System Flow Rate Verification/Calibration					
	Front Panel	Reference Standard	% Diff	Limits	RESULT
As Found (LPM)			n/a	± 2%	n/a
Post Calibration (LPM)			n/a	± 2%	n/a

Pressure Sensor Verification/Calibration					
	Chamber Pressure	Reference Standard	Difference	Limits	RESULT
As Found (mmHg)				± 2 mm Hg	n/a
Post Calibration (mmHg)				± 2 mm Hg	n/a

INTERNAL Temperature Sensor Verification/Calibration					
	Internal Temp	Reference Standard	Difference	Limits	RESULT
As Found (°C)				± 2°C	n/a

Operator Comments:

Performed by: Date:

QA Comments:

Verified by: Date:

Form DEP 09-02-D, Annual Calibration Form: Instructions

The Analyzer Maintenance Calibration Form is a Microsoft Excel form that is populated during the annual calibration of the flow, temperature and pressure. Complete the form by entering the information in the selected block and cells of the work sheet.

Identification Block: Enter the requested site and instrument identification information

Standard Block: Enter the manufacturer, model, serial number and the date the date of certification for each standard.

Perform each verification for pressure and temperature as specified in the standard operating procedures. Record the analyzer value and the standard values in their respective cells on the sheet. The percent difference will populate the % difference in the adjacent cell.

If the percent difference is within the acceptable limits, no calibration is required. If the value falls outside the acceptable range, recalibrate the instrument.

Complete the Operator Comments section, sign and date the form.
Send the forms to the QA Coordinator for review and signature.

Form DEP 09-02-E, Historical Maintenance Record

DEP 09-2
REV. NO. 0: 12/2016
Effective: xx/xx/xxxx

Form DEP 09-2-E: HISTORICAL MAINTENANCE RECORD

EQUIPMENT: Thermo Scientific 42i NO-NO2-NOx Analyzer

S/N.:_____ PROPERTY NO.:_____

Date	Maintenance	Operator Signature	QA Initials	QA Date

VERIFIED BY:_____ DATE:_____

Form DEP 09-02-E, Historical Maintenance Record: Instructions

To complete Form DEP-09-2 E, the information to the following listed items will be required:

Serial #:	Fill in the full serial number assigned to the instrument by the manufacturer
Property No:	Fill in the fixed asset tracking number also called the property number. This is the number usually assigned by the state or local agency. If not, enter "NA" in this space.
Date:	Fill in the current date that the maintenance is occurring. Fill out the date in this format: MM/DD/YY.
Maintenance:	Fill in a brief description of any major maintenance. This would not include routine calibrations or verifications but must include physical maintenance such as capillary changes, pump changes, or any replacement parts.
Signature:	Enter the name of the operator completing the data entry into the form.
QA Initial, Verified By:	The QA personnel sign and date the form after review.

Appendix B: Schedule of QA/QC and Preventive Maintenance Tasks

Task Description	Acceptance Limits	Frequency (at minimum)	SOP Section
Zero, span, and precision checks	±15% (corrective action when ±10% warning limit exceeded)	Every 14 days	12.1.2
Inspect/Change Desiccant	Maintenance Performed	Every 14 days	11.3A
Check converter efficiency	≥ 96%	Every 14 days During calibrations, span check, and performance audit	12.1.3
Change sample filter	Maintenance Performed	Every 90 days	11.3B
Calibration (adjusted) or Multi-Point QC check (unadjusted)	Zero within ±2ppb, Span within ± 2%, all other points within ±5% of calibration range of best-fit straight line	Every 90 days	10.0
Sample Line Integrity Check (SLIC)	± 2%	Every 90 days	10.4I
Clean fins and fan	Maintenance Performed	Semi-Annually	11.3D
Change Ozone Cleanser	Maintenance Performed	Semi-Annually	11.3E
Clean or replace the sample line	Maintenance Performed	Semi-Annually	11.3F
Calibrate Temperature Sensor	± 2°C	Annually	11.3G
Calibrate Pressure Sensor	± 2 mm Hg	Annually	11.3H
Inspect and/or clean capillaries and O-rings	Maintenance Performed	Annually	11.3I
Time Clock: Check analyzer time clock against a chronometer standard	± 1 minute	Annually	9.4.2E
DEP Performance Audit	Comparison of the analyzer response to a Florida DEP Transfer Standard	Annually	

Appendix C: Converter Efficiency Calculator

Converter Efficiency Calculator

Calibration/ Verification Event	[NO2]out (Corrected NO2) (X)	[NOx]orig (Before O3)	[NOx]rem (After O3)	[NO2]conv (Y)
Zero Set Point				0.000
Span				0.000
Pt. 1				0.000
Pt. 2				0.000
Precision				0.000

Slope (b)=

Converter Efficiency =

[NO2]conv = [NO2]out - ([NOx]orig - [NOx]rem)

INSTRUCTIONS: On each calibration and QC check form, the spreadsheet normally calculates the converter efficiency. If a separate calculation is needed, use the Converter Efficiency Calculator spreadsheet and record the following below:

A. Note the NO2 OUT (refer to the NO2 Gas Phase Titration section of the calibration or QC check form) for each of the points. This is the calculated NO_2 concentration generated for each adjusted calibration point during GPT.

B. Record NOX ORIG. This is the NOX span concentration prior to turning on the ozone lamp. This value is the same for all four entries. This value was calculated by linear regression.

C. Record the NOX REM concentration recorded during each NO_2 point. This value was also derived from linear regression.

D. Calculate NO2 CONV for each event with the equation:

NO2 CONV = (NO2 OUT - (NOx ORIG - NOX REM))

E. The spreadsheet will compute the slope by entering the NO2 OUT values as X and the NO2 CONV values as Y. The calculated slope will appear near the bottom of the converter efficiency form.

F. For the converter efficiency, the spreadsheet will multiply the slope by 100. This value will be recorded under the slope on the converter efficiency form. The converter efficiency must be greater than 96%. If it is not, the analyzer must be serviced and an entire adjusted calibration must be performed.

Appendix D: Glossary

Term	Definition
Annually, Semi-Annually	Occurring once every 12 months (365 days, 366 days for leap years) Occurring once every 6 months (183 days)
Biweekly	Occurring once every two weeks (14 days)
Calibration (adjusted)	A calibration where the instrument is adjusted and the coefficient, slope and offset are changed. This adjusted calibration involves adjusting the zero and/or span and verifying values at three other upscale concentrations between the zero and the span value.
CFR	Code of Federal Regulations
DAS	Data Acquisition system. Used for automated collection and recording of pollutant gas concentrations.
Flow Calibrator	Equipment used to mix zero air with a sample gas to furnish the desired concentration at the required flow.
GPT	Gas Phase Titration
Interference	Physical or chemical entities that cause NO2 measurements to be higher (positive) or lower (negative) than would be without the entity.
NIST	National Institute of Standards and Technology
NO_2	Nitrogen dioxide
NO	Nitric oxide
NO_X	Total Nitrogen oxides
NO, NO_2, NO_X Stability	Stability is defined for 10 one-minute averages of ±3 ppb with no upward or downward trend
O_3	Ozone
PMT	Photo Multiplier Tube
Quality Assurance (QA)	Refers to the planned or systematic activities used to provide confidence that the requirements for quality are fulfilled. An independent audit is an example of a QA activity. QA protocols determine whether the QC procedures are adequate.
Quality Control (QC)	Refers to the operational techniques and activities used to fulfill the requirements for quality. QC Checks referenced in this SOP, refer to quality control activities performed by the operator including zero/span/precision checks and multipoint calibration checks conducted immediately prior to and after instrument maintenance and calibration adjustments.
Quarterly	Occurring once every three months (90 days)
Sample Line Integrity Check (SLIC)	The quarterly check done to verify the integrity of the sample line and ensure that the sample line is not having a negative effect on the concentration values read by the analyzer. It is typically made from a piece of ¼" Teflon tubing with a Teflon "T" in the middle for a vent. One end is connected to the output of the flow calibrator and the other end to the input of the analyzer.
Span Gas	Span gas is defined as a gas specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the

Term	Definition
	desired measurement range. Typically, this is 80-90 % of the measurement range of the application of the instrument.
TEI	Thermo(Fisher Scientific) Environmental Instruments
Validation	Determining whether the system complies with requirements, performs the functions for which it is intended, and meets the organization's goals and user needs. It is a determination of correctness of the data and is usually performed only periodically (e.g., quarterly) or at the end of a project.
Verification (unadjusted)	Also referred to as a calibration check, the instrument is not adjusted and the coefficient, slope and offset remains the same. This check is performed at zero, span, and three upscale concentrations.
Zero Gas	Zero gas or zero calibration gas is defined as a gas that is similar in chemical composition to the measured medium but without the gas to be measured by the analyzer.
Zero, Span and Precision Check	The analytical check done to verify that the analyzer is operating satisfactorily. It is done at a minimum frequency of every 14 days.