FORSYTH COUNTY OFFICE OF ENVIRONMENTAL ASSISTANCE AND PROTECTION

STANDARD OPERATING PROCEDURE (SOP)

Sulfur Dioxide (SO2)

Signature Page

By the signatures below, the Forsyth County Office of Environmental Assistance and Protection (FCEAP) certifies that the information contained in the following Standard Operating Procedure (SOP) is complete and fully implemented as the official guidance for our Office. However, due to circumstances that may arise during the sampling year, some practices may change. If a change occurs, a notification of change and a request for approval will be submitted to EPA Region 4 at that time.

Name: __Cary Gentry__ Signature: _____ Date: 5/17/16
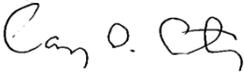
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Title: _____

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REVISION	DATE	CHANGES TO SOP

STANDARD OPERATING PROCEDURES FOR SULFUR DIOXIDE (SO$_2$)

Forsyth County Office of Environmental Assistance and Protection

3.0 Introduction

All equipment, chemicals, field operating procedures, and laboratory operating procedures for the continuous measurement of sulfur dioxide in the atmosphere using the pulsed fluorescence method are selected and performed according to (equivalent method) EQOA-0486-060 requirements. The following procedure manual is to be used as a supplement to the Code of Federal Regulations (CFR). Siting and various quality assurance (QA) procedures are followed in accordance with the Code of Federal Regulation Title 40 Part 50, Part 58 and EPA-454/B-13-003: Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II Ambient Air Quality Monitoring Program.

This "Standard Operating Procedure" (SOP) will provide guidance for the monitoring of SO$_2$ using the ESC 8832 datalogger, Thermo Environmental Instruments, Inc. 43i-tle Analyzer (Equivalent Method Number: EQOA-0486-060), Teledyne API 700EU Dynamic Dilution Calibrator and a Teledyne API T701H Zero Air Generator

3.1 Procurement of Calibration Standards, Zero Gases, and Monitoring Instrumentation

3.1.1 General Information

3.1.1.1 Calibration standards include known concentrations of sulfur dioxide used for calibrations, audits, precision checks, and span checks.

3.1.1.2 All calibration, audit, precision, and gas standards must be traceable to National Institute of Standards and Technology (NIST) Standard Reference Materials (SRM) or NIST/EPA

approved commercially available certified Reference Materials (CRM); using EPA approved traceability Protocols. A ̈Certificate of Analysis ̈ must accompany each gas certified to EPA Protocols. A copy of these certificates should be kept in the office by the QA staff member who oversees gas cylinder renewals. The API 700EU calibrator's Mass Flow Controllers (MFCs) must have their flow certified every 6 months and when necessary, calibrated to match a NIST traceable flow device. The flow certification process is covered in the Calibrator Operation SOP found in Section 12.

3.1.1.3 Zero Gases are not certified to NIST standards but must meet specific requirements (See section 3.1.2.7) and operate in good working order.

3.1.1.4 Monitoring instrumentation must be an EPA reference or equivalent method meeting the requirements specified in 40 CFR Part 53 and 40 CFR Part 58 Appendix C.

3.1.2 Specifications for Calibration Standards, Zero Gases and Monitoring Instrumentation

3.1.2.1 Calibration gases to be diluted by means of a dynamic calibration system shall contain a known concentration of SO_2 in nitrogen.

3.1.2.2 The specific concentration of a calibration standard must be certified according to EPA traceability protocol. This must be stated on the purchase order when ordering calibration gases.

3.1.2.3 Sulfur dioxide concentrations to be diluted by means of a dynamic calibration system are to be within the range of 6 - 60 ppm SO_2 in nitrogen. FCEAP runs on a 0-100 ppb range. SO2 hourly levels at the Hattie Ave. site rarely exceed 10 ppb and the highest average we have seen over the last 7 years was 31ppb. Therefore, we feel comfortable operating at the 0-100 range. The lower range also gives finer definition to the low ambient values we typically measure.

3.1.2.4 SO2 concentrations used for multi-point verifications/calibrations are produced by a verified calibration standard calibrator. Multi-point calibrations consist of a zero and 4 upscale points, the highest being a concentration of 80%-90% of the calibration scale range of the analyzer. The points are listed below.

> Point 1: 0 ppb SO_2 (Zero)
>
> Point 2: 90 ppb SO_2 (Span)
>
> Point 3: 70 ppb SO_2 (Mid-point)
>
> Point 4: 40 ppb SO_2 (Precision)
>
> Point 5: 30 ppb SO_2 (Low-point)

3.1.2.5 Audit concentrations must be produced by a system independent of the routine calibration system. A minimum of zero and three upscale points should be chosen to bracket 80% of the ambient data if at all possible. The points chosen must be in the following ranges, contained within the operational range that the FCEAP uses, which is 0-100 ppb. For FCEAP, two of the points chosen must be in the two required levels in the following ranges. Additional points can be added and run in any other level.

> Level 1: 0.3-2.9 ppb SO2
>
> Level 2: 3.0-4.9 ppb SO2 (required)
>
> Level 3: 5.0-7.9 ppb SO2
>
> Level 4: 8.0-19.9 ppb SO2
>
> Level 5: 20.0-49.9 ppb SO2
>
> Level 6: 50.0-99.9 ppb SO2 (required)
>
> Level 7: 100.0-149.9 ppb SO2 (Over FCEAP range)
>
> Level 8: 150.0-259.9 ppb SO2 (Over FCEAP range)
>
> Level 9: 260.0-799.9 ppb SO2 (Over FCEAP range)
>
> Level 10: 800.0-1000.0 ppb SO2 (Over FCEAP range)

Audit standards must be independent of the standards used for calibrations/verifications.

3.1.2.6 Sulfur dioxide concentrations used to perform precision checks must be in the range of 5-80 ppb SO$_2$.

3.1.2.7 Zero air to be used for calibrations, 90-day verifications, bi-weekly Zero/Span/Precision (ZSP) checks, nightly auto-calibrations, and audits must be free of contaminants, which will cause a detectable response on the SO2 analyzer. The zero air should contain < 1.0 ppb of SO2. A series of drierite columns or similar containers loaded with purafil, silica gel, charcoal, hopcalite, and molecular sieve is used to scrub compressed air. The compressed air is routed through a 5 μm Teflon filter.

Audit zero air is provided by a pump (diaphragm or oil-less piston) moving air through a series of scrubbers. The audit zero air is dried with silica gel, then scrubbed through purafil and charcoal. The audit zero air is finally filtered through a 5 μm particulate filter.

3.1.3 Gas Standard and Initial Instrument Checks

3.1.3.1 Upon receipt of gases, check to ensure that the certificate of analysis is included with each cylinder.

3.1.3.2 Check the concentration on the cylinder label against the concentration on the certificate for each cylinder.

3.1.3.3 Thoroughly check each gas cylinder to ensure that all specifications have been met by running a ZSP check on an up to date, calibrated, analyzer. Reject any gases that do not pass specifications and return them to the supplier.

3.1.3.4 Upon receipt of cylinder gas standards the following information must be clearly marked on the cylinder by affixing a tag to the cylinder:

> a: ID Reference Number
> b: Cylinder contents
> c: Cylinder concentrations
> d: Analysis and Expiration date
> e: Cylinder usage (i.e. - cal, span, precision, etc.)

Cylinder standards must not be used after the expiration date until recertified.

3.1.3.5 SO2 instrumentation must meet the requirements of the Technical Assistance Document for Precursor Gas Measurements (EPA -454/R-05-003, September 2005) or be an equivalent method as described in 40 CFR, Part 53. A list of EPA designated reference and equivalent methods is available from EPA.

> a: An EPA designation sticker must be affixed to the instrument.
>
> b: A factory manual must accompany the instrument.
>
> c: A record or log (hardcopy) of all maintenance done to the analyzer must be kept in the pocket on top of the analyzer. Update digital copy on shared drive as well.
>
> d: Instrument must be tested and performance documented in the FCEAP master Excel spreadsheet containing all check records for network equipment. This document is located in the S:\A&M\Repair Supplies and Logs\Instruments checks folder and is called SO2 Analyzer In-Lab checks.xls. Below is the layout:

SO2 Analyzer check

In lab checks only (these checks do **NOT** replace z/s/p checks, calibrations or audits!)
These checks are only to verify that the instrument is approximately reading what it is supposed to read.
Use after maintenance and repairs or to test a new instrument when receiving.

Date	7/7/2015		Initials	RA

Reason for checks

This is a new instrument, first check after receiving instrument.

	Instrument	SN
Generating	T700U	128
Reading	T100U	179
Gas Cylinder	CC367593	

	zero 0	span 90	mid 70	prec 40	low 30
generate	0	92.3	72	39	29.2
gen. lpm	3	3	4	4	4
read	-0.026	93.827	71.564	38.851	28.699
stability	0.012	0.081	0.04	0.0984	0.016
ppb diff	-0.03	1.53	-0.44	-0.15	-0.50
% diff	na	-1.63	0.61	0.38	1.75
		OK	OK	OK	OK

Observations

All point keeping a slow upward trend in 0.01-0.1 ppb steps after reaching the stated stability. The lower points (40 and 30 ppb) were much quicker at reaching a good stability.

After calibration, if 4% error tolerances are not met, inform the Program Manager and contact the manufacturer.

3.2 Initial Monitor Setup

3.2.1 Site Requirements

To ensure the uniform collection of air quality data, various siting criteria must be followed. 40 CFR 58 Appendix E outline these criteria. The criteria are summarized below for neighborhood spatial scales for SO2.

3.2.1.1 The sample inlet must be located 2-15 m above ground and a distance from the supporting structure > 1 m.

3.2.1.2 The probe inlet must be > 10 meters from the drip line of trees that are located between the urban city core and along the predominant summer daytime wind direction.

3.2.1.3 The distance from the probe inlet to any obstacles such as buildings must be at least twice the height the obstacle protrudes above the probe inlet.

3.2.1.4 There must be unrestricted airflow 270° around the inlet probe, or 180° if the probe is on the side of a building. The 270° arc must include the predominant wind direction, and for the

Winston-Salem area, the primary wind direction is from the SW.

3.2.1.5 The sample line should be as short as practical and should be constructed of FEP Teflon.

3.2.1.6 If the above siting criteria cannot be followed, it must be thoroughly documented and a waiver requested from the Air, Pesticides and Toxics Management Division (APTMD) of the USEPA. A complete site evaluation including all dimensions, pictures, maps, and the monitoring objective should be prepared as the site is being set up. This documentation should be maintained in the annual monitoring network plan.

3.2.2 Monitor Installation - Thermo Model 43i-tle SO₂ Analyzer

3.2.2.1 The analyzer should be placed on a sturdy table or in an appropriately sized instrument rack.

3.2.2.2 The table or rack should be as vibration free as possible.

3.2.2.3 The analyzer must operate within the temperature range of 20 - 30 C.

3.2.2.4 A verified thermometer should be installed near the analyzer to observe temperature readings to insure that temperature criteria are met. It is polled and checked along with other data to make sure it falls within limits. Identify and correct problem if it is not within limits. The thermometer will be verified semi-annually to ensure proper function (Fig 1).

Figure 1: Site temperature device

3.2.2.5 Connect ambient air to be measured to the bulkhead connector labeled "SAMPLE" on the rear panel of the instrument. Care should be taken to see that dirty, wet, or incompatible materials in the sample lines do not contaminate the sample. Teflon tubing with an OD of 1/4" and a minimum ID of 1/8" is required for all sample lines. The length of the tubing should be held to a minimum.

3.2.2.6 Confirm that a 5-µm Teflon particulate filter is installed in the filter holder and the holder is connected to the sample line before the sample port.

3.2.2.7 Plug in analyzer into a surge protected power supply.

3.2.2.8 Turn on power switch.

3.2.2.9 Check that the instrument is booting the firmware. Let it warm up for at least 1 hour. Use the menu on the front panel to check the instruments diagnostics. If the sample flow is outside its ranges, check for blockages, pump condition, and/or leaks.

3.2.2.10 Connect the calibration standard gas produced from the calibrator to the SO2 solenoid (Fig 2) valve that feeds SO2 calibrator concentrations to the sample probe box outside the building via a Teflon (FEP) line with OD of 1/4" and a minimum ID of 1/8". The transfer standard will send SO2 concentrations up the cal gas line into the probe box to a "tee". The tee is also connected to the short inlet line that goes to the inlet funnel and the sample feed going to the analyzer. In ambient operation the analyzer pulls ambient air from the inlet line and the cal gas line is sealed by the solenoid. In calibration operation the transfer standard supplies SO2 concentrations through the solenoid and cal gas line up to the probe box. The analyzer pulls what it needs through the sample line and the inlet line becomes the vent for the excess cal feed. The entire sample path except the short inlet line (less than 12") is used during all reportable QC/QA checks.
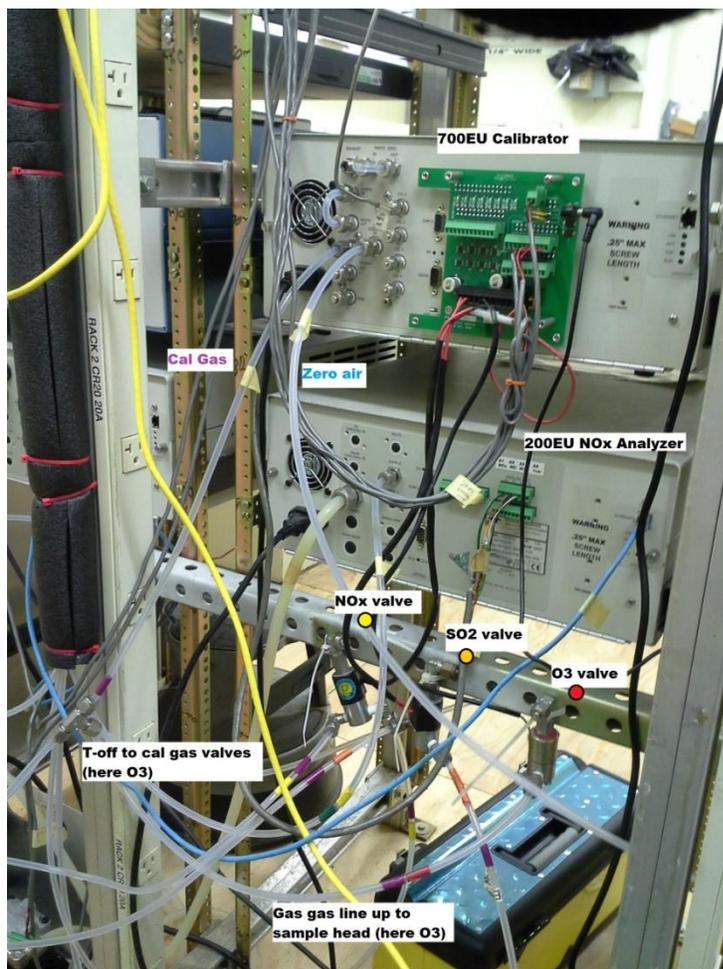
Figure 2: Plumbing behind the calibrator

3.2.2.11 An ESC 8832 Datalogger is used as the Datalogger. The Thermo SO2 Analyzer is connected to the 8832 through an analog connection. Configurations for individual channels are programmed into the 8832 Datalogger, site computer, and Office polling computer. Refer to Section 11 Datalogger 8832 SOP for more information. Check that the Datalogger channel has been properly initialized as follows:

3.2.2.11.1 To Login into the 8832, open 'HyperTerminal' on the PC and connect to the 8832 through the appropriate COM port or by using the correct IP address.

Type Esc 'site ID' AQM to enter Login screen.

Site ID in the Forsyth County Network:

> Clemmons Middle (CM)
>
> Hattie Avenue A (HA)
>
> Hattie Avenue B (HB)
>
> Peter's Creek (PC)
>
> Shiloh Church (SC)
>
> Union Cross (UC)

Press L (Login), type password, press Enter. Then press C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration). Press Enter to see the channel configurations.

3.2.2.11.2 Check the channel configuration entries (Fig. 3) to ensure that they correspond to the entries listed below:
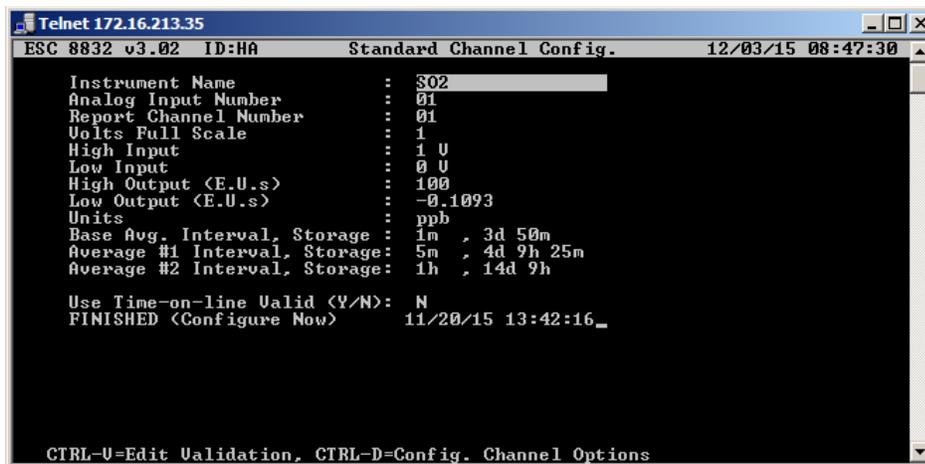
Figure 3: 8832 SO2 channel configuration

3.2.3 Analyzer Datalogger setup with iPort software

3.2.3.1 The analyzer should be programmed using the iPort software supplied from the manufacturer. Program the Long Records (LREC) to be 1 hour in length and the Short Records (SREC) to be 1 minute in length. See 43i-tle manual for details. Store both records for at least an 800 count to cover the necessary length of time between site visits.

3.2.4 Initial Analyzer Checks and Adjustment

3.2.4.1 Install 43i-tle into an instrument rack or place analyzer on a tabletop where the unit can run. Plug power cord into the 43i-tle and attach sample line to the sample port.

3.2.4.2 Turn power switch to 'ON'. The instrument will display the 'Power-Up' and 'Warm-Up' screens while the instrument is warming up and conducting self-tests. Let the instrument warm up for at least 1 hour.

3.2.4.3 Check the Gas Units. Press Menu, press Enter when arrow is next to "Gas Units". Set units to ppb.

3.2.4.4 Check the range. Press Menu and then arrow down to Range and press Enter. The range has the option of Single, Dual, or Autorange mode. Set to single range from 0-100 ppb.

3.2.4.5 Activate pressure and temperature correction. Actuate the "MENU" push button. Scroll to "INSTRUMENT CONTROLS". Choose "INSTRUMENT CONTROLS". Press "TEMP CORRECTION". Press enter if "TEMP CORRECTION" is off. This will turn on the "TEMP CORRECTION". To exit this menu after setting "TEMP CORRECTION" on, press "MENU". Choose "PRESSURE CORRECTION". Set pressure correction to on and exit this choice as instructed above for "TEMP CORRECTION".

3.2.4.6 Check Flash Lamp. From the Main Menu choose Instrument Controls. Then choose Flash Lamp. The Flash Lamp must be off when using the optical test LED.

3.2.4.7 Check the Temperatures. From the main menu, scroll down to "DIAGNOSTICS" and hit enter. Then choose "TEMPERATURES". The Internal temperature should be between 8.0°C and 47.0°C. The Chamber Temperature should be between 43.0°C and 47.0°C.

3.2.4.8 Check the Pressure. When in "DIAGNOSTIC", choose "PRESSURE". The pressure should be >700 mmHG.

3.2.4.9 Check the Flow. When in the "DIAGNOSTIC" menu, choose "FLOW". The flow should be between 0.350 LPM and 1.500 LPM. The flow should be near 0.500 LPM.

3.2.4.10 Check the Intensity. From the "DIAGNOSTIC" menu, choose "LAMP INTENSITY". The acceptable range is 10,000 to 50,000 Hz.

3.2.4.11 Perform a leak test in the sample mode by capping off the sample air inlet at the filter inlet fitting in the probe box on top of the site building. The pressure should drop to less than 200 Hg and the flow should read Zero. If not, the system has a leak. Trace each flow line and check all fittings for tightness. Retest. DO NOT PRESSURIZE THE SYSTEM.

3.2.4.12 After conducting steps within 3.1.3 and 3.2.4 under Initial Analyzer Checks and Adjustments the monitor can be placed into operation and a calibration performed.

3.3 Thermo Environmental Model 43i-tle SO2 Analyzer Instrument Description

General Principals: Pulsating ultraviolet light is band-pass filtered and focused into a fluorescence chamber. Here, it excites SO_2 molecules into higher energy states. As these states decay the excited SO_2 molecules emit a characteristic radiation. A second filter allows only this radiation to fall on a photomultiplier tube, which turns the radiation into an electrical signal. This signal is then filtered and amplified by the electronics to levels appropriate for display. The physics of SO_2 fluorescence, the linearity of the photomultiplier tube, and good instrument design ensure that this signal is linearly proportional to the SO_2 concentration. For a better understanding of the analyzer, read the manual before operating the instrument.

3.4 Calibrations/Verifications of a Thermo 43i-tle SO2 Analyzer

SO2 analyzers are to be calibrated upon receipt, when installed, if moved from current location, and when certain repairs are made. An adjusted calibration may be necessary if an analyzer malfunctions and is repaired, or if power is lost for more than 24 continuous hours at a site.

An Adjusted Calibration, during which the lowest point (Zero) and the highest point (Span) are adjusted on the analyzer itself, is used at the start of sample collections for a site, and/or when a biweekly ZSP check or 90 day verification fails. The resulting slope and intercept values are automatically stored in the instruments memory. In addition, a new slope and intercept will be calculated comparing the analog voltage (from the instrument) and the engineering units output from the 8832 datalogger in the Excel-based site logbook (fig. 5). This updated slope and intercept will be entered into the 8832. The adjusted calibration resets the performance check (Bi-weekly Zero/Span/Precision) schedule, starting with the performance date of the Adjusted Calibration.

During a 90 day verification (multipoint check - 4 points plus a zero) the results are recorded in "as found" condition. The 90 day verification does not reset the Bi-weekly Zero/Span/Precision (ZSP) schedule. The (ZSP) will remain on its previous schedule.

3.4.1 Adjusted Multi-Point Calibration

3.4.1.1 Typically the only time a Calibration is performed will be at the beginning of the analyzer's field operation or after certain maintenance or repairs.

A calibration must be performed if a 90-day verification or bi-weekly zero/span/precision (ZSP) check fails and the instrument is in good working order. Normally if either of these checks fail there is some problem within the monitoring system that needs addressing. If the Zero check is outside >± 0.005 ppm of known 0.000 or the Span check >± 10% of expected value, then an adjusted calibration will be done AFTER equipment failure is diagnosed, repaired, and instrument cleared for normal operation. If a typical slow drift causes the check to fail, no maintenance may be necessary but check with the program manager before proceeding.

3.4.1.2 Allow sufficient time for the SO2 analyzer and the calibration standard to warm up (~1 hour) as necessary, if they are not already on.

3.4.1.3 Always, if no major malfunctions have occurred and the monitor has been in normal operation, perform a bi-weekly zero/span/precision (ZSP) check prior to a calibration. If necessary, after the ZSP check, install a clean 5-µm particulate filter in the monitor filter holder in the probe line box on the roof of the site. Perform a system leak check (refer to 43i-tle manual) after replacing the filter and saturate the probe system with SO2 by running a SO2 span point (90 ppb). Record all information in the Excel-based site logbook (fig. 5), EDAS site logbook (fig. 15), and EDAS Digitrend graph.

3.4.1.4 Login to the 8832 using HyperTerminal.

Refer to Section 11 Datalogger 8832 SOP for more information.

Type Esc (two letter site ID) AQM Enter, to enter Login screen.

ESC 8832 v3.02 ID:HA   Home Menu   11/06/14 14:01:50

    H Help Screen

    L Login / Set User Level

    O Log Out / Exit

Press L to Login, type password, press Enter. C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration). Press M (Disable/Mark Channel Offline). Use arrows to skip to SO2, then, press Enter to disable the SO2 channel. (Fig. 4)

Figure 4: SO2 Channel Disabled

3.4.1.5 Prepare a calibration worksheet in the instrument logbook containing the following entries:

> Date/Time; Operator; Site/AQS ID; Datalogger check; Analyzer and Calibrator Make/Model/Serial Number/Diagnostics; SO2 Operational checks and SO2 Readings

The following example of the electronic data sheet (Fig. 5) will be used to document checks.

Figure 5: Instrument Logbook, Calibration Worksheet

3.4.1.6 Verify that the analyzer is working within specifications (see 3.2.4.5-3.2.4.11). Connect to the analyzer using iPort software. Open iPort and click the connect button. The simulator of the 43i-tle should show up on the screen. (Fig. 6)

Figure 6: iPort Simulator

3.4.1.7 Record the diagnostic observations in the logbook. If these specifications are not met consult the instrument instruction manual for corrective action.

3.4.1.8 Verify the output of the Gas Dilution System (Calibrator) is connected to the SO2 solenoid so gas is supplied to the sample line of the monitor to be calibrated. See section 3.2.2.10.

3.4.1.9 Using the Gas Dilution System (Calibrator), run the 'SO2 ZERO' sequence. This sequence is programmed (Fig. 7) into the 700EU Calibrator and will supply zero air to the 43i-tle.
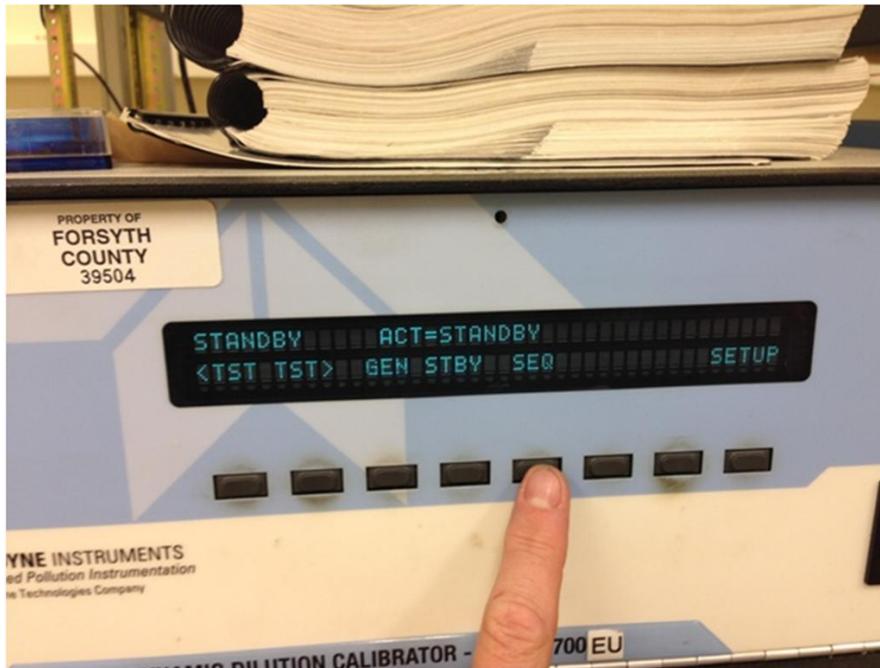
Figure 7: Calibrator Sequence Program

3.4.1.10 Verify zero air is making it into the 43i-tle. Readings should drop near zero within 30 seconds.

3.4.1.11 Allow the Model 43i-tle to sample zero air until a stable reading is obtained, at least 15 minutes, by checking the SO2 stability channel on the 8832. It needs to be less than 1 ppb. Take the analyzer out of Remote Mode and put it in Local Mode, by pressing the Enter button when on the Main Screen. Then go to the Main Menu, press the Menu button. From the Main Menu choose Calibration. From the Calibration menu choose Calibrate Zero. In the Calibrate Zero screen, press ENTER to set the SO2 reading to zero. Allow the SO2 stability channel to fall below 1 ppb again after adjustment.

Note: Make sure the analyzer is placed back in Remote Mode when finished with the calibration by pressing the Enter button again when on the Main Screen.

3.4.1.12 After stability is good, collect instantaneous snapshot of the voltage reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by going to the simulator and click 'TERM' for the terminal screen. The "TERM" button toggles from "GRAPH" to "TERM" when it is pressed. Type in 'SREC' beside "43i->" and hit enter. Copy the SREC string (Fig. 8) and paste it into the Excel logbook.
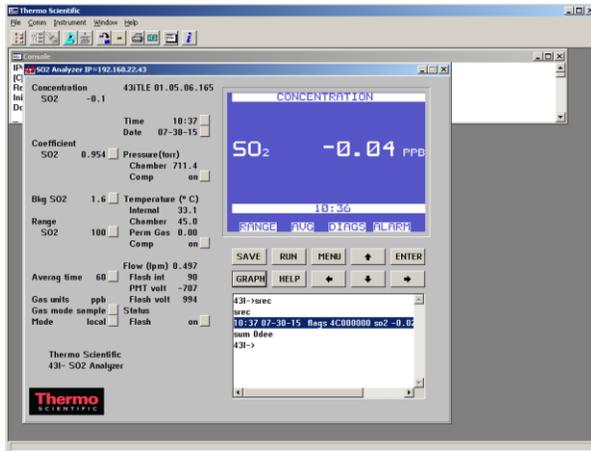
Figure 8: iPort Simulator SREC String

3.4.1.13 Using the Gas Dilution System (Calibrator), run the 'SO2 90' sequence (Fig. 9). This sequence is programmed into the 700EU Calibrator and will supply a concentration of 90 ppb of SO2 to the 43i-tle. Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize.
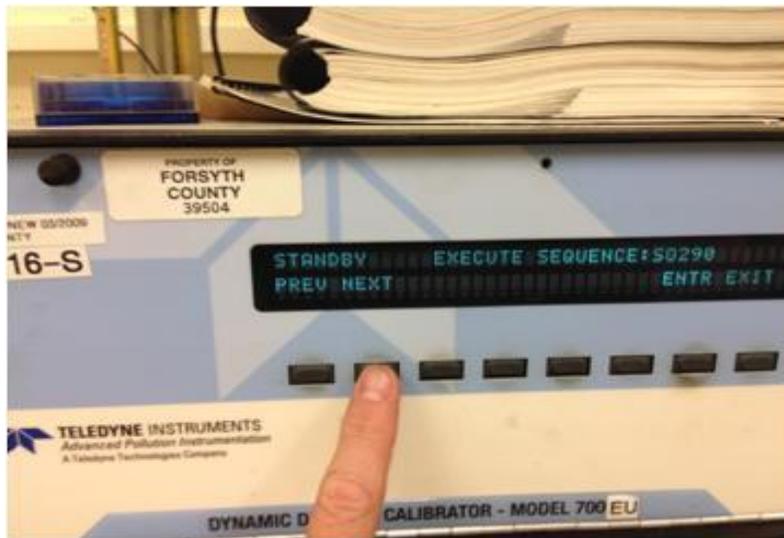
Figure 9: Calibrator Sequence Cycle Through/Selection

3.4.1.14 From the Main Menu choose Calibration. From the Calibration menu choose Calibrate Span. The first line of the display shows the current SO_2 concentration reading. The second line of the display shows the SO_2 range and the third line is where the SO_2 concentration is entered. Enter the SO_2 calibration gas concentration using the ↑, ↓, ←, and → pushbuttons. Press ENTER to calibrate the SO_2 reading to the SO_2 calibration gas.

3.4.1.15 After stability is good (< 1 ppb), collect instantaneous snapshot of the voltage reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook.

3.4.1.16 Using the Gas Dilution System (Calibrator), run the 'SO2 70' sequence. This sequence is programmed into the 700EU Calibrator and will supply a concentration of 70 ppb of SO2 to the 43i-tle. Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize. After stability is good (< 1 ppb), collect instantaneous snapshot of the voltage reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook.

3.4.1.17 Using the Gas Dilution System (Calibrator), run the 'SO2 40' sequence. This sequence is programmed into the 700EU Calibrator and will supply a concentration of 40 ppb of SO2 to the 43i-tle. Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize. After stability is good (< 1 ppb), collect instantaneous snapshot of the voltage reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook.

3.4.1.18 Using the Gas Dilution System (Calibrator), run the 'SO2 30' sequence. This sequence is programmed into the 700EU Calibrator and will supply a concentration of 30 ppb of SO2 to the 43i-tle. Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize. After stability is good (< 1 ppb), collect instantaneous snapshot of the voltage reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook. Return Calibrator to 'Standby" mode and place analyzer back in remote mode.

3.4.1.19. The percent difference for each point must be $< \pm 2.0\%$.

3.4.1.20 Review the linear regression results for SO_2 calculated in the calibration worksheet between the expected SO2 and the observed SO2 from the 8832. The linear regression line should meet the following specifications in order to be valid for reporting ambient air data: $98 \leq m \leq 102$, $-2.0 \leq b \leq 2.0$, and $r2 \geq 0.9990$ (the logger slope and intercept translates the raw voltage into engineering units for the data logger). If the line does not meet these specifications inform the Program Manager. If specifications are met, enter the new slope and intercept into the SO2 channel configuration in the 8832.

3.4.1.21 Review the linear regression results for SO_2 calculated in the calibration worksheet between the expected SO2 and the observed SO2 from the 43i-tle. The linear regression line should meet the following specifications in order to be valid for reducing ambient air data: $0.9800 < slope < 1.0200$, $-2.0 < intercept < 2.0$, and $r \geq 0.9990$ (the analyzer slope and intercept adjusts a ppb value to a corrected ppb value based on a best fit line across the five points). If the line does not meet these specifications inform the Program Manager. If specifications are met,

the new slope and intercept can be applied to any value stored in the internal datalogger in the analyzer if data is lost from the 8832.

3.4.1.22 If the above criteria cannot be met inform the Program Manager. If the criteria are met proceed with next step.

3.4.1.23 Open and label the Digitrend SO2 graph stored on the site computer with a memo stating what was done and look at the trace to verify points were flat and display a good "stair-step" appearance.

3.4.1.24 Verify Calibrator is in 'Standby' mode. This will allow the sample line to sample ambient air once again. Confirm analyzer is readings ambient levels once again within three minutes. If slow to return run a final zero to test for drift and flush line.

3.4.1.25 Once analyzer is reading ambient levels again, enable the data logger channel by returning to the 'CONFIGURATION MENU'.

3.4.1.25.1 Click on 'Configure Data Channels'

3.4.1.25.2 Click on 'Enable/Mark Channel Online'

3.4.1.25.3 Select channel to be enabled. Press Enter to enable the channel. The SO2 channel is now online.

3.4.2 SO2 90-day Verification

3.4.2.1 An SO2 90-day verification check must be done at least once every 90 days. Run the following points: 0 (Zero), 90 (Span), 70, 40 (Prec), and 30 ppb and verify results are all within 10% difference. This is to verify everything is running properly in an "as found" state. This check does not replace nor reset the bi-weekly ZSP check schedule.

3.4.2.2 Verify last auto-cal results from the night before are within tolerance (10%) and confirm everything is running properly. If they are not, contact the program manager.

3.4.2.3 Login to the 8832 using HyperTerminal.

3.4.2.4 Disable the SO2 channel.

Refer to Section 11 Datalogger 8832 SOP for more information.

Type Esc (two letter site ID) AQM Enter, to enter Login screen.

ESC 8832 v3.02 ID:HA   Home Menu   11/06/14 14:01:50

   H Help Screen

   L Login / Set User Level

   O Log Out / Exit

Press L to Login, type password, press Enter. C (Configuration Menu), D (Configure (Data) Channels), C (Change Old Configuration). Press M (Disable/Mark Channel Offline). Use arrows to skip to SO2, then press Enter to disable the SO2 channel.

3.4.2.5 Prepare a 90-day Verification worksheet in the instrument logbook containing the following entries:

> Date/Time; Operator; Site/AQS ID; Datalogger check; Analyzer and Calibrator Make/Model/Serial Number/Diagnostics; SO2 Operational checks and SO2 Readings

The following example of the electronic data sheet (Fig. 10) will be used to document checks. All information fields listed above must be included.

SO2 90-day Verification Worksheet

SITE:	HA	DATE:	2/25/2016		ANALYZER:	43i-TLE	816230552	Site Calibrator - API 700EU:	616-s			OPERATOR:	JRB
					Model Number	Serial Number			Serial Number	Last MFC Cert.			
ZERO AIR/API T701H:	60	29			11/20/2015	2/2/2015	CALIBRATION CYLINDER:	CC367593	12.72	500		8/9/15
	SERIAL #	PSI	Date of Last Maint.		Last Verification	Last Calibration			NUMBER	PPM	PRESSURE	EXP DATE

Current Coeff (slope): 0.959
Current Background (offset): 1.4

Slope and Offset From Analyzer

	SO2 FLOW Actual	SO2 FLOW Target	AIR FLOW Actual	AIR FLOW Target	EXPECTED SO2 PPB Y	OBSERVED DAS RAW PPB	OBSERVED API RAW PPB	CORRECTED DAS PPB	CORRECTED API PPB	% DIFF- DAS	% DIFF API
1	0	0	3.000	2.997	0.000	0.0421	-0.0040	-0.108	-0.021	#N/A	#N/A
2	0.0213	0.0213	2.979	2.991	90	90.17	90.057	89.921	90.058	-0.09	0.06
3	0.0276	0.0277	4.972	4.983	70	70.25	69.875	70.023	69.872	0.03	-0.18
4	0.0220	0.0222	6.978	6.984	40	40.21	40.090	40.016	40.081	0.04	0.20
5	0.0165	0.0164	6.983	6.969	30	30.32	30.017	30.137	30.006	0.46	0.02

All points must be less than 10% diff.

43i-tle Diagnostics

Pressure	714.7
Internal Temp	31.1
Chamber Temp	45.0
Flow	0.498
Lamp Intensity	89%

	DAS		LIMITS	
X1 Y:	slope =	0.9989	OK	98 <= M <= 102
X1 Y:	intercept =	-0.1496	OK	-0.50 <= B <= 0.50
X1 Y:	R2 =	1.0000	OK	R2 >= 0.9990

	API RECORDS		LIMITS	
X2 Y:	slope =	1.0002	0.9500 <= M <= 1.200
X2 Y:	INTERCEPT =	-0.0172	-0.50 <= B <= 0.50
X2 Y:	R2 =	1.0000	R2 >= 0.9990

ALL LINEAR REGRESSION VALUES WITHIN SOP LIMITS?   YES

Comments:
Adjusted Calibration done due to floor replacement being completed in building and all equipment removed while work was done.

SO2=-0.4104 (D)
13:35 11-05-15 flags 4C000000 so2 0.027

SO2 (A01)= 0.9001 V
15:40 02-25-15 flags 4C000000 so2 90.057

SO2 (A01)= 0.6987 V
15:53 02-25-15 flags 4C000000 so2 69.875

SO2 (A01)= 0.4014 V
16:01 02-25-15 flags 4C000000 so2 40.090

SO2 (A01)= 0.3006 V
16:12 02-25-15 flags 4C000000 so2 30.017

Figure 10: Instrument Logbook, 90-day Verification Worksheet

3.4.2.6 Verify that the analyzer is working within specifications (see 3.2.4.5-3.2.4.11). Connect to the analyzer using iPort software. Open iPort and click the connect button. The simulator of the 43i-tle should show up on the screen. (Fig. 6)

3.4.2.7 Record the diagnostic observations in the logbook. If these specifications are not met consult the instrument instruction manual for corrective action.

3.4.2.8 Verify the output of the Gas Dilution System (Calibrator) is connected to the SO2 solinoid so gas is supplied to the sample line of the monitor to be verified. See section 3.2.2.10.

3.4.2.9 Using the Gas Dilution System (Calibrator), run the 'SO2 ZERO' sequence. This sequence is programmed into the 700EU Calibrator and will supply zero air to the 43i-tle.

3.4.2.10 Verify zero air is making it into the 43i-tle. Readings should drop near zero within 30 seconds.

3.4.2.11 Allow the Model 43i-tle to sample zero air until a stable reading is obtained, at least 15 minutes, by checking the SO2 stability channel on the 8832. It needs to be less than 1 ppb.

3.4.2.12 After stability is good, collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by going to the simulator and click 'TERM' for the terminal screen. The "TERM" button toggles from "GRAPH" to "TERM" when it is pressed. Type in 'SREC' beside "43i->" and hit enter. Copy the SREC string (Fig. 5) and paste it into the Excel logbook.

3.4.2.13 Using the Gas Dilution System (Calibrator), run the 'SO2 90' sequence. This sequence is programmed into the 700EU Calibrator and will supply a concentration of 90 ppb of SO2 to the 43i-tle.

3.4.2.14 Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize.

3.4.2.15 After stability is good (< 1 ppb), collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook.

3.4.2.16 Using the Gas Dilution System (Calibrator), run the 'SO2 70' sequence. This sequence is programmed into the 700EU Calibrator and will supply a concentration of 70 ppb of SO2 to the 43i-tle. Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize. After stability is good (< 1 ppb), collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook.

3.4.2.17 Using the Gas Dilution System (Calibrator), run the 'SO2 40' sequence. This sequence is programmed into the 700EU Calibrator and will supply a concentration of 40 ppb of SO2 to the 43i-tle. Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize. After stability is good (< 1 ppb), collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook.

3.4.2.18 Using the Gas Dilution System (Calibrator), run the 'SO2 30' sequence. This sequence is programmed into the 700EU Calibrator and will supply a concentration of 30 ppb of SO2 to the 43i-tle. Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize. After stability is good (< 1 ppb), collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter.

Copy the result string and paste it into the Excel logbook. Return Calibrator to 'Standby" mode and place analyzer back in remote mode.

3.4.2.19. The percent difference for each point must be $< \pm 10.0\%$.

3.4.2.20 If the above criteria cannot be met inform the Program Manager. If the criteria are met proceed with next step.

3.4.2.21 Open and label the Digitrend SO2 graph stored on the site computer with a memo stating what was done and look at the trace to verify points were flat and display a good "stair-step" appearance.

3.4.2.22 Verify Calibrator is in 'Standby' mode. This will allow the sample line to sample ambient air once again. Confirm analyzer is readings ambient levels once again. If slow to return run a final zero to test for drift and flush line.

3.4.2.23 Once analyzer is reading ambient levels again, enable the data logger channel by returning to the 'CONFIGURATION MENU'.

3.4.2.23.1 Click on 'Configure Data Channels'

3.4.2.23.2 Click on 'Enable/Mark Channel Online'

3.4.2.23.3 Select channel to be enabled. Press Enter to enable the channel. The SO2 channel is now online.

3.5 Teledyne API 701 Zero Air Generator, Teledyne API T701H Zero Air Generator

A zero air system to be used in the field should be constructed as follows: a zero air generator, a valve connected to the output that is connected to two drying columns filled with fresh silica gel followed by a column of activated charcoal containing a layer of Purafil, the air is then passed through a 5 μm teflon filter to remove particulate.

3.5.1 A check of the zero air system should be performed annually.

3.5.2 Annually, the entire zero air system, including the zero air generator and drying columns, should be brought back to the laboratory.

3.5.3 At this time, replenish the drying column with fresh silica gel, activated charcoal, and fresh Purafil. Replace the filter at this time.

3.5.4 Replace the filter on rear of zero air generator. Check the canisters for leaks before re-installing them into the generator.

3.5.5 After the annual maintenance is completed, attach the zero air to a flow certified calibrator.

3.5.6 Prepare to run a zero point with the calibrator to an analyzer.

3.5.7 Let the analyzer stabilize and observe the SO2 value which should read ± .002 ppm of zero. If not, contact the Program Manager for how to proceed.

3.6 Thermo Environmental Model 43i-tle Maintenance

This section describes the periodic maintenance procedures that should be performed on the monitor to ensure proper, uninterrupted operation. Frequency of maintenance and service checks is indicated in each procedure.

3.6.1 Inspection of Pressure Reducing Capillary

Inspect and clean or replace the pressure reducing capillary - To ensure that the pressure reducing capillary is not dirty and does not impair the flow of sample gas through the instrument, it should be inspected approximately annually or as needed. The following procedure should be used:

3.6.1.1 Remove the instrument cover.

3.6.1.2 Locate capillary holder at top of flow meter and remove the cap nut.

3.6.1.3 Remove glass capillary (long – 13 mil) and "O" ring.

3.6.1.4 Check the capillary for particulate deposits within the bore. Clean or replace capillary (Part No. 8919) if particulate deposits are present.

3.6.1.5 Check "O" ring (Part No. 4800) for cuts or abrasions and replace if either are present.

3.6.1.6 Replace capillary in holder, making sure "O" ring is around capillary before inserting it into the holder.

3.6.1.7 Tighten holder cap over capillary enough to insure a tight seal.

3.6.2 Fan filter inspection and cleaning

Fan filter inspection and cleaning. Under normal use, the filter over the instrument fan located on the rear panel of the instrument should be cleaned and reconditioned at six-month intervals.

3.6.2.1 Remove the filter cover by gently pulling it off the fan guard.

3.6.2.2 Flush the filter with warm water or use a can of air to blow the dirt off the filter.

3.6.2.3 Re-install the filter and filter cover.

3.6.3 Particulate Filter Inspection

Sample particulate filter inspection is necessary every site visit (Fig 11). The filter should be inspected and for excessive dust and particulates, which restrict flow. Filters should be replaced once a month and a leak check performed (3.2.4.11). All filter replacements should be done AFTER a Quality control (QC) Zero-Span-Precision (ZSP) 14 day check.

Figure 11: Sample box filter housing

3.6.4 Flow check.

A flow rate of about 0.5 LPM should be observed for a standard instrument, if a flow rate of less than 0.35 LPM is observed by an audit instrument during annual maintenance, perform a leak check (3.2.4.11) and any other troubleshooting that may be necessary to fix the problem, i.e inspect pump flapper and diaphragm.

Preventive Maintenance Log for a 43i TLE				Maintenance Performed and completed		
Site:	Serial #:			Date	By	Notes
Check all electrical connections						
Check all pneumatic connections						
Clean flow capillary						
Rebuild pump						
Calibrate flow						
Leak check						
Adjust Analog Outputs (Full Scale)						
Run test points from calibrator to test SO2 readings						

Figure 12: Preventive maintenance log for a 43i-tle

3.7 Routine site visits

3.7.1 Visit Requirements

3.7.1.1The purpose of the routine site visit is to ensure the analyzer and dataloggers are operating properly. The following should be performed on routine site visits conducted at least every two weeks and more frequently, if necessary.

3.7.1.2 Upon arrival, visually inspect the site to ensure sample line and probe are intact, moisture free, and that there are no problems such as tree branches growing too close to the sample inlet, insect nests interfering with the probe inlets, etc.

3.7.1.3 Verify the time (EST) on 8832 data logger, analyzer, and site computer.

3.7.1.5 Examine all the Digitrend graphs day by day and check for atypical data, such as questionable spikes, drops, excessive noise, and square waves in the trace. Record any discrepancies on the Digitrend graph and in the logbook if necessary. Document any discrepancies as soon as possible and maintain the documentation in the proper files and notify Program Manager.

3.7.1.6 If the monitor is operating within specifications, record the Lamp, PMT, Temperature, Pressure, Intensities and Flow in the logbook. Inspect the Digitrend graph. Ensure that the previous day's auto-calibration cycle is typical and that the hourly data is typical.

Corrective action should be taken if the zero is > ± 0.5 ppb SO2 or the span is > ± 8% from the expected value. Corrective action must be taken if the zero is > ± 1 ppb SO2 or the span is > ± 10% SO2 from the expected value.

Check and ensure that the sample line is connected to the sampling manifold and that it is not contaminated by dirt or moisture. Any possible abnormalities should be investigated to ensure continuous uninterrupted quality controlled data collection. If any problems are found the operator is to notify the supervisor and do whatever is necessary to permanently correct the problem. If the operator is not absolutely sure the problem encountered is permanently rectified, he should visit the site later that day or the next working day to check the problem. The operator is to keep the supervisor informed on a daily basis as to the status of the problem. Detailed records of all corrective actions are to be maintained in the logbook.

3.8 Quality Assurance/Quality Control checks

Quality Assurance (QA)/Quality Control (QC) procedures include performance audits, 90-day verification checks, zero-span-precision (ZSP) 14-day checks, and calibration checks.

3.8.1 Performance Audit procedure

Audits are to be performed quarterly at a frequency <= 90 days apart. Analyzer accuracy audits are to be performed by an individual other than the analyst who performed the calibration. The QA staff performing the audit should also inspect the site's overall condition and report any issues to the Program Manager. Issues can include but not be limited to: safety hazards, operator oversights, EPA site requirements being met, building condition, overall neatness, and up-to-date documentation of the site's activities. The audit should be conducted using a gas dilution system, certified NIST EPA protocol cylinder gas (6 – 60 ppm range so required low audit levels can be attained), and zero air system that are independent of the normal calibration system. The following procedure should be followed when conducting audits:

3.8.1.1. The analyzer audit is conducted by challenging the measurement system with a series of known concentrations of calibration gas. The audit field procedure is similar to the 90-day verification procedure except that different points can be run. The audit must include zero and at least one point taken from three of the ten ranges:

      Level 1: 0.03 – 2.9 ppb SO2
      Level 2: 3.0 – 4.9 ppb SO2 (required)
      Level 3: 5.0 – 7.9 ppb SO2
      Level 4: 8.0 – 19.9 ppb SO2
      Level 5: 20.0 – 49.9 ppb SO2
      Level 6: 50.0 – 99.9 ppb SO2 (required)
      Level 7: 100.0 – 149.9 ppb SO2 (over-range for our monitor)
      Level 8: 150.0 – 259.9 ppb SO2 (over-range for our monitor)
      Level 9: 260.0 – 799.9 ppb SO2 (over-range for our monitor)
      Level 10: 800.0 – 1000 ppb SO2 (over-range for our monitor)

    3.8.1.2 The audit is to be recorded in the audit section of the analyzer logbook. Figure 13 should be used for a template of data that must be recorded in the logbook. Record the information but do not alter the analyzer settings in any way.

OZONE QUARTERLY AUDIT WORKSHEET

Site: HA
Site #: 37- 0067- 0022
Site analyzer: Thermo 43i-tle
Site Calibrator Standard: TAPI 700EU 616-s   Cert. Due:

Date: 05/27/2015
Auditor: LGA
Site Temp: 25.2
AUDIT STANDARD: API T700U SN: 128   Cert Due: 2/12/16

DIAGNOSTICS:

43i-tle ANALYZER DIAGNOSTICS:

SO2 coeff	0.954
SO2 bkg	1.6
Range	100
aver time	60
units	ppb
Pressure	714.7
Comp	ON
Internal Temp	31.1
Chamber Temp	45
Flow	0.456
Lamp Intensity	69%

Entered Logbook Comments: y
Entered Memo on Digital Chart: y
LRECs from 43i-tle Complete?: y
UPS Checked?: y
Fire Extinguisher Up to date?: y
Probe box/Sample line OK?: y
Site Cylinder OK?: y
SO2 channel enabled after check?: y

DATE OF LAST VERICAL: 5/27/15
DATE OF LAST AUDIT: 4/27/15

T700U AUDIT STD DIAGNOSTICS:

SERIAL NUMBER:	128
TOTAL FLOW (LPM)	3.0
REG PRESSURE (PSIG)	8.1
BOX TEMP (DEG.C)	33.7
O3 GEN REF (MV)	1.8
O3 GEN DRIVE (MV)	0.0
O3 LAMP TEMP (DEG. C)	48.8
PHOTO MEASURE (MV)	4527.5
PHOTO REF (MV)	4526.1
PHOTO FLOW (LPM)	0.8264
PHOTO LAMP TEMP (DEG. C)	58.0
PHOTO S PRESS (IN HG)	28.7
PHOTO STEMP (DEG. C)	43.0
PHOTO SLOPE	0.9780
PHOTO OFFSET (PPB)	1.4000
TEST	6.9
DIL PRESSURE (PSIG)	24.6
A-DIL (LPM)	3.0970
T-DIL (LPM)	2.9750

ZERO AIR SYSTEM:
Zero Air Model: API T701H
Serial Number:
Pressure (PSI): 28
Last Serviced:
Comments:

AUDIT CYLINDER:

COMMENTS:

ANALYZER/8832 DATA:

CURRENT SLOPES AND INTERCEPTS

	DAS	API RAW SREC
SLOPE	100.3156	1.0130
INT	-0.1052	-0.0013

AUDIT RESULTS:

SO2 FLOW Actual	SO2 FLOW Target	AIR FLOW Actual	AIR FLOW Target	Audit Target	Audit Cal Generate PPB	8832 OBS DAS PPB	43i-tle RAW PPB	43i-tle OBS PPB	8832 % DIFF PPB	43i-tle % DIFF PPB	8832 Audit OK?	43i-tle Audit OK?
0.000	0.000	3.000	3.008	ZERO	0.000	0.0002	0.1	0.1000	#N/A	#N/A	OK	OK
0.0090	0.0089	2.994	3.069	100.0	101.0	100.5	100.3	101.6026	-0.50	0.59	OK	OK
0.0060	0.0059	2.994	3.069	70.0	71.0	70.8	70.5	71.4152	-0.28	0.58	OK	OK
0.0030	0.0030	2.997	3.069	40.0	40.7	40.8	40.2	40.7213	0.25	0.05	OK	OK
0.0020	0.0020	2.997	3.069	15.0	15.4	15.6	15.3	15.4976	1.30	0.63	OK	OK
0.0015	0.0015	2.997	3.069	7.0	7.1	7.2	7.0	7.0897	1.41	-0.15	OK	OK
0.0010	0.0010	2.997	3.069	4.0	4.1	4.2	4.0	4.0507	2.44	-1.22	OK	OK
0.0007	0.0007	2.997	3.069	2.0	2.0	2.1	2.0	2.0247	5.00	1.22	OK	OK

8832 Readings
43i-tle Minute Aver.

O3 DAS REGRESSION RESULTS AND CRITERIA [X,Y]

SLOPE (M)	1.0054	INTERCEPT (B)	-0.1497	RSQR	1.0000

EXCELLENT (0.96 < < M < = 1.02) ✓
SATISFACTORY(0.90<=M<=1.10)
UNSATISFACTORY(M<0.90,M>1.10)

EXCELLENT (-0.002<=B< +0.002) ✓
SATISFACTORY(-0.010<=B<=0.010)
UNSATISFACTORY(B<-0.010, B>0.010)

EXCELLENT (>=0.9999) ✓
SATISFACTORY(>=0.9990)
UNSATISFACTORY(<0.9990)

Figure 13: Performance Audit Worksheet

3.8.1.3 The audit dynamic calibrator's mass flow controllers must be certified against authoritative standards such as an NIST traceable bubble meter, a wet test meter, or a BIOS flow calibrator within the last 6 months. The dynamic calibrator flows must be certified semi-annually.

3.8.1.4 Plug in the dynamic calibrator and turn power on. The calibration unit must warm up at least 30 minutes prior to use. Connect an independent source of zero air to the zero air inlet of the dynamic calibration unit. Turn on the zero air pump. Set the zero air delivery pressure to 25 psig. Attach a two-stage regulator to the audit SO2 cylinder. Quickly open and close the cylinder valve on the SO2 audit cylinder and adjust the 1st stage regulator valve to 24 psig. Open the second stage valve and allow the regulator to empty. Close the second stage valve. Repeat this process 5 times to evacuate residual gases in the regulator. **The regulator evacuation should be performed in a well ventilated area.** After the evacuation procedure fill the regulator with gas leaving the second stage valve closed. Connect the SO2 regulator to the audit calibrator with the appropriate tubing (stainless steel) and fitting (stainless steel). Open the second stage regulator

valve to the maximum. Adjust the second stage pressure to 24 psig. Check the fittings for leaks with Snoop®. Record the cylinder pressure.

3.8.1.5 Log in on the datalogger. Disable the SO2 channel. See section 3.4.1.4 on how to Disable the channel.

3.8.1.6 Verify the output of the Audit Gas Dilution System (Calibrator) is connected to the SO2 cal line so gas is supplied to the sample line of the monitor to be calibrated. See section 3.2.2.10.

3.8.1.7 Start the dynamic calibrator zero air sequence to deliver zero air to the analyzer. Use a total flow appropriate for the analyzer's needs, which should be ~3.0 LPM. Verify zero air is making it into the 43i-tle. Readings should drop near zero within 30 seconds.

3.8.1.8 Allow the Model 43i-tle to sample zero air until a stable reading is obtained, at least 15 minutes, by checking the SO2 stability channel on the 8832. It needs to be less than 1 ppb.

3.8.1.9 After stability is good, collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by going to the simulator and click 'TERM' for the terminal screen. The "TERM" button toggles from "GRAPH" to "TERM" when it is pressed. Type in 'SREC' beside "43i->" and hit enter. Copy the SREC string (Fig. 8) and paste it into the Excel logbook.

3.8.1.10 Using the dynamic calibrator run the next appropriate point in a given audit level per section 3.8.1.1.

3.8.1.11 Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize.

3.8.1.12 After stability is good (< 1 ppb), collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook.

3.8.1.13 Repeat 3.8.1.10 – 3.8.1.12 until audit is complete.

3.8.1.14. The percent difference for each point must be < ± 10.0%.

3.8.1.15 If the above criteria cannot be met inform the Program Manager. If the criteria are met proceed with next step.

3.8.1.16 Open and label the Digitrend SO2 graph stored on the site computer with a memo stating what was done and look at the trace to verify points were flat and display a good "stair-step" appearance.

3.8.1.17 Place Calibrator is in 'Standby' mode and disconnect the analyzer sample line from the audit calibrator. **Reconnect the cal line back to the solenoid that controls the auto-cal air**

flow. This will allow the sample line to sample ambient air once again. Confirm analyzer is readings ambient levels once again. If slow to return, run a final zero to test for drift and flush line.

3.8.1.18 Once analyzer is reading ambient levels again, enable the data logger channel by returning to the 'CONFIGURATION MENU'.

3.8.1.18.1 Click on 'Configure Data Channels'

3.8.1.18.2 Click on 'Enable/Mark Channel Online'

3.8.1.18.3 Select channel to be enabled. Press Enter to enable the channel. The SO2 channel is now online.

3.8.1.19 Close the SO_2 audit standard cylinder valve and disconnect from the calibration unit.

3.8.1.20 Enter notes of what was done in the EDAS site logbook.

3.8.1.21 As soon as possible after the QA procedure is performed the supervisor should review the results. Percent differences outside the ± 10% range must be investigated further to see if corrective maintenance or action is necessary. The audit results should also be compared with previous audit results for the analyzer. Other unusual trends (positive or negative biases, one audit range consistently more in error than the others, etc.) should also be investigated to determine if corrective action is necessary.

3.8.2 Bi-weekly Zero/Span/Precision (ZSP) Checks

3.8.2.1 Zero-Span-Precision (ZSP) 14-day checks include a zero plus two points of a known SO2 concentration. ZSP checks are intended to verify the analyzer multipoint calibration and may be used to validate and invalidate data. ZSP checks are to be performed at least every 14 days (More frequently if necessary).

3.8.2.2 A ZSP check is performed by challenging the analyzer with two test points after a zero test is done. The test points consist of a concentration of 30-50 ppb SO_2 and an SO_2 concentration of approximately 80% of the calibration scale (100 ppb) of the analyzer.

3.8.2.3 Log in on the 8832 datalogger.

3.8.2.3.1 Type in the Password and press ENTER.

3.8.2.3.2 Down/disable the SO2 channel.

3.8.2.3.3 The SO_2 channel is now offline. Check both the data logger and analyzer times and make sure they are correct. The datalogger time should be 1 minute of EST. Record the date, pollutant, monitor serial number, and the system operator signature in the instrument's Excel-based logbook (Fig. 14).

SO2 ZSP

DATE: 11/19/2015   TIME: 8:30 EST   OPERATOR: JRB   SITE: HA

DATA LOGGER CHECKS: MODEL 8832   SERIAL #: A4303K   Last 8832 Cal Done: 11/4/15
8832 Date Correct? y   Next 8832 Cal. Due: 5/4/16
8832 time within 15 s? y   CPU Date Correct? y
Time/Date of last 8832 poll by the CPU? 8:05   CPU Time Correct? y

43i-tle DIAGNOSTICS   819230552   6/24/15   700EU Diagnostics 616-s   8/24/2015
SO2 coeff 0.954   serial #   Last Calibration   serial #   Last MFC Cert
SO2 bkg 1.6
Range 100   9/20/15   Calibration Cylinder CC367593 9.8 1900 8/15/18
aver time 60   Last Verification   NUMBER PPM PRESSURE EXP DATE
units ppb
Pressure 714.7   12/19/15
Comp ON   Verification due   ZERO AIR/API T701H: 60 29 8/21/2014
Internal Temp 31.1   SERIAL # PSI Last Maint.
Chamber Temp 45   11/5/2015
Flow 0.498   Probe box filter changed   Checked minute data from last check for any bad data: Yes
Lamp Intensity 89%

		DAS	TEI 43i-TLE
Slope		100.3802	1.0122
Intercept		-0.0805	-0.1171

SULFUR DIOXIDE OPERATIONAL CHECKS:

POINTS	SO2 LPM Actual	SO2 LPM Target	AIR LPM Actual	AIR LPM Target	EXP [PPB]	OBS DAS PPB	OBS 43i-tle PPB	ADJ 43i-tle PPB	% DIFFERENCE DAS	% DIFFERENCE 43i-tle	DAS Diff OK?
ZERO	0	0	3.000	3.007	0.0	-0.410	0.027	-0.090	N/A	N/A	YES
SPAN	0.006	0.0059	2.994	3.069	90	90.7	86.6	87.49	0.80	-2.79	YES
PREC	0.003	0.0029	2.997	3.069	40	40.5	39.4	39.75	1.20	-0.63	YES

SULFUR DIOXIDE CONTROL LIMITS: DIAG OUTPUT:
ZERO DIFFERENCE <=+/-.005 PPB? YES   ZERO   SO2=-0.4104 (D)
SPAN DIFFERENCE <= +/- 10 %? YES   13:35 11-05-15 flags 4C000000 so2 0.027
PRECISION DIFFERENCE <=+/- 10%? YES
   SPAN   SO2= 90.72 (D)
Site temperature 25   13:47 11-05-15 flags 4C000000 so2 86.550
Entered Logbook Comments: y
Entered Memo on Digital Chart: y   PREC   SO2= 40.48 (D)
Downloaded LRECs from 43i-tle: y   14:01 11-05-15 flags 4C000000 so2 39.386
UPS Check: y
Fire Extinguisher Check: y   Comments:
Filter Change and Leak Check OK? y
Probe box/inlet/sample line OK? y
SO2 channel enabled after check? y

Figure 14: Instrument Logbook, Zero/Span/Precision (ZSP) worksheet

3.8.2.4 Verify that the analyzer is working within specifications (see 3.2.4.5-3.2.4.11). Connect to the analyzer using iPort software. Open iPort and click the connect button. The simulator of the 43i-tle should show up on the screen. (Fig. 6)

3.8.2.5 Record the diagnostic observations in the logbook. If these specifications are not met consult the instrument instruction manual for corrective action.

3.8.2.6 Verify the output of the Audit Gas Dilution System (Calibrator) is connected to the SO2 cal line so gas is supplied to the sample line of the monitor to be calibrated. See section 3.2.2.10.

3.8.2.7 Using the Gas Dilution System (Calibrator), run the 'SO2 ZERO' sequence. This sequence is programmed into the 700EU Calibrator and will supply zero air to the 43i-tle.

3.8.2.8 Verify zero air is making it into the 43i-tle. Readings should drop near zero within 30 seconds.

3.8.2.9 Allow the Model 43i-tle to sample zero air until a stable reading is obtained, at least 15 minutes, by checking the SO2 stability channel on the 8832. It needs to be less than 1 ppb.

3.8.2.10 After stability is good, collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by going to the simulator and click 'TERM' for the terminal screen. The "TERM" button toggles from "GRAPH" to "TERM" when it is pressed. Type in 'SREC' beside "43i->" and hit enter. Copy the SREC string (Fig. 5) and paste it into the Excel logbook.

3.8.2.11 Using the Gas Dilution System (Calibrator), run the 'SO2 90' sequence. This sequence is programmed into the 700EU Calibrator and will supply a concentration of 90 ppb of SO2 to the 43i-tle.

3.8.2.12 Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize.

3..2.14 After stability is good (< 1 ppb), collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook.

3.8.2.15 Using the Gas Dilution System (Calibrator), run the 'SO2 40' sequence. This sequence is programmed into the 700EU Calibrator and will supply a concentration of 40 ppb of SO2 to the 43i-tle. Allow the instrument to come to a stable reading. It may require 10 to 30 minutes for the point to stabilize. After stability is good (< 1 ppb), collect instantaneous snapshot of the ppb reading from the 8832 and a minute average (SREC) from the analyzer. Use iPort to retrieve the SREC from analyzer by typing 'SREC' beside "43i->" and hit enter. Copy the result string and paste it into the Excel logbook.

3.8.2.16. The percent difference for each point must be $< \pm 10.0\%$. The zero results should be $<\pm$ 0.5 ppb but must be $<\pm$ 1.0 ppb.

3.8.2.17 If the above criteria cannot be met inform the Program Manager. If the criteria are met proceed with next step.

3.8.2.18 Open and label the Digitrend SO2 graph stored on the site computer with a memo stating what was done and look at the trace to verify points were flat and display a good "stair-step" appearance.

3.8.2.18.1 Record the visit in the Agilaire EDAS logbook (Fig. 15).
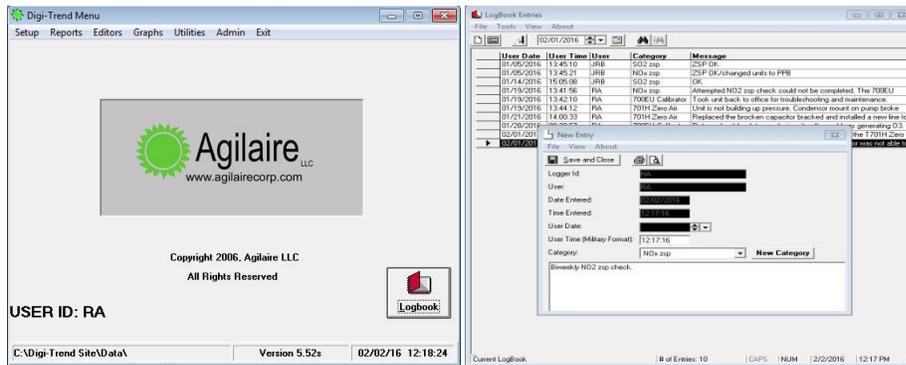
Figure 15: Agilaire EDAS logbook entry

3.8.2.19 Place Calibrator is in 'Standby' mode. This will allow the sample line to sample ambient air once again. Confirm analyzer is readings ambient levels once again. If slow to return run a final zero to test for drift and flush line.

3.8.2.20 Once analyzer is reading ambient levels again, enable the data logger channel by returning to the 'CONFIGURATION MENU'.

3.8.2.20.1 Click on 'Configure Data Channels'

3.8.2.20.2 Click on 'Enable/Mark Channel Online'

3.8.2.20.3 Select channel to be enabled. Press Enter to enable the channel. The SO2 channel is now online.

3.8.3 Thermo 43i-tle SO2 Analyzer Nightly Auto-Calibrations

Each night an auto-calibration is triggered by the datalogger and controlled by the calibrator to further test and confirm the equipment's operational status. This program starts at a selected time when ambient readings for a specific pollutant are at their lowest point in a typical diurnal pattern. The datalogger triggers the auto-cal to start but then hands over control to the calibrator. The timing of the check for both the datalogger and calibrator are in sync so the datalogger can capture expected results from the calibrator and the analyzer at the right moment. These records are flagged by the datalogger as calibrations and the results are reported to AQS as QC checks. All auto-cals run at least a zero point and a precision point (a point near the current standard) but could include additional points if needed. Auto cal results have to meet the 10% difference. If it does not meet this then corrective action is required. Some troubleshooting may be needed if results are greater than 7% so data loss can be avoided. Most auto-cals are also programmed so reportable hours are not lost in the process. Operators and staff review the results of the auto-cals every workday since all values show up on a daily report (see Data Handling and Reporting SOP section 10).

3.9 Data Handling - Documentation, Analysis, Editing, and Reporting

See the Data Handling and Processing SOP, which is Section 10.

REFERENCES

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Transfer Standards for Calibration of Air Monitoring Analyzers for SO2. Technical Assistance Document. EPA-454/B-10-001. United States Environmental Protection Agency, November, 2010.