

**Section 2.35.1: Electronics and Calibration Branch  
(ECB) Responsibilities**

**Continuous Particulate Sulfate ( $\text{SO}_4^{-2}$ ) Measurement  
(Using Thermo Electron Model 5020 SPA)  
QA Plan/SOP**

**Revision 0**

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## **2.35.1 Continuous Particulate Sulfate QA Plan: ECB Responsibilities**

The discussion provided in the following sections is intended to outline the **responsibilities** of the Electronics and Calibration Branch (ECB) relative to the set-up, installation, auditing and maintenance of the TEI Model 5020 Sulfate Particulate Monitor. Details of the operation of the analyzer itself or the equipment used to perform audits or to perform maintenance on the equipment is not provided in this document. It is assumed that the individual(s) performing such activities have had the necessary training and experience to adequately perform these duties.

### **2.35.1.1 Equipment Selection and Procurement**

The ECB shall procure air monitoring equipment and supplies for the Division of Air Quality as needed to support various air pollutant monitoring programs. EPA's Reference or Equivalent methods list should be reviewed to determine the makes and models acceptable for monitoring particulate sulfate. Since particulate sulfate is not a criteria pollutant, instrumentation for this specific purpose will not be listed. With support from the Projects and Procedures Branch (PPB), ECB will identify vendors of continuous particulate matter trace level sulfate analyzers and supporting equipment that meet or exceed the following specifications:

- A detection limit no higher than 1 ug/m<sup>3</sup> with an accuracy of  $\pm 2$  ppb on the 100 ppb scale;
- An acceptable output for the data logging system deployed with the instrument (digital output or analog output of 0 to 10 volts DC);
- All monitors and calibrators must operate on 115 volt AC 60Hz line current;
- All analog data acquisition systems must be calibrated to accept a 0 to 10 volt DC output and all digital data acquisition systems must be at least 10-bit and have RS232 and/or Ethernet connections; and
- Meet other specifications as necessary.

### **2.35.1.2 Description / Principle of Operation of the Thermo-Environmental Inc (TEI) Model 5020 Sulfate Particulate Analyzer**

A chemical speciation program was initiated by the United States Environmental Protection Agency (USEPA) to characterize the components of fine particulate matter (PM) with an aerodynamic diameter  $< 2.5$  microns (PM<sub>2.5</sub>). The resultant speciation database is expected to, among other things, help identify the sources of PM<sub>2.5</sub>, evaluate the effects of control strategies, assist with modeling and eventually establish trends. One of the components of PM<sub>2.5</sub> to be characterized is sulfate (SO<sub>4</sub><sup>-2</sup>). A significant contribution to PM<sub>2.5</sub> is thought to be ammonium sulfate, which is formed in the atmosphere by the chemical reaction between trace levels of sulfur dioxide (SO<sub>2</sub>) and ammonia. The Thermo Environmental, Inc. Model 5020 Sulfate Particulate Analyzer (TEI 5020 SPA), which measures atmospheric sulfate on a continuous basis and provides real time data, will be used to provide the information necessary to populate the database in support of the objectives listed above. In order to collect accurate and meaningful

data, the monitors must be operated in a consistent manner. **This document makes references to other supporting instrumentation such as the 146C gas calibrator and ESC 8816/8832 data acquisition systems, but does not provide in depth details of their operation. Please refer to the appropriate QA Plan/SOP found on the DAQ Internal Web Site or the instrument manual for specific separate guidance on their function and operation.**

Ambient air, potentially containing particulate matter (PM), is initially drawn through a size cut inlet that allows only PM with an aerodynamic diameter < 2.5 microns to pass to the “TEI Model 5020 Sulfate Particulate Analyzer”. (The 5020 SPA is comprised of two connected, but separate modules; a converter and an analyzer.) After the size cut process, the continuous sample stream first passes through a denuder that removes SO<sub>2</sub> and other acid gases, then through a high temperature converter that converts any PM<sub>2.5</sub> containing SO<sub>4</sub><sup>-2</sup> to SO<sub>2</sub> and finally to an analyzer that measures the resulting SO<sub>2</sub> concentration. This analyzer is a modified version of the TEI 43C TLE SO<sub>2</sub> analyzer and is similar in function and operation. The 5020 SPA quantifies sulfate by comparing the signal produced from an aerosol-laden sample (< 2.5 microns) that is drawn directly into the converter module (**unfiltered sample/SO<sub>2</sub> removed, referred to as the “Sample Mode”**) to a background signal (**filtered sample/SO<sub>2</sub> removed, referred to as the “Filter Mode”**) that is produced from raw ambient air that has passed through a high efficiency particulate (HEPA) filter and the denuder before passing through the converter. (Both the unfiltered and filtered gas stream pass through the denuder.) The difference in signal between the unfiltered sample (**SO<sub>2</sub> removed**) and the filtered sample (**SO<sub>4</sub><sup>-2</sup> and SO<sub>2</sub> removed**) can be attributed to SO<sub>2</sub> that is formed from the conversion of SO<sub>4</sub><sup>-2</sup> particles in the unfiltered sample stream. The analyzer module is calibrated with SO<sub>2</sub> and the resulting SO<sub>4</sub><sup>-2</sup> concentration (resulting from a software mathematical calculation) is reported in units of micrograms per cubic meter (ug/m<sup>3</sup>) at local conditions of temperature and pressure. Four ug/m<sup>3</sup> of SO<sub>4</sub><sup>-2</sup> is equivalent to approximately one part per billion (ppb) of SO<sub>2</sub>. With an averaging time of 60 seconds, the 5020 SPA has the capability of detecting SO<sub>2</sub> concentrations at nominally 0.05 ppb, which corresponds to a SO<sub>4</sub><sup>-2</sup> concentration of nominally 0.20 ug/m<sup>3</sup>.

#### **Model 5020 Monitor Description (Specifications)**

Preset Analog Ranges	0-5, 10, 25, and 100 ug/m <sup>3</sup> SO <sub>4</sub> 0-2, to 1000 ppb SO <sub>2</sub>
Zero Noise	0.05 ppb RMS (60 sec. avg. time)
Lower detectable limit	0.5 ug/m <sup>3</sup> SO <sub>4</sub> (15 minute cycle time)
Zero Drift (24 hour)	Less than 1 ppb
Span Drift (24 hour)	± 1%
Response Time	110 sec. (60 sec. avg. time)
Precision	1% of reading or 1 ppb (whichever is greater)
Linearity	± 1% of full-scale
Sample flow rate	0.4-0.5 liters/min. (standard)
Interferences (EPA levels)	NO rejection > 125
Operating temperature	20°-30°C
Power requirements	105-125 VAC @ 50/60 Hz 700 Watts

Physical dimensions	16.75" (W) X 8.62" (H) X 23" (D) Analyzer or Converter module
Outputs	Selectable voltage (0.1, 1.0, 5.0, 10 V) 4-20 mA RS-232/485 Interface

### **2.35.1.3 Description And Operation of TEI Model 146C and Zero Air Supply**

#### **TEI Model 146C Calibrator**

The Model 146C Calibrator supplies the required levels of clean air and SO<sub>2</sub> to perform zero, precision, span checks and multipoint calibrations. The Model 146C can be operated remotely from the datalogger to automatically perform zero, precision, and span checks or "locally" to perform audits by manually generating specific concentrations. The Model 146C is an accurate mass flow controlled gas dilution system. SO<sub>2</sub> gas from a National Institute of Standards and Technology (NIST) traceable Protocol certified cylinder (connected to Port C) is blended with "zero-air" to provide a desired concentration. From the known calibration of the two mass flow controllers, a pre-selected concentration can be calculated and delivered. A typical dilution ratio of about 100:1 to 1000:1 is used on cylinders.

The 146C calibrators must be re-certified on a quarterly basis.

#### **TEI Model 111 Zero-Air Supply System**

The purpose of the Model 111 is to supply pollutant-free air ("zero air") for proper zeroing and to provide clean diluent air for the generation of audit gas concentrations for ambient air analyzers. The trace level components removed from ambient air are SO<sub>2</sub>, NO, NO<sub>2</sub>, O<sub>3</sub>, CO, water vapor and hydrocarbons. Currently, there is no official re-certification procedure for this unit; however, the replacement of the scrubbing chemicals on an annual basis is mandatory.

#### **Gas Cylinders**

All calibration gas cylinders must be traceable to a NIST-Standard Reference Material (SRM) and be used within the certification period.

### **2.35.1.4 Initial Laboratory Startup of the TEI Model 5020**

The ECB shall conduct and document, initial operational tests before deploying an instrument. All pre-deployment testing/set-up is recorded in the Model 5020 instrument maintenance logbook that resides at the ECB facility. Refer to Figure 1 Appendix A, TEI Model 5020 components, for a diagram of the instrument components. Procedures to be completed include:

- Initial Inspection for damage and completeness of delivery;
- Assembly (Modification of inlet system, Setting of Parameters, Flow Verification, and Lamp Verification);
- Leak Check, flow check and Calibration; and
- Programming of data acquisition system to accommodate the cyclic operation of the TEI Model 5020.

## **Inspection**

Visually inspect the exterior of all items for damage. Remove the cover and inspect the electronics assembly and circuit boards for loose wires, cables, broken components, or other damage. Reconnect any loose components and if necessary, contact the manufacturer. Document all findings in the instrument maintenance logbook.

## **Assembly (and Modification and Initial Verification)**

Prior to deployment in the field, all instruments will undergo basic operational tests in the ECB lab. Results will be recorded in the instrument's logbook which remains on file in the ECB Lab.

The instrument will be set up in the lab with accompanying, calibrator, zero air system, cylinder, and data logging system along with the sample inlet system as shown in Figure 1 of Appendix A.

For new instruments, each TEI Model 5020 requires the addition of a sample inlet system. This system includes a 2.5 micrometer sharp cut cyclone, an isokinetic flow splitter, a mass flow controller (MFC) and associated pump to control the auxiliary flow rate needed for proper operation of the cyclone and a denuder. Except for the denuder, these items are not part of the TEI Model 5020 package and must be obtained from other vendors. The MFC must be one that has a flow range of 0-2 lpm with an accuracy of  $\pm 2\%$  (such as Omega Model FMA 5500/5400). The sharp cut cyclone must have an accuracy of  $\pm 2\%$  at a flow rate of 0.910 lpm (such as the BGI Model SCC 0.732). The flow splitter is of a custom design and must be fabricated according to the specifications provided as Figure 2 in Appendix A.

Install the 47 mm 1 micrometer pore size particulate filter in the filter holder on the rear of the converter module. Connect the sample inlet system to the sample inlet on the rear of the converter module. Connect the sample line from the sample outlet on the rear of the converter module to the sample inlet on the rear of the analyzer module. Using  $\frac{1}{4}$  inch Teflon tubing, connect the zero air supply from the outlet on the rear of the converter module to the flow splitter and also connect the auxiliary flow from the MFC to the flow splitter. Connect the analyzer module rear panel bulkhead labeled "exhaust" to a suitable vent outside of the monitoring room (**do not** vent to room air). Plug in power cords and turn on power to the analyzer module, converter module, auxiliary MFC and associated pump. The cooling fans, pumps, mode lights and fluorescent source should now be powered. Check to see that the high temperature converter is heating up and reaches a maximum pre-set temperature of 1000 degrees C. Allow the converter to "burn in" for at least 12 hours before continuing with the set up.

***Note: The details of the operation of the TEI 5020 instrument are provided in Section 2.35.2: "Operator's Responsibilities" QA/SOP as a separate document and should be used in conjunction with this document as well as the manufacturers' instrument manual. References to specific sections within the "Operator's Responsibilities" QA/SOP will be provided here to assist with instrument set-up and operation.***

Before the initial laboratory calibration is conducted, all instrument parameters must be set according to those given in *Section 2.35.2: “Operator’s Responsibilities” QA/SOP* sub-section 2.35.2.3.2, and summarized below.

Parameter	Set Point	Comments
Averaging Time	60 seconds	Fixed at set-up
Sample/Filter Time	10 minutes/5 minutes	Fixed at set-up
Transition Time	120 seconds	Fixed at set-up
Cal Stage Time	25 minutes	Fixed at set-up
Span Concentration	85 ppb	Fixed at set-up
Span Range	100 ppb	Fixed at set-up
Pressure Correction	ON	Fixed at set-up
Flash Lamp	ON	Fixed at set-up
Converter Temperature	1000 degrees C	900-1050 degrees C
Sample/Filter Mode	ON	Fixed at set-up
Date/Time	EST (must agree with 146C and data logger)	± 5seconds
Span Coefficient	Typically 0.90 to 1.1	Updated at time of calibration
Converter “Zero Air” Flow	At least 2.5 lpm	Flow is observed at rotometer attached to converter (in “Sample Mode” flow is at least 2.5 lpm: in “Filter Mode” flow goes to zero)

With the exception of the cyclone auxiliary flow, the following parameters are not adjustable during normal operation. However, the acceptable ranges are adjustable and are set by the ECB. During operation, if any parameter is outside of the acceptable range, an alarm will be activated and a **flashing asterisk** will be observed on run display screen.

Parameter	Typical Display Value	Acceptable Range
Internal Temperature	38 °C	35-40 °C
Optical Cell Temperature	45 °C	43-47 °C
Converter Temperature	± 50 °C of Conv. BTE Temp.	900-1050 °C
Converter BTE Temperature	± 50 °C of Conv. Temp.	900-1050 °C
Sample Pressure	710 mm Hg	700-800 mm Hg
Sample Flow	460 cc/min	440- 480 cc/m
Lamp Intensity	15,000 Hz	10,000-20,000 Hz

Lamp Voltage	1012 Volts	950-1200 Volts
Cyclone aux(illary) flow (note: this value is displayed on the PC screen via E:DAS as "Auxflow")	450 cc/min	Must equal 910 minus sample flow (flow is adjustable via set-pot screw on MFC)
Ambient Conditions, Press/Temp	760 mm Hg/25° C	NA
Photomultiplier Tube	-689 volts	NA

**Flow Check Procedure**

Air flow is generated at three locations within the TEI 5020 sampling and analysis system:

- 1) **Sample Flow** is generated by the pump in the analyzer unit, which creates a flow of nominally 460 cc/min. from the cyclone inlet through the analyzer. This flow is continually measured and monitored by the analyzer module with a readout provided by the analyzer under the **Diagnostics** menu for **Sample Pressure/Flow** display;
- 2) **Auxiliary or Cyclone By-Pass Flow** is generated by an external Thomas pump and is measured and controlled by an external mass flow controller. This flow is nominally 450 cc/min. and should be adjusted, as necessary, as discussed in Section 2.35.2: "Operator's Responsibilities" QA/SOP sub-section 2.35.2.3.6. This flow reading is displayed on the site PC through a signal from the data logger and is identified as "Auxflow".
- 3) **Zero Air Flow** is generated by a pump within the converter unit and is used in conjunction with the "Filter Mode" of the analyzer. This flow must be greater than the sum of the "sample flow" plus the "Auxflow" and must be re-configured by the ECB to be nominally 2.5-3.5 lpm. (This is accomplished by exchanging the supplied glass capillary with one that allows a higher flow.) This flow should not be confused with the zero air that is generated by the zero-air-pack and used for analyzer calibration and/or calibration checks with the 146C calibrator. Determining the actual value of this flow is not required, but should be at least 200-300 cc/min in excess of the total flow generated by 1 and 2 above. In the "Sample Mode", this flow is indicated by a rotometer connected to the converter vent outlet.

Choose Diagnostics from the Main Menu. Choose Flow/Pressure from the Diagnostics Menu, verify the current sample flow rate and record in the instrument maintenance logbook. The flow is measured by an internal flow sensor. A nominal flow rate of 460 cc/min. and a nominal sample pressure of 750 psi should be observed (if a flow rate of less than 350 cc/min. is observed a leak may be present.) Refer to **Section 2.35.2: "Operator's Responsibilities" QA/SOP** sub-section 2.35.2.3.6 for details.

## Leak Check and Calibration

### Leak Check (Through the entire system from cyclone inlet through analyzer)

A leak test should be performed before deployment to the field, and also whenever the flow is observed to be less 0.35 LPM. The details of the leak check procedure can be found in **Section 2.35.2: “Operator’s Responsibilities” QA/SOP** sub-section 2.35.2.3.5 and are summarized below:

**Note: At this point the leak check procedure can only be performed with the system in the sample mode (a 10 minute window) and not in the filter mode.**

1. From the run screen press **menu** button, use ↓ button to display **Diagnostics**, then press **Enter** button.
2. Use ↓ button to display **Sample Pressure/Flow**, then press **Enter** (for normal operation, the flow should be between 400 and 500 cc/min and the pressure should be between 700 and 800 mm Hg with steady readings. A flow of less than 400 cc/min and a pressure less than 700 mm Hg indicates potential problems in the sample flow path such as a plugging 47 mm filter, or failing converter core.
3. Remove the cyclone (friction fit, see Figure 1). Plug the sample inlet with a leak tight device (such as a section of rubber tubing). Disconnect the cyclone auxiliary flow line from the flow splitter and cap the 3/8” flow splitter outlet.
4. Observe the sample pressure/flow readout on the screen of the monitor for decreasing values. Values should be dropping toward zero. The system leak check passes when the flow drops below 200 cc/min and the pressure drops below 300 mmHg. This should require approximately 5 minutes. Document in the logbook.

### Calibration (Multi Point Procedure)

Referring to the 146C calibrator, attach a Teflon tube (FEP Teflon type only) from the fitting labeled "output" on the rear panel of the 146C calibrator to the "sample" input of the analyzer module. Connect a source of zero-air to the inlet port labeled zero-air on the 146C. Connect the standard SO<sub>2</sub> gas cylinder to the port labeled C.

The details of the calibration procedure can be found in **Section 2.35.2: “Operator’s Responsibilities” QA/SOP** sub-section 2.35.2.3.7 and are summarized below:

Conduct an adjusted initial calibration followed with linearity checks over the course of a few days to document instrument stability and repeatability. An EPA Protocol SO<sub>2</sub> Cylinder with a nominal concentration of 10 ppm is required. Table 1 provides the calibration values.

**Table 1. 5020 SPA SO<sub>2</sub> Calibration Ranges and Target Concentrations for 100 ppb Full Scale**

SPAN Level	Range, ppb	Target, ppb	Acceptable Limit
Span 1 (70-90 % of Full Scale)	70-90	85	± 3 ppb
Span 2 (40-50% of Full Scale)	40-50	45	± 3 ppb
Span 3 (16-20% of Full Scale)	10-100 <sup>A</sup>	7.0 <sup>A</sup>	± 2 ppb
Zero	0.0	0.0	± 1 ppb

<sup>A</sup> Per 40 CFR Part 58, the QC Check (i.e., Span 3) must be between 10 and 100 ppb or at a level that would more appropriately reflect the precision and bias at lower levels that are routinely encountered.

The instrument response is linear over the range of 0 to 100 ppb of SO<sub>2</sub>. Therefore the internal software allows only a single span point for calibration. A calibration consists of re-setting the instrument zero using zero air and re-setting the calibration factor using the highest calibration gas (i.e., Span 1). In doing so, the instrument calibration coefficient is manually adjusted and should be between 0.90 and 1.1 with a value of 1.0 being ideal. After performing a calibration, this value should be recorded in the logbook. Intermediate span points (Span 2 and Span 3) are introduced to the analyzer and are also recorded in the logbook.

*Calibration Procedure:*

**NOTE:** The following procedure is to be performed with the instrument **remaining** in the “automatic cycle mode”, i.e., normal operating mode for data collection. The analyzer run screen will show that the instrument is cycling between filter mode and sample mode, but the only parameter that is of concern is the “SO2 PPB”. **DO NOT USE THE “ZERO ADJUST” OR “SPAN ADJUST” FUNCTION UNDER THE “CALIBRATION” MENU. INSTEAD USE THE “INSTRUMENT ZERO” OR “SO2 SPAN COEFFICIENT” FUNCTION UNDER THE “CALIBRATION FACTORS” MENU.**

**A) Zero Set Procedure:**

- 1) Disconnect the ¼” Teflon sample line from the “Sample In” port on the rear of the analyzer. Disconnect the ¼” Teflon line (coming from the 146C calibrator) from the “Span/Zero” port on the rear of the analyzer (see Figure 1, Point C) and connect it to the “Sample In” port on the rear of the analyzer.
- 2) On the 146C calibrator, press **MENU**, press **ENTER** to display “Local Mode” then press **RUN**. Select “Gas C” and press **ENTER** then Select “Span 0” and press **ENTER**. This introduces zero gas to the analyzer.
- 3) From the “Main Menu” of the 5020 SPA analyzer, use the ↓ button to select “Calibration Factors”, use the ↓ button to select “Instrument Zero” and press **ENTER**.
- 4) Allow the “SO2 ppb” readings on the analyzer display to stabilize (will require at

least 30 minutes) and then use the ↑ or ↓ buttons until the average reading is  $0.00 \pm 1.0$  ppb, then press **ENTER**. Record in the logbook the next five one-minute SO<sub>2</sub> concentration values and the average. Also record the “True” 146C “Output PPB” concentration from the calibrator display.

**B) Span Set Procedure:**

- 1) From the “Main Menu” of the 5020 SPA analyzer, use the ↓ button to select “Calibration Factors”, use the ↓ button to select “SO<sub>2</sub> Span Coefficient” and press **ENTER**.
- 2) On the 146C calibrator, press the → button to move to “Span 1” (pre-set to 85 ppb) and press **ENTER**. In the logbook, record the 146C flows (push “Run” to see flows) and theoretical SO<sub>2</sub> concentration (i.e., 85 ppb). This introduces Span 1 gas to the analyzer.
- 3) Allow the “SO<sub>2</sub> ppb” readings on the analyzer display to stabilize (will require at least 30 minutes) and then use the ↑ or ↓ buttons to change the “COEF” value until the average reading is  $85.0 \pm 3$  ppb, then press **ENTER**. (The Coefficient value should be close to 1.00, record value in logbook.) Record in the logbook the next five one-minute SO<sub>2</sub> concentration values and the average. Also record the “True” 146C “Output PPB” concentration from the calibrator display.

**C) Verification of Calibration (Multi-point Calibration Check):**

To verify linearity, sequentially introduce zero air, Span 1 (85 ppb), Span 2 (45 ppb) and Span 3 (7 ppb) calibration gases from the 143C calibrator **with the 5020 SPA still in the “SO<sub>2</sub> Span Coefficient” menu. DO NOT press ENTER during this process as this will reset the calibration coefficient to an erroneous value.** After allowing sufficient time for each reading to stabilize as discussed above, record five one-minute 5020 SPA concentration values in the logbook and then compute and record the average of those one-minute concentration values. Also record the “True” 146C “Output PPB” concentration from the calibrator display. Acceptable ranges are provided in Table 1. If values are outside of the acceptable range, trouble shoot the system looking for leaks, proper operation of 146C calibrator etc. and repeat the multi-point calibration check.

Verify the instrument performance for all tests, document the results in the maintenance logbook and forward a copy of the logbook to the ECB Branch Supervisor. If the instrument fails to operate within specifications after repeated attempts, contact the manufacturer for assistance.

**Specific Programming**

Due to the cyclic operation of the 5020 SPA (10 minutes for sampling mode and 5 minutes for filter mode), the daily polling of concentration values and calibration checks by the Data

Acquisition System is problematic. Since the data acquisition system (DAS) queries the analyzer at specific times (once every 15 minute just prior to cycling into a filter mode), it is necessary that the clock times of the analyzer and the DAS be constantly synchronized and that the start of each cycle of the analyzer occurs at a specific pre-set clock time. The analyzer holds the current "SO4 cycle" concentration value for 15 minutes and then updates at the completion of a filter mode cycle. With this in mind, the analyzer must be initially started in the "Cyclic Run Sequence" at the top of any convenient hour. Operating in this fashion, the analyzer updates every 15 minutes (15 minutes after the hour, 30 minutes after the hour and so on). The DAS must be programmed to poll the analyzer every 15 minutes just prior to the analyzer updating the concentration value (12 minutes after the hour, 27 minutes past the hour and so on). The DAS must be programmed to synchronize the analyzer clock to the DAS once every hour. The timing of the automatic daily calibration check (which is controlled by the DAS) must be set to begin at a clock time that provides sufficient time to complete the calibration check and then return the analyzer to the "Cyclic Run Sequence" at the top of the hour. In the event of a power failure, the timing sequence discussed above would be interrupted. The DAS must be programmed to recognize the "P" flag and institute a timing sequence that allows the analyzer to return to the "Cyclic Run Sequence" at the top of the hour. The details of the specific programming commands for the DAS are included in the instrument logbook that is maintained at the ECB. It is the responsibility of the ECB to program the commands in the DAS. Clock synchronization checks should be coordinated with the regional field technician responsible for the instrument.

## **Inventory**

Upon approval of the tested unit, the unit shall be added to the fixed asset system. For each monitor, apply an inventory decal FAS # and complete an inventory load sheet showing the planned monitor location. Submit the inventory load sheet to the ECB branch Supervisor.

### **2.35.1.5 On-site Installation**

The ECB will install the monitor and its support equipment. Acquiring access to a site, and approval of the site is the responsibility of the regional office and the Projects and Procedures Branch. Phone service and electrical power should be secured by the regional office, along with any needed permits, new wiring, etc., prior to installation of the monitor equipment. The site location must meet the applicable site requirements and be approved by the Network Coordinator and EPA.

## **Install**

Verify that the building/shelter is sound and that the heating/cooling system is working. The sampling probe must be 3/8" stainless steel and lines must be FEP Teflon. Lines must be clean, and have a sample residence time of less than 20 seconds. The inlet line should be heated and wrapped with removable polyurethane foam in order to prevent condensation. For continuous, year-round sites, the probe will be changed at least every two years during a scheduled audit (even calendar years).

**WARNING:** Do not plug in the monitor, calibrator, modem, data logger, and interface

box until all cables are connected. ELECTRICAL SHOCK AND/OR EQUIPMENT DAMAGE MAY OCCUR OTHERWISE.

Connect the monitor, modem, data logger, backup data logger (if used) and computer observing polarity markings. Connect all instruments and support equipment power cords to a grounded surge suppressor, connected to a 115v AC, 60 Hz grounded receptacle. Connect the analyzer module to the 146C calibrator and the zero air system to the calibrator.

Configure the modem to auto answer on the first ring and to operate at 2400 bps. Configure the data loggers and PC software, including the scheduler, to run auto poll/cal. Primary and Backup data loggers can be ESC Model 8816's or 8832's. The ECB verifies that the system can be accessed remotely by phone from the ECB lab. (It is the responsibility of the region to program the E:DAS for the polling of information that is specific to the needs of the region.) Verify that all operational events, such as solenoid on/off are working. Bleed the calibration cylinder regulators and lines to purge / minimize room air in the calibration system. Check the analog outputs on the instrument after performing the operational checks.

#### **Check/Set Time and Date-Computer, Datalogger and Analyzer**

The times for the PDL, (and BUDL if being used) and computer must be EASTERN STANDARD TIME. The "synchronization" function in the ESC software will not be employed by the central EDAS computer or the regions' polling computers to avoid possibly short-changing data sets by constantly resetting clocks before a full hour can be polled. However, the "synchronization" function in the ESC software will be employed to keep the data logger and the TEI 5020 analyzer module at the same time.

**NOTES: The PDL and the BUDL (if being used) must have the same time and be synched to the NIST time provider in Colorado ( $\pm 1$  minute). Sources of the NIST time include: cell phones-most automatically synch to local NIST time; calling Colorado (303-499-7111); setting a watch to the NIST website (<http://nist.time.gov/>) within 24hrs of visiting the site. The site computer MUST be set to match the dataloggers to ensure that a full hour of data is retrieved/stored during regularly scheduled polling.**

#### **Installation Leak Check/Flow Check**

Before running an installation zero or span, leak check the SO<sub>2</sub> sampling/analysis system and verify that the sample flow rate, the zero air flow rate of the converter module and the flow rate of the auxiliary flow MFC are within specifications and document in the maintenance logbook and the site E:LOG "site set-up". Follow the procedures outlined in Section 2.35.1.4 of this document.

#### **Installation Zero-Span-Precision Check**

Run a three point check of the instrument to include; the zero point, the span point relative to the instruments expected operating range and, the precision point. This procedure **IS NOT** a substitute for the initial calibration to be performed by the region. This calibration check is intended as a field check to verify the instrument (and its associated components) have not

suffered a catastrophic mishap from lab bench to field shelter. The sampling system should introduce, and the instrument should successfully recognize, SO<sub>2</sub> concentrations in the appropriate magnitudes. Follow the procedures outlined in Section 2.35.1.4 of this document. If a problem is found with any component of the sampling system, the installers will contact the region and the ECB office with the details to initiate a resolution.

The Zero point will include checking the analog output (Z1) to the primary data logger and checking and adjusting the low-output engineering units to the back-up data logger. The Span point check will include checking the analog output (SP1) to the primary data logger and checking high-output engineering units to the back-up data logger. The PDL (Z1/SP1) should be adjusted to agree with the instrument concentration readings to within +/- 0.5 ppb). Document all actions in the site logbook.

**Communication Confirmation**

The person(s) performing the installation will contact the ECB at the conclusion of the installation, and ask that the site be “polled” to insure that it is ‘reachable’. Before leaving the site, sign out and reset the scheduler for normal operation. Document results in the site logbook.

**Transfer of Responsibility**

The person(s) performing the installation will contact the Regional Ambient Monitoring Environmental Coordinator and the Site Operator and inform them that the instrument installation has been completed. Document the successful installation using the ECB 109 Form and submit the form to the ECB Supervisor.

**2.35.1.6 Routine Maintenance**

**TEI 5020 SPA**

Periodic maintenance procedures should be performed when necessary to ensure proper operation of the 5020 SPA. Maintenance includes preventive, routine, and corrective tasks. ECB is expected to be entirely responsible for the corrective maintenance issues and to assist with preventative and routine maintenance that may fall outside the regions’ comfort levels or capabilities.

Step-by-step procedures for all maintenance activities should be followed as presented by the manufacturer in the instrument’s operation manual (Chapter 5, “Preventive Maintenance” and Chapter 7, “Servicing”, 6/5/97 version). Always down/disable the PDL and BUDL data channels when servicing and up/enable the channels when finished.

Items requiring maintenance by ECB and the schedule are list below:

**Table 2 Maintenance Items and Schedule**

<b>Activity</b>	<b>When</b>	<b>Comments</b>
Replace circuit boards	When identified as	Order from manufacturer

	a problem	
Supply Regional office with HEPA Filters (x2)	Every 12 months upon request	Maintain sufficient inventory
Replace UV Lamp	When voltage approaches 1200	Order from manufacturer
Supply Regional office with Denuders	Every 2-3 months upon request	Coordinate with PPB for the recharging of spent units
Change Hi-Temp Converter Core Components	Every 6 months	Schedule with Region; Requires 12 hour burn-in. see manual Section 5
Capillary Inspection (x2)	Every 12 months	One in analyzer and one in converter: see manual Section 5
Pump Rebuild (x3)	Every 12 months	One in analyzer, one in converter and the auxflow Thomas pump.
Supply Regional office with AuxFlow Sintered Filter	Every 6 months upon request	Located between splitter and cyclone auxiliary flow MFC: see Fig 1
Supply Regional office with 47 mm Filters	Every 12 months upon request	Maintain sufficient inventory

### TEI 146C Calibrator

Periodic maintenance and/or adjustment for the Model 146C is required to ensure proper operation. Refer to the “146C Calibrators” QA/SOP Operation guidelines (separate document, Section 2.3.4.1) for details and the instrument manual (Chapter 4, “Preventive Maintenance” and Chapter 7, “Servicing”, 11/20/98 version). Except for mass flow controller re-certification, which occurs every 9 months, the following maintenance activities are performed only when the calibrator malfunctions as determined by the site operator. Items requiring ECB maintenance are:

- Leak Checking
- Solenoid Replacement
- Circuit Board Replacement
- Mass Flow Controller Replacement
- Replacement of DVM
- Internal Adjustments
- Certification of Mass Flow Controllers (see section 2.3.3.5 of 146C Calibrator QA/SOP).

### Zero Air Pack and Compressor Checks

Periodic maintenance and/or adjustment for the Zero Air Pack are required to ensure proper operation. The ECB shall re-certify the zero air system once per year by:

- Replacing the silica gel with re-generated material (dark blue or purple color).
- Verifying that the pressure gauge on the Zero Air Supply is reading 30-40 psig.

- Verifying that the outlet pressure on the air compressor is reading between 30 and 40 psig. (If pressures are outside of the specifications, check and tighten all fittings and/or rebuild the compressor by replacing the pump diaphragms.)
- Draining any water from the compressor.

### 2.35.1.7 Accuracy Auditing

Each calendar quarter, at least one quarter of the state's monitors must be audited by an audit device that is different from the gas standard (SO<sub>2</sub>), calibrator (146C) and "zero air generator (Model 111) used for routine calibration. Items that shall be included in the audit are:

- Security of the Building
- Site / Building Temperature
- Condition of the Sample Line, Probe and cyclone
- Normal Operating Status of the Monitoring System

**Note: The individual performing the audit must determine the results (pass/fail) while on-site and report the findings to the regional environmental coordinator and the supervisor of the ECB.**

**The audit calibrator must be certified against a NIST traceable standard** once per quarter (every three months). The auditor must not be the operator who conducts the routine monitoring, calibrations, and analysis. **Conduct the audit before making adjustments.** The monitor must operate in its normal sampling mode, and the audit gas **must be introduced at the sample inlet port** of the analyzer module **and not at the zero/span calibration ports.**

**NOTE:** The audit procedure is to be performed with the instrument **remaining** in the "automatic cycle mode", i.e., normal operating mode for data collection. The analyzer run screen will show that the instrument is cycling between filter mode and sample mode, but the only parameter that is of concern is the "SO<sub>2</sub> PPB".

The difference between the actual concentration of the audit test gas and the concentration indicated by the analyzer is used to assess the accuracy of the monitoring data.

Allow audit calibrator to equilibrate at least one-half to one hour before challenging the monitor. Check the ambient sulfate concentration for the day (never conduct an audit during a time when ambient SO<sub>4</sub><sup>-</sup> concentrations are high (i.e., greater than 10 µg/m<sup>3</sup>). Down (disable) the "SO<sub>2</sub> Corrected", the "SO<sub>4</sub> cycle" and the "SO<sub>4</sub> continuous" channels.

Connect the audit calibrator outlet to the sample inlet of the analyzer module. Perform and record the following audit calibrator checks:

1. **Verify** the audit calibrator certification is current and that the zero air generator has fresh chemicals.
2. **Power ON** - Verify calibrator and zero air supply have power.

3. **Perform Audit** – Sequentially, introduce four concentrations (zero plus three up-scale concentrations) to the analyzer. Concentration ranges are given below:

Audit ID	Conc. Range, ppb
Audit Gas 1	0.00
Audit Gas 2	5-10
Audit Gas 3	40-50
Audit Gas 4	80-90

4. After allowing the concentration reading to stabilize, record five stable one-minute data logger concentrations and the corresponding value from the 146C calibrator. Average the five one-minute reading and calculate the % difference (except for zero) from the true value using the equation given below.
5. If the audit results are greater than +/- 15% of expected, the auditor must contact the ECB supervisor and/or the regional chemist **while on-site** and relay the results.

Reconnect the sample line coming from the converter module to the sample inlet on the back of the analyzer. After the analyzer has cycled through one filter mode, one sample mode and a second filter mode “up” the datalogger(s) and sign out.

Calculate percent difference ( $d_2$ ) at each concentration level (except zero) using the following equation:

$$d_2 = \frac{C_m - C_{ACT}}{C_{ACT}} \times 100$$

where:  $C_m$  = average SO<sub>2</sub> concentration measured in ppb (from the SO<sub>2</sub> CORR channel)  
 $C_{ACT}$  = Actual Concentration of audit gas produced by the audit calibrator. (Output in ppb). The instrument zero must be within ± 1 ppb of the calibrator zero gas.

6. Record  $d_2$  on the (audit form/worksheet) and in the instrument logbook. Verify that the form is correct and complete, and forward to the ECB supervisor. If the audit results are suspicious or unacceptable, the ECB supervisor will initiate the investigation of the problem and notify the responsible regional chemist and the Project and Procedures Branch Supervisor of the issue. The investigation can include, but is not limited to:
- Examination of the audit equipment
  - Review of the calibration records (both auto and manual)

- Confirming the audit results with a follow-up audit

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APPENDIX A  
(Figures)

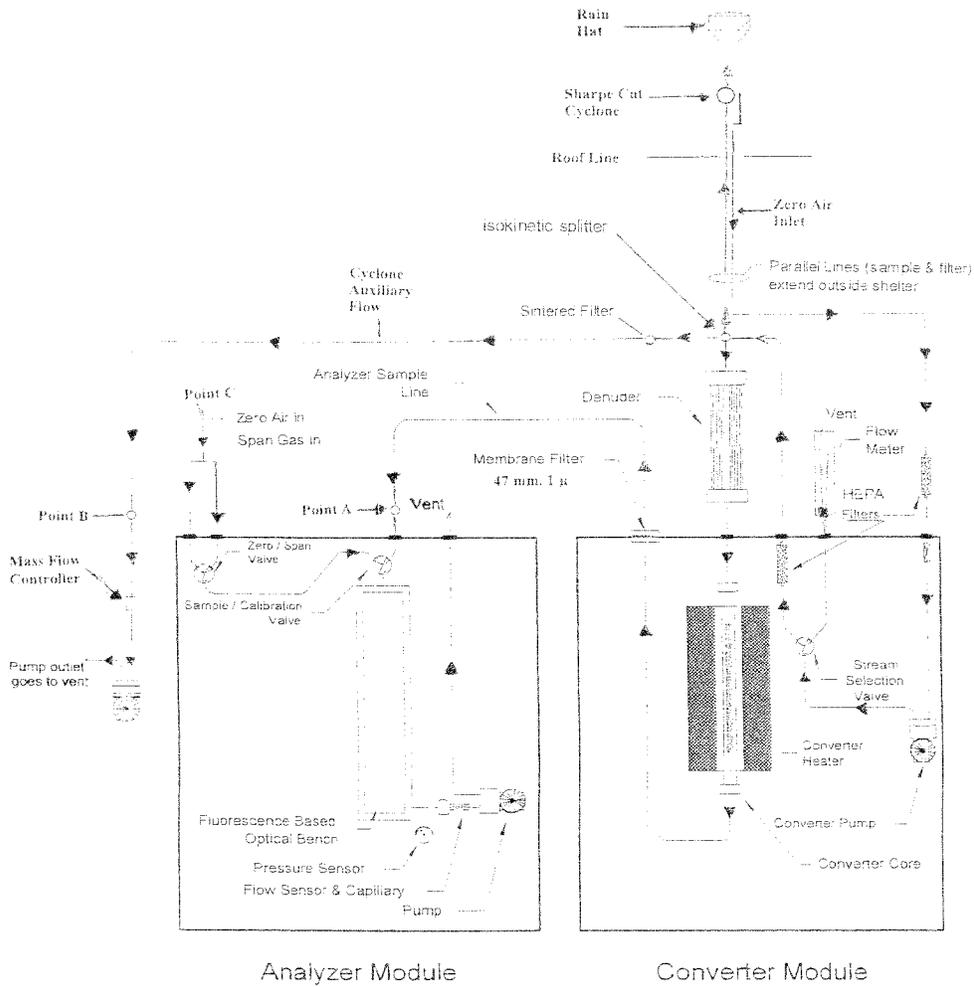


Figure 1 5020 Sampling and Analysis System Components

