

STATE OF CALIFORNIA
AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX V

PERFORMANCE AUDIT PROCEDURES
FOR
CONTINUOUS PM10 MONITORS

MONITORING AND LABORATORY DIVISION

DECEMBER 2009

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STATE OF CALIFORNIA
AIR RESOURCES BOARD

AIR MONITORING QUALITY SECTION

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX V.1

PERFORMANCE AUDIT PROCEDURES
FOR
CONTINUOUS PM10 MONITORS

MONITORING AND LABORATORY DIVISION

DECEMBER 2009

V.1.0 AUDIT PROCEDURES FOR CONTINUOUS PM10 MONITORS

There are two different types of continuous particulate matter (PM10) monitors operating in the California air-monitoring network. Audit procedures presented here are applicable to Rupprecht & Patashnick Series 1400A Tapered Element Oscillating Microbalance (TEOM) and the Met One Beta Attenuation Monitor 1020 (BAM) which operate at an actual flow rate of 16.67 liters per minute (LPM). Audit techniques may vary with different models of samplers due to differences in sampler configuration, sampler software, etc.

V.1.0.1 GENERAL INFORMATION

The primary goal of an auditing program is to identify system errors that may result in suspect or invalid data. A full assessment of the continuous PM10 particulate measurement system's accuracy can not be made as there are no PM standards available with which to challenge the instruments. Flow audits are conducted to ensure the inlet head is maintaining the proper flow rate to ensure a 10 micron (ug) cut-point of incoming particles. This accuracy assessment of the flow rate can be achieved by conducting an audit under the following guidelines:

1. Without special preparation or adjustment of the system to be audited.
2. By individuals with a thorough knowledge of the instrument or process being evaluated, but not by the site operator.
3. With standards traceable to the National Institute of Standards Technology (NIST) that are completely independent of those used in routine calibration.
4. With complete documentation of audit data for submission to the operating agency. Audit information includes, but is not limited to: types of instruments and audit transfer standards, model and serial numbers, transfer standard traceability, calibration information, and collected audit data.

The audit procedures described here produce two quantitative estimates of a continuous PM10 monitor's performance: The audit flow rate percent difference, and the designed flow rate percent difference. The audit flow rate percent difference determines the accuracy of the monitor's indicated flow rate by comparing it with a flow rate from the audit transfer standard. The percent difference between values of the monitor's flow rate measurement from an audit standard will determine the accuracy of the monitor's design measuring source under normal operating conditions.

The site operator should be present during the audit. This practice not only contributes to the integrity of the audit, but also allows the operator to explain the cause of discrepancies between measured audit data and the monitor's response.

V.1.0.2 FLOW RATE AUDIT APPARATUS

All audit transfer standards must be certified against a primary standard traceable to the NIST. Audit equipment for flow rate, temperature, and barometric pressure must not be the same as that equipment used for routine site checks/calibrations, but may be traceable to the same primary standard.

In addition to the apparatus listed in the following sections, an audit data worksheet (see Figures V.1.0.1 and V.1.0.2) is also needed to document audit information. This information includes, but is not limited to, sampler and audit transfer standard type, model and serial numbers, transfer standard traceability and calibration information, ambient temperature and pressure conditions, and collected audit data.

The following equipment is needed to perform a flow rate audit of the TEOM sampler:

1. Two certified calibrated transfer standard mass flow meters, (MFMs). One MFM is calibrated in the 0-30 standard liters per minute (SLPM) flow range, and is used to measure total and bypass flow rates. The second MFM is calibrated in the 0-5 SLPM flow range and is used to measure the sample flow rate. This enables the auditor to measure the critical flow rates directly without compounding transfer standard error through subtraction. The MFM transfer standards are NIST traceable and certified quarterly. The standard deviation must be within 1.0% of the last four calibrations.
2. A 10 foot x 3/8" outside diameter length of Teflon tubing with a flow audit adaptor to connect the transfer standard outlet to the sampler inlet.
3. Tools: Adjustable 6 and 8 inch wrenches, 9/16 inch combination wrench, 3/8 inch combination wrench.
4. Fittings: 3/8 inch Swagelok cap, 3/8 inch x 3/8 inch union.
5. TEOM monitor sampling filters; filter exchange tool.
6. A flow audit adapter for performing leak checks.

The following equipment is needed to perform a flow rate audit of a BAM sampler:

1. The BAM flow rate audit method includes a calibrated flow transfer standard, mass flow meter (MFM) with a range of 2-20 LPM that is used to measure the sampler's operational flow rate. The sampler's indicated flow rate is then compared with the actual flow rate indicated by the mass flow meter. The actual flow rate determined by the MFM is also compared with the design flow rate of 16.67 LPM. The MFM must be certified against a primary standard traceable to the NIST and shall be within ± 2 percent of the NIST traceable standard. The MFM shall be calibrated annually with the relative standard deviation within 1.0 percent of the last two calibrations.
2. A flow audit adaptor for performing leak checks.

V.1.0.3 TEMPERATURE SENSOR AUDIT APARATUS

An electronic, water-immersible, temperature probe capable of accurately measuring temperature to within $\pm 0.5^{\circ}\text{C}$, with a resolution of $\pm 0.1^{\circ}\text{C}$. It must be referenced to a NIST or American Society for Testing and Materials (ASTM) thermometer and checked annually. The temperature unit should be within $\pm 0.5^{\circ}\text{C}$ on the annual check.

NOTE: The ambient temperature value from the MFM screen is used to calculate flow calculations for the BAM.

V.1.0.4 PRESSURE SENSOR AUDIT APPARATUS

An audit of the sampler's barometric pressure sensor requires a barometer capable of accurately measuring ambient pressure to the nearest millimeter of mercury (mmHg) over the range of 550 to 800 mmHg. The barometer must be referenced within ± 5 mmHg of a barometer of known accuracy at least annually and must have a resolution of ± 1 mmHg. The barometric pressure reading from the MFM is used for the BAM audit while an electric pressure transducer is used for the TEOM audit.

QA AUDIT WORKSHEET TEOM SAMPLER

Site Name: _____ Date: _____

Operator: _____ Inlet Cleaning Schedule: _____

Auditors: _____ Inlet Last Cleaned: _____

Make and Model: _____

ID Number: _____

Audit Indicated Flow	
Main Flow	
Auxiliary Flow	
Total Flow	

Station Indicated Flow	
Main Flow	
Auxiliary Flow	
Total Flow	

Calibration Date: _____

Cal. Equip. Cert. Date: _____

Ambient Temperature: _____

Ambient Pressure: _____

Leak Test: Main: _____ AUX: _____

Make and Model: _____

ID Number: _____

Audit Indicated Flow	
Main Flow	
Auxiliary Flow	
Total Flow	

Station Indicated Flow	
Main Flow	
Auxiliary Flow	
Total Flow	

Calibration Date: _____

Cal. Equip. Cert. Date: _____

Ambient Temperature: _____

Ambient Pressure: _____

Leak Test: Main: _____ AUX: _____

Data recorded and verified by: _____

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MLD/QAS-035 (Rev. 1/5/2010)

Figure V.1.0.1
 QA Audit TEOM Worksheet

QA AUDIT WORKSHEET BAM 1020

Site Name: _____ Site No: _____ AIRS No: _____ Date: _____

Agency: _____ Site Operator: _____

Auditors: _____ Quarter: 1 [] 2 [] 3 [] 4 []

EPA Designation: _____ Collocated Yes [] No [] NAMS [] SLAMS [] PAMS [] SPM []

Sampler Information

Make	Model	ID Number	Last Calibration Date	Cal. Equipment Cert. Date	Collocated (Y/N)

Audit Equipment Information

Audit Device	Make/Model	Calibration Info. (Slope / Intercept)	ID Number	Range	Last Cal. Date
MFM					
Temperature Sensor					

Sampler Reference Values

Ambient Temperature	Barometric Pressure	Volumetric Flow Rate

BAM SOP's

Yes	No

Data Logger/BAM Verification

Time	Data Logger Reading	BAM Reading
	*	

* Data logger reading should be 1 microgram less than BAM reading. If not, notify the site operator.

Sampler Temperatures

Sample Sensor	Audit Sensor

Leak Test

Flow Rate (LPM)

Barometric Pressure

Sampler Sensor (mmHg)	Audit sensor (mmHg)

Audit Data Flow Rates

Audit Point	Sampler Flow (LPM)	MFMI (LPM)
1		
2		
3		

V.1.1 AUDIT DATA CALCULATIONS

V.1.1.1 AUDIT DATA CALCULATIONS FOR TEOM SAMPLERS

1. Calculate the audit standard flow rates using the transfer standard MFM calibration data. (See Equation 1 below.)

$$\text{Standard Flow } Q_{\text{std}} \text{ (SLPM)} = Q_{\text{ind}} \times m \pm i \text{ (Equa.1)}$$

Where: Q_{std} = Flow rate at standard temperature and pressure, SLPM

Q_{ind} = Flow meter display

m = Slope

i = Intercept

NOTE: It may be necessary to correct audit flow rates, if they are in standard conditions, to actual conditions. (See Equation 2 below.)

$$Q_a = Q_{\text{std}} \times \frac{T_a + 273.15}{298.15} \times \frac{760}{P_a} \text{ (Equa.2)}$$

Where: Q_a = Flow rate at actual conditions (LPM)

Q_{std} = Standard flow rate at standard temperature and pressure (298.15°K, 760 mm Hg) (SLPM)

T_a = Ambient temperature (°C)

P_a = Ambient barometric pressure (mm Hg)

2. Using Equation 2 above, calculate and record the Q_a “Main Flow”, “Auxiliary Flow” and “Total Flow” on the audit worksheet.
3. Determine the percent difference between the monitor flow rates and the audit measured flow rates as:

$$\text{Audit \% Difference} = \frac{[Q_a \text{ (monitor) (LPM)} - Q_a \text{ (Audit) (LPM)}]}{Q_a \text{ (Audit) (LPM)}} \times 100$$

V.1.1.2 AUDIT DATA CALCULATIONS FOR BAM SAMPLERS (VOLUMETRIC FLOW)

1. The MFM has built-in, calibrated temperature and pressure sensors so that the flow display on the MFM screen is the actual flow in liters per minute (LPM).
2. The actual temperature is calculated using the temperature transfer standard calibration data (Eq. 3).

$$\text{Actual Temp. } T_a = (T_{ind})(m) + i \quad (\text{Eq. 3})$$

Where: T_a = True temperature, °C

T_{ind} = Indicated reading from audit temperature probe, °C

m = Slope

i = Intercept

Calculate and record the difference between the audit temperature sensor readings and the sampler's temperature sensor readings.

NOTE: Audit temperature sensors are not used to calculate flow. MFM's have built-in, calibrated temperature sensor.

3. The actual barometric pressure is calculated using the transfer standard calibration data (Eq. 4). Once the actual pressure (P_a) is known, the difference between the audit pressure sensor reading and the sampler's pressure sensor reading is calculated and recorded.

$$\text{Actual Press. } P_a = (P_{ind})(m) + i \quad (\text{Eq. 4})$$

Where: P_a = Ambient barometric pressure, mmHg

P_{ind} = Indicated reading from audit barometer, mmHg

m = Slope

i = Intercept

NOTE: The BAM audit uses the barometric pressure value indicated on the MFM.

4. Determine the percent difference between the sampler indicated flow rates and the audit measured flow rates as:

$$\text{Audit \% Difference} = \frac{Qa(\text{Sampler}) - Qa(\text{Audit})}{Qa(\text{Audit})} \times 100$$

5. Determine the percent difference between the sampler design flow rates and the Qa (Audit) flow rates as:

$$\text{Design Condition \% Difference} = \frac{Qa(\text{Audit}) - 16.67}{16.67} \times 100$$

V.1.1.3 AUDIT DATA RECORDING AND REPORTING

Record all data and percent differences in appropriate worksheets. Deviations greater than $\pm 7\%$ will require an investigation or a recalibration. Audit flow rate percent differences greater than ± 10 percent, require an Air Quality Data Action (AQDA) request to be issued. Upon investigation, the invalidation or correction of all data from the last calibration forward or known date of change (to be determined by the reporting agency) may result.

Final verified audit data should be submitted to the operating agency as soon as possible. Delays may result in data loss; a sampler out of audit limits is also out of calibration limits, and the data collected may be invalid. If a sampler exhibits unsatisfactory agreement with the verified audit results, a calibration should be performed before the next run day.

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PERFORMANCE AUDIT PROCEDURES
FOR
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MONITORING AND LABORATORY DIVISION

SEPTEMBER 2002

V.2.0 AUDIT PROCEDURES FOR THE R&P TEOM SAMPLER

V.2.0.1 BACKGROUND

Audit procedures presented here are specific to the Rupprecht & Patashnick Series 1400A Tapered Element Oscillating Microbalance (TEOM) monitors (Figure V.2.0.1 and V.2.0.2) that operate at a designed flow rate of 16.7 liters per minute (LPM). Audit techniques may vary with other models due to differences in required flow rates and sampling configurations. A complete audit also includes verifying that the operator prior to the audit has performed the proper sampler maintenance procedures. Before the audit, verify from the operator that all-appropriate maintenance, scheduled calibrations, and unit checks have been performed.

V.2.0.2 TEOM FLOW RATE AUDIT

Since accurate measurement of PM₁₀ mass concentration is dependent upon flow rates under actual conditions, the audit must also be conducted in terms of actual conditions. The audit transfer standard's calibration data are corrected to the United States Environmental Protection Agency's (U.S. EPA) reference conditions (298°K, 760 mm Hg). Therefore, a conversion must be calculated to adjust the SLPM flow rate (Q_{std}) to an actual LPM flow rate (Q_a) (See Section V.1.1.0). The audit MFM calibration relationship is expressed in terms of standard volumetric flow rate (Q_{std}) as indicated by the audit MFM; these units are in SLPM.

NOTE: During the audit, inspect the overall condition of the monitor (wiring, monitor and inlet cleanliness, etc.) and the monitor's maintenance records. Record comments in the "comments" section of the QA Audit Worksheet for TEOM (Figure V.1.0.1).

1. Ensure TEOM is off-line from data logger.

IMPORTANT: Only proceed with the filter removal procedure if the front display panel shows that the filter loading is greater than 80%. Have the site operator assist in the removal of the filter. Otherwise, the TEOM flow rate audit can be completed by proceeding to Step 4 of this section.

2. Reset the Series monitor by pressing the <Fl> key on the front panel of the control unit (see Figure V.2.0.2).

NOTE: Data generated by the instrument during these audit procedures are only valid for the audit and cannot be used as data for record.

3. Remove and replace existing filter with, audit filter as follows:
 - a. Use the filter exchange tool provided by the manufacturer to exchange the filter.
 - b. Keep the sample pump running during filter exchange.
 - c. Open the door of the sensor unit. (See Figure V.2.0.3).
 - d. Locate the horizontal black handle on the mass transducer (shown in its upward position in Figure V.2.0.3) and carefully lift this handle upward, keeping one hand on the lower bar for support. The mass transducer will swing into its filter changing position, exposing the filter cartridge. When the mass transducer is in this open position, the tapered element automatically stops vibrating to facilitate filter exchange.
 - e. Remove existing filter by carefully inserting the lower fork of the filter exchange tool under the filter cartridge. Ensure that the filter disk is between the fork and the upper plate of the filter exchange tool. The tines of the fork should straddle the hub of the filter base. Gently lift the filter from the tapered element with a straight pull. Never twist the filter or apply sideways force to the tapered element. Do not handle filter with fingers. Place existing filter in a safe dry area in the mass transducer unit.
 - f. Place the audit filter in the filter exchange tool so that the filter disk lies between the fork and upper disc of the tool.
 - g. Hold the filter exchange tool in line with the tapered element and lightly insert the hub of the filter onto the tip of the tapered element. Ensure that the filter is seated properly. Then apply downward pressure to set it firmly in place.
 - h. Remove the filter exchange tool by retracting it sideways until it clears the filter.
 - i. Gently move the horizontal handle to its downward position to close the mass transducer. Allow the springs to gently close the last centimeter so that the distinct sound of metal-to-metal contact is heard. Do not let the mass transducer slam shut from the full open position.

- j. Close and latch the door to the sensor unit. Keep the door open for as short a time as possible to minimize the temperature variance to the system.
- k. Wait for the warning light to go off before resuming the audit. (The light should go off when the enclosure temperature reaches and maintains the station's predetermined temperature.)

WARNING: The case temperature needs to be checked at this time to ensure that it is operating at 50°C. To do this, use the <Fl> key to scroll through the menu until you locate, "Case Temp." If it is not operating at 50°C, the sampler is out of specifications and an AQDA needs to be issued. U.S. EPA has approved a seasonal change to 30°C, but this is only for the period from November 1 through March 1, and this is by written permission on a case-by-case basis.

- 4. Complete the top half of the audit data worksheet with the required information, including ambient temperature (Ta), in degrees Celsius, and ambient barometric pressure (Pa), in mmHg.
- 5. Scroll the display on the control unit to the main (sample) and auxiliary (bypass) flows. The display represents the actual volumetric flows (Qa) measured by the monitor's flow controllers with temperature and pressure corrections.
- 6. Confirm that these flows are within $\pm 2\%$ of their set points (3.00 LPM for the main flow and 13.7 LPM for the auxiliary flow). Any greater deviation may indicate plugged in-line filters or other blockages in the system. If this is the case, all data collected up to this period from the last calibration date may be subject to invalidation.

WARNING: U.S. EPA has approved of a flow splitter that allows the main flow rate set point to be either 3.00, 2.00, or 1.00 LPM. If the TEOM is equipped with an approved flow splitter manufactured by R&P, caution is needed when auditing the device. Be aware that the audit program is not set up to calculate design flow rates other than 3.00 LPM and 13.7 LPM. If the 2.00 LPM flow splitter is installed, the auxiliary flow rate will be 14.7 LPM. If the 1.00 LPM flow splitter is installed, the auxiliary flow rate will be 15.7 LPM. Total flow rate does not change, so be aware of this when entering the data into the computer.

7. Position the audit transfer standard within reach of the PM10 sampling inlet.
8. Energize the audit transfer standard and allow a warm up time of at least 5 minutes.

NOTE: Ensure that the transfer standard MFM display selector switch is in the proper position. Additionally, shade the transfer standard from direct sunlight, to prevent heating of the temperature elements inside the MFMs.
9. Carefully remove the PM10 sample inlet by placing one hand on the base of the filter head and the other on the neck of the tripod, gently twisting the filter head up and off.
10. Replace the inlet with the flow audit adaptor using the same gentle twisting motion.
11. Connect the flow audit adaptor line to the output of the 30 LPM mass flow meter. Allow the flow meter to stabilize for at least 5 minutes.
12. Move the display selector switch to the proper position on the audit transfer standard.
13. Read the total flow on the audit flow meter and record as Q_{ind} on the audit data worksheet. (If a non-volumetric flow meter is being used, make the necessary calculations to obtain the corrected volumetric flow rate for the current ambient temperature and barometric pressure. The volumetric flow measured by the audit flow meter must be 16.7 LPM, $\pm 10\%$ to be acceptable.)
14. Disconnect the bypass flow line where it connects to the bypass flow splitter filter (location in Figure V.2.0.1).
15. Cap the exit of the flow splitter filter with the 3/8" Swagelok cap.
16. Disconnect the flow audit adaptor line from the 30 LPM MFM and connect the line to the output of the 5 LPM MFM. Allow the flow meter to stabilize for at least 5 minutes.
17. Move the display selector switch to the corresponding position on the audit transfer standard.
18. Read the display on the audit transfer standard. (If a non-volumetric audit flow meter is being used, make corrections necessary to reduce to

volumetric LPM at the current ambient temperature and barometric pressure. The volumetric flow indicated by the audit flow meter must be 3.00, 2.00, or 1.00 LPM \pm 7% to be acceptable.) Record this under Qind for the main flow on the audit data worksheet.

19. Read the control unit's main flow and record as Qa on the audit data worksheet.
20. Disconnect the flow audit adaptor line from the 5 LPM MFM and reconnect the line to the output of the 30 LPM MFM. Allow the flow meter to stabilize for 5 minutes.
21. Disconnect the 3/8 inch tubing from the flow audit adaptor, connect the tubing to the bypass flow line using the 3/8 inch x 3/8 inch union.
22. Read the display on the audit transfer standard and record as auxiliary flow Qind on the audit data worksheet.
23. Read the auxiliary flow from the control unit. Record this under monitor auxiliary flow Qa on the audit data worksheet.
24. Record the total flow from the control unit by adding the values of main and auxiliary flow rates. Total flow is reported as total Qa on the audit data worksheet.
25. Remove the cap from the exit of the bypass flow splitter filter and replace the bypass flow line.

REQUIRED: To perform a system leak check, close the valve on the flow audit adaptor. Both the main (sample) flow and auxiliary (bypass) flow should read less than 0.15 LPM on the four line display of the control unit. If one of the flows is greater than 0.15 LPM then the system is not leak tight. In this case, check hose fittings and other critical locations in the flow system for leaks.

V.2.0.3 POST AUDIT CONFIGURATION

1. Disconnect audit flow device from the audit transfer standard.
2. Remove the flow audit adaptor.
3. Replace the PM10 inlet on the top of the flow splitter. (The instrument is now back to its normal operating configuration.)

4. Remove and replace audit filter with the existing filter. Repeat Steps 3 c-k above.
5. Reset the Series TEOM monitor by pressing the <Fl> key on the front panel of the control unit. (The instrument will automatically begin data collection after temperature and flow rates have remained stable at their set points for one hour.)
6. Ensure that TEOM is back on-line.

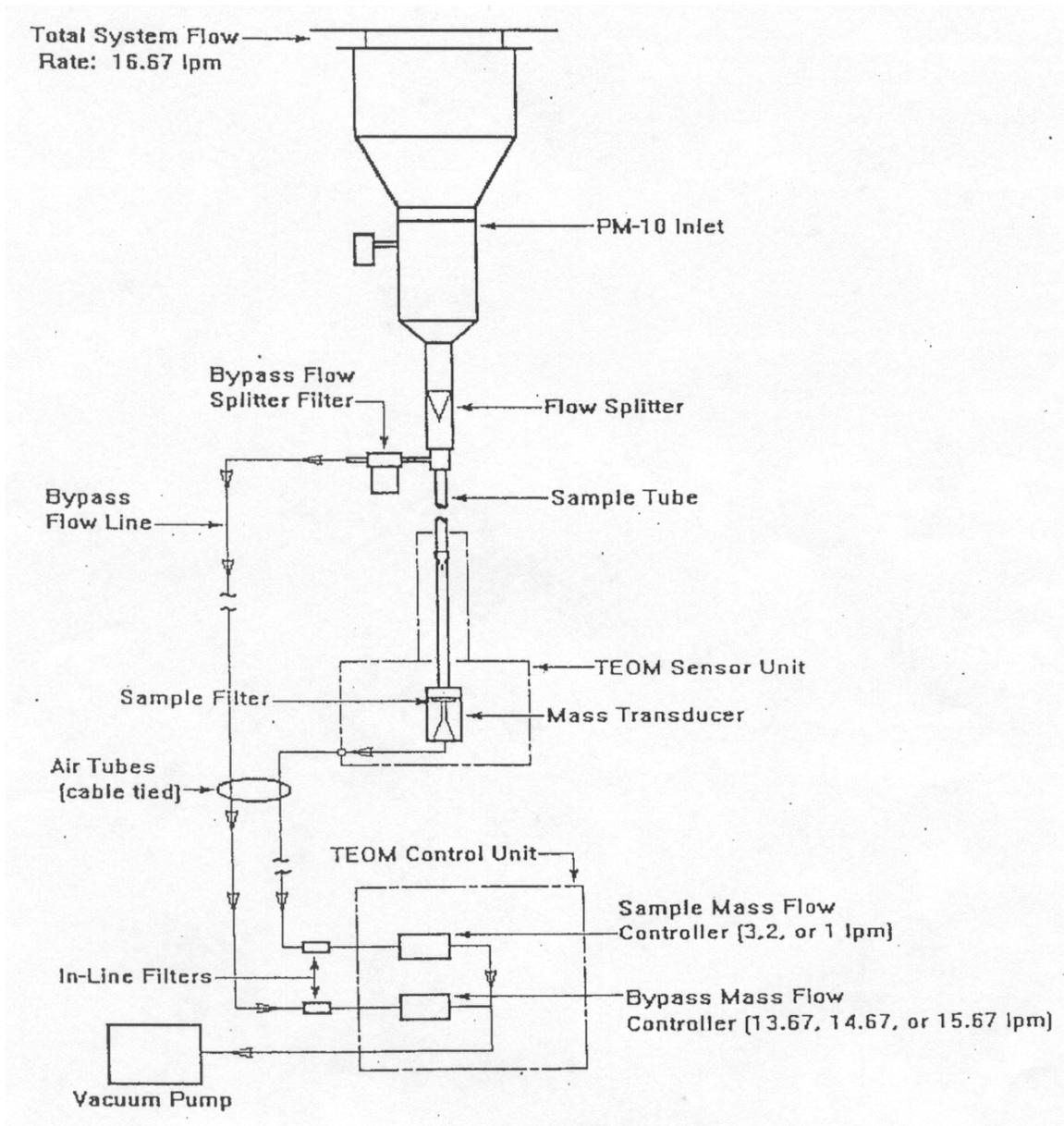


Figure V.2.0.1
Schematic Diagram of TEOM System

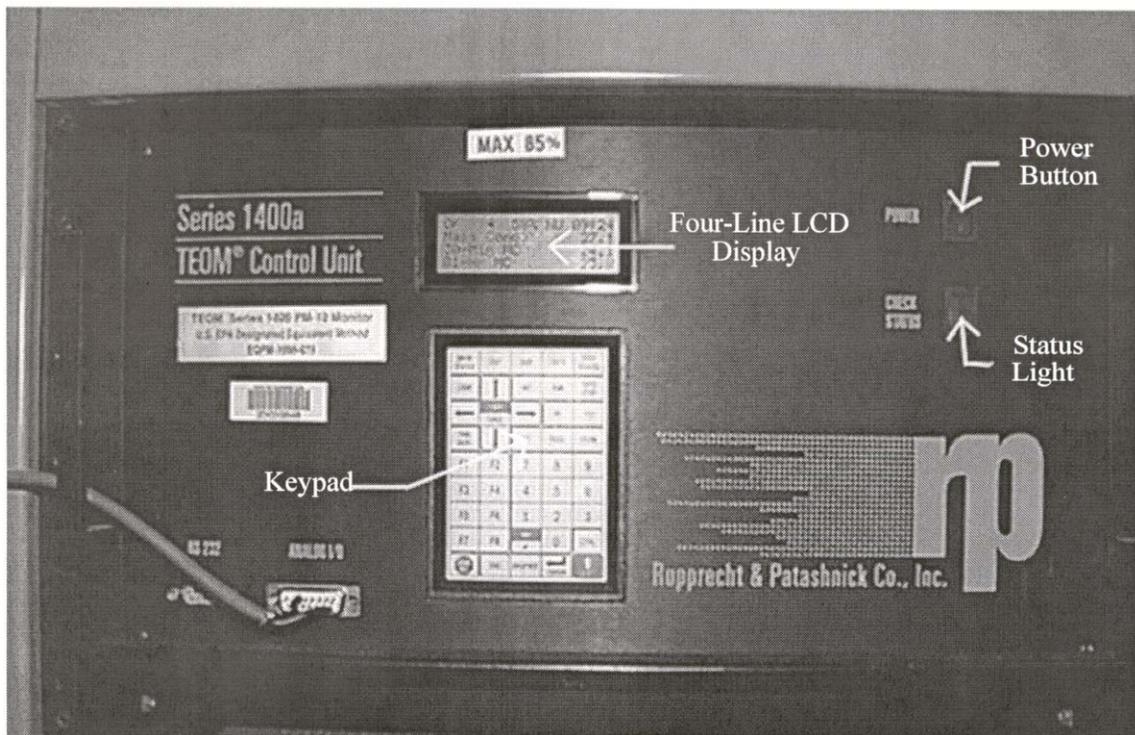


Figure V.2.0.2
Front Panel of the Teom Control Unit

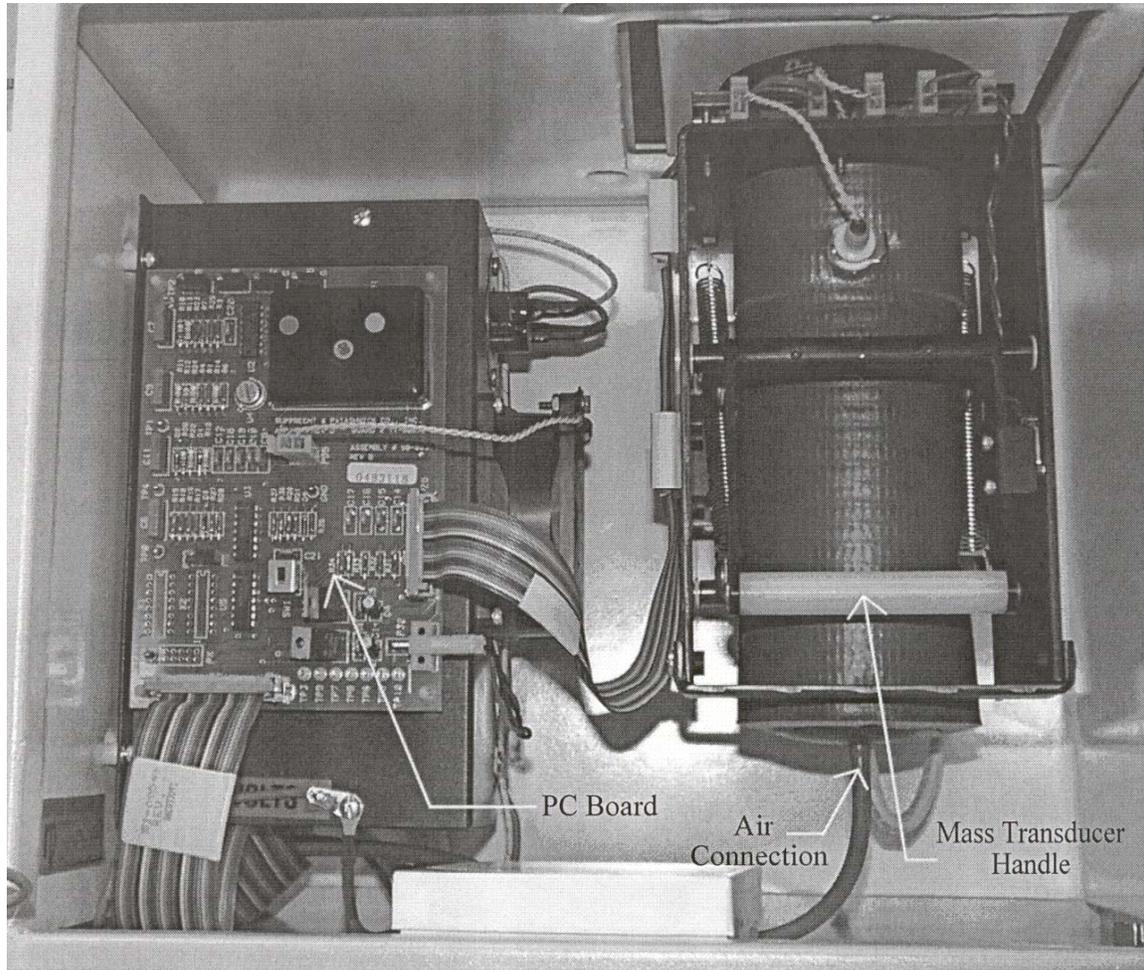


Figure V.2.0.3
Teom Sensor Unit

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PERFORMANCE AUDIT PROCEDURES
FOR
PM10 CONTINUOUS SAMPLERS

MONITORING AND LABORATORY DIVISION

DECEMBER 2009

V.3.0 AUDIT PROCEDURES FOR THE BETA ATTENUATION MASS
(BAM 1020) SAMPLER

V.3.0.1 BACKGROUND

The audit of a Met One BAM 1020 includes a determination of the sampler's total flow rate, ambient temperature sensor, and barometric pressure sensor. A complete audit also includes verifying that the proper sampler maintenance procedures have been performed by the operator **prior** to the audit. Before the audit, verify from the operator that all appropriate maintenance, scheduled calibrations, and unit checks have been performed. Request the site operator for a copy of the BAM SOP. In addition, verify that monthly leak checks and flow checks have been performed (NOTE: leak checks performed by the site operator should be less than 1.0 lpm). For the audit to be valid, both internal and external leak checks must meet the criteria set forth in 40 CFR Part 50, Appendix L.

An audit of the sampler's ambient temperature sensor may be performed with a single, collocated temperature check made with an audit sensor.

The barometric pressure sensor is audited by comparing readings from the pressure sensor on the sampler with the pressure reading from the mass flow meter (MFM). To ensure that audit readings reflect the pressure of the sampler's pressure sensor, be sure that the MFM and the sampler's pressure sensor are within 100 meters horizontal distance from each other and within 0.5 meters vertical distance from each other.

V.3.0.2 FLOW RATE, TEMPERATURE AND PRESSURE SENSOR AUDIT PROCEDURES

1. Turn on the MFM and allow for a minimum of 10-minute warm-up time. The MFM should rest on a flat surface and should not be moved during the audit so accurate readings can be maintained. If MFM has multiple venturi heads make sure the proper head is selected to match the flow rate being audited.
2. The audit of the Met One BAM 1020 must be started and completed between 5 minutes before the hour and 40 minutes after the hour. The time is located either on the station datalogger or the top right corner of the "NORMAL MODE" User Screen on the BAM 1020.
3. During the last 5 minutes before the top of the hour, obtain the datalogger's average hourly value for BAM filter loading. On the ESC 8800, this is done by pressing "REPEAT", then pressing "READ", then pressing the channel number (Usually this is channel 10 for ARB sites, but verify with the

operator) and then pressing “ENTER”. Write down the value shown onto the Worksheet.

4. After the top of the hour (the BAM1020 should be running), the BAM screen should be in the “Normal Mode” screen and displaying “Last C:...”(microgram). If the BAM is not displaying the loading value, consult with the site operator. Write shown value onto Worksheet. The datalogger value should be 1.0 microgram less than the BAM value.

NOTE: There are a variety of dataloggers currently being used. Consult with the site operator on the correct operations.

EXAMPLE: If the auditor arrived at 9:45 a.m., the auditor would turn on the MFM, then wait until 9:55 a.m. to take a reading from the datalogger. From 10:00 a.m.-10:40 a.m., check the BAM loading value and perform the following audit.

NOTE: If the sampler User Screen displays “TRANSPORT USE”, or the pump is not running, the sampler is in the process of setting up for the next hour’s run. Wait a few minutes after the hour and be sure that the pump is on before auditing the unit. If the User Screen displays “ERROR”, contact the site operator. The sampler is audited while running by proceeding with the following steps.

5. Verify with the station operator whether the sampler is set up to run in volumetric or metered mode. If the sampler is in **VOLUMETRIC** Mode, proceed with the following procedures. If it is in the **METERED** Mode, skip to Step 20.
6. With the user screen in the “NORMAL MODE”, press the soft-touch button under EXIT twice.
7. A screen titled “BETA ATTENUATION MONITOR” will be displayed. Press the soft-touch button under TEST.

NOTE: Depending on the BAM’s software, the pump may or may not shut off.

8. With the user screen in the “TEST MODE”, use the arrow scroll buttons to scroll to the FLOW option. Press the soft-touch button under SELECT.
9. If user screen displays ENTER PASSWORD, enter the password F1, F2, F3, and F4 (these buttons are pressed in the order given). If the password has been changed, ask the site operator for the current password.

10. With the user screen in the “VOLUMETRIC FLOW CALIBRATION MODE”, enter on the QA Audit BAM 1020 Worksheet (Worksheet)(see Figure Z.1.0.3) the AMBIENT TEMPERATURE, BAROMETRIC PRESSURE, and VOLUMETRIC FLOW RATE under the “REFERENCE” column. This user screen is used for the remainder of the audit.
11. Use the audit standard thermistor, not the MFM thermistor to perform a one-point check of the ambient temperature sensor as follows:
 - NOTE:** The BAM’s dedicated ambient temperature probe cannot be removed or submerged in water due to the complexity of removing the temperature probe from its solar radiation shield.
 - a. Since the solar radiation shield cannot be removed to access the sampler’s temperature sensor, position the audit temperature sensor directly beneath it.
 - NOTE:** If the BAM is utilizing the station’s meteorological outside ambient temperature sensor, position the audit temperature sensor as close to the outside temperature sensor without allowing the two sensors to touch. Protect the sensors from direct sunlight or excessive air movements as much as possible.
 - b. Allow both the audit sensor reading and the sampler’s temperature sensor reading to stabilize approximately one to two minutes.
 - c. Record the audit temperature sensor reading and the sampler’s AMBIENT TEMPERATURE reading on the Worksheet.
12. Audit the sampler’s barometric pressure sensor as follows:
 - a. Read the MFM display next to “**BP:**”, and the BAROMETRIC PRESSURE sensor reading from the sampler’s User Screen under the “BAM” column.
 - b. Record the MFM audit pressure and the sampler pressure reading on the Worksheet.
13. Press the soft-touch button under PUMP ON to turn on pump. Let the unit run for at least two to three minutes.

14. Turn the MFM off momentarily and then turn it back on while keeping it in the flat motionless position. Wait until the MFM completes its internal calibration before proceeding. Carefully remove the sampler inlet and replace with the MFM head unit. Ensure that O-ring(s) within the MFM are present and form a tight seal around the downtube.
15. Record **three** sampler average flow rate readings from the User Screen under the BAM column in conjunction with **three** MFM readings. Perform each flow audit approximately one minute apart. Do not stop the BAM 1020 during the three flow audits. Record each of the sampler's flow readings and the corresponding MFM readings on the Worksheet.

NOTE: The flow reading on the BAM 1020 User Screen will read as "xx.xl/m". This can be misleading because the "l" digit can be construed as the numeral "1", but actually stands for "liters".

16. Record ambient temperature from the thermistor as referenced in V.3.0.2.11. and record on the Worksheet.
17. Remove the MFM head unit while leaving the sampler running.
18. Perform the **external leak check** by installing the flow audit adapter with the valve in the open position over the sampler tube inlet. Slowly turn the valve closed and watch the sampler's display screen. The flow should read less than 1.0 LPM in the closed position. Record this value. Slowly turn the valve open so that sampler can return to normal run mode
19. Press the soft-touch button under PUMP OFF to turn off pump.
20. The following procedures apply to samplers that are set in **METERED** Mode:
 - a. If the sampler is in the "NORMAL MODE" screen, press the soft-touch button under EXIT twice to get to the "BETA ATTENUATION MONITOR" screen. Press the soft-touch button under TEST.
 - b. With the User Screen in the "TEST MODE", cursor to the PUMP option. Press the soft-touch button under SELECT.
 - c. Press the soft-touch button under the PUMP ON selection. Let the sampler run for at least 2-3 minutes. Apply Steps 14-19 above.

NOTE: Before the sampler's flow readings can be inputted in the audit program, they would have to be calculated to actual flow rate using the ambient temperature and barometric reading from audit devices. Use the following equation:

$$Q_a = (Q_{ind})(T_a/298.15 \text{ K})(760 \text{ mmHg}/P_a)$$

Where Q_a = Flow rate at actual conditions, LPM
(sampler flow rate used in audit program)

Q_{ind} = Indicated flow rate from sampler's metered mode screen.

$$T_a = ^\circ\text{C} + 273.15 \text{ where } ^\circ\text{C} = (^\circ\text{C}_{ind})(m) + b$$

P_a = Pressure reading from MFM screen

m = slope of audit device used

b = intercept of audit device used

- d. Press the soft-touch button under PUMP OFF to turn off pump.
- e. Press soft-touch button under EXIT.
21. With the screen back to the "BETA ATTENUATION SCREEN", press the soft-touch button under OPERATE.
22. With the "OPERATE MODE" screen displayed, press the soft-touch button under AVERAGE.
23. Follow Step 11 above to perform a one-point check of the ambient temperature.
24. Press the soft-touch button under NORMAL to display the "NORMAL MODE" screen.
25. Follow Step 12 above to perform an audit the sampler's barometric pressure sensor.
26. Press the soft-touch button under EXIT.

V.3.0.3 POST AUDIT CONFIGURATION

1. Remove the MFM from the sampler inlet (if it has not been previously removed) and replace the sampler inlet head.
2. From the user screen, press the soft-touch button under EXIT once.
3. A screen titled “BETA ATTENUATION MONITOR” will be displayed. Press the soft-touch button under OPERATE.
4. With the User Screen in the “OPERATE MODE”, press the soft-touch button under NORMAL.
5. The sampler should display the “NORMAL MODE” screen.

NOTE: The pump will not turn on until the top of the hour.

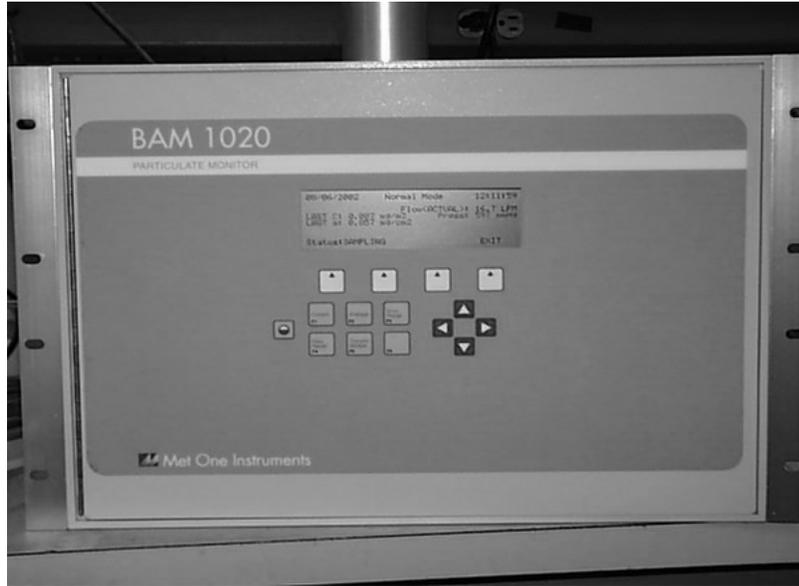


Figure V.3.0.1
BAM 1020 Front Panel/Door

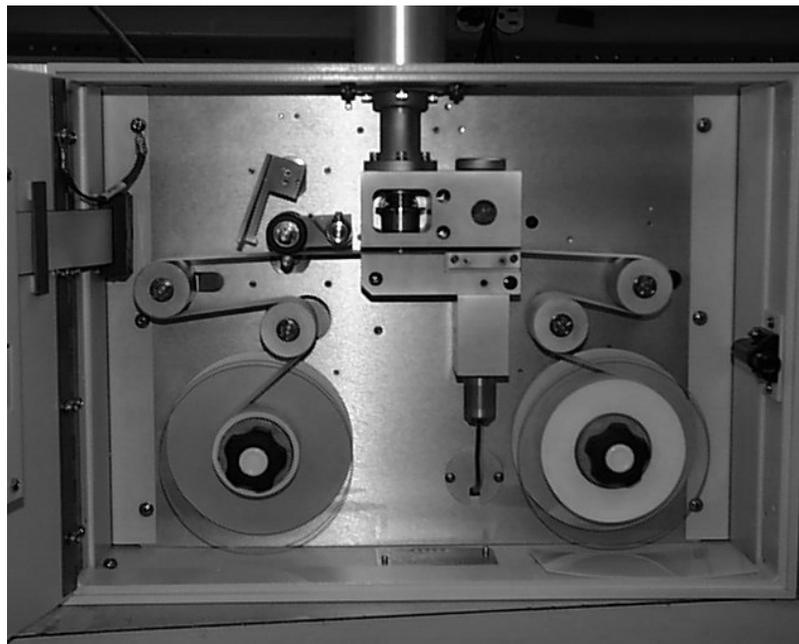


Figure V.3.0.2
BAM 1020 Filter Tape Assembly