Section I: ECB Responsibilities

Sulfur Dioxide Standard Operating Procedure
Revision 10
November 1, 2016

Approval Sign Off-Sheet

I certify that I have read and approve of the contents of the SO_2 ECB Standard Operating Procedure with an effective date of November 1, 2016.

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Table of Contents

2.8.1 Sulfur Dioxide Standard Operating Procedure (SOP): ECB Responsibilities

2.8.1.1 Equipment Selection and Procurement

The State of North Carolina Division of Air Quality (NC DAQ) operates sulfur dioxide monitors across the state for the purpose of monitoring the potential exposure of the general population to ambient levels of sulfur dioxide (SO_2).

The Electronics and Calibration Branch (ECB) shall procure air monitoring equipment and supplies for the Division of Air Quality. The Environmental Protection Agency's (EPA) Reference or Equivalent methods list should be reviewed to determine the makes and models acceptable for monitoring sulfur dioxide at the levels dictated by National Ambient Air Quality Standards (NAAQS). Each monitor used must be a reference or equivalent method (40 CFR 53 and 40 CFR 58, Appendix C).

All sulfur dioxide monitors used for non-trace level applications must have an acceptable output for the data logging system deployed with the instrument (digital output or analog output of 0 to 10-volt DC). All monitors and calibrators must operate on 115-volt AC 60Hz line current. All analog data acquisition systems must be calibrated to accept a 0 to 10-volt DC output, and must meet other specifications as necessary. All digital data acquisition systems must be at least 10-bit and have RS232 and/or Ethernet connections.

2.8.1.2 Description of the Thermo Model 43i and 43i-TLE Sulfur Dioxide Analyzer

The Model 43i and 43i-TLE SO_2 analyzers are based on the principle that SO_2 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,

$$SO_2 + h\nu_1 \rightarrow SO_2^{*} \rightarrow SO_2 + h\nu_2$$

The sample is drawn into the analyzer through the **SAMPLE** bulkhead, as shown in Figure 1: Principles of Operation. The sample flows through a hydrocarbon "kicker", which removes hydrocarbons from the sample by forcing the hydrocarbon molecules to permeate through the tube wall. The SO_2 molecules pass through the hydrocarbon kicker unaffected. The sample flows into the fluorescence chamber, where pulsating UV light excites the SO_2 molecules. The condensing lens focuses the pulsating UV light into the mirror assembly. The mirror assembly contains four selective mirrors that reflect only the wavelengths that excite SO_2 molecules. As the excited SO_2 molecules decay to lower energy states, they emit UV light that is proportional to the SO_2 concentration. The bandpass filter allows only the wavelengths emitted by the excited SO_2 molecules to reach the photo multiplier tube (PMT). The PMT detects the UV light emission from the decaying SO_2 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 analyzer outputs the SO_2 concentration to the front panel display and the analog outputs. The instrument is best described in detail, by separating it into three sections: the analyzer, optics, and electronics.

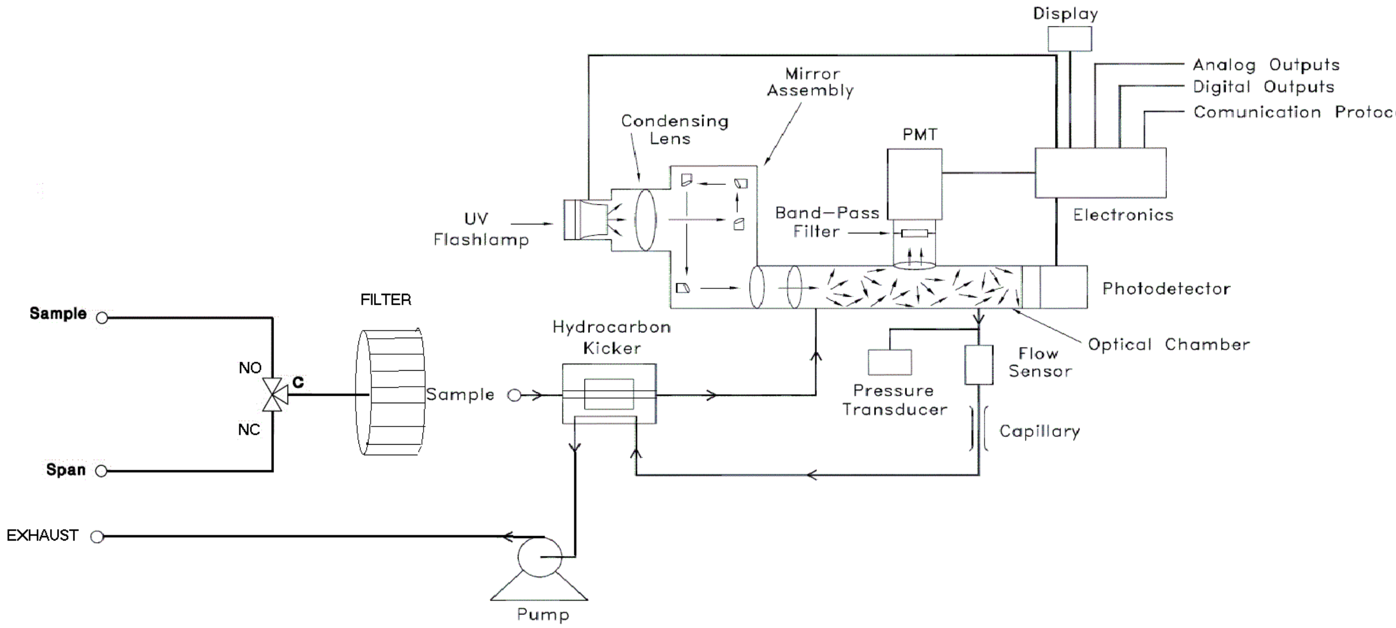

Figure 1: Principles of Operation for the Thermo Model 43i and 43i-TLE

Table 1: Model 43i and 43i-TLE Monitor Description (Specifications)

Preset ranges	0.05 – 1.0 ppm 0-1000 mg/m^3
Zero noise	0.5 ppb RMS (60 sec. avg. time)
Lower detectable limit	1.0 ppb (60 sec. avg. time)
Zero Drift (24 hour)	Less than 1 ppb
Span Drift (24 hour)	±1%
Response time	110 sec. (60 sec. avg. time)
Precision	1% of reading or 1 ppb (whichever is greater)
Linearity	±1% of full-scale ≤ 100 ppm ±5% of full-scale > 100 ppm
Sample flow rate	0.5 liters/min (standard)
Interferences (EPA levels)	Less than the lower detectable limit except for the following: NO < 3ppb; m-Xylene < 2ppb; H_2O < 2% of reading
Operating temperature	20 ºC – 30 ºC (may be safely operated over the range of 5 ºC – 40 ºC)
Power requirements	105 – 125 VAC at 50/60 Hz 100 Watts
Physical dimensions	16.75" (W) X 8.62" (H) X 23" (D)
Outputs	Selectable voltage 4 – 20 mA; RS-232/485 Interface

2.8.1.3 Description and Operation of Thermo Model 146i, Teledyne T700U Calibrator, and Teledyne Model 701 Zero Air Generator

A) Thermo Model 146i or Teledyne 700U Calibrator

The calibrator supplies the required levels of SO_2 to perform zero, precision, span checks and multipoint calibrations. The calibrator is operated remotely from the data logger to perform zero, precision, and span checks. This is an accurate mass flow controlled gas dilution system. SO_2 gas from a NIST traceable Protocol certified cylinder (connected to Port C) is blended with "zero-air" to provide a desired concentration. From the known calibration of the two mass flow controllers, the exact concentration can be calculated. A typical dilution ratio of about 100:1 to 1000:1 is used to generate the appropriate concentration.

Note: Teledyne 700U calibrator is only used at sites with both SO_2 and NO_2.

B) Teledyne Model 701 Zero Air Generator

The purpose of the Model Teledyne Model 701 Zero Air Generator is to supply pollutant-free air ("zero air") for proper instrument zeroing and to provide clean diluent air for use with the calibrator. Ambient Air is drawn into the system which removes water vapor, SO_2, NO, NO_2, O_3, CO and hydrocarbons.

C) Zero Air Generator Certification

Please reference Section 2.3.5: Zero Air Pack Certification and Auditing for instructions on the certification of the Zero Air Generators.

D) Gas Cylinders

All gas cylinders must be traceable to a National Institute of Standards and Testing – Standard Reference Material (NIST-SRM) and must be used prior to the expiration date (i.e., 2 years). These are termed “Protocol” gas.

The major components of a typical SO_2 monitoring system include:

1. Thermo 43i or 43i-TLE SO_2 Analyzer
2. Thermo 146i Dynamic Gas Calibrator
3. Zero Air Generator and Certified Protocol SO_2 Cylinder
4. ESC/AGILAIRE Model 8816 or 8832 Data Logger
5. A dedicated site PC and modem

2.8.1.4 Initial Laboratory Startup of the Model 43i and 43i-TLE

The ECB shall conduct and document, initial operational tests before deploying an instrument. Refer to Figure 2: Thermo Model 43i/43i-TLE Flowchart for a description of the instrument menu. Items to be completed include:

- Inspection
- Assembly (Modification, Range Setting, Flow Verification, and Lamp Verification)
- Leak Check and Calibration

A) Inspection

Visually inspect the exterior of all items for damage. Remove the cover and inspect the electronics assembly and circuit boards for loose wires, cables, broken components, or other damage. Reconnect any loose components and if necessary, contact the manufacturer.

B) Assembly, Modification and Initial Verification

Prior to deployment in the field, all instruments will undergo basic operational tests in the ECB lab, with results recorded in the instrument's logbook which is filed in the ECB lab.

The instrument should be set up in the lab with accompanying, calibrator, zero air system, cylinder, and data logging system.

The Thermo Model 43i and 43i-TLE require the addition of a 24 VDC solenoid valve to provide automatic zero and span capabilities. As shown on page 9-1 of the manual, and as approved by the EPA, this is an equivalent method (EQSA-0486-060). The solenoid addition requires the rear panel bulkheads to be reconfigured by moving the sample inlet, adding a span inlet and labeling the inlets "SPAN" and "SAMPLE". The exhaust is located in the original position and labeled accordingly. The rear panel has a separate port for span, sample and exhaust. Additionally, the sample and span inlets are directed through the solenoid and hydrocarbon kicker. All sample and span gasses pass through the hydrocarbon kicker before entering the optics.

Install a Teflon particulate inlet filter holder on the rear of the instrument. Connect the sample line to the particulate filter holder inlet. Connect the rear panel bulkhead labeled "exhaust" to a suitable vent outside of monitoring room (**do not** vent to room air). Plug in power cord and turn on power to instrument. The cooling fan, pump, mode lights and fluorescent source should now be powered. Check to see that the zero, span and sample modes are working by listening for solenoid clicks between modes.

Before the initial laboratory calibration is conducted on the 43i or 43i-TLE, zero and span must be equilibrated until no adjustments are necessary between the two settings. When the zero and span require no adjustments, the other calibration points can be run. Ensure that the Digital Volt Meter (DVM) and Data Logger are connected to output #1.

C) Initial Laboratory Setup

Attach a Teflon tube (FEP Teflon type only) from the fitting labeled "output" on the rear panel of the calibrator to the "span" input of the monitor. Connect a source of zero-air to the inlet port labeled zero-air. Connect the standard SO_2 gas cylinder to the port labeled C. Refer to Figure 2: Thermo Model 43i/43i-TLE Flowchart for a description of the instrument menu.

D) Standard and Service Modes

There are two modes on both of the analyzers. While sampling in the field, the SO_2 analyzer should always be in its default operating mode, called **Standard** mode within this SOP. When performing any maintenance, the analyzer will need to be switched to **Service** mode.

To turn **Service** mode on and off:

- Press the **Menu** button to go to the **Main Menu**.
- Use the arrow buttons to toggle to **Instrument Controls**, and then press **Enter**. Then toggle to **Service Mode**.
- When on the **Service Mode** screen, press **Enter** to switch between **Standard** and **Service** modes.

Always return the analyzer back to **Standard** mode after completing any tasks that require **Service** mode. Refer to Figure 3: Thermo Model 146i Flowchart for a description of the instrument menu.

E) Range Setting

Set the "range" setting on the 43i or 43i-TLE to the **“Single”** range mode to either 100 ppb or 500 ppb. In the “Single” range mode, there is one range, one averaging time, and one span coefficient. The 100 ppb or 500 ppb setting is specific to the site where the monitor is to be installed.

Using the analyzer front panel, chose **Range** from the Main Menu choices.

1. Press the **Menu** pushbutton.
2. Press the **Enter** pushbutton.
3. Press the down arrow button to move to SO_2 Range.
4. Press the arrow buttons to change the value.
5. Press the **Enter** pushbutton to save setting.

F) Verify the Lamp Voltage

The Model 43i and 43i-TLE are equipped with a lamp voltage control circuit, which automatically corrects for the degradation of the flash lamp with age.

To display the lamp voltage on the analyzer:

1. From the Diagnostics Menu, move the cursor to Voltage, and press **ENTER.**
2. Cursor down to **Interface Board** and press **ENTER.**
3. The Lamp voltage is displayed as Flash Supply.
4. If this voltage is at 1200 V, it is necessary to either replace the lamp or adjust the lamp voltage control circuit.
5. Log the lamp voltage in the instrument logbook.
6. Press **Menu**, and then press **Run.**

G) Flow Measurement on Monitor

Choose Diagnostics from the Main Menu. Choose Flow from the Diagnostics Menu, verify the current sample flow rate and record in logbook. The flow is measured by an internal flow sensor. A flow rate of about 0.5 LPM should be observed, if a flow rate of less than 0.35 LPM is observed a leak may be present.

H) Concentration Units

Set the instrument to read in parts per billion (ppb).

I) Averaging Time

The longer the averaging time, the smoother the data will be. Initially North Carolina will use 60 seconds as the averaging time.

J) Calibration Factors

Leave SO_2 background at zero and coefficients at 1 initially. They will automatically be corrected after zero/span points. Discussion of these factors is covered in later sections (Operator, calibration).

K) Diagnostic Checks and Settings

The following are diagnostic menu set points for the SO_2 analyzer:

Parameter	Minimum Set Point	Maximum Set Point
Internal Temperature	25 °C	33 °C
Pressure	715 mmHg	740 mmHg
Sample Flow	0.450 L/min	0.480 L/min
Lamp Intensity	80%	90%
+3.3 V Supply	±1 Volt	
+5.0 V Supply	±1 Volt	
+15.0 V Supply	±1 Volt	
+24.0 V Supply	±1 Volt	
-15.0 V Supply	±1 Volt	
-3.3 V Supply	±1 Volt	

L) Alarm Settings

The following Alarm Limits are used in the SO_2 analyzer:

Parameter	Minimum Alarm	Maximum Alarm
Internal Temperature	15.0 °C	45.0 °C
Chamber Temperature	43.0 °C	47.0 °C
Pressure	400 mmHg	1000 mmHg
Sample Flow	0.350 L/min	0.750 L/min
Lamp Intensity	40%	100%
Lamp Voltage	750 V	1200 V

M) Leak Check and Calibration

Two leak tests are performed (SAMPLE and SPAN).

Leak test the Monitor **SAMPLE** port. A leak test should be performed before deployment to the field, and also whenever the flow is observed to be less than 0.35 LPM:

1. Disconnect the sample line from the analyzer above the filter and block the opening with a leak-tight cap.
2. Press **Menu** and use the arrow buttons to move the cursor to **Diagnostics.** Select **Pressure** and press **Enter**. The pressure reading should be dropping. Wait until pressure drops below 180 mm Hg (flow should also go to zero). **NOTE:** If the pressure has not dropped below 180 mm Hg within three minutes, immediately remove the cap. Check that all fittings are tight and input lines are not cracked or broken. Do not cap off the line for more than three minutes or the system may pressurize.
3. Remove the cap and leak test the monitor **SPAN** port. Document in the logbook.

Leak test the Monitor **SPAN** port. Begin a "zero" event using the AV-Trend data logging system. Perform the following steps:

1. Disconnect the calibrator line from the analyzer and block the opening with the leak-tight cap.
2. Press **Menu** and use the arrow buttons to move to **Diagnostic**. Select **Pressure**, and press **Enter**. The pressure reading should be dropping. Wait until pressure drops below 180 mm Hg (flow should also be at zero). **NOTE:** If the pressure has not dropped below 180 mm Hg within three minutes, immediately remove the cap. Check that all fittings are tight and input lines are not cracked or broken and retest. **Do not cap off the line for more than three minutes or the system may pressurize**.
3. If leak check passes, remove the cap, reconnect the calibrator line to the span port and the sample line to the sample inlet. Clear the zero mode by aborting the zero cal. Document in the logbook. If leak check fails, troubleshoot the instrument and conduct any necessary repairs and repeat the leak check. Proceed to "multipoint calibration".

N) Conduct a multi-point calibration

To perform a multi-point calibration:

1. Place the analyzer into **Service** mode.
2. Activate the zero. Run the zero until the reading has stabilized. A good baseline for a stable reading is ten consecutive minutes where the concentration values are within ± 2ppb of each other.
3. From the **Main Menu**, use the arrows to toggle to **Service**, and then to **Flash Voltage Adjustment**.
4. Adjust the voltage until it is 800V.
5. Go back to the **Main Menu**. Again, use the buttons to move to **Service**, and then to **Initial Flash Reference**. The voltage should be between 2.8V – 4.5V.
6. Activate Span 1. Run Span 1 until there are ten consecutive readings that are

stable (within ± 2ppb of each other).

7. After the reading has stabilized, from the **Main Menu**, use the arrows to toggle to **Service**, and then to **PMT Supply Settings**.
8. Use the arrows to adjust the voltage so that the monitor concentration matches that on the calibrator. Hit **Enter** to save the span concentration.
9. Activate the zero air again. Let the zero run long enough to provide a stable reading (at least 10 consecutive minutes where the measured concentration values are within ± 2ppb of each other).
10. After the zero readings have stabilized, from the **Main Menu**, use the arrow buttons to toggle to **Calibration**, and then **Calibration SO2 Background**.
11. Hit **Enter** to set the SO_2 background to zero.
12. Activate the Span 1, and let the span gas flow long enough to provide a stable reading (at least 10 consecutive minutes where the measured concentration values are within ± 2ppb of each other).
13. After the reading has stabilized, from the Main Menu, **Main Menu**, use the arrow buttons to toggle to **Calibration**, and then **Calibration SO2 Coefficient**. Ensure that the SO_2 coefficient is set to the Span value.
14. Verify that the SO_2 background value and SO_2 coefficient value are correct by going to the **Main Menu**, and then using the arrows to toggle to **Calibration Factors**. The background and coefficient should be what you just inputted.
15. When you are sure that the correct values are used, place the instrument back into **Standard** mode.

Verify that the instrument passed all tests and document in the logbook. Fill out Form 109 and forward it to the ECB Branch Supervisor.

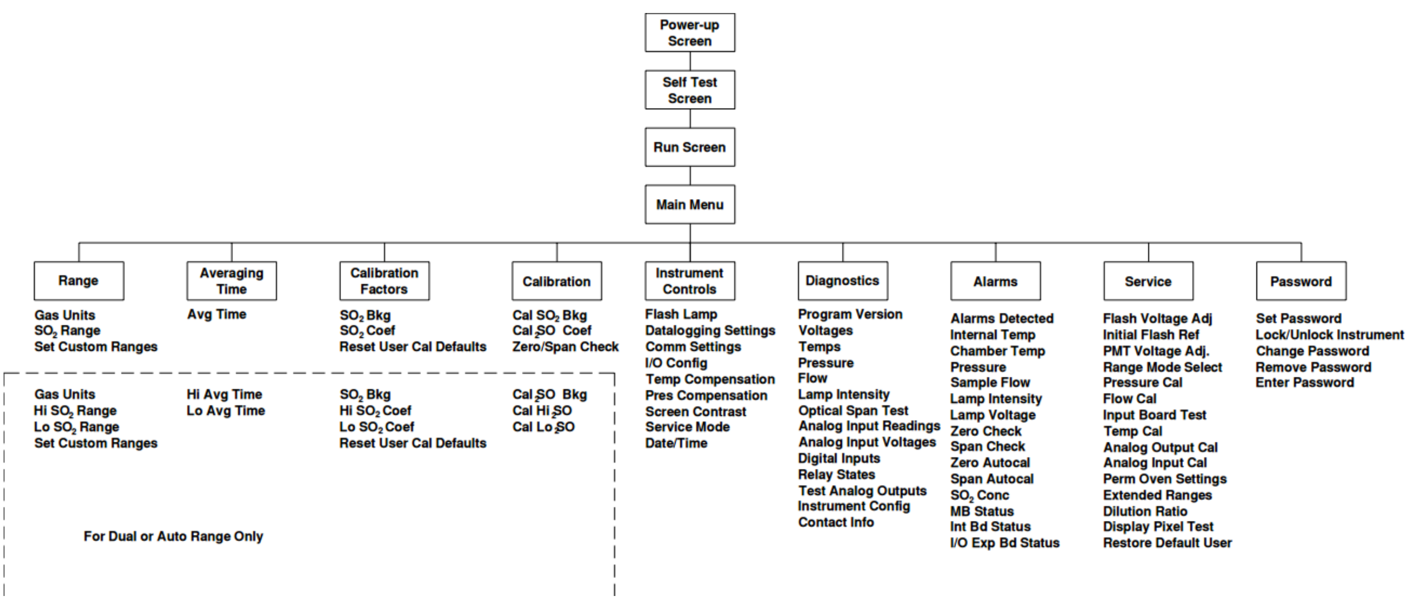

Figure 2: Thermo Model 43i or 43i-TLE Flowchart

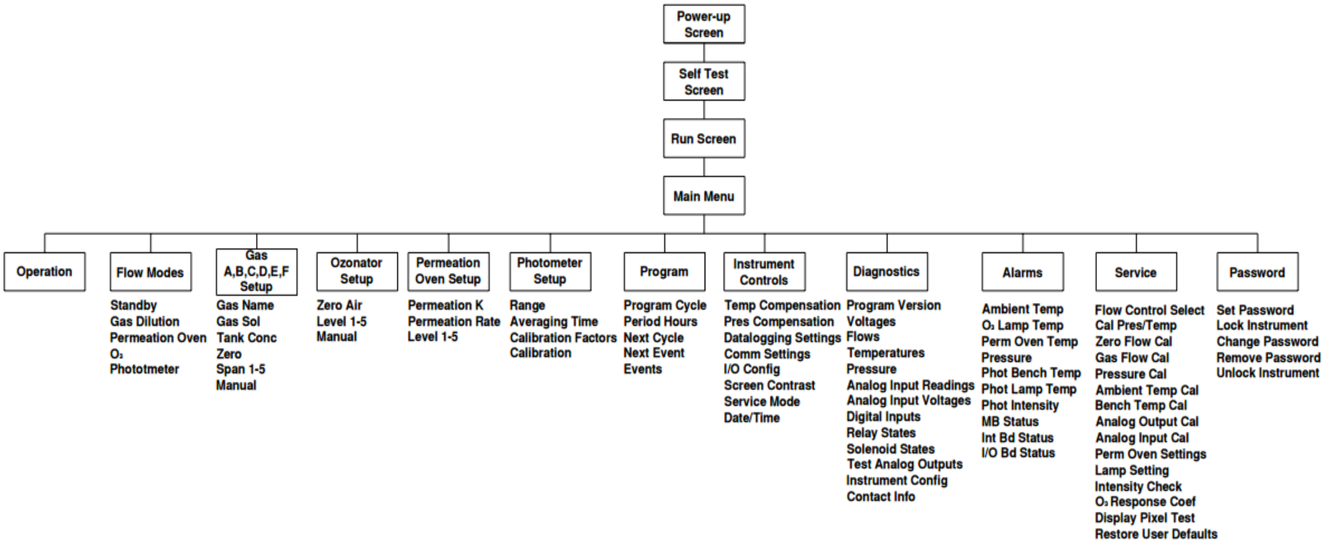

Figure 3: Thermo 146i Flowchart

2.8.1.5 <u>On-site Installation</u>

The ECB will install the monitor and its support equipment. Acquiring access to a site, and approval of the site is the responsibility of the DAQ regional office and the Projects and Procedures Branch. Internet/wireless service and electrical power should be secured along with any needed permits, new wiring, etc., prior to installation of the monitor equipment. The site location must meet the applicable site requirements and be approved by the Projects and Procedures Branch Supervisor and EPA. Refer to Figure 4: Plumbing and Wiring Diagram for Monitoring Setup and for general schematic of the set-up.

A) Install

1. Verify that the building/shelter is sound and that the heating/cooling system is working and can control the temperature at a preset level within the range of 20-30 °C. The sampling probe and lines must be FEP Teflon, or of an equivalent material. Lines must be clean, and have a sample residence time of less than 20 seconds. The inlet line should be wrapped with removable polyurethane foam in order to prevent condensation. In extreme cases, heat tape may be used. For continuous, year-round sites, the probe and funnel will be changed at least every two years during the audit (even calendar years).

2. Install one end of a short piece of vent line (any type of ¼" tubing) to the monitor exhaust fitting and place the other end through an opening to the outside of the shelter to vent the instrument (do not obstruct).

   WARNING: Do not plug in the monitor, calibrator, modem, data logger, and interface box until all cables are connected. ELECTRICAL SHOCK AND/OR EQUIPMENT DAMAGE MAY OCCUR OTHERWISE.

3. Connect the monitor, modem, data logger, and computer as shown in Figure 4: Plumbing and Wiring Diagram for Monitoring Setup. Observe polarity markings.

Connect all instruments and support equipment power cords to a grounded surge suppressor, connected to a 115v AC, 60 Hz grounded receptacle.

4. Configure the data logger and PC software, including the scheduler, to run auto poll/cal. The data logger can be ESC Model 8816's or 8832's. The ECB verifies that the system can be accessed remotely by computer from the ECB lab. (It is the responsibility of the region to program the AV-Trend for the polling of information that is specific to the needs of the region.)

5. Verify that all operational events, such as solenoid on/off are working. Bleed the calibration cylinder regulators and lines to purge/minimize room air in the calibration system. Check the analog outputs on the instrument after performing the operational checks.

B) **Check and Set Computer Time and Date**

The times for the data logger, AV-Trend, and computer must be Eastern Standard Time. They must have the same time and be synched to the NIST time provider in Colorado (± 1 minute). A task can be set up in AV-Trend to ensure that the times are synchronized.

1. Click on the date and time in the lower right corner of the computer screen.
2. Select **Change Date and Time** settings.
3. Select the **Internet Time** tab, and then press the **Change Settings** button.
4. Check the box that states **Synchronize with an Internet Server**. From the server drop down menu, select time.nist.gov.
5. Press **Update Now**.
6. Select **OK** to exit. The created task scheduler named **"Clock Sync"** in AV-Trend will sync the data logger and computer times.

If the data logger time is not within 1 minute of NIST time but it matches the computer time, then there is a problem with the computer time. Either the computer is not synchronizing properly with the NIST time or the clock is drifting too much and needs to be synchronized more often or the computer needs to be replaced. Call the ECB and they will help identify the issue and tell you what to do to correct it.

If the data logger time is not within 1 minute of NIST time and it does not match the computer time and the computer matches NIST time, then there is a problem with the synchronization of the data logger time with the computer. Call the ECB and they will give you instructions on how to synchronize the data logger to the computer.

Sources for getting the correct time:

1. Call the ECB and ask for the NIST time
2. Call the NIST Colorado time at (303) 499-7111
3. Correct time loaded into cell phone
4. Correct time website, http://nist.time.gov

C) Leak Check the System

Before running an installation zero or span, leak check the SO_2 sampling system.

For the Monitor SAMPLE port:

1. Disconnect the sample line from the analyzer and block the opening with a leak-tight cap.
2. Press "**Menu"** and use the arrow buttons to go to **Diagnostics**. Select **"Pressure"** and press **"Enter"**. The pressure reading should be dropping. Wait until pressure drops below 180 mm Hg. The flow should also be at zero.

NOTE: If the pressure has not dropped below 180 mm Hg within three minutes, immediately remove the cap. Check to see that all fittings are tight and input lines are not cracked or broken. Do not cap off the line for more than three minutes or the system may pressurize.

For the Monitor SPAN port:

1. Disconnect the calibrator line from the analyzer above the filter and block the opening with a leak-tight cap.
2. Press **Menu** and use the arrow buttons to go to **Pressure** and press **"Enter"**. The pressure reading should be dropping (flow should also go to zero). Wait until pressure drops below 180 mm Hg.

   NOTE: If the pressure has not dropped below 180 mm Hg within three minutes, the leak check has failed. Immediately remove the cap. Check to see that all fittings (leak-tight cap, filter housing, and filter inlet/outlet fittings) are tight and input lines are not cracked or broken and re-test. **Do not cap off the line for more than three minutes or the system may pressurize**. If the leak check passes, remove the cap, reconnect the calibrator line to the span port and the sample line to the sample inlet. Clear the zero mode by aborting the zero cal.

D) Running an Installation Zero-Span-Precision (Calibration Check)

In order to ensure the monitoring equipment was not damaged in transit or during installation, run a three-point check of the instrument to include; the zero point, the span point relative to the instrument's expected operating range and precision point. This procedure **IS NOT** a substitute for the initial calibration to be performed by the region. The installation calibration check is intended as a field check to verify the instrument (and its associated components) have not suffered a catastrophic mishap from lab bench to field shelter. The sampling system should introduce, and the instrument should successfully recognize, SO_2 concentrations at expected ambient levels. If a problem is found with any component of the sampling system, the installers will contact the region and the ECB office with the details to initiate a resolution.

The Zero point will include checking the analog output (Z1) to the data logger. The Span point check will include checking the analog output (SP1) to the data logger. Whenever possible the data logger (Z1/SP1) should be adjusted as close to correct as possible (within +/- 0.005ppm).

In addition to new site installation, the installation calibration check ***will be performed*** any time a component potentially affecting calibration is replaced, modified, or repaired including:

1. Monitor replacement/repair
2. Calibrator replacement/repair
3. Zero air system replacement/repair
4. Cylinder swap-out
5. Lamp replacement

The installation calibration after any of these events **does not** replace the region's responsibility to perform a full calibration (and hence "take ownership" of the monitor), but is intended to boost the overall confidence in the equipment at the transition point between the ECB and the Operator(s).

E) Communication Confirmation

Whenever possible, it is recommended that the ECB office be contacted at the conclusion of an installation, and asked to poll the site to insure that it is 'reachable'. Before leaving the site, sign out and reset the scheduler for normal operation.

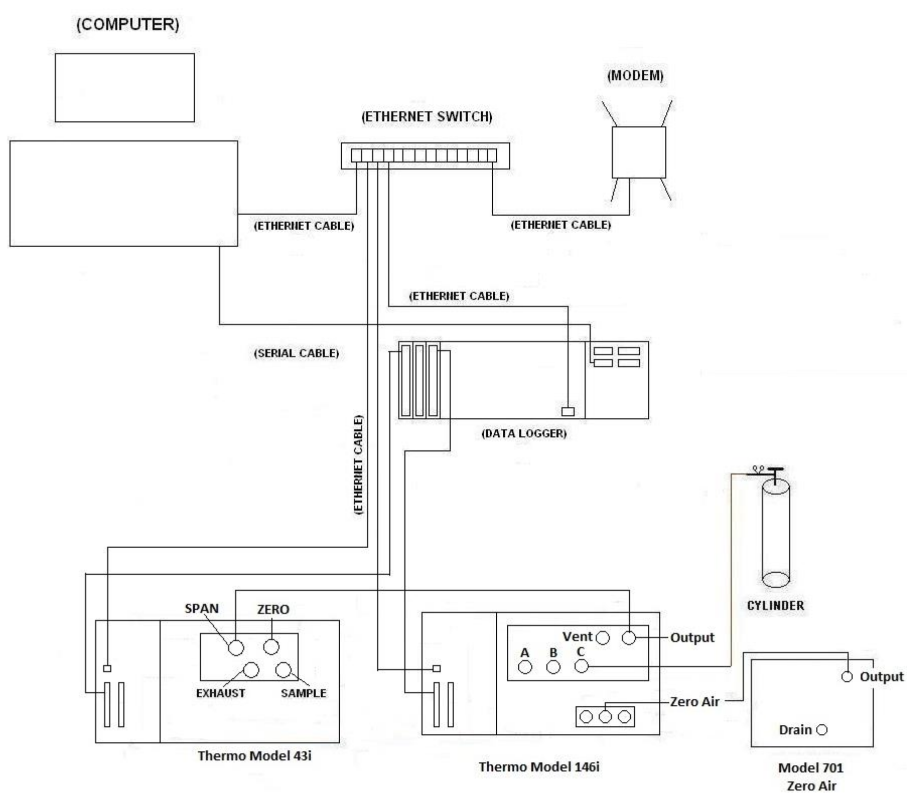

Figure 4: Plumbing and Wiring Diagram for Monitoring Setup

2.8.1.6 Routine Maintenance

A) Thermo Model 43i or 43i-TLE Analyzer

Periodic maintenance procedures should be performed when necessary to ensure proper operation of the analyzer. Maintenance includes preventive, routine, and corrective tasks. The ECB is expected to be entirely responsible for the corrective maintenance issues and to assist with preventative and routine maintenance that may fall outside the regions' comfort levels or capabilities. All maintenance activities must be documented by ECB personnel in the monitor's maintenance logbook.

Step-by-step procedures for all maintenance activities should be followed as presented by the manufacturer in the instrument's operation manual (Chapter 5, "Preventive Maintenance" and Chapter 7, "Servicing", 5/16/2015 version).

Always down/disable the data logger data channel.

Items requiring maintenance by ECB are:

1. Replacing the UV lamp (performed when lamp voltage approaches 1200 volts)
2. Replacing the printed circuit boards (performed when operational problem is traced to a particular component)
3. Leak Checks (performed after filter changes or when sample flow drops below 0.35 LPM as determined during monthly checks)
4. Replacing the pump diaphragm (performed when sample flow of 0.35 – 0.65 LPM cannot be achieved as determined during monthly checks)
5. Clean Optical Bench as needed
6. Replace PMT as needed
7. Clean/replace capillary (if sample flow falls below 0.35 LPM)

B) Thermo Model 146i Calibrator, or Teledyne T700U Calibrator

Periodic maintenance and/or adjustment for the calibrator is required to ensure proper operation. Except for mass flow controller re-certification, which occurs every 12 months, the following maintenance activities are performed only when the calibrator malfunctions as determined by the site operator. Items requiring ECB maintenance are:

1. Leak Checking
2. Solenoid Replacement
3. Circuit Board Replacement
4. Mass Flow Controller Replacement
5. Replacement of DVM
6. Internal Adjustments
7. Certification of Mass Flow Controllers (reference the Calibrator SOP Section 2.3.4)

C) Model 701 Zero Air Generator and Compressor Checks

Periodic maintenance and/or adjustment for the Zero Air Pack is required to ensure proper operation. The ECB shall re-certify the zero air system once per year by:

1. Verifying that the pressure gauge on the Zero Air Supply is reading 30 psi $\pm$ 2 psi.

2. Replacing chemicals that have been depleted.
   Please reference SOP 2.3.5 for more details.

After conducting any maintenance up the data logger channel (enable/mark channel online), document the work done in the site logbook (and instrument logbook if appropriate), and flag the data.

2.8.1.7 Accuracy Auditing

Each analyzer must be audited by the ECB at least once per calendar year. The audit must be performed using a calibrator and gas cylinder standard that is different from the standard and calibrator used for routine calibration and 1-pt QC checks. The ECB accomplishes this task by performing a through-the-probe audit. Several routine items that shall be included in the audit are:

- Security of the Building
- Site/Building Temperature (document NIST temperature and data logger temperature on the audit form)
- Condition of the Sample Line, Probe, and Funnel (replace as required) checked once per year during audit

A) **The audit calibrator must be certified against the primary standard <u>every 9 months</u>**. The auditor must not be the operator who conducts the routine monitoring, calibrations, and analysis. **Conduct the audit before making adjustments.** The monitor must operate in its normal sampling mode, and the audit gas must pass through the existing particulate filter. The difference between the actual concentration of the audit test gas and the concentration indicated by the analyzer is used to assess the accuracy of the monitoring data.

B) Allow audit calibrator to equilibrate at least one-half to one hour before challenging the monitor. Check and review the site temperature and the ambient SO_2 concentration for the day (never conduct an audit during an ambient SO_2 exceedance or a potential ambient SO_2 exceedance).

C) Down (disable) the SO_2 channel.

D) Connect the audit calibrator, cylinder, and zero air system as shown in Figure 5: Audit Plumbing Diagram for Monitoring Setup. Connect output of audit calibrator to probe funnel on roof as shown in Figure 5. The probe funnel setup should be connected as shown in Figure 6: Funnel and Probe Audit Setup Diagram. Perform the following <u>audit</u> calibrator checks:
   1. **Verify** the audit calibrator certification is current.
   2. **Power ON -** Verify calibrator has power by observing the LED screen.
   3. **Perform Audit** - At least four concentrations (zero plus three up-scale concentrations) must be introduced to an analyzer. Approximate concentration ranges for instruments operating at the 0 to 500 ppb range are given below:

Analyzer Span	Gas Flow (sccm)	Zero Flow (sccm)
Zero (0 ppb)	0	2,000
Level 1 (70 ppb)	27.85	4,000
Level 2 (18 ppb)	12.53	7,000
Level 3 (2.9 ppb)	3.78	13,000

To achieve the zero point, along with three up-scale concentrations, a 10.0 ±3 ppm cylinder must be used. A 50 sccm and 20 slpm audit calibrator is also required. For the Zero level, Level 1, and Level 2, input the Analyzer Span (conc) and Zero Flow (tflow) into the audit calibrator. For Level 3, input Gas Flow and Zero Flow under the manual settings in the audit calibrator.

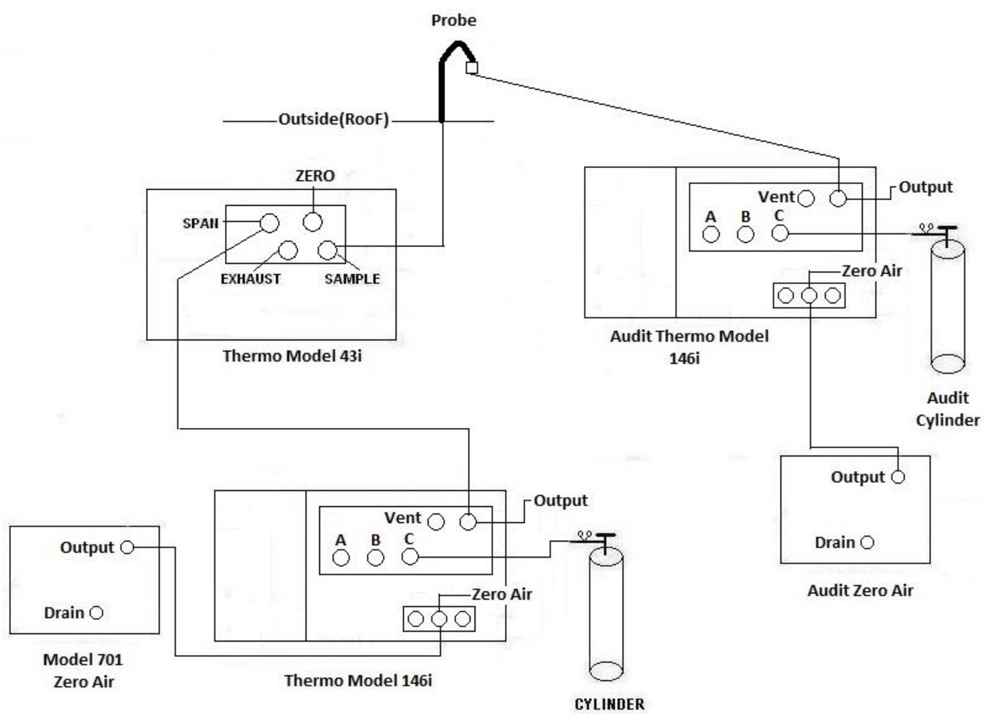

Figure 5: Audit Plumbing Diagram for Monitoring Setup

4. Review and record on an audit form (AQ-121) the current site temperature taken during audit from both the NIST thermometer and the data logger.
5. For each audit setting, record on the audit form; the instrument concentration and five corresponding stable one-minute data logger averages.
6. If the audit results are greater than +/- 10% of expected, contact the ECB supervisor and print out the last available auto calibration routine.
7. Disconnect the audit calibrator line from the outside probe, up the data logger channel, and log out.

E) If the audit results are suspicious or unacceptable, the ECB supervisor will initiate the investigation of the problem and will notify the responsible regional chemist and the Projects and Procedures Branch Supervisor of the issue.

F) Investigation can include, but is not limited to:
   1. Examination of the audit equipment
   2. Review of the calibration records (both auto and manual)
   3. Confirming the audit results with a follow-up audit

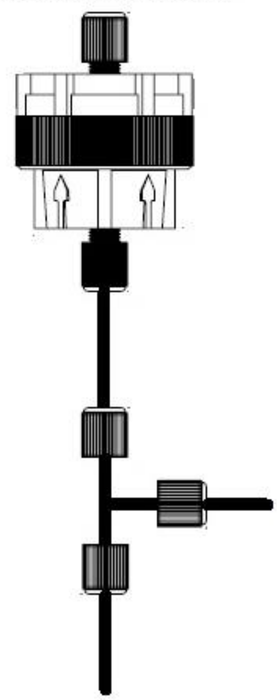

Figure 6: Funnel and Probe Audit Setup Diagram

2.8.1.8 Revision History

1. QA Plan/QAPP/SOP was changed to SOP throughout document.
2. Updated Revision Number throughout document.
3. Thermo 146C Dynamic Gas Calibrator was changed to Teledyne 700U or Thermo 146i Dynamic Gas Calibrator throughout document to reflect state-wide change in instrumentation.
4. Thermo 43C SO2 Analyzer changed to Thermo 43i or Thermo 43i-TLE SO2 analyzer throughout document to reflect the state wide change in instrumentation.
5. Passwords were removed throughout document.
6. Zero Air Pack changed to Teledyne Zero Air Generator Model 701 to reflect the statewide change in instrumentation.
7. Updated references from EDAS to AV-Trend throughout document.
8. Removed backup data logger (BUDL) and changed primary data logger, or PDL, to data

logger throughout document.

9. Updated Section 2.8.1.1 with additional information to reflect current regulations.
10. Added a reference within Section 2.8.1.3.C to Section 2.3.5 for instructions on the certification and calibration of the Teledyne Model 701 Zero Air Generator.
11. Added a list of the major components of an SO2 monitoring system to Section 2.8.1.3.D.
12. Added Section 2.8.1.4.D with instruction on toggling Service mode on and off on the analyzer.
13. Added instruction to Section 2.8.1.4.E for setting the monitor range on the analyzer.
14. Added instruction to Section 2.8.1.4.F for verifying the monitor lamp voltage on the analyzer.
15. Added Sections 2.8.1.4.H (Concentration Units), 2.8.1.4.I (Averaging Time), and 2.8.1.4.J (Calibration Factors).
16. Added Section 2.8.1.4.K - Diagnostic Checks and Settings, along with a table of the set points required for the Thermo 43i/43i-TLE analyzer.
17. Added Section 2.8.1.4.L - Alarm Settings, along with a table of the alarm limits used for the Thermo 43i/43i-TLE analyzer.
18. Added instructions to Section 2.8.1.4.M - Leak Check and Calibration.
19. Added detailed instructions on performing a multi-point calibration to Section 2.8.1.4.N.
20. Added Figure 2: Thermo Model 43i/43i-TLE Flowchart.
21. Added Figure 3: Thermo 146i Flowchart.
22. Clarified installation roles and responsibilities in Section 2.8.1.5.
23. Added Figure 4: Plumbing and Wiring Diagram for Monitoring Setup.
24. Updated Section 2.8.1.5.B with setting up automatic clock sync within the computer, AV-Trend, and the data logger. Removed the instruction on setting the site computer and data logger times automatically.
25. Removed the requirement in Section 2.8.1.5.B for the site computer to be set 5 minutes behind the data logger, as this is no longer a necessary to collect backup data.
26. Added clarification to the Leak Check instructions in Section 2.8.1.5.C.
27. Added additional routine maintenance tasks to Section 2.8.1.6.A for the Thermo 43i/43i-TLE Analyzer maintenance.
28. Updated Section 2.8.1.6.C with instructions for routine maintenance for the Teledyne Model 701 Zero Air Generator.
29. Added clarity on the frequency and tasks of sample line checks and replacement in Section 2.8.1.7.
30. Removed the requirement for 25% of the state's monitors to be audited per quarter, per the Revision to Appendix A from 40 CFR Part 58.
31. In Section 2.8.1.7, updated the frequency that the audit calibrator must be certified against a primary standard from quarterly to every 9 months.
32. Updated the table in Section 2.8.1.7.D for audit concentrations.
33. Added Figure 5: Audit Plumbing Diagram.
34. Added Figure 6: Funnel and Probe Audit Setup Diagram.
35. Added requirement to Section 2.8.1.7.D to record the temperature from the probe and the NIST thermometer onto the audit form.
36. Added Section 2.8.1.8 - Revision History.