This SOP is subject to
review and revision in 2015.

BAY AREA
AIR QUALITY
MANAGEMENT
DISTRICT

TECHNICAL SERVICES DIVISION

QUALITY ASSURANCE PROJECT PLAN

STANDARD OPERATING PROCEDURE

AIRMON SOP 223

THERMO 43I-TLE

REVISION 223.2.00 08/27/2012

Glen Colwell, Manager Air Monitoring Section	Date	Mark Stoelting, QA Officer Technical Services Division	Date

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1. PURPOSE

This Standard Operating Procedure (SOP) describes the installation, setup, general operation, calibration, maintenance, data collection, troubleshooting and repair of the Thermo Fischer Scientific, Inc. (THERMO) Model 43i-TLE (Trace Level Enhanced) SO2 analyzer. **NOTE**: This SOP supplements the procedures located in the THERMO Instrument Manual.

2. SUMMARY OF METHOD

The THERMO 43i-TLE operating principle is based on measuring the emitted fluorescence of SO2 produced by the absorption of ultraviolet (UV) light~~.~~ **NOTE:** Please refer to the appropriate THERMO Instrument manual for a further explanation.

The Thermo Scientific Model Series 43i-TLE is designated as a Federal Equivalent Method by the United States Environmental Protection Agency (EPA) for the measurement of ambient concentrations of trace level SO2 pursuant with the requirements defined in the Code of Federal Regulations (CFR), Title 40, Part 53.

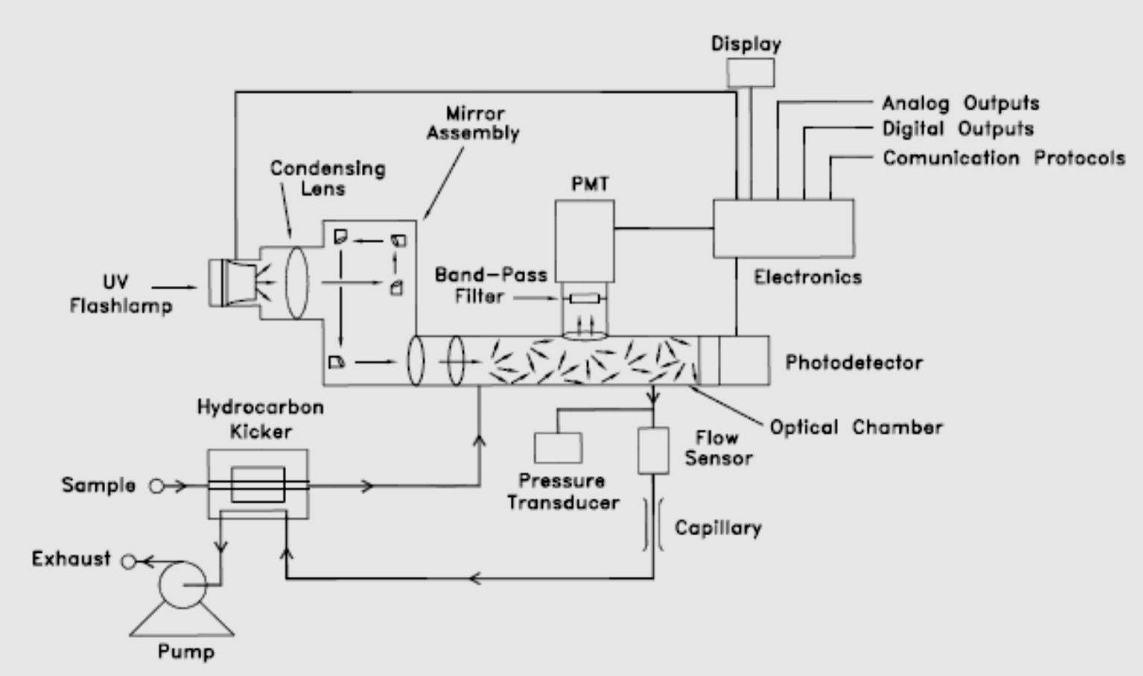


Figure 1**:** THERMO 43i-TLE Schematic

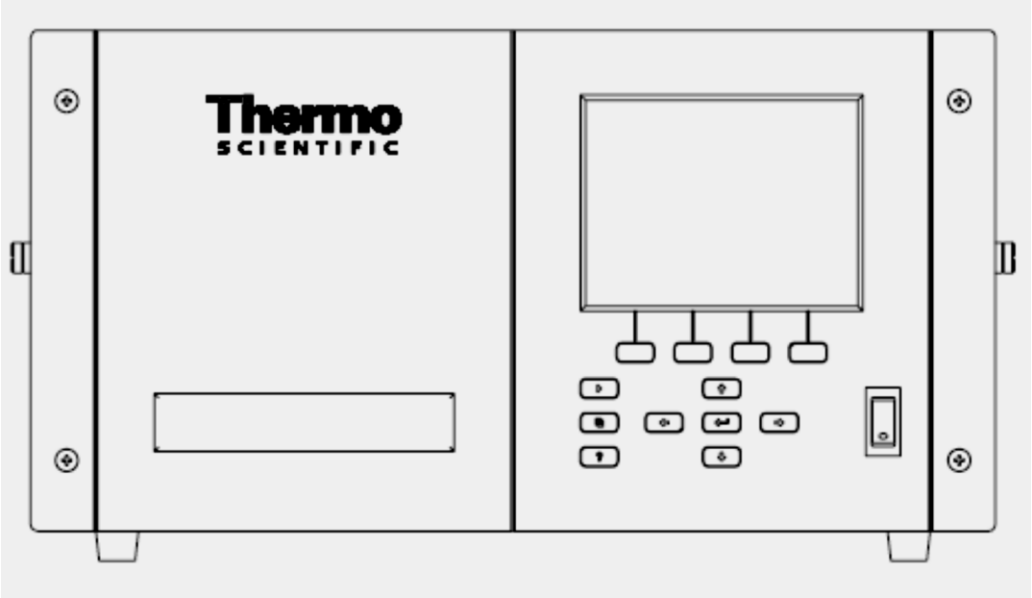


Figure 2: THERMO 43i-TLE Front Panel

3. DEFINITIONS

AQIS	Air Quality Instrument Specialist
BAAQMD	Bay Area Air Quality Management District
BKG	Background
CARB	California Air Resources Board
CFR	Code of Federal Regulations
COEF	Coefficient
DAS	Date Acquisition System
DMS	Date Management System
EPA	United States Environmental Protection Agency
MDL	Method Detection Level
MQO	Measurement Quality Objective
NAAQS	National Primary And Secondary Ambient Air Quality Standards
NIST	National Institute of Standards and Technology
PMT	Photo Multiplier Tube
ppb	Parts per billion
ppm	Parts per million
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
SO2	Sulfur Dioxide
SOP	Standard Operating Procedure
TLE	Trace Level Enhanced
THERMO	Thermo Fischer Scientific Inc.

4. HEALTH AND SAFETY WARNINGS

NOTE: Consult the THERMO Instrument Manual 'Safety Precautions' Sections for Preventive Maintenance, Troubleshooting, and Servicing in Chapters 5, 6, and 7, respectively.

5. CAUTIONS

NOTE: Consult the THERMO Instrument Manual 'Safety Precautions' Sections for Preventive Maintenance, Troubleshooting, and Servicing in Chapters 5, 6, and 7, respectively.

6. INTERFERENCES AND LIMITATIONS

Reactive materials, solvents and excessive particulates in the probe and sample inlet tubing could be possible interferences. Monitoring should be temporarily stopped if local sources of potential interferences are detected (i.e. paving, painting, etc.). Probe inlet tubing and manifold should be cleaned if contamination is suspected.

From the 43i TLE Instrument Manual: Interferences (EPA levels) less than lower detectable limit except for the following:

$$NO < 1ppb,\ M\text{-}Xylene < 1ppb,\ H_2O < 3\%\ of\ reading$$

Lower Detection Limit: 0.12 ppb (60 second averaging time)

7. PERSONNEL QUALIFICATIONS AND RESPONSIBILITIES

Installation, operation, maintenance, repair or calibration of the instrument and all support equipment should only be performed by properly trained personnel. Personnel should meet all minimum BAAQMD requirements and qualifications for an Air Quality Instrument Specialist (AQIS) I or II, Senior AQIS, and/or Supervising AQIS.

- The station operator AQIS is responsible for the operation and oversight of the instrument and all support equipment. The operator shall complete any required or recommended maintenance, minor repairs and/or occasional calibration of the instrument and all support equipment. The station operator AQIS is responsible for first level DMS data review and validation. The station operator AQIS may occasionally install or replace an instrument or support equipment. The Senior AQIS and Supervisor AQIS complete major installations, repairs and calibrations.

- BAAQMD MQA personnel manage the DMS and complete all final data review and submittal.

- BAAQMD PEG staff may conduct periodic performance and/or system's audits.

- EPA staff may conduct periodic performance and/or system's audits.

8. EQUIPMENT AND SUPPLIES

The THERMO 43i-TLE is normally installed and operated with the following equipment:

- THERMO Instrument Manual
- Instrument bench or instrument rack. **NOTE**: Rack installation requires the use of the appropriate instrument sliders securely attached to the analyzer!
- Grounded 3-wire plug
- 10-micron Teflon filters and a Teflon filter holder assembly with appropriate fittings
- ¼" OD Teflon sample line tubing. The length of the tubing should be less than 10 feet
- glass manifold
- Inlet probe and probe line material installed following EPA siting requirements
- external pump – Thomas vacuum pump
- Calibrator
- Zero-air supply
- Certified cylinder with SO2 component and regulator
- 1/8" SS tubing (from cylinder to the calibrator) and appropriate fittings; **NOTE**: All gas delivery connections should be leak tested upon installation!
- Data Acquisition System (DAS) with appropriate cables and adaptors (RS-232, DB9, CAT-5, etc.) with connection to the District's Data Management System (DMS); **NOTE**: Please refer to Section 10 of this SOP, "*DATA AND RECORDS MANAGEMENT"*
- Partial Station OPTIONAL: glass manifold
- Partial Station OPTIONAL: magnehelic gauge (-2" to + 2" magnehelic)
- Partial Station OPTIONAL: kicker pump (Thomas or other)

9. PROCEDURES

9.1 INITIAL SETUP

(**NOTE**: Please refer to the appropriate THERMO Instrument Manual for further information)

1. Inspect a new analyzer for any external damage. Carefully remove the instrument cover and check for any internal damage or missing parts. Check that all connectors and printed circuit boards are firmly attached. Remove any shipping screws inside the chassis and packing materials.

NOTE: For most applications, instruments must be installed and operated following EPA requirements for siting and location.

2. Connect a sample line and external filter assembly to the **SAMPLE IN** bulkhead on the rear panel of the analyzer. (Figures 3 and 4)
3. **OPTIONAL:** Disconnect internal pump**;** connect the **EXHAUST** bulkhead to an external pump. The line should be ¼ " OD. The length of the exhaust line should be as short as possible. Verify that there is no restriction in this line.
4. Plug the analyzer into an outlet of the appropriate voltage and frequency.

5. Press the power switch to “ON.”
6. Adjust all appropriate analyzer settings for range, averaging time, alarms, internal data logging and communications:
    a. Auto range Mode: Low Range 100 ppb; High Range 500 ppb
    b. Average Time 60 seconds
    c. Span Coefficient = 1.000
    d. Pressure Compensation on
    e. Temperature Compensation on
    f. 43i: data-logging and communications. Contact Senior AQIS or Supervisor AQIS for instructions
7. **NOTE**: If installing at a station, connect to a DAS; if the DAS is connected to the DMS, move the instrument to the appropriate site location and activate the instrument.
8. Allow at least one hour for the analyzer to stabilize;
9. Check/adjust lamp voltage:
10. Place analyzer into SERVICE mode
    a. From the Main Menu, press ↓ to scroll to **Service** and press enter, scroll to **Flash Voltage Adjustment** and press enter;
    b. The Set Flash Voltage Adjustment - Man screen appears; use the ↓ ↑ arrows to adjust to 1000V.
    c. Press enter to store the value.
11. **NOTE: If installed at a station, complete a full calibration**.
12. Enter any pertinent information into the appropriate DMS instrument e-log.

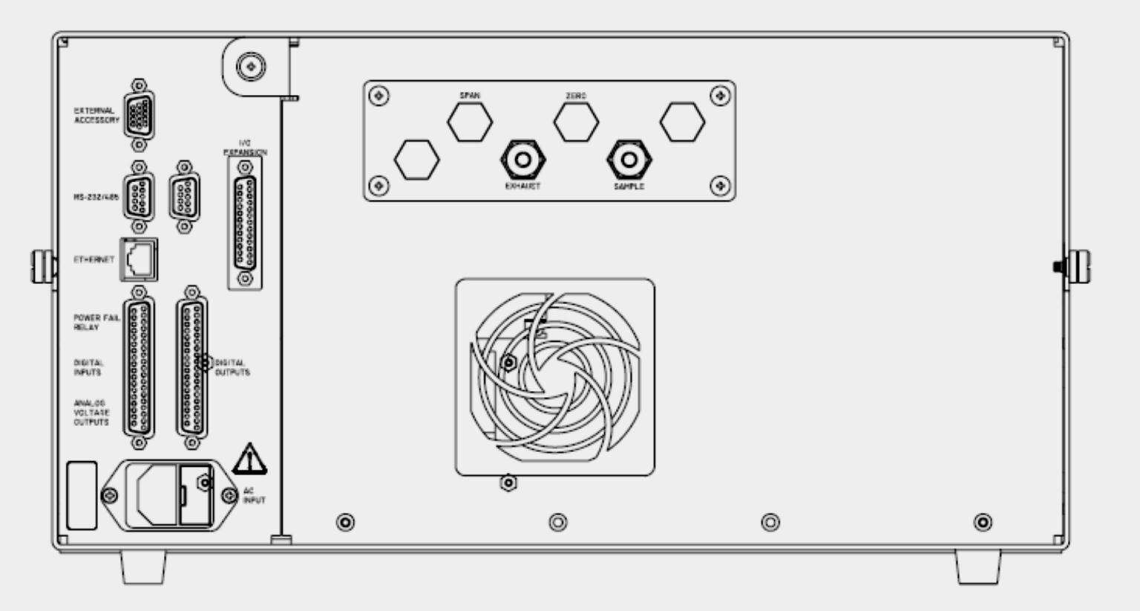


Figure 3: THERMO 43i-TLE Rear Panel

9.2 ACCEPTANCE TESTING

(**NOTE**: Please refer to the appropriate THERMO Instrument Manual for further information)

Staff will conduct acceptance testing on new instruments prior to deployment in the field. Setup analyzer following steps in Section 9.1 of this SOP in a mock station setting which includes an ultra-pure zero-air supply, a stable calibrator, certified multi-blend or SO2 cylinder, regulator, and a DAS connected to the DMS.

1. Calibrate analyzer (Section 9.3 of this SOP)
2. Check linearity by running a gas span, mid-high, mid-low, and precision level calibrations, allowing at least 20 minutes for all points;
3. Allow to run for a minimum of 1 week in a simulated station setup running automated nightly calibrations.
4. Check 1-minute and hourly data and parameters for stability, repeatability, flags and/or alarms, or any other atypical performance.
5. Enter any pertinent information into the appropriate DMS instrument e-log.
6. New instruments should have a BAAQMD S/N assigned.

9.3 CALIBRATION

(**NOTE**: Please refer to the appropriate THERMO Instrument Manual for further information)

District policy and EPA regulations typically require zero/span calibration when the instrument is newly installed, moved, repaired, interrupted for more than a few days, or when there is a span or zero calibration response ≥ +/- 10% or a QC 1-point precision shift by ≥ +/- 15%.

9.3.1 Procedure: Manual Calibration (Including Adjustments)

1. Start a zero-air calibration. If there is a kicker pump at the station, disconnect;
2. Allow the analyzer to sample zero air for a minimum of 15 minutes;
3. Check/adjust lamp voltage (see section **Error! Reference source not found.** of this SOP)
4. If the analyzer is indicating < +/- 3 ppb no further adjustment is necessary. If the analyzer is indicating > +/- 3 ppb then a zero calibration is required. Adjust "BKG" under Main menu Calibration Factors to obtain zero response.
5. Start a gas span.
6. Allow the analyzer to sample calibration gas for a minimum of 20 minutes;
7. If the value is ≤ +/- 3 % of the true concentration, no further adjustment is required. If the value is > +/- 3 %, or if the analyzer is new or recently repaired, adjust the photomultiplier tube (PMT) to match the true value.
    a. From the Main Menu, press ↓ to scroll to **Service** and press enter ;
    b. Scroll ↓to **PMT Supply Settings** and press enter; the PMT Supply Settings screen appears.
    c. At the PMT Supply Settings screen, press ↓ to select **Manual PMT Adjustment**. The Set PMT Voltage - Manual screen appears.
    d. At the Set PMT Voltage - Manual screen, use ↓↑ to increment/decrement the counts until the instrument displays the calibration gas concentration value.
    e. Place instrument back into remote mode
8. **OPTIONAL**: Adjust SPAN COEF under Main menu Calibration Factors to fine-tune analyzer response.
9. When the analyzer is calibrated and has remained stable for at least 15 minutes, the operator may elect to run mid-high, mid-low and/or precision level calibration points to check linearity.
10. Stop the calibration. If there is a kicker pump at the station, reconnect. Allow the reading to stabilize. Check that the analyzer is back in the **REMOTE** mode.
11. Record all pertinent information into the instrument e-log.
12. Visually check the entire system prior to leaving the station to verify correct operation!

9.4 AUTO-CALIBRATION, 'AUTO-CALS'

At most District air-monitoring locations, nightly automated calibrations ("auto-cals") are completed on a regular schedule. This may include the completion of precision, mid-low, mid-high, span and zero level calibrations on a rotational basis following all EPA requirements. The operator is responsible for reviewing nightly auto-cal results on the District DMS and taking any appropriate actions if the auto-cal results are unacceptable. **NOTE**: Please refer to Section 10 of this SOP, "*DATA AND RECORDS MANAGEMENT*"; and Section 11 of this SOP, "*QUALITY CONTROL AND QUALITY ASSURANCE*".

1. Log onto DMS.
2. Check that the analyzer nightly auto cal response is within its recommended Quality Control (QC) limits. If the instrument response is outside the specified quality control limit, the source of the problem is to be investigated and corrected. Violation of a QC limit does not require data action as long as an MQO is not also exceeded.
3. The operator will adjust the analyzer if the nightly auto-cal results or manual calibrations results are outside of the acceptable BAAQMD QC limits. QC limits are developed to provide an early warning of instrument problems prior to the exceedance of a Measurement Quality Objective (MQO).
4. If any MQO's are exceeded, the source of the problem is to be investigated and corrected and the operator shall invalidate all suspect or questionable 1-minute DMS data **unless** the error is a result of other equipment (i.e., malfunctioning calibrator, power-failure, etc.) **and** the operator has demonstrated that the instrument is functioning within its specified operating parameters.
5. Record all pertinent information into the instrument e-log.

9.5 SERVICE AND MAINTENANCE

The operator shall perform all recommended or required diagnostic checks, service and maintenance. The following table is a suggested general guideline for service and maintenance. **NOTE**: Please refer to the appropriate THERMO instrument manual for further information:

Maintenance Item	Suggested Period	SOP Section
Change inlet filter	**2-3 weeks**	9.5.1
Cooling fan filter servicing	**Monthly**	9.5.2
Instrument internal cleaning	**6 months**	9.5.3
Capillary inspection and cleaning	**6 months**	9.5.4
Pump rebuild	**Annually***	9.5.5 or 9.5.6
Full calibration	**Annually***	9.3
Method Detection Limit (MDL) tests	**Annually***	9.5.7

*These items may be performed more often as required.

Figure 4: Suggested Maintenance Schedule

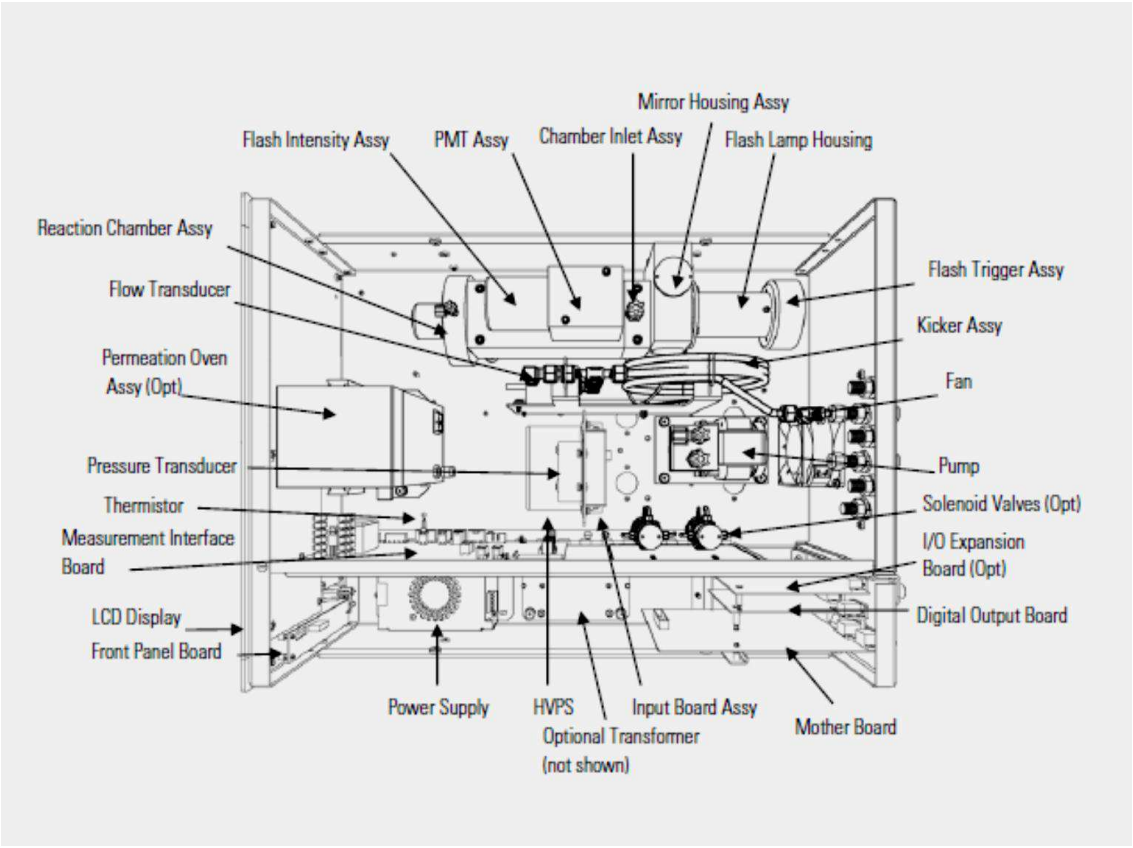


Figure 4: Internal Components 43i-TLE

9.5.1 Procedure: Change Inlet Filter

An in-line Teflon filter protects the analyzer from dirt and contaminants. Filters should be changed on a regular schedule. Use 10.0 Teflon filters.

1. Carefully open filter holder assembly;
2. Remove old filter, replace with new filter;
3. Carefully close filter holder assembly;
4. Enter the appropriate information into the DMS e-log for the instrument

9.5.2 Procedure: Cooling Fan Filter Servicing

1. Remove the fan guard from the fan and remove the filter.
2. Flush the filters with warm water and let dry (a clean, oil-free purge will help the drying process) or blow the filters clean with compressed air.
3. Re-install the filter and fan guard.

4. Enter the appropriate information into the DMS e-log for the instrument

9.5.3 Procedure: Clean Instrument Internal

1. Carefully open instrument cover;
2. Vacuum the instrument interior;
3. Carefully blow out remainder of dust with compressed air;
4. Carefully replace instrument cover;
5. Enter the appropriate information into the DMS e-log for the instrument

9.5.4 Procedure: Capillary Inspection and Cleaning

1. Disable the appropriate DAS channel.
2. Turn the instrument OFF and unplug the power cord.
3. Remove the instrument cover.
4. Locate the capillary holder.
5. Remove the glass capillary and o-ring. Inspect o-ring for cuts or abrasion, and replace as necessary.
6. Check capillary for particulate deposits. Clean or replace as necessary.
7. Replace capillary making sure the o-ring is around the capillary before inserting it into the body.
8. Finger-tighten the capillary nut enough to ensure a tight seal.
9. Re-install the cover.
10. Re-enable the appropriate DAS channel.
11. Enter the appropriate information into the DMS e-log for the instrument

9.5.5 Procedure: External Pump Rebuild

Most stations use an external Thomas vacuum pump. The pump should be checked and re-built annually or when flow/vacuum issues arise. The pump should pull at least 15 “Hg and be steady. Other pumps may be used, in which case, refer to the instructions that are provided with the pump rebuild kit. Noisy bearings should be replaced. Pumps that run hot, are excessively noisy, or fail to deliver a steady vacuum should be replaced.

OPTIONAL: In order to decrease instrument down-time, the operator may elect to switch in a new or rebuilt pump.

1. Disable the appropriate DAS channel.
2. Unplug pump; disconnect the ¼” line from the pump.
3. Place a mark on the pump head to indicate proper re-positioning.
4. Remove the 4 screws holing the pump top valve assembly; remove the top valve assembly.
5. Remove and inspect the pump diaphragm. If cracked, hardened, torn or damaged, replace diagram.
6. Remove valve plate assembly from the top valve plate, noting alignment.
7. Carefully inspect plate assembly. Remove the flapper valves and clean. Replace if corroded or damaged. Inspect the gasket. Replace if damaged.
8. Replace the valve plate assembly to the top valve plate, noting alignment.

9. Replace the pump top valve assembly;
10. Clean out windings with compressed air.
11. Plug in pump. Check with vacuum gauge.
12. Re-connect the ¼" line to the pump.
13. Check/re-calibrate analyzer.
14. Re-enable the appropriate DAS channel.
15. Enter the appropriate information into the DMS e-log for the instrument

9.5.6 Procedure: Internal Pump Rebuild

1. Disable the appropriate DAS channel.
2. Remove the cover.
3. Unplug pump from power supply; disconnect the ¼" fittings from top of the pump.
4. Place a mark on the pump head to indicate proper re-positioning.
5. Remove the 4 screws holing the pump top valve assembly; remove the top valve assembly.
6. Remove and inspect the pump diaphragm and valve plate. If cracked, hardened, torn or damaged, replace diagram and valve plate.
7. Replace the pump top valve assembly;
8. Re-connect ¼" fittings to top of the pump
9. Plug in pump.
10. Check/re-calibrate analyzer.
11. Re-install the cover.
12. Re-enable the appropriate DAS channel.
13. Enter the appropriate information into the DMS e-log for the instrument

9.5.7 Procedure: Annual Method Detection Limit tests

The MDL should be established on-site by supplying the analyzer at least seven times with a test atmosphere containing SO_2 at a concentration that is approximately one to five times greater than the estimated MDL, and recording the response. To perform the MDL test, run zero air through the analyzer and establish an acceptable zero; dilute pollutant gas to the targeted concentration (one to five times the estimated MDL) and collect 20 to 25 one minute observations. Repeat this seven times over the course of 5 to 14 days. Average the concentration from the 20-25 readings; calculate the standard deviation (S) of the average readings and compute the MDL. The MDL is then calculated as the standard deviation of the response values times the Student's t-value for the number of test measurements (40 CFR Part 136, Appendix B).

The MDL for high sensitivity SO_2 analyzers should be 0.30 ppb or lower over an averaging time of no more than 5 minutes.

1. Start trace level "manual_MDL_Full_CO" script in the morning after a 06:30 trace level CO auto zero is finished.
2. Run another "manual_MDL_Full_CO" script in the afternoon after a 12:30 trace level CO auto zero check is finished.
3. Repeat this procedure over a 5 to 14 day period until 11 acceptable tests are completed.
4. Export the Op Code 30 response values into a spreadsheet.

5. Copy Op Code 30 response values from export file into “2012 SO2 MDL tests” spreadsheet.
6. Calculate the MDL using the formulas in the spreadsheet. Save the MDL spreadsheet locally and in the AM Work files folder.
7. Enter the appropriate information into the DMS e-log for the instrument.

9.6 SAMPLE COLLECTION

NOTE: This SOP section is non-applicable and is left intentionally blank

9.7 SAMPLE HANDLING AND PRESERVATION

NOTE: This SOP section is non-applicable and is left intentionally blank

9.8 SAMPLE PREPARATION AND ANALYSIS

NOTE: This SOP section is non-applicable and is left intentionally blank

9.9 TROUBLESHOOTING

NOTE: Please refer to the appropriate THERMO Instrument Manual for further information.

NOTE: The operator should utilize the DMS to track and record various parameters (parametric data) which may be helpful for troubleshooting.

NOTE: 1-minute DMS data also includes instrument flags. For diagnostic flag codes, please refer to Appendix B of this SOP.

The operator should be aware of the following:

- Abnormal or out-of-range concentration values on instrument front display;
- ‘Alarm’ or alarm icon present on the analyzer front display;
- Abnormal or out-of-range diagnostic’s values (i.e., flow, pressure, chamber temperature, frequency, etc.);
- Abnormal or out-of-range DAS or DMS parametric data (i.e., flow, pressure, chamber temperature, frequency, etc.);
- Abnormal DAS or DMS instrument diagnostic flags;
- Abnormal or unusual auto calibration and/or manual calibration results;
- Unusual sounds (pump, kicker pump, etc.)

The operator should take the appropriate steps to resolve any instrument issue:

- Troubleshoot to identify faulty component or support equipment;

- Repair instrument or support equipment;
- Check and verify instrument's performance; re-calibrate if needed;
- Review and invalidate any data that does not meet the criteria in Section 11 of this SOP;
- Review and validate or invalidate any questionable data as 'suspect';
- Maintain the appropriate DMS instrument and/or station e-log. The operator must enter the appropriate information after the completion of any repairs, maintenance, or adjustments. The operator should note any data gaps.
- In cases of instrument failure or inability to repair on-site, the operator should contact the Senior AQIS and/or the Supervising AQIS in order to coordinate replacement of the instrument.

The operator should be aware of the following:

SYMPTOM: No response to calibration gas:
- Check instrument flows and pump function.
- Check all voltages, power supply, lamp, PMT etc. using instrument diagnostics.
- Check function of lamp trigger pack (should hear high pitched ticking sound).
- Check lamp function, if lamp is burned out, lamp supply voltage will be maxed out at 1200 volts.

SYMPTOM: Calibration Drift:
- Check temperature control board to ensure that reaction chamber temperature is held around 45 degrees C. If chamber temp is unstable, instrument response will drift. Thermistor failure giving inaccurate temp may cause temp control board to drive reaction chamber heat source too high or too low. Temp shift will cause drift in instrument response.

SYMPTOM: Excessive Noise:
- Check averaging time, should be set to 60 seconds.
- Suspect input board failure, swap out board.
- Defective or low sensitivity photomultiplier tube (PMT) will cause a noisy trace. To check, run zero air while monitoring output signal. If noise is present during zero, PMT will need replacing. **CAUTION**: PMT can be damaged with ambient light levels. PMT replacement should be performed in a darkened environment by an experienced technician.

SYMPTOM: Excessive response time
- May be due to dirty capillary tube or dirty sample filter.
- Check sample filter;
- Inspect and clean capillary if flows remain low after replacing sample filter.
- To clean capillary use wire cat whiskers and distilled water. Compressed air will also work.
- Replace any worn or cracked o-rings. Do not use vacuum grease!
- Check pump if capillary and o-rings are OK

SYMPTOM: Low Flow:

- Normal sample flow will be in the 0.5 – 1.3 lpm range, depending on the orifice installed in the flow path.
- Check sample filter;
- Inspect and clean orifice if flows remain low after replacing sample filter.
- To clean orifice use wire cat whiskers and distilled water. Compressed air will also work.
- Replace any worn or cracked o-rings. Do not use vacuum grease!
- Check pump if orifice and o-ring are OK

SYMPTOM: Lamp Degradation or Failure

- Mercury vapor lamp pulse of 10 times per second should be audible. If lamp trigger pack fails, first indication is lack of high pitched ticking sound coming from instrument.
- On instrument power up, there will be a delay in the lamp firing as the voltage comes up slowly to avoid board and lamp damage.
- **NOTE**: if lamp is unplugged or not working, the lamp intensity adjustment circuit will raise the lamp voltage to its' maximum value, i.e. 1200 volts.
- Lamp degradation over time will be compensated for by feedback from a lamp intensity control circuit, causing lamp to be driven with a higher voltage, thereby keeping the light intensity constant. Lamp voltage normally set at 800 volts when new. 800 to 850 volts is acceptable but higher lamp voltages may shorten life of lamp power supply board.
- 43i-TLE: Lamp intensity should be in the 20 – 50 kHz range.
- When replacing the mercury vapor lamp, best practice is to replace lamp trigger pack at the same time. Remove lamp and socket assembly from flash holder by loosening the single set screw. Do not touch lamp face or allow to become soiled, (use lab grade tissue or foam packing that bulb was packed in to insert new bulb into socket). Clean lamp face with methanol if soiled or touched. When reinstalling lamp and socket, ensure that locator pin on bottom of socket fits correctly into the housing slot before tightening the set screw. Chamber housing and trigger pack will be in contact, with no gaps, when correctly installed.
- After lamp replacement, adjust the lamp voltage to ~ 800 VDC.

OTHER:

- Zero BKG (background) set as necessary to obtain valid zero while running zero air.
- Span COEF (coefficient) allowable limits are 0.960 to 1.050 for 43i-TLE models. Best practice is to set span coefficient to 1.000 and adjust PMT voltage for true span concentration response.

9.10 COMPUTER HARDWARE AND SOFTWARE

The Model 43i-TLE is connected to a BAAQMD station DAS via its Serial RS-232 Port. The DAS collects 1-minute data. All 43i-TLE instrument parameters must be set accordingly. No further data calculations or reduction are required.

- DMS: Operator should be familiar with the operation of the DMS software including data review, auto-cal response data review, e-log entry, etc.
- DAS: The operator should be familiar with operation of the station's DAS and the DAS manual calibration script files
- iPort: The operator should be familiar with the use of THERMO iPort software

10. DATA AND RECORDS MANAGEMENT

- 1-minute concentration data (ppm) is collected by the station's DAS. The station DAS pushes data hourly to the BAAQMD DMS. Data is retained by the DMS for future review and usage.
- 1-minute analyzer parametric data are collected by the station's DAS. The station DAS pushes data hourly to the BAAQMD DMS. Data is retained by the DMS for future review and usage.
- Analyzer parametric data may include various instrument operating parameters such as flow rate, pressure, lamp temperature, instrument flags (please refer to the appropriate THERMO instrument manual and Appendix B and C of this SOP for an explanation of diagnostic flags), etc. The operator is encouraged to use the instrument parametric data as an aid to data review and validation and for troubleshooting
- District staff are responsible for data and records management including oversight of data capture into a station DAS, data ingestion into the District DMS, data review and validation, and data retention.

The operator is responsible for the following:

- Review and validate or invalidate any data that does not meet the criteria in Section 11 of this SOP;
- Review and validate or invalidate any questionable data flagged as 'suspect'
- Maintain the appropriate DMS instrument and/or station e-log. The operator must enter the appropriate information after the completion of any repairs, maintenance, or adjustments. The operator should note any data gaps. The operator may elect to manually collect data from the analyzer in the event of a DAS data collection error.

11. QUALITY CONTROL AND QUALITY ASSURANCE

Quality Control (QC) procedures include the completion of any required calibrations, service and maintenance. Quality Assurance (QA) procedures include the completion of any required audits.

11.1 QUALITY CONTROL

- The operator shall perform all recommended or required diagnostic checks, service and maintenance. Please refer to Section 9.5 of this SOP and the appropriate instrument

manual for more information. Note in the appropriate e-log all checks, service and maintenance made to the analyzer or support equipment!

- Zero, span, mid-low span, mid-high span, and precision level auto-cals are automatically run nightly, alternating between the various auto-cals. If an auto-cal measurement is outside the specified QC (quality control) limit, the source of the problem is to be investigated and corrected. The operator will then adjust the analyzer by running a manual zero or span calibration. Note in the appropriate e-log all repairs, maintenance or adjustments made to the analyzer or support equipment!
- **NOTE**: QC limits are developed to provide an early warning of instrument problems prior to the exceedance of a Measurement Quality Objective (MQO). Violation of a QC limit does not require data action as long as an MQO is not also exceeded.
- **NOTE**: Do not adjust the analyzer while running a precision! The operator may only adjust the analyzer by running a zero and span, followed by another precision. Note in the appropriate e-log all adjustments made to the analyzer!
- If any MQO's are exceeded, the source of the problem is to be investigated and corrected **and** the operator shall invalidate all suspect or questionable 1-minute DMS data **unless** the error is a result of other equipment (i.e., malfunctioning calibrator, power-failure, etc.) **and** the operator has demonstrated that the instrument is functioning within its specified operating parameters.
- **NOTE:** Operators should include comments regarding shelter temperatures, sensors, controls, etc. in DMS e-logs. Data quality/validity resolution resides with MQA.
- Hourly DMS data are manually invalidated by MQA if the station/shelter temperature range exceeds instrument certification limits. Data invalidations due to station temperature excursions are managed manually by MQA on a case-by-case basis per guidelines documented in Data Management SOP 601.

Parameter	Instrument	EPA Required Temp Range [1]	BAAQMD Station/Shelter Out Of Range Criteria
SO2	THERMO 43 (all)	20 -30 °C	≤ 19.5 °C or ≥ 30.5 °C FULL STATION ≤ 14.5C or ≥ 35.5C PARTIAL STATION

[1] **From EPA List of Designated Reference and Equivalent Methods, October 11, 2011**

Figure 5: BAAQMD Station/Shelter Temperature Criteria

Parameter	Requirement	Frequency	Acceptance Criteria
Sulfur Dioxide Trace Level	One-Point QC Check	Every 2 days	≤ ± 15%
	Zero/Span Check	Every 2 days	≤ 3 ppb Zero ≤ ± 7% Span diff
	Performance Evaluation	Semi-Annual	≤ ± 15%
	Bias Validation	Annual	95% of PE points fall within 95% PL for QC Checks

Figure 6: BAAQMD QC Limits for SO2 Trace Level

Parameter	Requirement	Frequency	Acceptance Criteria
Sulfur Dioxide Trace Level	Precision Checks	Every 2 days	≤ ± 15%
	Precision (QC Checks)	Annual	≤ 15%
	Bias (QC Checks)	Annual	≤ ± 10%
	Shelter Temperature	Hourly	15 - 35 °C

Figure 7: BAAQMD MQO's for SO2 Trace Level

11.2 QUALITY ASSURANCE

Quality Assurance activities include the following:

- District staff shall conduct performance and system's audits on a regular basis.
- CARB staff may conduct performance and/or systems audits
- EPA staff may conduct performance and/or systems audits

Parameter	Frequency	Acceptance Criteria
Sulfur Dioxide Trace Level	Semi-Annual	≤ ± 15%

Figure 8: BAAQMD Internal Audit Acceptance Criteria for SO2 Trace Level

12. AUTHORS

- Original Author: Morris Erickson
- Revised By: Stan Yamaichi, 5/30/2008
- Revised By: Stan Yamaichi/Lisle Rath 1/11/2012; removed 43C information, procedures and figures Added "43i-TLE information

- Revised By: Christopher Rumm, 06/20/2012; re-formatted SOP

13. REFERENCES

- Code of Federal Regulations, Title 40, Part 53
- Code of Federal Regulation, Title 40, Part 58
- EPA QA Handbook Vol. II, Quality Assurance Handbook for Air Pollution Measurement Systems
- EPA Air Quality Standards, 40 CFR Part 50, NAAQS for Criteria Pollutants
- Thermo Fischer Environmental, Inc. 43i-TLE SO2 Analyzer Instrument Manual: \\cifs-02\sections\Air_Mon\Instrument Manuals\THERMO
- Data Mgt SOP 601 Gaseous Pollutants

14. APPENDIXES

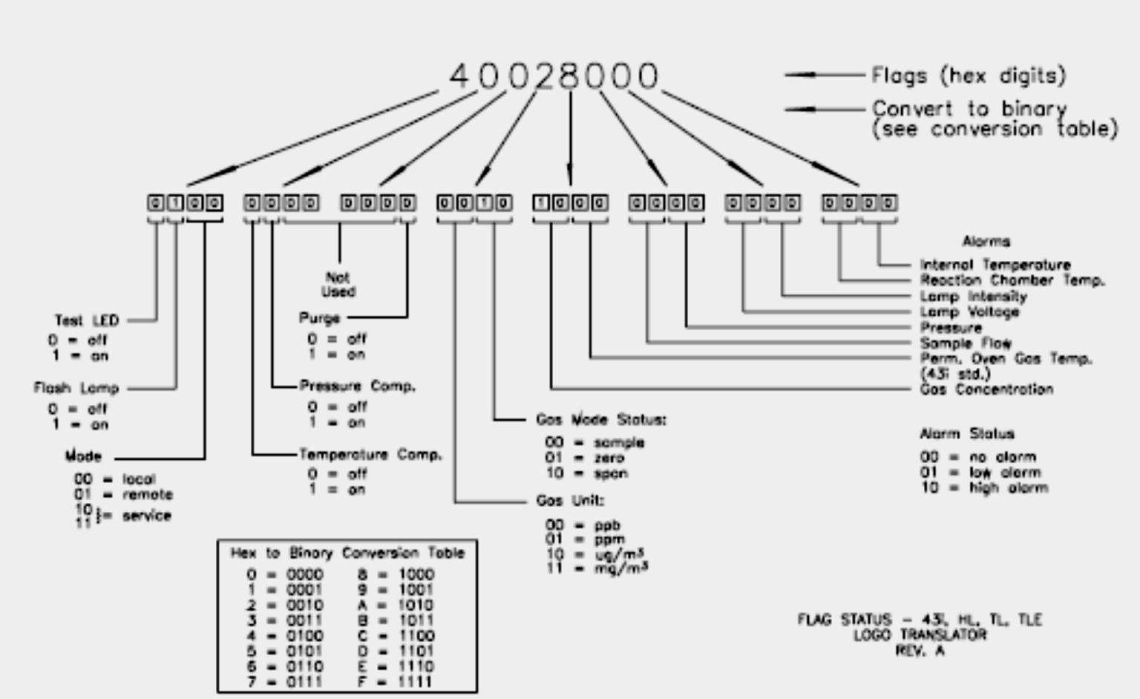
14.1 APPENDIX A: 43I-TLE SPECIFICATIONS

Preset ranges	0-10, 20, 50, 100, 200, 500, and 1000 ppb 0-20, 50, 100, 200, 500, 1000, and 2000 µg/m^3
Custom ranges	0-10 to 1000 ppb 0-20 to 2000 µg/m^3
Zero noise	0.14 ppb RMS (10 second averaging time) 0.06 ppb RMS (60 second averaging time) 0.025 ppb RMS (300 second averaging time)
Lower detectable limit	0.208 ppb (10 second averaging time) 0.12 ppb (60 second averaging time) 0.05 ppb (300 second averaging time)
Zero drift (24 hour)	< 0.2 ppb
Span drift	± 1% full-scale per week

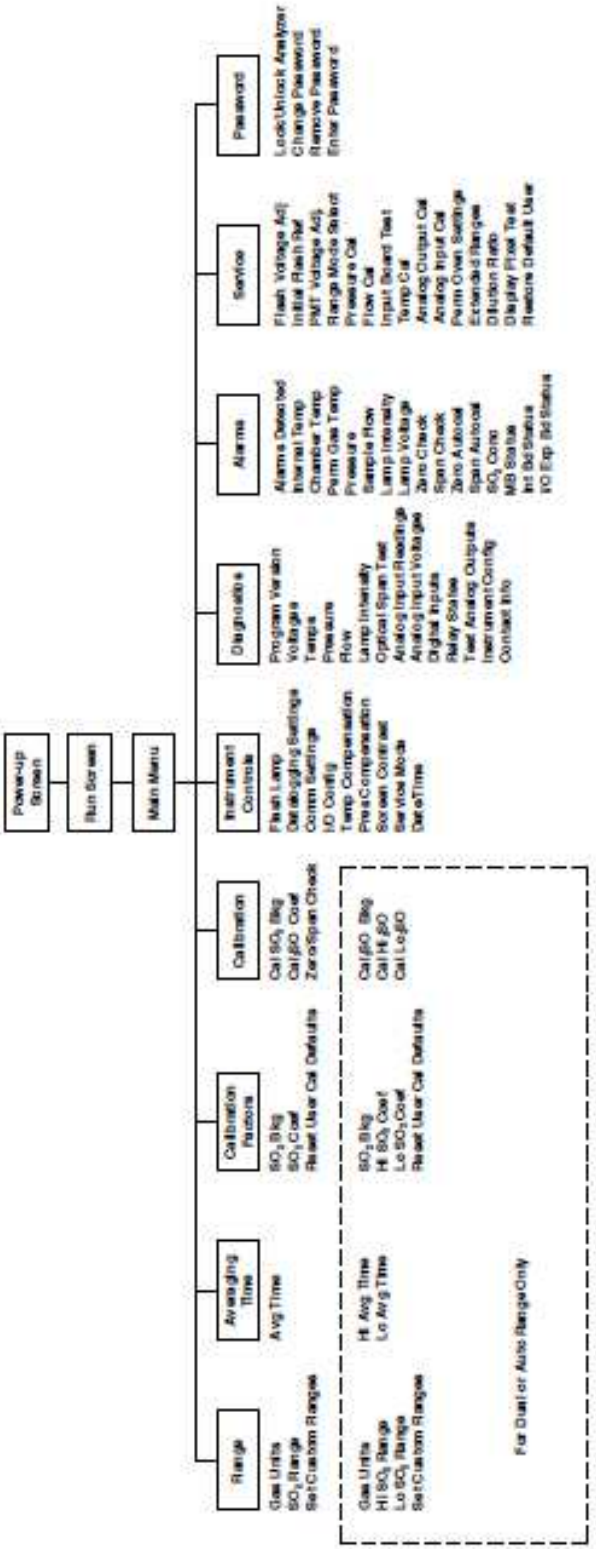
43i-TLE SPECIFICATIONS continued

Response time	80 sec (10 second averaging time) 110 sec (60 second averaging time) 320 sec (300 second averaging time)
Linearity	± 1% of full-scale
Sample flow rate	0.5 lpm (standard) 1.0 lpm (optional)
Interferences (EPA levels)	Less than lower detectable limit except for the following: NO < 1 ppb, M-Xylene < 1ppb, H_2O < 3% of reading
Operating temperature	15–35 °C (may be safely operated over the range of 0–45 °C)[1]
Power requirements	100 VAC @ 50/60 Hz 115 VAC @ 50/60 Hz 220-240 VAC @ 50/60 Hz 165 watts
Physical dimensions	16.75" (W) X 8.62" (H) X 23" (D)
Weight	Approximately 48 lbs.
Analog outputs	6 voltage outputs; 0–100 mV, 1, 5, 10 V (user selectable), 5% of full-scale over/under range, 12 bit resolution, user selectable for measurement input
Digital outputs	1 power fail relay Form C, 10 digital relays Form A, user selectable alarm output, relay logic, 100 mA @ 200 VDC
Digital inputs	16 digital inputs, user select programmable, TTL level, pulled high
Serial Ports	1 RS-232 or RS-485 with two connectors, baud rate 1200–115200, data bits, parity, and stop bits, protocols: C-Link, MODBUS, Geysitech (Bayern-Hessen), and streaming data (all user selectable)

14.2 APPENDIX B: 43I TLE ALARM FLAGS



14.3 APPENDIX C: 43I-TLE FLOWCHART OF MENU DRIVEN SOFTWARE



14.4 APPENDIX D: EXAMPLE OF 43I TLE MDL TEST RESULTS

				SO2								
	01/26/12		01/27/12		01/30/12		01/31/12		02/01/12		02/02/12	
	0.279	0.19	0.166	0.248	0.339	0.302	0.274	0.215	0.228	0.237	0.324	
	0.15	0.238	0.156	0.18	0.249	0.202	0.183	0.198	0.17	0.258	0.2	
	0.045	0.254	0.162	0.242	0.243	0.237	0.229	0.198	0.281	0.227	0.205	
	0.239	0.234	0.252	0.278	0.162	0.206	0.207	0.188	0.256	0.237	0.222	
	0.276	0.197	0.223	0.259	0.245	0.283	0.289	0.234	0.253	0.209	0.229	
	0.139	0.298	0.204	0.23	0.306	0.252	0.232	0.173	0.286	0.3	0.25	
	0.171	0.245	0.302	0.229	0.261	0.201	0.193	0.244	0.283	0.333	0.308	
	0.144	0.281	0.301	0.23	0.202	0.174	0.21	0.226	0.199	0.215	0.227	
	0.23	0.296	0.226	0.174	0.226	0.234	0.187	0.181	0.158	0.155	0.227	
	0.205	0.281	0.189	0.272	0.248	0.142	0.195	0.206	0.266	0.253	0.222	
	0.204	0.247	0.188	0.221	0.203	0.186	0.227	0.203	0.255	0.255	0.325	
	0.219	0.215	0.258	0.189	0.221	0.223	0.189	0.228	0.299	0.249	0.324	
	0.182	0.154	0.249	0.228	0.201	0.299	0.126	0.268	0.245	0.2	0.235	
	0.172	0.278	0.27	0.232	0.307	0.267	0.23	0.176	0.284	0.319	0.29	
	0.279	0.201	0.217	0.259	0.157	0.2	0.223	0.232	0.274	0.213	0.23	
	0.232	0.227	0.147	0.164	0.205	0.229	0.203	0.205	0.227	0.321	0.217	
	0.183	0.223	0.183	0.236	0.234	0.298	0.309	0.177	0.244	0.278	0.261	
	0.132	0.207	0.129	0.264	0.238	0.192	0.226	0.187	0.23	0.218	0.275	
	0.299	0.207	0.135	0.08	0.296	0.232	0.234	0.224	0.305	0.175	0.235	
	0.227	0.272	0.106	0.207	0.267	0.232	0.116	0.246	0.258	0.177	0.254	
	0.16	0.254	0.149	0.153	0.27	0.315	0.165	0.184	0.25	0.333	0.212	
	0.183	0.275	0.204	0.212	0.171	0.272	0.248	0.17	0.259	0.262	0.226	
	0.272	0.265	0.119	0.246	0.276	0.223	0.226	0.335	0.21	0.164	0.152	
	0.272	0.238	0.194	0.22	0.292	0.303	0.22	0.246	0.216	0.225	0.276	
	0.272	0.234	0.195	0.256	0.217	0.284	0.256	0.264	0.279	0.158	0.18	
Ave	0.20664	0.24044	0.19696	0.22036	0.24144	0.23952	0.21588	0.21632	0.2486	0.23884	0.24424	
STDEV	0.017421	ppb										
MDL	0.048152	ppb										
LDL	0.12	ppb										