May 2

STATEWIDE
STANDARD OPERATING PROCEDURE

FOR
THERMO FISHER SCIENTIFIC
MODEL 42i NOy Chemiluminescence Analyzer

State of Florida
Department of Environmental Protection (DEP)
Bureau of Air Monitoring

Prepared by: Florida PQAO Date: 4/29/2021

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Document History

Revision	Date	Responsible Person	Description of Change
0	September 2017	FAMAC	Initial Release
1	May 2021	PQAO	Update of external converter temperature (molybdenum converter) based on correspondence with ThermoFisher Scientific. Updated FAMAS to AirMVP. Updated references to T200UP (and T200UP parameters) and replaced them with 42i-Y-TLE Updated forms. Added best management practice of adding sample line filter to inlet port on converter.

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1.0 PURPOSE

The purpose of this standard operating procedure is to guide the field technician in the installation, set-up, calibration and maintenance of the Thermo Scientific (TEI) Model 42*i-Y* NOy Chemiluminescence Analyzer, used in the State of Florida Ambient Air Monitoring Program, for the national core monitoring network (NCore). Other information such as theory of operation, servicing and microprocessor control are covered in the manufacturer's instruction manual and will be referred to as needed. Both the manual and this SOP are to be kept with the instrument or be accessible in electronic format at all times.

These procedures are consistent with the data management requirements specified in the Quality Assurance Project Plan for the Florida NCore Program, (FDEP QAPP-005). The final data are verified and submitted to the Florida AirMVP database, then uploaded by the Florida Department of Environmental Protection (FDEP) to the US EPA Air Quality System (AQS).

2.0 SCOPE AND APPLICABILITY

The Florida Department of Environmental Protection and Florida Local Air Monitoring Agencies utilize the TEI Model 42i-Y analyzer to quantify all reactive gaseous nitrogen compounds (NOy), nitrogen oxide (NO) concentrations, and the difference between the two groups of nitrogen compounds (DIF) in the ambient air.

Reactive nitrogen compounds (NOy) consist of nitrogen oxides released from emission sources which are primarily nitrogen oxide (NO) and nitrogen dioxide (NO_2), collectively termed NOx, and numerous other inorganic and organic nitrogen oxides, which are collectively called NOz. This is illustrated in equation 2-1, below.

$$NO + NO_2 + NO_z = NO_y \qquad \text{(EQ 2-1)}$$

This document is intended to be used as a reference for the set-up, calibration, maintenance and operation of the 42i-Y NO/DIF/NOy analyzer. The proper utilization of this procedure by the operator, in conjunction with the equipment manufacturer's operation manual (and addendums), will conform to the local, state and federal data quality objectives, the State of Florida Quality Assurance Project Plans (QAPPs), the air monitoring regulations published in the Code of Federal Regulations (CFR).

3.0 SUMMARY OF THE METHOD

The 42i-Y analyzer provides the measurement of ambient NOy by photometrically measuring the light intensity, at wavelengths greater than 600 nm, resulting from the chemiluminescent reaction of nitric oxide (NO) with ozone (O_3). NOy compounds (other than NO) are first quantitatively reduced to NO by a molybdenum converter heated to about 350 °C located at the inlet of the sampling system. The NO, which commonly exists in association with NO_2 and numerous other inorganic and organic nitrogen oxides, and collectively are called NOz, passes through the converter unchanged, resulting in total reactive nitrogen species (NOy) concentration equal to NO plus NO_2 plus NOz; see equation 2-1, above. A portion of the ambient air is also reacted with O_3 without having passed through the converter, and the ambient NO concentration is measured. This value is subtracted from the NOy concentration yielding the difference parameter (DIF). The following equation broadly describes the chemiluminescent reaction:

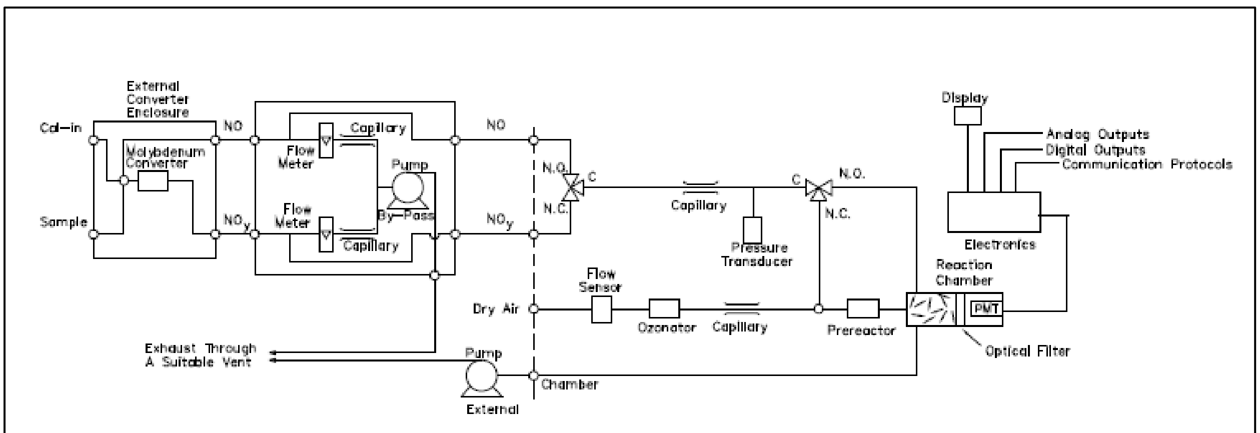
$$NO + O_3 \rightarrow NO_2 + O_2 + hv$$

Where; (EQ 3-1)

hv = emitted photon energy

The chemiluminescence that results from the reaction is monitored by an optically filtered high-sensitivity photomultiplier. The optical filter and photomultiplier respond to light in a narrow-wavelength band unique to the NO and O_3 reaction. The electronic signal produced in the photomultiplier is proportional to the NO concentration. This procedure is similar to the current methodology used to measure NOx, however, the converter temperature is higher in order to enhance conversion of NOz species and it is placed immediately downstream of the sample inlet to avoid line losses of "sticky" NOy species such as nitric acid, HNO_3.

Figure 3-1 Model 42i-Y NOy Flow Schematic



A flow diagram of the 42i-Y instrument is presented in figure 3-1, above. The ambient sample is drawn though the inlet probe and split into two parallel flow channels using a ½ inch PFT Teflon tee. Channel 1, the NO channel, passes

4.0 DEFINITIONS

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.

Audit – is often used in a generic way to mean check, inspect, examine, or assess, and many SOPs use the term to refer to QC procedures, such as flow checks or leak checks, that are carried out by field operators during the course of normal operations and maintenance.

Calibration – refers to the act of adjusting an instrument after comparison with a standard. When referring to the instrument software, the term "calibration" is used to indicate a procedure that would alter instrument output.

Control Limit (CL) – the relative percent difference between the theoretical value and the instrument response value which is considered out-of-tolerance, results in invalid data, and requires corrective action. The relative percent difference (%Diff) is computed according to Equation 4-1, below.

$$\%DIFF = \frac{(observed\ value - reference\ standard)}{reference\ standard}\ x\ 100$$

(EQ 4-1)

Multipoint Calibration Check – a procedure to challenge the analyzer with an initial zero concentration followed by four (4) upscale concentration points to determine the calibration is within acceptable limits and remains linear for NO, NOy, and NO_2 (DIF channel) analyzer responses.

Quality Control (QC) – refers to the operational techniques and activities used to fulfill the requirements for quality.

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.

Verification – is a review of interim work steps to ensure they are acceptable and to determine whether the system is consistent, adheres to standards, uses reliable techniques, and performs the selected functions in the correct manner.

Validation – determines 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.

Warning Limit (WL) – the relative percent difference between the theoretical value and the instrument response value which is less than, but approaching, out-of-tolerance conditions requiring further investigation and possible corrective actions.

Z/S/P Check – a quality control checks of the analyzer performed prior to any adjustments, maintenance or calibrations. This QC check consists of checking the ZERO drift, then the SPAN drift, and finally a check of the analyzer's response at the Precision point.

5.0 HEALTH AND SAFETY PRECAUTIONS

To prevent personal injury or damage to the NOy analyzer, the technician will adhere to the health and safety precautions outlined below. In addition, general safety rules regarding electricity and power tools will be observed.

5.1 Health Precautions

A. 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.

B. 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.

C. Always use a third ground wire on all instruments.

D. 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-Y Instruction Manual.

5.2 Safety Precautions

A. 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.

B. Keep the interior of the analyzer clean.

C. Inspect the system regularly for structural integrity.

D. To prevent problems with leaks, make sure that all sampling lines are reconnected after required checks and before leaving the site.

E. Inspect tubing for cracks and leaks.

F. 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.

G. 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.

H. Gas cylinders must be properly secured to the interior walls of the shelter with the appropriate straps before use.

6.0 INTERFERENCES

The 42i-Y is designed to minimize potential interferences, but poor siting, inadequate electrical power, bad electrical grounding, poor control of the sample air relative humidity (RH) in humid environments, oscillations in the temperature of the environmental enclosure, and significant vibrations are known sources of interference. The 42i-Y is supplied with a three-wire grounded power cord. Under no circumstances should this grounding system be defeated.

The instrument manufacturer also recommends that during installation and operation, the operator avoid pressurizing the monitor and do not allow liquids to enter the sample port. In addition, do not expose the instrument to excessive vibration or magnetic interference.

Interferences arising from improper siting can be avoided by exercising care during site selection and installation. Particular attention should be paid to the design criteria for monitoring NOy, including general monitoring requirements, spatial scales, and any special site requirements.

Ammonia, NH_3, may be converted to NO, resulting in increased NO readings. Therefore, the 42i-Y is not sited near ammonia sources. However, under normal circumstances, HN3 concentrations are low compared to ambient NO and thus the positive interference is negligible.

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 NOy concentrations should be able to:

a) Operate the 42i-Y analyzer;

b) Calibrate, audit, and troubleshoot the 42i-Y analyzer; and

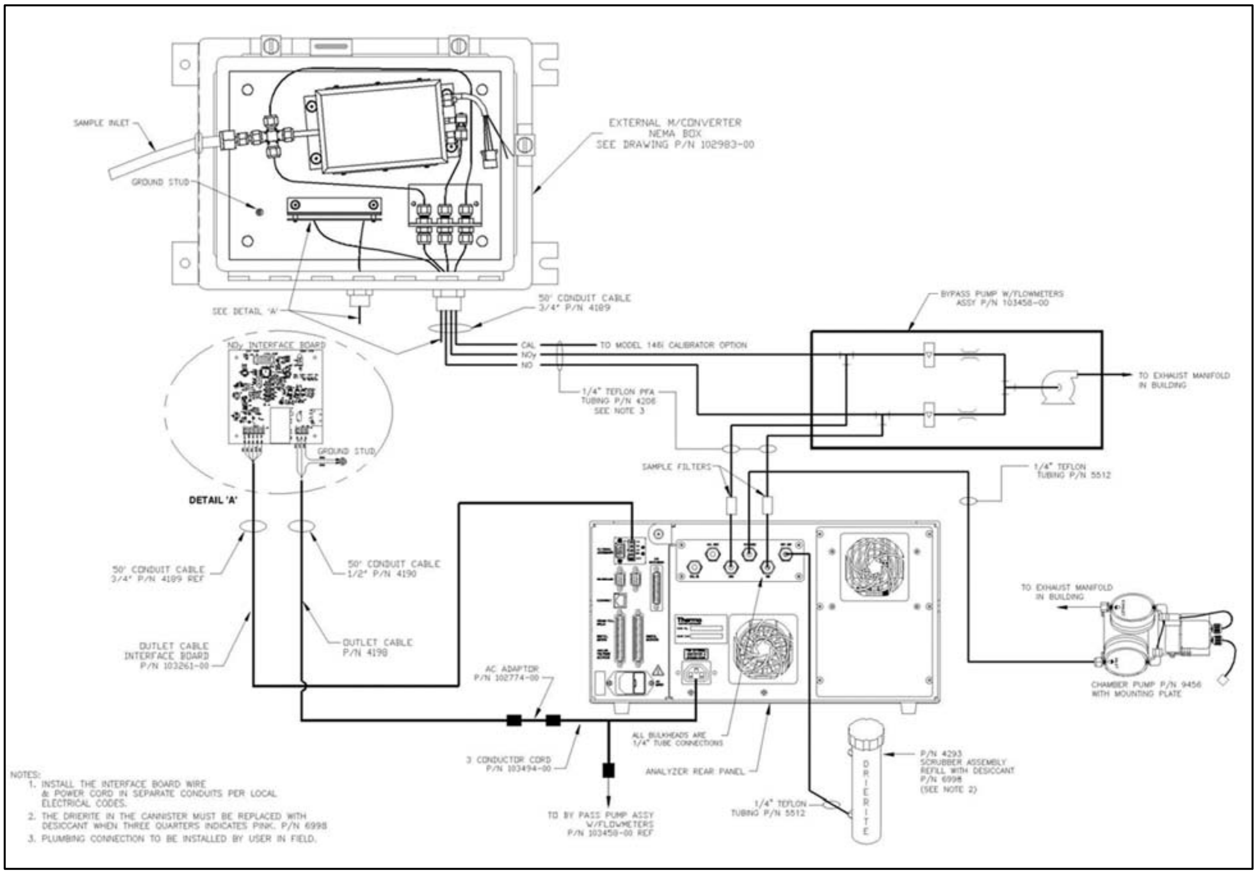
c) Operate the dilution calibrator and dilution (zero air) system.

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

The Thermo Fisher Scientific Instruction Manual for the Model 42i-Y NOy analyzer contains a regular bill of materials for the standard system hardware provided with each instrument purchased, in addition to information on the equipment required for instrument maintenance and calibrations. A typical installation diagram of the 42i-Y from the instrument manual is presented in Figure 8-1, below.

Figure 8-1: Model 42i-Y Typical Installation Diagram



The diagram illustrates the external molybdenum converter which is immediately downstream of the sample inlet mounted 10 meters above ground level (agl). The gas dilution calibrator and zero air scrubber assembly are shown as support equipment in the diagram. All supporting equipment for the operation of the 42i-Y analyzer are described below:

Zero Air System – A system suitable to remove contaminants such as NO, NO_2 and O_3. For example, the Thermo Environmental T111 or the T-API T701 zero air unit both of which are currently being used in Florida. Zero Air systems typically consist of a desiccant, Purafil Scrubber, Charcoal Scrubber, pressure adjustment control and a compressor. The SOP for each Zero Air unit should be referenced for maintenance intervals.

Calibration System – The calibration system must have an accurate NIST-traceable mass flow-controlled gas dilution system, NIST-traceable photometer, if applicable, and be capable of producing ozone for converting NO to NO_2 during gas phase titration (GPT). The air flow controller should be capable of maintaining constant air flows within ±2% of the required flow rate. For example, calibrators used in Florida include the T-API Models T700/T700U Multi-Gas Dilution Calibrator or Thermo Environmental Instruments Models 146C/146i Dynamic Dilution Calibrator.

NO Gas Cylinder – Calibration gas is needed to supply NO to the calibration system. The cylinder must be NIST-traceable and typically contains 10-50 ppm NO in N_2 (nitrogen) with less than 1 ppm NO_2 of impurities. However, the US EPA allows lower NO gas concentrations provided that the calibration gas flow does not fall outside the range of the flow calibrator.

NOTE: The cylinder should not be used below 200 psi or a higher value is specified by the manufacturer.

Gas Cylinder Pressure Regulator - 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.

Output Manifold - This is the external manifold between NOy analyzer and the GPT calibrator. The manifold receives NO, NOy, 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.

Log Book – The current year's hardcopy or electronic logbook containing all forms associated with the operation, maintenance and calibration of the 42i-Y analyzer.

Data Acquisition System (DAS) – A DAS is necessary for storage of ambient and ancillary data collected by the 42i-Y. Many of the monitoring agencies in Florida use the Agilaire, LLC 8872, 8832 or 8816 DAS as the primary recorder for all data collection. However, other data acquisition systems that meet the needs of data collection are acceptable.

Before beginning any procedures involving the analyzer calibration process ensure that the appropriate channel(s) on the DAS are marked "down" or off line. Marking a channel "down" or off line causes the DAS to disregard the calibration data and not average it with ambient concentrations throughout the duration of the calibration. The operator will record five, one minute averages from the DAS after the analyzer stabilizes at each calibration level. The corresponding analyzer channel(s) should be marked "off line" prior to conducting any of the following procedures: Diagnostic checks, QC Checks, multi-point checks and verifications, maintenance, or operational checks. Channels may also be marked "off line" when any analyzers data is deemed suspect.

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 20-30˚C according to the Florida Gaseous QAPP (FDEP QAPP-002).

Wiring, Tubing and Fittings – PTFE, PFA, FEP Teflon™, Pyrex® or borosilicate glass, or equivalent materials should be used exclusively throughout the intake system. Examine the tubing and discard if particulate matter is collects in the tubing. All fittings and ferrules should be made PTFE, PFA, FEP Teflon™, Pyrex® or borosilicate glass, or equivalent materials. 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 AND START-UP

Operator(s) are required to read the manufacturer's instruction manual for the 42i-Y. In addition, operators must be thoroughly familiar with the various controls and components of the analyzer prior to beginning operation.

9.1 Analyzer Siting and Sampling System

The 42i-Y NOy analyzer must meet the location and siting criteria referenced in the Code of Federal Regulations (CFR), Part 58, Appendix E, siting criteria for NO_2.

The ambient air inlet probe will be positioned at least 1 meter vertically or horizontally away from any supporting structure or walls and 10 meters above ground level. It 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 (preferable 360 degrees) 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 NOy sampling probe will be at least 20 meters or more from the drip line of any trees.

In order to collect ambient NOy concentrations with the 42i-Y analyzer that complies with the Technical Assistance Document (TAD) for the NCore monitoring network, the proper sampling system must be used. The primary components of this system include:

a) Sample train composed of ¼" OD Teflon or PTFE Tubing, with minimum inside diameter (ID) of ⅛". It is recommended that the length of this tubing be kept to less than 35 feet.

b) Sample inlet funnels composed of PTFE or borosilicate glass such as Pyrex.

It is imperative that all components of the sample train, including the inlets, tubing, and connections, be composed of the inert materials indicated above. NOy is categorized as a reactive gas and EPA studies have indicated these materials to be the only acceptable materials used in the sampling system of a NOy analyzer. For more information, refer to EPA Document "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, January 2017, Section 7.

9.2 Inspecting New/Refurbished 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 of 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.

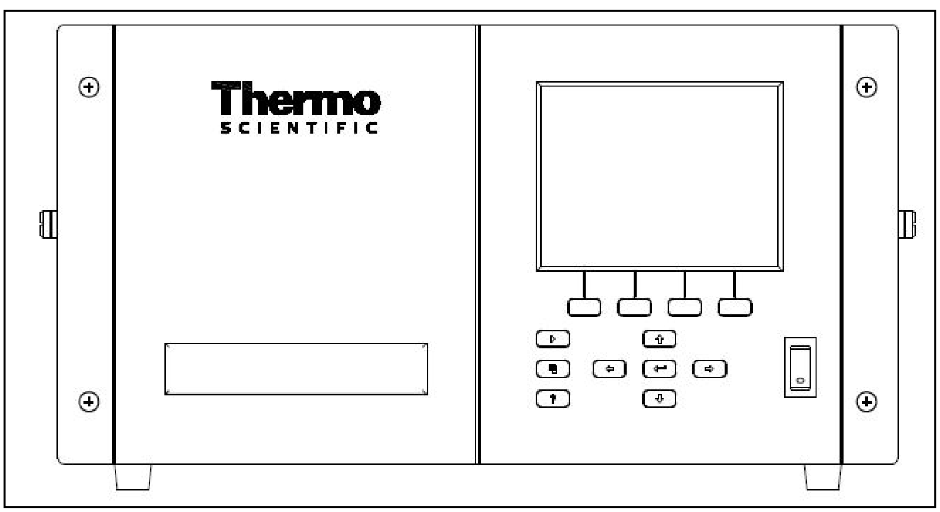
If you discover that the instrument was damaged during shipping and it becomes necessary to return it to the manufacturer, repack it in the same way it was delivered.

9.3 Installation and Start-up

This section discusses startup, operation and maintenance of the 42i-Y. analyzer. The 42i-Y has a digital front panel screen with control buttons below. This allows the user to check functions, switch operating parameters, adjust zero and span, and read warnings messages. It is extremely important that the user familiarize themselves with the menus available. Inadvertently changing parameters within the analyzer can damage the instrument and possibly invalidate data as well. Please reference the 42i-Y Instruction Manual (PN 102975-00, 27Sep2016) before adjusting any parameters that are set by the factory.

Figure 9-1 shows the front panel of the instrument. The operation of the analyzer is based on menu-driven software. The push buttons below the display screen control menu navigation and selection. The operator should refer to the instrument instruction manual for greater description and detail.

Figure 9-1: 42i-Y Front Panel Display



All operational checks and necessary adjustments are accomplished from the front panel. Each time the instrument is turned on, the Power-Up and Self-Test screens will be displayed while the instrument is warming up and performing self-checks. After warm-up, the Run screen will display NO, DIF, and NOy concentrations under normal operation.

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 takes you out of menu 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 shortcuts to the functions listed on the bottom of the display. These shortcuts can be user-selected.

Install the analyzer by placing it on a table or bench allowing access to both the front and rear of the instrument. 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. Follow the "Setup Procedure" and "Connection of External Devices" procedures Chapter 2 of the 42i-Y analyzer instruction manual, and then the following procedures to complete instrument startup:

9.3.1 Install one 5 micron (µm) Teflon particulate filter and filter housing to the "NO" sample port and one to the "NOy" sample port at the back of the analyzer. These are the external particulate filters for each sample line. Per Thermo recommendations, NOy instruments that are experiencing span instability, should have a Teflon filter installed in the filter housing of the inlet port for ambient air on the external converter box.

9.3.2 Connect the Ethernet cord from the instrument to the Data Acquisition System (DAS) for digital inputs. The data logger must be initialized and calibrated before official data collection begins. Refer to the standard operating procedures for the relevant data logger for specific data logger information.

9.3.3 Plug in the power cord for the external pump and push the front panel power switch to the "on" position. The sample pump should now operate, and the power-up screen will be displayed followed by the Self-Test screen, while the instrument warms up and performs its diagnostic checks.

9.3.4 Although the Operations Manual says to allow at least 90 minutes for the instrument to warm up and stabilize, the technician will allow the instrument at least 24 hours to warm up to properly condition the internal scrubbers and system components prior to calibration.

9.4 42i-Y Operational Settings

The analyzer set up is accomplished by software entries through the touch screen interface. The operator should verify and, if necessary, change the instrument parameter settings for mode, range, units, time, and date according to Table 9-2, prior to the initial calibration.

Table 9-2: Operational Settings

Parameter	Setting
MODE	SNGL
RANGE (NO/DIF/NOy)	200 PPB
UNITS	PPB – parts per billion
TIME	LST - Local Standard Time
DATE	mm/dd/yyyy

9.4.1 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;

9.4.2 Select RANGE and press [ENTER], and then follow the prompts to set NO, DIF and NOy channels to the same range, 2**00 PPB**;

9.4.3 Press Menu to return to the Main Menu screen;

9.4.4 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**

9.4.5 Press Menu to return to the Main Menu screen;

9.4.6 Set the internal clock to within, ± 1 minute of the site data acquisition system (DAS). Select *INSTRUMENT CONTROLS* and press [ENTER].

9.4.7 Use the up and down arrow buttons to select DATE/TIME. Press [ENTER].

9.4.8 Adjust the date and time using the up and down arrow buttons, and then Press [ENTER] to save. This time will remain on local standard time (LST) and use the 24-hour clock format.

9.4.9 Press Menu to return to the Main Menu screen, and then select *ALARMS* and press [ENTER].

9.4.10 Set each alarm *Parameter* according to Table 9-3, below, by navigating to the *Parameter* MIN and then the *Parameter* MAX screens. Use the up and down arrow buttons to adjust the setting, and then Press [ENTER] to save.

Table 9-3: Alarm Settings

Parameter	Units	Minimum	Maximum
Internal TEMP	°C	15	45
Chamber TEMP	°C	48	52
Cooler TEMP	°C	-20	-1
EXT Converter TEMP	°C	300	350
Chamber Pressure (Ch. 1)	mmHg	200	400
Chamber Pressure (Ch. 2)	mmHg	200	400
Sample Flow (Ch.1)	LPM	0.75	2.0
Sample Flow (Ch. 2)	LPM	0.75	2.0
Ozonator Flow	LPM	0.050	>0.050

NOTE: The Ozonator Flow alarm is a hard setting at 0.050 LPM. Inadequate ozonator flow below the set point will cause overheating and may permanently damage the ozonator.

9.4.11 Press Menu to return to the Main Menu screen, and then select *AVERAGING TIME*; press [ENTER] to set to ten seconds (10s).

9.5 Internal Data Back Up

The 42i-Y analyzer has the ability to retain data records for back up and diagnostic purposes. The Thermo iPort software installed on the air monitoring laptop computer or the site computer will allow access to the analyzer by a serial cable, usually to port 1 (RS-232) on the analyzer or Ethernet connection with the IP of the analyzer. For additional information refer to the iPort instruction manual.

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

9.6 Initial Calibration

After configuring and installing the analyzer at the air monitoring station, the technician performs an initial calibration according to the calibration procedures in Section 10 of this SOP.

9.7 Analyzer Removal

This section details the removal of an analyzer that is already installed at a site, such as if the analyzer requires extensive maintenance or replacement. The procedures for reinstalling the analyzer should not be confused with first time installation procedures. In some instances, the analyzer may need to be removed from the site; such as if it needed total replacement or if a site were to be deactivated. In such an instance, the following procedures should be followed.

NOTE: For removal/restart before and after a severe weather event, a manual z/s/p event must be performed to bracket the ozone data and also meet the specifications of zero not exceeding ±5.0 ppb and span not exceeding ±15.0% of theoretical value. Otherwise, the data will be invalid back to the last good z/s/p event.

9.7.1 Perform a manual Z/S/P check (Section 12.2) to bracket the data.

9.7.2 Using the data logger, down the affected analyzer input channel for the long term. Also, note, in the "Operator Comments" section, the removal of the analyzer on the Equipment Status Report, Form No. DEP 09-08-A.

9.7.3 Turn off the analyzer and unplug the power cord from the 120 VAC outlet.

9.7.4 At the rear of the analyzer, disconnect the ¼-inch sample inlet and exhaust tubing.

9.7.5 Cap all analyzer input and output ports.

9.7.6 If the analyzer is to be re-installed at the same location, label all of the wire connections that are connected to the analyzer to ensure proper re-installation.

9.7.7 All of the pertinent connections to the analyzer should now be disconnected. However, before actually removing the analyzer, inspect the location to ensure that no physical obstructions are present that could cause problems. Clear any obstructions, then remove the analyzer.

9.8 Analyzer Reinstallation

Any analyzer installation or reinstallation requires more than simply placing the analyzer into the desired location and hooking up the correct fittings and wires. Any reinstallation procedure must also incorporate all operational and precision checks required to place the analyzer back into fully certified ambient monitoring condition. The below procedure should be followed to perform this task.

9.8.1 Place the new/repaired analyzer into its new operating position.

9.8.2 Reconnect the sample inlet tubing to the sample port at the rear of the analyzer. Now connect the ¼-inch exhaust tubing to the exhaust port at the rear of the analyzer.

9.8.3 Reconnect the power plug to the power port at the rear of the analyzer and plug the opposite end into a 120 VAC outlet.

9.8.4 Reconnect the wiring that was previously labeled and removed in Step 9.7.4 above.

9.8.5 After the analyzer and all ancillary equipment are connected properly, proceed to Section 9.3 to check instrument settings and conduct the remaining installation procedures.

9.8.6 Complete a full calibration check of the instrument as described in Section 10 of this SOP, prior to the start of collecting ambient air quality data.

9.8.7 Activate the corresponding channels on the DAS to record the ambient NO, NOy, and DIF data.

10.0 INSTRUMENT CALIBRATION

The calibration procedure is used to document the relationship between the gas concentration measurements made by the analyzer and known concentrations. Florida Department of Environmental Protection Air Monitoring relies upon this documented relationship to establish the legal traceability of the ambient NO, DIF, and NOy measurements subsequently made by the analyzer. 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 provided that they are secured by a unique password.

The analyzer is required to be calibrated prior to its use in collecting ambient NO/NO_2/NOy data that may be reported to the AirMVP database. Thereafter, calibration of the 42i-Y analyzer shall be conducted quarterly (every 90 days) or as needed. Calibration procedures defined in this SOP according to the manufacturer's instructions in Chapter 4 of the Model 42i-Y NOy Instruction Manual. The analyzer must be recalibrated under the following conditions:

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

2. Following a bi-weekly zero response that exceeds ±5.0 ppb or a bi-weekly span response that exceeds 12% relative difference for NO or NO_2 (DIF channel).

3. Following any multipoint calibration QC check where the span, upscale and precision audit points exceeds ± 2% or the low point exceeds ± 1.5 ppb, 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.

4. Upon any indication of analyzer malfunction or change in calibration. This includes exceedance of the control limits during bi-weekly checks.

5. Following physical relocation of the analyzer.

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

NOTE: The multipoint calibration QC check refers to the calibration check after an adjustment or calibration of the analyzer, or any other multipoint check used to validate the ambient data.

In this procedure, the operator uses a dilution calibrator (e.g., T-API Model T700U) to provide the analyzer with zero air and various concentrations of NO/NO_2/NOy over the analyzer's measurement range. The analyzer's response to each concentration is recorded and, if necessary, the analyzer is adjusted to accurately measure the gas concentrations. Multiple gas concentrations are used to allow the analyzer's linearity to be assessed.

Table 10-1: Calibration Check Points

Event	**NO/NOy Linearity**	**NO_2 Linearity (GPT)**	
	NO/NOy Levels (ppb)	NO_{ORIG} (ppb)	NO_2 Levels (ppb)
Zero event	0	0	0
Span event	180	180	160
Upscale	100		80
Precision	34		34
Low Point	2.9		2.9

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 09-08-B, must be completed in its entirety, including the heading. Calibration forms may be pre-printed or, have entries on electronic forms made in advance, with any information that is unlikely to change during the time period covered by the logbook. The preprinted information typically includes the site name and AQS number, the instrument and calibrator information, and the calibration gas cylinder information. However, it is the technician's responsibility to ensure that any pre-printed information contained on the calibration form is correct. In the event any of the pre-printed information changes (e.g., temporary use of replacement equipment), the technician shall use standard initialed strikethrough(s) to correct the information.

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

10.1 Equipment Required for Calibration

In addition to the equipment and supplies listed in Section 8.0, above, the technician may need a hand-held calculator or equivalent calculation device (e.g., computer software) for computations if not using the Microsoft Excel™ electronic version of the calibration form. The electronic form contains formulas to automatically calculate the statistics and display the results related to each limit or performance criteria.

10.2 Preparation for Calibrations

Routine quarterly calibrations of the analyzer must be preceded by the z/s/p checks described in Section 12.0 of this SOP. The operator must ensure that those checks are completed, and the results documented before proceeding with the analyzer calibration.

If the analyzer is being installed for the first time at the monitoring site, or reinstalled following removal from the site, the operator must complete the following pre-calibration steps.

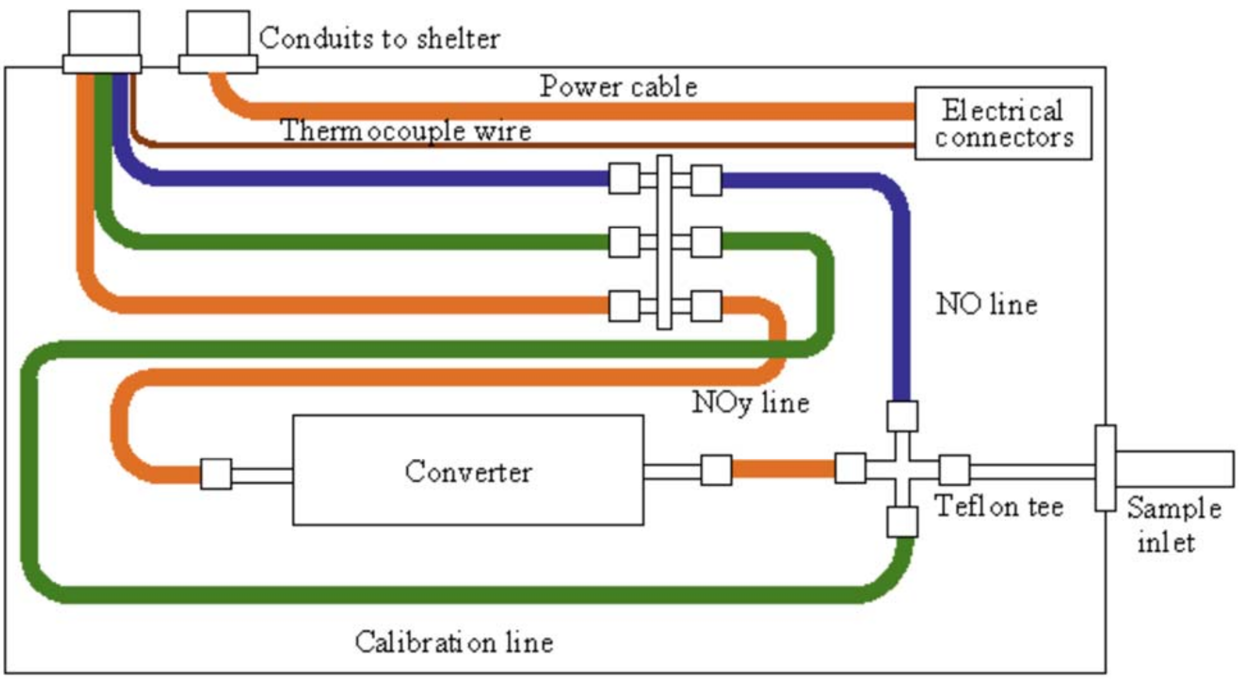
A. Ensure that the analyzer and calibration system are properly wired and plumbed as illustrated in figure 10-1, below. Also ensure that the DAS has been properly wired, initialized, and calibrated.

B. Ensure that the control settings of the analyzer are set as described in Section 9.4 of this SOP and that the analyzer has been allowed to warm up for several hours (preferably overnight) prior to the calibration.

C. The regulator on the gas cylinder must be purged 3 to 5 times prior to the use of a new calibration gas cylinder. In general, the procedure to purge a regulator requires the opening and closing the regulator valves as specified in the SOP for the make and model of the dilution calibrator.

D. Check the analyzer, calibrator, and the data logger clocks to ensure that they are all set to within ±2 min of a NIST-traceable standard.

Figure 10-1: 42i-Y External Converter Plumbing Schematic



NOTE: A thorough understanding of the analyzer's operation is necessary before performing any calibration. ***Do not adjust the analyzer until zero, precision, and span have been recorded to validate the data already collected.***

Record the multipoint calibration check in the appropriate spaces on the calibration form, DEP-09-08-B. The Microsoft Excel™ version of this form contains formulas to calculate the statistics and display the results related to each limit or performance criteria. However, if this form is used in hardcopy format, the operator must perform the calculations, manually and record each result.

10.2.1 Enter the equipment information in the *Identification* block of the calibration form.

10.2.2 Select "*Calibration*" as the [Procedure] from the dropdown menu on the MS Excel version of DEP Form No. 09-08-B, calibration form.

10.2.3 Enter the NO gas cylinder information from the certification label on the side of the cylinder, in the *Standards* block. These NO and NOx values are very important and are used in multiple calculations throughout DEP-09-08-B. Record tank concentrations in parts per million (ppm).

10.2.4 "Disable" the NO, NOy, and DIF data logger channels using the HyperTerminal link to the DAS data logger through the site PC or other established communication link to the site DAS. Record the time in the *Primary Recorder Status* block on the calibration form for the [Channel Off-line].

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

10.3 Zero Calibration

Conduct a **ZERO** calibration using the dilution (zero) air delivered to the 42i-Y analyzer to set or reset the Prereactor, NO and NOy Background gain factors for each channel.

10.3.1 Allow the analyzer to sample the zero air until NO, DIF, and NOy responses are stable.

NOTE: Stability, during any calibration or calibration check, is defined as 10 one-minute averages of ±2 ppb with no upward or downward trend.

10.3.2 From the Main Menu, select *CALIBRATION*, then select *CAL Prereactor Zero*.

NOTE: The Prereactor channel must be calibrated first and then calibrate the NO channel, then the NOy channel.

10.3.3 Press enter to set the zero concentration reading for to zero and store the new background zero.

NOTE: The average data logger response and average analyzer response should agree to within ±2 ppb. Otherwise, further zero adjustment, according to the procedures in the instrument's operational manual, is necessary.

10.3.4 Repeat steps 10.3.2 and 10.3.3 for the NO channel and then the NOy channel.

10.4 NO and NOy SPAN Calibrations

Conduct a NO, and then a NOy SPAN calibration at 180 ppb. This sets/resets the NO and NOy slope coefficients for each channel. The acceptable range for the NO and NOy slope coefficient value is 1.0 ± 0.3.

10.4.1 Initiate sampling of NO span gas and adjust the calibrator to generate an NO concentration of approximately 180 ppb.

10.4.2 Allow the responses to stabilize until 10 one-minute averages are within ±2 ppb with no upward or downward trend.

10.4.3 Calculate the NO and NOy concentrations, in ppb, being delivered by the calibrator using Equation 10-1, below and record this value on the calibration form, *NO Calibration* block for the calculated concentrations of NO and NOy.

NOTE: These values will be automatically calculated throughout the calibration when using the Microsoft Excel version of Form No. DEP 09-08-B. Otherwise, it is recommended that the operator complete this calculation manually and enter the results in the hardcopy version of form, DEP 09-08-B.

Equation 10-1: Calibration Gas Output Concentration

$$NO/NOy\,output = \frac{F_g}{(F_g + F_O + F_Z)} \times C_g \times 1000$$

Where; (EQ 10-1)

F_g = NO or NOy calibration gas flow (cc/min)
F_O = Flow through the ozone generator (cc/min)
F_Z = Zero air flow (cc/min)
C_g = NO or NOx gas concentrations in cylinder (ppm)

10.4.4 From the Main Menu, select *CALIBRATION*, then select *CAL NO Coefficient* and enter the Calculated NO Span concentration from Equation 10-1 above.

10.4.5 Press enter to store the calibrated NO Span coefficient.

10.4.6 Repeat steps 10.4.4 and 10.4.5 to calibrate the NOy coefficient.

10.4.7 Press to return to the main menu screen.

10.5 Review the Calibration

The technician must re-initiate the zero event to review any drift caused by the NO/NOy span calibration. Although the acceptable level of zero drift within 24 hours of calibrating the zero offset is ± 3.0 ppb, the zero response is typically within ± 1.0 ppb during this review. However, if it is necessary to make adjustments, the technician performs a ZERO calibration and/or the NO/NOy Span calibrations by repeating sections 10.3, and 10.4, 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 09-08-B.

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

10.6 NO/NOy Linearity Checks

The operator will verify that the calibration meets the performance criteria by challenging the analyzer with a beginning zero check and four upscale concentrations. An ending zero check is performed prior to returning analyzer to the normal operating mode for ambient air monitoring.

The linearity check for the NO/NOy channel on the instrument is performed immediately following the NO/NOy Span Calibration.

Using a least squares linear regression method, this procedure provides the data to calculate the slope, m, and intercept, b, for both the NO and NOy calibration curves. The Microsoft Excel™ version of Form DEP 09-08-B contains formulas to calculate the slope and intercept, and then enter the results in the *NO Calibration Curve* block the [New Cal] statistics. If this form is used in hardcopy format, the operator must perform the calculations, manually and record the result.

10.6.1 Perform an initial zero QC check by delivering zero air to the analyzer.

10.6.2 Allow the responses to stabilize until 10 one-minute averages are within ±2 ppb with no upward or downward trend. Then update the calibrator's calibration gas (F_g) and dilution (F_Z+F_D) air flows on the calibration form for the *zero* point in the *NO Calibration* block.

10.6.3 Record the average stabilized zero response on the calibration from, DEP 09-08-B, the calibration gas flow, and the dilution air flow, which should be 0.0 LPM, from the front of the Multi-Gas Calibrator for the initial zero of the *NO Calibration* block.

10.6.4 Record the average stabilized zero response on the calibration from for the observed NOy response.

10.6.5 Calculated the straight difference between the calibrated zero for NO, [Calc. NO] and the observed NO, [Obs. NO] concentration; record the [RESULT] on the calibration form as "PASS" or "CALIBRATE".

NOTE: The average data logger response and average analyzer response should agree to within ±3 ppb. Otherwise, further zero adjustment, according to the procedures in the instrument's operational manual, is necessary.

10.6.6 Deliver the Span concentration by setting the calibrator to generate an NO concentration of approximately 180 ppb to the analyzer.

10.6.7 Allow the responses to stabilize until 10 one-minute averages are within ±2 ppb with no upward or downward trend. Then record the calibrator's calibration gas (F_g) and dilution (F_Z+F_D) air flows on the calibration form for the span point in the *NO Calibration* block.

NOTE: The flows may be slightly different than recorded earlier in step 10.4.1. Therefore, the operator must pay close attention to updating the flow rates on the calibration form.

10.6.8 Calculate the NO and NOy concentrations being delivered by the calibrator using Equation 10-1 and record this value on the calibration form, *NO Calibration* block for the calculated concentrations, [Calc. NO] and [Calc. NOy].

10.6.9 Allow the analyzer to sample for an adequate period to achieve stability and display the measured (observed) NO and NOy concentrations.

10.6.10 Record the observed NO, [Obs. NO], and NOy, [Obs. NOy] responses on the calibration form for the *span* point in the *NO Calibration* block.

10.6.11 Calculated the relative percent difference between the calculated span for NO and the observed NO concentration; record the [RESULT] on the calibration form as “PASS” or “CALIBRATE”.

10.6.12 Deliver three more concentrations of NO gas to the analyzer: An *Upscale* concentration of 100 ppb; the *Precision* at 34 ppb; and *Low Point* at 2.9 ppb.

10.6.13 For each QC Check concentration point, allow the analyzer to stabilize until 10 one-minute averages are within ±2 ppb with no upward or downward trend. Then record the calibrator’s calibration gas (F_g) and dilution (F_Z+F_D) air flow on the calibration form for the span point in the NO Calibration block.

10.6.14 Calculate the NO and NOy concentrations being delivered by the calibrator using Equation 10-1 and record this value on the Calibration form, *NO Calibration* block for the calculated concentrations, [Calc. NO] and [Calc. NOy].

10.6.15 Record the observed NO and NOy responses and calculate the relative percent difference between the calculated NO and the observed NO concentration for the *Upscale* and *Precision* points, and the straight difference for the *Low Point*; record the [RESULT] on the calibration form as “PASS” or “CALIBRATE”.

10.6.16 Enter “n/a” for the *Previous Cal* [slope (m)] and [intercept (b)] in the *NO Calibration Curve* block.

10.6.17 Calculate and record the [slope (m)] and [intercept (b)] of the NO calibration curve using a least squares linear regression method, for the *New Cal,* in the *NO Calibration Curve* block.

NOTE: The Microsoft Excel™ version of Form DEP 09-08-B contains formulas to automatically calculate and record the slope and intercept.

10.7 DIF (NO_2) Linearity Checks (Gas Phase Titration)

The instrument calibration is further verified by a multipoint check of the linearity of the DIF channel using gas phase titration (GPT). A specified concentration of ozone is introduced into the dilution calibrator mixing chamber to react with the NO calibration gas (NO_{ORIG}) and produce the same amount of NO_2 in the test gas atmosphere. The 42i-Y analyzer draws in the test atmosphere passing it through the molybdenum catalyst to convert NO_2 to NO and displays the response on the NOy channel (NO_{ORIG}). A portion of the test atmosphere by-passes the convertor and is measured on the NO channel (NO_{REM}) of the analyzer. The DIF channel response is the difference between the total reactive NO_{ORIG} and the NO_{REM} in the test atmosphere, plus impurities in the calibration gas cylinder.

Note: Since the reactive NO species in the test atmosphere is only NO2, the DIF response will be referenced as NO2 in this section of the SOP.

To begin, establish the NO original concentration (NO_{ORIG}) by delivering approximately 180 ppb (90% full-scale) to the analyzer using the Multi-Gas dilution calibrator. This concentration will be maintained throughout GPT for NO_2 linearity checks.

10.7.1 Initiate NO_{ORIG} concentration of 180 ppb; sample until the analyzer's NO and NOy responses have stabilized. Stability is defined as 10 one-minute averages of ±2 ppb with no upward or downward trend.

10.7.2 On the calibration from, DEP 09-08-B, record the calibration gas (F_g), [Gas Flow], and dilution (F_Z+F_D), [Dil Flow], for the *NO_{ORIG} Calculation*.

10.7.3 Record the average NO original concentration, *Obs. NO_{ORIG},* and then calculate the corrected NO original concentration being delivered by the calibrator using Equation 10-2, below. Record this value under *Corr. NO_{ORIG}* for the NO_{ORIG} Calculation line on the form and for each calibration check point in the *NO_2 Check* block.

Note: The NO_{ORIG} values for each NO_2 Calibration Point will be automatically calculated throughout the NO_2 Check when using the Microsoft Excel version of Form DEP—09-08-B.

Equation 10-2: NO Concentration for GPT

$$Corr.NO_{ORIG} = \frac{1}{m}(Obs\ NO_{ORIG} - b)$$

Where; (EQ 10-2)

Corr. NO_{ORIG} = Original NO concentration near 90% of full-scale range of the analyzer.
Obs. NO_{ORIG} = analyzer response for the NO concentration measured during the NO/NOy linearity check.
m = slope of the NO calibration curve.
b = intercept value of the NO calibration curve.

10.7.4 Adjust the ozone generator in the dilution calibrator to provide sufficient ozone to produce a decrease in the NO concentration to 80% of full scale (approximately 160 ppb). The decrease must not exceed 90% of the NO concentration; record the Ozone setting for the span point in the NO_2 *Check* block of the calibration form.

NOTE: The NO_2 concentration is directly proportional to the amount of ozone produced by the dilution calibrator. Therefore, the technician shall refer to the dilution calibrator's operation manual to determine the proper setting for generating sufficient ozone to produce 160 ppb of NO_2 during GPT.

10.7.5 Correct the analyzer's average NO remaining response according to the NO calibration curve using EQ 10-2, by replacing the Corr. NO_{ORIG} term with Corr. NO_{REM} and then record it as the *Corr. NO_{REM}* value on the on the calibration form for the NO_2 span calibration point.

10.7.6 Calculate the NO_2 concentration being delivered by the calibrator using Equation 10-3, below, and record this value as *Calc. NO_2* on the form.

Form DEP 09-08-B calculates the NO_2 calibration gas concentration to reflect the sum of the NO_2 concentration generated by the GPT plus any NO_2 impurity. Use Equation 10-3, below. This value is recorded as the calculated NO_2 concentration, *Calc. NO_2*.

Equation 10-3: Calculated NO_2 Concentration

$$Calc.NO_2 = Corr.NO_{ORIG} - Corr.NO_{REM} + NO_{2\ IMP}$$

Where; (EQ 10-3)

Corr. NO_{ORIG} = Original NO concentration near 90% of full-scale generated by the calibrator and read from the analyzer.

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

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

10.7.7 Record the analyzer's average NO_2 response as *Obs. NO_2* on the on the calibration form for the NO_2 span calibration point.

10.7.8 Calculated the relative percent difference between the calculated span for NO_2 and the observed NO_2 concentration; record the result on the calibration form.

10.7.9 Adjust the ozone generator in the dilution calibrator to provide sufficient ozone to produce three more concentrations of NO_2 to the analyzer: An Upscale concentration of 100 ppb; the Precision at 34 ppb; and Low Point at 2.9 ppb.

NOTE: The NO_2 concentration is directly proportional to the amount of ozone produced by the dilution calibrator. Therefore, the technician shall refer to the dilution calibrator's operation manual to determine the proper setting for generating sufficient ozone to produce the desired concentration of NO_2 during GPT.

10.7.10 For each NO_2 concentration point, allow the analyzer to stabilize until 10 one-minute averages are within ±2 ppb with no upward or downward trend.

10.7.11 Correct the analyzer's average NO remaining response according to the NO calibration curve using EQ 10-2, by replacing the Corr. NO_{ORIG} term with Corr. NO_{REM} and then record it as the *Corr. NO_{REM}* value on the on the calibration form for each calibration point.

10.7.12 For each NO_2 concentration point, calculate the NO_2 concentration being delivered by the calibrator using Equation 10-3 and record this value as *Calc. NO_2* on the form.

10.7.13 For the Upscale and Precision NO_2 concentration points, determine the relative percent difference between the calculated upscale and precision points for NO_2 and the observed NO_2 concentration; record the result on the calibration form as the relative percent difference.

10.7.14 Enter "n/a" in the [RESULT] field since the acceptance criteria is based on the "Best Fit Concentration" calculated in the *Calibration Assessment* block.

10.7.15 For the Low NO_2 Point, determine the straight difference between the calculated and average observed NO_2 concentrations; record the result on the calibration form.

10.7.16 Enter “n/a” in the [RESULT] field since the acceptance criteria is based on the “Best Fit Concentration” calculated in the *Calibration Assessment* block.

10.7.17 Transcribe the *Calc. NO_2* value for each calibration point on the “Calibrator Value (X)” row in the *Calibration Assessment* block.

10.7.18 Transcribe the *Obs. NO_2 value* for each calibration point on the “Instrument Value (Y)” row in the *Calibration Assessment* block.

10.7.19 Calculate and record the slope (m) and intercept (b) using the least squares linear regression method.

10.7.20 Apply the slope and intercept to calculate and record each point in the row labeled “Best Fit Concentration”.

10.7.21 Calculated and record the relative percent difference (%Diff) between the *Best Fit Concentration* and the *Instrument Value (Y)*; record the RESULT as “*PASS*” or “*CALIBRATE*” on the calibration form.

NOTE: The Upscale and Precision calibration check points must be within ±2% of the Best Fit Linear Regression Line. For the Low Point, calculate the straight difference where the acceptance criteria is within ± 1.5 ppb. The Microsoft Excel™ version of this form contains formulas to automatically calculate the Calibration Assessment statistics and display the results related to each limit or performance criteria.

10.7.22 Deliver ZERO air until the analyzer displays 0.5 ppb or less; record the average of 5 readings for *Corr. NO_{ORIG}* and *Corr. NO_{REM}* in the Ending Zero row of the *NO_2 Check* block.

10.7.23 Record the [Impurities] and calculate the NO_2 and record the *Calc. NO_2* value and average *Obs. NO_2* response from the analyzer.

10.7.24 Calculated and record the relative percent difference (%Diff) and then record the RESULT as “*PASS*” or “*CALIBRATE*” on the calibration form.

10.7.25 Complete the *Converter Efficiency Check* according to procedures in section 12.3 of this SOP.

10.7.26 Return the calibrator to “STANDBY” mode. Allow the analyzer to sample ambient air for 10 minutes.

10.7.27 Change the NO/DIF/NOy channels on the DAS back to ambient mode by enabling the channels and record the time of the [Channel On-line] in the *Primary Recorder Status* block of the calibration form.

10.7.28 Complete the calibration form by adding any pertinent *Operator Comments*. Then sign and date the form and submit it to the QA staff for review.

11.0 INSTRUMENT MAINTENANCE

PREVENTIVE MAINTENANCE

This section describes periodic maintenance performed, on field instruments sampling ambient air by a field technician, in order to ensure both accurate and uninterrupted performance. The stability of the chemiluminescence reaction between NO and O_3 is dependent upon the proper verification of multiple instrument sensors. These procedures are documented on Form No. DEP 09-08-C, TEI 42i-Y Maintenance Log. Once the form is 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 technician will "disable" the channels affected on the data logger before performing maintenance and "enable" the channels to ambient mode when completed.

The technician shall provide a descriptive comment indicating the purpose for completing maintenance on Form No. DEP 09-08-A, Equipment Status Report, explaining any conditions that are out of tolerance and any maintenance checks answered with a "NO" or "UNSCHEDULED" answer. Once the Maintenance Log is complete, the technician will submit it and the Equipment Status Report to the field technician's supervisor, or other designated QA Staff, for quality control, accuracy and data review. The supervisor will review and approve the Maintenance Log by recording their name [QA Reviewer] and the [Review Date] on the form. The QA Reviewer may also add specific comments related to the maintenance activities in the Equipment Status Report [QA Comment] box, then sign and date the Equipment Status Report.

Table 11-1: Preventive Maintenance Schedule for the TEI Model 42i NOy Analyzer

Section	Item	Schedule
11.1	Perform Pneumatic System Leak Check	Quarterly
11.2	Replace External Sample line Particulate Filters	Quarterly
11.3	Replace Pump Pack Scrubber	Quarterly
11.4	Clean PMT Cooler Fins and fan filters	Semi-Annually
11.5	Inspect capillaries and O-rings	Semi-Annually
11.6	Clean or Replace Sample Lines	Annually
11.7	Check System Flow Rate	Annually
11.8	Check Pressure Sensors	Annually
11.9	Check RCELL Temperature Sensor	Annually

11.1 Pneumatic System Leak Check

Leaks are the most common cause of analyzer malfunction. This section presents a simple leak check. The detailed procedure can be found in chapter 5 of the Model 42i NOy Instruction Manual. **This procedure should be done following any major maintenance or any time a leak is suspected of impacting results.**

11.1.1 With the analyzer and by-pass pump "OFF", inspect all internal and external tubing (pneumatic lines).

11.1.2 Cap three of the four ports on the rear of panel of the by-pass pump with a leak-tight cap, excluding the exhaust port.

11.1.3 Connect a suitable vacuum gauge to the fourth port and turn pump "ON".

11.1.4 Verify that the pressure reading on the vacuum gauge drops below 160 mmHg. If not, investigate the system for leaks.

Note: If the pump diaphragm is in good condition and the capillaries are not blocked, the vacuum should drop below 160 mmHg within one minute.

11.1.5 Re-connect the sample line and document the leak check results on the maintenance log. If the leak test fails, record any corrective actions on the equipment status report, DEP 09-08-A.

11.2 Replace External Particulate Filter(s)

The external, 5 microns (µm) particulate filters are located in the filter housing for the NO sample line and the NOy sample line. Both are just upstream of the analyzer bulkhead. It is replaced with a new 5 µm filter during maintenance performed each calendar quarter or sooner, if necessary.

A detailed description of replacing the sample filter can be found in Chapter 5 of the Model 42i NOy Instruction Manual.

11.2.1 Prior to beginning this procedure, the technician must use PTFE-coated tweezers or wear non-powdered, vinyl, nitrile, or latex gloves to handle the filter element and any part of the filter holder assembly to avoid contamination of the new particulate filter and assembly.

11.2.2 Disconnect the sampling pump from the back of the analyzer or turn it off by disconnecting power to the pump, leaving the 42i-Y analyzer with power but not drawing sample air.

11.2.3 Open the hinged front panel to access the internal filter assembly.

11.2.4 Unscrew the retaining ring and disassemble the filter body to replace the internal sample particulate filter.

NOTE: Be sure the element is fully seated and centered in the bottom of the holder before reassembly.

11.2.5 Restart the analyzer to perform a NO span check as described in Section 10.6, above, to ensure that the filter is not affecting the NO concentrations. If so, check for leaks around the filter assembly and continue sampling the span concentration until the reading is normal.

11.2.6 Finish the sample filter change with a final zero.

11.3 Inspect/Replace Ozone Scrubber

The external ozone scrubber on the sample pump will be replaced every calendar quarter; 90 days.

11.3.1 Disconnect the external scrubber from the exhaust manifold and replace the activated charcoal in the scrubber.

11.3.2 Reconnect tubing to scrubber and analyzer.

11.3.3 Record the procedure as completed in the Maintenance Log (Form DEP 09-08-C).

11.4 Inspect/Clean PMT Cooler Fins and Analyzer Fan

The cooler fins on the photomultiplier tube (PMT) cooler should be inspected and cleaned every 6 months; 182 days. In addition, the fan in the analyzer body and in the by-pass pump are serviced every 6 months; 182 days. This ensures good heat transfer and optimum performance.

11.4.1 Turn "OFF" the analyzer and remove the instrument cover to locate the PMT cooler.

11.4.2 Blow off the cooler fins using clean, pressurized air or vacuum the fins. Make sure any particulate accumulation between the fins is removed.

11.4.3 Remove the tow fan guard from the fans and remove the filters.

11.4.4 Flush the filter with warm water and let dry or blow the filters clean with compressed air.

11.4.5 Clean the fan guard with warm water or blow clean with compressed air.

11.4.6 Reinstall the filter and fan guard.

11.4.7 Replace the instrument cover and document the procedure in the Maintenance Log (DEP-09-08-C).

11.5 Inspect/Replace Capillaries and O-Rings

The 42i-Y analyzer contains capillaries above the analyzer reaction cell and within the by-pass pump. The capillaries normally only require inspection when the instrument performance indicates that there may be a flow problem or a leak test failure. However, the operator shall inspect the capillaries and O-rings for damage, every 6 months and replace, if necessary.

11.5.1 Turn "OFF" the analyzer and by-pass pump, and then remove the covers.

11.5.2 Remove the fittings from the reaction chamber body in the analyzer and the fittings from the rotometer in the by-pass pump.

11.5.3 Remove the glass capillaries, ferrules, and O-rings to inspect and/or replace as necessary.

Note: Inspect the inside of the glass capillaries for particulate deposits. Clean with compressed clean air.

11.5.4 Replace the capillary in the reaction chamber body, making sure the O-ring is around the capillary before inserting it into the block. Likewise, replace the capillary in the by-pass pump capillary holder.

11.5.5 Re-install the fittings and all components, making sure they are slightly more than hand tight.

11.5.6 Re-install covers, and then turn power "ON".

11.5.7 Record the procedure as completed in the Maintenance Log (Form DEP 09-08-C).

11.6 Clean or Replace Sample Lines

In order to ensure that accurate samples are being transmitted from the inlet manifold to the analyzer, it is essential that the sample lines be kept clear of any obstructions and free of possible contaminants. In order to ensure sample line integrity, these sample lines need to be cleaned or replaced, annually or if a contaminant is detected during a span check.

11.6.1 Detach all of the sample lines and filter holder from the inlet to the back of the analyzer, including the sample inlet tube that penetrates into the manifold.

11.6.2 Remove the filter membrane from the external filter holder using the same method listed in Section 11.2, above.

11.6.3 Replace or clean the sample lines going to the calibrator and analyzer, and then re-install the sample line filter assembly. To clean the sample line, first rinse with isopropyl alcohol, and then rinse again with deionized water. The final step is to blow contaminant-free compressed air (zero air) through the line until it is completely dry.

11.6.4 Using the procedure in Section 11.2 above, replace the sample filter membrane in the sample filter holder.

11.6.5 Perform a zero/span check to verify the operational status. Condition or replace the line if the span is not within ±2% of the actual value. Record the difference in the Calibration Log, Form DEP 09-08-B.

11.6.6 Record the sample line maintenance as completed in the Maintenance Log (DEP 09-08-C).

UNSCHEDULED MAINTENANCE AND CORRECTIVE ACTIONS

Unscheduled maintenance may occur to correct problems discovered with the analyzer during routing quality control checks, instrument alarms or as a result of changing environmental conditions. The operator will refer to the T200/42I-Y-TLE Instruction Manual (Chapter 12-Troubleshooting and Service) for information on troubleshooting, part repair and replacement. Additionally, the operator may contact Teledyne-API Technical Support for diagnostic assistance seeking solutions and corrective actions.

If the analyzer is operable, but must be removed from the field for repairs, a z/s/p check for $NO/NOy/NO_{diff}$ must be performed and documented on the calibration form, Form No. DEP 09-08-B, **prior** to removal.

12.0 QUALITY ASSURANCE & QUALITY CONTROL

The precision or repeatability of the ambient NO/DIF (including NO_2)/NOy measurements made by the analyzer is determined by the results of valid precision checks. The validity of the ambient NO/DIF/NOy data obtained from the analyzer is primarily determined from the results of valid zero, span and precision checks. The zero, span, and precision check (z/s/p) was previously discussed in detail in Section 10, Instrument Calibration, of this SOP.

The z/s/p is the primary quality control data validation activity. A z/s/p check is run against the analyzer in an "as found" or "unadjusted" condition using the same system that was used to calibrate the analyzer. This check brackets those data produced since the last valid z/s/p check. The analyzer must sample the calibration gas through as much of the ambient sampling line as practicable, including the external particulate filter on the sample line.

NOTE: Operational checks that do not conform to these requirements, in any material manner, may not be used to calculate analyzer precision or determine compliance with applicable data validation control limits.

When performing any quality control check of the analyzer, the technician will document the operational status of the instrument on the Equipment Status Report (DEP 09-08-A); in addition to recording the calibration check on the Form No. DEP 09-08-B and the annual verifications on Form No. DEP 09-08-D.

12.1 Equipment Status Report

An Equipment Status Report (DEP 09-08-A) is completed prior to <u>any</u> 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.

12.1.1 Record and verify the information in the *Identification* and *Standards* blocks of the Equipment Status Report (DEP 09-08-A).

12.1.2 In the *Analyzer Checks* block, indicate if a System Alarm is "ON" or "OFF" and then record the DAS channel for NO, NOy and DIF.

12.1.3 From the Main Menu on the 42i-Y, select *DIAGNOSTICS* and then scroll through the menu options to enter the parameters in the *Analyzer Checks* block.

12.1.4 Navigate back to the Main Menu and select *CALIBRATION FACTORS* to record the current background and coefficient factors.

12.1.5 Complete the *Concurrency Checks* and then complete the equipment status report form by adding any pertinent *Operator Comments*; sign and date the form and then submit it to the QA staff for review.

12.2 Routine QC Checks

Routine manual (operator-observed) z/s/p checks must be performed at least every 14 days (bi-weekly). More frequent checks are permitted for diagnostic purposes or confirming instrument repairs. 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).

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

A. 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.

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

C. 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.

D. 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 z/s/p checks, the operator will follow the NO/NOy Linearity Check procedures in Section 10.6 and the DIF (NO_2) Linearity Check procedures in Section 10.7, above, for the initial zero and then only the span and precision check points.

Table 12-1 is a summary of the Measurement Quality Objectives for NO/DIF/NOy, as reported by the Florida Ambient Air Monitoring Network. The ***Acceptance Criteria*** define the QC limits for the 42i-Y analyzer. A *One Point QC Check for Precision* is performed as part of a z/s/p QC check and the *Calibration QC Check* is a multipoint verification that any adjustments to the instrument response are acceptable.

QC checks at the Span and Precision points which result in the percent difference greater than the ***Control Limit*** of 15.0 % require corrective actions that may include calibrating the analyzer according to Section 10.0 of this SOP. QC checks which result in the percent difference greater than the ***Warning Limit*** of 12.0% require the technician to investigate the poor performance which may include taking corrective actions.

Once the routine QC check is complete, the operator will submit the equipment status report and calibration form to QA Staff for review and document retention in the agency Document Management System.

12.3 Converter Efficiency (CE) Check

Over time, the molybdenum converter deteriorates and the conversion of NOz (including NO_2) to NO is incomplete. Therefore, the converter efficiency (CE) for the 42i-Y analyzer must be ≥ 96% and checked every 14 days. The technician determines the instrument converter efficiency using the data recorded during a z/s/p check or multipoint verification of the calibration (i.e. calibration check). The CE is the slope of the curve generated by plotting the expected NO_2, $[NO_2]_{CONV}$, versus the observed NO_2, $[NO_2]_{OUT}$.

The expected NO_2 concentration, $[NO_2]_{CONV}$ is calculated by Equation 12-1, below. This value is labeled "Calc. NO_2" on the calibration form, DEP 09-08-B. The observed NO_2, $[NO_2]_{OUT}$, is the response from the 42i-Y during GPT. This value is labeled "Obs. NO_2" on the calibration form, DEP 09-08-B. Once the QC check is complete, the technician will calculate the slope (m) of the converter efficiency curve using the least-squares linear regression method, and then multiplying the slope by 100 to express CE in a percentage.

NOTE: The CE check is automatically calculated on the Microsoft Excel™ version of Form DEP 09-08-B.

Equation 12-1: NO_2 Converted

$$[NO_2]_{CONV} = [NO_2]_{OUT} - (Corr.NO_{ORIG} - Corr.NO_{REM})$$

Where; (EQ 12-1)

$[NO_2]_{CONV}$ = the calculated concentration of NO_2 converted labeled as "Calc. NO_2" on the calibration form, DEP 09-08-B.

$[NO_2]_{OUT}$ = the observed NO_2 response from the 42i-Y analyzer read from the DIF channel labeled as "Obs. NO_2" on the calibration form, DEP 09-08-B.

Corr. NO_{ORIG} = the Original NO concentration available for GPT corrected to the most recent NO calibration curve.

Corr. NO_{REM} = the NO concentration remaining after GPT corrected to the most recent NO calibration curve.

The CE check procedure is as follows:

12.3.1 Calculate the slope (m) of the converter efficiency curve generated by plotting the expected NO_2, $[NO_2]_{CONV}$, versus the observed NO_2, $[NO_2]_{OUT}$.

12.3.2 Multiply the slope by 100 and record the %CE in the Converter Efficiency Check block of the calibration form, DEP 09-08-B.

12.3.3 Record the RESULT as "*PASS*" for CE ≥ 96.1% or "*REPAIR*" if CE ≤ 96.0%.

12.3.4 Complete the calibration form by adding any pertinent *Operator Comments*. Then sign and date the form and submit it to the QA staff for review.

The technician will refer to the troubleshooting chapter of the Model 42i NOy Instruction Manual to diagnose and "REPAIR" a failing converter when the CE ≤ 96.0%.

Table 12-1: QA/QC Schedule

Parameter	Acceptance Criteria	Frequency
One Point QC Check for Precision	Control within ± 15.0% (percent difference) Warning identified at > 12.0%	minimum every 14 days
Zero/span check	Zero drift within ± 5.0 ppb Span drift within ± 10.0 %	minimum every 14 days
Converter Efficiency	> 96.0%	During calibrations, z/s/p checks and Performance Audits; minimum every 14 days
Multipoint Calibration QC Check	Zero within ± 3.0ppb, Span, Upscale and Precision points within ± 2.0% of calibration range best-fit straight line, Low point within ±1.5 ppb.	Upon initial installation; every 90-days thereafter
Flow Sensor Verification	±2.0% of NIST-traceable standard in operating range (0.5-2.0 LPM)	Annually, every 365-days
Temperature Sensor Verification	± 2°C	Annually, every 365-days
Pressure Transducer Verification	± 2 mmHg	Annually, every 365-days
Performance Audit	Within ± 15.0% of audit levels 3-10; within ± 1.5 ppb of audit levels 1&2.	Annually, every 365-days

12.4 Multipoint Calibration Check

Every 90 days, the technician will challenge the 42i-Y analyzer with a zero check and four upscale calibration check points to verify the analyzer response and determine the linearity of the calibration curve. The multipoint verification is performed according to the procedures in Sections 10.6 and 10.7, of this SOP.

If the multipoint QC check falls outside the acceptance criteria as specified in Table 12-1, above, the technician will troubleshoot and calibrate the 42i-Y, if necessary. When the instrument is brought back within tolerance, the technician will set the DAS channels back "On-line" to resume collecting ambient air quality data.

12.5 Pressure Transducer Verification

The pressure transducer of the 42i-Y is instrumental in the proper calculation of nitrogen oxides. The sensor must be verified on an annual basis, calibrated if necessary, and the results recorded on Form No. DEP 09-08-D, the Annual Calibration form. The pressure sensor is acceptable when it is ≤ ±2 mmHg of a NIST-traceable barometer, and within the operating range, 200 – 450 mmHg.

NOTE: The 42i-Y uses one pressure transducer which measures the pressure in each flow path, Ch.1 for the NO path and Ch.2 for the NOy path. However, this procedure may be completed once for either channel. The pressure verification check is performed at the ambient barometric pressure.

12.5.1 Remove the instrument cover.

12.5.2 Disconnect the tubing from the pressure transducer; allow the internal components of the analyzer to equalize to ambient air pressure for a minimum of 5-minutes.

12.5.3 From the Main Menu, select *SERVICE* and scroll to *PRESSURE CALIBRATION*; and then press Enter to display the *PRESSURE SENSOR CAL* screen.

12.5.4 Select *SPAN* to display the *CALIBRATE PRESSURE SPAN* screen.

12.5.5 Document the 42i-Y pressure at SPAN on the Annual Calibration form, DEP 09-08-D, and the ambient pressure observed on the NIST-traceable reference standard, "As Found".

12.5.6 Calculate the difference between the ambient pressure from the reference standard to the reading on the front panel of the 42i-Y, and then, record the [RESULT] as "*PASS*" or "*CALIBRATE*" on the annual calibration form.

12.5.7 If a calibration is necessary, press the Main Menu once, to return to the *PRESSURE SENSOR CAL* screen; otherwise, proceed to step 12.5.16.

NOTE: To calibrate the pressure sensor, the technician will first calibrate the pressure sensor at zero with the system under vacuum, and then the pressure sensor at span with the system at ambient.

12.5.8 Connect a vacuum pump known to produce a vacuum less than 1 mmHg to the pressure transducer.

12.5.9 From the *PRESSURE SENSOR CAL* screen, select *ZERO* to display the *CALIBRATE PRESSURE ZERO* screen.

12.5.10 Wait at least 10 seconds for the zero reading to stabilize, then press to save the zero-pressure value.

12.5.11 Disconnect the vacuum pump from the pressure transducer, leaving the system tubing exposed to allow the internal components of the analyzer to equalize to ambient air pressure for a minimum of 5-minutes.

12.5.12 Press the Main Menu once, to return to the *PRESSURE SENSOR CAL* screen, and then select *SPAN* to display the *CALIBRATE PRESSURE SPAN* screen.

12.5.13 Wait at least 10 seconds for the ambient reading to stabilize, use the arrow keys to enter the known barometric pressure, and then press to save the pressure value.

12.5.14 Document the 42i-Y pressure at SPAN on the Annual Calibration form, DEP 09-08-D, and the ambient pressure observed on the NIST-traceable reference standard, "Post-Calibration".

12.5.15 Calculate the difference between the ambient pressure from the reference standard to the reading on the front panel of the 42i-Y, and then, record the [RESULT] as "*PASS*" or "*CALIBRATE*" on the annual calibration form.

12.5.16 Record the pressure sensor check as completed in the Maintenance Log, Form No. DEP 09-08-C.

12.6 Temperature Sensor Verification

The internal temperature is also a critical component in the proper calculation of nitrogen oxide concentrations. The thermistor that monitors the internal temperature of the analyzer is verified annually. Since there is no adjustment to this thermistor, if it deviates from the NIST-traceable temperature standard by more than ± 1°C, the technician will replace the thermistor.

12.6.1 With the analyzer still running, remove the instrument cover to locate the internal thermistor and allow the sensor to equalize to ambient temperature for a minimum of 5-minutes.

12.6.2 From the Main Menu, select *SERVICE* and scroll to *TEMPERATURE CALIBRATION*; and then press Enter to display the *CALIBRATE AMBIENT TEMP* screen.

12.6.3 Holding the thermistor next to the probe of a certified, NIST-traceable temperature reference standard, compare the reference standard to the internal temperature displayed on the analyzer screen.

12.6.4 Document the 42i-Y observed temperature on the Annual Calibration form, DEP 09-08-D, and the actual temperature from the NIST-traceable reference standard, "As Found".

12.6.5 Calculate and record the difference between the temperature from the reference standard to the current temperature reading on the front panel of the 42i-Y, and then, record the [RESULT] as "*PASS*" or "*CALIBRATE*" on the annual calibration form.

12.6.6 If a calibration is necessary, consult with the manufacturer's service technician to replace the thermistor and document the necessary repairs in the *Operator Comments* section of Form No. DEP 09-08-D; otherwise, proceed to the next step.

12.6.7 Record the RCEL Temp Sensor check as completed in the Maintenance Log, Form No. DEP 09-08-C.

12.7 Flow Sensor Verification

The rate of sample gas and ozone flow through the 42i-Y analyzer is a key part of the NOy/NO/DIF concentration calculations. Therefore, an annual check and/or calibration, if necessary, of the flow sensor is required. The total system flow rate is acceptable when it is ≤ ±2% of a NIST-traceable flow standard, and within the operating range, 0.5 – 2.0 LPM.

NOTE: The 42i-Y uses one flow sensor to measure system flow rates in each flow path, Ch.1 for the NO path and Ch.2 for the NOy path. This procedure may be completed once for the NO channel by changing the operation to "Manual Mode".

12.7.1 With the 42i-Y analyzer running, connect a certified flow rate standard, such as the Bios Defender 220, to the "NO Sample" port on the back of the 42i-Y analyzer.

12.7.2 From the Main Menu, select *INSTRUMENT CONTROLS* and scroll to *AUTO/MANUAL MODE.*

12.7.3 Using the arrow keys, toggle the setting to "MANUAL NO" and save the value by pressing.

12.7.4 Return to the Main Menu, select *SERVICE* and scroll to *FLOW CALIBRATION*; and then press Enter to display the *FLOW SENSOR CAL* screen.

12.7.5 Select *SPAN* to display the *CALIBRATE FLOW SPAN* screen.

12.7.6 Document the 42i-Y flow at SPAN on the Annual Calibration form, DEP 09-08-D, and the actual flow observed on the NIST-traceable reference standard, "As Found".

12.7.7 Using EQ 4-1, calculate and record the relative percent difference (%Diff) between the actual flow from the reference standard to the reading on the front panel of the 42i-Y, and then, record the [RESULT] as "*PASS*" or "*CALIBRATE*" on the annual calibration form.

12.7.8 Return to the Main Menu, select *INSTRUMENT CONTROLS* and scroll to *AUTO/MANUAL MODE.*

12.7.9 Using the arrow keys, toggle the setting to "AUTO" and save the value by pressing.

12.7.10 If a calibration is necessary, press the Main Menu once, to return to *the FLOW SENSOR CAL* screen; otherwise, proceed to step 12.7.16.

NOTE: To calibrate a flow sensor, the technician will first calibrate the flow rate at zero* and *then the flow rate at span.

12.7.11 Turn "OFF" the sample pump and select ZERO to display the *CALIBRATE FLOW ZERO* screen.

12.7.12 Toggle the keys on the front panel of the analyzer to match the actual flow recorded by the flow standard, and then press Enter to save the new setting.

12.7.13 Turn “ON” the sample pump and select SPAN to display the *CALIBRATE FLOW SPAN* screen.

12.7.14 Toggle the keys on the front panel of the analyzer to match the actual flow recorded by the flow standard, and then press Enter to save the new setting.

12.7.15 Record the new flow rate at SPAN setting on DEP 09-08-D, Annual Calibration form, “Post Calibration”.

12.7.16 Record the annual flow rate check as completed in the Maintenance Log, Form No. DEP 09-08-C.

13.0 DATA ACQUISITION AND RECORDS MANAGEMENT

The 42i-Y analyzer can be interfaced with analog connection, serial or via network Ethernet cables. The Florida Ambient Air Monitoring Network is configured to use digital connections from the 42i-Y analyzer through the data acquisition system to the main data storage in the main office. The Florida Statewide Data Handling and data Validation SOP covers the data handling for the state of Florida.

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

Technical Assistance Document for Precursor Gas Measurements in the NCore Multi-Pollutant Monitoring Network, Version 4, USEPA OAQPS, EPA-454/R-05-003, September 2005.

Model 42i NOy Instruction Manual, Thermo Scientific, Part Number 102975-00, 27Sep2016.

15.0 APPENDICES

15.1 Appendix A – Forms

1. DEP Form No. 09-08-A – Equipment Status Report
2. DEP Form No. 09-08-B – Calibration
3. DEP Form No. 09-08-C – Maintenance Log
4. DEP Form No. 09-08-D – Annual Calibration (Temperature, Pressure, and Flow)

Form No. DEP 09-08-A, 42i NOy Equipment Status Report

DEP SOP 09 08
Revision No. 0
Revision Date: 9/1/2020

Form No. DEP 09-08-A **TEI 42i-Y Equipment Status Report**

Identification Block

Date Performed:		Site Name:		AQS #:		Procedure:	
Instrument Mfr:	THERMO	Model:	42i-Y	Serial #:		Date Calibrated:	
Calibrator Mfr:	TELEDYNE	Model:	T700U	Serial #:		Photometer Cert.:	
						MFC Calibrated:	
Data Logger Mfr:		Model:		Serial #:		Date Certified:	

Standards Block

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

Analyzer Checks

CALIBRATION FACTORS	Value
NO Bkg.	
NOy Bkg	
Prereactor Bkg (will alarm at > 2ppb)	
NO Coef.	
DIF Coef.	
NOy Coef.	

OTHER PARAMETERS	Range	Value	If Out of Limits**
System Alarm	On/Off		Record alarm in comments, troubleshoot
Internal Temp (°C)	N/A		
Chamber Temp (°C)	47 - 51		Check Rxn Chamber
Cooler Temp (°C)	< 10		Check PMT Cooler
Ext Conv Temp (°C)	325 ± 25		Check NO2 > NO Conv.
Chamber Press Ch 1 (mmHg)	200 450		
Chamber Press Ch 2 (mmHg)	200 450		
Sample Flow Ch 1 (LPM)	0.5 - 2.0		Replace Pump
Sample Flow Ch 2 (LPM)	0.5 - 2.0		Replace Pump
Bypass Flow Ch 1 (LPM)	0.5 - 2.0		Check capillary for blockage. Replace Pump
Bypass Flow Ch 2 (LPM)	0.5 - 2.0		Check capillary for blockage. Replace Pump
Ozonator Flow (LPM)	> 0.050		Check ozone capillary for blockage. Replace as necessary.
Prereactor Zero	~ 0		

** Refer to Table 6-1 in User's Manual for further Troubleshooting Guidance

Maintenance Checks

Sample Lines	Maint. Action	
Particulate Filter	Maint. Action	

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: ____________

Instructions:

This Equipment Status Report is formatted as an electronic spreadsheet used specifically for the TEI 42i-Y-TLE. It is completed for all instrument operational checks, internal performance audits, calibrations, and scheduled or unscheduled maintenance. The information contained in each activity report may be aggregated as a running instrument operational log.

If this form is used in hardcopy format, the operator must perform the straight difference calculations for each *Concurrency Check* and enter the RESULT as “PASS” or “CALIBRATE”.

1. Complete the site and instrument information in the *Identification Block* at the top of the form. Select the [Procedure] type from the cell dropdown menu to identify the activity performed.
2. In the *Standards Block*, complete the instrument information for the NIST traceable time standard used during this calibration check. Be sure to enter the date of the last certification for the time transfer standard referenced during this activity.
3. In *the Shelter Checks* B*lock*, enter the MIN and MAX shelter temperatures, if applicable, and then enter the current shelter temperature.
4. In the *Analyzer Checks Block*, scroll through the instrument display and enter the observed values.
5. In the *Maintenance Checks Block*, use the cell dropdown menu to select the applicable response.
6. In the *Calibration Constraints Block*, enter the values from the 42I-Y-TLE analyzer. **When preforming a calibration, these values will be recorded “as found”, prior to any analyzer adjustments**.
7. In the *Concurrency Checks Block*, enter the values from the 42i-Y-TLE analyzer display and the values from the DAS.
8. Enter a detailed description of the purpose for this ESR and note any issues with the instrument in the comment box for [Operator Comments].
9. Enter/Sign the as [Performed by] with the operator’s name and signature [Date].

The operator should provide descriptive comments indicating the purpose for completing an Equipment Status Report, explain any conditions that are out of tolerance, and any maintenance checks answered with a “NO”. Once the form is complete, the operator will submit it to the QA officer or field team supervisor for verification and review. The QA officer or supervisor may add comments in the [QA Comment] box, then sign and date the report.

Form No. DEP 09-08-B, 42i NOy Calibration Form

DEP SOP 09-08
Revision No. 0
Revision Date: 9/1/2020

Form No. DEP 09-08-B **TEI 42i-Y NOy Analyzer Calibration Form**

Identification Block

Date Performed:		Site Name:		AQS #:		Procedure:	
Instrument Mfr:	THERMO	Model:	42i-Y-TLE	Serial #:		Date Calibrated:	
Calibrator Mfr:		Model:		Serial #:		Photometer Cert.:	
						MFC Calibrated:	
Zero Air System Mfr:		Model:		Serial #:		Date Serviced:	
Data Logger Mfr:		Model:		Serial #:		Date Certified:	
Monitoring Objective:							

Standards Block

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

NO Calibration Curve

	slope (m)	intercept (b)
Previous Cal:		
New Cal:	n/a	n/a
	(1.0 +/- 0.3)	

Primary Recorder Status

	Time (hh:mm)
Channel Off-line:	
Channel On-line:	

Converter Efficiency Check

	CE	Result	Limit
Converter Eff.			96% - 104%

Impurity Calculation

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

Gas Flow Conversion: 1000 cc/min = 1 LPM

NO Calibration

Calibration Point	Gas Flow (L/min)	Dil Flow (L/min)	Calc. NO	Calc. NOy	Obs NO	Obs NOy	NO % Diff	Limits	RESULT
Initial Zero (0 ppb)	0		0.00	0.00			n/a	± 5.0 ppb	
Span (≤90% scale; 180)							n/a	10.0%	
Upscale (100)					n/a	n/a	n/a	15.0%	n/a
Precision (34)							n/a	15.0%	n/a
Low Point (2.9)					n/a	n/a	n/a	15.0%	n/a

Gas Phase Titration

	Gas Flow (L/min)	Total Flow (L/min)	Obs NO_{orig}	Corr NO_{orig}
NO_{orig} Calculation	0.0804	5.930		#VALUE!

NOy-DIF Check

Calibration Point	O_3 (% ppb)	Corr NO_{orig}	Corr NO_{rem}	Impurities	Calc NOy-DIF	Obs NOy-DIF	% Diff	Limits	RESULT
Span (≤80% scale; 160)							n/a	10.0%	
Upscale (80)		n/a	n/a		n/a	n/a	n/a	15.0%	n/a
Precision (34)							n/a	15.0%	
Low Point (2.9)		n/a	n/a		n/a	n/a	n/a	15.0%	n/a
Final Zero	0						n/a	± 5.0 ppb	

Calibration Assessment

	Zero	Low Point	Precision	Upscale	Span	
Calibrator Value (X)	-	-	-	-	-	
Instrument Value (Y)	-	-	-	-	-	
Best Fit Concentration	-	-	-	-	-	
% Diff (Best fit Conc vs. Y values)	-	-	-	-	-	(≤ ± 2.1%)
RESULT:		-	-	-	-	
Straight Diff (Best fit Conc vs. Y values)	-	-	-	-	-	(≤ ± 1.5 ppb)
RESULT:		-	-	-	-	

slope (m)	intcpt (b)
-	-

Operator Comments:

Performed by: ____________ Date: ____________

QA Comments:

Verified by: ____________ Date: ____________

Instructions:
This Calibration Form is formatted as an electronic spreadsheet used specifically for the TEI 42i-Y-TLE. It is completed for all instrument operational checks, internal performance audits, calibrations, and scheduled or unscheduled maintenance. The information contained in each activity report may be aggregated as a running instrument operational log.

If this form is used in hardcopy format, the operator must perform the calculations for determining Converter Efficiency, Gas Impurities, NO Calibration and Linearity Checks, GPT concentrations, NO_2 Linearity Checks, and the Calibration Assessment using the least squares regression. In addition, the operator must enter the RESULT as “PASS” or “CALIBRATE”.

1. Complete the site and instrument information in the *Identification Block* at the top of the form. Select the [Procedure] type from the cell dropdown menu to identify the activity performed.
2. In the *Standards Block*, complete the calibration gas cylinder information for the gas standard used during this calibration or calibration check. Be sure to enter the [Date Certified] and the [Expiration Date].
3. Enter the gas cylinder impurity in the *Impurity Calculation Block*. These values are automatically calculated and entered when using the electronic version of this form.
4. In the *Primary Recorder Status Block*, enter the times the DAS channels are taken off-line and placed back on-line to collect ambient data.
5. In the *NO Calibration Block*, enter the total air flow indicated by the dilution calibrator and the average [Observed NO] and [Observed NOy] indicated by the analyzer for the [zero] calibration point.
6. Enter the drift from zero (0 ppb) for the observed NO concentration and the [RESULT] for the calibration point. These values are automatically calculated and entered when using the electronic version of this form.
7. Enter the gas and total air flows indicated by the dilution calibrator for the next calibration point.
8. Enter the [Calculated NO] and [Calculated NOy] values for the calibration point. These values are automatically calculated and entered when using the electronic version of this form.
9. Enter the average [Observed NO] and [Observed NOy] indicated by the analyzer for the calibration point.
10. Calculate and record the relative percent difference or straight ppb difference (for the low audit point) and the [RESULT] for the calibration point. These values are automatically calculated and entered when using the electronic version of this form.
11. Repeat steps 7 through 10 above, for each calibration point.
12. In the *NO Calibration Curve Block*, enter the [slope] and [intercept] from the most recent [Previous Cal] NO calibration curve if the [Procedure] is a *Z/S/P check*. For *Calibration checks*, the slope and intercept are entered in [New Cal] based on the NO calibration curve.
13. In the *Gas Phase Titration Block*, enter the gas and total air flows indicated by the dilution calibrator for GPT, and the [Obs. NO $_{ORIG}$], and then calculate the [Corr. NO $_{ORIG}$] value for GPT. This value is automatically calculated and entered when using the electronic version of this form.
14. In the block for NO_{diff} *Check*, enter the values for Ozone setting from the dilution calibrator, the [Corr. NO $_{ORIG}$] and the average [Corr. NO $_{REM}$].

15. Calculate and then enter the [Impurities] and the [Calc. NO_{diff}] values. These values are automatically calculated and entered when using the electronic version of this form.
16. Record the average [Obs. NO_{diff}] concentration from the DAS, and then calculate and enter the relative % difference between the calculated and observed (indicated) NO_2 concentration. This value is automatically calculated and entered when using the electronic version of this form.
17. Record the [RESULT] of the NO_2 QC check for the span concentration. This value is automatically calculated and entered when using the electronic version of this form.
18. Repeat steps 14 through 17, for each additional calibration point and then calculate and record the relative percent difference or straight ppb difference (for the low audit point) and the [RESULT] for each calibration point. These values are automatically calculated and entered when using the electronic version of this form.
19. For calibration events, the *Calibration Assessment* information is automatically calculated and entered when using the electronic version of this form. Otherwise, the operator must record each *Calibrator Value (X)* and *Instrument Value (Y)*, then determine the *slope* and *intercept* by least squares linear regression analysis; calculate and record the *Best Fit Concentrations*, and then calculate and record the relative % differences, then finally record the [RESULT].
20. Enter *Operator Comments*, sign with first initial and last name in *Performed by* and enter the *Date*.

SLIC Entries:

1. With the SLIC line in place, record the calibration gas flow and total flow values from the dilution calibrator for generating NO_{ORIG} for GPT and record as [Calc. NOy].
2. Record the average [Obs. NO_{diff}].
3. Repeat entries 1 and 2 for SPAN, with the sample line in place.
4. Calculate and record the relative % difference between the observed (indicated) NO_{diff} concentrations for the SPAN and SLIC checks and the [RESULT]. These values are automatically calculated and entered when using the electronic version of this form.

The operator should provide descriptive comments indicating the purpose for completing calibration form and any conditions requiring further attention. Once the form is complete, the operator will submit it to the QA officer or field team supervisor for verification and review. The QA officer or supervisor may add comments in the [QA Comment] box, then sign and date the report.

The form will display days left until certifications due or cylinder expiration as well as NO, NOy, and NO_{diff} values for 1-point QC checks.

Form No. DEP 09-08-C, 42i NOy Maintenance Log

Form No. DEP 09-08-C

Thermo Model 42i-Y NOy Maintenance Log

DEP 09-08
Revision No. 1
Effective: May 2021

Identification Block							
Year:		Site Name:		AQS #:		Auto QC Check:	
Instrument Mfr:	TEI	Model:	42i-Y	Serial #:			

	Maintenance Activity:	System Leak Check	External Filter Replaced	PMT Fins & Fan Cleaned	Inspect/Replace Capillaries & O-rings	Sample Line Maintenance	Internal Temperature Sensor	Pressure Sensors Check	Flow Sensor Check	External Charcoal Ozone Scrubber Servicing		
	Frequency:	Quarterly	Quarterly	Semi-Annual	Semi-Annual	Annual	Annual	Annual	Annual	Annual		
	Initial Date Completed:											
	Maintenance Due Date:											
Maintenance Date	Operator										QA Reviewer	Review Date
	Maintenance Due Date:											
	Maintenance Due Date:											
	Maintenance Due Date:											
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	Maintenance Due Date:											

Operator Comments:

QA Comments:

Instructions:

This Maintenance Log is formatted as an electronic spreadsheet used specifically for the TEI 42i-Y-TLE Analyzer. It is completed for all scheduled or unscheduled maintenance activities.

The responses on the electronic version on the Maintenance Log utilize a dropdown menu list in each cell. If this form is used in hardcopy format, the operator must enter the response as "YES", "NO", "NOT DUE", "UNSCHEDULED".

OPERATOR

1. Enter the site and instrument information in the Identification Block section at the top of the report.
2. Enter the date maintenance is initiated in the [Maintenance Date] field.
3. Enter the first initial and last name of the operator who performed the maintenance activity in the [Operator] field.
4. Provide an answer to each of the maintenance activities using the dropdown menu {e.g. YES, NO, Not Due, Unscheduled}. Enter YES for activities completed. Enter NO for intentional omissions which will be explained in the Equipment Status Report (DEP 09-08-A). Enter NOT DUE for maintenance activities scheduled on a semi-annual or annual basis, as appropriate. Enter Unscheduled for any UNSCHEDULED maintenance activity which will be explained in the Equipment Status Report (DEP 09-08-A).

QA REVIEWER

1. Enter the first initial and last name of the QA Staff who reviewed the maintenance log in the [QA Reviewer] field.
2. Enter the date of review in the [Review Date] field.
3. Select the rows containing the maintenance activities reviewed by QA Staff to "lock" the cells from further editing.
4. By January 30th of the calendar year, submit the Maintenance Log for the previous calendar year to the agency's QA Coordinator for retention in the agency's Data Management System.

DEP Form No. DEP 09-08-D, 42i NOy Annual Calibration Form

DEP SOP 09-08
Revision No. 0
Revision Date: 09/01/2020

Form No. DEP 09-08-D **TEI 42i-Y Annual Calibration Form**

Identification Block							
Date Performed:		Site Name:		AQS #:		Parameter:	
Instrument Mfr:	THERMO	Model:	42i-Y-TLE	Serial #:		Date Calibrated:	
Data Logger Mfr:		Model:		Serial #:		Date Calibrated:	
Calibrator Mfr:	TELEDYNE	Model:	T700U	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:	

Temperature Sensor Verification

	Temperature	Reference Standard	Difference	Limits	RESULT
As Found (°C)			n/a	± 1°C	n/a

Pressure Transducer Verification/Calibration

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

Flow Sensor Verification/Calibration

	Front Panel	Reference Standard	% Diff	Limits	RESULT
As Found (cm^3/min)			n/a	± 2%	n/a
Post Calibration (cm^3/min)			n/a	± 2%	n/a

Operator Comments:

Performed by: ______ Date: ______

QA Comments:

Verified by: ______ Date: ______

Instructions:

This Annual Calibration Form is formatted as an electronic spreadsheet used specifically for the TEI 42i-Y-TLE. It is completed for the initial calibration or recalibration after major component repair/replacement and annually thereafter. The information contained in each activity report may be aggregated as a running instrument operational log.

If this form is used in hardcopy format, the operator must perform the straight difference calculations for each *Concurrency Check* and enter the RESULT as “PASS” or “CALIBRATE”.

1. Complete the site and instrument information in the *Identification Block* at the top of the form. Select the [Procedure] type from the cell dropdown menu.
2. In the *Standards Block*, complete the instrument information for the NIST traceable standards used during this annual calibration. Be sure to enter the [Date Certified] and the [Expiration Date].
3. In the *Temperature Sensor Verification Block*, enter the temperature displayed by the 42i-Y-TLE and the reference standard. There is no adjustment. The temperature sensor must be replaced if it fails.
4. In the *Pressure Transducer Verification/Calibration Block*, enter the pressure displayed by the 42i-Y-TLE and the reference standard. If the difference exceeds the limit, adjust the pressure reading for the instrument to match the standard and recheck.
5. In the *Flow Sensor Verification/Calibration Block*, enter the flow displayed by the 42i-Y-TLE and the reference standard. If the difference exceeds the limit, adjust the flow reading for the instrument to match the standard and recheck.
6. Enter *Operator Comments*, sign with first initial and last name in *Performed by* and enter the *Date*.

The operator should provide descriptive comments indicating the purpose for completing the Annual Calibration form and any conditions requiring further attention. Once the form is complete, the operator will submit it to the QA officer or field team supervisor for verification and review. The QA officer or supervisor may add comments in the [QA Comment] box, then sign and date the report.

15.2 Appendix C – GLOSSARY

CE	-	Converter Efficiency
CFR	-	Code of Federal Regulations
cm^3/min	-	cubic centimeters per minute
CPU	-	Central Processing Unit
DAS	-	Data Acquisition System
DEP	-	Florida Department of Environmental Protection
DFU	-	Dry Filter Unit
EPA	-	U. S. Environmental Protection Agency
AirMVP	-	Florida Air Monitoring Database
FEM	-	Federal Equivalent Method
FEP	-	Fluorinated Ethylene Propylene
GPT	-	Gas Phase Titration
LED	-	Light Emitting Diode
LPM	-	liters per minute
NIST	-	National Institute of Standards and Technology
NO	-	Nitrogen Oxide
NOy	-	Reactive Oxides of Nitrogen
NOdiff	-	Difference between Reactive Oxides and Nitrogen Oxide
O_3	-	Ozone
PFA	-	Perfluoroalkoxy
PTFE	-	Polytetrafluoroethylene
QA	-	Quality Assurance
QAPP	-	Quality Assurance Project Plan
QC	-	Quality Control
RH	-	Relative Humidity
SLIC	-	Sample Line Integrity Check
SOP	-	Standard Operating Procedure
Z/S/P	-	Zero/Span/Precision