

# **Standard Operation Procedures for NO-NO<sub>2</sub>-NO<sub>x</sub>**

In Use By

**Polk County Air Quality  
Ambient Air Monitoring Personnel**

**For Calendar Year 2018**

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**PREPARED BY**

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*Polk County Air Quality Air Pollution Monitoring Specialist*

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*Date*

**SIGNATURES/APPROVALS**

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*Polk County Air Quality Assurance Officer*

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*Date*

## POLK COUNTY AIR QUALITY DIVISION

STANDARD OPERATING PROCEDURE MANUAL FOR THERMO SCIENTIFIC NO-NO<sub>2</sub>-NO<sub>x</sub> MONITORING

## Table of Contents

	Page #
2.1 Purpose.....	3
2.2 Scope .....	3
2.3 References.....	3
2.4 Introduction.....	3
2.5 Health and Safety Warning/Precautions.....	4
2.6 Sampler Setup.....	4
2.6.1 Site Selection.....	4
2.6.1.1 The Monitoring Station.....	5
2.6.1.2 Probe Placement.....	5
2.6.2 Inspecting New Equipment.....	6
2.6.3 Equipment Installation.....	6
2.6.4 Programming Equipment.....	7
2.6.4.1 Range and Units.....	7
2.6.4.2 Averaging Time.....	8
2.6.4.3 Temperature Compensation.....	8
2.6.4.4 Pressure Compensation.....	8
2.6.4.5 Baud Rate.....	8
2.6.4.6 Clock Set.....	8
2.6.4.7 Auto Mode.....	9
2.7 Standards.....	9
2.8 Calibrations.....	10
2.8.1 Calibration Procedures for the TL-42i using the 146i Calibrator.....	11
2.8.1.1 Pre-Calibration.....	11
2.8.1.2 Calibration of NO/NO <sub>x</sub> .....	11
2.8.1.3 Calibration of NO <sub>2</sub> .....	12
2.8.2 Converter Efficiency.....	14
2.9 Quality Control.....	14
2.9.1 Station Inspection.....	14
2.9.2 Station Log Book.....	14
2.9.3 Bi-Weekly Zero, Precision and Span Checks.....	15
2.9.4 Data Acquisition and Telemetry.....	15
2.10 Equipment, Maintenance and Trouble Isolation.....	16
2.10.1 Preventative Maintenance.....	16
2.10.1.1 Analyzer Leak Check.....	16
2.10.1.2 Sample Line Leak Check.....	16
2.10.1.3 Particulate Filter Changes.....	17
2.10.1.4 Cleaning the Fan Filters.....	17
2.10.1.5 Cleaning the PMT Cooler Fins.....	17
2.10.1.6 Replacing the Sample Lines.....	17
2.10.2 Trouble Isolation.....	17
2.10.3 Environmental Control for Monitoring Equipment.....	17
2.11 Quality Assurance.....	18
2.11.1 Direct Comparison Audit.....	18
2.11.2 Federal Audits.....	19
2.12 Data Quality Assessment.....	19
2.12.1 Precision.....	19
2.12.2 Accuracy.....	20
2.12.3 Data Completeness.....	20
2.13 Procedures for Bi-Weekly Verifications.....	20
2.13.1 Maintenance Mode for Agilaire Model 8832 Data Loggers.....	20
2.13.2 Remote Mode.....	20
2.13.3 Maintenance and Diagnostics Check.....	21
2.13.4 Bi-Weekly Zero, Precision and Span Checks.....	22
2.13.4.1 Zero Air Check.....	22

2.13.4.2	Span Check (NO/NO <sub>x</sub> ).....	23
2.13.4.3	Precision Check (NO/NO <sub>x</sub> ).....	23
2.13.4.4	Span Checks (NO <sub>2</sub> ).....	24
2.13.4.5	Precision Checks (NO <sub>2</sub> ).....	25
2.13.4.6	Converter Efficiency Check.....	26
2.13.5	Invalidate Data and Recalibrate.....	26
2.14	Automated Zero/Precision/Span Checks.....	26
2.14.1	Calibration Program in the 146i Calibrator.....	27
2.14.1.1	Program Cycle.....	27
2.14.1.2	Period Hours.....	27
2.14.1.3	Next Cycle.....	27
2.14.1.4	Events.....	27
2.14.2	Calibration Program for the TL-42i.....	29
2.14.2.1	Next Time.....	29
2.14.2.2	Period Hours.....	30
2.14.2.3	Automated Check Duration.....	30
2.14.2.4	Averaging Time.....	30
2.14.3	Communication Settings in Agilaire AirVision Software.....	30
2.14.4	Calibration Program in Agilaire AirVision Software.....	30

**FIGURES**

Figure 2-1	Thermo Scientific TL-42i NO-NO <sub>2</sub> -NO <sub>x</sub> Analyzer.....	6
Figure 2-2	Gas Phase Titration System.....	10
Figure 2-3	Agilaire Model 8832 Data Logger.....	21

**TABLES**

Table 2-1	Diagnostic Checks.....	22
Table 2-2	Measurement Quality Objectives.....	32

Appendix A	Forms and Field Sheets.....	35
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## 2.0 STANDARD OPERATING PROCEDURE FOR NO-NO<sub>2</sub>-NO<sub>x</sub>

### 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-NO<sub>2</sub>-NO<sub>x</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> 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.
- 2.3.3 EPA Quality Assurance Guidance Document 2.3, Reference Method for the Determination of Nitrogen Dioxide in the Atmosphere (Chemiluminescence), February, 2002, Draft.
- 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.
- 2.3.6 EPA-454/B-17-001, January, 2017. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program.
- 2.3.7 Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program, Appendix D. Revision 1, March, 2017.
- 2.3.8 40 Code of Federal Regulations (CFR) Part 50, Appendix F, Measurement Principle and Calibration Procedure for the Measurement of NO<sub>x</sub> in the Atmosphere.
- 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 Assessment Monitoring Stations (PAMS).
- 2.3.11 40 Code of Federal Regulations (CFR) Part 58, Appendix E, Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring.

### 2.4 Introduction

The U.S. Environmental Protection Agency (EPA) has determined nitrogen dioxide (NO<sub>2</sub>) is a health and environmental concern. For this reason, National Ambient Air Quality Standards (NAAQS) have been

established for NO<sub>2</sub>. As a result, an air monitoring network to monitor for NO<sub>2</sub> was established in the Des Moines Metropolitan Statistical Area (MSA) and is maintained by Polk County Air Quality Division, Iowa.

Measurements of nitrogen dioxide (NO<sub>2</sub>) in ambient air are based on the principle that nitric oxide (NO) and ozone (O<sub>3</sub>) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO<sub>2</sub> molecules decay to lower energy states:



Ambient air is drawn into the NO-NO<sub>2</sub>-NO<sub>x</sub> sample inlet. The sample flows into a solenoid valve which splits the flow between the NO and NO<sub>x</sub> mode. NO<sub>x</sub> mode converts NO<sub>2</sub> to NO (measuring total NO<sub>x</sub>) 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 O<sub>3</sub>. The O<sub>3</sub> reacts with the NO present in each sample producing electronically excited NO<sub>2</sub> molecules. A photomultiplier tube housed in a thermoelectric cooler detects the NO<sub>2</sub> 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 NO<sub>x</sub> are both measured with NO<sub>2</sub> concentration calculated by difference. (NO<sub>x</sub> – NO = NO<sub>2</sub>).

The dynamic parameter requirement ensures that the NO-O<sub>3</sub> 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 NO<sub>2</sub>, it is important to understand that the reactive oxides of nitrogen in the atmosphere are primarily nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>), known together

as NO<sub>x</sub>. During the daytime, there is a rapid interconversion of NO and NO<sub>2</sub>. NO emitted into the air is converted to NO<sub>2</sub> by photochemical reactions promoted by sunlight eventually creating ozone downwind of the sources. The main sources of NO<sub>x</sub> 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<sub>x</sub> to allow more time for the formation of NO<sub>2</sub>.

For more detailed information concerning site selection for NO-NO<sub>2</sub>-NO<sub>x</sub> 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<sub>2</sub>-NO<sub>x</sub> 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 about 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>-NO<sub>x</sub> 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.

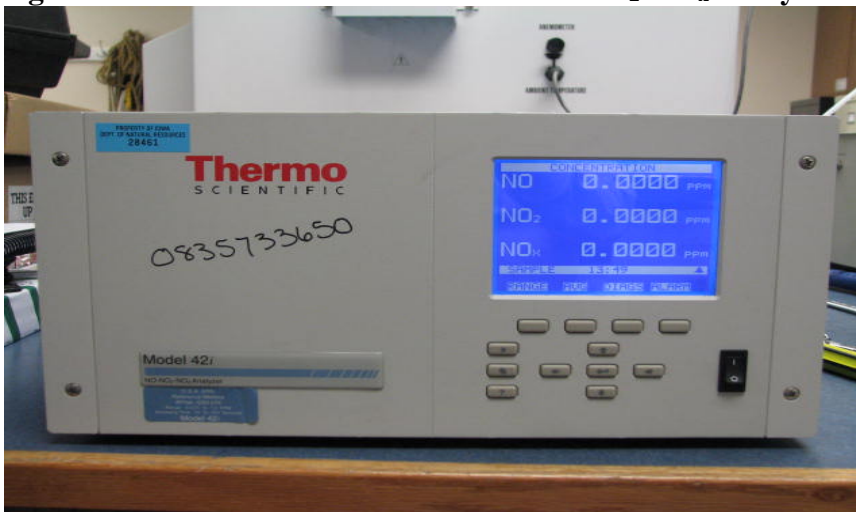
Inspect the interior of the instrument for damage, such as broken components or loose circuit boards. Make sure that all of the circuit boards are completely secured. Loose boards could short out the motherboard. If no damage is evident, the monitor is ready for calibration, installation and operation. 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<sub>2</sub>-NO<sub>x</sub> 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<sub>2</sub>-NO<sub>x</sub> 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<sub>2</sub>-NO<sub>x</sub> 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<sub>2</sub> concentration. However, if particulate matter builds up on the filter, the particulate matter will destroy some of the NO<sub>2</sub> in the sample.

Since the instrument's exhaust consists of ambient air with some NO<sub>2</sub> 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<sub>2</sub>-NO<sub>x</sub> 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<sub>2</sub> Range and NO<sub>x</sub> Range.

The Gas Units Screen defines how the NO-NO<sub>2</sub>-NO<sub>x</sub> 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<sub>2</sub>-NO<sub>x</sub> 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<sub>2</sub>-NO<sub>x</sub> 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<sub>2</sub>-NO<sub>x</sub> 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/NO<sub>x</sub>), NO Mode (manual NO), or NO<sub>x</sub> mode (manual NO<sub>x</sub>). **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, NO<sub>2</sub>, and NO<sub>x</sub> 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/NO<sub>x</sub> 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 N<sub>2</sub> with less than 1.0 ppm NO<sub>2</sub> 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 NO<sub>2</sub> standard and for determining the amount of NO<sub>2</sub> 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.

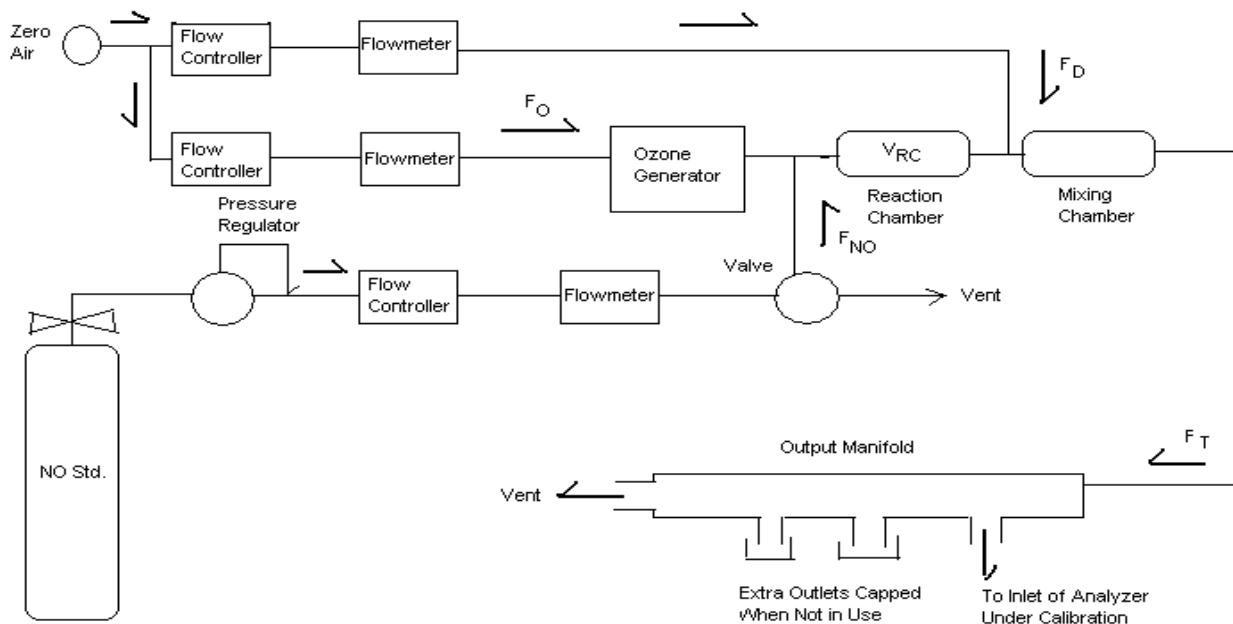
Precautions must be taken to remove "dead" pockets of contaminants which are created within the regulator whenever it is removed from the cylinder. This problem can be minimized by carefully evacuating the regulator (also known as purging) after it is connected to the cylinder. Air trapped in the regulator can result in the NO converting to NO<sub>2</sub> 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**

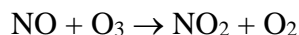


## 2.8 Calibrations

The Thermo Scientific Model TL-42i NO-NO<sub>2</sub>-NO<sub>x</sub> 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<sub>2</sub> and NO<sub>x</sub> relationship between the analyzer and the true NO and NO<sub>2</sub> concentrations. This procedure involves the gas phase titration (GPT) of a NO standard with

O<sub>3</sub> to produce NO<sub>2</sub>. This method is based upon the rapid gas phase reaction between NO and O<sub>3</sub> to produce stoichiometric quantities of NO<sub>2</sub>.



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-NO<sub>2</sub>-NO<sub>x</sub> 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-42*i* using the 146*i* 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-42*i* is on. Press the front panel **MENU** button on the TL-42*i* 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/NO<sub>x</sub>

The GPT requires the use of the NO/NO<sub>x</sub> channel of the analyzer to determine the amount of NO<sub>2</sub> generated by titration. Therefore, it is necessary to calibrate and determine the linearity of the NO/NO<sub>x</sub> channels before proceeding with the NO<sub>2</sub> calibration.

On the Main Screen (or Standby Screen) of the 146*i* 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 146*i* 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, NO<sub>2</sub>, and NO<sub>x</sub> channels.

Press the front panel **MENU** button on the TL-42*i* 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<sub>x</sub> BACKGROUND** and press **ENTER**. Press **ENTER** to set the NO<sub>x</sub> 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<sub>2</sub>, and NO<sub>x</sub> 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<sub>x</sub> concentration.

**NOTE: The NO, NO<sub>x</sub>, and Prereactor Background coefficients should be less than 15 ppb. The NO and NO<sub>x</sub> span coefficients should always fall between 0.900 and 1.100, and the NO<sub>2</sub> 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<sub>2</sub>, and NO<sub>x</sub> 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<sub>2</sub>**

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<sub>2</sub> calibration must be performed using an NO<sub>x</sub> 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<sub>2</sub>, and NO<sub>x</sub> channels. NO<sub>2</sub> should stabilize out at approximately 0 ppb. NO/NO<sub>x</sub> should stabilize out at approximately 225 ppb. Record all information in the site log.

At this point the zero NO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>, and NO<sub>x</sub> channels.

NO<sub>2</sub> is calibrated according to a direct comparison between the NO concentration obtained when NO<sub>2</sub> is set to zero and the NO concentration obtained at approximately 80% the URL of the uncalibrated NO<sub>2</sub> channel (i.e. 200).

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

Where:

NO<sub>orig</sub> = Original NO data logger reading, when NO<sub>2</sub> is set to zero

NO<sub>rem</sub> = Final NO data logger reading when NO<sub>2</sub> is approx. 200 ppb

NO<sub>2(imp)</sub> = Conc. of NO<sub>2</sub> impurity in standard NO cylinder

**NOTE: To ensure that NO is in excess during Gas Phase Titration, NO<sub>rem</sub> should be at least 10% of the value of NO<sub>orig</sub>.**

The NO<sub>2</sub> impurities in the NO concentration standard are determined by:

$$\text{NO}_{2(\text{imp})} = \frac{(\text{F}_{\text{NO}} (\text{sccm}))(\text{Impurities from cylinder gas (ppb)})}{\text{F}_{\text{NO}} + \text{F}_{\text{O}} + \text{F}_{\text{D}}}$$

Where:

F<sub>NO</sub> = NO Flow

F<sub>O</sub> = Ozone Flow

F<sub>D</sub> = 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<sub>2</sub> 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<sub>2</sub> concentration. Press **ENTER** to calibrate the analyzer to the desired NO<sub>2</sub> concentration.

**NOTE: If the analyzer calculates a NO<sub>2</sub> span coefficient of less than 0.96, either the entered NO<sub>2</sub> 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 (NO<sub>2</sub>)**

During a calibration, the converter efficiency must be determined for each NO<sub>2</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> 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, Chemiluminescence NO-NO<sub>2</sub>-NO<sub>x</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> 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/NO<sub>x</sub> 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/NO<sub>x</sub> concentrations of approximately 10 ppb (the precision) and approximately 225 ppb (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/NO<sub>x</sub> value is 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  $\pm 3.0$  ppb
- The precision difference is  $\pm 1.5$  ppb, or  $\pm 15\%$ , whichever is greater.
- The span drift is outside  $\pm 10\%$

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-NO<sub>2</sub>-NO<sub>x</sub> 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 NO<sub>2</sub> 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<sub>x</sub> concentrations in the network are the Thermo Scientific Models TL-42*i* and the 146*i* 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  $\downarrow$  buttons to scroll to **DIAGNOSTICS** and press **ENTER**. From the Diagnostic Menu, use the  $\downarrow$  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  $\downarrow$  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-NO<sub>2</sub>-NO<sub>x</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> within the measurement range of the analyzer. The 146i Multi-Gas Calibrators can be programmed to generate the desired NO-NO<sub>2</sub>-NO<sub>x</sub> 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 99<sup>th</sup> 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, NO<sub>2</sub>, and NO<sub>x</sub> channels. The results are recorded on the Quarterly Audit Sheet, Form 5, Appendix A. The NO<sub>2</sub> 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  $\pm 1.5$  ppb, or  $\pm 15\%$ , whichever is greater

- The percent difference is outside  $\pm 15\%$  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-NO<sub>2</sub>-NO<sub>x</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> 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  $\pm 1.5$  ppb
- The percent difference is outside  $\pm 15\%$  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-NO<sub>2</sub>-NO<sub>x</sub> analyzer has a 90 percent confidence limit of coefficient of variation for precision of  $\leq 15\%$ , 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 NO<sub>2</sub> 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-NO<sub>2</sub>-NO<sub>x</sub> 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.

**Figure 2-3: The Agilaire Model 8832 Data Logger**

### 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<sub>x</sub>. Scroll down and record span coefficients for NO, NO<sub>2</sub>, and NO<sub>x</sub>.

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<sub>2</sub> 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

Check	Explanation
Voltages	The DC power supply voltages
Temperatures	The internal instrument and chamber temperatures
Pressure	The reaction chamber pressure
Flow	The sample flow rate

### 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-42*i* 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 146*i* Calibrator. The 146*i* Calibrator vent port is connected to the TL-42*i* site analyzer's sample port.

On the Main Screen (or Standby Screen) of the 146*i* 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 146*i* 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, NO<sub>2</sub>, and NO<sub>x</sub> 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:

$C_M$  = data logger concentration, ppb

$C_{146}$  = Calibrator concentration, ppb

**2.13.4.2 Span Check (NO/NO<sub>x</sub>)**

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/NO<sub>x</sub>). Perform the span check using a cylinder containing 9-20 ±2 ppm NO in N<sub>2</sub> with less than 1 ppm NO<sub>2</sub>. 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, NO<sub>2</sub>, and NO<sub>x</sub> 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/NO<sub>x</sub>)**

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/NO<sub>x</sub>.

Allow the TL-42i site analyzer to stabilize for a minimum of 15 minutes, then record the resultant data logger readings from the NO, NO<sub>2</sub>, and NO<sub>x</sub> 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 (NO<sub>2</sub>)

At this point the precision and span readings for NO/NO<sub>x</sub> have been recorded, perform the Span Checks for NO<sub>2</sub>. 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 NO<sub>x</sub> 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, NO<sub>2</sub>, and NO<sub>x</sub> channels on the Verification Field Sheet. NO<sub>2</sub> should stabilize around 0 ppb. NO/NO<sub>x</sub> channels should stabilize around 185 ppb.

At this point, the zero NO<sub>2</sub> 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 NO<sub>2</sub> reading of approximately 185 ppb. Allow the TL-42i site analyzer to stabilize, then record the resultant data logger readings from the NO, NO<sub>2</sub>, and NO<sub>x</sub> 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<sub>ORIG</sub> and NO<sub>REM</sub> for slope and intercept prior to calculating NO<sub>2(ACTUAL)</sub>. The NO<sub>2ACTUAL</sub> readings are then determined by using the formula:

$$NO_{2Actual} = (NO_{ORIG} - NO_{REM}) + \frac{F_{NO} * NO_{2imp}}{F_T}$$

Where:

NO<sub>orig</sub> = Original NO data logger reading

NO<sub>rem</sub> = NO data logger reading, after addition of O<sub>3</sub>

F<sub>NO</sub> = NO flow rate (scm) as determined by the pollutant MFC

NO<sub>2imp</sub> = Conc. of NO<sub>2</sub> impurity in standard NO cylinder

F<sub>T</sub> = Total actual flow put out by the calibrator, scm

After determining the actual NO<sub>2</sub> readings for the span check, calculate the percent difference using the formula:

$$\% \text{ Difference} = \frac{NO_{2(Indicated)} - NO_{2(Actual)}}{NO_{2(Actual)}} \times 100$$

Where:

NO<sub>2 (Indicated)</sub> = data logger concentration, ppb

**2.13.4.5 Precision Check (NO<sub>2</sub>)**

At this point span readings for NO<sub>2</sub> have been recorded, perform the Precision Checks for NO<sub>2</sub>. 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 NO<sub>x</sub> 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, NO<sub>2</sub>, and NO<sub>x</sub> channels on the Verification Field Sheet. NO<sub>2</sub> should stabilize around 0 ppb. NO/NO<sub>x</sub> channels should stabilize around 30 ppb.

At this point, the zero NO<sub>2</sub> 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 NO<sub>2</sub> reading of approximately 10 ppb. Allow the TL-42i site analyzer to stabilize, then record the resultant data logger readings from the NO, NO<sub>2</sub>, and NO<sub>x</sub> 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<sub>ORIG</sub> and NO<sub>REM</sub> for slope and intercept prior to calculating NO<sub>2(ACTUAL)</sub>. The NO<sub>2(ACTUAL)</sub> readings are then determined by using the formula:

$$NO_{2Actual} = (NO_{ORIG} - NO_{REM}) + \frac{F_{NO} * NO_{2imp}}{F_T}$$

Where:

NO<sub>orig</sub> = Original NO data logger reading

NO<sub>rem</sub> = NO data logger reading, after addition of O<sub>3</sub>

F<sub>NO</sub> = NO flow rate (sccm) as determined by the pollutant MFC

NO<sub>2imp</sub> = Conc. of NO<sub>2</sub> impurity in standard NO cylinder

F<sub>T</sub> = Total actual flow put out by the calibrator, sccm

After determining the actual NO<sub>2</sub> readings for the precision check, calculate the percent difference using the formula:

$$\% \text{ Difference} = \frac{NO_2 \text{ (Indicated)} - NO_2 \text{ (Actual)}}{NO_2 \text{ (Actual)}} \times 100$$

Where:

NO<sub>2 (Indicated)</sub> = 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 NO<sub>2</sub> 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  $\pm 15\%$  (whichever is greater), or if the zero drift is  $\geq 3.0$  ppb, or if the span drift is  $\pm 10\%$ . 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  $\leq 3.0$  ppb, a span drift  $\leq 10\%$ , and a difference for precision of 1.5 ppb or  $\leq 15\%$ , whichever is greater. If the daily automated precision 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

- 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 fourth 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/NO<sub>2</sub>/NO<sub>x</sub> auto-check has 7 separate events. The Events will be programmed as follows:

**EVENT 1 – NO/NO<sub>2</sub>/NO<sub>x</sub> (Zero)**

ENABLE  
 DURATION            10 MINS  
 GAS D                8000 SCCM  
 ZERO                 0.000 ppm  
 OZONE OFF

**EVENT 2 – NO/NO<sub>x</sub> (Span)**

ENABLE  
 DURATION            25 MINS  
 GAS D                4100 SCCM  
 SPAN 2               0.225 ppm  
 OZONE OFF

**EVENT 3 – NO/NO<sub>x</sub> (Precision)**

ENABLE  
 DURATION            10 MINS  
 GAS D                19500 SCCM  
 SPAN1                0.011ppm  
 OZONE OFF

**EVENT 4 – NO<sub>2</sub> (Span)**

ENABLE	
DURATION	10 MINS
GAS D	4100 SCCM
SPAN 2	0.225 ppm
OZONE 3	13%

**EVENT 5 – NO<sub>2</sub> (Span-Zero)**

ENABLE	
DURATION	10 MINS
GAS D	4100 SCCM
SPAN 2	0.225 ppm
OZONE 1	0%

**EVENT 6 – NO<sub>2</sub> (Precision)**

ENABLE	
DURATION	10 MINS
GAS D	19000 SCCM
SPAN 3	0.030 ppm
OZONE 4	7%

**EVENT 7 – NO<sub>2</sub> (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 Agilaire 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 Agilaire 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 us for NO/NO<sub>2</sub>/NO<sub>x</sub>:

- NO/NO<sub>x</sub> Zero Phase: 35=off, 36=off, 37=off, 38=off, 39=off, 40=off
- NO/NO<sub>x</sub> Precision Phase: 35=on, 36=off, 37=off, 38=off, 39=off, 40=off
- NO/NO<sub>x</sub> Span Phase: 35=off, 36=on, 37=off, 38=off, 39=off, 40=off
- NO<sub>2</sub> Span Phase: 35=off, 36=on, 37=off, 38=off, 39=off, 40=on
- NO<sub>2</sub> Span/Zero Phase: 35=off, 36=on, 37=off, 38=off, 39=on, 40=off
- NO<sub>2</sub> Precision Phase: 35=on, 36=on, 37=off, 38=on, 39=off, 40=on
- NO<sub>2</sub> 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<sub>x</sub> Zero Phase: 35=0&36=0&37=0&38=0&39=0&40=0
- NO/NO<sub>x</sub> Precision Phase: 35&36=0&37=0&38=0&39=0&40=0
- NO/NO<sub>x</sub> Span Phase: 35=0&36&37=0&38=0&39=0&40=0
- NO<sub>2</sub> Span Phase: 35=0&36&37=0&38=0&39=0&40
- NO<sub>2</sub> Span/Zero Phase: 35=0&36&37=0&38=0&39&40=0
- NO<sub>2</sub> Precision Phase: 35&36&37=0&38&39=0&40
- NO<sub>2</sub> Precision/Zero Phase: 35&36&37=0&38=0&39&40=0



Table 2-2: Measurement Quality Objectives

**NO<sub>2</sub>, NO<sub>x</sub>, NO Validation Template**

1) Requirement (NO <sub>2</sub> )	2) Frequency	3) Acceptance Criteria	Information /Action
<b>CRITICAL CRITERIA- NO<sub>2</sub></b>			
<i>Sampler/Monitor</i>	NA	<i>Meets requirements listed in FRM/FEM designation</i>	1) 40 CFR Part 58 App C Sec. 2.1 2) NA 3) 40 CFR Part 53 & <a href="#">FRM/FEM method list</a>
<i>One Point QC Check Single analyzer</i>	<i>Every 14 days</i>	$< \pm 15.1\%$ (percent difference) or $< \pm 1.5$ ppb difference whichever is greater	1 and 2) <a href="#">40 CFR Part 58 App A Sec. 3.1.1</a> 3) 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 <a href="#">Technical Note on AMTIC</a>
Zero/span check	Every 14 days	Zero drift $< \pm 3.1$ ppb (24 hr) $< \pm 5.1$ ppb (>24hr-14 day) Span drift $< \pm 10.1\%$	1 and 2) <a href="#">QA Handbook Volume 2</a> Sec. 12.3 3) Recommendation and related to DQO
<i>Converter Efficiency</i>	During multi-point calibrations, span and audit Every 14 days	$(\geq 96\%)$ 96% – 104.1%	1) 40 CFR Part 50 App F Sec. 1.5.10 and 2.4.10 2) Recommendation 3) 40 CFR Part 50 App F Sec. 1.5.10 and 2.4.10 Regulation states $\geq 96\%$ , 96 – 104.1% is a recommendation.
<b>OPERATIONAL CRITERIA- NO<sub>2</sub></b>			
Shelter Temperature Range	Daily (hourly values)	20.0 to 30.0° C. (Hourly avg) or per manufacturers specifications if designated to a wider temperature range	1, 2 and 3) <a href="#">QA Handbook Volume 2</a> Sec. 7.2.2  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 <a href="#">AMTIC</a> provides temp. range for given instrument. FRM/FEM monitor testing is required at 20-30 ° C range per 40 CFR Part 53.32
Shelter Temperature Control	Daily (hourly values)	$< 2.1^\circ$ C SD over 24 hours	1, 2 and 3) <a href="#">QA Handbook Volume 2</a> Sec. 7.2.2
Shelter Temperature Device Check	every 182 days and 2/calendar year	$< \pm 2.1^\circ$ C of standard	1, 2 and 3) <a href="#">QA Handbook Volume 2</a> Sec. 7.2.2
<i>Annual Performance Evaluation Single Analyzer</i>	<i>Every site every 365 days and 1/ calendar year</i>	Percent difference of audit levels 3-10 $< \pm 15.1\%$ Audit levels 1&2 $< \pm 1.5$ ppb difference or $< \pm 15.1\%$	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. <a href="#">AMTIC Technical Memo</a>
<i>Federal Audits (NPAP)</i>	20% of sites audited in calendar year	Audit levels 1&2 $< \pm 1.5$ ppb difference all other levels percent difference $< \pm 15.1\%$	1 & 2) 40 CFR Part 58 App A Sec. 3.1.3 3) NPAP QAPP/SOP

1) Requirement (NO <sub>2</sub> )	2) Frequency	3) Acceptance Criteria	Information /Action
<i>Verification/Calibration</i>	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 $\leq 2$ min Dynamic parameter $\geq 2.75$ ppm-min All points $< \pm 2.1\%$ or $\leq \pm 1.5$ ppb difference of best-fit straight line whichever is greater and Slope $1 \pm .05$	1) 40 CFR Part 50 App F 2 and 3) Recommendation  Multi-point calibration (0 and 4 upscale points)  Slope criteria is a recommendation
<i>Gaseous Standards</i>	All gas cylinders	<u>NIST Traceable</u> (e.g., EPA Protocol Gas) 50-100 ppm of NO in Nitrogen with $< 1$ ppm NO <sub>2</sub>	1) 40 CFR Part 50 App F Sec. 1.3.1 2) NA <a href="#">Green Book</a> 3) 40 CFR Part 50 App F Sec. 1.3.1. A technical memo may change the concentration requirement.  Gas producer used must participate in EPA <a href="#">Ambient Air Protocol Gas Verification Program</a> 40 CFR Part 58 App A Sec. 2.6.1
<i>Zero Air/ Zero Air Check</i>	Every 365 days and 1/ calendar year	Concentrations below LDL	1) <a href="#">40 CFR Part 50 App F</a> 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 $< \pm 2.1\%$	1, 2 and 3) Recommendation based on SO <sub>2</sub> requirement in 40 CFR Part 50 App A-1 Sec. 4.1.2
<b>Detection (FEM/FRMs)</b> 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.			
<i>Noise</i>	Every 365 days and 1/ calendar year	$\leq 0.005$ 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
<i>Lower detectable level</i>	Every 365 days and 1/ calendar year	$\leq 0.01$ ppm	1) 40 CFR Part 53.23 (c) (definition & procedure) 2) Recommendation 3) 40 CFR Part 53.20 Table B-1
<b>SYSTEMATIC CRITERIA- NO<sub>2</sub></b>			
<i>Standard Reporting Units</i>	<i>All data</i>	<i>ppb (final units in AQS)</i>	1, 2 and 3) 40 CFR Part 50 App S Sec. 2 (c)
<i>Rounding convention for data reported to AQS</i>	<i>All routine concentration data</i>	<i>1 place after decimal with digits to right truncated</i>	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.
<i>Completeness</i>	<i>Annual Standard</i>	$\geq 75\%$ 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)
	<i>1-hour standard</i>	1) 3 consecutive calendar years of complete data 2) 4 quarters complete in each year 3) $\geq 75\%$ sampling days in quarter 4) $\geq 75\%$ 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

<b>1) Requirement (NO<sub>2</sub>)</b>	<b>2) Frequency</b>	<b>3) Acceptance Criteria</b>	<b>Information /Action</b>
<i>Sample Residence Time Verification</i>	Every 365 days and 1/ calendar year	$\leq 20$ Seconds	1) 40 CFR Part 58 App E, Sec. 9 (c) 2) Recommendation 3) 40 CFR Part 58 App E, Sec. 9 (c)
<i>Sample Probe, Inlet, Sampling train</i>	<i>All sites</i>	<i>Borosilicate glass (e.g., Pyrex<sup>®</sup>) or Teflon<sup>®</sup></i>	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
<i>Siting</i>	Every 365 days and 1/ calendar year	<i>Meets siting criteria or waiver documented</i>	1) 40 CFR Part 58 App E, Secs 2-6 2) Recommendation 3) 40 CFR Part 58 App E, Sec. 2-6
<i>Precision (using 1-point QC checks)</i>	<i>Calculated annually and as appropriate for design value estimates</i>	<i>90% CL CV &lt; 15.1%</i>	1) <a href="#">40 CFR Part 58 App A</a> Sec. 2.3.1.5 & 3.1.1 2) 40 CFR Part 58 App A Sec. 4 (b) 3) 40 CFR Part 58 App A Sec. 4.1.2
<i>Bias (using 1-point QC checks)</i>	<i>Calculated annually and as appropriate for design value estimates</i>	<i>95% CL &lt; <math>\pm</math> 15.1%</i>	1) 40 CFR Part 58 App A Sec. 2.3.1.5 & 3.1.1 2) 40 CFR Part 58 App A Sec. 4 (b) 3) 40 CFR Part 58 App A Sec. 4.1.3

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

Date	02/23/16
Time	10:00AM
Site	Carpenter
Pollutant	NOX
Operator	JM

Gases

Standard Cylinder Conc.	10.71	PPM
Serial Number	CC12458	
Expiration Date	03/11/16	
Candidate Cylinder Conc.	10.17	PPM
Serial Number	ND45562	
Expiration Date	12/28/18	

Instruments

Gas Calibrator	Thermo 146i	1126649800
Last Verification	2/17/2016	
Monitor	Thermo TL-42i	1117248572
Last Calibrated	4/21/2015	

EXTERNAL ZERO TEST

	<i>AIR</i>	<i>GAS</i>	<i>Known Value</i>	<i>Instrument Response</i>
Verification	Zero Air Actual MFC	Gas Pollutant Actual MFC	NO	NO
	SCCM	SCCM	PPB	PPB
Standard Zero	7995	0.000	0.0	0.0
Candidate Zero	7995	0.000	0.0	0.0

VERIFICATION

	<i>AIR</i>	<i>GAS</i>	<i>Known Value</i>	<i>Instrument Response</i>	<i>% Difference</i>	<i>Pass</i>
Verification	Zero Air Actual MFC	Gas Pollutant Actual MFC	NO	NO	NO	NO
	SCCM	SCCM	PPB	PPB	PPB	PPB
Standard Precision 20	12959	24.24	20.0	19.5		
Candidate Precision 20	12959	25.56	20.0	19.0	2.6	TRUE

Standard Span 225	4019	86.34	225.0	219.8		
Candidate Span 225	4013	90.95	225.0	214.0	2.7	TRUE

Average Percent Diffenece	Is Average Percent Diffence ±4% ?
2.7	TRUE

Is Candidate Gas OK ?
TRUE

Form 2: Calibration Field Sheet

NO-NO<sub>2</sub>-NO<sub>x</sub> 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: \_\_\_\_\_

Prec 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): \_\_\_\_\_

NO<sub>2</sub> Reading (ppm): \_\_\_\_\_

NO<sub>x</sub> Reading (ppm): \_\_\_\_\_

Date Last Calibration: \_\_\_\_\_

Ambient: \_\_\_\_\_

Site: \_\_\_\_\_

Make adjustments per service manual

Diagnostic Check		
ALARMS DETECTED:		
Alarm	Value	Corrective Action
Internal Temp (°C) (15 - 45°C)		Consult Manual
Chamber Temp (°C) (48 - 52°C)		Check Reaction Chamber
Cooler Temp (°C) (-25 to -1°C)		Check PMT Cooler
Conv. Temp (°C) (300 - 350°C)		Check NO <sub>2</sub> to NO Converter
Pressure (200 -450 mm Hg)		Replace Reaction Chamber
Sample Flow (0.75 - 2.0 LPM)		Replace Pump
Ozonator Flow (> 0.050 LPM)		Replace Pump
Leak Check (Flow = 0; Pressure < 250 mmHg)		Locate Leak Replace solenoid valves Replace Capillaries

Note: Refer to Section 2.8 of Polk County Air Quality's Standard Operating Procedures NO-NO<sub>2</sub>-NO<sub>x</sub> for exact calibration procedures.

**Section 2: NO/NO<sub>2</sub>/NO<sub>x</sub>**

Revised: January 26, 2018

Revision Number: 17

**Gas A Dilution – NO/NO<sub>x</sub>**

**Zero Air Check**

Zero Actual: \_\_\_\_\_scm

Gas Actual: \_\_\_\_\_scm

**Point 1 NO/NO<sub>x</sub> (200 ppb)**

Calibrator Actual: \_\_\_\_\_

Zero Actual: \_\_\_\_\_scm

Gas Actual: \_\_\_\_\_scm

**Point 2 NO/NO<sub>x</sub> (150 ppb)**

Calibrator Actual: \_\_\_\_\_

Zero Actual: \_\_\_\_\_scm

Gas Actual: \_\_\_\_\_scm

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading				ESC Reading			
% diff.				% diff.				% diff.			

**Point 3 NO/NO<sub>x</sub> (100 ppb)**

Calibrator Actual: \_\_\_\_\_

Zero Actual: \_\_\_\_\_scm

Gas Actual: \_\_\_\_\_scm

**Point 4 NO/NO<sub>x</sub> (50 ppb)**

Calibrator Actual: \_\_\_\_\_

Zero Actual: \_\_\_\_\_scm

Gas Actual: \_\_\_\_\_scm

**Point 5 NO/NO<sub>x</sub> (20 ppb)**

Calibrator Actual: \_\_\_\_\_

Zero Actual: \_\_\_\_\_scm

Gas Actual: \_\_\_\_\_scm

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>	9)	NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading				ESC Reading			
% diff.				% diff.				% diff.			

**GPT – NO<sub>2</sub>**

**Zero Air Check**

GPT : 0%

Zero Air Flow: \_\_\_\_\_scms

Gas Air Flow: \_\_\_\_\_scms

**Point 1 (~185 ppb)**

GPT %: \_\_\_\_\_

**Point 2 (~150 ppb)**

GPT %: \_\_\_\_\_

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading				ESC Reading			
[NO <sub>2</sub> ] ACT				[NO <sub>2</sub> ] ACT				[NO <sub>2</sub> ] ACT			
% diff.				% diff.				% diff.			

**Point 3 (~100 ppb)**

GPT % : \_\_\_\_\_

**Point 4 (~50 ppb)**

GPT %: \_\_\_\_\_

**Point 5 (~20 ppb)**

GPT %: \_\_\_\_\_

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading				ESC Reading			
[NO <sub>2</sub> ] ACT				[NO <sub>2</sub> ] ACT				[NO <sub>2</sub> ] ACT			
% diff.				% diff.				% diff.			

**Coefficients:**

	NO BKG (< 15 ppb)	NO <sub>x</sub> BKG (< 15 ppb)	PREREACTOR (< 15 PPB)	NO COEF (0.900-1.100)	NO <sub>2</sub> COEF (0.960-1.100)	NO <sub>x</sub> COEF (0.900-1.100)	PMT	COUNTS
Before								
After								

Form 3 – Calibration Linear Regression

NO/NO<sub>2</sub>/NO<sub>x</sub> Multi-Point calibration spreadsheet

Analyzer:	THERMO 42i	Operator	JM
Serial No.:	1117248572	Calibrator:	1126649800
Site:	Carpenter	Cal Gas:	ND45562
Full Scale:	250	Conc.	10.17 ppm
1% of Full Scale:	2.5	Exp. Date	12/28/2018
Date:	November 27, 2017		

NO Cal

Known Conc.	Measured Conc.	rpd	slope	intercept	rsq	forecast	distance to least acceptable		Pass/Fail
							squares line	distance	
0	0	n/a	0.9936	-0.3959	1.0000	-0.3959	0.3959	2.500	pass
20.0	19.5	-2.5%				19.4753	0.0247	2.500	pass
50.2	49.2	-2.0%				49.4807	0.2807	2.500	pass
100.2	99	-1.2%				99.1587	0.1587	2.500	pass
150.6	148.9	-1.1%				149.23408	0.3341	2.500	pass
226.2	224.7	-0.7%				224.34716	0.3528	2.500	pass

NO<sub>x</sub> Cal

Known Conc.	Measured Conc.	rpd	slope	intercept	rsq	forecast	distance to least acceptable		Pass/Fail
							squares line	distance	
0	-0.1	n/a	0.9923	-0.2973	1.0000	-0.2973	0.1973	2.500	pass
20.0	19.6	-2.0%				19.5489	0.0511	2.500	pass
50.3	49.6	-1.4%				49.6158	0.0158	2.500	pass
100.4	99	-1.4%				99.3305	0.3305	2.500	pass
150.9	149.3	-1.1%				149.4421	0.1421	2.500	pass
226.6	224.8	-0.8%				224.5599	0.2401	2.500	pass

NO<sub>2</sub>

Known Conc.	Measured Conc.	rpd	slope	intercept	rsq	forecast	distance to least acceptable		Pass/Fail
							squares line	distance	
0.0	0	n/a	1.0066	-0.3204	1.0000	-0.3204	0.3204	2.500	pass
20.3	20	-1.5%				20.1131	0.1131	2.500	pass
51.4	51	-0.8%				51.4176	0.4176	2.500	pass
101.1	101.6	0.5%				101.4443	0.1557	2.500	pass
146.9	147.6	0.5%				147.54542	0.0546	2.500	pass
182	182.9	0.5%				182.87619	0.0238	2.500	pass



Form 4 – Calibration Converter Efficiency

NO<sub>2</sub> Calibration Spreadsheet

<b>Station:</b>	Carpenter	<b>Date:</b>	11/27/2017	<b>Operator:</b>	JM
<b>Analyzer:</b>	1117248572	<b>Calibrator:</b>	1126649800	<b>Cylinder:</b>	ND45562
<b>Cylinder Conc.</b>	10.17				
<b>Impurity</b>	0.02				

Yellow highlight signifies values entered by user.  
 Green highlight signifies NO<sub>2</sub> Actual for precision data

NO, NO<sub>x</sub> CALIBRATION

Calibration	AIR		GAS		Known Value		Instrument Response		
	Zero Air MFC		Pollutant MFC		NO	NO <sub>x</sub>	NO	NO <sub>x</sub>	NO <sub>2</sub>
	SCCM	SCCM	PPB	PPB	PPB	PPB	PPB	PPB	PPB
Zero	7986	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Point 5 (20 PPB)	12958	25.52	20.0	20.0	19.5	19.6	0.0	0.0	0.0
Point 4 (50 PPB)	4355	21.60	50.2	50.3	49.2	49.6	0.4	0.4	0.4
Point 3 (100 PPB)	6318	62.87	100.2	100.4	99.0	99.0	-0.2	-0.2	-0.2
Point 2 (150 PPB)	5553	83.46	150.6	150.9	148.9	149.3	0.1	0.1	0.1
Point 1 (200 PPB)	3987	90.69	226.2	226.6	224.7	224.8	0.3	0.3	0.3
Ozone Lamp 0%	3987	90.69							

NO<sub>2</sub> UPSCALE CALIBRATION (GPT)

Calibration points NO <sub>2</sub>	Instrument Response			Corrected Instrument Response and Calculated Concentrations		
	NO	NO <sub>x</sub>	NO <sub>2</sub>	[NO]ORIG	[NO]REM	[NO <sub>2</sub> ]ACT
	PPB	PPB	PPB	PPB	PPB	PPB
Ozone Lamp 0%	224.7	224.7	0.2	226.5	226.5	0.4
Point 5 (20 PPB)	205.0	225.1	20	226.5	206.7	20.3
Point 4 (50 PPB)	174.1	225.2	51	226.5	175.6	51.4
Point 3 (100 PPB)	124.7	226.1	101.6	226.5	125.9	101.1
Point 2 (150 PPB)	79.2	226.7	147.6	226.5	80.1	146.9
Point 1 (185 PPB)	44.3	227.1	182.9	226.5	45.0	182.0

	SLOPE	INT.
NO	0.9936	-0.3931
NO <sub>x</sub>	0.9920	-0.2603

NO<sub>2</sub> CONVERTER EFFICIENCY TEST

Pollutant Level	[NO <sub>2</sub> ]Actual	[NO <sub>2</sub> ]ORIG	[NO <sub>2</sub> ]REM	[NO <sub>2</sub> ]CONV	Converter Efficiency	Is Converter Efficiency 1 ±0.04 ?
Point 5 (20 PPB)	20.3	226.8	227.2	20.7	102.0%	TRUE
Point 4 (50 PPB)	51.4	226.8	227.3	51.9	101.0%	TRUE
Point 3 (100 PPB)	101.1	226.8	228.2	102.5	101.4%	TRUE
Point 2 (150 PPB)	146.9	226.8	228.8	148.9	101.4%	TRUE
Point 1 (185 PPB)	182.0	226.8	229.2	184.4	101.3%	TRUE

Converter Efficiency (from slope)	Is Converter Efficiency 1 ±0.04 ?
101.3%	TRUE

Form 5 – Audit Field Sheet

NO-NO<sub>2</sub>-NO<sub>x</sub> Audit Sheet

Site: Carpenter

Routine Site Information

Date/Time: \_\_\_\_\_  
 Operator/Auditor: \_\_\_\_\_

Analyzer Serial #: \_\_\_\_\_  
 Date of last calibration: \_\_\_\_\_  
 Audit Calibrator Serial #: \_\_\_\_\_  
 Date of last calibration: \_\_\_\_\_  
 Cylinder Gas Serial #'s: \_\_\_\_\_  
 Cylinder Expiration Dates: \_\_\_\_\_  
 Cylinder > 200 psig (Y or N) \_\_\_\_\_  
 Cylinder Concentration: \_\_\_\_\_  
 Cylinder NO Concentration: \_\_\_\_\_  
 Cylinder NO<sub>x</sub> 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 NO<sub>x</sub> BKG: \_\_\_\_\_  
 Record Prereactor BKG: \_\_\_\_\_  
 Record NO Coef: \_\_\_\_\_  
 Record NO<sub>2</sub> Coef: \_\_\_\_\_  
 Record NO<sub>x</sub> Coef: \_\_\_\_\_  
 Reading NO: \_\_\_\_\_  
 Reading NO<sub>2</sub>: \_\_\_\_\_  
 Reading NO<sub>x</sub>: \_\_\_\_\_  
 Date Last Zero/Prec/SpanCheck \_\_\_\_\_ Days \_\_\_\_\_  
 Ambient: \_\_\_\_\_

Diagnostic Check		
ALARMS DETECTED:		
Alarm	Value	Corrective Action
Internal Temp (°C) (8 - 47°C)		Consult Manual
Chamber Temp (°C) (47 - 51 °C)		Check Reaction Chamber
Cooler Temp (°C) (-40 to 10°C)		Check PMT Cooler
Conv. Temp (°C) (300 - 700°C)		Check NO <sub>2</sub> to NO Converter
Pressure (150 - 300 mm Hg)		Replace Reaction Chamber
Sample Flow (0.350 - 0.900 LPM)		Replace Pump
Ozonator Flow (> 0.050 LPM)		Replace Pump

Make adjustments per service manual

Gas A Dilution – NO/NO<sub>x</sub>

Zero Air Check

Calibrator Actual: \_\_\_\_\_  
 Zero Flow: \_\_\_\_\_ sccms  
 Gas Flow: \_\_\_\_\_ sccms

Level 4 (8.0-19.9 ppb)

Calibrator Actual: \_\_\_\_\_  
 Zero Flow: \_\_\_\_\_ sccms  
 Gas Flow: \_\_\_\_\_ sccm

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading			
% diff				% diff			

Level 5 (20-49.9 ppb)

Calibrator Actual: \_\_\_\_\_  
 Zero Flow: \_\_\_\_\_ sccm  
 Gas Flow: \_\_\_\_\_ sccm

Level 7 (100-299.9 ppb)

Calibrator Actual: \_\_\_\_\_  
 Zero Flow: \_\_\_\_\_ sccm  
 Gas Flow: \_\_\_\_\_ sccm

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading			
% diff				% 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.

$$\frac{ESC (Y) - Calibrator (X)}{Calibrator (X)} \times 100 = \% \text{ Difference}$$

**Gas A Dilution – NO/NO<sub>2</sub>**

**Zero Air Check**

GPT %: \_\_\_\_\_

Zero Air Flow: \_\_\_\_\_ sccms

Gas Air Flow: \_\_\_\_\_ sccms

**Level 1 (0.3-2.9 ppb)**

GPT %: \_\_\_\_\_

**Level 4 (8-19.9 ppb)**

GPT %: \_\_\_\_\_

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading				ESC Reading			
NO <sub>2</sub> Actual				NO <sub>2</sub> Actual				NO <sub>2</sub> Actual			
% diff				% diff				% diff			

**Zero Air Check**

GPT %: \_\_\_\_\_

Zero Air Flow: \_\_\_\_\_ sccms

Gas Air Flow: \_\_\_\_\_ sccms

**Level 5 (20-49.9 ppb)**

GPT %: \_\_\_\_\_

**Level 7 (100-299.9 ppb)**

GPT %: \_\_\_\_\_

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading				ESC Reading			
NO <sub>2</sub> Actual				NO <sub>2</sub> Actual				NO <sub>2</sub> Actual			
% diff				% diff				% 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.

$$NO_{2(Actual)} = (NO_{ORIG} - NO_{REM}) + NO_{2(imp)}$$

**Where:**

**NO<sub>2</sub>Actual = Actual NO<sub>2</sub> concentration**

**NO<sub>2</sub>(imp) = Calculated NO impurities**

**NO<sub>ORIG</sub> = Original NO data logger reading, when NO<sub>2</sub> is set to zero**

**NO<sub>REM</sub> = Remaining NO data logger reading, after addition of O<sub>3</sub>**

$$NO_{2(imp)} = \frac{(F_{NO} (sccm))(Impurities from cvlinder gas (ppb))}{F_{NO} + F_O + F_D}$$

**Where:**

**F<sub>NO</sub> = NO Flow**

**F<sub>O</sub> = Ozone Flow**

**F<sub>D</sub> = Dilution Flow**

Form 6 – Audit Converter Efficiency

NO<sub>2</sub> Audit Spreadsheet

Station:	Carpenter	Date:	12/14/2016	Operator:	JVB
Analyzer:	1117248572	Calibrator:	1126649799	Cylinder:	CC28174
High Cylinder Conc.	10.16	PPM			
Impurity	0.03	PPM			

Yellow highlight signifies values entered by user.  
 Green highlight signifies NO<sub>2</sub> Actual for precision data

NO, NO<sub>x</sub> AUDIT

Audit	AIR	GAS	Known Value		Instrument Response		
	Zero Air MFC	Pollutant MFC	NO	NO <sub>x</sub>	NO	NO <sub>x</sub>	NO <sub>2</sub>
	SCCM	SCCM	PPB	PPB	PPB	PPB	PPB
Zero	7982	0.00	0.0	0.0	0.0	0.4	0.4
Level 4 (8-19 PPB)	18961	20.53	11.0	11.0	10.0	10.2	0.2
Level 5 (20-49 PPB)	11952	35.48	30.1	30.2	27.9	28.3	0.4
Level 7 (100-299 PPB)	5904	88.59	150.2	150.6	144.4	144.6	-0.1
Ozone Lamp 0%-Low	18926	55.91					
Ozone Lamp 0%-High	5904	88.59					

NO<sub>2</sub> AUDIT (GPT)-LOW RANGE

Audit	Instrument Response			Corrected Instrument Responses and Calculated Concentrations		
	NO	NO <sub>x</sub>	NO <sub>2</sub>	[NO]ORIG	[NO]REM	[NO <sub>2</sub> ]ACT
Points NO <sub>2</sub>	PPB	PPB	PPB	PPB	PPB	PPB
Ozone Lamp 0%	27.9	28.2	0.2	29.5	29.5	0.1
Level 1 (3-2.9 PPB)	25.7	28.2	2.5	29.5	27.2	2.4
Level 4 (8-19 PPB)	13.3	28.5	15.1	29.5	14.3	15.2

NO<sub>2</sub> AUDIT (GPT)-HIGH RANGE

Audit	Instrument Response			Corrected Instrument Responses and Calculated Concentrations		
	NO	NO <sub>x</sub>	NO <sub>2</sub>	[NO]ORIG	[NO]REM	[NO <sub>2</sub> ]ACT
Points NO <sub>2</sub>	PPB	PPB	PPB	PPB	PPB	PPB
Ozone Lamp 0%	146.6	146.1	-0.7	152.6	152.6	0.4
Level 5 (20-49 PPB)	116.7	146.6	29.6	152.6	121.6	31.5
Level 7 (100-299 PPB)	38.9	147.7	108.7	152.6	40.9	112.2

LOW GAS

	SLOPE	INT.
NO	0.9641	-0.5220
NO <sub>x</sub>	0.9603	-0.1785

NO<sub>2</sub> CONVERTER EFFICIENCY TEST

Pollutant	[NO <sub>2</sub> ]Actual	[NO <sub>2</sub> ]ORIG	[NO <sub>2</sub> ]REM	[NO <sub>2</sub> ]CONV	Converter Efficiency	Is Converter Efficiency 1 ±0.04 ?
Level	PPB	PPB	PPB	PPB		
Level 1 (0.3-2.9 PPB)	2.4	29.6	29.6	2.4	100.0%	TRUE
Level 4 (8-19 PPB)	15.2	29.6	29.9	15.5	102.1%	TRUE
Level 5 (20-49 PPB)	31.5	152.3	152.8	32.0	101.7%	TRUE
Level 7 (100-299 PPB)	112.2	152.3	154.0	113.8	101.5%	TRUE

Converter Efficiency (from slope)	Is Converter Efficiency 1 ±0.04 ?
101.5%	TRUE

**Form 7 – Verification Field Sheet**

**NO-NO<sub>2</sub>-NO<sub>x</sub> Verification Sheet**

Site: \_\_\_\_\_

**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: \_\_\_\_\_  
 Cylinder > 200 psig (Y or N) \_\_\_\_\_  
 Cylinder Concentration: \_\_\_\_\_  
 Cylinder NO Concentration: \_\_\_\_\_  
 Cylinder NO<sub>x</sub> 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 NO<sub>x</sub> BKG: \_\_\_\_\_  
 Record PreReactor BKG: \_\_\_\_\_  
 Record NO Coef: \_\_\_\_\_  
 Record NO<sub>2</sub> Coef: \_\_\_\_\_  
 Record NO<sub>x</sub> Coef: \_\_\_\_\_  
 Reading NO: \_\_\_\_\_  
 Reading NO<sub>2</sub>: \_\_\_\_\_  
 Reading NO<sub>x</sub>: \_\_\_\_\_  
 Date Last \_\_\_\_\_  
 Zero/Prec/SpanCheck \_\_\_\_\_ Days \_\_\_\_\_  
 Ambient: \_\_\_\_\_

Make adjustments per service manual

Diagnostic Check		
ALARMS DETECTED:		
Alarm	Value	Corrective Action
Internal Temp (°C) (15 - 45°C)		Consult Manual
Chamber Temp (°C) (48 - 52°C)		Check Reaction Chamber
Cooler Temp (°C) (-25 to -1°C)		Check PMT Cooler
Conv. Temp (°C) (300 - 350°C)		Check NO <sub>2</sub> to NO Converter
Pressure (200 - 450 mm Hg)		Replace Reaction Chamber
Sample Flow (0.75 - 2.0 LPM)		Replace Pump
Ozonator Flow (> 0.050 LPM)		Replace Pump

**Gas A Dilution – NO/NO<sub>x</sub>**

**Zero Air Check**

Zero Air Flow: \_\_\_\_\_ sccms  
 Gas Air Flow: \_\_\_\_\_ sccms

**Precision Check (~11 ppb)**

Calibrator Actual: \_\_\_\_\_  
 Zero Air Flow: \_\_\_\_\_ sccm  
 Gas Air Flow: \_\_\_\_\_ sccm

**Span Check (~200 ppb)**

Calibrator Actual: \_\_\_\_\_  
 Zero Air Flow: \_\_\_\_\_ sccm  
 Gas Air Flow: \_\_\_\_\_ sccm

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
300 sec reading				300 sec reading				300 sec reading			
Drift				Diff. Drift				% diff. Drift			

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.

$$\text{Zero Drift} = \text{Current Data Logger Reading} - \text{Calibrator Reading}$$

$$\% \text{ Difference Drift} = \frac{(\text{Current Data Logger Reading} - \text{Calibrator Reading}) \times 100}{\text{Calibrator Reading}}$$

**LOW GPT – NO<sub>2</sub>**

**Zero Air Check**

GPT %: \_\_\_\_\_

Zero Air Flow: \_\_\_\_\_ sccms

Gas Air Flow: \_\_\_\_\_ sccms

**Precision Check (~10 ppb)**

GPT %: \_\_\_\_\_

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading			
NO <sub>2</sub> Actual				NO <sub>2</sub> Actual			
Drift				Diff Drift			

**HIGH GPT – NO<sub>2</sub>**

**Zero Air Check**

GPT % : 0%

Zero Air Flow: \_\_\_\_\_ sccms

Gas Air Flow: \_\_\_\_\_ sccms

**Span Check (~185 ppb)**

GPT %: \_\_\_\_\_

	NO	NO <sub>2</sub>	NO <sub>x</sub>		NO	NO <sub>2</sub>	NO <sub>x</sub>
ESC Reading				ESC Reading			
NO <sub>2</sub> Actual				NO <sub>2</sub> Actual:			
Drift				% diff.			

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  $\geq 3.0$  ppb, or if the span drift is  $\pm 10\%$ . See Section 2.8 for calibration procedures.

$$NO_{2(Actual)} = (NO_{orig} - NO_{rem}) + NO_{2(imp)}$$

**Where:**

**NO<sub>2</sub>Actual** = Actual NO<sub>2</sub> concentration

**NO<sub>2</sub>(imp)** = Calculated NO impurities

**NO<sub>orig</sub>** = Original NO conc, when NO<sub>2</sub> is set to zero

**NO<sub>rem</sub>** = Remaining NO conc, after addition of O<sub>3</sub>

$$NO_{2(imp)} = \frac{(F_{NO} (sccm))(Impurities from cylinder gas (ppb))}{F_{NO} + F_O + F_D}$$

**Where:**

**F<sub>NO</sub>** = NO Flow

**F<sub>O</sub>** = Ozone Flow

**F<sub>D</sub>** = Dilution Flow

Form 8 – Verification Converter Efficiency

NO <sub>2</sub> Verification Spreadsheet							
<b>Station:</b>	Carpenter	<b>Date:</b>	1/31/2018	<b>Operator:</b>	CH		
<b>Analyzer:</b>	1117248572	<b>Calibrator:</b>	1126649800	<b>Cylinder:</b>	ND4556		
<b>High Cylinder Conc</b>	10.17	PPM					
<b>Impurity</b>	0.02	PPM					
			<b>Yellow highlight signifies values entered by user.</b>				
			<b>Green highlight signifies NO<sub>2</sub> Actual for precision data</b>				
NO, NO <sub>x</sub> VERIFICATION							
	<i>AIR</i>	<i>GAS</i>	<i>Known Value</i>		<i>Instrument Response</i>		
	<b>Zero Air MFC</b>	<b>Pollutant MFC</b>	<b>NO</b>	<b>NO<sub>x</sub></b>	<b>NO</b>	<b>NO<sub>x</sub></b>	<b>NO<sub>2</sub></b>
	<b>SCCM</b>	<b>SCCM</b>	<b>PPB</b>	<b>PPB</b>	<b>PPB</b>	<b>PPB</b>	<b>PPB</b>
Zero	7986	0.00	0.0	0.0	0.0	0.1	0.1
Prec (11 PPB)	19456	21.10	11.0	11.0	10.9	11.0	0.2
Span (225 PPB)	3982	90.67	226.4	226.9	228.4	229.1	0.8
Ozone Lamp 0%-Low	18947	56.00					
Ozone Lamp 0%-High	3982	90.67					
NO <sub>2</sub> VERIFICATION (GPT)-LOW RANGE							
VERIFICATION	<i>Instrument Response</i>			<i>Corrected Instrument Responses and Calculated Concentrations</i>			
Points NO <sub>2</sub>	NO	NO <sub>x</sub>	NO <sub>2</sub>	[NO]ORIG	[NO]REM	[NO <sub>2</sub> ]ACT	
	PPB	PPB	PPB	PPB	PPB	PPB	
Ozone Lamp 0%	29.4	29.7	0.3	29.2	29.2	0.1	
Prec (10 PPB)	20.4	29.7	9.1	29.2	20.3	9.0	
NO <sub>2</sub> VERIFICATION (GPT)-HIGH RANGE							
VERIFICATION	<i>Instrument Response</i>			<i>Corrected Instrument Responses and Calculated Concentrations</i>			
Points NO <sub>2</sub>	NO	NO <sub>x</sub>	NO <sub>2</sub>	[NO]ORIG	[NO]REM	[NO <sub>2</sub> ]ACT	
	PPB	PPB	PPB	PPB	PPB	PPB	
Ozone Lamp 0%	228.1	228.1	0.1	226.1	226.1	0.4	
Span (185 PPB)	42.9	229.3	186.5	226.1	42.6	184.0	
SLOPE							
	SLOPE	INT.					
NO	1.0092	-0.1067					
NO <sub>x</sub>	1.0099	-0.0213					
NO <sub>2</sub> CONVERTER EFFICIENCY TEST							
Pollutant	[NO <sub>2</sub> ]Actual	[NO <sub>2</sub> ]ORIG	[NO <sub>2</sub> ]REM	[NO <sub>2</sub> ]CONV	Converter Efficiency	Is Converter Efficiency 1 ±0.04 ?	
Level	PPB	PPB	PPB	PPB			
Prec (10 PPB)	9.0	29.4	29.4	9.0	100.0%	TRUE	
Span (185 PPB)	184.0	225.9	227.1	185.1	100.6%	TRUE	
<b>Converter Efficiency (from slope)</b>		<b>Is Converter Efficiency 1 ±0.04 ?</b>					
100.7%		TRUE					

NOTE: All formulas for calculating converter efficiency come from: EPA Quality Assurance Guidance Document 2.3, Reference Method for the Determination of Nitrogen Dioxide in the Atmosphere (Chemiluminescence), February, 2002, Draft.

**Form 9 – Corrective Action Form**

**Polk County Air Quality - Corrective Action Form**

To: \_\_\_\_\_ Polk County Air Quality \_\_\_\_\_  
(position)

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: \_\_\_\_\_