Roy Cooper
Governer
Elizabeth Biser
Secretary
Michael A. Abraczinskas
Director

NORTH CAROLINA
Environmental Quality

DAQ-12-001.1: ECB Responsibilities Sulfur Dioxide Standard Operating Procedure

Revision 11

Effective Date: August 10th, 2022

NORTH CAROLINA
Department of Environmental Quality

Disclaimer:

This document, and any revision hereto, is intended solely as a reference guide to assist Electronics and Calibration Branch (ECB) technicians in the setup, common procedures, operation, and the collection of data related to the North Carolina Division of Air Quality's Sulfur Dioxide (SO_2) Program. This document is intended as a supplement to, and not a substitute for, the education, training and experience required for the efficient operation of ambient air quality monitoring equipment and the collection of scientifically valid data. If an event affecting SO_2 monitoring is outside the purview of this Standard Operating Procedure, contact the ECB management and the Raleigh Central Office for guidance.

Approval Sign Off-Sheet

I certify that I have read and approve of the contents of the ECB Responsibilities SO_2 Operator Standard Operating Procedure, Revision 11, with an effective date of August 10th, 2022.

Primary Standard Operating Procedure Author
Jeremy Pope, Environmental Chemist

DocuSigned by: Jeremy Pope
6CB642D69CB24E5...

Signature: ______________________ Date: 8/5/2022

Electronics and Calibration Branch Supervisor
Derrick House

DocuSigned by: Derrick House
2BED2E5865E148E...

Signature: ______________________ Date: 8/5/2022

Projects and Procedures Branch Supervisor
Joette Steger

DocuSigned by:
B278E8186CEC4DC...

Signature: ______________________ Date: 8/5/2022

Ambient Monitoring Section Chief
Patrick Butler

DocuSigned by: Patrick Butler
4290A7E2D2A0420...

Signature: ______________________ Date: 8/5/2022

Director of Air Quality
Mike Abraczinskas

DocuSigned by: Michael Abraczinskas
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Signature: ______________________ Date: 8/5/2022

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2.0 Sulfur Dioxide Standard Operating Procedure: ECB Responsibilities

The U.S. Environmental Protection Agency (EPA) has determined that short-term exposures to Sulfur Dioxide (SO_2) can harm the human respiratory system and make breathing difficult. Vulnerable groups such as people with asthma and children are sensitive to these effects of SO_2. SO_2 can react with other compounds in the atmosphere to form small particles. These particles may penetrate deeply into the lungs and in sufficient quantities can contribute to health problems. High concentrations of SO_2 can also damage foliage and plant life. The Clean Air Act of 1970 set the National Ambient Air Quality Standards (NAAQS), through which concentrations of SO_2 are limited to ensure public safety. This standard was revised in 2010.

High concentrations of SO_2 in the air can lead to the formation of other sulfur oxides. Due to this, SO_2 is used as an indicator of these formations. Sulfur oxide formations can produce acid rain. Fossil fuel combustion at power plants and other industrial facilities are the greatest sources of SO_2 emission. However, smaller sources of SO_2 emissions include industrial processes, natural sources, and vehicles that burn fuel with a high sulfur content. The North Carolina Division of Air Quality (NC DAQ) of the Department of Environmental Quality (DEQ) determines the ground level concentration of ambient air SO_2 throughout North Carolina as required by the 1970 Clean Air Act and the subsequent Amendments thereto. In short, the Clean Air Act established ambient air quality as a natural resource that must be protected. The EPA has designated the responsibility to administer and assist in the nationwide program to protect and improve air quality and each state is assigned the direct responsibility for assuring air quality within its borders.

In support of these requirements, the State of North Carolina operates SO_2 monitors across the state for the purpose of monitoring the ambient SO_2 exposure of the general population. To collect accurate, meaningful data the monitors must be set up and maintained in a consistent manner. The goal of this document is to establish a continuous, verifiable, and defensible set of procedures, and a means to record events and activities regarding the site and the instrument as required by the EPA in 40 Code of Federal Regulations (CFR) Parts 50, 53, and 58.

3.0 Equipment Selection and Procurement

The NC DAQ operates SO_2 monitors across the state for the purpose of monitoring the potential exposure of the general population to ambient levels of SO_2.

The Electronics and Calibration Branch (ECB) shall procure air monitoring equipment and supplies for the NC DAQ. The EPA Reference or Equivalent methods list should be reviewed to determine the makes and models acceptable for monitoring SO_2 at the levels dictated by the NAAQS. Each monitor used must be a reference or equivalent method (40 CFR 53 and 40 CFR 58, Appendix C).

All SO_2 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-volts direct current [VDC]). All monitors and calibrators must operate on 115-volt alternating current (VAC) 60 hertz (Hz) line current. All analog data acquisition systems must be calibrated to accept a 0 to 10-VDC 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.

4.0 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.

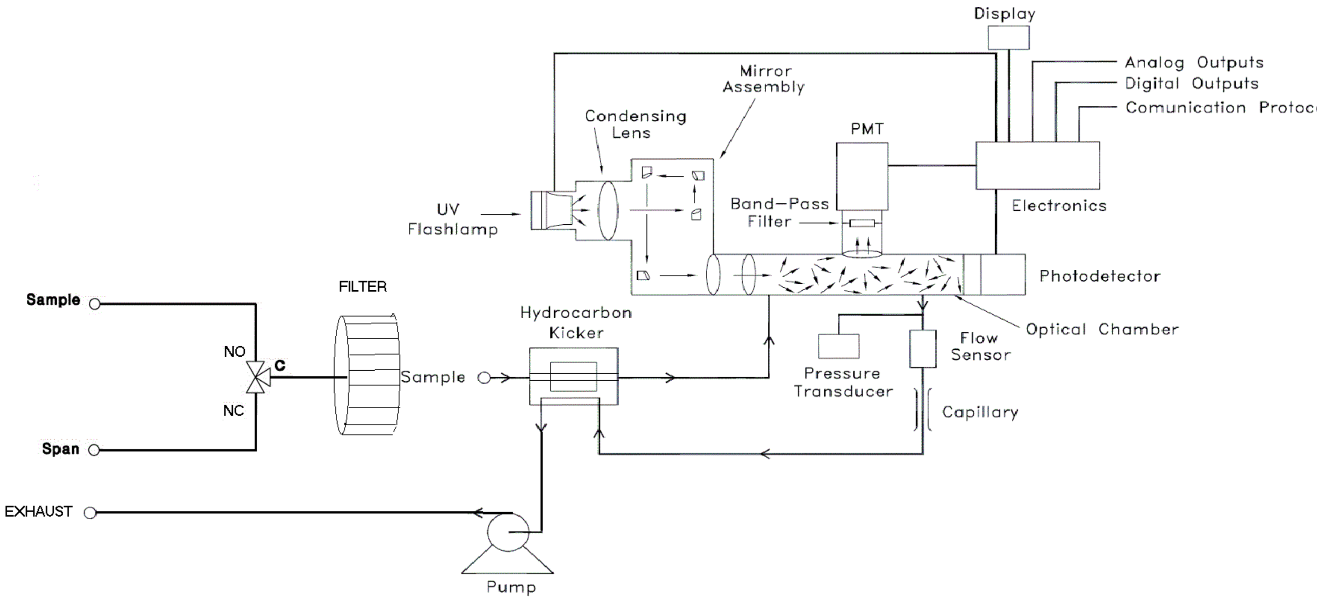


Figure 1: Principles of Operation for the Thermo Model 43i and 43i-TLE

Preset ranges	0.05 – 1.0 parts per million (ppm) 0-1000 milligrams per cubic meter (mg/m^3)
Zero noise	0.5 parts per billion (ppb) root mean square (RMS) (60 second averaging time)
Lower detectable limit	1.0 ppb (60 second averaging time)
Zero Drift (24 hour)	Less than 1 ppb
Span Drift (24 hour)	±1%
Response time	110 sec. (60 second averaging 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/minute (standard)
Interferences (EPA levels)	Less than the lower detectable limit except for the following: Nitrogen oxide (NO) < 3ppb; m-Xylene < 2ppb; water (H_2O) < 2% of reading
Operating temperature	20 – 30 degrees Celsius (ºC) (may be safely operated over the range of 5 – 40 ºC)
Power requirements	105 – 125 VAC at 50/60 Hz 100 Watts
Physical dimensions	16.75 inches (Wide) x 8.62 inches (High) x 23 inches (Deep)
Outputs	Selectable voltage 4 – 20 milliamperes (mA); RS-232/485 Interface

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

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

5.1 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 National Institute of Standards and Technology (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 nitrogen dioxide (NO_2).

5.2 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, ozone (O_3), carbon monoxide (CO) and hydrocarbons.

5.3 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.

5.4 Gas Cylinders

All gas cylinders must be traceable to a NIST – Standard Reference Material (NIST-SRM) and must be used prior to the expiration date (i.e., 4 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. Envidas Ultimate
5. A dedicated site personal computer (PC) and modem

6.0 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

6.1 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.

6.2 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 the monitoring room (**do not** vent to room air). Plug in the power cord and turn on power to the 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.

6.3 Initial Laboratory Setup

Attach a Teflon tube (fluorinated ethylene propylene [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.

6.4 Standard and Service Modes

There are two modes on both 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.

6.5 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.

6.6 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 volts (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**.

6.7 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 liters per minute (LPM) should be observed, if a flow rate of less than 0.35 LPM is observed a leak may be present.

6.8 Concentration Units

Set the instrument to read in ppb.

6.9 Averaging Time

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 (DAQ-12-001.2 Section 5.5).

6.10 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 degrees Celsius (°C)	33 °C
Pressure	715 millimeters mercury (mmHg)	740 mmHg
Sample Flow	0.450 LPM	0.480 LPM
Lamp Intensity	80%	90%
+3.3 V Supply	±1 V	
+5.0 V Supply	±1 V	
+15.0 V Supply	±1 V	
+24.0 V Supply	±1 V	
-15.0 V Supply	±1 V	
-3.3 V Supply	±1 V	

Table 2: Diagnostic Menu Minimum and Maximum Set Points

6.11 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 LPM	0.750 LPM
Lamp Intensity	40%	100%
Lamp Voltage	750 V	1200 V

Table 3: Alarm Minimums and Maximums

6.12 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 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 mmHg (flow should also go to zero). **NOTE**: If the pressure has not dropped below 180 mmHg 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 Envidas View software. 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 mmHg (flow should also be at zero). NOTE: If the pressure has not dropped below 180 mmHg 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 phase by aborting the zero calibration in the Envidas View software. 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".

6.13 Conduct a 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 800 V.
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 2.8 V – 4.5 V.
6. Activate Span 1. Run Span 1 until there are ten consecutive readings that are stable (within ± 2 ppb 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 ± 2 ppb 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 SO_2 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 ± 2 ppb 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 SO_2 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

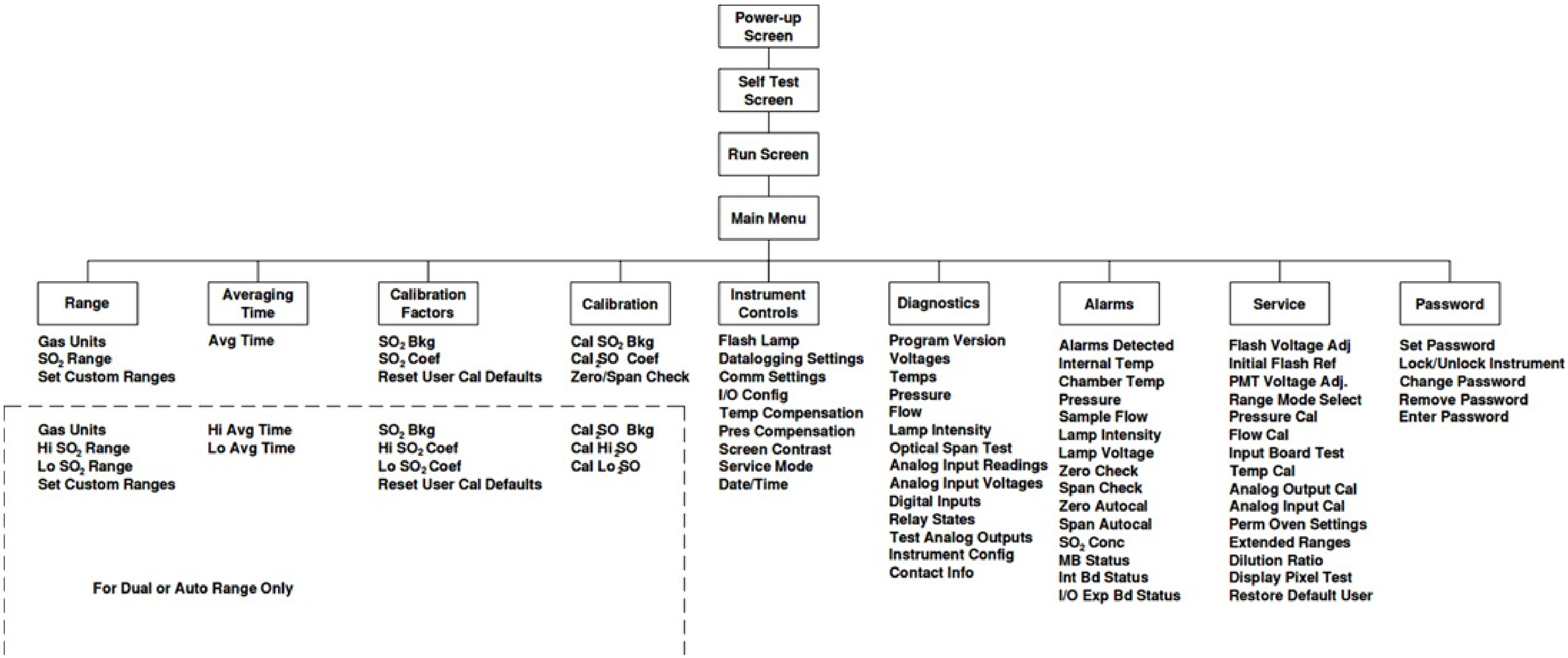
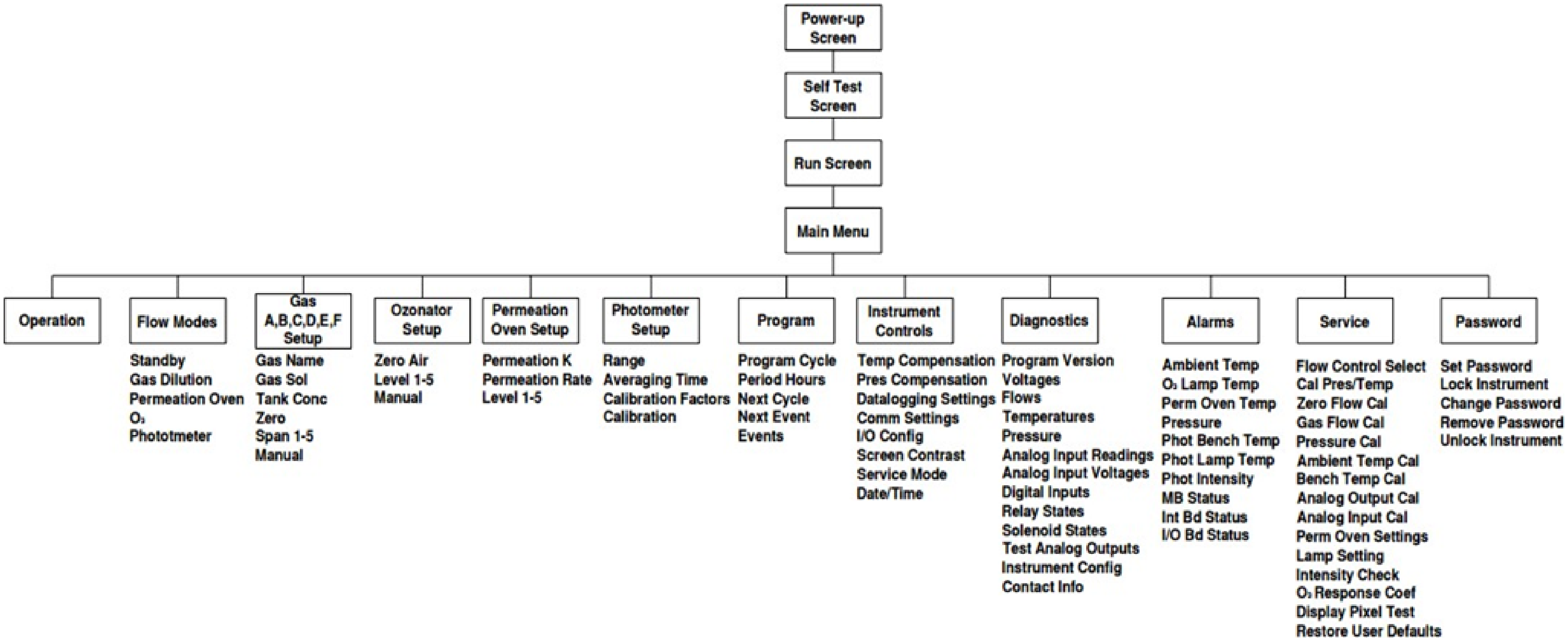


Figure 3: Thermo 146i Flowchart



7.0 On-site Installation

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 NC 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.

7.1 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 heat tape and removable polyurethane foam to prevent condensation. 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-inch 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, and interface box until all cables are connected. ELECTRICAL SHOCK AND/OR EQUIPMENT DAMAGE MAY OCCUR OTHERWISE.

3. Connect the monitor, modem, and computer. Observe polarity markings. Connect all instruments and support equipment power cords to a grounded surge suppressor, connected to a 115 VAC, 60 Hz grounded receptacle.

4. Configure the Envidas Ultimate software to run an automated Precision/Zero/Span or PZS. The ECB verifies that the system can be accessed remotely by computer from the ECB lab.

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.

7.2 Leak Check the System

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

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 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 mmHg (flow should also go to zero). **NOTE**: If the pressure has not dropped below 180 mmHg 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 Envidas View software. 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 mmHg (flow should also be at zero). NOTE: If the pressure has not dropped below 180 mmHg 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 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 phase by aborting the zero calibration in the Envidas View software. Document in the logbook. If the leak check fails, troubleshoot the instrument, and conduct any necessary repairs and repeat the leak check. Proceed to "multipoint calibration".

7.3 Running an Installation Precision-Zero-Span

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 functionality test 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.

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

1. Monitor replacement/repair
2. Two consecutive failed nightly PZS checks
3. System/Power off for 72 hours

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).

7.4 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 ensure that it is 'reachable'. Before leaving the site, sign out and reset the scheduler for normal operation.

8.0 Routine Maintenance

8.1 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).

Items requiring maintenance by ECB are:

1. Replacing the UV lamp (performed when lamp voltage approaches 1200 V)
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

8.2 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. Testing solenoids that have been removed to determine where failures occurred
4. Circuit Board Replacement
5. Mass Flow Controller Replacement
6. Replacement of the digital voltmeter (DVM)

7. Internal Adjustments

8. Certification of Mass Flow Controllers (reference the Calibrator SOP Section 2.3.4 and DAQ-13-007.1)

8.3 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 ± 2 psi.

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

9.0 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-point 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 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 every 12 months**. 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 matter 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 the 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) Log into Envidas View, select SO_2 channel and place the channel flag "To Audit".

D) Connect the audit calibrator, cylinder, and zero air system as shown in Figure 4: 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 5: Funnel and Probe Audit Setup Diagram. Perform the following audit 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.

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.

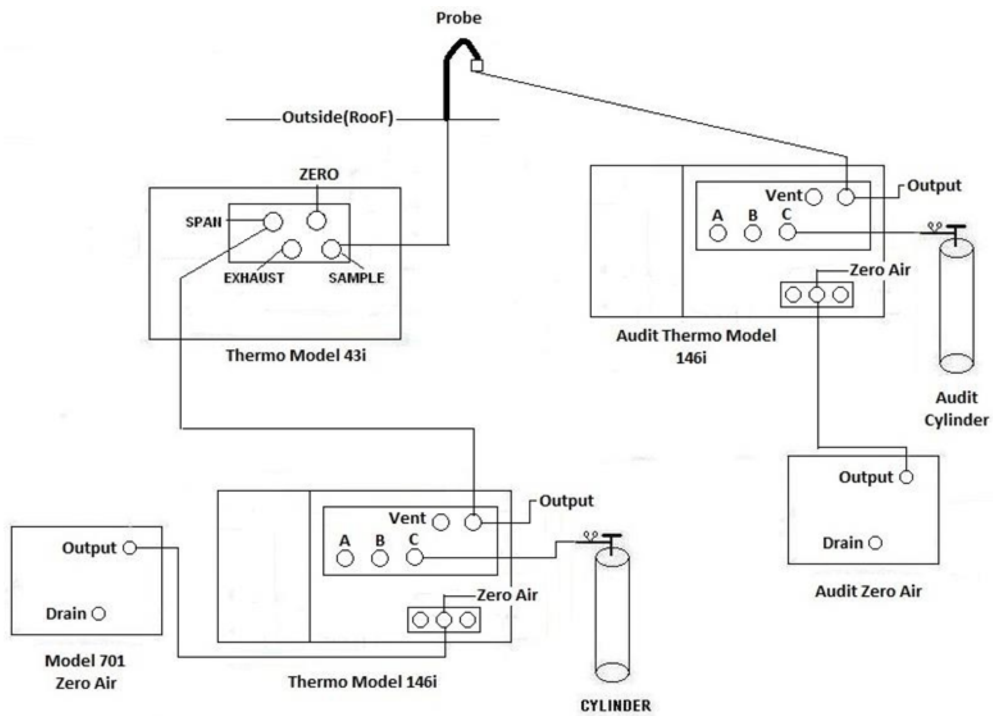


Figure 4: Audit Plumbing Diagram for Monitoring Setup

4. Review and record on an audit form (AQ-121) the current site temperature taken during the audit from the NIST thermometer.

5. For each audit setting, record on the audit form; the instrument concentration and five corresponding stable one-minute 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, select SO_2 channel in Envidas and remove the channel flag “To Audit.” Then 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 coordinator 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 PZS records (both auto and manual)
3. Confirming the audit results with a follow-up audit

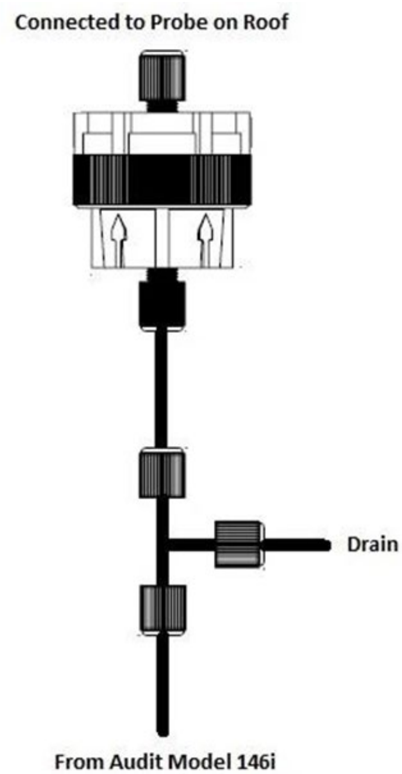


Figure 5: Funnel and Probe Audit Setup Diagram

10.0 Revision History

- SOP put into modern format
- Added Glossary
- Removed instances that mentioned Dataloggers instead of Envidas
- Changed 7.1 to state heat tape should be used in all instances.
- Changed 7.1 to state that all sites should have their probe line changed every 2 years.

Appendix A: Glossary

Acceptance criteria – is the pollutant-specific criteria that must be met to collect valid data specified by the United States Environmental Protection Agency in their validation templates, included as Appendix D to the United States Environmental Protection Agency Quality Assurance Handbook.

Calibration – is the act of changing or setting values in a monitor.

- *Gaseous Monitor Calibration* – is the act of setting response values stored in a monitor while running a series of challenge concentrations. A calibration for a monitor is accomplished by pressing a button to change the values stored in the monitor for each challenge concentration. For carbon monoxide a calibration involves running three upscale points to set or reset the coefficients. For all other gaseous monitors the challenge concentrations include zero and at least one span point.
- *Particulate Matter Calibration* - For low volume particulate matter monitors a calibration is the changing or resetting of the span and offset using three flow points bracketing the desired flow point. For PM monitors the temperature and pressure calibration is changing or resetting a slope using a one-point measurement. The temperature and pressure calibration must be completed before the flow calibration.

Calibration Criteria – are pollutant-specific limits established by the Division of Air Quality that a calibration must meet to pass and be used to collect valid data. The calibration criteria may be equal to or more stringent than the EPA acceptance criteria.

Control Limits – are limits established by the United States Environmental Protection Agency and published in the Code of Federal Regulations at 40 CFR Part 58 Appendix A. These limits may not be exceeded. They are listed as acceptance criteria in the Environmental Protection Agency validation tables in Appendix D to the United States Environmental Protection Agency Quality Assurance Handbook and North Carolina Division of Air Quality validation tables in the North Carolina Division of Air Quality quality assurance project plans. The precision, zero and span for gaseous monitors or flow rate verification for particulate matter monitors must be within the control limits for the collected data to be valid. Data collected when the precision, zero and span or flow rate verifications are outside of the control limits will be invalidated and replaced with a null code.

Electronics and Calibration Branch Performance Evaluation – is a check performed by the Electronics and Calibration Branch electronics technicians to confirm the correct operation of an instrument. At a minimum it involves challenging the instrument with a zero and two upscale points. One of the upscale points must be at the detection limit of the instrument. The other upscale point is either at the level of the national ambient air quality standard or at the level of the highest measured values. The Electronics and Calibration Branch electronics technicians must perform an Electronics and Calibration Branch performance evaluation on each instrument at least once every 365 days and at least once every calendar year.

Flowrate Audit - is a measurement of flow, ambient pressure and ambient temperature to ensure correct operation of the monitor, performed by someone other than the operator using a certified flow standard different from that used to calibrate or verify the monitor.

Flowrate Verification – is a measurement of flow, ambient pressure and ambient temperature by the operator to ensure correct operation of the monitor.

Functionality Test – is a test of the monitor, calibrator, cylinder, or zero air supply conducted by an ECB electronics technician, either remotely or on site, to evaluate whether the system is performing as expected. It may include running a zero and span or multiple points. Since functionality tests involving the running of points do not necessarily run the points long enough for them to stabilize and are not necessarily recorded in an elog, results of functionality tests are not reported to AQS. Functionality tests, alone, cannot be used as weight of evidence to demonstrate that the monitor is functioning properly.

Installation – is when a monitor is both taken to a site and plugged in. A leak check followed by a calibration is required on installation and before data reporting.

Manual Performance Checks – are any performance checks completed by the regional operator to evaluate the instrument and its performance. A manual performance check could be a precision, zero, span or just a zero and a span or just a one-point quality control check. It could be performed remotely or on-site. It includes manual 14-day one-point quality control checks performed at the site.

Moving – for a gaseous monitor, is removing the monitor from the monitoring shelter.

Multi-point Verification – is the check that the operator performs after completing a calibration on a gaseous monitor. It includes running a zero, span and two (for sulfur dioxide) or three intermediate, equally spaced concentrations to verify the linearity of the calibration and assess the overall success of the calibration. A multi-point verification may be used instead of a calibration for carbon monoxide and other pollutants, when allowed by an SOP, for the calibration required once every 365 days or when calibrators and cylinders are replaced.

National Performance Audit Program Performance Evaluation – is a performance check completed by United States Environmental Protection Agency contractors to confirm the correct operation of an instrument. It involves challenging the instrument with a zero and several upscale points.

One-Point Quality Control Check – is a check performed at least once every two weeks on each gaseous monitor. It must fall within the range of 0.5 to 5 parts per million for carbon monoxide and 5 to 80 ppb for all other gaseous pollutants. Any check that meets the requirements of a one-point quality control check must be reported to the Air Quality System.

Precision, zero, span or PZS – is the automated scheduled check that runs each night to measure drift in the zero, span and one-point-quality control check also known as the precision point.

- *Failed PZS* – is a check where all of the calibration equipment worked properly to provide the desired gas at the desired concentration but the instrument failed to read the concentration within the EPA-established control limits. [Note that the action or warning limits are stricter than the control limits.] For SO_2 and O_3 the data for a failed PZS are reported to AQS. The data are invalidated back to the last passing PZS. The operator is required to take corrective action. Valid data cannot be reported until the problem is corrected or the instrument is recalibrated.
- *Invalid PZS* – is a check where one or more components of the calibration system (solenoid, zero air generator, gas cylinder, ozone generator, mass flow controllers, etc.) used to produce the challenge concentration failed for some reason. As a result, the system failed to provide the desired gas at the desired concentration. The operator is required to take action within two working days to identify and document the cause of an invalid PZS. The invalid PZS for ozone and sulfur dioxide is reported to the Air Quality System with a null code that describes the reason the PZS failed. Because the PZS is invalid, no data are invalidated as long as the calibration system is fixed and a passed PZS runs within 14 days. If the operator fails to act within the prescribed timeframe, the data may be flagged with a “6” for not following the standard operating procedure.
- *Passed PZS* – is a check where all of the calibration equipment worked properly to provide the desired gas at the desired concentration and the instrument successfully measured the concentration within the EPA-established control limits. For sulfur dioxide and ozone the

data for a passed PZS are reported to AQS. The operator is only required to take corrective action if the check is outside of the EPA Region 4 recommended warning limits for two consecutive days.

- *Valid PZS* – is a check where all of the calibration equipment (solenoid, zero air generator, gas cylinder, ozone generator, mass flow controllers, etc.) used to produce the challenge concentration worked properly to provide the desired gas at the desired concentration. A valid PZS is necessary to have either a passed PZS or a failed PZS. A valid PZS refers only to the status of the equipment used to produce the challenge concentration and not the monitor that measures the challenge concentration.

Shut down – is when the monitor is no longer collecting reportable data.

Start up – is when the monitor is now collecting reportable data.

Systems Test – is a test of the monitor, calibrator, cylinder, zero air supply, or other support equipment conducted by an operator, either remotely or on site, to evaluate whether the system is performing as expected. It may include, but is not limited to, running a zero and span or multiple points. Since systems tests involving the running of points do not necessarily run the points long enough for them to stabilize, results of systems tests are not reported to AQS. Systems tests must be recorded in an elog and, alone, cannot be used as weight of evidence to demonstrate that the monitor is functioning properly.

Warning Limits – are limits recommended by the United States Environmental Protection Agency Region 4 and adopted by the North Carolina Division of Air Quality, which are stricter or tighter than the United States Environmental Protection Agency established control limits. The North Carolina Division of Air Quality has put them into place to minimize data loss. When the precision, zero and span for gaseous monitors or flow rate verification for particulate matter monitors are outside of the warning limits, the operator must take corrective action to identify the cause. If the cause is normal drift, the operator will recalibrate the instrument. If the cause is more serious, the instrument may be replaced or repaired and then recalibrated. Action must be taken but the data remain valid as long as the precision, zero and span or flow rate verification remains within the control limits. Data may be flagged with a “6” for not following the standard operating procedure if the operator fails to act within the timeframe prescribed by the standard operating procedure.

Weight of evidence – is documentation and verifiable proof that the monitor or calibration system was either working properly or failed in some manner. To demonstrate the system was working properly, the weight of evidence should thoroughly document that whatever occurred at the time had no effect on the data or did not compromise the quality or validity of the data collected. To be acceptable for use as weight of evidence, any points ran must be run by the regional office staff, must be documented in an elog, and must at a minimum include a precision point, zero point and span point. Whenever points are run to provide weight of evidence that the monitor is functioning properly, they must be reported to AQS.