Standard Operation Procedures for NO-NO$_2$-NO$_x$

In Use By
Polk County Air Quality
Ambient Air Monitoring Personnel

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2.0 STANDARD OPERATING PROCEDURE FOR NO-NO₂-NOₓ

2.1 Purpose
To establish a standard operating procedure (SOP) manual for the Polk County Air Quality Division personnel concerning the setup, operation, bi-weekly zero/precision/span checks, calibrations, audits and maintenance of NO-NO₂-NOₓ monitors maintained and operated by Polk County staff. This SOP is intended for individuals responsible for collecting ambient air monitoring data supported by the Polk County Air Quality Division.

2.2 Scope
These procedures are to be used by Polk County Air Quality Division personnel. The objective of this SOP is to familiarize the station operator with procedures used in the collection of air monitoring data. The accuracy of the data obtained from any instrument depends upon the instrument’s performance and the operator’s skill. It is important that the station operator become familiar with both this SOP as well as the manufacturer’s instruction manual in order to achieve a high level of data quality. This SOP is to be used as an outline and is not intended to replace the equipment manufacturer’s manual or procedures. This SOP describes the proper procedures for the setup, operation, bi-weekly zero/precision/span checks, calibrations, audits and maintenance of Thermo Fisher Scientific’s Trace Level 42i analyzers equipment operated by Polk County Air Quality personnel.

2.3 References

2.3.1 Thermo Scientific, Model 42i Trace Level, Chemiluminescence NO-NO₂-NOₓ Analyzer, Instruction Manual. Part Number 102855-00, December 20, 2007.

2.3.2 Thermo Electron Corporation, Model 146i, Dynamic Gas Calibrator, Instruction Manual. Part Number 102482-00, January 22, 2006.


2.3.4 EPA-600/4-75-003 December 1975, Technical Assistance Document for the Chemiluminescence Measurement of Nitrogen Dioxide.

2.3.5 EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards EPA-600/R-12/531, May 2012.


2.3.9 40 Code of Federal Regulations (CFR) Part 58, Appendix A, Quality Assurance Requirements for State and Local Air Monitoring Stations (Slams).

2.3.10 40 Code of Federal Regulations (CFR) Part 58, Appendix D, Network Design for State and Local Air Monitoring Stations (SLAMS), National Air Monitoring Stations (NAMS), and Photochemical Assesment Monitoring Stations (PAMS).


2.4 Introduction
The U.S. Environmental Protection Agency (EPA) has determined nitrogen dioxide (NO₂) is a health and environmental concern. For this reason, National Ambient Air Quality Standards (NAAQS) have been
established for NO₂. As a result, an air monitoring network to monitor for NO₂ was established in the Des Moines Metropolitan Statistical Area (MSA) and is maintained by Polk County Air Quality Division, Iowa.

Measurements of nitrogen dioxide (NO₂) in ambient air are based on the principle that nitric oxide (NO) and ozone (O₃) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO₂ molecules decay to lower energy states:

\[ \text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2 + \text{hv} \]

Ambient air is drawn into the NO-NO₂-NOₓ sample inlet. The sample flows into a solenoid valve which splits the flow between the NO and NOₓ mode. NOₓ mode converts NO₂ to NO (measuring total NOₓ) while the NO mode makes no changes to the air stream and measures NO only. Samples from both modes flow to a reaction chamber where they are alternately introduced to react with dry air passed through an ozonator to provide a source of O₃. The O₃ reacts with the NO present in each sample producing electronically excited NO₂ molecules. A photomultiplier tube housed in a thermoelectric cooler detects the NO₂ luminescence and converts it to an electrical signal, which is then sent to the analyzer’s front panel display and analog outputs. The concentration of NO and NOₓ are both measured with NO₂ concentration calculated by difference. (NOₓ – NO = NO₂).

The dynamic parameter requirement ensures that the NO-O₃ reaction has been completed. The dynamic parameter conditions are met for any reasonable NO flow (12.5–100 sccm) and [NO]STD (40-60 ppm). If the NO concentration of the stock gas cylinder, or flow through the NO MFC in the calibrator falls outside of these ranges, a calculation will be done to ensure that the residence time is \( \leq \) 2 minutes and the dynamic parameter is \( \geq \) 2.75 ppm-min, in accordance with formulas given to the analyzer operator’s manual. Section 8-4, Thermo Scientific 146i Instruction Manual.

2.5 Health and Safety Warning/Precautions

Only properly trained personnel should perform TL-42i testing, installation, operation, maintenance and calibration procedures. As with all monitoring equipment, precautions should be taken when working around electricity, power tools and above ground elevations.

Cylinder gases are used in tandem with Mass Flow Control (MFC) calibrators for the TL-42i. Gas cylinders can sometimes contain 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 valve breaks off, the cylinder can become explosive or a projectile.

Transportation of cylinders is regulated by the Department of Transportation (DOT). It is strongly recommended that all agencies contact the DOT or Highway Patrol to learn the most recent regulations concerning transport of cylinders. It is possible to blend other compounds with CO cylinder gas. In this case, it is recommended that MSDS for all compounds be made available to all staff that use and handle the cylinders or permeation tubes.

2.6 Sampler Setup

2.6.1 Site Selection

In selecting a location to measure for NO₂, it is important to understand that the reactive oxides of nitrogen in the atmosphere are primarily nitric oxide (NO) and nitrogen dioxide (NO₂), known together
as NO\textsubscript{x}. During the daytime, there is a rapid interconversion of NO and NO\textsubscript{2}. NO emitted into the air is converted to NO\textsubscript{2} by photochemical reactions promoted by sunlight eventually creating ozone downwind of the sources. The main sources of NO\textsubscript{x} are motor vehicles, power plants, industry, and outdoor burning. It is recommended that the station be located downwind of the expected point of maximum NO\textsubscript{x} to allow more time for the formation of NO\textsubscript{2}.

For more detailed information concerning site selection for NO-NO\textsubscript{2}-NO\textsubscript{x} monitoring, refer to the 40 Code of Federal Regulations (CFR), Part 58, Appendix D, or the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 6.2, entitled "Monitoring Site Location."

2.6.1.1 The Monitoring Station

The structure housing the monitoring equipment may consist of a trailer, a room in a building, or a shelter designed specifically for air monitoring purposes. A clean, dry, secure and temperature controlled space is required so that the sampling equipment can operate properly.

Careful thought and planning is required in locating a monitoring station. The individual responsible for the installation must consider:

- Proximity to the nearest power source. A 120 VAC source is required for the operation of the NO-NO\textsubscript{2}-NO\textsubscript{x} monitoring equipment.
- The space where the equipment is housed must maintain a temperature range of 20-30 degrees Celsius. This usually requires the need for an air conditioner and a heater controlled by a thermostat.
- The accessibility of the equipment to the operator. The operator must be able to safely access the equipment during regular business hours.
- The security of the equipment. Monitoring instruments are expensive. They must be placed in a location where security can be assured.
- Contracts for rental of space or power. Contracts need to be signed with the owner of the property where the instruments are located.
- Local building codes. In most cases, the contractor installing the power, structure, concrete, etc. know the local building codes.
- Dirty, dusty areas must be avoided.

2.6.1.2 Probe Placement

Once the location of the station has been identified, the individual responsible for the installation must be familiar with the criteria for locating the probe. The location of the sample probe is critical and individuals performing the installation must follow these specific guidelines:

- The inlet probe must be located between 3-15 meters above ground level.
- The inlet probe must be at least 1 meter vertically or horizontally away from any supporting structures.
- To avoid interference from obstructions, air flow must be unrestricted in an arc of at least 270° around the inlet probe, or 180° if the probe is on the side of a building.
- Trees can provide surfaces for NO\textsubscript{2} adsorption or reactions and obstruct wind flow. To reduce this possible interference, the inlet probe must be at least 10 meters from the drip line of the trees.
- When siting NO\textsubscript{2} analyzers for neighborhood and urban scale monitoring, it is important to minimize interferences from automotive sources. Minimum
separation distance between roadways and probes depends on the roadway's average daily traffic.

For more detailed information concerning site selection for NO-NO$_2$-NO$_x$ monitoring, refer to the 40 Code of Federal Regulations (CFR), Part 58, Appendix E, or the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II.

2.6.2 Inspecting New 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 Thermo Scientific at 1-866-282-0430 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.

2.6.3 Equipment Installation
Polk County Air Quality Division will use the Thermo Scientific Model 42i Trace Level (TL-42i) Chemiluminescence NO-NO$_2$-NO$_x$ Analyzer displayed in Figure 2-1 for sampling nitrogen dioxide. Installation of the TL-42i consists of connecting the sample tubing to the sample gas inlet fitting and connecting the primary power and the data logger device. An external pump must also be plumbed to the instrument. The sampler inlet line connection should be made with ¼-inch outer diameter Teflon tubing.

Figure 2-1: Thermo Scientific TL-42i NO-NO$_2$-NO$_x$ Analyzer
The Thermo TL-42i runs on an external twin-head vacuum pump. Connect the pump vacuum port (inlet) to the Exhaust bulkhead. Connect the pump exhaust to a suitable vent or charcoal scrubber.

Because the analyzer is an optical instrument, it is possible that particulate in the gas sample could interfere with the NO-NO\textsubscript{2}-NO\textsubscript{X} readings, even though the sampling/referencing cyclic operation of the instrument is designed to eliminate such interference. In order to avoid frequent cleaning of the optics and flow handling components, a Teflon filter must be installed between the ambient sample line and the sample port of the analyzer prior to operation. A 0.5-micron Teflon filter will not degrade the NO\textsubscript{2} concentration. However, if particulate matter builds up on the filter, the particulate matter will destroy some of the NO\textsubscript{2} in the sample.

Since the instrument’s exhaust consists of ambient air with some NO\textsubscript{2} removed, ensure that the exhaust cannot re-enter the sample system.

Install the monitor’s electrical connections as indicated in the manual.

The power backup, data acquisition equipment, and any monitoring equipment, calibration equipment, or other ancillary equipment should be installed according to information supplied in the appropriate manuals.

2.6.4 Programming the TL-42i
When the instrument is first turned on, the exhaust fan will start and the Power-Up and Self-Test screens will be displayed. These screens will be displayed until the instrument has completed its warm up and self-checks. Allow 30 minutes for the instrument to stabilize.

After the warm-up period the Run Screen, or Normal Operating Screen, is displayed. The Run Screen displays the NO-NO\textsubscript{2}-NO\textsubscript{X} concentrations. Press the MENU button to access the Main Menu, which contains a list of submenus. Instrument parameters and features are divided into the submenus according to their function. Use the ↑ or ↓ buttons to move the cursor to each submenu.

2.6.4.1 Range and Units
The Range menu defines the concentration range of the analog outputs. Polk County Air Quality will use the “Single Range” option with the selected range of 0 – 250 ppb for the analyzer. To set the range for the instrument, press the MENU button to access the Main Menu. Press the ↓ button until the cursor is on “NO Range”, and press ENTER. Press the ↓ button until the cursor is on SET CUSTOM RANGES, and press ENTER. Press the ↓ button to scroll to CUSTOM RANGE 1 and press ENTER. Use the ← and → buttons to move the cursor left or right. Use the ↑ or ↓ buttons to increment or decrement the numeric value to set the range to “250” and press ENTER. Press MENU to return to the Range Menu. Repeat procedures to set NO\textsubscript{2} Range and NO\textsubscript{X} Range.

The Gas Units Screen defines how the NO-NO\textsubscript{2}-NO\textsubscript{X} concentration reading is expressed. From the Range Menu, select GAS UNITS to display the Gas Units screen. Use the ↓ button to select “PPB” and press ENTER. Press MENU twice to return to the Run Screen.
2.6.4.2 Averaging Time
The averaging time defines a time period (1 to 300 seconds) during which NO-NO$_2$-NO$_X$ measurements are taken. The average concentration of the readings is calculated for that time period. Polk County Air Quality will use 60 seconds as the averaging time for data collection and during calibrations, audits, and zero/precision/span checks.

From the Main Menu, use the ↓ button to scroll to AVERAGING TIME and press ENTER. From the Averaging Time Screen, use the ↑ or ↓ buttons to scroll through the preset ranges. Press ENTER to select the desired averaging time. Press RUN to return to the Run Screen.

2.6.4.3 Temperature Compensation
Temperature compensation corrects for any changes to the instrument’s output signal due to variations in internal instrument temperature. When the temperature compensation is off, the first line of the display shows the factory standard temperature of 30°C. Polk County Air Quality will run the NO-NO$_2$-NO$_X$ analyzer with the temperature compensation set to ON.

From the Main Menu, use the ↓ button to scroll to INSTRUMENT CONTROLS and press ENTER. From the Instrument Controls Screen, use the ↓ button to scroll to TEMPERATURE COMPENSATION, and press ENTER. Press ENTER to toggle the temperature compensation on or off. Press RUN to return to the Run Screen.

2.6.4.4 Pressure Compensation
Pressure compensation corrects for any changes to the instrument’s output signal due to variation in the reaction chamber pressure. When the pressure compensation is off, the first line display shows the factory standard pressure of 150 mmHg. Polk County Air Quality Department will run the NO-NO$_2$-NO$_X$ analyzer with the pressure compensation set to ON.

From the Main Menu, use the ↓ button to scroll to INSTRUMENT CONTROLS and press ENTER. From the Instrument Controls Screen, use the ↓ button to scroll to PRESSURE COMPENSATION, and press ENTER. Press ENTER to toggle the pressure compensation on or off. Press RUN to return to the Run Screen.

2.6.4.5 Baud Rate
The Baud Rate Screen is used to set the RS-232 interface baud rate. The Polk County Air Quality Department will use a baud rate of 9600.

From the Main Menu, use the ↓ button to scroll to INSTRUMENT CONTROLS and press ENTER. From the Instrument Controls Screen, use the ↓ button to scroll to COMMUNICATION SETTINGS and press ENTER. From the Communication Settings Screen, use the ↓ button to scroll to BAUD RATE, and press ENTER. Use the ↑ or ↓ buttons to scroll through the preset rates. Press ENTER to select the desired baud rate. Press RUN to return to the Run Screen.

2.6.4.6 Clock Set
To set the correct time and date on the instrument, press MENU to return to the Main Menu. Use the ↓ button to scroll to INSTRUMENT CONTROLS and press ENTER. Use the ↓ buttons to scroll to DATE/TIME and press ENTER. The date and time should be set to the data logger time. Use the → button to select: year, month, day, hour, minutes, or seconds. Use the ↑
or ↓ buttons to increase/decrease the desired value. Set the appropriate date and time and press ENTER. Press RUN to return to the Run Screen. The instrument is now set with the appropriate time, date, full scale range and units.

NOTE: The clock should be checked at each site visit and adjusted if off from the data logger by more than 2 minutes.

3.6.4.7 Auto Mode
The Auto/Manual Mode screen allows selection of the automatic mode (NO/NOX), NO Mode (manual NO), or NOX mode (manual NOX). Polk County Air Quality will always run the TL-42i in Auto Mode. The auto cycle mode switches the mode solenoid valves automatically on a 10 second cycle so that NO, NO2, and NOX concentrations are determined.

To set the TL-42i to Auto Mode, press MENU to return to the Main Menu. Use the ↓ button to scroll to INSTRUMENT CONTROLS and press ENTER. Use the ↓ buttons to scroll to AUTO/MANUAL MODE and press ENTER. Use the ↓ buttons to scroll to NO/NOX MODE and press ENTER.

NOTE: It is recommended that you allow the TL-42i to warm up for 24-hours before you attempt checks or calibration.

2.7 Standards
A cylinder containing 9 to 20 ppm NO in N2 with less than 1.0 ppm NO2 is used as the concentration standard for verifications, calibrations and audits. The cylinder must be certified to EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards as stated in EPA Publication NO. EPA-600/R-12-531. Procedures for certifying the NO cylinder (working standard) against a NIST traceable NO or NO2 standard and for determining the amount of NO2 impurity are given in EPA Publication NO. EPA-006/4-75-003, “Technical Assistance Document for the Chemiluminescence Measurement of Nitrogen Dioxide.” The cylinder should be recertified on a regular basis as determined by the local quality control program.

The gas certification process is quite rigorous. However, it is still possible to receive a cylinder gas out of specification. Polk County Air Quality will verify that a new cylinder gas is within specification before it is put into use. Immediately prior to removing an old cylinder, perform a zero/precision/span check, making sure that relevant criteria are met. Change to the new cylinder, and update the Thermo 146i with the new stock gas concentration. Adjust the 146i to produce a target concentration equivalent to the precision level last used with the old cylinder. If the instrument reading is within 4% of the expected value, proceed to calibrate the analyzer with the new stock cylinder. If it is not within 4%, investigate and resolve the disparity prior to using the new cylinder. Record all information on the Gas Comparison Spreadsheet, Form 1, Appendix A.

Operators will be required to replace the NO cylinder when the cylinder pressure drops below 200 PSI. This will involve removing the regulator on the depleted cylinder and installing the regulator on a replacement cylinder.

Precautions must be taken to remove “dead” pockets of contaminants which are created within the regulator whenever it is removed from the cylinder. This problem can be minimized by carefully evacuating the regulator (also known as purging) after it is connected to the cylinder. Air trapped in the regulator can result in the NO converting to NO2 within the regulator resulting in errors during calibration. Better results will be achieved by alternately pressurizing and depressurizing the regulator once it has been attached to the cylinder.
Contamination with even a small amount of moisture from back diffusion can cause the NO concentration to become unstable. The lower the cylinder concentration, the more susceptible it is to any contamination from "abuse" in the field. The best way to ensure low concentration cylinders are not contaminated by back diffusion is to make sure whenever the cylinder valve is open, there is gas flow out of the cylinder. If this procedure is always applied, it is impossible for any air or other contaminants to enter the cylinder, and the practice of repeated vacuum purging of regulators is not necessary.

Polk County addresses this issue by:

- The cylinder utilized is only used for this site and is not removed until expiration of the certificate.
- The gas dilution system is fixed at this site and is not used at any other site so is not moved unless for maintenance or re-certification.
- The regulator will continuously be kept pressurized with cylinder gas.

**Figure 2-2: Gas Phase Titration System**

### 2.8 Calibrations
The Thermo Scientific Model TL-42i NO-NO\textsubscript{2}-NO\textsubscript{x} monitor is calibrated whenever the following occurs: installation of a new monitor, instrument repair, when a zero/precision/span check fail to meet acceptance criteria limits, after 6 months has expired since the last calibration, or yearly if a daily automated zero/precision/span checks are being performed, or at the operator's discretion.

The Purpose of the calibration is to determine the NO, NO\textsubscript{2} and NO\textsubscript{x} relationship between the analyzer and the true NO and NO\textsubscript{2} concentrations. This procedure involves the gas phase titration (GPT) of a NO standard with
O₃ to produce NO₂. This method is based upon the rapid gas phase reaction between NO and O₃ to produce stoichiometric quantities of NO₂.

\[ \text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2 \]

The calibration check is a quality control procedure used to verify that the air monitoring system is operating properly. The check involves comparing the response of the station analyzer to NO-NO₂-NOₓ concentrations generated by the station gas calibration system.

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

### 2.8.1 Calibration Procedures for the TL-42i using the 146i Calibrator

#### 2.8.1.1 Pre-Calibration

Change the averaging time to 60 seconds. From the Main Menu, use the ↓ button to scroll to AVERAGING TIME and press ENTER. From the Averaging Time Screen, use the ↑ or ↓ buttons to scroll through the preset ranges. Press ENTER to select an averaging time of 60 seconds. Press RUN to return to the Main Screen.

Make sure that the ozonator in the TL-42i is on. Press the front panel MENU button on the TL-42i site analyzer to display the Main Menu. Use the arrow keys to select INSTRUMENT CONTROLS and press ENTER. Scroll to OZONATOR and press enter. Press ENTER again to turn the ozonator on.

#### 2.8.1.2 Calibration of NO/NOₓ

The GPT requires the use of the NO/NOₓ channel of the analyzer to determine the amount of NO₂ generated by titration. Therefore, it is necessary to calibrate and determine the linearity of the NO/NOₓ channels before proceeding with the NO₂ calibration.

On the Main Screen (or Standby Screen) of the 146i Calibrator, press the MENU button to access the Main Menu Screen. Scroll to OPERATION and press ENTER. Use the ← and → buttons to select desired GAS and press ENTER. Use the ↓ button to scroll down to SPAN. Use the ← and → buttons to scroll to ZERO and press ENTER to put the 146i Calibrator in zero air mode. Allow the analyzer to sample zero gas for a minimum of 15 minutes until stable readings are obtained on the NO, NO₂, and NOₓ channels.

Press the front panel MENU button on the TL-42i site analyzer to display the Main Menu. Use the arrow keys to select CALIBRATION and press ENTER to display the Calibration Menu.

Select CALIBRATE PREREACTOR ZERO and press ENTER. Press ENTER to set the prereactor reading to zero. Press the MENU button to return to the Calibration Menu.

Select CALIBRATE NO BACKGROUND and press ENTER. Press ENTER to set the NO reading to zero. Press the MENU button to return to the Calibration Menu.
Select **CALIBRATE NO\textsubscript{x} BACKGROUND** and press **ENTER**. Press **ENTER** to set the NO\textsubscript{x} reading to zero. Press the **MENU** button to return to the Calibration Menu.

Adjust the flow rate from the NO standard to generate an NO concentration of approximately 80% the upper range limit (URL) of 250 ppb (i.e. 200). Allow the site analyzer to stabilize for a minimum of 15 minutes and record all data logger readings from the NO, NO\textsubscript{2}, and NO\textsubscript{x} channels.

Press the front panel **MENU** button on the TL-42i site analyzer to display the Main Menu. Use the arrow keys to select **CALIBRATION** and press **ENTER**. Scroll to **CALIBRATE NO COEFFICIENT** and press **ENTER**. Use the ← and → buttons to move the cursor left and right. Use the ↓ or ↑ buttons to increment and decrement the digit to the expected NO concentration and press **ENTER**.

Repeat to calibrate the NO\textsubscript{x} concentration.

**NOTE:** The NO, NO\textsubscript{x}, and Prereactor Background coefficients should be less that 15 ppb. The NO and NO\textsubscript{x} span coefficients should always fall between 0.900 and 1.100, and the NO\textsubscript{2} span coefficient should be between 0.960 and 1.100. If outside that range, refer to Thermo Scientific’s Instruction Manual Chapter 7 “Servicing” procedures for PMT Voltage Adjustment.

After the zero and 80% URL points have been set, determine at least 4 approximately evenly spaced points between zero and the 80% URL without further adjustment to the analyzer. SPAN 1 - 5 have been programmed for calibrations. SPAN 2 is set to 150 ppb, SPAN 3 is set to 100 ppb, SPAN 4 is set to 50 ppb, and SPAN 5 is set to 20 ppb.

Allow the site analyzer to stabilize for a minimum of 15 minutes at each SPAN Point and record all data logger readings from the NO, NO\textsubscript{2}, and NO\textsubscript{x} channels.

Repeat for SPAN 2 - 5, respectively. Record all information on the Calibration Field Sheet, Form 2, Appendix A.

### 2.8.1.3 Calibration of NO\textsubscript{2}

On the main screen of the 146i Calibrator, use the ↓ button to scroll to the third line. Use the ← and → buttons to scroll to **OZON MAN**.

**Note:** Check and make sure that the second line is set to 225 ppb. The NO\textsubscript{2} calibration must be performed using an NO\textsubscript{x} concentration of 225 ppb.

Push the **MENU** button on the 146i Calibrator. Scroll to **OZONATOR SETUP** and press **ENTER**. Scroll to **MANUAL** and press **ENTER**. The ozone reading on the 146i Calibrator will be displayed as a percentage. Use the arrow keys to set the ozone level to 0%. When the analyzer responses stabilize, record the resultant data logger readings on the NO, NO\textsubscript{2}, and NO\textsubscript{x} channels. NO\textsubscript{2} should stabilize out at approximately 0 ppb. NO/NO\textsubscript{x} should stabilize out at approximately 225 ppb. Record all information in the site log.
At this point the zero NO\textsubscript{2} reading has been performed. Press the MENU button on the Calibrator. Scroll to OZONATOR and press ENTER. Scroll to MANUAL and press ENTER. Use the arrow keys to adjust the ozonator percentage to obtain a NO\textsubscript{2} reading approximately 200 ppb. Allow the site analyzer to stabilize for a minimum of 15 minutes and record all data logger readings from the NO, NO\textsubscript{2}, and NO\textsubscript{X} channels.

NO\textsubscript{2} is calibrated according to a direct comparison between the NO concentration obtained when NO\textsubscript{2} is set to zero and the NO concentration obtained at approximately 80% the URL of the uncalibrated NO\textsubscript{2} channel (i.e. 200).

\[ \text{NO}_{2\text{Actual}} = (\text{NO}_{\text{orig}} - \text{NO}_{\text{rem}}) + \text{NO}_{2\text{(imp)}} \]

Where:
- \text{NO}_{\text{orig}} = \text{Original NO data logger reading, when NO}_2 \text{ is set to zero}
- \text{NO}_{\text{rem}} = \text{Final NO data logger reading when NO}_2 \text{ is approx. 200 ppb}
- \text{NO}_{2\text{(imp)}} = \text{Conc. of NO}_2 \text{ impurity in standard NO cylinder}

**NOTE:** To ensure that NO is in excess during Gas Phase Titration, \text{NO}_{\text{rem}} should be at least 10% of the value of \text{NO}_{\text{orig}}.

The NO\textsubscript{2} impurities in the NO concentration standard are determined by:

\[ \text{NO}_{2\text{(imp)}} = \left( \frac{\text{F}_{\text{NO}} \cdot \text{(Impurities from cylinder gas (ppb))}}{\text{F}_{\text{NO}} + \text{F}_0 + \text{F}_D} \right) \]

Where:
- \text{F}_{\text{NO}} = \text{NO Flow}
- \text{F}_0 = \text{Ozone Flow}
- \text{F}_D = \text{Dilution Flow}

**NOTE:** The flow through the zero air mass flow controller of the Thermo 146i calibrator represents the sum of the dilution air and the flow past the ozone lamp.

Press the front panel MENU button on the TL-42i site analyzer to display the Main Menu. Use the arrow keys to select CALIBRATION and press ENTER. Scroll to CALIBRATE NO\textsubscript{2} COEFFICIENT and press ENTER. Use the ← and → buttons to move the cursor left and right. Use the ↓ or ↑ buttons to increment and decrement the digit to the expected NO\textsubscript{2} concentration. Press ENTER to calibrate the analyzer to the desired NO\textsubscript{2} concentration.

**NOTE:** If the analyzer calculates a NO\textsubscript{2} span coefficient of less than 0.96, either the entered NO\textsubscript{2} concentration is incorrect, the converter is not being heated to the proper temperature, the instrument needs servicing, or the converter needs replacement or servicing.

After the zero and 80% URL points have been set, determine at least 4 approximately evenly spaced points between zero and the 80% URL without further adjustment to the analyzer. Record all information on the Calibration Field Sheet, Form 2, Appendix A.
Generate the regression analysis calculations by least squares the slope, intercept, and correlation coefficient of the site analyzer response versus the calibration standard concentrations, Form 3, Appendix A.

Record all information in the site log.

2.8.2 Converter Efficiency (NO₂)
During a calibration, the converter efficiency must be determined for each NO₂ level. However, the critical criteria of 0.96 to 1.04 ultimately applies to the slope of the calibration curve. It is the average converter efficiency from the calibration curve which is used to determine if the converter needs serviced or replaced. Use the Converter Efficiency Spreadsheet to determine if the calibration passes, Form 4, Appendix A.

For more detailed information concerning calibration of a Thermo Scientific TL-42i NO-NO₂-NOₓ analyzer, refer to the Quality Assurance Guidance Document 2.3, Reference Method for the Determination of Nitrogen Dioxide in the Atmosphere (Chemiluminescence), February, 2002, Draft; and the Instruction Manual, Model 42i, Cheirimluminescence NO-NO₂-NOₓ Analyzer.

2.9 Quality Control

2.9.1 Station Inspection
Before entering the station, the perimeter should be inspected for damage. Extreme weather conditions, neglect of station maintenance or vandalism may have resulted in damage to the site since the operator's last visit. Check that the sample probe is intact and has not been damaged.

Once the operator has entered the monitoring station, she/he should first:

- Check for any obvious analyzer malfunctions. For example, check to see that the equipment is running, the pumps are operating and the instrument is cycling properly.
- Note any unusual odors or noise. An unusual odor may indicate a point source of a pollutant or a strange new noise can indicate a malfunction in the equipment. These observations should be recorded in the station log book and may prove to be invaluable if the data is challenged.

The station operator is responsible for making several observations during the station inspection. Any of the above described observations must be thoroughly detailed in the site log book.

Once the initial inspection is made, the operator must proceed with a routine inspection and perform a zero/precision/span check on the NO-NO₂-NOₓ analyzer.

2.9.2 Station Log Book
A station log book must be maintained at each monitoring site and should accurately reflect site operations. The log book will be identified with the station name, station number, date, time, operator, instrument identification, parameter, scale and units. All entries shall include the date, time, quality control checks, and maintenance on equipment, audits, equipment changes and missing or invalid data. Additional information should include: maintenance performed on the station, abnormal traffic patterns, nearby construction, or sample line cleaning.
Should the data be challenged, the information recorded in the log book is invaluable. A written record of observations concerning abnormal operations or localized occurrences is critical if a violation of ambient air standards were recorded during this period. Completed log books be maintained by Polk County Air Quality and will be archived for future reference.

2.9.3 Bi-Weekly Zero, Precision and Span Checks

The zero, precision and span check is a quality control procedure used to verify that the air monitoring system is operating properly. The check involves comparing the response of the station analyzer to NO/NOx/NO2 concentrations generated by the station 146i calibrator. The deviation between the "indicated" value of the analyzer and the "actual" or "true" value of the calibrator is then determined.

Zero air and NO/NOx concentrations of approximately 11 ppb (the precision) and approximately 225 ppb (the span) and NO2 concentrations of approximately 10 ppb (the precision) and 185 (the span) are generated by the calibrator. Each concentration is measured by the calibrator and the site analyzer. Following the precision check, the deviation from the true NO/NOx/NO2 values are determined.

The following critical criteria require recalibration of the field analyzer and invalidation of the data unless there is compelling reason and justification not to do so:
- The zero drift is outside of ± 3.0 ppb
- The precision difference is ± 1.5 ppb, or ± 15%, whichever is greater.
- The span drift is outside ±10%

Acceptance criteria can be found in Table 2-2: The Measurement Quality Acceptance Tables from the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Appendix D Revision 1, March, 2017.

The zero/precision/span check must be performed once every fourteen days and is always performed in the same manner. Failure to perform and document zero/precision/span data within the required frequency and concentration will result in the invalidation of data. The operator is required to submit the completed field sheet to the Quality Assurance Officer for review. For more detailed procedures on, Zero, Precision and Span Checks refer to Section 2.13.4.

2.9.4 Data Acquisition and Telemetry

Data acquisition involves retrieval of the ambient air quality data from the data logger. The station operator has the primary responsibility for distinguishing valid measurements from indications caused by malfunctioning instruments or source interferences. The telemetry system can be used by a station operator to scan data transmitted from the monitoring station to a central location. This enables the operator to connect to the monitor site and examine the data recorded at the monitoring station (i.e. NO-NO2-NOx concentrations and station temperature). The station operator should be familiar with daily concentration variations (i.e. the times daily maximum concentrations occur and the interrelationship of ozone). By recognizing abnormal data, the operator is alerted that the instruments may not be operating properly and a station visit may be necessary. However, monitoring a station by telemetry is not to be substituted for the site visit.

In the event of an exceedance of the 1-hour NO2 standard, data averages of no longer than 5 minutes will be critical in validating the data and investigating the cause of the exceedance. All data loggers are set up to collect 1 minute, 15 minute and 1 hour averages, with 1 minute being the "base average". The 15 minute and hourly averages are called "extended average #1 and #2, respectively. The 1 minute, 15
minute and 1 hour averages are polled and stored before the data is overwritten. For more specific instructions on data acquisition, see Polk County Air Quality AirVision SOP Section 18.

2.10 Equipment, Maintenance and Trouble Isolation
The equipment used to calibrate, audit, perform bi-weekly zero/precision/span checks and monitor NO\textsubscript{X} concentrations in the network are the Thermo Scientific Models TL-42i and the 146i Calibrator, Teledyne 701H Zero Air Generator, and the Agilaire Model 8832 data logger. A flow controller with a flow rate regulated $\pm$ 2% of readings over 20-100% of its full-scale range as specified in 40 CFR, Pt. 50, App. F. Compressed cylinder gas with an EPA protocol Gas as specified in EPA – 600/R97/12.

2.10.1 Preventative Maintenance
Each instrument must be periodically examined and serviced to anticipate and prevent instrument failure. Scheduled maintenance on the instruments will prevent costly repairs and loss of data. The routine maintenance required on the analyzers by the station operator is minimal and outlined in the manufacturer’s manual. By keeping track of the instrument responses from week to week, the operator can observe trends, which would alert the operator of a potential problem, and to correct the situation before the instrument fails.

2.10.1.1 Analyzer Leak Check
An analyzer leak check should be performed on a yearly basis, or as needed for trouble shooting purposes. To perform a system leak check on the analyzer, disconnect the sample line from the SAMPLE INLET on the back panel, and plug all fittings except the exhaust port.

Press the MENU button to display the Main Menu. Use the ↓ buttons to scroll to DIAGNOSTICS and press ENTER. From the Diagnostic Menu, use the ↓ buttons to scroll to SAMPLE FLOW and press ENTER. The flow reading should slowly drop to zero. Press the MENU button to return to the Diagnostics Menu. Use the ↓ buttons to scroll to PRESSURE and press ENTER. The pressure reading should drop below 250 mmHg. If the flow and pressure do not drop to their desired limits, there is a leak in the system. Check to see that all fittings are tight, and none of the input lines are cracked or broken.

2.10.1.2 Sample Line Leak Check
A sample line leak check should be performed on a yearly basis, and anytime new sample line is installed. Unscrew the sample line from the back of the analyzer, and connect to the vacuum pressure gauge. The sample line must be capped off on the top side of the roof before proceeding.

Turn vacuum pump on and wait for the pump to remove all air from the sample line. The vacuum gauge will indicate a steady reading of approximately 21 inches of Hg vacuum when the lines have been evacuated. The vacuum reading must be at least 15 inches of Hg for the leak check to take place.

Close the valve that is located between the vacuum gauge and the pump. Once the valve is closed record the reading from the gauge and start a timer. Shut the pump off and wait 1 minute. Record the reading from the vacuum gauge.

The acceptable leak rate for the sample lines is 0.5 inches of Hg for the 1 minute check. If the leak check fails, make sure all lines are connected securely to the vacuum gauge and the line is
capped off the roof, and repeat the check. If a second leak check fails, look for the leak and/or replace sample line if needed.

2.10.1.3 Particulate Filter Changes
A 0.5 micron Teflon filter housed in a Teflon filter holder is located on the outside of the analyzer and is connected to the sample line. The filter should be checked every two weeks and changed when noticeably dirty. Slow response of the analyzer during the zero/precision/span check is an indication of a dirty filter or contaminants in the sample line. To replace the used filter, loosen the two halves of the filter holder and replace the dirty filter with a new filter.

2.10.1.4 Cleaning the Fan Filters
Under normal use, the fan filters on the rear panel should be cleaned every six months. If the instrument is operated in excessively dirty surroundings, it may be necessary to clean the fan filters more frequently.

2.10.1.5 Cleaning the PMT Cooler Fins
The Photomultiplier tube (PMT) cooler fins should be inspected and cleaned once every six months. This assures optimal performance of the cooler.

Using clean pressurized air, blow off the cooler fins. Make sure that any particulate accumulation between the fins has been removed. If necessary, employ a small brush to remove residual particulate accumulation.

2.10.1.6 Replacing the Sample Lines
It is the operator’s responsibility to maintain the sample lines. The sample lines must be replaced if the operator suspects a loss in NO-NO₂-NOₓ concentrations due to contamination in the line, or every two years.

2.10.2 Trouble Isolation
The instruments in Polk County Air Quality’s air monitoring network are very reliable. However, after a period of continuous use problems may occur. Leaks in the system, built up dirt and U.V. lamp failure are typical. After time, the operator should be able to quickly distinguish the symptoms and causes of equipment failure.

It is suggested that each station operator consult the Model TL-42i, Chemiluminescence NO-NO₂-NOₓ Analyzer Instruction Manual and compile personal notes on troubleshooting as they gain experience with the Thermo Scientific. The operator is encouraged to contact Thermo Scientific technical support at 1-866-282-0430 when attempting any repairs.

2.10.3 Environmental Control for Monitoring Equipment
Instrument vibration should be reduced as much as possible. Use shock-absorbing feet for the monitor. Any pumps must be fitted with rubber feet to reduce vibration. All pumps connected to the analyzer should be connected using tubing that will prevent the transfer of vibrations back to the instrument and/or the instrument rack.

All instruments should be shielded from natural or artificial light.

Ensure constant voltage to surge protection devices and equipment.
Regulate the housing temperature between 20-30°C. Hourly temperature readings are collected by the polling computer during daily polling. Polk County will make every effort to operate the monitor in the 20-30°C range. Data will be investigated to determine the validity of the data for hourly concentrations where the shelter temperatures fall outside the range of (20-30°C). Data collected during temperatures outside of this range may be subject to invalidation, in accordance with the March 2017 Redbook’s guidelines for operational criteria.

2.11 Quality Assurance

The audit schedule for SLAMS monitoring, is that each analyzer must be audited at least once per year. Polk County should audit 25 percent of their analyzers per quarter as specified in Section 3.2.2 of 40 CFR Part 58 Appendix A. However, it is Polk County Air Quality Division’s policy to audit the NO-NO₂-NOₓ analyzer once per quarter.

2.11.1 Direct Comparison Audit

Once during each calendar quarter, the designated Quality Assurance Officer, utilizing the procedures and calculations specified in 40 CFR 58, Appendix A, "Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS)," will audit the NO-NO₂-NOₓ analyzer using a direct comparison.

An audit is an independent assessment of the accuracy of data generated by an ambient air analyzer. Independence is achieved by having the audit performed by an operator other than the one conducting the routine field measurements and by using audit standards, reference materials, and equipment different from those routinely used in monitoring. Proper implementation of an auditing program will ensure the integrity of the data and assess the accuracy of the data.

An audit consists of challenging the TL-42i continuous analyzer with known concentrations of NO-NO₂-NOₓ within the measurement range of the analyzer. The 146i Multi-Gas Calibrators can be programmed to generate the desired NO-NO₂-NOₓ audit concentrations, see Polk County Air Quality SOP Section 26.

Generate at least three of the following CFR audit concentrations: 0.0003-0.00029 ppm, 0.0030-0.0049 ppm, 0.0050-0.0079 ppm, 0.0080-0.0199 ppm, 0.0200-0.0499 ppm, 0.0500-0.0999 ppm, 0.1000-0.2999 ppm, 0.3000-0.4999 ppm, 0.5000-0.7999 ppm, and 0.8000-1.000 ppm. One point should be within two to three times the method detection limit of the instruments. The second point should be less than or equal to the 99th percentile of the data at the site. The third point should be around the primary NAAQS concentration or the highest 3-year concentration at the site.

Allow each audit concentration to stabilize for a minimum of 15 minutes and record all data logger readings from the NO, NO₂, and NOₓ channels. The results are recorded on the Quarterly Audit Sheet, Form 5, Appendix A. The NO₂ Converter Efficiency should also be determined during an audit. Use the Converter Efficiency Spreadsheet to determine if it passes, Form 6, Appendix A. During each audit, the converter efficiency must be determined for each audit level. However, the critical criteria of 0.96 to 1.04 ultimately applies to the slope of the curve. It is the average converter efficiency from the curve which is used to determine if the converter needs serviced or replaced.

The audit fails if any of the following acceptance criteria are not met:

- For EPA Audit Levels 1 and 2, the acceptance criteria is ± 1.5 ppb, or ±15%, whichever is greater
• The percent difference is outside ±15% for EPA Audit Levels 3-10.

If there is no reason to believe the results are incorrect or not representative of the analyzers performance, the cause for the audit failure must be investigated and corrected. In addition, if the absolute value of the zero reading is greater than 1.5 ppb during an audit, the results must also be investigated. An investigation initiated by audit results that are outside the above limits may require the invalidation of data. Record all information in the site log.

NOTE: For more detailed information concerning audit performances for NO-NO₂-NOₓ monitoring, refer to the “Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II” or 40 CFR 58.

2.11.2 Federal Audits
Agency staff may be sent an audit device, such as for the National Performance Audit Program (NPAP). The agency staff does not know the NO-NO₂-NOₓ concentrations produced by the audit equipment. Responses of the on-site analyzer are then compared against those of the generator and a linear regression is calculated.

The Polk County Air Quality Department will participate in the USEPA performance audit program for NO-NO₂-NOₓ and in all other EPA audit programs, which may arise in the future. According to the March 2017 Redbook, The audit fails if any of the following acceptance criteria are not met:

• For EPA Audit Levels 1 and 2, the acceptance criteria is ± 1.5 ppb
• The percent difference is outside ±15% for EPA Audit Levels 3-10.

If there is no reason to believe the results are incorrect or not representative of the analyzers performance, the cause for the audit failure must be investigated and corrected. An investigation initiated by audit results that are outside the above limits may require the invalidation of data. Record all information in the site log.

2.12 Data Quality Assessment
For each calendar quarter and year, Polk County Air Quality will prepare data precision, accuracy and completeness reports for the Iowa Department of Natural Resources (Iowa DNR) and EPA-Region 7 in accordance with the current Letter of Agreement (LOA).

2.12.1 Precision
Precision is defined as the measure of agreement among individual measurements of the same property taken under the same conditions. Precision is assessed from checks that are performed at least once every two weeks (see Section 2.13). Calculations to assess precision are given below and should be used to assess precision on a quarterly basis. It is recommended that the NO-NO₂-NOₓ analyzer has a 90 percent confidence limit of coefficient of variation for precision of ≤15 %, and for bias as an upper 95 percent confidence limit for the absolute bias of 15%. The goal for acceptable measurement uncertainty is defined for precision, as an upper 90 percent confidence limit for the coefficient of variation (CV) of 15 percent; and for bias as an upper 95 percent confidence limit for the absolute bias of 15 percent.

The precision will be evaluated and reported employing the frequencies, procedures and calculations in 40 CFR Part 58, Appendix A, "Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS)"
2.12.2 Accuracy

The Polk County Air Quality Program participates in the USEPA performance audit program for NO₂ and in all other EPA audit programs, which may arise in the future. Using results from the performance audits and the calculations specified in 40 CFR 58, Appendix A, "Quality Assurance Requirements for State and Local Air Monitoring Stations". The accuracy will be evaluated and reported.

2.12.3 Data Completeness

The completeness of the data will be determined for each monitoring instrument and expressed as a percentage. Percent valid data will be a gauge of the amount of valid data obtained from the monitoring instrument, compared to the amount expected under ideal conditions (24 hours per day, 365 days per year). Exceptions will be made for analyzers with a seasonal sampling period, which were not installed at the beginning, or which were discontinued prior to the end of any reporting period for calculation purposes.

2.13 Procedures for Bi-Weekly Verifications

New station operators will be provided with on-site training by an experienced operator before they operate a station on their own. The following procedures are intended to assist the operator in performing and documenting monitoring procedures. Monitoring personnel must become familiar with the Operating and Maintenance Manuals for Thermo Scientific Model 42i Trace Level, Chemiluminescence NO-NO₂-NOₓ Analyzer, Instruction Manual, and Model 146i, Dynamic Gas Calibration System, Instruction Manual.

2.13.1 Maintenance Mode for Agilaire Model 8832 Data Loggers

Figure 2-3 displays the Agilaire Model 8832 data logger used for data collection. During any maintenance, zero/precision/span checks, calibrations, or site visit the data logger must be placed into maintenance mode. This mode flags hourly data with an (M), indicating the analyzer is in the process of being checked by the technician. Scroll down to LOGIN/SET USER LEVEL and press ENTER. Login to the data logger using the appropriate password and press ENTER. Use the arrow keys to select Configuration Menu and press ENTER. Use the arrow keys to select CONFIGURE (DATA) CHANNEL and press ENTER. Use the arrow keys to select PUT CHANNEL IN MAINTENANCE MODE and press ENTER. Select the correct pollutant channel and press ENTER. Repeat procedures for all appropriate channels. Proceed with maintenance, bi-weekly precision/span check, or calibration of the analyzer.

2.13.2 Remote Mode

Press the escape button (Esc) until the main menu is reached. Take the data logger out of maintenance mode when the task has been completed. Use the arrow keys to select Configuration Menu and press ENTER. Use the arrow keys to select CONFIGURE DATA CHANNELS and press ENTER. Use the arrow keys to select TAKE CHANNEL OUT OF MAINTENANCE and press ENTER. Repeat procedures to take all channels out of maintenance mode. Press the (Esc) button until the main menu is reached. Use the arrow keys to select LOG OUT and press ENTER. Record all information on tasks performed in the site log.
2.13.3 Maintenance and Diagnostics Check
Check and record monitor readings on the data logger. Check and record any alarms on the analyzer. If alarms are present, check field sheet for out-of-control limits and perform any necessary maintenance. See Model TL-42i Instruction Manual, Chapter 7-Servicing, and Section 2.11.1 Preventative Maintenance. Record any maintenance performed in the site log.

Check and record the calibration factors. Press MENU and scroll to CALIBRATION FACTORS and press ENTER. Record the background coefficients for NO and NO_x. Scroll down and record span coefficients for NO, NO_2, and NO_x.

Check the Teflon particulate filters and change as needed. If particulate matter builds up on the filter, the particulate matter will destroy some of the NO_2 in the sample.

Write down any maintenance that was performed on the instrument or additional comments that may affect the air monitoring system. Examples include:

- replacement of UV lamps, pumps or tubing
- repairs or maintenance made to or around the shelter
- abnormal localized occurrences nearby
- suggestions for improvements to the system
- supplies that are needed
- checks or audits that were performed
Table 2-1 Diagnostic Checks

<table>
<thead>
<tr>
<th>Check</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltages</td>
<td>The DC power supply voltages</td>
</tr>
<tr>
<td>Temperatures</td>
<td>The internal instrument and chamber temperatures</td>
</tr>
<tr>
<td>Pressure</td>
<td>The reaction chamber pressure</td>
</tr>
<tr>
<td>Flow</td>
<td>The sample flow rate</td>
</tr>
</tbody>
</table>

2.13.4 Bi-Weekly Zero, Precision and Span Checks

2.13.4.1 Zero Air Check
The zero air must be free of contaminants that could cause a detectable response on the TL-42i analyzer. Polk County Air Quality Division uses the Teledyne 701H air generator with charcoal, Purafil®, and hydrocarbon scrubbers for the source of zero air. For more information on zero air scrubbers, see Polk County Air Quality SOP Section 25 for instructions for the Zero Air Module Model 701/701H.

The external zero air generator is connected to the zero air port on the back of the 146i Calibrator. The 146i Calibrator vent port is connected to the TL-42i site analyzer’s sample port.

On the Main Screen (or Standby Screen) of the 146i Calibrator, press the MENU button to access the Main Menu Screen. Scroll to OPERATION and press ENTER. Use the ← and → buttons to select desired GAS and press ENTER. Use the ↓ button to scroll down to SPAN. Use the ← and → buttons to scroll to ZERO and press ENTER to put the 146i Calibrator in zero air mode. Allow the site analyzer to stabilize for a minimum of 15 minutes and record all data logger readings from the NO, NO₂, and NOₓ channels on the Verification Field Sheet, Form 7, Appendix A.

Polk County Air Quality uses the Agilaire Model 8832 data loggers for data recording. The values indicated on the data logger are the values that are being transmitted to, and recorded by the central computer. Therefore, it is important that the data logger readings are recorded on the field sheet.

Determine the analyzer zero drift by comparing the collected zero concentration to the actual Calibrator concentration. Refer to Section 2.9.3 for acceptable control limits.

\[
\text{Zero Drift} = C_M - C_{146}
\]

Where:
\[C_M = \text{data logger concentration, ppb}\]
\[C_{146} = \text{Calibrator concentration, ppb}\]
2.13.4.2 Span Check (NO/NOx)
At this point the zero air readings have been recorded, perform the span check. On the Main Screen (or Standby Screen) of the 146i Calibrator, press the MENU button to access the Main Menu Screen. Scroll to OPERATION and press ENTER. Use the ↓ button to scroll down to SPAN. Use the ← and → buttons to scroll to SPAN 1 and press ENTER. SPAN 1 has been programmed to produce the span level of 90% the upper range limit of the instrument (or 225 ppb NO/NOx). Perform the span check using a cylinder containing 9-20 ±2 ppm NO in N₂ with less than 1 ppm NO₂. Begin turning the flow regulator on from the cylinder. Next, turn on the flow adjustment valve to produce sufficient flow. The flow can be read on the 146i Calibrator display screen by accessing the DIAGNOSTICS FLOW screen. This screen reports the actual gas and zero-air flows and the corresponding target flows.

Allow the TL-42i site analyzer to stabilize for a minimum of 15 minutes, then record the resultant data logger readings from the NO, NO₂, and NOₓ channels on the Verification Field Sheet, Form 7, Appendix A.

Determine the analyzer span drift by comparing the collected span concentration to the actual Calibrator concentration. Refer to Section 2.9.3 for acceptable control limits.

\[
\text{Span Drift} = \frac{C_M - C_{146}}{C_{146}} \times 100
\]

Where:
\( C_M \) = data logger concentration, ppb
\( C_{146} \) = Calibrator concentration, ppb

2.13.4.3 Precision Check (NO/NOx)
At this point the span readings have been recorded, perform the precision level check. Use the ← and → buttons to scroll to SPAN 5 and press ENTER. SPAN 5 has been programmed to produce the precision level of approximately 11 ppb NO/NOx.

Allow the TL-42i site analyzer to stabilize for a minimum of 15 minutes, then record the resultant data logger readings from the NO, NO₂, and NOₓ channels on the Verification Field Sheet, Form 7, Appendix A.

Using the following equation to determine the percent difference between the data logger and the calibrator:

\[
\% \text{Difference} = \frac{C_M - C_{146}}{C_{146}} \times 100
\]

Where:
\( C_M \) = data logger concentration, ppb
\( C_{146} \) = Calibrator concentration, ppb

Acceptance criteria can be found in Table 2-2: The Measurement Quality Acceptance Tables from the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Appendix D Revision 1, March, 2017.
2.13.4.4 Span Check (NO₂)
At this point the precision and span readings for NO/NOₓ have been recorded, perform the Span Checks for NO₂. On the Main Screen (or Standby Screen) of the 146i Calibrator, press the MENU button to access the Main Menu Screen. Scroll to OPERATION and press ENTER. Use the ↓ button to scroll to the third line. Use the ← and → buttons to scroll to OZON MAN.

NOTE: Check and make sure that the second line is set to SPAN 1 which is programmed to obtain and NOₓ concentration of 225 ppb.

Push the MENU button on the 146i Calibrator. Scroll to OZONATOR and press ENTER. Scroll to MANUAL and press ENTER. The ozone reading on the 146i Calibrator will be displayed as a percentage. Use the arrow keys to set the ozone level to 0%. Allow the TL-42i site analyzer to stabilize for a minimum of 15 minutes, then record the resultant data logger readings from the NO, NO₂, and NOₓ channels on the Verification Field Sheet. NO₂ should stabilize around 0 ppb. NO/NOₓ channels should stabilize around 225 ppb.

At this point, the zero NO₂ reading has been performed. Press the MENU button on the 146i Calibrator. Scroll to OZONATOR and press ENTER. Scroll to MANUAL and press ENTER. Use the arrow keys to adjust the ozonator percentage to obtain a NO₂ reading of approximately 185 ppb. Allow the TL-42i site analyzer to stabilize, then record the resultant data logger readings from the NO, NO₂, and NOₓ channels on the Verification Field Sheet, Form 7, Appendix A.

Using the NO Verification relationship determined in Section 2.13.4.1 - 2.13.4.3, correct NO_ORIG and NO_REM for slope and intercept prior to calculating NO₂(Actual). The NO₂(Actual) readings are then determined by using the formula:

\[
\text{NO}_2\text{Actual} = (\text{NO}_{\text{Orig}} - \text{NO}_{\text{Rem}}) + \frac{F_{\text{NO}} \times \text{NO}_{2\text{imp}}}{F_T}
\]

Where:
- NO_orig = Original NO data logger reading
- NO_rem = NO data logger reading, after addition of O₃
- F_NO = NO flow rate (sccm) as determined by the pollutant MFC
- NO₂imp = Conc. of NO₂ impurity in standard NO cylinder
- F_T = Total actual flow put out by the calibrator, sccm

After determining the actual NO₂ readings for the span check, calculate the percent difference using the formula:

\[
\% \text{ Difference} = \frac{\text{NO}_2\text{(Indicated)} - \text{NO}_2\text{(Actual)}}{\text{NO}_2\text{(Actual)}} \times 100
\]

Where:
- NO₂ (Indicated) = data logger concentration, ppb
2.13.4.5 Precision Check (NO₂)
At this point span readings for NO₂ have been recorded, perform the Precision Checks for NO₂. On the Main Screen (or Standby Screen) of the 146i Calibrator, press the MENU button to access the Main Menu Screen. Scroll to OPERATION and press ENTER. Use the ↓ button to scroll to the third line. Use the ← and → buttons to scroll to OZON MAN.

NOTE: Check and make sure that the second line is set to SPAN 4 which is programmed to obtain and NOₓ concentration of 30 ppb.

Push the MENU button on the 146i Calibrator. Scroll to OZONATOR and press ENTER. Scroll to MANUAL and press ENTER. The ozone reading on the 146i Calibrator will be displayed as a percentage. Use the arrow keys to set the ozone level to 0%. Allow the TL-42i site analyzer to stabilize for a minimum of 15 minutes, then record the resultant data logger readings from the NO, NO₂, and NOₓ channels on the Verification Field Sheet. NO₂ should stabilize around 0 ppb. NO/NOₓ channels should stabilize around 30 ppb.

At this point, the zero NO₂ reading has been performed. Press the MENU button on the 146i Calibrator. Scroll to OZONATOR and press ENTER. Scroll to MANUAL and press ENTER. Use the arrow keys to adjust the ozonator percentage to obtain a NO₂ reading of approximately 10 ppb. Allow the TL-42i site analyzer to stabilize, then record the resultant data logger readings from the NO, NO₂, and NOₓ channels on the Verification Field Sheet, Form 7, Appendix A.

Using the NO Verification relationship determined in Section 2.13.4.1 - 2.13.4.3, correct NO.orig and NO.rem for slope and intercept prior to calculating NO₂(actual). The NO₂(actual) readings are then determined by using the formula:

\[ \text{NO}_2\text{Actual} = (\text{NO}_{\text{Orig}} - \text{NO}_{\text{Rem}}) + \frac{F_{\text{NO}} \cdot \text{NO}_2\text{Imp}}{F_T} \]

Where:
- \( \text{NO}_{\text{Orig}} = \) Original NO data logger reading
- \( \text{NO}_{\text{rem}} = \) NO data logger reading, after addition of \( \text{O}_3 \)
- \( F_{\text{NO}} = \) NO flow rate (sccm) as determined by the pollutant MFC
- \( \text{NO}_2\text{Imp} = \) Conc. of NO₂ impurity in standard NO cylinder
- \( F_T = \) Total actual flow put out by the calibrator, sccm

After determining the actual NO₂ readings for the precision check, calculate the percent difference using the formula:

\[ \% \text{Difference} = \frac{\text{NO}_2\text{(Indicated)} - \text{NO}_2\text{(Actual)}}{\text{NO}_2\text{(Actual)}} \times 100 \]

Where:
- \( \text{NO}_2\text{(Indicated)} = \) data logger concentration, ppb

Log all site visits into the logbook (every detail of the visit must be logged).

Refer to Section 2.13.2 to log out from the data logger.
2.13.4.6 Converter Efficiency Check
During each bi-weekly verification, the converter efficiency must be determined for the NO2 precision and Span values. However, the critical criteria of 0.96 to 1.04 ultimately applies to the slope of the verification curve. It is the average converter efficiency from the verification curve which is used to determine if the converter needs serviced or replaced. Use the Converter Efficiency Spreadsheet to determine if the verification passes, Form 8, Appendix A.

NOTE: If a problem is recognized while performing maintenance, diagnostic, zero air, weekly precision or span checks which has or could affect data, a corrective action form is to be filled out describing the problem identified and the action taken to correct the problem, Form 9, Appendix A. All forms and documentation must be submitted to the Quality Assurance Officer.

2.13.5 Investigate and Recalibrate Analyzer
The following critical criteria requires recalibration of the field analyzer and invalidation of the data unless there is compelling reason and justification not to do so: if the precision check results in a percent difference of 1.5 ppb or ±15% (whichever is greater), or if the zero drift is ≥ 3.0 ppb, or if the span drift is ±10%. See Section 2.8 for calibration procedures.

NOTE: In order to minimize data loss, Polk County personal will recalibrate the instrument when the results of bi-weekly checks reach recalibration thresholds, unless there is compelling reason and justification not to do so. Recalibration criteria refer to thresholds that typically require recalibrating the analyzer, but do not require the invalidation of data. Recalibration criteria should be set to levels that are as tight as practically possible, and based on historical performance data. They may change after reviewing typical differences from control charts.

2.14 Automated Zero/Precision/Span Checks
The External 24-hour Zero, Precision and Span Checks are conducted at a concentration of 10 ppb for precision and between 80-90% of full range scale (185 ppb) for span utilizing the auto function of the Thermo Scientific 146i Dynamic Gas Calibrator in conjunction with the TL-42i analyzer. The data is flagged for this period with a “C” on the data logger.

The automated zero/precision/span checks are used to determine if the TL-42i is operating properly, and if drift in instrument response has occurred. For these checks, the challenge gas should be sampled through as much of the sampling inlet system as practical to mimic the actual sampling of ambient air. The results of the zero/precision/span checks should be plotted on control charts to graphically illustrate the trends in the response of the analyzer to the challenge gases.

Polk County Air Quality Division will analyze “drift” as a direct comparison of the current indicated concentration collected from the site analyzer to the actual concentration collected from the Calibrator. Polk County Air Quality Division will strive to obtain a zero drift ≤ 3.0 ppb, a span drift ≤ 10%, and a difference for precision of 1.5 ppb or ≤ 15%, whichever is greater. If the daily automated zero, precision, or span check fails, the instrument will be recalibrated and the data will be invalidated to the last acceptable check, unless there is a compelling reason and justification not to do so.

There are several components to a successful automated zero/precision/span checks:
• A zero air generator that gives an output of at least 10 psig. The generator is equipped with dual scrubbers of charcoal and “Perma Pure” to remove any water vapor or contaminants which may result in scrubbing. See Polk County Air Quality SOP Section 25 for instructions for the Teledyne 701 Zero Air Generator.

• A Calibration Program setup in the 146i Calibrator

• A Calibration Program setup in the TL-42i Site Analyzer

• Digital input communications setup in AirVision Software for Agilaire Model 8832 data logger

• A Calibration Program setup in the AirVision Software for the Agilaire Model 8832 data logger

2.14.1 Calibration Program in the 146i Calibrator

A calibration program must be set up in the 146i Calibrator before the calibration will occur. From the Main Menu, use the ↓ button to scroll to PROGRAM MENU and press ENTER. From the Program Menu, use the ↓ button to scroll to PROGRAM CYCLE and press ENTER.

2.14.1.1 Program Cycle

The Program Cycle screen is used to turn the program mode on or off. The Program Cycle must be enabled for a programmed event to occur. From the Program Cycle Status Screen, press ENTER enable the program cycle.

2.14.1.2 Period Hours

The period Hours screen defined the period or interval between zero and span checks. Periods between 0 and 999 hours are acceptable. To turn the check off, set the period to 0.

From the Program Menu, use the ↓ button to scroll to PERIOD HOURS and press ENTER. Use the ← and → buttons to move the cursor left or right, and the ↑ and ↓ buttons to increment or decrement to the desired numeric value. Polk County Air Quality will use a sample period of 24-hours.

2.14.1.3 Next Cycle

The Next Cycle screen is used to view and set the next zero and span check date and time. Once the initial check is performed, the date and time of the next check is calculated and displayed.

From the Program Menu, use the ↓ button to scroll to NEXT CYCLE and press ENTER. Use the → button to select: year, month, day, hour, minutes, or seconds. Use the ↑ or ↓ buttons to increase/decrease the desired value. Set the appropriate date and time and press ENTER. Polk County Air Quality will run their auto-calibration program daily at 01:05.

2.14.1.4 Events

The Events Menu is used to configure events that are part of the program cycle. The number of events and total time of enabled events are displayed. The target values on the right side of the display, is an abbreviated line that describes the settings for that specific event, and should show the desired values based on the displayed operation parameters on the left side. Specific parameters include:

• Gas: A-F, Zero
Section 2: NO/NO₂/NOₓ
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- Span level for the gas: 1-5, Zero
- Ozonator and permeation levels: 1-5, Off
- Photometer mode: I=internal, E=external, C=control
- Event duration time in minutes

**Note:** The 146i Calibrator has been programmed for the span levels and ozonator percentages necessary for the zero/precision/span checks. See Polk County Air Quality SOP Section 26 for instructions on programming the precision and span concentrations in the 146i for the Dynamic Gas Calibrators.

To setup an Event, from the Program Menu, use the ↓ button to scroll to **EVENTS** and press **ENTER**. Use the ↓ button to scroll to Event 1 and press **ENTER**. Event 1 will be used for the zero check. On the first line, use the → button to enable the event and press **ENTER**. Set the duration on the second line, use the ← and → buttons to move the cursor left or right, and the ↑ and ↓ buttons to increment or decrement to the desired numeric value. Select the Gas port on the third line, use the ↑ and ↓ buttons to scroll to **GAS D** and press **ENTER**. Select the Span concentration on the forth line, use the ↑ and ↓ buttons to scroll to the desired span and press **ENTER**. For Gas Phase Titration, select the Ozonator percentage. Use the ↑ and ↓ buttons to scroll to the desired Ozonator % and press **ENTER**.

The NO/NO₂/NOₓ auto-check has 7 separate events. The Events will be programmed as follows:

**EVENT 1 – NO/NO₂/NOₓ (Zero)**
ENABLE
DURATION 10 MINS
GAS D 8000 SCCM
ZERO 0.000 ppm
OZONE OFF

**EVENT 2 – NO/NOₓ (Span)**
ENABLE
DURATION 25 MINS
GAS D 4100 SCCM
SPAN 2 0.225 ppm
OZONE OFF

**EVENT 3 – NO/NOₓ (Precision)**
ENABLE
DURATION 10 MINS
GAS D 19500 SCCM
SPAN 1 0.011 ppm
OZONE OFF
EVENT 4 – NO₂ (Span)
ENABLE
DURATION 10 MINS
GAS D 4100 SCCM
SPAN 2 0.225 ppm
OZONE 3 13%

EVENT 5 – NO₂ (Span-Zero)
ENABLE
DURATION 10 MINS
GAS D 4100 SCCM
SPAN 2 0.225 ppm
OZONE 1 0%

EVENT 6 – NO₂ (Precision)
ENABLE
DURATION 10 MINS
GAS D 19000 SCCM
SPAN 3 0.030 ppm
OZONE 4 7%

EVENT 7 – NO₂ (Precision-Zero)
ENABLE
DURATION 10 MINS
GAS D 19000 SCCM
SPAN 3 0.030 ppm
OZONE 1 0%

2.14.2 Calibration Program in the TL-42i
A calibration program must be set up in the TL-42i so that the zero port and span port are opened at the appropriate time. This program will occur simultaneously with the calibration program in the 146i Calibrator. From the Main Menu, use the ↓ button to scroll to CALIBRATIONS and press ENTER. From the Calibration Menu, use the ↓ button to scroll to ZERO/SPAN CHECK and press ENTER.

2.14.2.1 Next Time
The Next Time screen is used to view and set the next zero/span check date and time. Once the initial check is performed, the date and time of the next check is calculated and displayed.

From the Zero/Span Check Menu, use the ↓ button to scroll to NEXT TIME and press ENTER. Use the → button to select: year, month, day, hour, minutes, or seconds. Use the ↑ or ↓ buttons to increase/decrease the desired value. Set the appropriate date and time and press ENTER. Polk County Air Quality will use a sample time of 01:05 hours.

NOTE: At each site visit, the internal clock on the site analyzers and Calibrator should be synced to the time on the data logger.
2.14.2.2 Period Hours
The period Hours screen defined the period or interval between zero/precision/span checks. Periods between 0 and 999 hours are acceptable. To turn the check off, set the period to 0.

From the Zero/Span Check Menu, use the ↓ button to scroll to PERIOD HR and press ENTER. Use the ← and → buttons to move the cursor left or right, and the ↑ and ↓ buttons to increment or decrement to the desired numeric value. Polk County Air Quality will use a sample period of 24-hours.

2.14.2.3 Automated Check Duration
The Zero/Precision/Span checks are plumbed through the span port. The Duration Minutes Screen defines how long the span port is sampled by the instrument. Durations between 0 and 99 minutes are acceptable.

To set the span duration, use the ← and → buttons to move the cursor left or right, and the ↑ and ↓ buttons to increment or decrement to the desired numeric value. Polk County Air Quality will sample calibration gas through the span port for a total of 95 minutes.

2.14.2.4 Averaging Time
The Averaging Time screen allows the user to adjust the zero/span averaging time. This averaging time is used by the analyzer only when performing an automatic check. The analyzer's averaging time is used for all other functions.

From the Zero/Span Check Menu, use the ↓ button to scroll to AVERAGE TIME and press ENTER. Use the ↑ and ↓ buttons to scroll to 60 SEC and press ENTER.

24.14.3 Communication Settings in Agilare AirVision Software
The Model 146i communicates with the 8832 ESC data logger via of Modbus through the Ethernet. For an instrument-controlled calibration, the digital inputs must be assigned in AirVision, in order for the instrument to communicate with the logger when a calibration is occurring and when there is a change from one calibration phase to another. See Polk County Air Quality AirVision SOP Section 18 for instructions on programming digital inputs in AirVision software.

24.14.4 Calibration Program in Agilare AirVision Software
A Calibration Program must be set up in AirVision in order for the software to recognize that the instrument is in calibration mode and flags the data with a “C”. An Instrument-Controlled Calibration program will be used. An instrument-controlled calibration is initiated by the calibration program set up in the Thermo 146i Calibrator, refer to Section 2.14.1. The data logger senses the zero, precision, and span phases through its digital input lines. For each phase, a specific pattern of input control line status is defined. The data logger monitors input control line status and when the specified pattern is met, the corresponding calibration phase is initiated. There is no predefined duration for individual phases programmed into the AirVision calibration program; each phase will continue until the input line pattern is no longer met. The duration of each phase is determined by the calibration program in the Thermo 146i Calibrator, refer to Section 2.14.1. At the end of each phase, the concentrations are written into the calibration report. See Polk County Air Quality AirVision SOP Section 18 for instructions on setting up a calibration program in AirVision software.
The specific pattern of input control line status currently in use for NO/NO\textsubscript{X}/NO\textsubscript{2}/NO\textsubscript{X}:

- NO/NO\textsubscript{X} Zero Phase: 35=off, 36=off, 37=off, 38=off, 39=off, 40=off
- NO/NO\textsubscript{X} Precision Phase: 35=on, 36=off, 37=off, 38=off, 39=off, 40=off
- NO/NO\textsubscript{X} Span Phase: 35=off, 36=on, 37=off, 38=off, 39=off, 40=off
- NO\textsubscript{2} Span Phase: 35=off, 36=on, 37=off, 38=off, 39=off, 40=on
- NO\textsubscript{2} Span/Zero Phase: 35=off, 36=on, 37=off, 38=off, 39=on, 40=off
- NO\textsubscript{2} Precision Phase: 35=on, 36=on, 37=off, 38=on, 39=off, 40=on
- NO\textsubscript{2} Precision/Zero Phase: 35=on, 36=on, 37=off, 38=off, 39=on, 40=off

NOTE: When reading the status inputs from the Model 8832 data logger, the following patterns will be observed:

- NO/NO\textsubscript{X} Zero Phase: 35=0&36=0&37=0&38=0&39=0&40=0
- NO/NO\textsubscript{X} Precision Phase: 35=0&36=0&37=0&38=0&39=0&40=0
- NO/NO\textsubscript{X} Span Phase: 35=0&36=0&37=0&38=0&39=0&40=0
- NO\textsubscript{2} Span Phase: 35=0&36=0&37=0&38=0&39=0&40
- NO\textsubscript{2} Span/Zero Phase: 35=0&36&37=0&38=0&39&40=0
- NO\textsubscript{2} Precision Phase: 35=36&37=0&38&39=0&40
- NO\textsubscript{2} Precision/Zero Phase: 35=36&37=0&38=0&39&40=0
# Table 2-2: Measurement Quality Objectives

## NO₂, NOₓ, NO Validation Template

<table>
<thead>
<tr>
<th>NO₂, NOₓ, NO Validation Template</th>
<th>3) Acceptance Criteria</th>
<th>Information /Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Requirement (NO₂)</td>
<td>2) Frequency</td>
<td>CRITICAL CRITERIA- NO₂</td>
</tr>
<tr>
<td>Sampler/Monitor</td>
<td>NA</td>
<td>Meets requirements listed in FRM/FEM designation</td>
</tr>
<tr>
<td>One Point QC Check</td>
<td>Every 14 days</td>
<td>Meets requirements listed in FRM/FEM designation</td>
</tr>
</tbody>
</table>
| Single analyzer | | 1) 40 CFR Part 58 App C Sec. 2.1  
2) NA  
3) 40 CFR Part 53 & FRM/FEM method list |
| Zero/span check | Every 14 days | Recommendation based on DQO in 40 CFR Part 58 App A Sec. 2.3.1.5 QC Check Conc range 0.005 - 0.08 ppm and 05/05/2016 Technical Note on AMTIC |
| Converter Efficiency | During multi-point calibrations, span and audit, Every 14 days | Recommendation based on DQO in 40 CFR Part 58 App A Sec. 2.3.1.5 QC Check Conc range 0.005 - 0.08 ppm and 05/05/2016 Technical Note on AMTIC |

## OPERATIONAL CRITERIA- NO₂

<table>
<thead>
<tr>
<th>Operational Criteria</th>
<th>Daily (hourly values)</th>
<th>Information /Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelter Temperature Range</td>
<td>20.0 to 30.0°C (Hourly avg) or per manufacturers specifications if designated to a wider temperature range</td>
<td>Generally, the 20-30.0 °C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance. FRM/FEM list found on AMTIC provides temp. range for given instrument. FRM/FEM monitor testing is required at 20-30 °C range per 40 CFR Part 53.32</td>
</tr>
<tr>
<td>Shelter Temperature Control</td>
<td>&lt; 2.1°C SD over 24 hours</td>
<td>1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2</td>
</tr>
<tr>
<td>Shelter Temperature Device Check</td>
<td>&lt; ± 2.1°C of standard</td>
<td>1, 2 and 3) QA Handbook Volume 2 Sec. 7.2.2</td>
</tr>
</tbody>
</table>
| Annual Performance Evaluation Single Analyzer | Every site every 365 days and 1/ calendar year | 1) 40 CFR Part 58 App A Sec. 3.1.2  
2) 40 CFR Part 58 App A Sec. 3.1.2  
3) Recommendation - 3-audit concentrations not including zero. AMTIC Technical Memo |
| Federal Audits (NPAP) | 20% of sites audited in calendar year | 1 & 2) 40 CFR Part 58 App A Sec. 3.1.3  
3) NPAP QAPP/SOP |
### Section 2: NO/NO₂/NOₓ

Revised: February 24, 2020  
Revision Number: 20

<table>
<thead>
<tr>
<th>1) Requirement (NO₂)</th>
<th>2) Frequency</th>
<th>3) Acceptance Criteria</th>
<th>Information /Action</th>
</tr>
</thead>
</table>
| **Verification/Calibration** | Upon receipt/adjustment/repair/installation/moving  
Every 182 day and 2/ calendar year if manual zero/span performed biweekly  
Every 365 day and 1/ calendar year if continuous zero/span performed daily | Instrument residence time ≤ 2 min  
Dynamic parameter ≥ 2.75 ppm-min  
All points ≤ ± 2.1 % or ≤ ± 1.5 ppb difference of best-fit straight line whichever is greater and Slope 1 ≤ .95 | 1) 40 CFR Part 50 App F  
2 and 3) Recommendation  
Multi-point calibration (0 and 4 up scale points)  
Slope criteria in a recommendation |
| **Gaseous Standards** | All gas cylinders | NIST Traceable  
(e.g., EPA Protocol Gas)  
50-100 ppm of NO in Nitrogen with < 1 ppm NO₂ | 1) 40 CFR Part 50 App F Sec. 1.3.1  
2) NA  
3) 40 CFR Part 50 App F Sec. 1.3.1. A technical memo may change the concentration requirement.  
Gas producer must participate in EPA Ambient Air Protocol Gas Verification Program 40 CFR Part 58 App A Sec. 2.6.1 |
| **Zero Air/ Zero Air Check** | Every 365 days and 1/ calendar year | Concentrations below LDL. | 1) 40 CFR Part 50 App F Sec. 1.3.2  
2 and 3) Recommendation |
| **Gas Dilution Systems** | Every 365 days and 1/ calendar year or after failure of 1 point QC check or performance evaluation | Accuracy ≤ ± 2.1 % | 1, 2 and 3) Recommendation based on SO₂ requirement in 40 CFR Part 50 App A-1 Sec. 4.1.2 |

**Detection (FEM/FRMs)** Noise and Lower Detectable Limits (LDL) are part of the FEM/FRM requirements. It is recommended that monitoring organizations perform the LDL test to minimally confirm and establish the LDL of their monitor. Performing the LDL test will provide the noise information.

**Noise**  
Every 365 days and 1/ calendar year  
≤ 0.005 ppm  
1) 40 CFR Part 53.23 (b) (definition & procedure)  
2) Recommendation - info can be obtained from LDL  
3) 40 CFR Part 53.20 Table B-1

**Lower detectable level**  
Every 365 days and 1/ calendar year  
≤ 0.01 ppm  
1) 40 CFR Part 53.23 (c) (definition & procedure)  
2) Recommendation  
3) 40 CFR Part 53.20 Table B-1

**SYSTEMATIC CRITERIA - NO₂**

<table>
<thead>
<tr>
<th>Standard Reporting Units</th>
<th>All data</th>
<th>pph (final units in AQS)</th>
<th>1, 2 and 3) 40 CFR Part 50 App S Sec. 2 (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rounding convention for data reported to AQ S</strong></td>
<td>All routine concentration data</td>
<td>1 place after decimal with digits to right truncated</td>
<td>1, 2 and 3) 40 CFR Part 50 App S Sec. 4.2 (a) The rounding convention is for averaging values for comparison to NAAQS not for reporting individual hourly values.</td>
</tr>
</tbody>
</table>
| **Completeness** | Annual Standard | ≥ 75% hours in year | 1) 40 CFR Part 50 App S Sec. 3.1(b)  
2) 40 CFR Part 50 App S Sec. 3.1(a)  
3) 40 CFR Part 50 App S Sec. 3.1(b) |
| | 1-hour standard | 1) 3 consecutive calendar years of complete data  
2) 4 quarters complete in each year  
3) ≥ 75% sampling days in quarter  
4) ≥ 75% of hours in a day | 1) 40 CFR Part 50 App S Sec. 3.2(b)  
2) 40 CFR Part 50 App S Sec. 3.2(a)  
3) 40 CFR Part 50 App S Sec. 3.2(b)  
More details in 40 CFR Part 50 App S |
<table>
<thead>
<tr>
<th>1) Requirement (NO₂)</th>
<th>2) Frequency</th>
<th>3) Acceptance Criteria</th>
<th>Information /Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Residence Time Verification</td>
<td>Every 365 days and 1/ calendar year</td>
<td>≤ 20 Seconds</td>
<td>1) 40 CFR Part 58 App E, Sec. 9 (c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2) Recommendation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3) 40 CFR Part 58 App E, Sec. 9 (c)</td>
</tr>
<tr>
<td>Sample Probe, Inlet, Sampling train</td>
<td>All sites</td>
<td>Borosilicate glass (e.g., Pyrex®) or Teflon®</td>
<td>1, 2 and 3) 40 CFR Part 58 App E Sec. 9 (a) FEP and PFA have been accepted as equivalent material to Teflon. Replacement or cleaning is suggested as 1/year and more frequent if pollutant load or contamination dictate</td>
</tr>
<tr>
<td>Siting</td>
<td>Every 365 days and 1/ calendar year</td>
<td>Meets siting criteria or waiver documented</td>
<td>1) 40 CFR Part 58 App E, Secs 2-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2) Recommendation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3) 40 CFR Part 58 App E, Sec. 2-6</td>
</tr>
<tr>
<td>Precision (using 1-point QC checks)</td>
<td>Calculated annually and as appropriate for design value estimates</td>
<td>90% CL CV &lt; 15.1%</td>
<td>1) 40 CFR Part 58 App A Sec. 2.3.1.5 &amp; 3.1.1</td>
</tr>
<tr>
<td>Bias (using 1-point QC checks)</td>
<td>Calculated annually and as appropriate for design value estimates</td>
<td>95% CL &lt; 15.1%</td>
<td>2) 40 CFR Part 58 App A Sec. 4 (b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3) 40 CFR Part 58 App A Sec. 4.1.2</td>
</tr>
</tbody>
</table>

Note: Polk County Air Quality’s SOP may specify more stringent requirements or non critical criteria or more frequent QA procedures than required by the EPA. The operational and systematic criteria listed in the MQO Table are the Federal minimum criteria only.
APPENDIX A – Forms and Field Sheets

Form 1......................................................... Gas Comparison Spreadsheet
Form 2......................................................... Calibration Field Sheet
Form 3......................................................... Calibration Linear Regression
Form 4......................................................... Calibration Converter Efficiency
Form 5......................................................... Audit Field Sheet
Form 6......................................................... Audit Converter Efficiency
Form 7......................................................... Verification Field Sheet
Form 8......................................................... Verification Converter Efficiency
Form 9......................................................... Corrective Action Form
### Form 1: Gas Comparison Spreadsheet

<table>
<thead>
<tr>
<th>Date</th>
<th>02/23/16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>10:00AM</td>
</tr>
<tr>
<td>Site</td>
<td>Carpenter</td>
</tr>
<tr>
<td>Pollutant</td>
<td>NOx</td>
</tr>
<tr>
<td>Operator</td>
<td>JM</td>
</tr>
</tbody>
</table>

#### Gases

<table>
<thead>
<tr>
<th>Standard Cylinder Conc.</th>
<th>10.71</th>
<th>PPM</th>
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</thead>
<tbody>
<tr>
<td>Serial Number</td>
<td>GCA3458</td>
<td></td>
</tr>
<tr>
<td>Expiration Date</td>
<td>03/11/16</td>
<td></td>
</tr>
<tr>
<td>Candidate Cylinder Conc.</td>
<td>10.17</td>
<td>PPM</td>
</tr>
<tr>
<td>Serial Number</td>
<td>ND34562</td>
<td></td>
</tr>
<tr>
<td>Expiration Date</td>
<td>12/28/18</td>
<td></td>
</tr>
</tbody>
</table>

#### Instruments

<table>
<thead>
<tr>
<th>Gas Calibrator</th>
<th>Thermo 1463</th>
<th>1126646600</th>
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</thead>
<tbody>
<tr>
<td>Last Verification</td>
<td>2/17/2016</td>
<td>1117248672</td>
</tr>
<tr>
<td>Last Calibrated</td>
<td>4/21/2016</td>
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</tr>
</tbody>
</table>

### EXTERNAL ZERO TEST

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<thead>
<tr>
<th>Verification</th>
<th>AIR</th>
<th>Zero Air Actual MFC</th>
<th>GAS</th>
<th>Gas Pollutant Actual MFC</th>
<th>Known Value</th>
<th>Instrument Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Zero</td>
<td>SCCM</td>
<td>7995</td>
<td>SCCM</td>
<td>0.000</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Candidate Zero</td>
<td>7995</td>
<td>0.000</td>
<td>0.0</td>
<td>0.0</td>
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### VERIFICATION

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<th>AIR</th>
<th>Zero Air Actual MFC</th>
<th>GAS</th>
<th>Gas Pollutant Actual MFC</th>
<th>Known Value</th>
<th>Instrument Response</th>
<th>% Difference</th>
<th>Pass</th>
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</thead>
<tbody>
<tr>
<td>Standard Precision 20</td>
<td>SCCM</td>
<td>120959</td>
<td>SCCM</td>
<td>24.24</td>
<td>NO</td>
<td>NO</td>
<td>PPB</td>
<td>PPB</td>
</tr>
<tr>
<td>Candidate Precision 20</td>
<td>120959</td>
<td>25.58</td>
<td>20.0</td>
<td>19.5</td>
<td></td>
<td></td>
<td></td>
<td>TRUE</td>
</tr>
</tbody>
</table>

| Standard Span 225 | 4015 | 225.0 | 215.8 | 2.6 | TRUE |
| Candidate Span 225 | 4013 | 225.0 | 214.0 | 2.7 | TRUE |

### Average Percent Difference

<table>
<thead>
<tr>
<th>Average Percent Difference</th>
<th>Is Average Percent Difference ≤4% ?</th>
<th>Is Candidate Gas OK ?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7</td>
<td>TRUE</td>
<td>TRUE</td>
</tr>
</tbody>
</table>
Form 2: Calibration Field Sheet

NO-NO2-NOx Calibration Sheet

Routine Site Information

Date/Time: _____________________________
Operator: ______________________________

Analyzer Serial #: _____________________________
Date of last Calibration: _____________________________
Calibrator Serial #: _____________________________
   Date of last Calibration: _____________________________
   Date of last Verification: _____________________________
   Date of last Audit: _____________________________
Pre-cylinder #: _____________________________
Cylinder Expiration Date: _____________________________
Cylinder > 200 psig (Y or N) _____________________________
Cylinder Concentration: _____________________________
Cylinder NO Concentration: _____________________________
Cylinder NOX Concentration: _____________________________
Impurity in Tank: _____________________________
Zero Air Generator Serial #: _____________________________
Date of last annual maintenance: _____________________________

Station Observations Made (Y or N) _____________________________
Changed Filter? (Y or N) _____________________________
Sample Line Checked? (Y or N) _____________________________

NO Reading (ppm): _____________________________
NO2 Reading (ppm): _____________________________
NOx Reading (ppm): _____________________________

Date Last Calibration: _____________________________
Ambient: _____________________________

Site: _____________________________

<table>
<thead>
<tr>
<th>Diagnostic Check</th>
<th>ALARMS DETECTED:</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm</td>
<td>Value</td>
<td></td>
</tr>
<tr>
<td>Internal Temp (°C)</td>
<td>(15 - 45°C)</td>
<td>Consult Manual</td>
</tr>
<tr>
<td>Chamber Temp (°C)</td>
<td>(48 - 52°C)</td>
<td>Check Reaction Chamber</td>
</tr>
<tr>
<td>Cooler Temp (°C)</td>
<td>(-25 to -1°C)</td>
<td>Check PMT Cooler</td>
</tr>
<tr>
<td>Conv. Temp (°C)</td>
<td>(300 - 350°C)</td>
<td>Check NO2 to NO Converter</td>
</tr>
<tr>
<td>Pressure</td>
<td>(200 - 450 mm Hg)</td>
<td>Replace Reaction Chamber</td>
</tr>
<tr>
<td>Sample Flow</td>
<td>(0.75 - 2.0 LPM)</td>
<td>Replace Pump</td>
</tr>
<tr>
<td>Ozonator Flow</td>
<td>(&gt; 0.050 LPM)</td>
<td>Replace Pump</td>
</tr>
<tr>
<td>Leak Check</td>
<td>(Flow = 0; Pressure &lt; 250 mmHg)</td>
<td>Locate Leak Replace solenoid valves Replace Capillaries</td>
</tr>
</tbody>
</table>

Note: Refer to Section 2.8 of Polk County Air Quality’s Standard Operating Procedures NO-NO2-NOx for exact calibration procedures.
### Gas A Dilution – NO/NOₓ

#### Zero Air Check

<table>
<thead>
<tr>
<th>Zero Actual: _____ scem</th>
<th>Gas Actual: _____ scem</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 1 NO/NOx (200 ppb)

<table>
<thead>
<tr>
<th>Calibrator Actual:</th>
<th>Zero Actual: _____ scem</th>
<th>Gas Actual: _____ scem</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 2 NO/NOx (150 ppb)

<table>
<thead>
<tr>
<th>Calibrator Actual:</th>
<th>Zero Actual: _____ scem</th>
<th>Gas Actual: _____ scem</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 3 NO/NOx (100 ppb)

<table>
<thead>
<tr>
<th>Calibrator Actual:</th>
<th>Zero Actual: _____ scem</th>
<th>Gas Actual: _____ scem</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 4 NO/NOx (50 ppb)

<table>
<thead>
<tr>
<th>Calibrator Actual:</th>
<th>Zero Actual: _____ scem</th>
<th>Gas Actual: _____ scem</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 5 NO/NOx (10 ppb)

<table>
<thead>
<tr>
<th>Calibrator Actual:</th>
<th>Zero Actual: _____ scem</th>
<th>Gas Actual: _____ scem</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

### GPT – NO₂

#### Zero Air Check

<table>
<thead>
<tr>
<th>GPT: _____ 0%</th>
<th>Zero Air Flow: _____ scemns</th>
<th>Gas Air Flow: _____ scemns</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 1 (-185 ppb)

<table>
<thead>
<tr>
<th>GPT %:</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 2 (-150 ppb)

<table>
<thead>
<tr>
<th>GPT %:</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 3 (-100 ppb)

<table>
<thead>
<tr>
<th>GPT %:</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 4 (-50 ppb)

<table>
<thead>
<tr>
<th>GPT %:</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

#### Point 5 (-20 ppb)

<table>
<thead>
<tr>
<th>GPT %:</th>
<th>NO</th>
<th>NO₂</th>
<th>NOₓ</th>
<th>ESC Reading</th>
<th>% diff.</th>
</tr>
</thead>
</table>

### Coefficients:

<table>
<thead>
<tr>
<th>NO BKG (&lt; 15 ppb)</th>
<th>NOₓ BKG (&lt; 15 ppb)</th>
<th>PREREACTOR (&lt; 15 PPB)</th>
<th>NO COEF (0.900-1.100)</th>
<th>NO₂ COEF (0.960-1.100)</th>
<th>NOₓ COEF (0.900-1.100)</th>
<th>PMT</th>
<th>COUNTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After</td>
<td></td>
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<td></td>
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</table>
## Section 2: NO/NO2/NOx

Revised: February 24, 2020
Revision Number: 20

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**Form 3 – Calibration Linear Regression**

**NO/NO2/NOx Multi-Point calibration spreadsheet**

<table>
<thead>
<tr>
<th>Analyzer:</th>
<th>THERMO 42i</th>
<th>Site:</th>
<th>Carpenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial No.:</td>
<td>1117248572</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Scale:</td>
<td>250 ppb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% of Full Scale:</td>
<td>2.5 ppb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td>November 27, 2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operator:</td>
<td>JM</td>
<td>Calibrator:</td>
<td>1126649800</td>
</tr>
<tr>
<td>Cal Gas:</td>
<td>ND45562</td>
<td>Concentration:</td>
<td>10.17 ppm</td>
</tr>
<tr>
<td>Exp. Date:</td>
<td>12/28/2018</td>
<td>Concentration:</td>
<td></td>
</tr>
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### NO Cal

<table>
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<tr>
<th>Known Conc.</th>
<th>Measured Conc.</th>
<th>rpd</th>
<th>slope</th>
<th>intercept</th>
<th>rsq</th>
<th>forecast</th>
<th>distance to least squares line</th>
<th>acceptable distance</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>n/a</td>
<td>0.9936</td>
<td>-0.3959</td>
<td>1.0000</td>
<td>0.3959</td>
<td>0.3959</td>
<td>2.500</td>
<td>pass</td>
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<tr>
<td>20.0</td>
<td>19.5</td>
<td>-2.5%</td>
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</tr>
<tr>
<td>50.2</td>
<td>49.2</td>
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<td>150.6</td>
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### NOx Cal

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<th>Measured Conc.</th>
<th>rpd</th>
<th>slope</th>
<th>intercept</th>
<th>rsq</th>
<th>forecast</th>
<th>distance to least squares line</th>
<th>acceptable distance</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.1</td>
<td>n/a</td>
<td>0.9923</td>
<td>-0.2973</td>
<td>1.0000</td>
<td>-0.2973</td>
<td>0.1973</td>
<td>2.500</td>
<td>pass</td>
</tr>
<tr>
<td>20.0</td>
<td>19.6</td>
<td>-2.0%</td>
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<tr>
<td>50.3</td>
<td>49.6</td>
<td>-1.4%</td>
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### NO2

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<th>Measured Conc.</th>
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<th>slope</th>
<th>intercept</th>
<th>rsq</th>
<th>forecast</th>
<th>distance to least squares line</th>
<th>acceptable distance</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0</td>
<td>n/a</td>
<td>1.0066</td>
<td>-0.3204</td>
<td>1.0000</td>
<td>-0.3204</td>
<td>0.3204</td>
<td>2.500</td>
<td>pass</td>
</tr>
<tr>
<td>20.3</td>
<td>20</td>
<td>-1.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>0.5%</td>
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</tbody>
</table>

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## Section 2: NO/NO₂/NOₓ
Revised: February 24, 2020
Revision Number: 20

### Form 4 – Calibration Converter Efficiency

#### NO₂ Calibration Spreadsheet

<table>
<thead>
<tr>
<th>Station:</th>
<th>Carperer</th>
<th>Date:</th>
<th>11272017</th>
<th>Operator:</th>
<th>JM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyzer:</td>
<td>117240572</td>
<td>Calibrator:</td>
<td>112643800</td>
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<td>Cylinder Conc.:</td>
<td>10.17</td>
<td>PPM</td>
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<td>Impurities</td>
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#### NO, NOₓ Calibration

<table>
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<tr>
<th>Calibration</th>
<th>Zero Air MFC SCCM</th>
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<th>NO</th>
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<th>NO</th>
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<th>NO</th>
<th>NOₓ</th>
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<tr>
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<td>Point 5 (20 PPM)</td>
<td>2555</td>
<td>26.52</td>
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<td>48.6</td>
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<td>Point 3 (100 PPM)</td>
<td>6318</td>
<td>62.97</td>
<td>100.2</td>
<td>100.4</td>
<td>95.0</td>
<td>95.6</td>
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<td>83.46</td>
<td>150.6</td>
<td>150.9</td>
<td>149.9</td>
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<td>90.69</td>
<td>226.2</td>
<td>226.6</td>
<td>224.7</td>
<td>224.8</td>
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<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
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<tr>
<td>Ozone Lamp 0%</td>
<td>3987</td>
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#### NO₂ Upscale Calibration (GPT)

<table>
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<th>Corrected Instrument Response and Calculated Concentrations</th>
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<tr>
<td>Ozone Lamp 0%</td>
<td>22.47</td>
<td>22.47</td>
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<td>Point 5 (20 PPM)</td>
<td>205.0</td>
<td>225.1</td>
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<td>Point 4 (50 PPM)</td>
<td>174.1</td>
<td>225.2</td>
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<td>Point 3 (100 PPM)</td>
<td>124.7</td>
<td>226.1</td>
</tr>
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<td>Point 2 (150 PPM)</td>
<td>79.2</td>
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<td>Point 1 (200 PPM)</td>
<td>44.3</td>
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<tr>
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<th>NO₂</th>
<th>[NO] ORIG</th>
<th>[NO] REM</th>
<th>[NO] ACT</th>
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<th>INT</th>
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<tr>
<td>NO</td>
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<td>-0.3931</td>
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<td>-0.2603</td>
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#### NO₂ Converter Efficiency Test

<table>
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<tr>
<th>Pollutant</th>
<th>[NO₂] Actual</th>
<th>[NO₂] ORIG</th>
<th>[NO₂] REM</th>
<th>[NO₂] CONV</th>
<th>Converter Efficiency</th>
<th>Is Converter Efficiency ≤ 0.04?</th>
</tr>
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<tbody>
<tr>
<td>Level</td>
<td>PPB</td>
<td>PPB</td>
<td>PPB</td>
<td>PPB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point 5 (20 PPM)</td>
<td>20.0</td>
<td>226.8</td>
<td>227.2</td>
<td>20.7</td>
<td>102.0%</td>
<td>TRUE</td>
</tr>
<tr>
<td>Point 4 (50 PPM)</td>
<td>51.4</td>
<td>226.8</td>
<td>227.3</td>
<td>51.9</td>
<td>101.0%</td>
<td>TRUE</td>
</tr>
<tr>
<td>Point 3 (100 PPM)</td>
<td>101.1</td>
<td>226.8</td>
<td>228.2</td>
<td>102.5</td>
<td>101.4%</td>
<td>TRUE</td>
</tr>
<tr>
<td>Point 2 (150 PPM)</td>
<td>146.8</td>
<td>226.8</td>
<td>229.0</td>
<td>148.9</td>
<td>101.4%</td>
<td>TRUE</td>
</tr>
<tr>
<td>Point 1 (200 PPM)</td>
<td>192.0</td>
<td>226.8</td>
<td>232.2</td>
<td>194.4</td>
<td>101.3%</td>
<td>TRUE</td>
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<table>
<thead>
<tr>
<th>Converter Efficiency (from slope)</th>
<th>Is Converter Efficiency ≤ 0.04?</th>
</tr>
</thead>
<tbody>
<tr>
<td>101.3%</td>
<td>TRUE</td>
</tr>
</tbody>
</table>

40
Form 5 – Audit Field Sheet

NO-NO₂-NOₓ Audit Sheet

Routine Site Information

Date/Time: ______________________________
Operator/Auditor: ______________________

Analyzer Serial #: ______________________
Date of last calibration: __________________
Audit Calibrator Serial #: __________________
Date of last calibration: __________________
Cylinder Gas Serial #: __________________
Cylinder Expiration Dates: __________________
Cylinder > 200 psig (Y or N) __________________
Cylinder Concentration: __________________
Cylinder NO Concentration: __________________
Cylinder NOX Concentration: __________________
Impurity in Tank: _______________________

Zero Air Generator Serial #: __________________
Date of last annual maintenance: __________________

Station Observations Made? (Y or N) ______
Sample Line Checked? (Y or N) ______

Record NO BKG __________________
Record NOx BKG: __________________
Record Prereactor BKG: __________________
Record NO Coef: __________________
Record NO₂ Coef: __________________
Record NOx Coef: __________________
Reading NO: __________________
Reading NO₂: __________________
Reading NOx: __________________
Date Last: ____________________
Zero/Prec/SpanCheck: ______ Days ______
Ambient: ______________________

Site: Carpenter

<table>
<thead>
<tr>
<th>Diagnostic Check</th>
<th>ALARMS DETECTED:</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm</td>
<td>Value</td>
<td></td>
</tr>
<tr>
<td>Internal Temp (°C)</td>
<td>(8 - 47°C)</td>
<td>Consult Manual</td>
</tr>
<tr>
<td>Chamber Temp (°C)</td>
<td>(47 – 51 °C)</td>
<td>Check Reaction Chamber</td>
</tr>
<tr>
<td>Cooler Temp (°C)</td>
<td>(-40 to 10°C)</td>
<td>Check PMT Cooler</td>
</tr>
<tr>
<td>Conv. Temp (°C)</td>
<td>(300 - 700°C)</td>
<td>Check NO₂ to NO Converter</td>
</tr>
<tr>
<td>Pressure</td>
<td>(150 - 300 mm Hg)</td>
<td>Replace Reaction Chamber</td>
</tr>
<tr>
<td>Sample Flow</td>
<td>(0.350 – 0.900 LPM)</td>
<td>Replace Pump</td>
</tr>
<tr>
<td>Ozonator Flow</td>
<td>(&gt; 0.050 LPM)</td>
<td>Replace Pump</td>
</tr>
</tbody>
</table>

Gas A Dilution – NO/NOₓ

Zero Air Check
Calibrator Actual: __________________
Zero Flow: ______________ sccm
Gas Flow: ______________ sccm
ESC NO Reading
ESC NO₂ Reading
ESC NOₓ Reading
% diff

Level 4 (8.0-19.9 ppb)
Calibrator Actual: __________________
Zero Flow: ______________ sccm
Gas Flow: ______________ sccm
ESC NO Reading
ESC NO₂ Reading
ESC NOₓ Reading
% diff

Level 5 (20-49.9 ppb)
Calibrator Actual: __________________
Zero Flow: ______________ sccm
Gas Flow: ______________ sccm
ESC NO Reading
ESC NO₂ Reading
ESC NOₓ Reading
% diff

Level 7 (100-299.9 ppb)
Calibrator Actual: __________________
Zero Flow: ______________ sccm
Gas Flow: ______________ sccm
ESC NO Reading
ESC NO₂ Reading
ESC NOₓ Reading
% diff

If the percent difference is outside the 1.5 ppb or for audit levels 1-2, or the percent difference is outside ±15% for all other audit levels, and there is reason to believe the results are incorrect or not representative of the analyzers performance, the check may be repeated. The cause for the error must be investigated and corrected. An investigation initiated by audit results outside the above limits may require invalidation of data.

\[
\text{ESC (Y')} = \frac{\text{Calibrator (X)}}{\text{Calibrator (X')}} \times 100 \% \quad \text{Difference}
\]
**Gas A Dilution – NO/NO₂**

### Zero Air Check

<table>
<thead>
<tr>
<th>Zero Air Flow: sccms</th>
<th>GPT %:</th>
<th>Level 1 (0.3-2.9 ppb)</th>
<th>Level 2 (3.0-19.9 ppb)</th>
<th>Level 4 (8-19.9 ppb)</th>
<th>Level 5 (20-49.9 ppb)</th>
<th>Level 7 (100-299.9 ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC Reading</td>
<td></td>
<td>ESC Reading</td>
<td>ESC Reading</td>
<td>ESC Reading</td>
<td>ESC Reading</td>
<td>ESC Reading</td>
</tr>
<tr>
<td>NO₂ Actual</td>
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<td>NO₂ Actual</td>
<td>NO₂ Actual</td>
<td>NO₂ Actual</td>
<td>NO₂ Actual</td>
<td>NO₂ Actual</td>
</tr>
<tr>
<td>% diff</td>
<td></td>
<td>% diff</td>
<td>% diff</td>
<td>% diff</td>
<td>% diff</td>
<td>% diff</td>
</tr>
</tbody>
</table>

If the percent difference is outside the 1.5 ppb or for audit levels 1-7, or the percent difference is outside ±15% for all other audit levels, and there is reason to believe the results are incorrect or not representative of the analyzers performance, the check may be repeated. The cause for the error must be investigated and corrected. An investigation initiated by audit results outside the above limits may require invalidation of data.

\[
\text{NO}_2(\text{Actual}) = (\text{NO}_{\text{ORIG}} - \text{NO}_{\text{REM}}) + \text{NO}_2(\text{imp})
\]

Where:
- \( \text{NO}_2\text{Actual} \) = Actual NO₂ concentration
- \( \text{NO}_2\text{imp} \) = Calculated NO impurities
- \( \text{NO}_{\text{ORIG}} \) = Original NO data logger reading, when NO₂ is set to zero
- \( \text{NO}_{\text{REM}} \) = Remaining NO data logger reading, after addition of O₃

\[
\text{NO}_2\text{imp} = (\text{FNO (sccm)})(\text{Impurities from cylinder gas (ppb)})
\]

Where:
- \( \text{FNO} \) = NO Flow
- \( \text{FO} \) = Ozone Flow
- \( \text{FD} \) = Dilution Flow
Form 6 – Audit Converter Efficiency

**NO₂ Audit Spreadsheet**

<table>
<thead>
<tr>
<th>Station:</th>
<th>Carpenter</th>
</tr>
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<tbody>
<tr>
<td>Date:</td>
<td>12/14/2016</td>
</tr>
<tr>
<td>Operator:</td>
<td>JVB</td>
</tr>
<tr>
<td>Analyzer:</td>
<td>111246572</td>
</tr>
<tr>
<td>Calibrator:</td>
<td>112696799</td>
</tr>
<tr>
<td>Cylinder:</td>
<td>CC281174</td>
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<tr>
<td>High Cylinder Conc.:</td>
<td>10.16 PPM</td>
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<td>Impurity:</td>
<td>0.03 PPM</td>
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### NO₂ Audit

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<th>AIR NOₓ Audit</th>
<th>GAS NOₓ Audit</th>
<th>Known Value</th>
<th>Instrument Response</th>
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<tr>
<td>Audit</td>
<td>Zero Air MFC</td>
<td>No</td>
<td>NO</td>
</tr>
<tr>
<td>SCDM</td>
<td>PPM</td>
<td>PPM</td>
<td>PPM</td>
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<td>Level 4 (8-19 PPM)</td>
<td>78.92</td>
<td>0.00</td>
<td>0.0</td>
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<td>Level 5 (20-49 PPM)</td>
<td>190.61</td>
<td>20.53</td>
<td>11.0</td>
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<td>Level 7 (100-299 PPM)</td>
<td>590.6</td>
<td>83.59</td>
<td>150.2</td>
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<td>Ozone Lamp 0% Low</td>
<td>196.18</td>
<td>55.91</td>
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<td>Ozone Lamp 0% High</td>
<td>590.6</td>
<td>83.59</td>
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### NO₂ Audit (High Range)

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<th>Audit</th>
<th>Instrument Response</th>
<th>Corrected Instrument Responses and Calculated Concentrations</th>
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<tr>
<td>Points NO₂</td>
<td>NO</td>
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<td>PPM</td>
<td>PPM</td>
<td>PPM</td>
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<tr>
<td>Ozone Lamp 0%</td>
<td>27.9</td>
<td>28.2</td>
</tr>
<tr>
<td>Level 1 (3-29 PPM)</td>
<td>25.7</td>
<td>26.2</td>
</tr>
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<td>Level 4 (8-19 PPM)</td>
<td>13.3</td>
<td>28.6</td>
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### NO₂ Audit (Low Range)

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<th>Instrument Response</th>
<th>Corrected Instrument Responses and Calculated Concentrations</th>
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<tr>
<td>Points NO₂</td>
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<td>PPM</td>
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<td>Ozone Lamp 0%</td>
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### LOW GAS

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### NO₂ Converter Efficiency Test

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<th>NO</th>
<th>NOₓ</th>
<th>NO</th>
<th>NOₓ</th>
<th>NO</th>
<th>NOₓ</th>
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<tbody>
<tr>
<td>Level</td>
<td>PPM</td>
<td>PPM</td>
<td>PPM</td>
<td>PPM</td>
<td>PPM</td>
<td>PPM</td>
<td>PPM</td>
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<td>Level 1 (0-3-29 PPM)</td>
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<td>29.6</td>
<td>2.4</td>
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<td></td>
</tr>
<tr>
<td>Level 4 (8-19 PPM)</td>
<td>15.2</td>
<td>29.6</td>
<td>29.9</td>
<td>15.5</td>
<td>102.1%</td>
<td>TRUE</td>
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</tr>
<tr>
<td>Level 5 (20-49 PPM)</td>
<td>31.5</td>
<td>152.3</td>
<td>152.8</td>
<td>32.0</td>
<td>101.7%</td>
<td>TRUE</td>
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<tr>
<td>Level 7 (100-299 PPM)</td>
<td>112.2</td>
<td>154.0</td>
<td>154.0</td>
<td>113.8</td>
<td>101.5%</td>
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**NO₂ Converter Efficiency (from slope)**

<table>
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<tr>
<th>Is Converter Efficiency 1 &lt; 0.04?</th>
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<tbody>
<tr>
<td>101.5%</td>
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</table>

Section 2: NO/NO₂/NOₓ

Revised: February 24, 2020

Revision Number: 20
Form 7 – Verification Field Sheet

NO-NO2-NOx Verification Sheet

Routine Site Information
Date/Time: ____________________________
Operator: ____________________________

Analyzer Serial #: ____________________________
Date of last Calibration: ____________________________
Calibrator Serial #: ____________________________
Date of last Calibration: ____________________________
Date of last Verification: ____________________________
Date of last Audit: ____________________________

Prec cylinder #: ____________________________
Cylinder Expiration Date: ____________________________ Y or N
Cylinder Pressure (psig) ____________________________ Y or N
Cylinder Concentration: ____________________________
Cylinder NO Concentration: ____________________________
Cylinder NOx Concentration: ____________________________
Impurity in Tank: ____________________________
Zero Air Generator Serial #: ____________________________
Date of last annual maintenance: ____________________________

Station Observations Made ____________________________ Y or N
Changed Filter? ____________________________ Y or N
Sample Line Checked? ____________________________ Y or N

Record NO BKG: ____________________________
Record NOx BKG: ____________________________
Record PreReactor BKG: ____________________________
Record NO Coef: ____________________________
Record NO2 Coef: ____________________________
Record NOx Coef: ____________________________
Reading NO: ____________________________
Reading NO2: ____________________________
Reading NOx: ____________________________
Date Last Zero/Prec/Span Check: ____________________________ Days
Ambient: ____________________________

Site: ____________________________

Diagnostic Check
ALARMS DETECTED:

<table>
<thead>
<tr>
<th>Alarm</th>
<th>Value</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Temp (°C) (15 - 45°C)</td>
<td>Consult Manual</td>
<td></td>
</tr>
<tr>
<td>Chamber Temp (°C) (48 – 52°C)</td>
<td>Check Reaction Chamber</td>
<td></td>
</tr>
<tr>
<td>Cooler Temp (°C) (-25 to -1°C)</td>
<td>Check PMT Cooler</td>
<td></td>
</tr>
<tr>
<td>Conv. Temp (°C) (300 - 350°C)</td>
<td>Check NO2 to NO Converter</td>
<td></td>
</tr>
<tr>
<td>Pressure (200 - 450 mm Hg)</td>
<td>Replace Reaction Chamber</td>
<td></td>
</tr>
<tr>
<td>Sample Flow (0.75 - 2.0 LPM)</td>
<td>Replace Pump</td>
<td></td>
</tr>
<tr>
<td>Ozonator Flow (&gt; 0.030 LPM)</td>
<td>Replace Pump</td>
<td></td>
</tr>
</tbody>
</table>

Make adjustments per service manual.

Gas A Dilution – NO/NOx

Zero Air Check

<table>
<thead>
<tr>
<th>NO Air Flow:</th>
<th>sccm</th>
<th>Gas Air Flow:</th>
<th>sccm</th>
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<tbody>
<tr>
<td>ESC reading</td>
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<td>ESC reading</td>
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<tr>
<td>Drift</td>
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<td>Diff</td>
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</table>

Precision Check (<11 ppb)

Calibrator Actual: ____________________________

<table>
<thead>
<tr>
<th>NO Air Flow:</th>
<th>sccm</th>
<th>Gas Air Flow:</th>
<th>sccm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC reading</td>
<td></td>
<td>ESC reading</td>
<td></td>
</tr>
<tr>
<td>Diff</td>
<td></td>
<td>% diff</td>
<td></td>
</tr>
</tbody>
</table>

Span Check (<200 ppb)

Calibrator Actual: ____________________________

<table>
<thead>
<tr>
<th>NO Air Flow:</th>
<th>sccm</th>
<th>Gas Air Flow:</th>
<th>sccm</th>
</tr>
</thead>
</table>

The following critical criteria require recalibration of the field analyzer and invalidation of the data unless there is compelling reason and justification not to do so: if the precision check results in a percent difference <1.5 ppb, or if the zero drift is >5.0 ppb, or if the span drift is ± 10%. See Section 2.8 for calibration procedures.

Zero Drift = Current Data Logger Reading – Calibrator Reading

% Difference Drift = (Current Data Logger Reading – Calibrator Reading) x 100
Calibrator Reading
### LOW GPT – NO₂

**Zero Air Check**
- GPT %: ______
- Zero Air Flow: ______ sccms
- Gas Air Flow: ______ sccms

<table>
<thead>
<tr>
<th></th>
<th>NO</th>
<th>NO₂</th>
<th>NO₃</th>
<th>NO</th>
<th>NO₂</th>
<th>NO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC Reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO₂ Actual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Precision Check (~10 ppb)**
- GPT %: ______

### HIGH GPT – NO₂

**Zero Air Check**
- GPT %: ______
- Zero Air Flow: ______ sccms
- Gas Air Flow: ______ sccms

<table>
<thead>
<tr>
<th></th>
<th>NO</th>
<th>NO₂</th>
<th>NO₃</th>
<th>NO</th>
<th>NO₂</th>
<th>NO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC Reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO₂ Actual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Span Check (~185 ppb)**
- GPT %: ______

The following critical criteria require recalibration of the field analyzer and invalidation of the data unless there is compelling reason and justification not to do so: if the precision check results in a percent difference of 1.5 ppb, or if the zero drift is ≥3.0 ppb, or if the span drift is ≥10%. See Section 2.8 for calibration procedures.

\[
NO₂(\text{Actual}) = (NO_{\text{orig}} - NO_{\text{rem}}) + NO₂(\text{imp})
\]

Where:
- \(NO₂(\text{Actual})\) = Actual NO₂ concentration
- \(NO₂(\text{imp})\) = Calculated NO impurities
- \(NO_{\text{orig}}\) = Original NO conc, when NO₂ is set to zero
- \(NO_{\text{rem}}\) = Remaining NO conc, after addition of O₃

\[
NO₂(\text{imp}) = \frac{NO_2(\text{sccm}) \times \text{Impurities from cylinder gas (ppb)}}{F_{NO} + F_O + F_D}
\]

Where:
- \(F_{NO}\) = NO Flow
- \(F_O\) = Ozone Flow
- \(F_D\) = Dilution Flow
Form 8 – Verification Converter Efficiency

### NO₂ Verification Spreadsheet

<table>
<thead>
<tr>
<th>Station:</th>
<th>Carpenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td>1/3/2018</td>
</tr>
<tr>
<td>Operator:</td>
<td>CM</td>
</tr>
<tr>
<td>Analyzer:</td>
<td>t7245072</td>
</tr>
<tr>
<td>Calibrator:</td>
<td>1024445000</td>
</tr>
<tr>
<td>Cylinder:</td>
<td>NOH556</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High Cylinder Concentration</th>
<th>8.076 PPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impurity</td>
<td>0.02 PPM</td>
</tr>
</tbody>
</table>

Yellow highlight signifies values entered by user. Green highlight signifies NO₂ Actual for precision data.

#### NO, NO₂ Verification

<table>
<thead>
<tr>
<th>AP</th>
<th>GAS</th>
<th>Known Value</th>
<th>Instrument Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero Air MFC</td>
<td>Pollutant MFC</td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>SCCM</td>
<td>SCCM</td>
<td>PPB</td>
</tr>
<tr>
<td>Zero</td>
<td>7906</td>
<td>0.00</td>
<td>0.0</td>
</tr>
<tr>
<td>Prec (100 PPM)</td>
<td>10546</td>
<td>21.0</td>
<td>11.0</td>
</tr>
<tr>
<td>Span (225 PPM)</td>
<td>3982</td>
<td>90.67</td>
<td>228.4</td>
</tr>
<tr>
<td>Ozone Lamp 0% Low</td>
<td>18947</td>
<td>56.00</td>
<td></td>
</tr>
<tr>
<td>Ozone Lamp 0% High</td>
<td>3982</td>
<td>90.67</td>
<td></td>
</tr>
</tbody>
</table>

#### NO₂ Verification (GPT) - Low Range

<table>
<thead>
<tr>
<th>Points NO₂</th>
<th>NO</th>
<th>NO₂</th>
<th>NO₂</th>
<th>[NO] Orig</th>
<th>[NO] REM</th>
<th>[NO] ACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone Lamp 0%</td>
<td>PPB</td>
<td>29.4</td>
<td>29.7</td>
<td>0.3</td>
<td>29.2</td>
<td>29.2</td>
</tr>
<tr>
<td>Prec (10 PPM)</td>
<td>20.4</td>
<td>29.7</td>
<td>9.1</td>
<td>29.2</td>
<td>20.3</td>
<td>9.0</td>
</tr>
</tbody>
</table>

#### NO₂ Verification (GPT) - High Range

<table>
<thead>
<tr>
<th>Points NO₂</th>
<th>NO</th>
<th>NO₂</th>
<th>NO₂</th>
<th>[NO] Orig</th>
<th>[NO] REM</th>
<th>[NO] ACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone Lamp 0%</td>
<td>PPB</td>
<td>229.3</td>
<td>228.1</td>
<td>0.1</td>
<td>226.1</td>
<td>226.1</td>
</tr>
<tr>
<td>Span (195 PPM)</td>
<td>42.9</td>
<td>229.3</td>
<td>186.5</td>
<td>226.1</td>
<td>42.6</td>
<td>104.0</td>
</tr>
</tbody>
</table>

#### SLOPE

| NO | -0.067 |
| NO₂ | -0.023 |

#### NO₂ Converter Efficiency Test

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>[NO₂] Actual</th>
<th>[NO₂] Orig</th>
<th>[NO₂] REM</th>
<th>[NO₂] Conv</th>
<th>Converter Efficiency</th>
<th>Is Converter Efficiency 1 ± 0.04 ?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>PPB</td>
<td>PPB</td>
<td>PPB</td>
<td>PPB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prec (10 PPM)</td>
<td>9.0</td>
<td>29.4</td>
<td>29.4</td>
<td>9.0</td>
<td>100.0%</td>
<td>TRUE</td>
</tr>
<tr>
<td>Span (195 PPM)</td>
<td>184.0</td>
<td>225.9</td>
<td>227.1</td>
<td>185.1</td>
<td>100.0%</td>
<td>TRUE</td>
</tr>
</tbody>
</table>

#### Converter Efficiency (from slope) Is Converter Efficiency 1 ± 0.04 ?

- 100.7% TRUE

---

Form 9 – Corrective Action Form

Polk County Air Quality - Corrective Action Form

To: ____________________________ Polk County Air Quality __________________
( suicides)

From: __________________________

Copies of completed form to: AQ Supervisor, File

Urgency: [ ] Emergency (immediate action needed) [ ] Urgent (24 Hr.)
[ ] Routine (7 days) [ ] Next scheduled visit [ ] Information only

**Problem Identification:**

Site: __________________________

System: _________________________

Date: _________________________

Description of Problem: ___________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Recommended Action: _____________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Signature of Initiator: ____________________________ Date: _________________________

**Problem Resolution:**

Date of Corrective Action: _________________________________________________________

Summary of Corrective Action: _____________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Result of Corrective Action: _______________________________________________________ 
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Signature of resolver: ____________________________ Date: _________________________

Signature of QA Officer: ____________________________ Date: _________________________