

STANDARD OPERATING PROCEDURES
THERMO ELECTRON CORPORATION
MODEL 43C-TLE TRACE LEVEL
SULFUR DIOXIDE INSTRUMENT

Version 2.1

April 26, 2005



Section 1.1 Acknowledgments

This Standard Operating Procedure (SOP) for Sulfur Dioxide – Trace Level is the product of EPA’s Office of Air Quality, Planning and Standards. The following individuals are acknowledged for their contributions.

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STANDARD OPERATING PROCEDURES THERMO ELECTRON CORPORATION MODEL 43C-TLE TRACE LEVEL SULFUR DIOXIDE INSTRUMENT

3.0 PROCEDURES

3.1 Scope and Applicability

Sulfur Dioxide (SO₂) is a colorless, nonflammable gas that has a strong suffocating odor. SO₂ originates from fuel containing sulfur (mainly coal and oil) burned at power plants and during metal smelting and other industrial processes. High levels of SO₂ can result in temporary breathing impairment for asthmatic children and adults who are active outdoors. Long-term exposure to high levels of SO₂, in the presence of high levels of particulate matter, may aggravate existing cardiovascular disease and respiratory illness.

The Thermo Electron Corporation model 43C-TLE combines proven detection technology and advanced diagnostics for the determination of trace levels of SO₂. This SOP will detail the operation, preventive maintenance, cautions and health warnings.

The Detection Limit (DL) for a non-trace level SO₂ analyzer is 10 parts per billion (ppb) (*Code of Federal Regulations*, Volume 40, Part 53.23c, or, in the shortened format used hereafter, 40 CFR 53.23c)³. However, the 43C-TLE has an estimated DL of 100 parts per trillion (ppt), which is accomplished by an increased detector sensitivity, as well as increasing the length of the standard instrument's optics bench. This document will discuss the Trace Level (TL) operating procedures in detail.

3.2 Summary of Method

The Model 43C-TLE Trace Level operating principle is based on measuring the emitted fluorescence of SO₂ produced by the absorption of ultraviolet (UV) light. Pulsating UV light is focused through a narrow band-pass filter mirror allowing only light wavelengths of 190 to 230 nm to pass into the fluorescent chamber. SO₂ absorbs light in this region without any quenching by air or most other molecules found in polluted air. The SO₂ molecules are excited by UV light and emit a characteristic decay radiation. A second filter allows only this decay radiation to contact a photomultiplier tube (PMT). Electronic signal processing transfers the light energy impinging on the PMT into a voltage which is directly analyzed. Specifically,



where:

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

The 43C-TLE instrument operates in the following fashion:

1. In sample mode, the sample is drawn into the analyzer through the SAMPLE bulkhead. The sample flows through a hydrocarbon "kicker," which operates on a selective permeation principle, allowing only hydrocarbon molecules to pass through the tube wall. The driving force for the hydrocarbon removal is the differential partial pressure across the wall. This differential pressure is produced within the instrument by passing the sample gas through a capillary tube to reduce its pressure and

feeding it into the shell side of the hydrocarbon kicker. The SO₂ molecules pass through the hydrocarbon “kicker” unaffected.

2. The sample flows into the fluorescence chamber, where pulsating UV light excites the SO₂ molecules. The condensing lens focuses the pulsating UV light into the mirror assembly. The mirror assembly contains eight selective mirrors that reflect only the wavelengths which excite SO₂ molecules.
3. As the excited SO₂ molecules decay to lower energy states they emit UV light that is proportional to the SO₂ concentration. The band pass filter allows only the wavelengths emitted by the excited SO₂ molecules to reach the PMT. The PMT detects the UV light emission from the decaying SO₂ molecules. The photo detector, located at the back of the fluorescence chamber, continuously monitors the pulsating UV light source and is connected to a circuit that compensates for fluctuations in the UV light.
4. The sample then flows through a flow sensor, a capillary, and the shell side of the hydrocarbon “kicker.” The model 43C-TLE trace level outputs the SO₂ concentration to the front panel display and the analog or digital outputs.

3.3 Definitions

Here are some key terms for this method.

Table 3-1, Definitions of Key Terms

<u>Term</u>	<u>Definition</u>
DAS	Data acquisition system. Used for automatic collection and recording of Sulfur Dioxide concentrations.
Interferences	Physical or chemical entities that cause Sulfur Dioxide measurements to be higher (positive) or lower (negative) than they would be without the entity. (See Section 3.6).

3.4 Health and Safety Warnings

To prevent personal injury, please heed these warnings concerning the 43C-TLE.

1. Always use a third ground wire on all instruments.
2. Always unplug the analyzer when servicing or replacing parts.
3. If it is mandatory to work inside an analyzer while it is in operation, use extreme caution to avoid contact with high voltages. The analyzer has a 110 volt Volts Alternating Current (VAC) power supply. Refer to the manufacturer's instruction manual and know the precise locations of the VAC components before working on the instrument.
4. Avoid electrical contact with jewelry. Remove rings, watches, bracelets, and necklaces to prevent electrical burns.

3.5 Safety Precautions

To avoid damaging internal components of the 43C-TLE, the following precautions should be taken:

1. Wear an anti-static wrist strap that is properly connected to earth ground (note that when the analyzer is unplugged, the chassis is not at earth ground);
2. If an anti-static wrist strap is not available, be sure to touch a grounded metal object before touching any internal components;
3. Handle all printed circuit boards by the edge;
4. Carefully observe the instructions in each procedure specified in Chapter 7 of the manual;

5. Normally, if Teflon™ filters are used in the sample train, cleaning the optical bench will not be required. However, in the event that the bench is cleaned, be careful to avoid damaging the interior of the sample chamber. Use extreme caution when cleaning or servicing the sample chamber(s). In addition the mirrors are very fragile; avoid dropping the instrument. This may damage, misalign or crack the mirrors and cause expensive repairs;
6. Keep the interior of the analyzer clean;
7. Inspect the system regularly for structural integrity;
8. To prevent major problems with leaks, make sure that all sampling lines are reconnected after required checks and before leaving the site;
9. Inspect tubing for cracks and leaks;
10. It is recommended that the analyzer be leak checked after replacement of any pneumatic parts;
11. If cylinders are used in tandem with Mass Flow Control (MFC) calibrators, use and transport is a major concern. Gas cylinders can sometimes contain pressures as high as 2000 pounds per square inch (psi). Handling of cylinders must be done in a safe manner. If a cylinder is accidentally dropped and valve breaks off, the cylinder can become explosive or a projectile;
12. Transportation of cylinders is regulated by the Department of Transportation (DOT). It is strongly recommended that all agencies contact the DOT or Highway Patrol to learn the most recent regulations concerning transport of cylinders;
13. It is possible (and practical) to blend other compounds with SO₂. If this is the case, it is recommended that MSDS for all compounds be made available to all staff that use and handle the cylinders or permeation tubes; and
14. Shipping of cylinders is governed by the DOT. Contact the DOT or your local courier about the proper procedures and materials needed to ship high-pressure cylinders.

3.6 Interferences

The most common source of interference is from other gases that fluoresce in a similar fashion to SO₂ when exposed to UV light. The most significant of these is a class of hydrocarbons called polynuclear aromatic hydrocarbons (PAH); of which naphthalene is a prominent example. Xylene is another hydrocarbon that can cause interference. These hydrocarbons are removed via the hydrocarbon “kicker” (see section 3.2 for explanation on the hydrocarbon “kicker”).

Nitrogen oxide (NO) fluoresces in a spectral range close to SO₂. Interference from NO is addressed by the presence of the band pass filter, which allows only the wavelengths emitted by the excited SO molecules to reach the PMT.

3.7 Personnel Qualifications

The person(s) chosen to operate the Thermo 43C-TLE should have a minimum of qualifications. The understanding of basic chemistry and electronics are a must. The understanding of digital circuitry is helpful, but not required. Also, courses in data processing and validation are also welcome.

3.8 Equipment and Supplies

Monitoring Apparatus: The design of the 43C-TLE combines proven detection technology with advanced diagnostics for greater flexibility and reliability. A diagram of the 43C-TLE instrument is described in Figure 3-1. The three main components are:

- Pneumatic System: Consists of sample inlet line, particulate filter, reaction chamber, flowmeter, and pump, all used to bring ambient air samples to the analyzer inlet.
- Analytical System: This portion of the instrument consists of the UV lamp, mirrors, photo-detector and band pass filter.

- **Electronic Hardware:** The part of the analyzer that generally requires little or no maintenance. If the 43C-TLE is operated above the manufacturer's recommended temperature limit, however, individual integrated chips can fail and cause problems with data storage or retrieval.

Other apparatus and equipment includes the following.

Instrument Shelter: A shelter is required to protect the analyzer from precipitation and adverse weather conditions, maintain operating temperature within the analyzer's temperature range requirements, and provide security and electrical power. The recommended shelter temperature range is 20-30°C.

Spare Parts and Incidental Supplies: See the 43C-TLE manual, Chapter 5, for a list of recommended spare parts.

Calibration System: A system that creates concentrations of SO₂ of known quality is necessary for establishing traceability. This is described in detail in the Environics Series 9100 Computerized Ambient Monitoring Calibration System SOP. Please reference this document.

DAS: A data acquisition system is necessary for storage of ambient and ancillary data collected by the 43C-TLE. This is detailed in the "Data Acquisition and Management SOP."

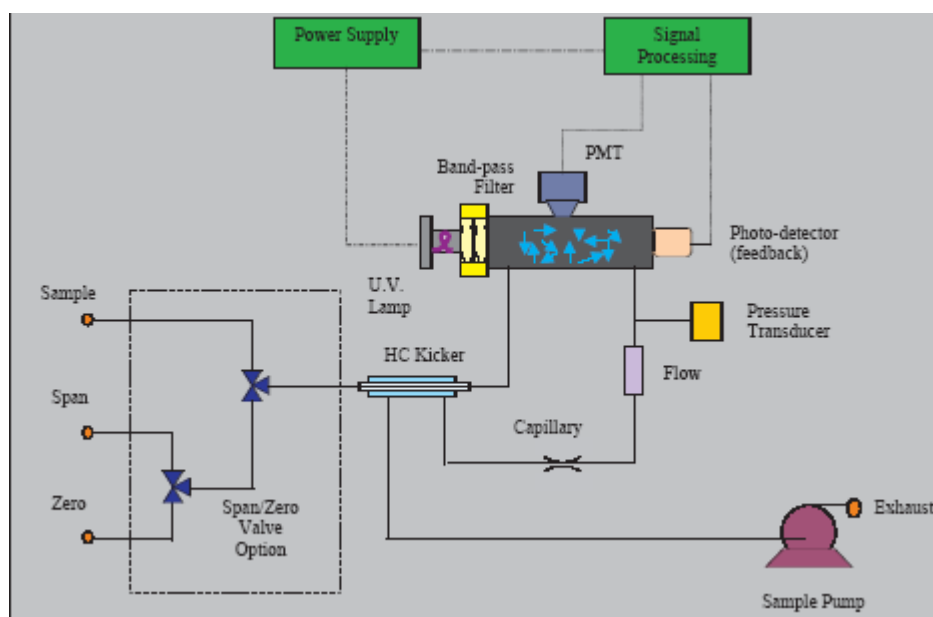


Figure 3-1 Model 43C-TLE Flow Diagram

Wiring, Tubing and Fittings: Teflon™, stainless steel, and borosilicate glass are inert materials that should be used exclusively throughout the intake system. Stainless steel tubing should be avoided because it is expensive, hard to clean, and can develop micro-cracks that are difficult to detect. Teflon™ tubing is the best choice for the connection between the intake manifold and the 43C-TLE inlet. Examine and discard if particulate matter collects in the tubing. All fittings and ferrules should be made of Teflon™ or stainless steel. Connection wiring to the DAS should be shielded two strand wire or RS-232 cables for digital connections.

Reagents and Standard: The 43C-TLE does not require any reagents since the instrument uses photometry to analyze for sulfur dioxide. All standards for the SO₂ method can be obtained in compressed cylinders and must be NIST traceable. Please see the Environics Series 9100 Computerized Ambient Monitoring Calibration System SOP.

3.9 Procedure

3.9.1 Sample Collection: Sampling for trace level SO₂ is performed by drawing ambient air through a sample manifold directly into the analyzer continuously via a vacuum pump. All inlet materials must be constructed from Teflon™, or borosilicate glass. The siting criteria for SO₂ Trace Level instruments in detailed in 40 CFR 58, appendix A⁴.

3.9.2 Sample Handling and Preservation: SO₂ samples receive no special preparation prior to analysis. Therefore this SOP does not need a section on Sample Handling and Preservation.

3.9.3 Instrument Operation , Startup and Maintenance

This section discusses startup, operation and maintenance of the 43C-TLE. The 43C-TLE has a digital front panel screen with pushbuttons below. This allows the user to check functions, switch operating parameters, and adjust zero and span. Recommend at start-up of instrument and after a warm-up period for the instrument, run through the menu items and record the current settings. **It is extremely important that the user familiarize themselves with the menus available. Inadvertently changing parameters within the analyzer can damage the instrument and possibly invalidate data as well. Please reference the Thermo 43C-TLE owner's manual and read it carefully before adjusting any parameters that are set by the factory.**

3.9.3.1 Start up

1. Before the instrument is operated, inspect the instrument for any damage. If damage is observed to the shipping box or the instrument, contact your shipping personnel.
2. Carefully remove the cover and check for internal damage. Please see Chapter 2 of the 43C-TLE manual.
3. Check that all connectors and printed circuit boards are firmly attached.
4. Once you have removed any packing material and performed your inspection, replace the cover.
5. Connect the sample line to the **SAMPLE** bulkhead on the rear panel of the instrument. See Chapter 2 of the 43C-TLE manual.
6. Connect the **EXHAUST** bulkhead to a suitable vent.
7. Connect a suitable recording device to the rear panel terminals. Please see EPA SOP on "Data Management" for details.
8. Plug the instrument into a grounded power strip that has surge protection. It is also advisable to purchase an Uninterrupted Power Supply (UPS). An UPS will protect the 43C-TLE from power surges and keep the unit operating until an operator can shut it down.
9. Press the power rocker switch to "ON."

3.9.3.2 Operation and Range Setting

1. The exhaust fan will start and the Power-Up and Self-Test screens will be displayed. These screens are displayed each time the instrument is turned on, and will continue to be displayed till the instrument has completed its warm up and self-checks. You should allow 30 minutes for the instrument to stabilize.
2. After the warm-up period the Run screen, the normal operating screen, is displayed. This screen is where the SO₂ concentration is displayed.
3. From the Run screen, the Main Menu, which contains a list of submenus, can be displayed by pressing the **MENU** pushbutton. If the instrument is in **REMOTE** mode, press **ENTER** and select **LOCAL** mode in order to be able to change parameters.
4. Instrument parameters and features are divided into the submenus according to their function. Use the **UP/DOWN ARROW** pushbuttons to move the cursor to each submenu. **Note:** When the Main Menu is entered directly from the Run screen, the **LEFT ARROW** pushbutton may be used to jump to the most recently displayed submenu screen.

5. To set the range for the instrument, press the **DOWN ARROW** pushbutton till the cursor is on "Range." Press the **ENTER** pushbutton to display the Range Menu.
6. In the upper right corner of the display, the word SINGLE, DUAL, or AUTO is displayed to indicate the active mode. For a detailed explanation about the SINGLE, DUAL, or AUTORANGE mode, see Chapter 3 (page 3-7) of the manual. This SOP addresses setting the range for a single range.
7. Press the **ENTER** pushbutton for the Gas Units screen. Use the **DOWN ARROW** pushbutton to select "PPB" and press **ENTER**. Press **MENU** to return to the Range Menu.
8. Use the **DOWN ARROW** pushbutton to display the Range screen and press **ENTER**.
9. Use the **UP/DOWN ARROW** pushbuttons to scroll through the preset ranges. Select "100.0" and press **ENTER**. Press **MENU** to return to the Range Menu.
10. Press **RUN** to return to the Run screen.
11. To set the correct time and date on the instrument, press **MENU** to return to the Main Menu. Press the **DOWN ARROW** pushbutton till the cursor is on Instrument Controls. Press **ENTER** to display the Instrument Controls screen.
12. Use the **UP/DOWN ARROW** pushbuttons to scroll through the choices. Select "Time" and press **ENTER**.
13. Use the **UP/DOWN ARROW** pushbuttons to increase/decrease the hours and minutes; use the **LEFT/RIGHT ARROW** pushbuttons to move the cursor left and right. Set the appropriate time and press **ENTER**. Press **MENU** to return to the Instrument Controls screen.
14. Select "Date" and press **ENTER**.
15. Use the **UP/DOWN ARROW** pushbuttons to increase/decrease the month, day, and year; use the **LEFT/RIGHT ARROW** pushbuttons to move the cursor left and right. Set the appropriate date and press **ENTER**. Press **RUN** to return to the Run screen.
16. The instrument is now set with the appropriate time, date, full scale range and units.
17. It is recommended that you allow the 43C-TLE 24 hours before you attempt function checks or calibration.
18. If your DAS does not have RS-232 capabilities, then proceed to the next section, Diagnostic Checks/Manual Checks. If you have connected the 43C-TLE to a computer or DAS, review the Diagnostic Check from your computer screen.

3.9.3.3 Diagnostic Checks/Manual Checks

To determine whether the 43C-TLE is working properly, the field operators should perform the Diagnostic Checks every time they visit the monitoring station. It is good practice for the operator to check these Diagnostic Checks either by the computer or manually. Below are instructions on how to perform this manually. Please note that the 43C-TLE has set upper and lower ranges for some of these Diagnostic checks. Please reference the owner's manual for these ranges.

1. To display the Diagnostics menu, from the Run screen press the **MENU** pushbutton to display the Main Menu. Use the **UP/DOWN ARROW** pushbuttons to move the cursor to "Diagnostics." Press **ENTER** for the Diagnostics screen.
2. Use the **UP/DOWN ARROW** pushbuttons to toggle through the function check tree. The following table illustrates the functions that should be recorded. Please see Chapter 3 (page 3-34) 43C-TLE manual for more details. A maintenance check sheet is attached in Appendix A of this SOP.
3. On the Program Number screen, the version numbers of the program installed are displayed. Prior to contacting the factory with any questions regarding the instrument, note the program numbers.

Table 3-2 Diagnostic Checks

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

Once the Diagnostic checks have been established and recorded for the 43C-TLE, it is time to calibrate the instrument. Please refer to section 3.9.4 of this SOP.

3.9.3.4 Preventive Maintenance

Preventive maintenance should **prevent** down-time and data loss. Table 3.3 lists the preventive maintenance items that are listed in the model 43C-TLE manual, Chapter 5. The maintenance procedures described in Chapter 5 of the manual should be performed every six months.

Table 3-3 Preventive Maintenance Schedule for the 43C-TLE

Item	Schedule
Visual inspection and cleaning	Bi-annually
Sample particulate filter inspection	Weekly
Verify Test Function	Weekly
Perform Level I calibration	Daily
Capillary inspection and replacement	Bi-annually
Perform flow check	Bi-annually
Fan filter inspection and cleaning	Bi-annually
Lamp voltage check	Bi-annually

3.9.3.5 Instrument Troubleshooting

The 43C-TLE manual has an excellent troubleshooting guide in Chapter 6.

3.9.4 Calibration and Standardization

The calibration of the 43C-TLE is performed by comparing the output of the instrument against standardized gases of known quality. Generation of these gases is detailed in the Enviroics Series 9100 Computerized Ambient Monitoring Calibration System SOP. This section will detail how to adjust the 43C-TLE to the standardized gases. Once the calibration has been performed, compare the response of your DAS to the calculated “source” value. If this is outside of +/-10%, then adjust the instrument response as detailed in the next sections.

3.9.4.1 Adjustment to Zero Air

Before running the zero air through the 43C-TLE, ensure that the zero air is free from contaminants. One way to determine if the zero air is free from contaminants is through the use of multiple zero air sources, and determining which source produces the lowest response⁵. Appendix D of the 43C-TLE manual provides suggestions for generating trace-quality zero air.

In order to adjust the output of the 43C-TLE to zero air, perform the following:

1. Allow the instrument to sample zero air from a manifold that is at near atmospheric pressure for a minimum of 15 minutes.
2. From the Main Menu select the Calibration menu; select the “Calibrate Zero” screen.
3. Press **ENTER** to set the SO₂ reading to zero.
4. Press **MENU** to return to the Calibration menu.
5. Press **RUN** to return to the Run screen.

3.9.4.2 Adjustment to Calibration Gas

It is desirable, but not essential, to calibrate the 43C-TLE at low SO₂ levels (typically, less than 20 ppb). However, fluorescence SO₂ analyzers have been shown to be inherently linear over a wide dynamic range. If low concentration SO₂ calibration cylinders (less than 50 ppm) are used, there is the potential for contamination by back diffusion from a poorly purged regulator. Contamination with even a small amount of moisture from back diffusion can cause the SO₂ concentration to become unstable; the lower the cylinder concentration, the more susceptible it is to any contamination from “abuse” in the field⁵. The best way to ensure low concentration cylinders are not contaminated by back diffusion is to make sure whenever the cylinder valve is open, there is gas flow out of the cylinder.

Appendix D of the 43C-TLE manual offers additional discussion on trace level calibration issues.

In order to adjust the output of the 43C-TLE to NIST traceable calibration gas, perform the following:

1. Switch the calibration unit to generate a known concentration of SO₂. Allow the instrument to sample calibration gas from a manifold that is at near atmospheric pressure for a minimum of 15 minutes.
2. From the Main Menu select the Calibration menu; select the “Calibrate SO₂” screen.
3. On the bottom line, there will be individual digits with which the span value can be set. In order to change the concentration, use the **UP/DOWN ARROW** pushbuttons to increase/decrease each digit; use the **LEFT/RIGHT ARROW** pushbuttons to move the cursor left and right.
4. Press **ENTER** to calibrate the SO₂ reading to the SO₂ calibration gas.
5. This operation changes the calculation equation and adjusts the SO₂ span coefficient of the instrument.
6. Press **MENU** to return to the Calibration menu.
7. Press **RUN** to return to the Run screen.

3.10 Data Analysis and Calculations

Data analysis for this analyzer is detailed in the “Data Acquisition and Management SOP.”

4.0 QUALITY CONTROL AND QUALITY ASSURANCE

The following section has brief definitions of the QA/QC indicators. Table 4-1 has the Measurement Quality Objectives (MQOs) of the Thermo 43C-TLE. Please note that this section details primarily with the QA indicators. Quality Control for continuous electronic instruments, such as the 43C-TLE consists of performing the diagnostic checks, maintenance and calibrations. These procedures are detailed in sections 3.9.3 and 3.9.4: Instrument Operation, Startup and Maintenance and Calibration and Standardization. Appendix A has an example of a Quality Control and Maintenance Record developed by the EPA for this instrument.

4.1 Precision

Precision is defined as the measure of agreement among individual measurements of the same property taken under the same conditions. For SO₂, this refers to testing the SO₂ analyzer in the field at concentrations between 0.0003 and 0.005 ppm. The test must be performed, at a minimum, once every two weeks. Calculations for Precision can be found in Reference item 3.

4.2 Bias

Bias is defined as the degree of agreement between a measured value and the true, expected, or accepted value. Quantitative comparisons are made between the measured value and the true, standard value during audits. Generally, three upscale points and a zero point are compared. Two audit types commonly used for SO₂, direct comparison and blind, are discussed below. The SOP should discuss plans for each type of audit.

- **Direct Comparison Audits:** An independent audit system is brought to the monitoring location and produces gas concentrations that are assayed by the monitoring station's SO₂ analyzer. In most cases, a person outside of the agency or part of an independent QA group within the agency performs the audit. The responses of the on-site analyzer are then compared against the calculated concentration from the independent audit system and a linear regression is generated
- **Blind Audits:** In blind audits (also called performance evaluation audits); agency staff are sent an audit device, such as the National Performance Evaluation Program (NPEP). The agency staff does not know the SO₂ concentrations produced by the audit equipment. Responses of the on-site analyzer are then compared against those of the generator and a linear regression is calculated.

4.3 Representativeness

Representativeness refers to whether the data collected accurately reflect the conditions being measured. It is the data quality indicator most difficult to quantify. Unless the samples are truly representative, the other indicators are meaningless. Since the NCORE Level I and II siting criteria are urban and regional, the trace level SO₂ criteria are the same. Please reference the National Monitoring Strategy⁵ for a discussion of NCORE Level II SO₂ monitoring scale.

4.4 Completeness

Completeness is defined as the amount of data collected compared to a pre-specified target amount. For SO₂, EPA requires a minimum completeness of 75% (40 CFR 50, App.H.3). Typical completeness with the 43C-TLE values can approach 90-93%.

4.5 Comparability

Comparability is defined as the process of collecting data under conditions that are consistent with those used for other data sets of the same pollutant. The 43C-TLE meets the MQOs for a trace level SO₂ instrument. Please see Table 4-1.

4.6 Method Detection Limit

The method detection limit (MDL) or detectability refers to the lowest concentration of a substance that can be determined by a given procedure. The 43C-TLE must be able to detect a minimum value of 300 ppt of SO₂.

Table 4-1 Measurement Quality Assurance Objectives

Requirement	Frequency	Acceptance Criteria	Reference	Information or Action
Bias	NCORE, once per year	To be determined.	40 CFR Pt.58	To be determined.
Precision	1 every 2 weeks	Concentration: 0.0003 -0.005 ppm, Coefficient of Variance: To be determined.	40 CFR Pt.58 Appendix A	To be determined.
Completeness	Quarterly, Annually	NCORE, 75%	National Monitoring Strategy.	If under 75%, institute Quality Control Measures
Representativeness	N/A	Neighborhood, Urban or Regional Scale	40 CFR 58	N/A
Comparability	N/A	Must be a Trace Level instrument. See Sections 3.1 and 3.2 of this document.	National Monitoring Strategy.	N/A
Method Detection Limit	N/A	300 ppt	National Monitoring Strategy	Testing is performed at the factory.

5.0 REFERENCES

1. Code of Federal Regulations, Title 40, Part 53.23c
2. Code of Federal Regulation, Title 40, Part 58, Appendix A
3. The National Air Monitoring Strategy, Final Draft, 4/29/04,
<http://www.epa.gov/ttn/amtic/monstratdoc.html>
4. Instruction Manual, Model 43C Trace Level SO₂ Analyzer
5. Trace SO₂ Monitoring Guidance for the MANE-VU Regional Aerosol Intensive Network (RAIN) program, Draft (dated March 7, 2005).

Appendix A

Environmental Protection Agency
 Monthly Quality Control and Maintenance Records
 Thermo 43C-TLE SO₂ Analyzer

Site Name/Location _____

Technician _____

Month/Year _____

Serial Number _____ Range _____

Parameter	Date	Date	Date	Acceptance Criteria
DC Voltage				
PMT Voltage				
Internal Temp				
Chamber Temp				
Chamber Pressure				
Sample Flow				
UV Lamp Intensity				
Other Tests				
Optical Span Test				

Date	Comments and Notes

Figure A-1 Thermo 43C-TLE Quality Control and Maintenance Record