

Standard Operation Procedures for Trace Level SO₂

In Use By

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

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STANDARD OPERATING PROCEDURE MANUAL FOR THE THERMO SCIENTIFIC 43i TRACE LEVEL SO₂

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24.0 STANDARD OPERATING PROCEDURE FOR SO₂ MONITORING USING THE THERMO SCIETIFIC 43i TRACE LEVEL MONITOR

24.1 Purpose

To establish a standard operating procedure (SOP) manual for the Polk County Air Quality Division personnel concerning the setup, operation, zero/precision/span checks, calibrations, audits and maintenance of trace level sulfur dioxide (TL-SO₂) 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.

24.2 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 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, zero/precision/span checks, calibrations, audits and maintenance of trace level sulfur dioxide equipment operated by Polk County Air Quality personnel.

24.3 References

- 24.3.1 40 Code of Federal Regulations (CFR) Part 53.23c. Test Procedures.**
- 24.3.2 40 Code of Federal Regulations (CFR) Part 58, Appendix A. Quality Assurance Requirements for State and Local Air Monitoring Stations (Slams).**
- 24.3.3 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).**
- 24.3.4 40 Code of Federal Regulations (CFR) Part 136, Appendix B.**
- 24.3.5 The National Air Monitoring Strategy, Final Draft, 4/29/04.**
<http://www.epa.gov/ttn/amtic/monstratdoc.html>.
- 24.3.6 Model 43i Trace Level-Enhanced Pulsed Fluorescence SO₂ Analyzer Instruction Manual. Thermo Scientific. Part Number 102780-00. January 14, 2008.**
- 24.3.7 Model 146i Dynamic Gas Calibrator. Thermo Scientific. Part Number 102482-00, January 30, 2008.**
- 24.3.8 Trace SO₂ Monitoring Guidance for the MANE-VU Regional Aerosol Intensive Network (RAIN) program, Draft (dated March 7, 2005).**
- 24.3.9 EPA-454/R-05-003, Technical Assistance Document (TAD) For Precursor Gas Measurements in the NCore Multi-Pollutant Monitoring Network, September, 2015.**
- 24.3.10 EPA-454/B-13-003, Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, May, 2013.**
- 24.3.11 EPA-454/B-13-003, Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Appendix D, July, 2014.**

24.4 Introduction

Sulfur dioxide (SO₂) has been identified as a key precursor of fine particulate matter (PM_{2.5}) and, thus, plays an important role in PM-related health effects. Sulfur Dioxide (SO₂) is a colorless, nonflammable gas that has a strong suffocating odor. SO₂ originates from fuel containing sulfur (mainly coal and oil) burned at power plants and during metal smelting and other industrial processes. High levels of SO₂ can result in temporary breathing impairment for asthmatic children and adults who are active outdoors. Long-term exposure to high levels of SO₂, in the presence of high levels of particulate matter, may aggravate existing cardiovascular disease and respiratory illness.

Polk County Air Quality Division uses the Thermo Scientific Model 43*i*-TLE pulsed fluorescence SO₂ analyzer to measure Trace Level SO₂. The 43*i*-TLE is based on the principle that SO₂ molecules absorb ultraviolet (UV) light and become excited at one wavelength, then decay to a lower energy state emitting UV light at a different wavelength. Specifically,



where: hv_1 = incidence light,
 hv_2 = fluoresced light, and
 SO_2^* = SO₂ in its excited state

In sample mode, the sample is drawn into the analyzer through the SAMPLE bulkhead, as shown in Figure 24-1. The sample flows through a hydrocarbon “kicker,” which operates on a selective permeation principle, allowing only hydrocarbon molecules to pass through the tube wall. The driving force for the hydrocarbon removal is the differential partial pressure across the wall. This differential pressure is produced within the instrument by passing the sample gas through a capillary tube to reduce its pressure and feeding it into the shell side of the hydrocarbon kicker. The SO₂ molecules pass through the hydrocarbon “kicker” unaffected.

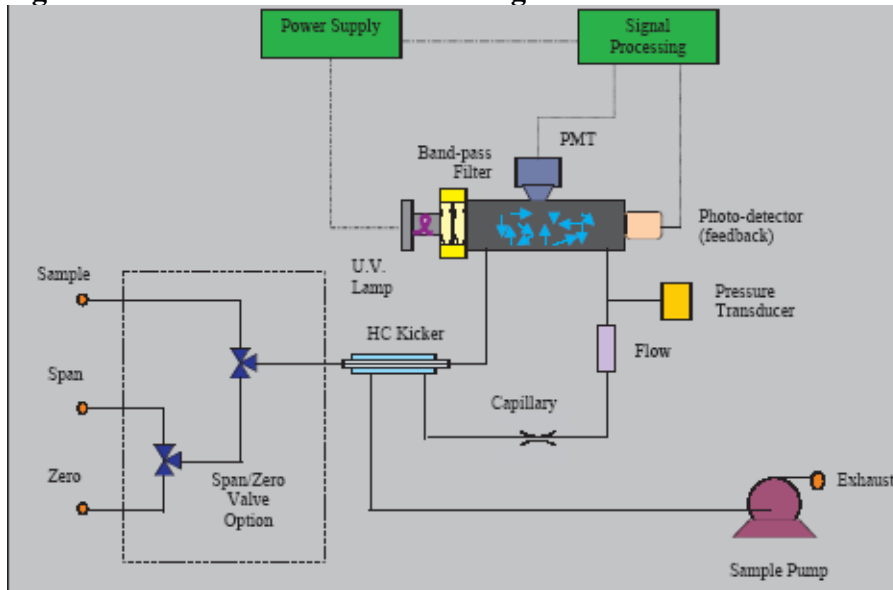
The sample flows into the fluorescence chamber, where pulsating UV light excites the SO₂ molecules. The condensing lens focuses the pulsating UV light into the mirror assembly. The mirror assembly contains eight selective mirrors that reflect only the wavelengths, which excite SO₂ molecules.

As the excited SO₂ molecules decay to lower energy states they emit UV light that is proportional to the SO₂ concentration. The band pass filter allows only the wavelengths emitted by the excited SO₂ molecules to reach the photomultiplier tube (PMT). The PMT detects the UV light emission from the decaying SO₂ molecules. The photo detector, located at the back of the fluorescence chamber, continuously monitors the pulsating UV light source and is connected to a circuit that compensates for fluctuations in the UV light.

The sample then flows through a flow sensor, a capillary, and the shell side of the hydrocarbon “kicker.” The Model 43*i*-TLE trace level outputs the SO₂ concentration to the front panel display and the analog or digital outputs

The Detection Limit (DL) for a non-trace level SO₂ analyzer is 10 parts per billion (ppb) (40 CFR 53.23c). However, the 43*i*-TLE has an estimated DL of 100 parts per trillion (ppt), which is accomplished by an increased detector sensitivity, as well as increasing the length of the standard instrument’s optics bench. This document will discuss the Trace Level (TL) operating procedures in detail. The goal of this method is a “true” 1-hour average limit of detection (LOD) of less than 0.3 ppb, for determining ambient air concentrations of SO₂.

Figure 24-1 Model 43i-TLE Flow Diagram



24.5 Health and Safety Warning/Precautions

Only properly trained personnel should perform 43i-TLE 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 43i-TLE. 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 SO₂ 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.

24.6 Sampler Setup

24.6.1 Site Selection

For detailed information concerning site selection for trace level SO₂ monitoring, refer to Table 24-3 of this SOP or the 40 Code of Federal Regulations (CFR), Part 58, Appendix E, or the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 6.2, entitled "Monitoring Site Location."

24.6.1.1 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 operation of the SO₂ monitoring instruments.
- The space where the equipment is housed must maintain a temperature range of 20-30°C. 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 to be located.
- Local building codes. In most cases, the contractor installing the power, structure, concrete, etc. know the local building codes.

24.6.1.2 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 sample inlet should be located between 3-15 meters above ground level
- The distance of the probe inlet must be at least 20 meters from nearby obstructions (buildings and trees)
- The vertical and horizontal distance of the probe inlet must be at least one meter from the ground and support structure
- The probe should be positioned with at least 270 degrees of unrestricted airflow

For more detailed information concerning site selection for sulfur dioxide monitoring, refer to Table 24-3 of this SOP or the 40 CFR 58, Appendix E or the Quality Assurance Handbook for Air Pollution Measurement Systems , Volume II, Section 7.2, entitled "Sampling Probes and Manifolds."

24.6.2 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.

24.6.3 Equipment Installation

Installation of a 43i-TLE (Figure 24-2) monitor consists of connecting the sample tubing to the sample gas inlet fitting and connecting the primary power and the data logger device. The sampler inlet line connection should be made with ¼ -inch outer diameter Teflon tubing.

The entrance of the sampling system must ensure that rain cannot enter the system. An inverted funnel and sample line must be placed outside the trailer or enclosure to prevent water from entering the sample line.

Because the analyzer is an optical instrument, it is possible that particulate in the gas sample could interfere with the TL-SO₂ readings. Although, 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, installation of a 0.5-micron Teflon filter between the ambient sample line and the sample port of the analyzer must be done before the operation of the analyzer. A Teflon filter will not degrade the TL-SO₂ concentration. However, if particulate matter builds up on the filter, the particulate matter will destroy some of the TL-SO₂ in the sample.

Since the instrument's exhaust consists of ambient air with some TL-SO₂ removed, ensure that the exhaust cannot re-enter the sample system.

Install the monitor's electrical connections as indicated in the operating 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 operating manuals.

Figure 24-2: Thermo Scientific Model 43i-TLE SO₂ Analyzer



24.6.4 Programming Equipment

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 TL-SO₂ concentration. 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.

24.6.4.1 Range and Units

The Range Screen defines the concentration range of the analog outputs. Polk County Air Quality will use the “Single Range” option with the selected range of 0 – 100 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 “Range.” Press ENTER to display the SO₂ Range Menu, and select RANGE. Use the ↑ or ↓ buttons to scroll through the preset ranges. Select “100.0” and press ENTER. Press MENU to return to the Range Menu.

The Gas Units Screen defines how the SO₂ concentration reading is expressed. From the Range Menu, select GAS UNITS to display the Gas Units screen. Use the ↑ or ↓ button to select “PPB” and press ENTER. Press RUN to return to the Run Screen.

24.6.4.2 Averaging Time

The averaging time defines a time period (1 to 300 seconds) during which SO₂ measurements are taken. The average concentration of the readings is calculated for that time period. Polk County Air Quality will use the setting of 60 seconds as the averaging time for the collection of data. An averaging time of 60 seconds will also be used 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.

24.6.4.3 Temperature Compensation

Temperature Compensation provides compensation for any changes to the instrument’s output signal due to variations in internal instrument temperature. When the temperature correction is off, the first line of the display shows the factory standard temperature of 30°C. Polk County Air Quality will run the TL-SO₂ analyzer with the temperature correction 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.

24.6.4.4 Pressure Compensation

Pressure Compensation provides compensation for any changes to the instrument’s output signal due to variation of fluorescence chamber pressure. When the pressure correction is off, the first line display shows the factory standard pressure of 750 mmHg. Polk County Air Quality will run the TL- SO₂ analyzer with the pressure correction 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.

24.6.4.5 Flash Lamp

The Flash Lamp Screen turns the lamp on and off. Polk County Air Quality will run the TL-SO₂ analyzer with the flash lamp 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 **FLASH LAMP**, and press **ENTER**. Press **ENTER** to toggle the flash lamp on or off. Press **RUN** to return to the Run Screen.

24.6.4.6 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 **SERIAL SETTINGS** and press **ENTER**. From the Serial 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.

24.6.4.7 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. To Edit, press **ENTER** and 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.

NOTE: It is recommended that you allow the 43i-TLE 24-hours before you attempt checks or calibration.

24.7 Standards

A cylinder containing 2 to 10 ppm SO₂ in N₂ is used as the concentration standard. The cylinder must be traceable to a National Institute of Standards and Technology (NIST) SO₂ in N₂ Standard Reference Material. Procedures for certifying the SO₂ cylinder (working standard) against a NIST traceable SO₂ standard is given in EPA Publication NO. EPA-454/R-05-003, "Technical Assistance Document for High Sensitivity Sulfur Dioxide Measurements." 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. 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. See Form 1, Appendix A for Gas Comparison Spreadsheet.

Operators will be required to replace the SO₂ 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. Better results will be achieved by alternately pressurizing and depressurizing the regulator once it has been attached to the cylinder.

It is desirable, but not essential, to calibrate the 43i-TLE at low SO₂ levels (typically less than 20 ppb). However, fluorescence SO₂ analyzers have been shown to be inherently linear over a wide dynamic range. If low concentration SO₂ calibration cylinders are used, there is the potential for contamination by back diffusion from a poorly purged regulator. Due to the inherent linearity of the analyzer, the ability to calibrate to very low SO₂ levels is not a significant factor in generating “true-trace” level quality SO₂ data. Polk County Air Quality will generate a calibration curve utilizing zero and 3 up-scale points.

Contamination with even a small amount of moisture from back diffusion can cause the SO₂ 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.

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.

24.8 Qualification, Certification and Recertification

Gas dilution in the 146i Dynamic Gas Calibrator is achieved by utilizing two or more mass flow controllers. One is a high flow controller (typically 20 slm full scale) to govern the diluting zero air. The other controller is for low flow (typically 100 sccm) and governs the flow of the gas to be diluted. See Polk County Air Quality SOP Section 26 for calibration instructions of the 146i Mass Flow Controllers.

24.9 Calibration

The Thermo Scientific 43i-TLE analyzers are calibrated whenever the following occurs: installation of a new monitor, replacement of broken parts, when a zero/precision/span check fails by more than 10%, 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 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 SO₂ concentrations generated by the station gas calibration system. The calibration levels shall be:

- Zero
- Level 1 – 70 - 90 ppb
- Level 2 – 50 - 65 ppb
- Level 3 – 30 - 45ppb
- Level 4 – 5 - 15 ppb

Using linear regression, a calibration relationship is determined using the indicated values of the analyzer and the actual values of the Calibrator. Acceptance criteria can be found in Table 24-3 of this SOP from the Measurement Quality Acceptance Tables from the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Appendix D. EPA-454/B-13-003, July 2014. The calibration data is saved for use as a point of reference for subsequent calibrations.

On the Main Screen (or Standby Screen) of the 146i Calibrator, press the MENU button to access the Main Menu Screen. Scroll to **OPERATION** and press **ENTER**. Use the ← and → buttons to select desired **GAS** and press **ENTER**. Use the ↓ button to scroll down to **SPAN**. Use the ← and → buttons to scroll to **ZERO** and press **ENTER** to put the 146i Calibrator in zero air mode. With the zero air flowing, verify that the Calibrator and data logger reads 0.000 ppb ± 0.2 ppb. Allow the analyzer to sample zero gas until a stable reading is obtained on the SO₂ channel.

Press the front panel **MENU** button on the 43i-TLE site analyzer to display the Main Menu. Use the arrow keys to select **CALIBRATION** and press **ENTER** to display the Calibration Menu.

Select **CAL SO₂ BACKGROUND** and press **ENTER**. In the **SO₂ BACKGROUND** screen, press **ENTER** to set the SO₂ reading to zero. Press the **MENU** button to return to the Calibration Menu.

Adjust the flow rate from the SO₂ standard to generate and SO₂ concentration of approximately 80% the upper range limit (URL) of 100 ppb (i.e. 80 ppb). Allow the Calibrator and data logger to obtain stable readings on the SO₂ channel.

Press the front panel **MENU** button on the 43i-TLE site analyzer to display the Main Menu. Use the arrow keys to select **CALIBRATION** and press **ENTER**. Scroll to **CAL SO₂ COEF** 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 SO₂ concentration and press **ENTER**.

After the zero and 80% URL points have been set, determine at least 3 approximately evenly spaced points between zero and the 80% URL without further adjustment to the analyzer. SPAN 1 - 4 have been programmed for calibrations. SPAN 4 is set to 0.080 ppm, SPAN 3 is set to 0.060 ppm, SPAN 2 is set to 0.040 ppm, and SPAN 1 is set to 0.010 ppm.

Perform the calibration checks by a direct comparison between the 146i Calibrator and data logger. Allow the Calibrator and data logger to obtain stable readings on the SO₂ channel and record readings. Repeat for SPAN 4 - 1, respectively. 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.

24.10 Quality Control

24.10.1 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 enters the monitoring station:

- 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 station 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 TL-SO₂ analyzer.

24.10.2 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 will be maintained by Polk County Air Quality and will be archived for future reference.

24.10.3 Bi-Weekly Zero, Precision and Span Checks

The zero/precision/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 TL-SO₂ concentrations generated by the station 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 SO₂ concentrations of 10 ppb (precision) and 80 ppb (span) are generated by the Calibrator. Each concentration is measured by the Calibrator and the station analyzer. Following the precision and span checks, the deviation from the true TL-SO₂ 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 ± 5.0 ppb
- The precision difference is ± 1.5 ppb, or $\pm 10\%$, whichever is greater.
- The span drift is outside $\pm 10\%$

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 may result in the invalidation of data. The operator is required to submit the completed field sheet form to the Quality Assurance Officer for review. For more detailed procedures on, Zero, Precision and Span Checks refer to Section 24.14.4 Zero, Precision and Span Checks.

24.10.4 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 "call" the monitor site and examine the data recorded at the monitoring station (i.e. TL-SO₂ concentrations and station temperature). The station operator should be familiar with daily concentration variations (i.e. the times daily maximum concentrations). 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. See Polk County Air Quality SOP Section 18 for instructions on data acquisition.

24.11 Equipment, Maintenance and Trouble Isolation

24.11.1 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 instruction 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. Table 24-1 displays a preventative maintenance schedule for the operator at the end of these procedures.

24.11.1.1 Analyzer Leak Check

A system 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 the fitting.

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 **FLOW** and press **ENTER**. The flow reading should slowly drop to zero. Press the **MENU** button to return to the Diagnostics Menu. Use the \uparrow buttons to scroll to **PRESSURE** and press **ENTER**. The pressure reading should drop below 180 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.

24.11.1.2 Sample Line Leak Check

A comprehensive 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 in Hg vacuum when the lines have been evacuated. The vacuum reading must be at least 15 in 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 in 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.

24.11.1.3 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.

24.11.1.4 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.

Table 24-1: Preventive Maintenance Schedule for the 43i-TLE

Item	Schedule
Visual inspection and cleaning	1/6 months
Sample particulate filter inspection	1/2 Weeks
Verify Test Function	1/2 Weeks
Perform Level I auto check	1/day
Capillary inspection and replacement	1/6 months
Perform flow check	1/6 months
Fan filter inspection and cleaning	1/6 months
Sample Leak Check	1/year

24.11.1.5 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 SO₂ concentrations due to contamination in the line, or every two years.

24.11.2 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 UV 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 43i Trace Level SO₂ 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.

24.11.3 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. The operator's manual indicates that in non-condensing environments or when a water drop-out is present the instrument may be safely operated over the range of 0-45°C. Hourly enclosure 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).

24.12 Quality Assurance

The audit schedule for SLAMS monitoring, is that each analyzer must be audited at least once a year. Polk County should audit 25 percent of the analyzers per quarter. Since Polk County operates only one TL-SO₂ analyzer, it should be audited at least once a year as specified in Table 24-2 of this SOP or in the "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II – Ambient Air Specific Methods." However, it is Polk County Air Quality Division's policy to audit the TL-SO₂ analyzer once per quarter.

24.12.1 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)," the TL-SO₂ analyzer will be audited using a direct comparison between the analyzer's current indicated value and the audit standard's current known concentration.

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 43i-TLE continuous analyzer with known concentrations of SO₂ within the measurement range of the analyzer. The 146i Dynamic Gas Calibrators can be programmed to generate the desired TL-SO₂ audit concentrations, see Polk County Air Quality SOP Section 26.

Generate at least three of the following SLAMS audit concentrations: 0.0003-0.0029 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, 0.1000-0.1499 ppm, 0.1500-0.2599 ppm, 0.2600-0.7999 ppm, and 0.8000-1.000 ppm. One point should be within two to three times the method detection limit of the instruments. The second point should be less than or equal to the 99th percentile of the data at the site. The third point should be around the primary NAAQS concentration or the highest 3-year concentration at the site.

Allow each audit concentration to stabilize for a minimum of 5 minutes. Record the site analyzers response from the data logger display. Readings should be taken only after a stable response is exhibited by the site analyzer. The results are recorded on the Quarterly Audit Field Sheet, Form 4, Appendix A.

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

- For EPA Audit Levels 1 and 2, acceptance criteria is ± 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. 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 TL-SO₂ monitoring, refer to the “Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II” or 40 CFR 58 or Table 24-3 of this SOP.

24.12.2 Federal Audits

Agency staff are sent an audit device, such as for the National Performance Audit Program (NPAP). The agency staff does not know the TL-SO₂ 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 TL-SO₂ and in all other EPA audit programs, which may arise in the future. According to the May 2013 Redbook, The audit fails if any of the following acceptance criteria are not met:

- For EPA Audit Levels 1 and 2, the acceptance criteria is ± 1.5 ppb
- The percent difference is outside $\pm 15\%$ 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.

24.13 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).

24.13.1 Precision

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)".

24.13.2 Accuracy

The Polk County Air Quality Program participates in the USEPA performance audit program for SO₂ 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.

24.13.3 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.

24.14 Procedures for Bi-Weekly Checks

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 Instruction Manual for Thermo Scientific Model 43i Trace Level, SO₂ Analyzer.

24.14.1 Maintenance Mode for Agilaire Model 8832 Data Loggers

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 (or just press L)** and press **ENTER**. Login to the data logger using the appropriate password and press **ENTER**. Use the arrow keys to scroll to **CONFIGURATION MENU (C)** and press **ENTER**. Use the arrow keys to select **CONFIGURE (DATA) CHANNEL (D)** and press **ENTER**. Use the arrow keys to select **PUT CHANNEL IN MAINTENANCE MODE (I)** and press **ENTER**. Select the correct pollutant channel and press **ENTER**. Repeat procedures for all appropriate channels. Proceed with maintenance, weekly precision/span check, or calibration of the analyzer. Figure 24-3 displays and data logger Model 8832.

Figure 24-3: The Agilaire Data Logger (Model 8832)



24.14.2 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. Check and record all diagnostics on the Verification Field Sheet, Form 5, Appendix A. Table 24-2 displays a list of diagnostic checks and their explanations.

Check and record the calibration factors on the 43i-TLE. Press **MENU** and scroll to **CALIBRATION FACTORS** and press **ENTER**. Record the SO₂ BKG and SO₂ COEF coefficients.

Table 24-2 Diagnostic Checks

Check	Explanation
Voltages	The current DC power supply and PMT power supply voltages
Temperatures	The current internal instrument and chamber temperatures
Pressure	The current chamber pressure
Flow	The current sample flow rate
Lamp Intensity	The current % UV lamp intensity
Optical Span Test	A quick way of checking the optics and electronics for span drift
Test Analog Outputs	Enable analog outputs to be set to zero and full scale to adjust analog outputs to agree with the front panel display

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

24.14.3 Zero, Precision and Span Checks

Use the 146*i* to perform the precision/span checks by diluting the cylinder gas to the desired precision/span levels. The precision/span check must be performed through the sample line filter when used in daily sampling. The ranges are as follows:

- Precision: 5 - 15 ppb
- Span: 70 - 90 ppb

The zero air must be free of contaminants that could cause a detectable response on the SO₂ analyzer. Polk County Air Quality Division uses the Teledyne 701 air generator with charcoal and Purafil® 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 a manifold which is connected to the zero air port on the back of the 146*i* Calibrator. The 146*i* Calibrator output port is connected to the span port on the 43*i*-TLE.

24.14.3.1 Span Check

On the 43*i*-TLE, press the **RUN** button to put the site analyzer in **SPAN** mode.

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 **SPAN 3** and press **ENTER**. **SPAN 3** has been programmed to produce the span level of 70-90% the upper range limit of the instrument (or 70 - 90 ppb). Perform the span check using a cylinder containing 2 - 10 ppm SO₂ in N₂. The flow can be read on the 146*i* Calibrator display screen by pressing the Diagnostics Quick button. Scroll to Flow and select Enter. This screen reports the actual gas and zero-air flows and the corresponding target flows.

Allow the site analyzer to run for 5 minutes or until stable, and then record the SO₂ flow, zero actual and gas actual readings from the TL-SO₂ channels on the Verification Field Sheet, Form 5, Appendix A. Repeat for other spans.

NOTE: 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's % difference by using the following equation to determine the percent difference between the data logger and the transfer standard:

$$\%Difference = \frac{C_M - C_{146}}{C_{146}} \times 100$$

Where:

C_M = data logger concentration, ppb

C_{146} = Calibrator concentration, ppb

Refer to Section 24.10.3 for acceptable control limits.

For control limits and recommended corrective actions, refer to Table 24-3, the Measurement Quality Objective Tables from the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Appendix D. EPA-454/B-13-003, July 2014. If a calibration is necessary, it must be performed after the zero/precision/span checks are finished.

24.14.3.2 Precision Check

At this point the span readings have been recorded, perform the precision level 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 on the 146i to scroll to **SPAN 1** and press **ENTER**. **SPAN 1** has been programmed to produce the precision level of 5-15 ppb.

Allow the site analyzer to stabilize for a minimum of 5 minutes and record all data logger readings from the TL-SO₂ channels on the Verification Field Sheet, Form 5, Appendix A.

24.14.3.3 Zero Check

At this point the precision reading has been recorded, perform the zero 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 on the Calibrator to scroll to **ZERO** and press **ENTER** to put the 146i Calibrator in zero air mode. With the zero air flowing, verify that the Calibrator and data logger reads 0.000 ppb ± 5.0 ppb. Allow the site analyzer to stabilize for a minimum of 5 minutes and record all data logger readings from the TL-SO₂ channels on the Verification Field Sheet, Form 5, 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 6, Appendix A. All forms and documentation must be submitted to the Quality Assurance Officer.

24.14.3.4 Invalidate Data and Recalibrate

If the precision check results in a difference of ± 1.5 ppb or ± 10% (whichever is greater), or if the zero drift is ± 5.0 ppb, or if the span drift is ± 10%, the site analyzer must be recalibrated and

the data will be invalidated back to the last valid zero/precision/span check unless there is compelling reason and justification not to do so. See Section 24.9 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.

24.14.4 Standby Mode

Once all checks have been completed, put the 146i Calibrator back in Standby Mode. On the 146i press the quick button (OPER) and use the ← → arrows to change the gas to off and press Enter. Then press the quick button (MODE). Scroll to Standby and press enter. Then press the run button to get to the standby screen.

On the Data Logger press the escape button (Esc) until the main menu is reached. Take the data logger out of maintenance mode by using the arrow keys to scroll to **CONFIGURATION MENU (C)** and press **ENTER**. Use the arrow keys to select **CONFIGURE DATA CHANNELS (D)** and press **ENTER**. Use the arrow keys to select **TAKE CHANNEL OUT OF MAINTENANCE (O)** 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.

24.15 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 80 ppb for span utilizing the auto function of the Thermo Scientific 146i Dynamic Gas Calibrator in conjunction with the 43i-TLE 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 43i-TLE is operating properly, and if drift in instrument response has occurred. For these checks, the challenge gas should be sampled through as much of the sampling inlet system as practical to mimic the actual sampling of ambient air. The results of the zero/precision/span checks should be plotted on control charts to graphically illustrate the trends in the response of the analyzer to the challenge gases.

Polk County Air Quality Division will analyze “drift” as a direct comparison of the current indicated concentration collected from the site analyzer to the actual concentration collected from the Calibrator. Polk County Air Quality Division will strive to obtain a zero drift ≤ 3.0 ppb, a span drift $\leq 10\%$, and a difference for precision of 1.5 ppb or $\leq 10\%$, 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 43i-TLE 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

24.15.1 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**.

24.15.1.1 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.

24.15.1.2 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.

24.15.1.3 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 22:00.**

24.15.1.4 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

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. To set the zero air duration, use the ↓ button to scroll to **ENABLED** 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 sample zero air for 19 minutes. Use the ↓ button to scroll to **GAS B** and press **ENTER**. Use the ↓ button to scroll to **ZERO** and press **ENTER**.

From the Events Menu, use the ↓ button to scroll to **EVENT 2** and press **ENTER**. Event 2 will be used for the precision check. To set the precision duration, use the ↓ button to scroll to **ENABLED** 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 sample precision gas for 19 minutes. Use the ↓ button to scroll to **GAS B** and press **ENTER**. Use the ↓ button to scroll to **SPAN 1** (for precision) and press **ENTER**. Span 1 has been programmed to sample gas at the precision level of 10 ppb.

From the Events Menu, use the ↓ button to scroll to **EVENT 3** and press **ENTER**. Event 3 will be used for the span check. To set the span duration, use the ↓ button to scroll to **ENABLED** 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 sample span gas for 19 minutes. Use the ↓ button to scroll to **GAS B** and press **ENTER**. Use the ↓ button to scroll to **SPAN 3** (for span) and press **ENTER**. Span 3 has been programmed to sample gas at the span level of 80 ppb. 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.

24.15.2 Calibration Program in the 43i-TLE

A calibration program must be set up in the 43i-TLE so that the span port is 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**.

24.15.2.1 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 22:00 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.

24.15.2.2 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.**

24.15.2.3 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 57 minutes.**

24.15.2.4 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**.

24.15.3 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.

24.15.4 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 24.15.1. 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 24.15.1. **Polk County uses a 19-minute duration for each desired phase.** 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 TL-SO₂:

- Zero Phase: 34 = on, 35 = off, 36 = off
- Precision Phase: 34 = on, 35 = on, 36 = off
- Span Phase: 34 = on, 35 = on, 36 = on

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

- Zero Phase: 34&35=0&36=0
- Precision Phase: 34,35&36=0
- Span Phase: 34&35&36

Table 24-2: Measurement Quality Objectives

SO₂ Validation Template

1) Requirement (SO ₂)	2) Frequency	3) Acceptance Criteria	Information /Action
CRITICAL CRITERIA- SO₂			
<i>One Point QC Check Single analyzer</i>	1/2 weeks	≤ +10% (percent difference)	1 and 2) 40 CFR Part 58 App A Sec 3.2 3) Recommendation based on DQO in 40 CFR Part 58 App A Sec 2.3.1.2 QC Check Conc range 0.01 - 0.10 ppm Relative to routine concentrations
Zero/span check	1/2 weeks	Zero drift ≤ ± 3.0 ppb (24 hr) ≤ ± 5.0 ppb (>24hr-14 day) Span drift ≤ ± 10 %	1 and 2) QA Handbook Volume 2 Section 12.3 3) Recommendation and related to DQO
OPERATIONAL CRITERIA- SO₂			
Shelter Temperature Range	Daily (hourly values)	20 to 30° C. (Hourly avg) or per manufacturers specifications if designated to a wider temperature range	1, 2 and 3) QA Handbook Volume 2 Section 7.2.2 Generally the 20-30 ° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance. FRM/FEM list found on AMTIC provides temp. range for given instrument. FRM/FEM monitor testing is required at 20-30 ° C range per 40 CFR Part 53.32
Shelter Temperature Control	Daily (hourly values)	≤ ± 2° C SD over 24 hours	1, 2 and 3) QA Handbook Volume 2 Section 7.2.2
Shelter Temperature Device Check	1/6 mo	± 2° C of standard	1, 2 and 3) QA Handbook Volume 2 Section 7.2.2
<i>Annual Performance Evaluation Single Analyzer</i>	<i>Every site 1/year 25 % of sites quarterly</i>	Percent difference of audit levels 3-10 ≤ ± 15% Audit levels 1&2 ± 1.5 ppb difference or ± 15%	1 and 2) 40 CFR Part 58 App A sec 3.2.2 3) Recommendation - 3-audit concentrations not including zero. AMTIC guidance 2/17/2011 http://www.epa.gov/ttn/amtic/coreldoc.html
<i>Federal Audits (NPAP)</i>	1/year at selected sites 20% of sites audited	Audit levels 1&2 ± 1.5 ppb difference all other levels percent difference ± 15%	1) 40 CFR Part 58 App A sec 2.4 2) NPAP adequacy requirements on AMTIC 3) NPAP QAPP/SOP
<i>Verification/Calibration</i>	Upon receipt/adjustment/repair/ installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	All points within ± 2 % of calibration range of best-fit straight line	1) 40 CFR Part 50 App A-1 Section 4 2 and 3) Recommendation Multi-point calibration (0 and 4 upscale points)
<i>Gaseous Standards</i>	<i>All gas cylinders</i>	<i>NIST Traceable (e.g., EPA Protocol Gas)</i>	1) 40 CFR Part 50 App A-1 Section 4.1.6.1 2) NA Green book 3) 40 CFR Part 50 App F Section 1.3.1 Producers must participate in Ambient Air Protocol Gas Verification Program 40 CFR Part 58 App A sec 2.6.1
<i>Zero Air/ Zero Air Check</i>	1/year	Concentrations below LDL	1) 40 CFR Part 50 App A-1 Section 4.1.6.2

1) Requirement (SO ₂)	2) Frequency	3) Acceptance Criteria	Information /Action
		< 0.1 ppm aromatic hydrocarbons	2) Recommendation 3) Recommendation and 40 CFR Part 50 App A-1 Section 4.1.6.2
Gas Dilution Systems	1/year or after failure of 1 point QC check or performance evaluation	Accuracy ± 2 %	1) 40 CFR Part 50 App A-1sec 4.1.2 2) Recommendation 3) 40 CFR Part 50 App A-1 sec 4.1.2
Detection (FEM/FRMs)			
Noise	NA	0.001 ppm (standard range) 0.0005 ppm (lower range)	1) 40 CFR Part 53.23 (b) (definition & procedure) 2) NA 3) 40 CFR Part 53.20 Table B-1
Lower detectable level	1/year	0.002 ppm (standard range) 0.001 ppm (lower range)	1) 40 CFR Part 53.23 (c) (definition & procedure) 2) Recommendation 3) 40 CFR Part 53.20 Table B-1
SYSTEMATIC CRITERIA- SO₂			
Sampler/Monitor	NA	Meets requirements listed in FRM/FEM designation	1) 40 CFR Part 58 App C Section 2.1 2) NA 3) 40 CFR Part 53 & FRM/FEM method list
Standard Reporting Units	All data	ppb (final units in AQS)	1, 2 and 3) 40 CFR Part 50 App T Sec 2 (c)
Rounding convention for data reported to AQS	All data	1 place after decimal with digits to right truncated	1, 2 and 3) 40 CFR Part 50 App T Sec 2 (c)
Completeness	1 hour standard	Hour – 75% of hour Day- 75% hourly Conc Quarter- 75% complete days Years- 4 complete quarters 5-min value reported only for valid hours	1, 2 and 3) 40 CFR Part 50 App T Section 3 (b), (c) More details in CFR on acceptable completeness. 5-min values or 5-min max value only reported for the valid portion of the hour reported. If the hour is incomplete no 5-min or 5-min max reported.
Sample Residence Time Verification	1/year	< 20 seconds	1) 40 CFR Part 58 App E, section 9 (c) 2) Recommendation 3) 40 CFR Part 58 App E, section 9 (c)
Sample Probe, Inlet, Sampling train	All sites	Borosilicate glass (e.g., Pyrex®) or Teflon®	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
Siting	1/year	Meets siting criteria or waiver documented	1) 40 CFR Part 58 App E, sections 2-5 2) Recommendation 3) 40 CFR Part 58 App E, sections 2-5
Precision(using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 10%	1) 40 CFR Part 58 App A sec 2.3.1.6 & 3.2.1 2) 40 CFR Part 58 App A sec 4 (b) 3) 40 CFR Part 58 App A sec 4.1.2
Bias (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ ± 10%	1) 40 CFR Part 58 App A sec 2.3.1.6 & 3.2.1 2) 40 CFR Part 58 App A sec 4 (b) 3) 40 CFR Part 58 App A sec 4.1.3
Annual PE Primary QA Organization (PQAO)	1/year	95% of audit percent differences fall within the one point QC check 95% probability intervals	1) 40 CFR Part 58 App A Section 3.2.2 2) Recommendation

1) Requirement (SO ₂)	2) Frequency	3) Acceptance Criteria	Information /Action
<i>Evaluation</i>		<i>at PQAQ level of aggregation</i>	3) 40 CFR Part 58 App A sec 4.1.4 and 4.1.5

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-Critical Forms and Field Sheets

Form 1 Gas Comparison Spreadsheet
Form 2..... Calibration Field Sheet
Form 3..... Calibration Linear Regression
Form 4..... Quarterly Audit Field Sheet
Form 5..... Verification Field Sheet
Form 6..... Corrective Action Form

Form 1 – Gas Comparison Spreadsheet

Date	
Time	
Site	Carpenter
Pollutant	SO ₂
Operator	JM

Gases

Standard Cylinder Conc.	13.30	PPM
Serial Number	CA02147	
Expiration Date	03/06/17	
Canidate Cylinder Conc.	5.056	PPM
Serial Number	CC338311	
Expiration Date	12/14/20	

Instruments

Gas Calibrator	Thermo 146i	1124449426
Last Verification	9/13/2016	
Monitor	Thermo 43i	917736619
Last Calibrated	12/12/2016	

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	SO ₂	SO ₂
	SCCM	SCCM	PPB	PPB
Standard Zero			#DIV/0!	
Canidate Zero			#DIV/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	SO ₂	SO ₂	SO ₂	SO ₂
	SCCM	SCCM	PPB	PPB	PPB	PPB
Standard Precision 10.0			10.0			
Candidate Precision 10.0			10.0		#DIV/0!	#DIV/0!
Standard Span 80.0			80.0			
Candidate Span 80.0			80.0		#DIV/0!	#DIV/0!

Average Percent Diffenece	Is Average Percent Diffence ±4% ?
#DIV/0!	#DIV/0!

Is Candidate Gas OK ?
#DIV/0!

Form 2 – Trace SO₂ Calibration Field Sheet

Date: _____
 Time: _____
 Tech: _____
 Analyzer Ser #: _____
 Date of last calibration: _____
 Calibrator Ser #: _____
 Date of last calibration: _____
 Date of last audit: _____
 Date of last verification: _____
 Zero Air Ser #: _____
 Last annual maintenance: _____
 Gas cylinder ser #: _____
 Gas expiration date: _____
 Cylinder >200 psig? (Y or N) _____
 Psig reading: _____
 Cylinder concentration: _____
 Zero Coefficient Reading: _____
 Precision Coefficient Reading: _____
 Station Observations Made: (Y or N) _____
 Data logger recording shelter temp? (Y or N) Reading: _____
 Changed Filter? (Y or N) _____
 Sample Line Checked? (Y or N) _____
 Date/Days Elapsed: _____
 Ambient: _____

Checks	Value	Alarm? (Y or N)	If Yes, Suggested Corrective Actions
BIAS Voltage: (5 Volts)			Refer to Instruction Manual.
BIAS Voltage: (15 Volts)			Refer to Instruction Manual.
BIAS Voltage: (-15 Volts)			Refer to Instruction Manual.
Internal Temp: (8-47°C)			Refer to Instruction Manual.
Chamber Temp: (43-47°C)			Refer to Instruction Manual.
Pressure: (400-1000 mmHg)			Replace pressure transducer
Flow: (0 - 2.5 LPM)			Replace Pump
Lamp Intensity: (20-100%)			Check that the lamp and trigger pak are securely fastened

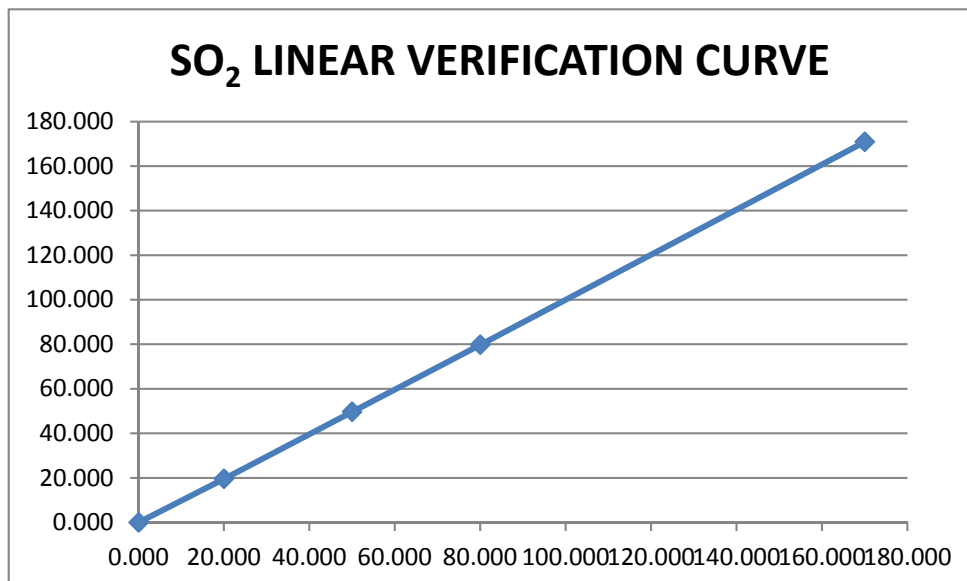
	Zero Actual scm	Gas Actual scm	ESC Reading 'Monitor'	146 C Calibrator 'Assessment'	CALCULATIONS
Reading					$\% \text{ Difference Drift} = \frac{(\text{Data Logger Reading} - \text{Transfer Standard Reading})}{\text{Transfer Standard Reading}} \times 100$
					DRIFT Zero Drift = Current Data Logger Reading – Calibrator Reading
1) Unadjusted Zero Span 0					
Level 4 Span 1 (5-15 ppb) Set Point: 10 ppb					
Level 3 Span 1 (30 - 45 ppb) Set Point: 40 ppb					
Level 2 Span 3 (50 - 65 ppb) Set Point: 60 ppb					
Level 1 Span 4 (70 - 90 ppb) Set Point: 80 ppb					
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 difference of 1.5 ppb or 10% (whichever is greater) or span check results in a percent difference $\pm 10\%$ or if the zero drift is ± 5.0 ppb. See SOP for calibration procedures.					

Form 3 – Calibration Linear Regression

Trace Level Sulfur Dioxide Multi-Point Calibration Spreadsheet

Analyzer:	Thermo 43i TL-SO ₂
Serial No.:	1016742909
Site:	Carpenter
Operator:	JM
Full Scale: ppb	100
2% of Full Scale: ppm	2
Date:	October 13, 2015
Zero Set Pt Prior:	1.72
Span Set Pt Prior:	0.903
Zero Set Pt Post:	1.57
Span Set Pt Post:	0.902
Zero/Span Adjust Made?:	yes
Cal. Gas Serial #	CC122627
Gas Expiration Date	10/30/2016

Known Conc.	Measured Conc.	rpd	slope	intercept	rsq	forecast	distance to least squares line	acceptable distance	Pass/Fail
0.000			1.0064	-0.4117	1.0000			4.000	pass
10.000								4.000	pass
40.000								4.000	pass
80.000								4.000	pass
100.000								4.000	pass



Section 24: Trace Level SO₂

Revised: December 20, 2016

Revision Number: 10

Form 4 – Trace SO₂ Audit Sheet

Date: _____
 Time: _____
 Tech: _____
 Analyzer Ser #: _____
 Date of last calibration: _____
 Calibrator Ser #: _____
 Date of last calibration: _____
 Date of last audit: _____
 Date of last verification: _____
 Zero Air Ser #: _____
 Last annual maintenance: _____
 Gas cylinder ser #: _____
 Gas expiration date: _____
 Cylinder >200 psig? (Y or N) _____
 Psig reading: _____
 Cylinder concentration: _____
 Zero Coefficient Reading: _____
 Precision Coefficient Reading: _____
 Station Observations Made: (Y or N) _____
 Data logger recording shelter temp?
 (Y or N) Reading: _____
 Changed Filter? (Y or N) _____
 Sample Line Checked? (Y or N) _____
 Date/Days Elapsed: _____
 Ambient: _____

Checks	Value	Alarm? (Y or N)	If Yes, Suggested Corrective Actions
BIAS Voltage: (5 Volts)			Refer to Instruction Manual.
BIAS Voltage: (15 Volts)			Refer to Instruction Manual.
BIAS Voltage: (-15 Volts)			Refer to Instruction Manual.
Internal Temp: (8-47°C)			Refer to Instruction Manual.
Chamber Temp: (43-47°C)			Refer to Instruction Manual.
Pressure: (400-1000 mmHg)			Replace pressure transducer
Flow: (0 - 2.5 LPM)			Replace Pump
Lamp Intensity: (20-100%)			Check that the lamp and trigger pak are securely fastened

	Zero Actual scm	Gas Actual scm	ESC Reading 'Monitor'	146 C Calibrator 'Assessment'	CALCULATIONS
Reading					
					DRIFT Zero Drift = Current Data Logger Reading – Calibrator Reading
1) Unadjusted Zero Span 0 (±1.5 ppb)					
					% Difference % Difference Drift = $\frac{(\text{Data Logger Reading} - \text{Transfer Standard Reading}) \times 100}{\text{Transfer Standard Reading}}$
2) Level 1 (0.3 – 2.9 ppb)					
3) Level 2 (3.0 - 4.9 ppb)					
4) Level 6 (50 - 99.9 ppb)					
If the percent difference is outside 1.5 ppb or ±15% for audit levels 1-2, or if the percent difference is outside ± 15% for audit levels 3-10, and there is reason to believe the results are incorrect or not representative of the analyzers performance, the check must be repeated. The cause for the error must be investigated and corrected. An investigation initiated by audit results outside the above limits may require the invalidation of data.					

Form 5 –Trace SO₂ Verification Field Sheet

Date: _____
 Time: _____
 Tech: _____
 Analyzer Ser #: _____
 Date of last calibration: _____
 Calibrator Ser #: _____
 Date of last calibration: _____
 Date of last audit: _____
 Date of last verification: _____
 Zero Air Ser #: _____
 Last annual maintenance: _____
 Gas cylinder ser #: _____
 Gas expiration date: _____
 Cylinder >200 psig? (Y or N) _____
 Psig reading: _____
 Cylinder concentration: _____
 Zero Coefficient Reading: _____
 Precision Coefficient Reading: _____
 Station Observations Made: (Y or N) _____
 Data logger recording shelter temp?
 (Y or N) Reading: _____
 Changed Filter? (Y or N) _____
 Sample Line Checked? (Y or N) _____
 Date/Days Elapsed: _____
 Ambient: _____

Checks	Value	Alarm? (Y or N)	If Yes, Suggested Corrective Actions
BIAS Voltage: (5 Volts)			Refer to Instruction Manual.
BIAS Voltage: (15 Volts)			Refer to Instruction Manual.
BIAS Voltage: (-15 Volts)			Refer to Instruction Manual.
Internal Temp: (8-47°C)			Refer to Instruction Manual.
Chamber Temp: (43-47°C)			Refer to Instruction Manual.
Pressure: (400-1000 mmHg)			Replace pressure transducer
Flow: (0 - 2.5 LPM)			Replace Pump
Lamp Intensity: (20-100%)			Check that the lamp and trigger pak are securely fastened

	Zero Actual scm	Gas Actual scm	ESC Reading 'Monitor'	146 C Calibrator 'Assessment'	CALCULATIONS
Reading					
					DRIFT Zero Drift = Current Data Logger Reading – Calibrator Reading
1) Unadjusted Zero Span 0					
					% Difference % Difference Drift = (Data Logger Reading – Transfer Standard Reading) x 100 Transfer Standard Reading
2) Precision Level Span 1 (5 - 15 ppb) Set Point: 10 ppb					
3) Span Level Span 3 (70-90 ppb) Set Point: 80 ppb					
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 difference of 1.5 ppb or 10% (whichever is greater) or span check results in a percent difference ± 10% or if the zero drift is ± 5.0 ppb. See SOP for calibration procedures.					

Form 6 – Corrective Action Form
Polk County Corrective Action Form

To: _____ Polk Co. 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: _____
