STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX Z

PERFORMANCE AUDIT PROCEDURES
FOR
PM2.5 SAMPLERS

MONITORING AND LABORATORY DIVISION

MARCH 2004

TABLE OF CONTENTS

APPENDIX Z

PERFORMANCE AUDIT PROCEDURES
FOR
PM2.5 SAMPLERS

		PAGES	REVISION	DATE
Z.1.0	**GENERAL INFORMATION**	8	3	3/9/04
	Z.1.0.1 Auditing Procedures			
	Z.1.0.2 Performance Audits of PM2.5 Samplers			
	Z.1.0.3 Audit Apparatus			
	Z.1.0.4 Audit Data Calculations			
	Z.1.0.5 Audit Data Reporting			
Z.2.0	**AUDIT PROCEDURES FOR SINGLE CHANNEL SAMPLER (R&P PARTISOL®-FRM MODEL 2000)**	6	4	3/9/04
	Z.2.0.1 Background			
	Z.2.0.2 Flow Rate, Temperature and Pressure Sensor Audit Procedures			
	Z.2.0.3 Post Audit Configuration			
Z.3.0	**AUDIT PROCEDURES FOR SEQUENTIAL SAMPLER (ANDERSEN MODEL RAAS® 2.5-300)**	13	3	3/9/04
	Z.3.0.1 Background			
	Z.3.0.2 Flow Rate, Temperature and Pressure Sensor Audit Procedures for Samplers with Version 5 Software			
	Z.3.0.3 Post Audit Configuration for Samplers with Version 5 Software			
	Z.3.0.4 Flow Rate, Temperature and Pressure Sensor Audit Procedures for Samplers with Version 6 Software			
	Z.3.0.5 Post Audit Configuration for Samplers with Version 6 Software			

TABLE OF CONTENTS (cont.)

APPENDIX Z

PERFORMANCE AUDIT PROCEDURES
FOR
PM2.5 SAMPLERS

		PAGES	REVISION	DATE
Z.4.0	**AUDIT PROCEDURES FOR SEQUENTIAL SAMPLE (RUPPRECHT & PATASHNICK MODEL 2025 PARTISOL® - PLUS)**	8	2	3/9/04
	Z.4.0.1 Background			
	Z.4.0.2 Flow Rate, Temperature, and Pressure Sensor Audit Procedures			
	Z.4.0.3 Post Audit Configuration			
Z.5.0	**AUDIT PROCEDURES FOR THE BETA ATTENUATION MASS (BAM 1020) SAMPLER**	7	2	3/9/04
	Z.5.0.1 Background			
	Z.5.0.2 Flow Rate, Temperature and Pressure Sensor Audit Procedures			
	Z.5.0.3 Post Audit Configuration			

FIGURES

APPENDIX Z

PERFORMANCE AUDIT PROCEDURES
FOR
PM2.5 SAMPLERS

Page

Figure Z.1.0.1 QA Audit PM2.5 Sampler Worksheet (Single and Sequential Samplers).....7

Figure Z.1.0.2 QA Audit BAM 1020 Worksheet 8

Figure Z.1.0.3 Quality Assurance Audit Report 9

Figure Z.3.0.1 Main Menu and Auditing Menus for Andersen Model RAAS® 2.5-300 PM2.5 Multiple Filter Sampler Version 5 Software……13
(From Anderson's Operating Manual, Revision 37, March 1998)

Figure Z.4.0.1 Air Hose Attached to Left Cylinder……...8

Figure Z.4.0.2 WINS Impactor Removal……..8

Figure Z.4.0.3 Filter Temperature Audit……...8

Figure Z.5.0.1 BAM 1020 Front Panel/Door……7

Figure Z.5.0.2 BAM 1020 Filter Tape Assembly……7

STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX Z.1.0

PERFORMANCE AUDIT PROCEDURES
FOR
PM2.5 SAMPLERS

MONITORING AND LABORATORY DIVISION

MARCH 2004

Z.1.0 GENERAL INFORMATION

Z.1.0.1 AUDITING PROCEDURES

The primary goal of an auditing program is to identify system errors that may result in suspect or invalid data. Accurate assessment of the 2.5 micrometer (μm) particulate matter (PM) measurement system may only be made by conducting an audit under the following guidelines:

1. Without special preparation or adjustment of the system to be audited.

2. By an individual with a thorough knowledge of the instrument or process being evaluated, but not by the routine operator.

3. With accurate calibrated National Institute of Standards and Technology (NIST) traceable transfer standards 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 provide quantitative estimates of a PM2.5 sampler's performance. These quantitative values consist of the flow rate percent difference, the design flow rate percent difference, the ambient temperature difference, the filter temperature difference, and the barometric pressure difference. In addition, for some multiple filter samplers, the following procedures provide quantitative values of the inactive filter temperature difference and the dry gas meter (DGM) temperature difference.

The flow rate percent difference indicates the accuracy of the sampler's indicated flow rate by comparing the indicated flow rate measurement with the measurement from an audit transfer standard. The design flow rate percent difference determines how closely the sampler's flow rate matches the inlet design flow rate under ideal operating conditions. The ambient temperature, filter temperature, and barometric pressure differences reflect the difference between the audit measurement for temperature or pressure and the respective measurement indicated by the sampler.

An independent observer should be present during the audit, preferably the routine operator of the sampling equipment. The presence of the operator will both facilitate the overall audit procedure and contribute to its integrity. For example, the operator may offer information that will help the auditor to determine the cause of discrepancies between measured audit data and the sampling equipment response.

Z.1.0.2 PERFORMANCE AUDITS OF PM2.5 SAMPLERS

Audit procedures presented here are applicable to Rupprecht & Patashnick (R&P) Partisol®-FRM Model 2000 single filter (single channel), the Andersen Model RAAS® 2.5-300 multiple filter (sequential), the Rupprecht & Patashnick (R&P) Model 2025 Partisol® - Plus sequential sampler and the Met One Beta Attenuation Monitor 1020 (BAM) PM2.5 samplers, 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.

A calibrated BGI Incorporated DeltaCal (DeltaCal) 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 DeltaCal. The actual flow rate determined by the QAS DeltaCal is also compared with the design flow rate of 16.67 LPM.

Since the flow rate of air through the sampler is measured at actual conditions, the audit must also be in terms of actual conditions. The DeltaCal's digital screen displays the actual flow along with the actual temperature and barometric pressure.

Accurate measurement of PM2.5 mass concentration is dependent upon the ability of the sampler to maintain an inlet volumetric flow rate of 16.67 LPM in response to variations in ambient temperature and pressure. The performance audits of PM2.5 samplers must therefore, include an audit of the flow rate and an audit of the sampler's ambient temperature and barometric pressure sensors. Audit procedures are also included for a single-point temperature check of the sampler's filter temperature sensor and a single point-check of the inactive filter temperature sensor. The Andersen Model RAAS® 2.5 sampler also requires a single-point check of the dry gas meter temperature sensor.

Z.1.0.3 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 Z.1.0.1 and Z.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.

Z.1.0.3.1 FLOW RATE AUDIT APPARATUS

The following equipment is needed to perform a flow rate audit of the PM2.5 sampler:

1. Certified (NIST traceable) flow transfer standard DeltaCal (2-20 LPM) with the most recent calibration report. The audit transfer standard must be certified against a primary standard traceable to the NIST and shall be within $\pm$2 percent of the NIST traceable standard. The transfer standard shall be calibrated annually with the relative standard deviation within 1.0 percent of the last two calibrations.

2. A flow rate audit filter/cassette. (No filter required for the BAM 1020)

Z.1.0.3.2 TEMPERATURE SENSOR AUDIT APPARATUS

The following equipment is needed to perform an audit of the PM2.5 sampler's temperature sensors:

1. An electronic, water-immersible, temperature probe capable of accurately measuring temperature to within $\pm$0.5^{o}C, with a resolution of $\pm$0.1^{o}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^{o}C on the annual check.

   NOTE: If the audit temperature sensor is affected by radio frequency interference generated by external sources or by the sampler itself, a sensor unaffected by such interference should be used (e.g., a mercurial thermometer).

NOTE: Water bath is not done on the BAM 1020 since only a one-point temperature check is required.

2. Three thermos containers.

3. Immersion heating element or alternate method to heat water.

4. Finely cubed or crushed ice.

Z.1.0.3.3 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 DeltaCal is used.

Z.1.0.4 AUDIT DATA CALCULATIONS

1. The DeltaCal has built-in, calibrated temperature and pressure sensors so that the flow display on the DeltaCal 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).

Actual Temp. $Ta = (Tind)(m) + i$ (Eq. 3)

Where:

Ta = True temperature, ^{o}C

$Tind$ = Indicated reading from audit temperature probe, ^{o}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. DeltaCals have built-in, calibrated temperature sensor.

3. The barometric pressure reading from the DeltaCal (mmhg) is the actual barometric pressure value.

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:

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

6. Record differences and percent differences as appropriate. Audit flow rate percent differences greater than $\pm$4 percent, or design condition percent differences greater than $\pm$5 percent, require an investigation or a recalibration. Additionally, differences between audit temperature and sampler temperature measurements greater than $\pm 2^{o}$C, or differences between audit pressure and sampler pressure measurements greater than $\pm$10 mmHg, require corrective action. 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.

Z.1.0.5 AUDIT DATA REPORTING

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.

QA AUDIT WORKSHEET
PM2.5 SINGLE AND SEQUENTIAL SAMPLERS

Site Name:_____ Site Num:_____ Date:_____

Agency: _____ Site Operator:_____

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

EPA Desgination No. _____ Collocated Yes[ ] No[ ] NAMS[ ] SLAMS[ ] PAMS[ ] SPM[ ]

Sampler Information

Make	Model	ID Number	Last Cal. Date	Cal. Equip. Cert. Date

*Sampler Calibration Information (Offset and Span Values)

Measurement	Offset	Span
Ambient Temperature (Amb)		
Filter Temperature (Fltr)		
Barometric Pressure (Baro)		
Flow Rate		

* Depending on sampler type, some values may not be present.

Sampler Flow Rates - Audit MFM

Audit Point	Sampler (LPM)	Audit MFM (Display)
1		
2		
3		

Sampler Flow Rates - Chinook

Audit Point	Sampler (LPM)	Chinook DeltaP
1		
2		
3		

Sampler Temperature Water Bath Method

Test Point	Sampler Sensor	Audit Sensor
1 (Cold)		
2 (Ambient)		
3 (Warm)		

Sampler Temperature Collocated Method

Test Point	Sampler Sensor	Audit Sensor
1 (Amb)		
2 (DGM)		

Sampler Filter Temperatures

Test Point	Sampler Sensor	Audit Sensor
1 Filter (active)		
2 Filter (Inactive)		

Barometric Pressure

Sampler Sensor (mmHg)	Audit Sensor (volts)

QA-PM2.5SC1 REVISED 02/02

Figure Z.1.0.1
QA Audit PM2.5 Sampler Worksheet
(Single and Sequential Samplers)

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
DeltaCal					
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)	DeltaCal (mmHg)

Audit Data Flow Rates

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

Air Resources Board
Quality Assurance Section

BAM 1020
Revised 2/24/2004

Figure Z.1.0.2
QA Audit BAM 1020 Worksheet

Technical Appendix - PM2.5

Audit Information

Audit MFM Display Reading	Average Audit Flow (SLPM)	Average Audit Flow (LPM)	Station Indicated Flow	**Average Percent Difference**	**Percent Difference from Design**
16.70	16.83	16.70	16.60	**-0.6**	**0.2**

	Station Indicated Values	Audit Sensor Display Reading	Van Actual Values	**Difference**
Filter Temp.	29.8	28.5	28.7	**1.1**
Ambient Temp. (cold)	1.8	1.2	1.3	**0.5**
Ambient Temp. (warm)	26.9	26.6	26.8	**0.1**
Ambient Temp. (hot)	43.0	44.0	44.3	**-1.3**
Barometric Pressure	767.0	766.0	766.0	**1.0**
Temperature For Flow Audit		25.0		

Design flow rate limits are 15.84 to 17.50 CFM for PM2.5 samplers.

Failures and Warnings

All audit parameters are within specified limits!

Instrument/AIRS Information

ARB Number	04628	AIRS Number	060070002
Audit Date	2004-03-01	Inst. Make and Model	R & P 2000
Van	A	Serial Number	20005000
Quarter	1	Last Cal Date	2004-06-10

Comments

Figure Z.1.0.3
Quality Assurance Audit Report

STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX Z.2.0

PERFORMANCE AUDIT PROCEDURES
FOR
PM2.5 SAMPLERS

MONITORING AND LABORATORY DIVISION

MARCH 2004

Z.2.0 AUDIT PROCEDURES FOR SINGLE CHANNEL SAMPLER (R&P PARTISOL®-FRM MODEL 2000)

Z.2.0.1 BACKGROUND

The audit of a single channel sampler includes a determination of the sampler's total flow rate, filter temperature sensor, 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. In addition, verify that internal and external leak checks have been performed between the last sample run and the audit, or immediately before the current sampling run in those cases where an audit will interrupt a sampling episode. 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.

Auditing the filter temperature sensor of a single channel sampler consists of a single, collocated temperature check made with an audit sensor. The accuracy of the collocated check, however, is limited to the sum of the accuracy of the sampler's filter temperature sensor and the audit temperature sensor. This accuracy value should be referenced if it is greater than the audit limit of $\pm 2^{o}C$.

An audit of the sampler's ambient temperature sensor may be performed using three water baths, each at different temperatures. However, if it is determined from the operator that the sampler's ambient temperature probe may not be immersed in water, a single, collocated temperature check may be conducted.

The barometric pressure sensor is audited by comparing readings from the pressure sensor on the sampler with the pressure reading from the DeltaCal. To ensure that audit readings reflect the pressure of the sampler's pressure sensor, be sure that the DeltaCal 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.

Z.2.0.2 FLOW RATE, TEMPERATURE AND PRESSURE SENSOR AUDIT PROCEDURES

Some samplers require that the password protection feature be deactivated prior to conducting an audit. Consult with the site operator. To deactivate password protection, press the "enter" key on the console, followed by the sampler's five

digit serial number (or other five digit code as established by the operator), followed again by enter. A message will be displayed indicating that the password feature has been deactivated.

NOTE: If the sampler is sampling at the time of the audit, allow a 10-minute warm-up time for the DeltaCal transfer standard and then proceed through the following audit procedures beginning from Step 1 and skipping Step 2. The DeltaCal should be held in the upright position during the flow audit to maintain accurate readings. If the sampler is not sampling, skip Step 1 and proceed, beginning from Step 2.

1. From the main screen, press F4 to enter the stop mode. The operating mode field in the upper right corner of the main screen will change from SAMP to STOP and the pump will stop within 30 seconds.

2. Check the operating mode field in the upper right corner of the main screen to see if the current setting is WAIT, DONE, or ERR. Press F4. This will change the current settings above to STOP mode.

3. Press F5 to enter the "Setup" screen.

4. Press F2 to enter the "Calibration" screen.

5. Record the Offset and Span values for flow rate, filter temperature, ambient temperature, and barometric pressure.

   NOTE: Do not enter the edit screen or attempt to change the calibration settings.

6. Press ESC (escape) once to return to the "Setup" screen.

7. Press F5 to enter the "Audit" screen.

8. Carefully pull the handle of the filter platform forward to lower the platform.

9. Remove sampling filter cassette, if present, from the cassette carrier. Place the sample filter/cassette in a covered container to prevent contamination.

10. With the filter platform lowered, and the filter temperature sensor accessible, perform a one-point check of the filter temperature sensor as follows:

    NOTE: The filter temperature sensor is silver and is located within the filter cassette housing directly beneath the filter.

    a. Position the audit temperature sensor as close as possible to the sampler's filter temperature sensor without allowing the two sensors to touch.

    b. Allow both the audit sensor reading and the sampler's filter temperature sensor reading on the main screen to stabilize.

    c. Record the audit temperature reading and sampler filter temperature readings on the QA Audit Worksheet PM2.5 Single & Sequential Samplers (Worksheet)(see Figure Z.1.0.1).

11. Place an audit filter in the cassette carrier and insert the carrier into position in the sampler.

12. Raise the filter platform by slowly pushing the filter platform handle back to its original position.

    NOTE: Be sure the filter platform is raised completely and a tight seal is formed between the upper and lower halves of the filter stage.

13. Turn the DeltaCal off momentarily and then turn it back on while keeping it in the upright position. Wait until the DeltaCal completes its internal calibration before proceeding. Carefully remove the sampler inlet and replace with the DeltaCal head unit. Ensure that O-ring(s) within the DeltaCal are present and form a tight seal around the downtube.

14. With the "Audit" screen displayed, press <F3:Pump> and then <F2:Valve>. Pump will start up. Let sampler run for a minimum of 5 minutes.

15. Record **three** sampler flow rate readings approximately one (1) minute apart directly from the main screen under Sampler Qa.

16. Record **three** successive indicated DeltaCal readings approximately one (1) minute apart, in conjunction with the sampler flow rate readings.

17. Record the ambient temperature on the DeltaCal screen on the Worksheet.

18. Remove the DeltaCal head unit. Leave the sampler running.

19. 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.

20. Press <F2:Valve> and then <F3:Pump> to stop sampler. This will complete the flow audit.

21. Complete the top half of the Worksheet with the required information, including identification information and slope and intercept values where applicable.

22. Use the audit standard thermistor, <u>not</u> the DeltaCal thermistor to perform all water bath, filter and inactive filter checks. With the "Audit" screen displayed, audit the sampler's ambient temperature sensor as follows (water bath):

    NOTE: If the sampler's temperature sensor is not immersible in water, skip this Step and proceed to Step 23 to conduct a collocated ambient temperature sensor audit.

    a. Prepare the ice, ambient, and hot temperature water baths, and allow for temperature equilibration.

    b. Have the operator remove the ambient temperature sensor from the sampler's solar radiation shield.

        NOTE: Check the sampler temperature sensor for signs of cracking or wear prior to immersion in water baths. If there is visible damage to the sampler's ambient temperature sensor, do not proceed with the audit until the sensor has been repaired or replaced.

c. Immerse the audit sensor and sampler's temperature sensor into the ice bath. Gently agitate the water with the audit temperature probe for approximately 30 seconds. Allow the readings to stabilize. Read and record both the audit temperature sensor reading and the sampler temperature sensor reading.

d. Move the audit sensor and sampler's temperature sensor to the ambient temperature bath. Repeat the same procedures as the ice bath audit.

e. Be sure that the hot water temperature is between 40° and 45°C before immersing the sensors. Repeat the same procedures as the ice bath audit.

f. Ask the operator to place the sensor back into the radiation shield and tighten any clamps, if necessary.

g. Proceed to Step 24.

23. Audit the sampler's ambient temperature sensor as follows (collocated method):

a. Have the operator remove the ambient temperature sensor from the sampler's solar radiation shield.

b. Position the audit sensor as close as possible to the sampler sensor without allowing the two sensors to touch. Protect the sensors from direct sunlight or excessive air movements as much as possible.

c. Allow both the audit sensor and sampler temperature sensor display values to stabilize. Read and record the audit temperature on the Worksheet. Read and record the sampler's sensor reading.

d. Ask the operator to place the sensor back into the radiation shield and tighten any clamps, if necessary.

24. Audit the sampler's barometric pressure sensor as follows:

a. Read the DeltaCal display next to"**BP**:", and the barometric pressure sensor reading from the sampler's display screen.

b. Record the DeltaCal audit pressure and the sampler pressure reading on the Worksheet.

25. Press the ESC key twice to return to the "Main" screen.

Z.2.0.3 POST AUDIT CONFIGURATION

1. Remove the DeltaCal from the sampler if it has not been removed.

2. Replace the sampler inlet head.

3. Be sure that the station operator has replaced all temperature sensors which may have been removed for the audit.

4. Carefully pull the handle of the filter platform forward to lower the platform.

5. Remove the audit filter and replace any sampling filter originally present.

6. Raise the filter platform. If a sampling episode was underway at the time the audit began proceed to Step 7. If the sampler was in the WAIT, DONE, or ERR mode, proceed to Step 9.

7. With the "Main" screen displayed, press F4 to restart sampler.

8. Pump should restart.

9. Close the sampler case door.

STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX Z.3.0

PERFORMANCE AUDIT PROCEDURES
FOR
PM2.5 SAMPLERS

MONITORING AND LABORATORY DIVISION

MARCH 2004

Z.3.0 AUDIT PROCEDURES FOR SEQUENTIAL SAMPLER (ANDERSEN MODEL RAAS® 2.5-300)

Z.3.0.1 BACKGROUND

The audit of a sequential sampler includes a determination of the sampler's total flow rate, active filter temperature sensor, inactive filter temperature sensor, ambient temperature sensor, DGM 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. In addition, verify that internal and external leak checks have been performed between the last sample run and the audit, or immediately before the current sampling run in those cases where an audit will interrupt a sampling episode. 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.

Auditing the filter temperature sensor of a sequential sampler consists of a single, collocated temperature check made with an audit sensor. The accuracy of the collocated check, however, is limited to the sum of the accuracy of the sampler's filter temperature sensor and the audit temperature sensor. This accuracy value should be referenced if it is greater than the audit limit of $\pm 2^{o}C$.

An audit of the sampler's ambient temperature sensor may be performed using three water baths, each at different temperatures. However, if it is determined from the operator that the sampler's ambient temperature probe may not be immersed in water, a single, collocated temperature check may be conducted. Collocated temperature checks may be conducted of the active and inactive temperature sensors and the DGM temperature sensor. An audit of the DGM temperature sensor should be conducted only if the operator removes the sensor from the DGM and only if the operator is comfortable doing so.

The barometric pressure sensor is audited by comparing readings from the pressure sensor on the sampler with the pressure reading from the DeltaCal. To ensure that audit readings reflect the pressure of the sampler's pressure sensor, be sure that the DeltaCal and the sampler's pressure sensor are within100 meters horizontal distance from each other and within 0.5 meters vertical distance from each other.

Z.3.0.2 FLOW RATE, TEMPERATURE, AND PRESSURE SENSOR AUDIT PROCEDURES FOR SAMPLERS WITH VERSION 5 SOFTWARE.

NOTE: The following procedures are for Andersen PM2.5 sequential samplers with Version 5 or older software (Version 3, 4, etc.). Procedures for samplers with Version 6 or newer software are in Z.3.0.4. Verify with the site operator which software is currently being used.

Since the sequential sampler measures the flow rate on a volumetric basis, the temperature of the air flowing through the sampler's DGM is critical. The following audit procedures include a single-point check of the sampler's DGM temperature sensor. The procedures also include a single-point check of the sampler's inactive filter temperature sensor. The main menu on the sequential sampler is identified by a list of the following selection items: SETUP RUN, VIEW RUN, SAMPLE, LEAK CHECK, VERIFY FLOW, DATA TRANSFER, and MAINTENANCE (see Figure Z.3.0.1). Selection of a main menu item will typically enable access to a submenu. Menu and submenu items are selected by using the up or down arrow keys located on the sampler's control console and pressing ENTER.

NOTE: If the sampler is sampling at the time of the audit, allow a 10-minute warm-up time for the DeltaCal transfer standard and then proceed through the following audit procedures beginning from Step 1. The DeltaCal should be held in the upright position during the flow audit to maintain accurate readings. If the sampler is not sampling, skip Steps 1 and 2 and proceed, beginning from Step 3.

1. From the main menu, cursor to SAMPLE and press ENTER.

2. Cursor to PAUSE and press ENTER. The sampling episode will now be suspended for the audit. The main menu will still be displayed.

3. From the main menu, cursor to MAINTENANCE and press ENTER.

4. Cursor to AUTOMATION CTRL and press ENTER.

5. Cursor to UNLOAD FILTER and press ENTER.

6. Press CANCEL twice to return to the main menu.

7. From the main menu, cursor to MAINTENANCE and press ENTER.

8. Cursor to MONITOR and press the period key (**.**) followed by ENTER.

9. A screen titled "A/D Counts/Value" will be displayed. Press the down arrow key once.

10. A screen titled "Gain/Offset" will be displayed. Record the gain and offset values for ambient temperature, active filter temperature, and barometric pressure in the appropriate section of the QA Audit PM2.5 Sampler Worksheet for Single and Sequential Samplers (Worksheet)(see Figure Z.1.0.1). Also, record the value of the DGM calibration.

    NOTE: The DGM calibration will be indicated in the Gain/Offset screen as "DGM cal" with units of cc/tk.

11. After all values are recorded, press CANCEL twice to return to the main menu.

12. Cursor to MAINTENANCE and press ENTER.

13. Cursor to MONITOR and press ENTER.

14. With the filter platform lowered, the filter temperature sensor accessible, and the monitor screen displayed, perform a one-point check of the filter temperature sensor as follows:

    NOTE: The filter temperature sensor is a bead-tip thermocouple and is located within the filter cassette housing directly beneath the filter carousel.

    a. Position the audit temperature sensor as close as possible to the sampler's filter temperature sensor without allowing the two sensors to touch.

    b. Allow both the audit sensor reading and the sampler's filter temperature sensor reading on the main screen to stabilize.

    c. Record the audit temperature sensor reading and the sampler filter temperature reading on the Worksheet.

15. Following a check of the active filter temperature sensor, conduct a one-point check of the sampler's inactive filter temperature sensor as follows:

    NOTE: The inactive filter temperature sensor is a bead-tip thermocouple protruding below the filter tray to the left of the carousel.

    a. Position the audit temperature sensor as close as possible to the sampler's inactive filter temperature sensor without allowing the two sensors to touch.

b. Allow both the audit sensor reading and the sampler's inactive filter temperature sensor reading on the main screen to stabilize.

c. Record the audit temperature sensor reading and the sampler temperature reading on the Worksheet.

16. Carefully remove the filter area cover and note the position of all filters. Remove a sampling filter, if present, from an accessible filter bay. Place the sampling filter in a covered container to prevent contamination.

17. Carefully insert an audit filter into the vacant filter bay. Be sure the audit filter is installed securely between the filter cassette clips and is level with the filter carousel.

18. Replace the filter area cover.

NOTE: To prevent filter contamination, keep the amount of time the filter area cover is removed from its position over the filters to a minimum.

19. Press CANCEL twice to return to the main menu.

20. Cursor to VERIFY FLOW and press ENTER.

NOTE: A subscreen will be displayed with the title "Initializing Automation Control". This screen indicates that the sampler has entered an automatic mode in which the filter carousel will lower, rotate to position 1, then rise and seal. Do not attempt to bypass the automation control sequence.

21. Following the automation control sequence, a filter selection screen (FILTER 1, FILTER 2, FILTER 3, etc.) will be displayed. Cursor to that filter corresponding to the position of the audit filter. For example, if the audit filter was placed in the filter bay number 5, the cursor should be placed on FILTER 5.

22. Turn the DeltaCal off momentarily and then turn it back on while keeping it in the upright position. Wait until the DeltaCal completes its internal calibration before proceeding. Carefully remove the sampler inlet and replace with the DeltaCal head unit. Ensure that O-ring(s) within the DeltaCal are present and form a tight seal around the downtube.

23. Press ENTER. The filter carousel will automatically reposition itself so that the audit filter is directly beneath the downtube. The sampler pump will be activated and information on flow rate and average flow rate will be displayed.

24. Record **three** sampler average flow rate readings approximately one (1) minute apart directly from the main screen on the Worksheet.

25. Record **three** successive indicated DeltaCal readings approximately one (1) minute apart, in conjunction with the sampler flow rate readings.

26. Record the ambient temperature on the DeltaCal screen on the Worksheet.

27. Remove the DeltaCal head unit. Leave the sampler running.

28. 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.

29. Complete the top half of the Worksheet with the required information, including identification information and slope and intercept values, where applicable.

30. At the end of the flow audit, press CANCEL once to stop the sampler pump and return to the main menu.

31. Cursor to MAINTENANCE and press ENTER.

32. Cursor to MONITOR and press ENTER.

33. Use the audit standard thermistor, <u>not</u> the DeltaCal thermistor to perform all water bath, filter, inactive filter and DGM temp checks. Audit the sampler's ambient temperature sensor as follows (water bath):

    NOTE: If the sampler's temperature sensor is not immersible in water, skip this Step and proceed to Step 36 to conduct a collocated ambient temperature sensor audit.

    a. Prepare ice, ambient, and hot temperature water baths, and allow for temperature equilibration.

    b. Have the operator remove the ambient temperature sensor from the sampler's solar radiation shield.

        NOTE: Check the sampler temperature sensor for signs of cracking or wear prior to immersion in water baths. If there is visible damage to the sampler's ambient

temperature sensor, do not proceed with the audit until the sensor has been repaired or replaced.

c. Immerse the audit sensor and sampler's temperature sensor into the ice bath. Gently agitate the water with audit temperature probe for approximately 30 seconds. Allow the readings to stabilize. Read and record both the audit sensor and the sampler temperature sensor reading.

d. Move the audit sensor and sampler's temperature sensor to the ambient temperature bath. Repeat the same procedures as the ice bath audit.

e. Be sure that the hot water temperature is between 40° and 45°C. Before immersing the audit sensors. Repeat the same procedures as the ice bath audits.

f. Ask the operator to place the sensor back into the radiation shield and tighten any clamps, if necessary.

g. Proceed to Step 37.

34. Audit the sampler's ambient temperature sensor as follows (collocated method):

a. Have the operator remove the ambient temperature sensor from the sampler's solar radiation shield.

b. Position the audit sensor as close as possible to the sampler sensor without allowing the two sensors to touch. Protect the sensors from direct sunlight or excessive air movements as much as possible.

c. Allow both the audit sensor and sampler temperature sensor display values to stabilize. Read and record both values.

d. Ask the operator to place the sensor back into the radiation shield and tighten any clamps, if necessary.

35. Audit the sampler's DGM temperature sensor as follows:

a. Have the operator remove the temperature sensor from the sampler's DGM.

b. Position the audit sensor as close as possible to the sampler sensor without allowing the two sensors to touch. Protect the sensors from direct sunlight or excessive air movements as much as possible.

c. Allow both the audit sensor and sampler temperature sensor display values to stabilize. Record the audit sensor reading and the sampler sensor reading.

d. Ask the operator to place the sensor back into the DGM.

36. Audit the sampler's barometric pressure sensor as follows:

a. Read the DeltaCal's display next to **"BP:"**, and the barometric pressure sensor reading from the sampler's display screen.

b. Record the DeltaCal audit pressure and the sampler pressure reading on the Worksheet.

Z.3.0.3 POST AUDIT CONFIGURATION FOR SAMPLERS WITH VERSION 5 SOFTWARE

1. Remove the DeltaCal from the sampler inlet if it has not been removed.

2. Replace the sampler inlet head.

3. Be sure that the station operator has replaced all temperature sensors which may have been removed for the audit.

4. From the monitor display, press CANCEL twice to return to the main menu.

5. Cursor to VERIFY FLOW and press ENTER.

6. From the filter selection screen (i.e., FILTER 1, FILTER 2, etc.), cursor to the original filter position and press ENTER. Once the carousel has re-positioned itself and the platform has been elevated, the sampler pump will automatically start.

7. Press CANCEL to stop the sampler pump.

8. Remove the audit filter and replace any sampling filter originally present.

9. If a sampling episode was in progress at the time of the audit, cursor to SAMPLE and press ENTER; then press RESUME.

10. Close the sampler case door.

Z.3.0.4 FLOW RATE, TEMPERATURE, AND PRESSURE SENSOR AUDIT PROCEDURES FOR SAMPLERS WITH VERSION 6 SOFTWARE.

NOTE: The following procedures are for Andersen PM2.5 sequential samplers with Version 6 software. Procedures for samplers with Version 5 (or older) software are in Z.3.0.2. Verify with the site operator which software is currently being used.

Since the sequential sampler measures the flow rate on a volumetric basis, the temperature of the air flowing through the sampler's DGM is critical. The following audit procedures include a single-point check of the sampler's DGM temperature sensor. The procedures also include a single-point check of the sampler's inactive filter temperature sensor. The main menu on the sequential sampler is identified by a list of the following selection items: ON LINE ↔ OFF LINE, FILTERS, EVENTS, DATA TRANSFER, and MAINTENANCE. Selection of a main menu item will typically enable access to a submenu. Menu and submenu items are selected by using the up or down arrow keys located on the sampler's control console and pressing ENTER.

NOTE: If the sampler is sampling at the time of the audit, allow a 10-minute warm-up time for the DeltaCal and then proceed through the following audit procedures beginning from Step 1. The DeltaCal should be held in the upright position during the flow audit to maintain accurate readings. If the sampler is not sampling, skip Step 1 and proceed, beginning from Step 2.

1. From the main menu, the ON LINE ↔ OFF LINE menu item should be highlighted. If not, cursor to it and press ENTER. The sampling episode will now be suspended for the audit.

2. From the main menu, cursor to MAINTENANCE and press ENTER.

3. With the screen in "Maintenance Menu", cursor to monitor and press ENTER.

4. Press the down arrow key once to get to the "Calibration Values:" screen (it will display "Screen 2 of 3")

5. Record the gain and offset values for ambient temperature, active filter temperature, and barometric pressure in the appropriate section of the QA Audit Worksheet PM2.5 Single & Sequential Samplers (Worksheet) (see Figure Z.1.0.1). Also, record the value of the DGM calibration.

NOTE: The DGM calibration will be indicated in the "Calibration Values:" screen as "DGM cal" with units of cc/tk.

6. After all values are recorded, press CANCEL once to return to the "Maintenance Menu".

7. Cursor to "QC" and press ENTER to display the "QC Menu" screen.

8. Cursor to "Dry Gas Meter" and press ENTER.

9. Press CANCEL to display the "Select Position" screen.

10. Carefully remove the filter area cover and note the position of all filters. Remove a sampling filter, if present, from an accessible filter bay. Place the sampling filter in a covered container to prevent contamination.

11. Carefully insert an audit filter into the vacant filter bay. Be sure the audit filter is installed securely between the filter cassette clips and is level with the filter carousel.

12. Replace the filter cover area cover.

NOTE: To prevent filter contamination, keep the amount of time the filter area cover is removed from its position over the filters to a minimum.

13. Cursor to the position that corresponds with the audit filter's position and press ENTER.

14. The sampler will now position the audit filter into sampling position. Once in place, the screen will be in the "Select Flow Device" screen.

15. Turn the DeltaCal off momentarily and then turn it back on while keeping it in the upright position. Wait until the DeltaCal completes its internal calibration before proceeding. Carefully remove the sampler inlet and replace with the DeltaCal head unit. Ensure that O-ring(s) within the DeltaCal are present and form a tight seal around the downtube.

15. With the "Select Flow Device" screen displayed, cursor to "Amb Flow Device" and press ENTER.

16. When "Verify Flow Rate 16.67 L/m" appears on the screen, press ENTER to start pump.

17. Let the sampler run for 5 minutes to stabilize and display the "Avg Flow:".

18. Record **three** sampler average flow rate readings approximately one (1) minute apart directly from the display screen on the Worksheet.

19. Record **three** successive indicated DeltaCal readings approximately one (1) minute apart, in conjunction with the sampler flow rate readings.

20. Record the ambient temperature on the DeltaCal screen on the Worksheet.

21. Remove the DeltaCal head unit. Leave the sampler running.

22. 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.

23. Press CANCEL three times to stop the sampler pump and return to the "Maintenance Menu" screen.

24. Cursor to "Automation Ctrl" and press ENTER. This will display the "AC Menu" screen.

25. Cursor to "Unload Filter" and press ENTER. Remove the audit filter.

26. Press CANCEL to return to the "Maintenance Menu" screen.

27. Cursor to "Monitor" and press ENTER. This will display the "Current Values:" screen ("Screen 1 of 3" should be displayed). This screen will be used for all the temperature and barometer audits.

28. Use the audit standard thermistor, <u>not</u> the DeltaCal thermistor to perform all water bath, filter, inactive filter and DGM temp checks. Audit the sampler's ambient temperature sensor as follows (water bath):

    NOTE: If the sampler's temperature sensor is not immersible in water, skip this Step and proceed to Step 29 to conduct a collocated ambient temperature sensor audit.

    a. Prepare ice, ambient, and hot water baths and allow for temperature equilibration.

    b. Have the operator remove the ambient temperature sensor from the sampler's solar radiation shield.

    c. Immerse the audit sensor and sampler's temperature sensor into the ice bath. Gently agitate the water with the temperature probes for

approximately 30 seconds. Allow the readings to stabilize. Read and record both the audit sensor reading and the sampler temperature sensor reading.

d. Move the audit sensor and sampler's temperature sensor to the ambient temperature bath. Repeat the same procedure as the ice bath audit.

e. Be sure that the hot water bath is between 40° and 45°C before immersing the sensors. Repeat the same procedure as the ice bath audit.

f. Ask the operator to place the sensor back into the radiation shield and tighten any clamps, if necessary.

29. Audit the sampler's ambient temperature sensor as follows (collocated method):

a. Have the operator remove the ambient temperature sensor from the sampler's solar radiation shield.

b. Position the audit sensor as close as possible to the sampler sensor without allowing the two sensors to touch. Protect the sensors from direct sunlight or excessive air movements as much as possible.

c. Allow both the audit sensor and sampler temperature sensor display values to stabilize. Read and record both values.

d. Ask the operator to place the sensor back into the radiation shield and tighten any clamps, if necessary.

30. Audit the sampler's DGM temperature sensor as follows:

a. Have the operator remove the temperature sensor from the sampler's DGM.

b. Follow Procedure 26 b and c above for auditing the DGM temperature sensor.

c. Ask the operator to place the sensor back into the DGM.

31. Audit the filter temperature sensor using the Procedure 29 b and c above.

NOTE: The filter temperature sensor is a bead-tip thermocouple and is located within the filter cassette housing directly beneath the filter carousel.

32. Following a check of the active filter temperature sensor above, conduct a one-point check of the sampler's inactive filter temperature sensor using the Procedure 29 b and c above.
    NOTE: The inactive filter temperature sensor is a bead-tip thermocouple protruding below the filter tray to the left of the carousel.

33. Audit the sampler's barometric pressure sensor as follows:

    a. Read the DeltaCal display next to "**BP:**", and the barometric pressure sensor reading from the sampler's display screen.

    b. Record the DeltaCal audit pressure. Record the sampler pressure reading from the "Current Values:" screen.

Z.3.0.5 POST AUDIT CONFIGURATION FOR SAMPLERS WITH VERSION 6 SOFTWARE

1. Remove the DeltaCal from the sampler inlet if it has not been removed.

2. Replace the sampler inlet head.

3. Be sure the station operator has replaced all temperature sensors which may have been removed for the audit.

4. From the "Current Values:" screen, press CANCEL twice to return to the "Main Menu". If the sampler was sampling at the time of the audit, verify that ON LINE ↔ OFF LINE is selected and then press ENTER. The carousel will rotate to its original sampling (filter) position and continue the scheduled run.

5. Close the sampler case door.

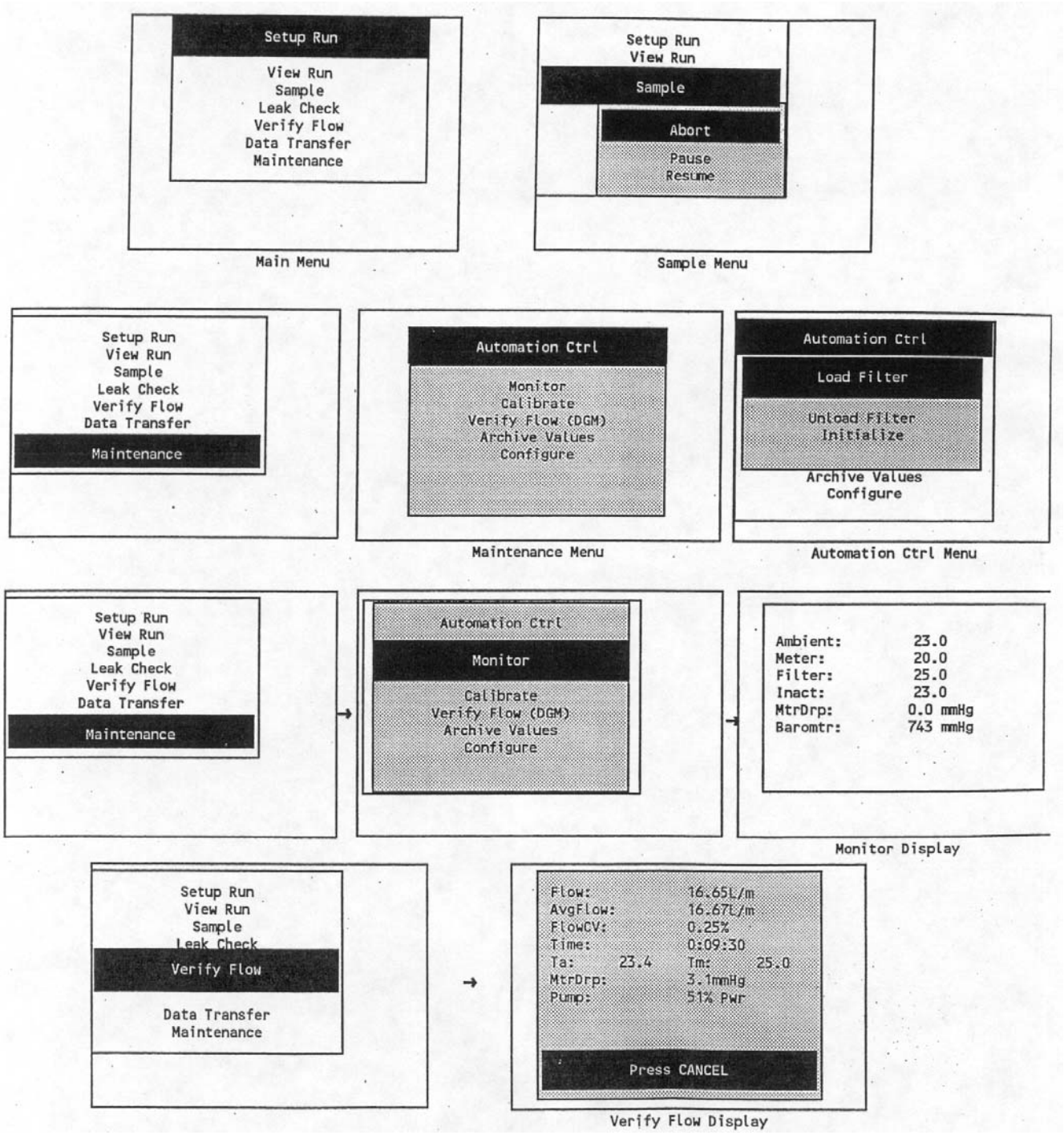

Figure Z.3.0.1
Main Menu and Auditing Menus for Andersen Model RAAS®2.5-300 PM2.5 Multiple Filter Sampler Version 5 Software(From Andersen's Operating Manual, Revision 37, March 1998)

STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX Z.4.0

PERFORMANCE AUDIT PROCEDURES
FOR
PM2.5 SAMPLERS

MONITORING AND LABORATORY DIVISION

MARCH 2004

Z.4.0 AUDIT PROCEDURES FOR SEQUENTIAL SAMPLER (RUPPRECHT & PATASHNICK MODEL 2025 PARTISOL®- PLUS)

Z.4.0.1 BACKGROUND

The audit of a sequential sampler includes a determination of the sampler's total flow rate, active filter temperature sensor, 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. In addition, verify that internal and external leak checks have been performed as part of the maintenance schedule. 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.

Auditing the filter temperature sensor of a sequential sampler consists of a single, collocated temperature check made with an audit sensor. The accuracy of the collocated check, however, is limited to the sum of the accuracies of the sampler's filter temperature sensor and the audit temperature sensor. This accuracy value should be referenced if it is greater than the audit limit of $\pm 2^{o}C$.

An audit of the sampler's ambient temperature sensor may be performed using three water baths, each at different temperatures. However, if it is determined from the operator that the sampler's ambient temperature probe may not be immersed in water, a single, collocated temperature check may be conducted. Collocated temperature checks may be conducted of the active temperature sensor.

The barometric pressure sensor is audited by comparing readings from the pressure sensor on the sampler with the pressure reading from the DeltaCal. To ensure that audit readings reflect the pressure of the sampler's pressure sensor, be sure that the DeltaCal and the sampler's pressure sensor are within100 meters horizontal distance from each other and within 0.5 meters vertical distance from each other.

Z.4.0.2 FLOW RATE, TEMPERATURE, AND PRESSURE SENSOR AUDIT PROCEDURES

The following audit procedures will include an audit of the sampler's total flow rate, the active filter temperature, the ambient filter temperature and the barometric pressure. Selection of the <MENU> button will enable access to the "Service Menu" screen where other submenu items can be selected. By using the up or down arrow keys and the F1 through F5 keys located on the sampler's control console, the desired command can be selected. Pressing the <ESC> key once or twice on the control console will bring back the main display menu "Partisol 2025". Also, pressing the <ESC> key will help determine which mode the sampler is currently in.

1. Turn on the DeltaCal and allow for a minimum of 10-minute warm-up time. The DeltaCal should be held in the upright position during the flow audit to maintain accurate readings.

   CAUTION: If the sampler is in SAMPLING or WAIT Mode at the time of the audit, proceed to Step 15 for alternate procedures. Proceeding with Step 2 while the unit is in SAMPLING or WAIT Mode will cause the unit to not resume sampling after the audit.

2. With the sampler in the stop mode, press <MENU> on the touch panel to display the Master Menu screen. Scroll to the ">Service Mode" and press <ENTER> on the touch panel.

3. The display will prompt "Are you sure?" Press <F4: Yes> to continue.

4. Audit the sampler's flow rate as follows:

   a. Remove the air hose to the left supply magazine. See Figure Z.4.0.1

   b. Turn the left supply magazine clockwise slightly to let it drop out of its holding position.

   c. Stack the audit filter on top of the piston or unsampled filters of the supply magazine. The filters are installed with the recessed side facing up.

      NOTE: The piston or the existing unsampled filters may have to be pushed down to accommodate the audit filter. This is done by placing the audit filter on top of the piston or the unsampled filters and applying downward pressure on the

plastic filter holder edges until the audit filter is flushed or below the rim of the magazine.

d. Reinstall the supply magazine by inserting it in the holding position and turning it counterclockwise until it is in place. Be sure that the air inlet on the bottom is aligned with the air supply hose. Reattach the air supply hose on the supply magazine.

NOTE: If the sampler was in SAMPLING or WAIT Mode prior to audit, sampler may already be in Audit screen.

e. Press <F1: Audit>.

f. When in the Audit screen, press <F4: FiltAdv> to advance the audit filter to the sampling position. If display screen shows that filter exchange had failed, check for loose air hose connection or improper filter installation.

g. Turn the DeltaCal off momentarily and then turn it back on while keeping it in the upright position. Wait until the DeltaCal completes its internal calibration before proceeding. Carefully remove the sampler inlet and replace with the DeltaCal head unit. Ensure that O-ring(s) within the DeltaCal are present and form a tight seal around the downtube.

h. Press <F2: Valve 1> and then <F1: Pump> to turn on pump.

i. Wait until the "Cur Flow" display stabilizes.

j. Record **three** sampler average flow rate readings from "Cur Flow" approximately one (1) minute apart directly from the display screen.

k. Record **three** consecutive indicated DeltaCal readings approximately one (1) minute apart, in conjunction with the sampler flow rate readings.

l. Record the ambient temperature on the DeltaCal screen on the Worksheet.

m. Remove the DeltaCal head unit while leaving the sampler running.

n. 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.

o. Press <F1: Pump> and then <F2: Valve 1> to shut off pump.

p. Remove the storage magazine on the right side of the sampler by turning the tube clockwise and slightly to let it drop down from its holding position.

q. Remove the top filter from the storage magazine. This is the filter that was originally in the sampling position before the audit. Reinstall the storage magazine to its original position.

r. Install the original filter in the left supply magazine as described in Step 4 a-d.

s. After the original filter is installed in the supply magazine, press <F4: FiltAdv> to load the original filter into the sampling position. This will advance the audit filter into the storage magazine.

t. Remove the storage magazine on the right side as described in Step 4p.

u. Remove the audit filter (top filter) and reinstall the storage tube by inserting it in its position and turning counterclockwise until it is in place.

NOTE: Skip to Step 15 if sampler was previously in SAMPLING or WAIT Modes prior to audit.

5. Press <ESC> on the touch pad and the screen should display Service Menu screen. Using the arrow keys, scroll down to ">Calibration/Audit" and press <F3: SensCal>.

6. Record sampler ambient temperature and pressure settings on worksheet. Note that the "Actual" column on the screen corresponds to the "Gain" column on the Worksheet.

7. Press <F4: FiltCal> to record filter temperature values.

8. Press <F5: FlowCal> to record the "Offset" and "Span" value of the flow settings and record them under the "Flow Rate (DGM calibration cc/tk)" row.

NOTE: The R & P sequential sampler does not utilize DGM.

9. Press <ESC> to return to the Service Menu screen.

10. Press <F1:Audit> to display the Audit screen.

11. Use the audit standard thermistor, not the DeltaCal thermistor to perform all water baths, filter and inactive filter checks. Audit the sampler's ambient temperature sensor as follows (water bath):

NOTE: If the sampler's temperature sensor is not immersible in water, skip this Step and conduct a collocated ambient temperature sensor audit (Step 12).

a. Prepare ice, ambient, and hot temperature water baths and allow for temperature equilibration.

b. Have the operator remove the ambient temperature sensor from the sampler's solar radiation shield.

NOTE: Check the sampler temperature sensor for signs of cracking or wear prior to immersion in water baths. If there is visible damage to the sampler's ambient temperature sensor, inform the site operator of the problem before proceeding.

c. Immerse the audit sensor and sampler's temperature sensor into the ice bath. Gently agitate the water with the audit temperature probe for approximately 30 seconds. Allow the readings to stabilize. Read and record both the audit sensor and the sampler temperature sensor reading.

d. Repeat Step (11 c) for ambient temperature bath.

e. Repeat Step (11 c) for the hot water bath. The hot water temperature should be between 40º and 45ºC.

f. Ask the site operator to reinstall the ambient temperature sensor back into the radiation shield.

12. Audit the sampler's ambient temperature sensor as follows (collocated method):

e. Have the operator remove the ambient temperature sensor from the sampler's solar radiation shield.

f. Position the audit sensor as close as possible to the sampler sensor without allowing the two sensors to touch. Protect the sensors from direct sunlight or excessive air movements as much as possible.

g. Allow both the audit sensor and sampler temperature sensor display values to stabilize. Read and record both values.

h. Ask the operator to place the sensor back into the radiation shield and tighten any clamps, if necessary.

13. Audit the sampler's filter temperature sensor as follows:

a. Remove the sample inlet head by pulling straight upward. Unlatch and open the sampler's top cover. Pull straight upward to remove the WINS impactor as shown in Figure Z.4.0.2.

b. Insert the audit temperature sensor into the sampling chamber as shown in Figure Z.4.0.3. Position the audit temperature sensor as close as possible to the sampler's filter temperature sensor without allowing the two sensors to touch.

c. Allow both the audit sensor reading and the sampler's Audit screen reading for "Filt Temp" to stabilize.

d. Record the audit temperature sensor reading and the sampler filter temperature reading on the Worksheet.

e. Reinstall the WINS impactor and close the sampler's top cover.

14. Audit the sampler's barometric pressure sensors as follows:

a. Read the DeltaCal display next to "**BP:**", and the barometer pressure sensor reading from the sampler's Audit screen.

b. Record the DeltaCal audit pressure and the sampler pressure reading on the Worksheet.

15. This step is **only used** if the sampler is in the **Sampling** or **Wait Modes**:

a. Press <RUN/STOP> once or twice to enter the Audit Mode. The unit then will display the Audit Confirmation screen. **Press <F1: Audit>**, and then press any key to continue.

CAUTION: Do not press <F2: Stop> or <F5: Resume>. The unit will not resume sampling (after your audit procedures are finished) at the set points that was previously programmed. The unit will advance its sampling cycle to the next day and then enter the Wait Mode.

b. Press <MENU> twice, make sure that ">Audit" is selected and then press <ENTER> on the touch panel. This will display the Audit screen.

c. Now proceed with the audit using Steps 4, 11,12, and 13.

CAUTION: Steps 5-10 must be omitted if the sampler was in the **Sampling** or **Wait Modes** prior to audit. Thus, gain, offset, span and zero values cannot be obtained.

Z.4.0.3 POST AUDIT CONFIGURATION

1. Remove the DeltaCal from the sampler inlet if it has not been removed.

2. Replace the sampler inlet head.

3. Be sure that the station operator has replaced all temperature sensors, which may have been removed for the audit.

4. From the Audit screen, press <ESC> on the touch pad twice. This will return the screen to the main "Partisol 2025" menu.

5. If the sampler was in Sampling or Wait Mode prior to audit, press <RUN/STOP> on the touch pad to resume sampling. Otherwise, the site operator may have to program the sampler for future sampling schedules.

6. Close the sampler door.

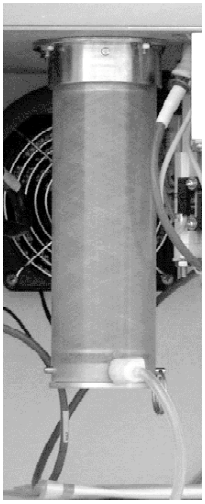

Figure Z.4.0.1
Air Hose Attached To Left Cylinder

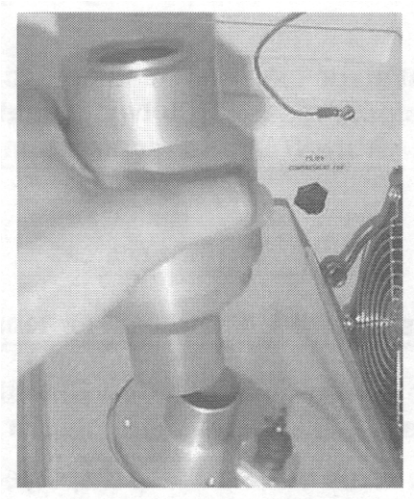

Figure Z.4.0.2
WINS Impactor Removal Figure

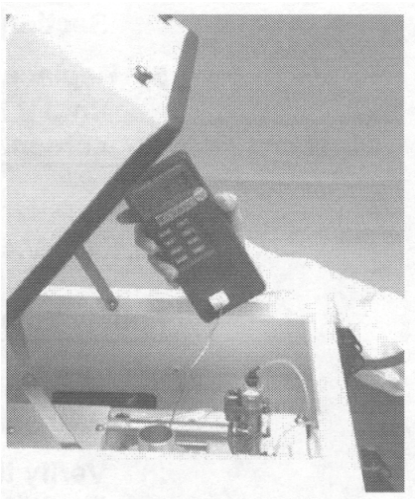

Figure Z.4.0.3
Filter Temperature Audit

STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX Z.5.0

PERFORMANCE AUDIT PROCEDURES
FOR
PM2.5 SAMPLERS

MONITORING AND LABORATORY DIVISION

MARCH 2004

Z.5.0 AUDIT PROCEDURES FOR THE BETA ATTENUATION MASS (BAM 1020) SAMPLER

Z.5.0.1 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 DeltaCal. To ensure that audit readings reflect the pressure of the sampler's pressure sensor, be sure that the DeltaCal and the sampler's pressure sensor are within100 meters horizontal distance from each other and within 0.5 meters vertical distance from each other.

Z.5.0.2 FLOW RATE, TEMPERATURE AND PRESSURE SENSOR AUDIT PROCEDURES

1. Turn on the DeltaCal and allow for a minimum of 10-minute warm-up time. The DeltaCal should be held in the upright position during the flow audit to maintain accurate readings.

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 DeltaCal, 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 DeltaCal 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 DeltaCal display next to "**BP:**", and the BAROMETRIC PRESSURE sensor reading from the sampler's User Screen under the "BAM" column.

    b. Record the DeltaCal 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 DeltaCal off momentarily and then turn it back on while keeping it in the upright position. Wait until the DeltaCal completes its internal calibration before proceeding. Carefully remove the sampler inlet and replace with the DeltaCal head unit. Ensure that O-ring(s) within the DeltaCal 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** DeltaCal 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 DeltaCal 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 the ambient temperature on the DeltaCal screen on the Worksheet.

17. Remove the DeltaCal 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:

$$Qa = (Qind)(Ta/298.15\ K)(760\ mmhg/Pa)$$

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

Qind = Indicated flow rate from sampler's metered mode screen.

Ta = °C + 273.15 where °C = (°Cind)(m) + b

Pa = Pressure reading from DeltaCal 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.

Z.5.0.3 POST AUDIT CONFIGURATION

1. Remove the DeltaCal 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.

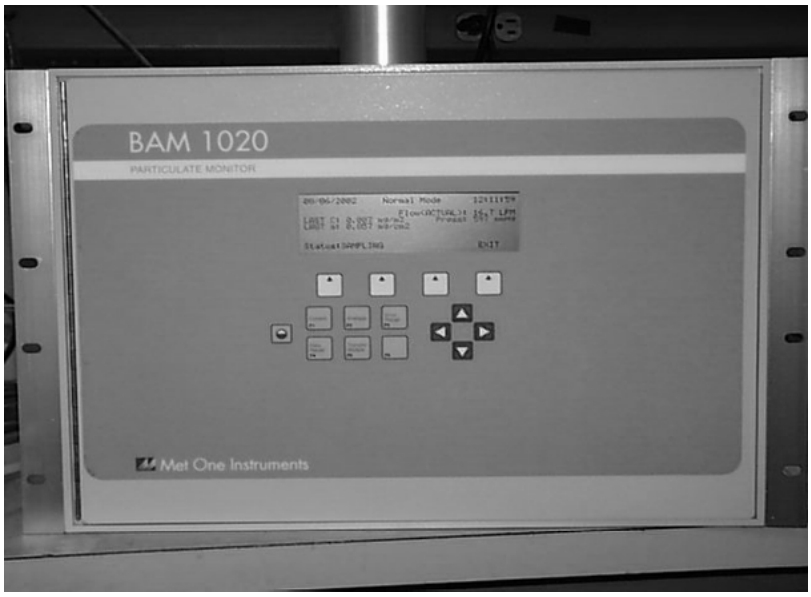

Figure Z.5.0.1
BAM 1020 Front Panel/Door

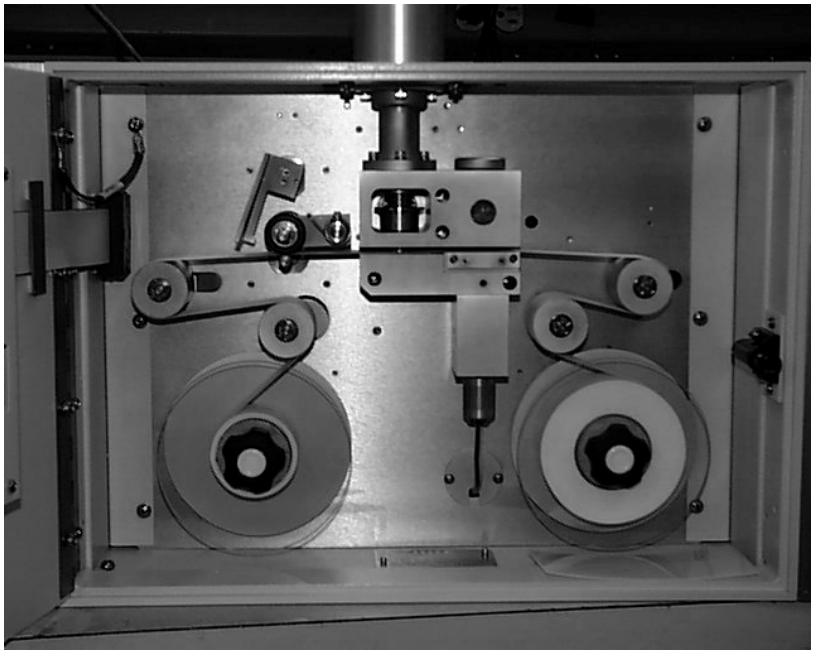

Figure Z.5.0.2
BAM 1020 Filter Tape Assembly