Section II: Operator Responsibilities
Sulfur Dioxide Standard Operating Procedure

Revision 12

Effective Date: November 1, 2016
I certify that I have read and approve of the contents of the SO₂ Operator Standard Operating Procedure with an effective date of November 1, 2016.

Regional Office Representative
Tony Sabetti, Regional Coordinator/Lead
Signature: ___________________________ Date: 9/30/16

Regional Office Representative
Rik Tebeau, Regional Coordinator/Lead
Signature: ___________________________ Date: 10/12/16

Central Office Lead
Jyoti Bapat, Environmental Chemist
Signature: ___________________________ Date: 10/12/16

Acting Electronics and Calibrations Branch Supervisor
Patrick Butler
Signature: ___________________________ Date: 10-12-16

Projects and Procedures Branch Supervisor
Joette Steger
Signature: ___________________________ Date: 9/07/16

Acting Ambient Monitoring Section Chief
Lori Cherry
Signature: ___________________________ Date: 10-13-16

EPA Region 4 Superfund and Air Section Chief
Laura Ackerman
Signature: ___________________________ Date: __________
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2.8.2.1 General Background Information and Initial Site Checks

The State of North Carolina operates sulfur dioxide monitors across the state for the purpose of monitoring the ambient SO\textsubscript{2} exposure of the general population. In order to collect accurate, meaningful data the monitors must be operated 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 with regard to the site and the instrument as required by the United States Environmental Protection Agency (US EPA), 40 CFR 50, 53, and 58.

All original records must be legible, complete, accurate, dated, and signed or initialed by the operator and retained as part of the permanent analyzer operational record. This includes both the electronic logbook (elog) and the site logbook. The operator’s name and/or initials presented on the elog will certify that the activities indicated have been performed in accordance with this Standard Operating Procedure (SOP) and that the information contained on the form is accurate (reference Appendix B of Quality Assurance Project Plan (QAPP) for examples of elog and forms). All records will be reviewed and verified by the Regional Chemist and audited by the responsible chemist at the North Carolina Division of Air Quality (NC DAQ) Central Office.


2.8.2.1.1 Instrumentation and Equipment for Continuous SO\textsubscript{2} Monitoring

- Thermo Environmental 43i or 43i-TLE SO\textsubscript{2} Analyzer
- Teledyne 700U or Thermo 146i Dynamic Gas Calibrator
- Certified SO\textsubscript{2} Protocol compressed gas cylinder
- Teledyne Air Generator Model 701
- ESC model 8832 (or 8816) Data Logger
- Dedicated site PC
- Modem and Moxa Serial Server

**Note:** Reference SOP 2.8.2 Version 10 for instruction on using the Thermo Model 43C SO\textsubscript{2} Analyzer, Thermo Model 146C Dynamic Gas Calibrator, and Model 111 Zero Air Packs. Reference Section I: ECB Responsibilities for set-up and plumbing diagrams.
2.8.2.1.2 Common Continuous Monitoring Principles Applicable to the SO$_2$ System

- **Calibration:** A calibration is required: 1) at the initial start-up of a new site; 2) when the monitor itself is replaced; 3) when the results of two consecutive daily auto-calibration check results fail to meet acceptance criteria; 4) when the operation is interrupted for more than 2 days without power (such as in the case with hurricanes or shelter repairs); and 5) once every 365 days (even if running smoothly over that time span) per EPA guidance. See Section 2.8.2.2.3 for details.

- **Calibration Check:** In lieu of the 14-day manually performed calibration check, the results of the daily auto-calibration check results will be used. The NC DAQ daily auto-calibration check includes a zero point, a span point, and the precision point. The precision point for the daily auto-calibration check is now called the 1-pt QC check, to align terminology with that of the EPA. The daily auto-calibration checks occur in the early morning hours of each day. The daily auto-calibration check can also be used for the calibration check prior to a cylinder/calibrator change out and the daily auto-calibration check on the day following such equipment changes can be used in lieu of a recalibration. The auto-calibration check may also be used as the final check when a site is closed and as a check on the calibration after the operation is restored following a power outage lasting for 2 days or less. The operator can, at his/her discretion, perform a manual calibration check or calibration at any time he/she feels it is necessary to ensure the collection of quality data. **Note that the value for the precision point for a calibration check is not the same as the value for the 1-pt QC check for the daily auto-calibration check.** See Section 2.8.2.2.4 for details.

- The clock times of the components at the site are to be verified, and if necessary corrected, during each site visit.

- At each site visit the site is to be inspected for general maintenance issues such as condition of the shelter and sample lines.

- Operators are to visit the site at least once every 28 days.

- No checks, that affect data, are to be made during periods when the potential for the exceedance of the SO$_2$ National Ambient Air Quality Standards (NAAQS) exists.

2.8.2.1.3 Site Visit and Checks

Upon arrival at the site, observe the outside of the shelter and probe inlet, looking for vandalism or security breaches. Verify that the probe inlet is in place and that the sample line is not blocked by insects or other debris. **Document all observations and actions on the elog.** More information on locating and opening the elog can be found in Section 2.8.2.3.1. If there is any evidence of vandalism the operator should contact the appropriate law enforcement department (generally this is the city police department if the monitor is within city limits or the county sheriff’s department if outside city limits) as well as the Regional Chemist, the Central Office (CO), and the Electronics and Calibration Branch (ECB) of DAQ. Check the data loggers for appropriate date/time and concentration readings (see Section 2.8.2.1.5 for specifics). The Regional Chemist and a member of the Projects and
Procedures Branch (PPB) should review the data generated during any “out-of-control” period to determine if the data should be flagged or invalidated. Appendix A provides the schedule of activities required when site Operators visit the site. Figures showing the layout of the front (Figure 1) and rear panels (Figure 2) of the 43i/43i-TLE and 146i are shown below.

A) Shelter Temperature

Measure the internal temperature of the building in °C using a NIST traceable thermometer placed next to the shelter temperature sensor. If the NIST traceable thermometer was brought to the site, allow sufficient time for the reading to stabilize. Compare the two temperature readings and record this reading in the elog. If the shelter temperature sensor is reading greater than ± 2° of the reference contact the ECB. Adjust the site thermostat as necessary to maintain the shelter temperature within a 20° to 30°C range. If the temperature cannot be stabilized and controlled within this range, notify the regional chemist and the ECB that corrective action is required. Note: The shelter temperature should remain fairly constant and not vary more than ± 2° C standard deviation over 24 hours. The statistician in the Central Office keeps track of this statistic. The Regional Chemist will be notified if an issue arises.
Figure 2: Diagram of Thermo 43i/43i-TLE rear panel

B) Electrical Power and Sample Line Check
Observe the analyzer, calibrator, computer, and data loggers for indications of a power failure, and if needed, correct the cause. If the analyzer or calibrator loses power, allow an equilibration period of approximately 24 hours for the instrument(s) to stabilize after being powered up. The instrument can remain offline at this time. Visually inspect the sample line tubing, especially at any bends, to ensure that it has not been accidentally kinked, crimped, cut, or to ensure that insects have not nested in the lines. Particulate matter and/or water may also collect in the sample line leading to the instrument. Ensure that the shelter air conditioner is not blowing on the sample line, as this can cause condensation to build up in the line. The ECB is required to replace the sample line every two years, and will perform a sample line integrity check at their yearly audit (Reference Section I: ECB Responsibilities for details). **Record all events in the elog.**

C) Gas Cylinder and Calibrator Check
Verify that the calibration gas cylinder and calibrator are in certification and document certification dates in the elog. Calibrator certification is valid for **twelve months** and the
calibration and/or expiration date(s) should be indicated on a sticker on the front panel. Gas cylinders at a concentration of 40 ppm or greater are certified for two years from the original date of the manufacturer’s certification. If the cylinder pressure is less than 500 psig, the ECB should be notified that a new cylinder is required. The delivery of a new cylinder or calibrator must be coordinated with the region. The cylinder is not to be used if the pressure is below 200 psi.

Verify that the calibrator has the correct cylinder SO₂ concentration stored in memory.

Cylinder concentration can be accessed on the 146i through the following steps:
1. On the calibrator, press the “Main Menu” button.
2. Place the calibrator into Service mode.
3. Navigate using the arrow buttons to Gas Setup.
4. Select Gas C.
5. Navigate using the arrows again to Tank Conc, and press ENTER.

Cylinder concentration can be accessed on the 700U through the following steps:
1. On the calibrator main screen, press the Setup button.
2. Press the Gas button.
3. Press the (Cyl) cylinder button.
4. Select Port 3.
5. If the cylinder concentration needs to be changed, press the Edit button.
6. Enter the correct concentration, and press Enter.

Record the cylinder concentration stored in the calibrator in the appropriate location in the SO₂ elog.

The daily auto-calibration check performed in the early morning on the day of the equipment change will be used in lieu of a calibration check. Immediately following the installation of a new cylinder or calibrator, the region must verify that the system is functioning properly. This will be accomplished by observing the results of the daily auto-calibration check performed in the morning of the day immediately following the equipment exchange. The operator may, at his/her discretion, perform a calibration or calibration check. However, a calibration is no longer required as long as the daily auto-calibration check is within control limits (See Table 1). The procedures for performing a calibration or calibration check are provided in Sections 2.8.2.2.3 and 2.8.2.2.4. Verify that the 146i has the correct cylinder SO₂ concentration stored in memory. Record the pertinent information in the elog.

D) Standard and Service Mode
There are two modes on the analyzer. While sampling in the field, the SO₂ 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 or 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 toggle **Service** mode on or off.

If **Service** mode was turned on, be sure to always turn **Service** mode off prior to starting regular sampling. Refer to Figure 3: Thermo Model 146i Flowchart for a description of the instrument menu.

### 2.8.2.1.4 Analyzer and Calibrator Operational Checks

On the front panel press the **Menu** button to get to the Main Menu. The Main Menu contains many submenus (see Figure 3 for the 43i/43i-TLE, Figure 4 for the 146i, or Figure 5 for the 700U). Instrument parameters and settings can be found within the submenus according to their function. To select a submenu screen, use the up and down arrow buttons to move cursor up or down, select the submenu and press **ENTER**. No values are to be changed without calling the ECB and getting their approval. If the ECB approves changing a value, document the change in the logbook. To exit a screen, press **MENU** to return to Main Menu and choose another submenu or press **RUN** to return to the Run Screen.

#### A) Alarm Checks (Thermo 43i or 43i-TLE Analyzer, Thermo 146i Calibrator, or Teledyne 700U Calibrator)

Check for “Alarm” on the displays. If no alarms are present, record the Alarm On check box in the elog as **no** and continue. If either screen shows an alarm, record the Alarm On check box as **yes** in the elog for the appropriate instrument/s. View the Alarm menu to determine the cause and enter in the Notes section of the elog and notify the ECB.

To view the alarms:
1. Press the **MENU** button on the front of the instrument.
2. Use the arrow buttons to select the **Alarm Submenu**.
3. Press the **ENTER** button.
4. Use the arrow buttons to select the item that is in Alarm Status.
   **NOTE**: Items that are not in alarm status are labeled **OK**.
5. Press the **ENTER** button.
6. Determine the cause of the alarm. Consult with the ECB prior to performing calibrations or maintenance.
7. Press the **<MENU>** button twice to return to the main menu screen.
Figure 3: Thermo Model 43i/43i-TLE SO₂ Analyzer Flowchart

Figure 4: Thermo 146i Calibrator Flowchart
The following alarm limit is used in the operation of the Thermo 146i calibrators:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Temperature</td>
<td>10 °C</td>
<td>40 °C</td>
</tr>
</tbody>
</table>

The following alarm limit is used in the operation of the Teledyne 700U calibrator:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Temperature</td>
<td>5 °C</td>
<td>40 °C</td>
</tr>
</tbody>
</table>
The following Alarm Limits are used in the operation of the Thermo 43i and 43i-TLE Analyzers:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal temperature</td>
<td>15 ºC</td>
<td>45 ºC</td>
</tr>
<tr>
<td>Chamber Temperature</td>
<td>43 ºC</td>
<td>47 ºC</td>
</tr>
<tr>
<td>Pressure</td>
<td>400 mm Hg</td>
<td>1000 mm Hg</td>
</tr>
<tr>
<td>Flow</td>
<td>0.350 LPM</td>
<td>0.750 LPM</td>
</tr>
<tr>
<td>Lamp Intensity</td>
<td>40%</td>
<td>100%</td>
</tr>
<tr>
<td>Lamp Voltage (43i)</td>
<td>750 V</td>
<td>1200 V</td>
</tr>
<tr>
<td>Lamp Voltage (43i-TLE)</td>
<td>950 V</td>
<td>1200 V</td>
</tr>
</tbody>
</table>

B) Analyzer Operational Checks
1. Verify that the Range of the SO₂ analyzer is 0.5 ppm (500 ppb). As of Revision 11, all SO₂ monitors in the DAQ network, regardless of model, are set to a range of 0.5 ppm (500 ppb). The only exception is the trace level monitor at the NCORE site which is covered under a separate SOP.
2. Choose Range from the Main Menu (<MENU>, ↑ or ↓) on the analyzer display. If the monitor range is different than the range specified for the site, contact ECB for the correct instrument/calibration status.

C) Diagnostic Checks (Analyzer and Calibrator)
Select the Diagnostics Menu (View only screen) and record in the elog.

Diagnostic checks for the Thermo 146i Calibrator:
1. Check current DC voltages of the motherboard for +3.3 V (±1 V), +5.0 V (±1 V), +15 (±1 V), 24.0 V (±1 V), and -3.3 V (±1 V) power supplies.
2. Check internal temperature.

Diagnostic checks for the Thermo 43i and 43i-TLE Analyzer:
1. Check current DC voltages for the +3.3 (±1 V), +5 (±1 V), +15 (±1 V), +24 (±1 V) and -3.3 (±1 V) power supplies.
2. Check internal temperature and chamber temperature (under Temperature). (Note: Internal temperature should be between 10.0 and 45.0°C and chamber temperature should be between 43.0 and 47.0°C. If outside of these limits, the Alarm would also be flagged.)
3. Check pressure (acceptable range is 400 to 1000 mmHg).
4. Check the flow (acceptable range 0.350 to 0.750 Liters/minute).
5. Check lamp intensity (acceptable range 40% to 100%).
6. Check the lamp voltage (under Voltage). Acceptable range is 750 to 1200 V for the 43i and 950 to 1200 V for the 43i-TLE
7. If outside of specified ranges, contact ECB. (Note: If the lamp voltage is running at or very near to 1200 V it has degraded to its highest point and may need to be adjusted or changed out. Contact ECB).

8. Verify the averaging time (for the Analyzer) by pressing MENU, select **Averaging Time**. Press ENTER, verify that AVG Time is set to 60 sec. To return to the home display, press Run.

**D) Zero Air Generator**
1. Verify that the pressure gauge on the Teledyne Model 701 Zero Air Generator is reading 30 ± 2 psig and record the reading on the elog.
2. As the expiration date for the Model 701 Zero Air Generator approaches, contact the ECB to make arrangements for new materials.

**E) Cooling Fan and Fan Filter Check**
1. Check to ensure the fans are running.
2. On the back of the instruments there are cooling fans with sponge filters inside. Check to see if the filters are clean during every site visit and clean the filters at least once every 28 days. The fan housing can be popped off the back of the instrument and the filter may be removed and cleaned if necessary by using the compressor to generate compressed air). After cleaning, replace the filter and the housing. Record this activity in the elog.

**2.8.2.1.5 Data Logger Time and Date Checks and Adjustments**
Record the computer, data logger, and NIST time on the elog created for a site visit.

The times for the data logger, AV-Trend, and computer must be EASTERN STANDARD TIME. Additionally, 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. Confirm that the task is enabled.
7. 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

2.8.2.2 Detailed Procedures

2.8.2.2.1 Filter Change Procedure
The particulate filter (5.0-micron 47 mm Teflon®) must be replaced at a minimum of every 28 days. The filter is replaced as follows:

1. Disable the SO\textsubscript{2} channel on the data logger.
2. Perform a leak check on both the Span and Sample ports prior to changing the filter (Reference Section 2.8.2.2 for leak check procedure). This will ensure the integrity of the system prior to making any changes to the filter.
3. On the back of the analyzer, remove the filter holder (if necessary) and disassemble using the special filter wrenches.
4. Remove the existing filter and discard. Remove any extraneous material from filter housing.
5. Touching only the outer edges, place a new filter in the holder (orientation of filter is not critical).
6. Reassemble the filter holder and reattach to instrument in same orientation as before removal (i.e., filter inlet/outlet connected to proper lines). Do not over tighten the filter holder for this can tear the filter and/or damage the holder.
7. Perform a leak check as discussed below.
8. Record in the elog that the leak checks prior and after the filter change passed. Record in the elog that the filter has been changed.
9. Bring the SO\textsubscript{2} channel back up (unless continuing with calibration).
   Note: Filter conditioning is not required.
2.8.2.2.2 Leak Check Procedure

A Leak Check must be performed at least once every 28 days in conjunction with a filter change.

A) For the Monitor SAMPLE port, perform the following on the analyzer:

1. Disconnect the sample line from the sample inlet port on the rear of the instrument and block the opening with a leak-tight cap. (Do not disconnect the lines going to the filter inlet or the filter outlet.)
2. From the Diagnostics Menu, use the arrow buttons to select “Pressure” and press “Enter”. The pressure reading should start to drop.
3. Wait until the pressure drops below 180 mm Hg which should take approximately 3 minutes.
4. At this time, using the Diagnostics Menu, toggle back and forth between “Pressure” and “Flow” monitoring both readings. The flow should drop to “zero” liters per minute (LPM), but may take an additional 1-3 minutes after the pressure has dropped below 180 mm Hg. If the flow does not read exactly 0.000, but displays a value of 0.1 LPM or lower, the flow criteria for the leak check still passes. (Inform the ECB if this situation occurs so that the ECB can make a small adjustment to the flow meter at some convenient future time.)

   **NOTE:** If the pressure has not dropped below 180 mm Hg within three minutes, 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 retest. Do not cap off the line for more than 5-6 minutes or the system may pressurize. If either the flow or the pressure is not acceptable, the leak check fails. Contact the ECB.
5. Remove the cap and document in the elog. Press Run to return to the home screen on the analyzer.

B) For the Monitor SPAN port begin the test by running a zero.

On the data logger in AV-Trend:

1. Select "C" (configure menu)
2. Select "C" (configuration calibration menu)
3. Select “1” (single phase calibration)
4. Select “SO2CAL”
5. Select “SPAN0”
6. Scroll down to “Phase Duration” and change to 30 m
7. Select “Start Single Cal NOW”
8. The zero should begin. **The zero must be active to conduct Span Port leak check.**
On the analyzer, perform the following steps:

1. Disconnect the calibrator Teflon® line from the calibration gas inlet port on the rear of the analyzer. Block off the calibration gas inlet port on the back of the analyzer with a leak-tight cap.

2. From the Diagnostics Menu, press “Menu”, use the arrow buttons to select “Pressure”, and press “Enter”. The pressure reading should start to drop.

3. Wait until the pressure drops below 180 mm Hg which should take approximately 3 minutes.

4. At this time, using the Diagnostics Menu, toggle back and forth between “Pressure” and “Flow” monitoring both readings. The flow should drop to “zero” liters per minute (LPM), but may take an additional 1-3 minutes after the pressure has dropped below 180 mm Hg. If the flow does not read exactly 0.000, but displays a value of 0.1 LPM or lower, the flow criteria for the check still passes. (Inform the ECB if this situation occurs so that the ECB can make a small adjustment to the flow meter at some convenient future time.)

   **NOTE:** If the pressure has not dropped below 180 mm Hg within three minutes, 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 retest. Do not cap off the line for more than 5-6 minutes or the system may pressurize. If either the flow or pressure is not acceptable, the leak check fails. Contact the ECB.

   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.

3. Remove the cap and document results in the elog. Press Run to return to the home screen on the analyzer.

**2.8.2.2.3 Manual Calibration**

A calibration IS required
- At initial set-up
- When the SO₂ monitor is replaced
- After two consecutive span point results from the daily auto-calibration check did not pass the acceptance criteria given in Table 1
- When the monitor has not been in operation for more than 2 days (such as in cases with hurricanes or shelter repairs when the daily auto-calibration check results cannot be used in place of the 14-day calibration check)
- Once every 365 days per EPA guidance
A calibration **IS NO LONGER** required after the replacement of any of the following components:

- The zero air supply
- The calibrator
- The SO₂ cylinder

This is applicable only when the very next daily auto-calibration check is shown to be within acceptance limits (see Table 1). If this auto-calibration check fails, a calibration is required. It is imperative that the operator be aware of when components are changed so that the results of the next daily auto-calibration check can be reviewed. Therefore, arrangements with the ECB for delivery should be scheduled in advance.

A monitor calibration consists of 1) setting the “Zero” using a source of zero air and 2) setting the SPAN (SO₂ coefficient) using a calibration gas with a concentration of nominally 80% of the monitor’s range (i.e., 400 ppb SO₂). Zero adjustments affect the span; however, span adjustments do not affect the zero. The procedures to accomplish this are provided below.

**NOTE:** The SO₂ channel on the data logger should still be down from the required checks performed previously (if the channel is not, down the channel before proceeding).

If desired, a graph of the minute data during a calibration can be created to track the stabilization of each value. Instructions on how to graph the minute data in AV-Trend are located in Appendix B.

**A) Zero Procedure:**

1. On the site computer using the data logger in AV-Trend
   - Select “C” (Configuration Menu)
   - Select “C” (Calibration Menu)
   - Select “1” (start single phase calibration)
   - Select “SO2CAL”
   - Select “SPAN0”
   - Change Phase Duration to 1 hour and press Enter
   - Press Enter when “Start Single Cal NOW” is highlighted
   - Hit `<ESC>` twice to return back to home menu

2. To view the minute data on the data logger:
   - Select “D” (display real-time)
   - Select “C” (continuous average report)
3. On the Monitor

The data logger should read nominally 0.0 ± 3.0 ppb on the SO₂ channel. Adjust the analyzer zero setting by doing the following:

- From the Main Menu:
  a. Use the arrow buttons to select Calibration Factors and then select SO₂ Background. Record this value on the elog as the “SO₂ background” BEFORE CALIBRATION. (If this value is outside of a 0 to 50 ppb range, contact the ECB.) Return to the Main Menu.
  b. Use the arrow buttons to select Calibration Factors and then select SO₂ Coefficient. Record this value in the elog as the SO₂ Coefficient BEFORE CALIBRATION. If this value is outside of a 0.900 to 1.100 ppb range, contact the ECB. Return to the Main Menu.

- Press the Menu button on the front of the analyzer and, using the arrow buttons, move the cursor to select Calibration menu. Press the ENTER button to display the Calibration menu.

- Select “Cal SO₂ Background” and press the ENTER button. The Calibrate Zero screen will appear with the first line of the display showing the current SO₂ reading. With the analyzer producing a stable reading for at least 20 minutes (constant within 0.0 ± 2.0 ppb and not trending up or down) on zero air, press the ENTER button to set the SO₂ reading to zero. The display flashes the message “Saving” and the SO₂ reading is added to the background correction. Record this value on the elog as the “SO₂ Background” AFTER CALIBRATION.

- Allow the monitor to stabilize and then record the next five one-minute data logger concentration values on the elog. The elog will compute the average of these five one minute values. If the values are not within ± 2.0 ppb of zero, repeat steps 2 and 3 above.

4. To stop the zero on the data logger:
   - Press <ESC> to go back to the main screen
   - Select “C” (Configuration Menu)
   - Select “C” (Calibration Menu)
   - Select “W” (Abort Cal)
   - Select SO2CAL and press Enter

B) Span Procedure:

The Span 1 concentration is preset to a value within the range of "70 to 90% of full scale" of the analyzer’s range setting. Allow the analyzer concentration reading to stabilize for at least 20 minutes. After the reading has stabilized (not changing by more than ± 3.0 ppb and not trending up or down), Follow the steps below to adjust/calibrate the span.
1. On the site computer using the data logger in AV-Trend
   - Select “C” (Configuration Menu)
   - Select “C” (Calibration Menu)
   - Select “1” (start single phase calibration)
   - Select “SO2CAL”
   - Select “SPAN1”
   - Change Phase Duration to 1 hour and press Enter
   - Press Enter when “Start Single Cal NOW” is highlighted
   - Hit <ESC> twice to return back to home menu

2. To view the minute data on the data logger:
   - Select “D” (display real-time)
   - Select “C” (continuous average report)

3. On the calibrator
   - Press the Diags button
   - Toggle to Flows
   - Record the flow in the appropriate box on the elog

4. On the monitor
   The data logger and analyzer outputs should read approximately the expected concentration (400ppb) to within ± 5% on the SO₂ channel. Adjust the analyzer span by doing the following:
   - Press the Menu button and use the arrows to select Calibration. Press Enter.
   - Use the arrows to toggle to Cal SO₂ Coefficient and press Enter.
   - The first line of the display shows the current SO₂ reading, and the third line shows the calibration gas concentration. To adjust the calibration gas concentration, use the left and right arrow buttons to move the cursor to a different digit. Use the up and down arrow buttons to adjust each digit to the true SO₂ Span 1 concentration.
   - Press Enter to calibrate the analyzer to the true 146i “Output PPB” display SO₂ calibration gas concentration. The screen will flash the message “Saving” and will display the corrected SO₂ reading.
   - Record this value on the elog as the “SO₂ Coefficient” AFTER CALIBRATION. Press Run to return to the Run screen.
   - Allow the monitor to stabilize and then record the next five one-minute data logger concentration values on the elog. The elog will compute the average of these five one-minute values. If the values are not within ± 5% of the “True Span 1 concentration”, repeat steps 2, 3, 4, and above.
4. To stop the Span 1 gas flow on the data logger:
   - Press <ESC> to go back to the main screen
   - Select “C” (Configuration Menu)
   - Select “C” (Calibration Menu)
   - Select “W” (Abort Cal)
   - Select SO2CAL and press Enter

C) Calibration Verification Procedure:
The purpose of this procedure is to verify the linearity of the monitor at multiple concentrations after the completion of a calibration.

Span 1 average values from the “Span Procedure” and the average Zero values from the Zero procedure under “Calibration” may be used if “passing”. This will eliminate having to repeat these two points.

1. Select “C” (Configuration Menu)
2. Select “C” (Calibration Menu)
3. Select “1” (start single phase calibration)
4. Select “SO2CAL”
5. Select “SPAN0”
6. Change Phase Duration to 1 hour and press Enter
7. Press Enter when “Start Single Cal NOW” is highlighted
8. Hit <ESC> twice to return back to home menu
9. Select “D” (Display real-time)
10. Select “C” (Continuous average report)
11. Allow the instrument to stabilize for a minimum of 10 minutes and produce a stable reading. Record the 5 one-minute values following the 10-minute stabilization period from the data logger on the elog. The elog will compute the average of these five one-minute values.
12. Abort the completed Span point by hitting <ESC> on the data logger until the home screen is reached.
13. Select “C” (Configuration Menu)
14. Select “C” (Calibration Menu)
15. Select “W” (Abort Calibration)
16. Enter when the cursor is on “SO2CAL”, press Enter.
17. Hit <ESC> until the home screen is reached.
18. Repeat steps 1 – 8 for Span1, Span2, and Span3. Replace Span0 in step 5 with the applicable Span level.

NOTE: The average zero on the data logger must be within $\pm 2$ ppb of the true value. The concentration displayed on the data logger for Span 1 and Span 2 must be
within ± 5% of the true value. The concentration displayed on the data logger for Span 3 must be within ± 3 ppb of the true value. See Table 1 for a summary of Span Values and Acceptance Criteria.

### Table 1: Acceptance Criteria for Calibrations and Daily Auto-Calibration Checks

<table>
<thead>
<tr>
<th>Operation</th>
<th>Concentration (^A) / Acceptance Criteria</th>
<th>SPAN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Zero</td>
</tr>
<tr>
<td>Daily Auto-Calibration Check</td>
<td>Concentration (ppb)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Acceptance (±)</td>
<td>1 ppb</td>
</tr>
<tr>
<td>Calibration and Calibration</td>
<td>Concentration (ppb)</td>
<td>0</td>
</tr>
<tr>
<td>Verification</td>
<td>Acceptance (±)</td>
<td>1 ppb</td>
</tr>
</tbody>
</table>

\(^A\) Concentrations are nominal values  
\(^B\) Span 2 for Daily Auto Calibration is not used  
\(^C\) Span 3 value must be between 10 and 100 ppb per EPA

### Table 2: Acceptance Criteria for Manual Calibration Checks

<table>
<thead>
<tr>
<th>Operation</th>
<th>Concentration (^A) / Acceptance Criteria</th>
<th>SPAN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Zero</td>
</tr>
<tr>
<td>Manual Calibration Check</td>
<td>Concentration (ppb)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Acceptance (±)</td>
<td>1 ppb</td>
</tr>
</tbody>
</table>

\(^A\) Concentrations are nominal values  
\(^B\) Not Applicable  
\(^C\) Note that S-4 has been substituted for S-3

If any calibration points are not within specification with respect to the criteria given in Table 1 or Table 2, the calibration (or check) is not acceptable and must be re-run to identify and correct any problems. If a second attempt fails, contact the ECB for guidance.
2.8.2.2.4 Manual Calibration Check

The purpose of a calibration is to correlate the output of a monitoring system with known traceable concentrations of SO$_2$. The purpose of a calibration check is to periodically check or verify that the monitor’s calibration has not changed. The EPA refers to calibration checks as “One Point QC-Checks” and requires that they be performed at least once every 14 days. DAQ uses daily auto-calibration check results in lieu of the 14-day manual calibration check. In order for the auto-calibration checks to be a successful substitute, certain activities must be followed.

- Continued daily review (by the regional office) of the daily auto-calibration check results which occur in the early morning hours of each day
- A three (3) point daily auto-calibration check using Zero Air, Span 1 (400 ppb) and Span 3 (20 ppb) as listed in Table 1
- The submittal of all valid 1-pt QC Check results from the daily auto-calibration check to the AQS by the Central Office. No reporting action is required by the Regional Office
- The elimination of the quarterly AQ-98 form for SO$_2$ which was used to report the results of the 14-day 1-pt QC checks
- Immediate action is required by the operator if one or more of the three (3) Span Points listed in Item 2 above are outside of the acceptance criteria provided in Table 1 for two (2) consecutive days. This immediate action will be taken on the second of the two consecutive days experiencing an out-of-control situation. If the consecutive days fall on a weekend or extended weekend then action must take place on the first work day following such a period
- Immediate action will consist of performing an “investigative” manual calibration check (called SO2MAN on the data logger) using the four points provided in Table 2 which include Zero Air, Span 1 (400 ppb), Span 2 (100 ppb) and Span 4 (70 ppb). This manual calibration check should ideally be performed at the monitoring site, but may be performed remotely from the regional office using ECB assistance.

  NOTE: Span 4 is a substitution for Span3 in the manual calibration check procedure and is run at 70 ppb. The change is necessary in order to distinguish a manual calibration check from the 1-pt QC check which must be reported to AQS.

- A manual calibration is required if the manual calibration check confirms an out-of-control situation.

The procedure for performing a manual calibration check is provided below.

NOTE: No checks that affect data are to be made during periods of ambient exceedances.

A) Manual Calibration Check Procedure

A manual calibration check must be performed if the daily auto-calibration check results are outside of the acceptance criteria for two consecutive days. Make no monitor
adjustments before the calibration check. Conduct a manual calibration check as follows:

1. Down the SO2 channel on the data logger.
2. Press <Esc> <Esc> to return to main menu.
3. Select “D” (display real-time).
4. Select “B” (base average one minute). Updated data should display a (D) indicating that the channel is downed.
5. On the data logger, press <Esc> <Esc> to return to Home Menu.
6. Select “C” (Configuration Menu).
7. Select “C” (Calibration Menu).
8. Select “1” (start single phase calibration).
9. Select “SO2MAN” to view the options for the manual calibration check.
10. Select “SPAN0”.
11. Change “Phase Duration” to 1 hour.
12. When “Start Single Cal NOW” is highlighted, press Enter.
13. Press <Esc> <Esc> to go back to the Home Menu.
14. Select “D” (display real-time).
15. Select “C” (for minute data).
16. Hit Enter four times to start the continuous report.
17. Allow the monitor to stabilize at least a minimum of 10 minutes and then record in the elog the next five one-minute data logger concentration values.
18. Stop Span0 on the data logger by pressing <ESC> until the logger reaches the main menu.
19. Select “C” (Configuration Menu).
20. Select “C” (Configure Calibrations).
22. Select SO2TCAL and press Enter.
23. Press <ESC> twice to return to the home menu.
24. Repeat steps 5 – 23 for Span1, Span2, and Span4, ensuring that the correct span level is selected under SO2MAN.

Record each result in the elog. The zero on the data logger must be within 0 ± 1 ppb. The concentration displayed on the data logger for Span 1, Span 2 and Span 4 must be within ± 5 % of the true value. See Table 2 for a summary of the Acceptance Criteria.

If the manual calibration check is found to be unacceptable, then conduct the required manual calibration.

The SO2 channel can be enabled after the completion of the manual calibration check using the following steps:
1. Hit <ESC> until the data logger has reached the main menu.
2. Select “C” (Configuration Menu).
3. Select “D” Configure (Data Channels).
4. Select “E” Enable/Mark Channel Online.
5. Select “SO2” and Press <ENTER>.
6. Hit <ESC> until the data logger has once again reached the main menu.

2.8.2.5 Data Retrieval and End Processing
Every month, the CO statistician initiates a data review by providing a raw data report (in a spread sheet format) to each Regional Office (Reference Section III: Regional Office Polling and Data Review and Section IV: Data Review and Validation QA Plan for Continuous Gaseous and Non-Speciated Particulate Monitors for details on data review). The CO may request the Regional Office to send additional data that are needed beyond what the CO requires for verifying any missing data supplied by the Regional Office. These data can be retrieved from the “site computer” if needed.

When finished, exit to the “Home Menu” on the data logger, by pressing <Esc> and <Esc>. Verify the flags are cleared and the channel is enabled by pressing "D" and then "F". If the flags are cleared, press ESC and ESC to go back to the home menu, press “O” (Log out).

2.8.2.3 File Management
Field operators must have a PC (or lap top) to generate the elog files from a Microsoft Excel template file. The SO$_2$ “Logbook”, “Calibration” and “Cal Check” elog sheets are provided by the Central Office and updated periodically. The file naming protocol is provided below.

A formalized file naming convention has been established through consensus of the regions and the Central Office and should be used by all regions.

2.8.2.3.1 Opening, Naming and Storing the site files
The elog template file used at the site should be stored on the PC used for field operations by the field technician. Elogs can also be found in IBEAM or on the Ambient network drives. To access this file, open the elog template file using Excel. Every time a new elog is filled out using the template, it must be renamed and saved as a separate and complete workbook (all sheets, i.e., tabs, saved) to preserve the record. Do not copy over a previously completed elog (Refer to the Logbook file naming convention “Policy Memorandum” dated January 1, 2011 which is located in the DAQ IBEAM module and summarized below.)
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November 1, 2016
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2.8.2.3.2  Data Handling and Validation
All site files generated in the field will be stored on a dedicated server in the Regional Office, in a folder named for the SO₂ official operations files (Example: BV_SO₂_Official Files). These files should be transferred to the Official File on a frequent and regular schedule as established by the Region. This is necessary to prevent the potential loss of such files from the field computer and to maintain a “paper trail” for providing defensible data. This also makes the data easily and readily available for review by the Regional Chemist and transfer to the P: drive for review by the Central Office. The files on the site/operator PC can be copied and transferred to the common hard drive and/or be transferred as attachments in email for storage in the official folder.

The site files should be transferred every two weeks, and backed up on a monthly basis. This serves as a backup system in the event the official PC fails or is removed or the site files are damaged. These files will be retained for a minimum of five years. When the need arises to review a file for data validation or site operations the official folder is used or a hardcopy is created from this file. For details on data validation procedures, please reference Section III (SOP 2.8.3): Regional Office Polling and Data Review and Section IV (SOP 2.41.4): Data Review and Validation QA Plan for Continuous Gaseous and Non-Speciated Particulate Monitors.

2.8.3.2  SO₂ Monthly Data Summary Validation
Monthly data summaries are provided to the Regional Offices (ROs) by the CO in an electronic format using a Microsoft Excel spread sheet. At the end of the descriptive file name provided to the RO will be the number _1 (example: descriptive file name _1.xls). The RO must open this file, rename the file by changing the number _1 to _2 and then save the file. After the RO has reviewed and edited the data, the edited file (_2) is resaved to the shared P: drive. This edited file is reviewed by the CO, edited further if needed after consultation with the RO and then saved after renaming the file using a _3. The fully edited file data are then uploaded into AQS by the CO.
The validation checks that will be done are:
1. Providing proper null codes indicating calibrations, audits etc.
2. Providing missing valid data.
3. Documenting any invalid data as to reason with proper null code.
4. Identifying any data that may be associated with exceptional events.

In some cases, “valid” data that are judged to be out of the ordinary are retained and an informational flag is added in AQS by the CO. An example would be high concentration values resulting from an exceptional event. EPA has recently begun applying stricter standards for what it will accept as an exceptional event. In any case where the Region wishes data to be considered “exceptional”, the Region should gather sufficient documentation to support the claim in accordance with a policy memorandum from the CO dated June 29, 2007. Unusually high concentration values that may be the result of an exceptional event must be noted as such on the AQS monthly data summary reports, but not deleted. Any exceptional event data will be flagged in AQS by the Central Office using the appropriate qualifier code.

A list of Null Codes that are routinely used during data validation on the AQS monthly summary report is found in Table 3.

<table>
<thead>
<tr>
<th>Null Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE</td>
<td>Shelter Temperature outside Limits</td>
</tr>
<tr>
<td>AN</td>
<td>Machine or Equipment Malfunction</td>
</tr>
<tr>
<td>AS</td>
<td>Poor Quality Assurance Results</td>
</tr>
<tr>
<td>AT</td>
<td>Calibration (by ECB)</td>
</tr>
<tr>
<td>AV</td>
<td>Power Failure</td>
</tr>
<tr>
<td>AZ</td>
<td>QC (ECB) Audit</td>
</tr>
<tr>
<td>BA</td>
<td>Maintenance and Routine Repairs (including filter changes)</td>
</tr>
<tr>
<td>BC</td>
<td>Multi-point Calibration</td>
</tr>
<tr>
<td>BD</td>
<td>Auto Calibration</td>
</tr>
<tr>
<td>BF</td>
<td>Precision/Zero/Span</td>
</tr>
<tr>
<td>BJ</td>
<td>Operator Error</td>
</tr>
<tr>
<td>BK</td>
<td>Site Computer/Data Logger Down</td>
</tr>
</tbody>
</table>
2.8.2.4 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 SO₂ analyzer throughout document to reflect the state wide change in instrumentation.
5. Thermo 43i-TLE was added throughout document, as it can be used interchangeably with the Thermo 43i SO₂ analyzer if both are run on a 500 ppb scale.
6. Passwords were removed throughout document.
7. Zero Air Pack changed to Teledyne Zero Air Generator Model 701 to reflect the statewide change in instrumentation.
8. Updated references from EDAS to AV-Trend throughout document.
9. Updated Section 2.8.2.1 to reflect current regulations.
10. Updated Instrumentation and Equipment list for Continuous SO₂ Monitoring in Section 2.8.2.1.1.
11. Added reference to Section I: ECB Responsibilities for set-up and plumbing diagrams.
13. Clarified the calibration check points for NC DAQ in Section 2.8.2.1.2.
14. Changed requirement for maximum number of days without power (for weather or for shelter repairs) before a calibration is required from 7 days to 2 days per EPA recommendation.
15. Changed requirement for minimum site visit frequency from every 14 days to every 28 days.
16. Clarified tasks involved in site visit in Section 2.8.2.1.3.
17. Added Figure 1: Diagram of the 43i and 146i front panel buttons and Figure 2: Diagram of the Thermo 43i rear panel to Section 2.8.2.1.3.
18. Added instruction to Section 2.8.2.1.3.B to ensure that the air conditioning unit is not blowing directly onto the sampling line.
19. Added reference to Section I: ECB Responsibilities in Section 2.8.2.1.3.B for the procedure for sample line integrity checks, along with who will perform them.
20. Updated the length of calibrator certification from nine months to twelve months.
21. Added instruction to Section 2.8.2.1.3.C for checking and recording the cylinder SO₂ concentration that is stored in the Teledyne 700U or Thermo 146i calibrators and for not using the cylinder if the pressure is below 200 psi.
22. Added Section 2.8.2.1.3.D with instruction on how to toggle Service mode on and off on the Thermo 43i SO₂ analyzer. Removed all references to Local and Remote modes, as they are not applicable for the i model analyzer and calibrator.
23. Reorganized Section 2.8.2.1.4 for easier comprehension.
24. Added Alarm Checks for the Teledyne 700U calibrator to Section 2.8.2.1.4.A.
25. Added Figures 3, 4, and 5 - Thermo 43i SO₂ analyzer flowchart, Thermo 146i calibrator flow chart, and Teledyne 700U Calibrator flow chart.
26. Updated diagnostic checks in Section 2.8.2.1.4.C.
27. Updated Section 2.8.2.1.4.D to reflect new procedures for the 701 Zero Air Generator.
28. Updated Section 2.8.2.1.5 with new instruction on how to determine computer clock time, data logger time, and AV-Trend time, along with how automated time sync task. Removed instruction on setting the site computer and data logger times manually.
29. Removed the requirement in Section 2.8.2.1.5 for the site computer to be set 5 minutes behind the data logger, as this is no longer necessary to collect backup data.
30. Added instruction to record all relevant times and dates in the electronic logbook.
31. Clarified filter change procedure in Section 2.8.2.2.1. Added requirement to perform a leak check on the Span and Sample ports before and after changing the filter.
32. Clarified the leak check procedure in Section 2.8.2.2.
33. Added clarification to when a manual calibration is required in Section 2.8.2.2.3.
34. Updated Section 2.8.2.2.3.A for the Zero procedure portion of the calibration to include more detailed instructions.
35. Updated Section 2.8.2.2.3.B for the span procedure portion of the calibration to include more detailed instructions.
36. Added detailed instructions to Section 2.8.2.2.3.C for the calibration verification procedure.
37. Updated Table 1 and 2 to include tighter acceptance criteria for the zero as a part of the daily auto-calibration check and the manual calibration check. Also updated Table 1 for the lower Span 3 point, as required by Appendix A from 40 CFR Part 58.
38. Clarified instruction in Section 2.8.2.2.4 for the requirement and acceptance of the daily auto-calibration check.
39. Updated Section 2.8.2.2.4.A with detailed instruction on the manual calibration check procedure.
40. Updated Section 2.8.2.3.1 with the location of blank electronic logbooks.
41. Added references to Section III (SOP 2.8.3): Regional Office Polling and Data Review and Section IV (SOP 2.41.4): Data Review and Validation QA Plan for Continuous Gaseous and Non-Speciated Particulate Monitors to Section 2.8.2.3.2.
42. Added additional commonly used EPA and AQS null void codes to Table 3 in Section 2.8.3.2.3.
43. Moved revisions to Revision History under Section 2.8.2.4.
44. Updated Schedule of Activities in Appendix A.
45. Removed Appendix with instructions for silica gel change procedures, as this is no longer applicable with the new Teledyne Model 701 Zero Air Generator.
46. Added Appendix B with instructions on how to graph minute data in AV-Trend.
APPENDIX A

Schedule of Activities
## Schedule of Required Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Daily</th>
<th>Every 28 Days</th>
<th>Section Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review data and daily auto- calibration results</td>
<td>X</td>
<td></td>
<td>2.8.2.3.3</td>
</tr>
<tr>
<td>Site visit</td>
<td></td>
<td>X</td>
<td>2.8.2.1.3</td>
</tr>
<tr>
<td>Logger/Computer data/time check</td>
<td></td>
<td>X</td>
<td>2.8.2.1.5</td>
</tr>
<tr>
<td>Verify Shelter Temperature</td>
<td></td>
<td>X</td>
<td>2.8.2.1.3</td>
</tr>
<tr>
<td>Manual Calibration Check</td>
<td>(As needed)</td>
<td>(As needed)</td>
<td>2.8.2.2.4</td>
</tr>
<tr>
<td>Change Filter</td>
<td></td>
<td>X</td>
<td>2.8.2.2.1</td>
</tr>
<tr>
<td>Perform Leak Check</td>
<td></td>
<td>X</td>
<td>2.8.2.2.2</td>
</tr>
<tr>
<td>Manual Calibration</td>
<td>(As needed)¹</td>
<td>(As needed)¹</td>
<td>2.8.2.2.3</td>
</tr>
</tbody>
</table>

¹ Manual calibration is required at least every 365 days per EPA guidance.
Appendix B

Real-Time Minute Data Graphing in AV-Trend
Real-Time Minute Data Graphing in AV-Trend

1. Link to the data logger in AV-Trend.
2. In the Configuration Editors menu, select Task Scheduler.
3. There may be more than one task already created within the Task Scheduler, but each site should already have a task created to poll minute data. The ECB has set up a task, called ‘Graphing Poll’ on AV-Trend to be activated when needed. The task should not be enabled during normal operation. If the check box under the Task Enabled column is not checked, click on the task and then press the save button (the floppy disk at the top of the screen). The details of the task will appear in the bottom half of the AV-Trend screen.

4. Using the data logger window, navigate through your procedure as normal to start an event (calibration, calibration check, etc.).
5. Select Status Displays in the bottom of the left hand column, and then select Real-time Data Trending.
6. In the **Real-time Data Trending** window, select the site parameter(s) that is to be monitored.

7. In the drop down menu for **Average Interval**, select 001m – Minute average from instantaneous.

8. In the setting for **Number of Hours in Lookback**, select 1. This is the option for how far back the graph will be plotted.

9. Ensure that **Dynamic Scaling** is checked.

10. Select **Auto Refresh** from the top of the screen. This will automatically update the graph with minute data.

11. If the **Show Grid** and **Show Chart** buttons are selected at the top of the screen, data will begin populating the window.
12. Select **Print/Export Chart** to save the graph. In the top right corner are two PDF options. Select the first PDF option to save onto the CPU, removable data, or in any other desired destination.

13. When graphing the minute data is complete, disable the ‘Graphing Poll’ task in the **Task Scheduler** screen by highlighting the task unchecking the Task Enable box below. **Make sure to press the save button (floppy disk icon at the top of the screen) to complete disabling the task.**