CALIFORNIA
AIR RESOURCES BOARD

Performance Audit Procedures for Continuous Particulate Matter Monitors

Volume V
Audit Procedures Manual for Air Quality Monitoring

QMB SOP Appendix AR
Version 1.0

Quality Assurance Section
Quality Management Branch
Monitoring and Laboratory Division

Approval Signatures	Approval Date
Ranjit Bhullar Ranjit Bhullar, Manager Quality Assurance Section	June 8, 2020
MSingh Manisha Singh, Ph.D., Chief Quality Management Branch	June 8, 2020

Disclaimer: Mention of any trade name or commercial product in this standard operating procedure does not constitute endorsement or recommendation of this product by the California Air Resources Board. Specific brand names and instrument descriptions listed in the standard operating procedure are for equipment used by the California Air Resources Board. Any functionally equivalent instrumentation is acceptable.

PERFORMANCE AUDIT PROCEDURES
FOR CONTINUOUS PARTICULATE MATTER MONITORS

TABLE OF CONTENTS

PERFORMANCE AUDIT PROCEDURES
FOR CONTINUOUS PARTICULATE MATTER MONITORS

FIGURES AND TABLES

Page

ACRONYMS AND DEFINITIONS

Acronym	Definition
AIS	Audit Information System
AQDA	Air Quality Data Action
AQS	Air Quality System (U.S. EPA database)
ASC	Aerosol Sampler Conditioner
AT	Ambient Temperature
BAM	Beta Attenuation Monitor
BP	Barometric Pressure
CAN	Corrective Action Notification
CARB	California Air Resources Board
°C	Degrees Celsius
HEPA	High Efficiency Particulate Air (filter)
LPM	Liters Per Minute
NIST	National Institute of Standards and Technology
NOV	Non-linearity Offset Value
PM	Particulate Matter
ppb	Parts Per Billion
ppm	Parts Per Million
Q_a	Flow rate at actual conditions
QAS	Quality Assurance Section
QMB	Quality Management Branch
SOP	Standard Operating Procedure
SSI	Selective Size Inlet
TEOM	Tapered Element Oscillating Microbalance
U.S. EPA	United States Environmental Protection Agency
VFM	Volumetric Flow Meter
VSCC	Very Sharp Cut Cyclone

AR.1.0 INTRODUCTION

Different types of continuous particulate matter (PM) samplers operate in the California ambient air monitoring network. The audit procedures presented here are applicable to the Tapered Element Oscillating Microbalance (TEOM) 1400 and 1405 series, the Met One Beta Attenuation Monitor (BAM1020 and BAM1022) and E-BAM Plus, and the TAPI 602 Beta Plus and TAPI T640 (T640). These monitors are federally approved to measure for PM_{10} and/or $PM_{2.5}$ sized particulates. Certain samplers can also measure for a PM Coarse ($PM_{10-2.5}$) fraction. Audit techniques may vary with different models of samplers due to differences in sampler configuration, sampler software, etc.

AR.1.1 SUMMARY OF METHOD

An accurate measurement of PM is highly dependent on the flow rate on any given sampler. Therefore, the accuracy of a particulate sampler is determined by comparing the sampler's flow rate to a certified flow standard. Accordingly, flow audits are conducted to assess whether the flow rate through the entire sampling system, with the PM_{10} head removed, is maintained within required specifications.

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 an individual who possesses 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 and Technology (NIST) and completely independent of those used during routine calibration and verification.

4. With complete documentation of audit data and results compiled into a report for submission to the operating agency. Audit data includes, but is not limited to: audit measured values and correlating station sampler responses, relevant documentation pertaining to the sampler being audited, calibration date, flow standard identification number and certification date, and other sampler related information.

AR.1.2 INTERFERENCES

The interferences associated with auditing continuous PM monitors include factors that can alter the flow rate measurement through the inlet or audit standard. Changes in flow rate can be the result of a leak or constriction, which may be caused by improper installation of the audit standard. Flow rate measurement is ambient temperature (AT) and barometric pressure (BP) dependent.

AR.1.3 PERSONNEL QUALIFICATIONS

All new California Air Resources Board (CARB) auditors undertake a one year training program that is administered, monitored, and documented by the Quality Assurance Section (QAS) manager. The training includes in-office reading and coursework, hands-on field experience conducting audits, learning the Audit Information System (AIS), and shadowing an experienced auditor for one year. In-field evaluations are conducted by the QAS manager to ensure gradual progression.

United States Environmental Protection Agency (U.S. EPA) reviews CARB's training program routinely for approval as equivalent to U.S. EPA's national certification and recertification courses. Auditors should be familiar with the regulations and guidance cited in the References (Section AR.5.0) prior to conducting any audits. Each auditor is expected to have a minimum level of on-the-job training, and a familiarity with the audit equipment prior to conducting an audit.

NOTE: A station operator familiar with the equipment should be present during the entire audit to perform the required manipulation of the station equipment as needed. Auditors should check for proper operation, verify values and readings, and record audit data, all of which shall be conducted with minimal change to the normal configuration of the sampler being audited.

AR.1.4 HEALTH, SAFETY, AND CAUTIONS

Audit personnel must follow all general health and safety guidelines as instituted by the facility where each audit is being conducted. All audit equipment, including vehicles, should be used only for the purpose it was intended. Also, audits must be completed in the manner described in this standard operating procedure (SOP), and consistent with the applicable manufacturer's operations manual. Care should be taken

when accessing samplers, especially on station rooftops. All equipment being audited must be readily and safely accessible.

AR.1.5 EQUIPMENT AND SUPPLIES

All audit standards must be certified annually against a higher authority, NIST traceable reference standard. 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 reference standard.

In addition to the apparatus listed in the following sections, an audit worksheet is also needed to document audit information. The information being recorded includes, but is not limited to, station sampler and ID, audit transfer standard type and ID, model and serial numbers of each, audit flow device traceability and calibration information, AT and BP conditions and collected audit data.

In order to conduct performance audits for continuous PM monitors, the following equipment is required:

1. A currently certified audit standard(s) with the appropriate range for the instrument(s) to be audited. See Table AR-1 for the acceptable measurement tolerance applicable to each audit standard.

Table AR-1. Audit standard acceptable measurement tolerances

Audit Standard	Acceptable Measurement Tolerance
Flow Rate	<± 2.1% of NIST traceable standard
Temperature	± 0.1 °C of standard resolution, ± 0.5 °C accuracy
Pressure	± 1 mmHg resolution, ± 5 mmHg accuracy

2. Various standard audit worksheets for PM monitors (specific to audit).

3. A dedicated laptop to open the Audit Information System program to conduct and calculate audit results. This program is the depository for any/all information related to the particular audit being conducted.

4. Leak check adapter.

5. Tygon tubing.

6. HEPA filters.

AR.2.0 PROCEDURES

AR.2.1 GENERAL

Upon arriving at the station, confer with the operator to determine the most optimal time to start the audit(s), so as to minimize the loss of ambient monitoring data. Consult with the operator prior to navigating through display screens or making changes to the station equipment.

Taking record of the past six months of monthly flow and leak checks, temperature, pressure, and clock verification dates is required for all audits of continuous PM monitors.

Allow the audit standards to warm up and equilibrate in accordance with manufacturers' recommendations. This is normally achieved by placing the audit standards within reach of the sampling inlet and exposed to the ambient conditions but not in direct sun.

During the course of an audit, ambient conditions such as temperature and pressure can vary to potentially influence the assessment results. As such, it is advisable to collect these measurements from the audit devices and sampler sequentially within as short a time interval as practically possible.

AR.2.2 PERFORMING AN AUDIT ON A TEOM SERIES 1400

1. See Figure AR-1 for the TEOM Schematic.

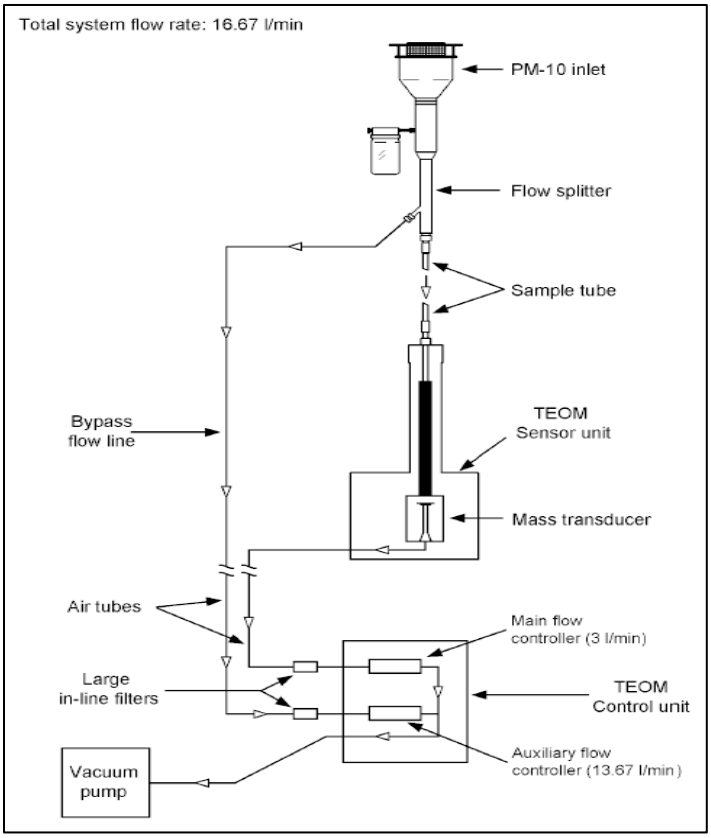
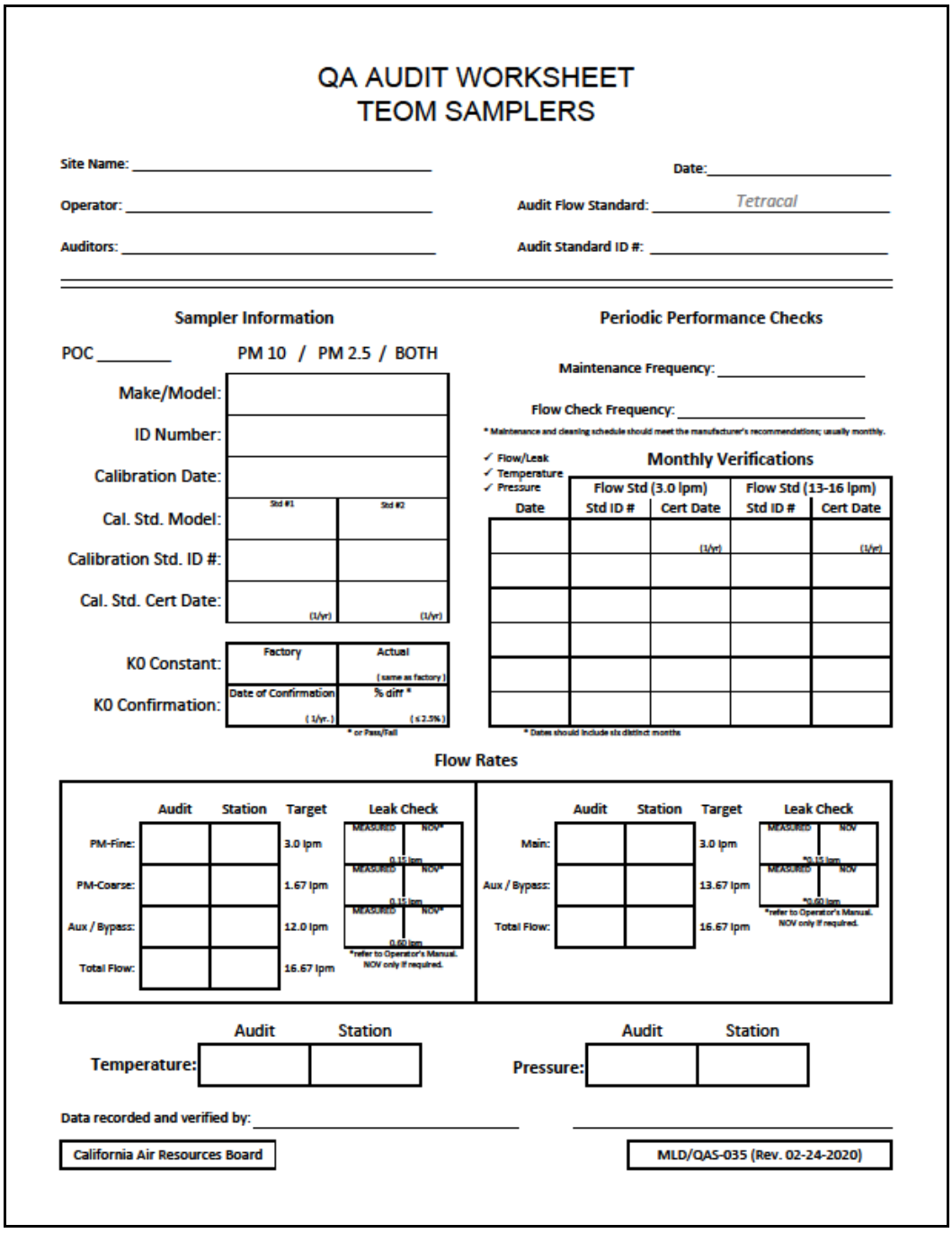


Figure AR-1. TEOM Schematic

2. Situate audit flow and temperature standards near the sampler inlet, avoiding placement in direct sunlight.

3. Start recording station and equipment information on TEOM Worksheet Sheet (Figure AR-2). Record for both the main and auxiliary flows.



QA AUDIT WORKSHEET
TEOM SAMPLERS

Site Name: _____ Date: _____

Operator: _____ Audit Flow Standard: Tetracal

Auditors: _____ Audit Standard ID #: _____

Sampler Information

POC _____ PM 10 / PM 2.5 / BOTH

Make/Model:		
ID Number:		
Calibration Date:		
Cal. Std. Model:	Std #1	Std #2
Calibration Std. ID #:		
Cal. Std. Cert Date:	(1/yr)	(1/yr)

K0 Constant:	Factory	Actual (same as factory)
K0 Confirmation:	Date of Confirmation (1/yr.)	% diff * (≤2.5%)

* or Pass/Fail

Periodic Performance Checks

Maintenance Frequency: _____

Flow Check Frequency: _____

* Maintenance and cleaning schedule should meet the manufacturer's recommendations; usually monthly.

✓ Flow/Leak
✓ Temperature
✓ Pressure

Monthly Verifications

Date	Flow Std (3.0 lpm) Std ID #	Flow Std (3.0 lpm) Cert Date	Flow Std (13-16 lpm) Std ID #	Flow Std (13-16 lpm) Cert Date
		(1/yr)		(1/yr)

* Dates should include six distinct months

Flow Rates

	Audit	Station	Target	Leak Check MEASURED	Leak Check NOV*
PM-Fine:			3.0 lpm		
				0.15 lpm	
PM-Coarse:			1.67 lpm		
				0.15 lpm	
Aux / Bypass:			12.0 lpm		
				0.60 lpm	
Total Flow:			16.67 lpm		

*refer to Operator's Manual. NOV only if required.

	Audit	Station	Target	Leak Check MEASURED	Leak Check NOV
Main:			3.0 lpm		
				*0.15 lpm	
Aux / Bypass:			13.67 lpm		
				*0.60 lpm	
Total Flow:			16.67 lpm		

*refer to Operator's Manual. NOV only if required.

	Audit	Station
Temperature:		

	Audit	Station
Pressure:		

Data recorded and verified by: _____ _____

California Air Resources Board

MLD/QAS-035 (Rev. 02-24-2020)

Figure AR-2. TEOM Audit Worksheet

4. Verify with the operator that the TEOM is offline or that the data recorder is placed in maintenance/audit mode.

5. At the main control panel, request operator to press the <STEP SCREEN> key to bring up a Menu screen displaying LISTING OF SCREENS at the top. Four lines are displayed at a time.

6. Request the operator to proceed to the "K0 Confirmation" screen (Figure AR-3) by either scrolling with the up (<↑>) or down (<↓>) arrow keys <ENTER>, or by pressing the <1> <7> <ENTER> keys, and then scroll to reveal the Actual K0 and % Diff values.

K0 Confirm	209.44188
Filt Wght	0.07903
287.53182	209.44186
Audit K0	9683
Actual K0	9627
% Diff	0.58

Figure AR-3. TEOM 1400 series "K0 Confirmation" screen example.

7. Record the displayed Actual K0 value as the Factory K0 constant on the audit worksheet, and verify that it is identical to the K0 value listed near the mass transducer.

8. Obtain from the operator and record the date of K0 confirmation.

9. Record % Diff value on the audit worksheet.

10. Once equilibrated to the ambient conditions, turn on the audit flow and temperature standards and allow them to warm-up until the readings have stabilized.

11. Confirm with operator the location of the sampler's temperature sensor and placement of the audit temperature standard probe for collocation.

12. Read the BP and temperature values from the applicable standard(s) and record under Audit pressure and temperature on the audit worksheet.

13. Request operator to display SET TEMPS/ FLOWS screen (<1> <9> <ENTER> keys) on the sampler control panel.

14. Obtain the sampler ambient temperature "Amb Temp" and ambient pressure "Amb Pres" readings and record under Station temperature and pressure on the audit worksheet.

15. Request the operator to return to the Main screen and to scroll with the up (< ↑ >) or down (< ↓) arrow keys until the "Main Flow" (SAMPLE FLOW) and "Aux Flow" (BYPASS FLOW) lines are displayed. These values represent the actual volumetric flows as measured by the monitor's flow controllers (Figure AR- 4).

```
OK       4+    11%    NU      09:44
Main Flow                     3.00
Aux Flow                      13.66
---------<
```

Figure AR-4. TEOM 1400 series Main screen with flow rates displayed.

16. Record these values as Station Main and Aux/ Bypass on the audit worksheet. The sum of these two values is recorded as the Station Total Flow.

17. Remove PM10 sample inlet from the inlet tube. Install the flow audit adapter (Figure AR-5) onto the sampler inlet with the valve in the open position.

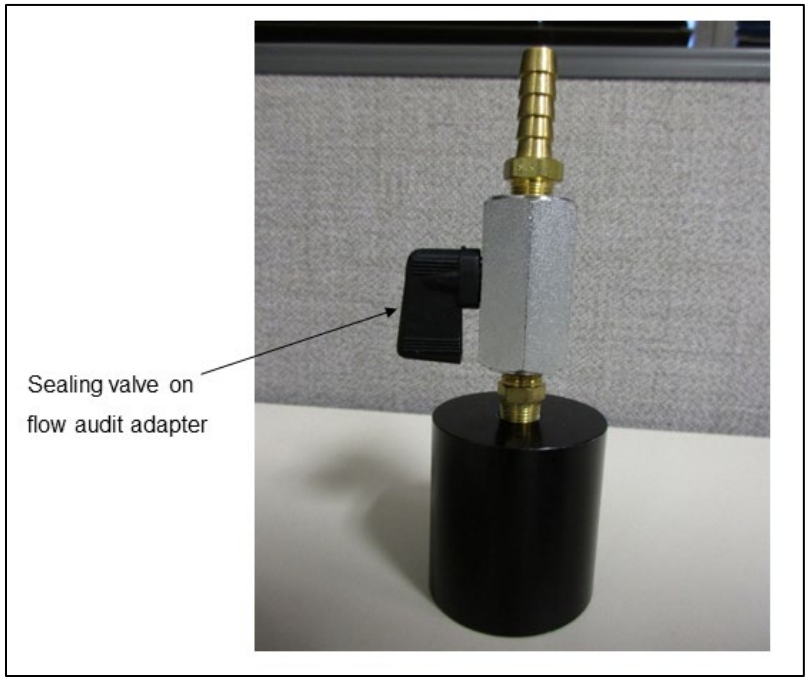


Figure AR-5. Flow audit adapter.

18. Request operator to power on the pump in order to draw a sample stream through the system and then remove the TEOM filter from the mass transducer.

19. Request operator to turn on the control unit.

20. Close the valve of the flow audit adapter.

21. From the sampler screen display (Figure AR-4), record the Main Flow and Aux Flow readings under Leak Check on the audit worksheet.

22. To determine the non-linearity offset value (NOV), slowly open the valve located on the flow audit adapter and power off the vacuum pump.

    IMPORTANT: Opening the sealing valve slowly reduces pressure buildup and the likelihood of dislodging particulate matter within the system's tubing. Failure to do so may damage the TEOM or cause inaccurate readings.

23. Wait 1 minute and observe the main flow and auxiliary flow readings. These are the NOVs for both the main flow and readings. Record these values on the audit worksheet.

24. Inform operator to replace the TEOM filter in the mass transducer.

25. Request the operator to press <F1> or <RUN> key.

26. From the display screen (Figure AR-4), observe flow rate readings.

27. Once the sampler flow readings have stabilized, attach the audit flow standard to the top of the flow audit adapter on the sampler inlet tube. Record the flow measurement as the Audit Total Flow on the audit worksheet.

28. Disconnect the green bypass flow line from the bypass extension on the bottom of the flow splitter (Figure AR-6).

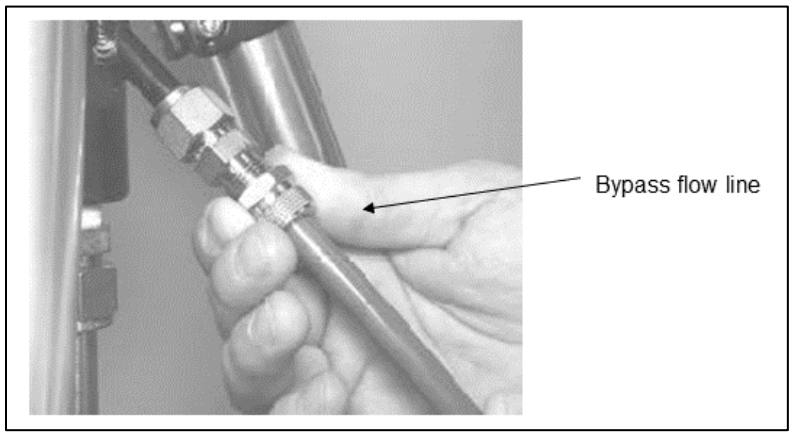


Figure AR-6. TEOM Bypass Flow Splitter Filter

29. Cap the exit of the flow splitter bypass extension with the 3/8" Swagelok cap (Figure AR-7).

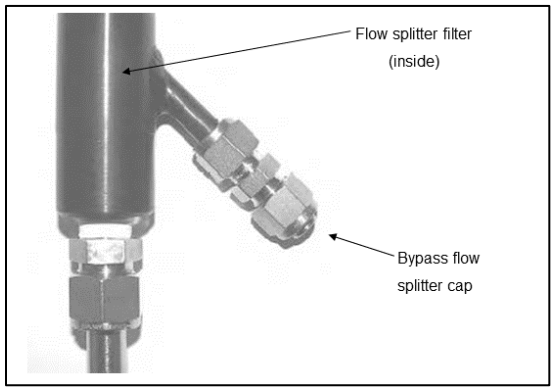


Figure AR-7. TEOM Flow Splitter and Cap

30. Connect the audit flow standard to the green bypass line using a Tygon tube.

31. Record the flow rate reading from the audit flow standard under Audit Aux/ Bypass on the audit worksheet.

32. With the Bypass still capped, measure the flow rate from the audit flow standard on the inlet tube and record as Audit Main on the audit worksheet.

33. Remove the 3/8" Swagelok cap from the flow splitter bypass extension and re-connect the bypass flow line onto the flow splitter bypass extension.

34. Return the sampler to the proper operational configuration.

35. Refer to Section AR.3.0 Post Audit Procedures.

AR.2.3 PERFORMING AN AUDIT ON A TEOM SERIES 1405

The TEOM Series 1405 (Figure AR-8) comes in four models providing one to three PM measurements: PM_{10}, $PM_{2.5}$ (Fine) and PM Coarse ($PM_{10-2.5}$). In addition to PM measurement capabilities, a Filter Dynamics Measurement System (FDMS) option can be added to account for the volatile and semi-volatile fraction. The Thermo Scientific models include: TEOM 1405 Ambient Particulate Monitor; TEOM 1405-F Ambient Particulate Monitor with FDMS; TEOM 1405-D Dichotomous Ambient Particulate Monitor; and TEOM 1405-DF Dichotomous Ambient Particulate Monitor with FDMS.

Figure AR-8. TEOM 1405 monitor.

1. Confirm with the operator the sampler model in operation.

2. Situate audit flow and temperature standards near the sampler inlet, avoiding placement in direct sunlight.

3. Start recording station and equipment information on TEOM Worksheet Sheet (Figure AR-2). Record for both the main and auxiliary flows.

4. Verify with the operator the TEOM is offline or that the data recorder is placed in maintenance/audit mode.

5. In the TEOM Data screen, request the operator to select the Service button to display the Service screen, then select the Verification button to display the Verification screen.

6. Request the operator to select the Instrument Audit button to display the Instrument Audit screen (Figure AR-9 for the 1405 Ambient and Figure AR-10 for the 1405-D Dichotomous Ambient).

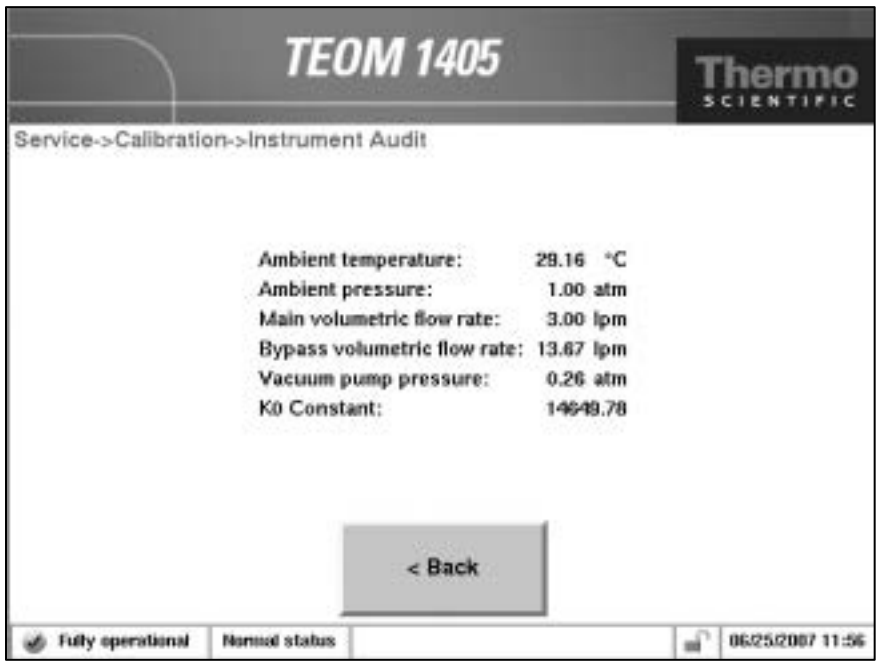


Figure AR-9. TEOM 1405 Ambient Instrument Audit Screen.

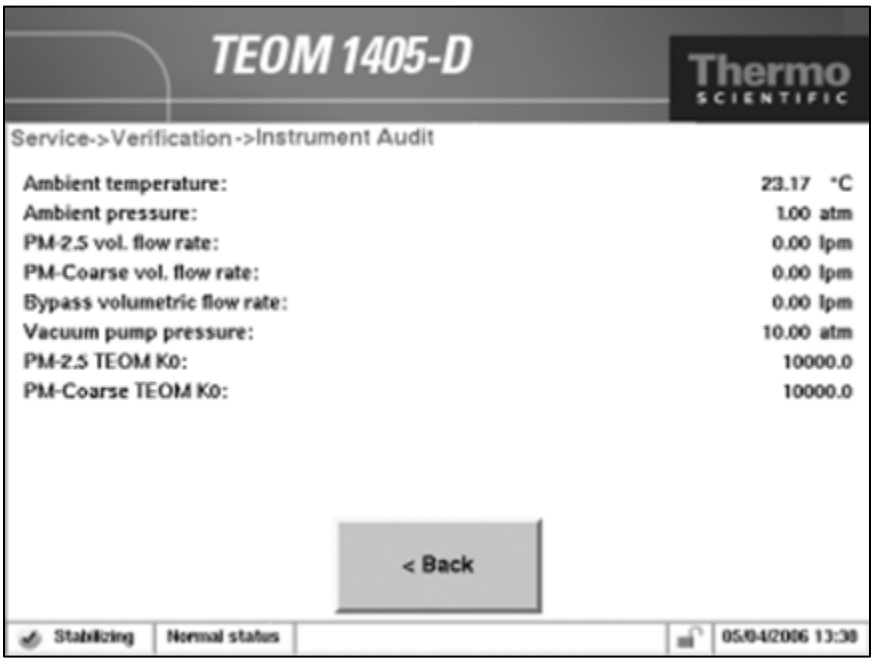


Figure AR-10. TEOM 1405-D Dichotomous Ambient Instrument Audit Screen.

7. Record the K0 Constant listed for the instrument onto the audit worksheet and verify that it is identical to the K0 Constant listed on the plate near the mass transducer.

8. Obtain from the operator and record the date of K0 confirmation.

9. With the 1405 model, record the Main volumetric flow rate and the Bypass volumetric flow rate values in the Station Main and Aux/ Bypass boxes, respectively, on the audit worksheet. The sum of these two values is recorded as the Station Total Flow.

10. With the 1405-D model, record the $PM_{2.5}$ vol. flow rate, the PM-Coarse vol. flow rate and the Bypass volumetric flow rate values in the Station PM-Fine, PM-Coarse and Aux/ Bypass boxes, respectively, on the audit worksheet. The sum of these three values is recorded as the Station Total Flow.

11. Once equilibrated to the ambient conditions, turn on the audit flow and temperature standards and allow them to warm-up until the readings have stabilized.

12. Confirm, with operator, the location of the sampler's temperature sensor and placement of the audit temperature standard probe for collocation.

13. Read the BP value from the flow standard and temperature value from the temperature standard and record under Audit Pressure and Temperature on the audit worksheet.

14. Obtain the sampler ambient temperature and ambient pressure readings listed on the Instrument Audit screen (Figure AR-9) and record under Station Temperature and Pressure on the audit worksheet.

15. Request the operator to return to the verification screen, then select the Leak Check Button for display of the Leak Check Wizard screen.

16. Request the operator to remove the TEOM filter from the transducer prior to selecting the Next button.

17. The Disconnect Vacuum Line screen will display.

18. Request the operator to remove the main vacuum line (pump) connected to the pump from the back of the unit (Figure AR-11) prior to selecting the Next > button.

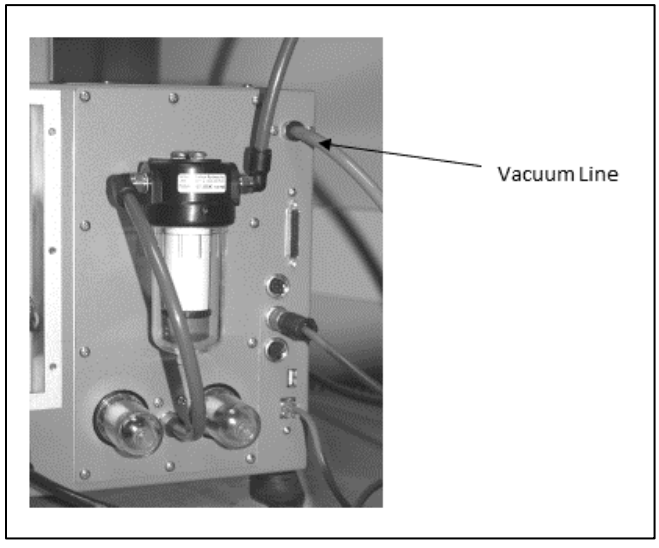


Figure AR-11. Back of TEOM

19. The Stabilizing screen will display. Allow 1 minute for the flows to stabilize before requesting the operator to select the Next > button.

20. The Reconnect Vacuum Line screen will display.

21. Request operator to reinstall the pump/ vacuum tubing into the back of the unit prior to selecting the Next > button.

22. The Remove Inlet screen will display.

23. Request operator to remove the PM_{10} inlet prior to selecting the Next > button.

24. The Attach Audit Adapter screen will display.

25. Attach the flow audit adapter (Figure AR-5) to the top of the sampler inlet and slowly close the valve. Request the operator to select the Next > button.

26. The Stabilizing screen will display. Allow 1 minute for the flows to stabilize before recording these as the Leak Check Main and Aux/ Bypass values onto the audit worksheet.

27. Slowly open the valve on the flow audit adapter to restore flow to the system.

    IMPORTANT: Opening the sealing valve slowly reduces pressure buildup and the likelihood of dislodging particulate matter within the system's tubing. Failure to do so may damage the TEOM or cause inaccurate readings.

28. Request the operator to select the Next > button.

29. The Completing the Leak Check Wizard screen will display. If the leak check passes, a "You have successfully completed the Leak Check" message will appear. No matter the leak check result, proceed with the remaining steps.

30. Inform the operator to install a new TEOM filter in the mass transducer.

31. The flow audit depends on the sampler model in operation. Proceed to the applicable steps.

32. 1405 Ambient flow audit:

    i. Once the sampler flow readings have stabilized, attach the audit flow standard to the top of the flow audit adapter on the sampler

inlet tube. Record the flow measurement as the Audit Total Flow on the audit worksheet.

ii. Disconnect the green bypass flow line from the bypass extension on the bottom of the flow splitter (Figure AR-6).

iii. Cap the exit of the flow splitter bypass extension with the 3/8" Swagelok cap (Figure AR-7).

iv. Connect the audit flow standard to the green bypass line using a Tygon tube.

v. Record the flow rate reading from the audit flow standard under Audit Aux/ Bypass on the audit worksheet.

vi. With the Bypass still capped, measure the flow rate from the audit flow standard on the inlet tube and record as Audit Main on the audit worksheet.

33. 1405-D Dichotomous Ambient flow audit (see Figure AR-12 for identification of sample lines).

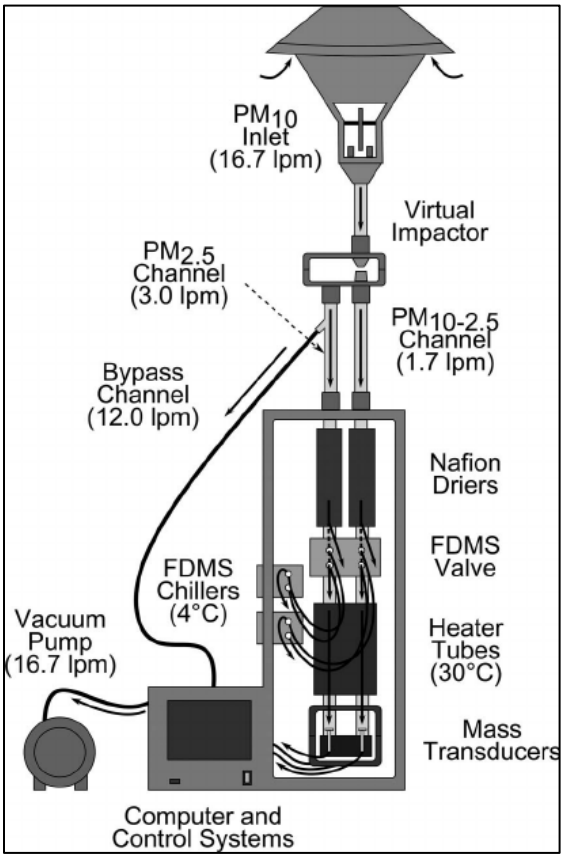


Figure AR-12. TEOM-1405D Schematic

i. Once the sampler flow readings have stabilized, attach the audit flow standard to the top of the flow audit adapter on the sampler inlet tube. Record the flow measurement as the Audit Total Flow on the audit worksheet.

ii. Disconnect the green bypass flow line from the bypass extension on the bottom of the flow splitter.

iii. Cap the exit of the flow splitter bypass extension with the 3/8" Swagelok cap.

iv. Connect the flow audit standard to the green bypass line using a Tygon tube.

v. Record the flow rate reading from the audit flow standard under Audit Aux/ Bypass on the audit worksheet.

vi. With the Bypass still capped, request the operator to carefully remove the virtual impactor.

vii. Attach the flow audit adapter to the $PM_{2.5}$ sample tube. Using a Tygon tube attach the audit flow standard to the flow audit adapter. Record the flow rate reading under Audit PM-Fine on the on the audit worksheet.

viii. Attach a Tygon tube from the audit flow standard to the $PM_{10-2.5}$ sample tube. Check with operator for an adapter that can facilitate this connection. Record the flow rate reading under Audit PM- Coarse on the on the audit worksheet.

34. Remove the 3/8" Swagelok cap from the flow splitter bypass extension and re-connect the bypass flow line onto the flow splitter bypass extension.

35. Return the sampler to the proper operational configuration.

36. Refer to Section AR.3.0 Post Audit Procedures.

AR.2.4 PERFORMING AN AUDIT ON A MET ONE BAM 1020

1. See Figure AR-13 for illustration of the BAM 1020.

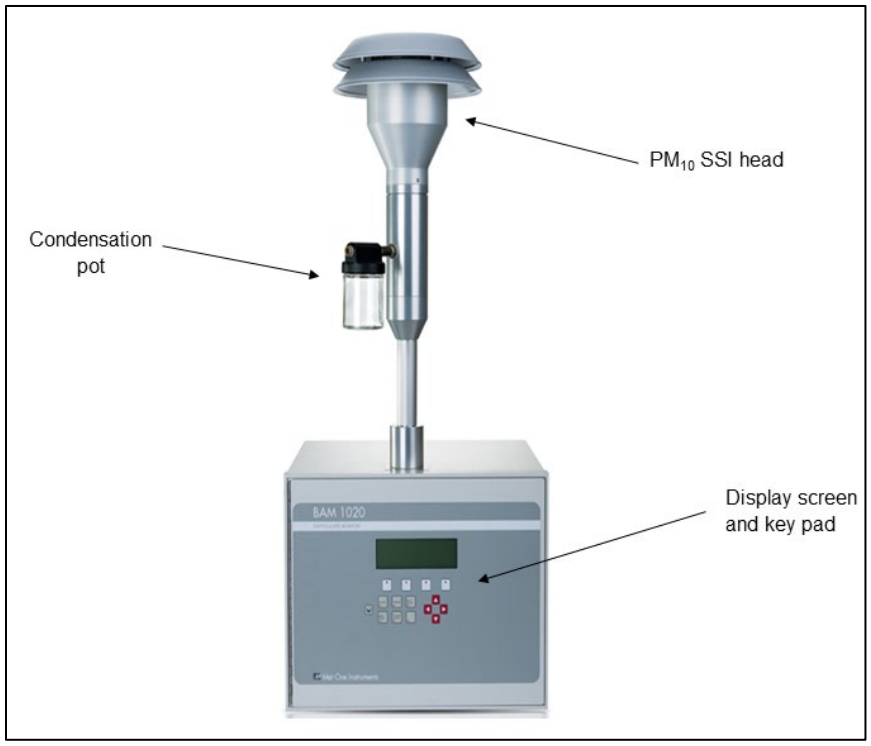
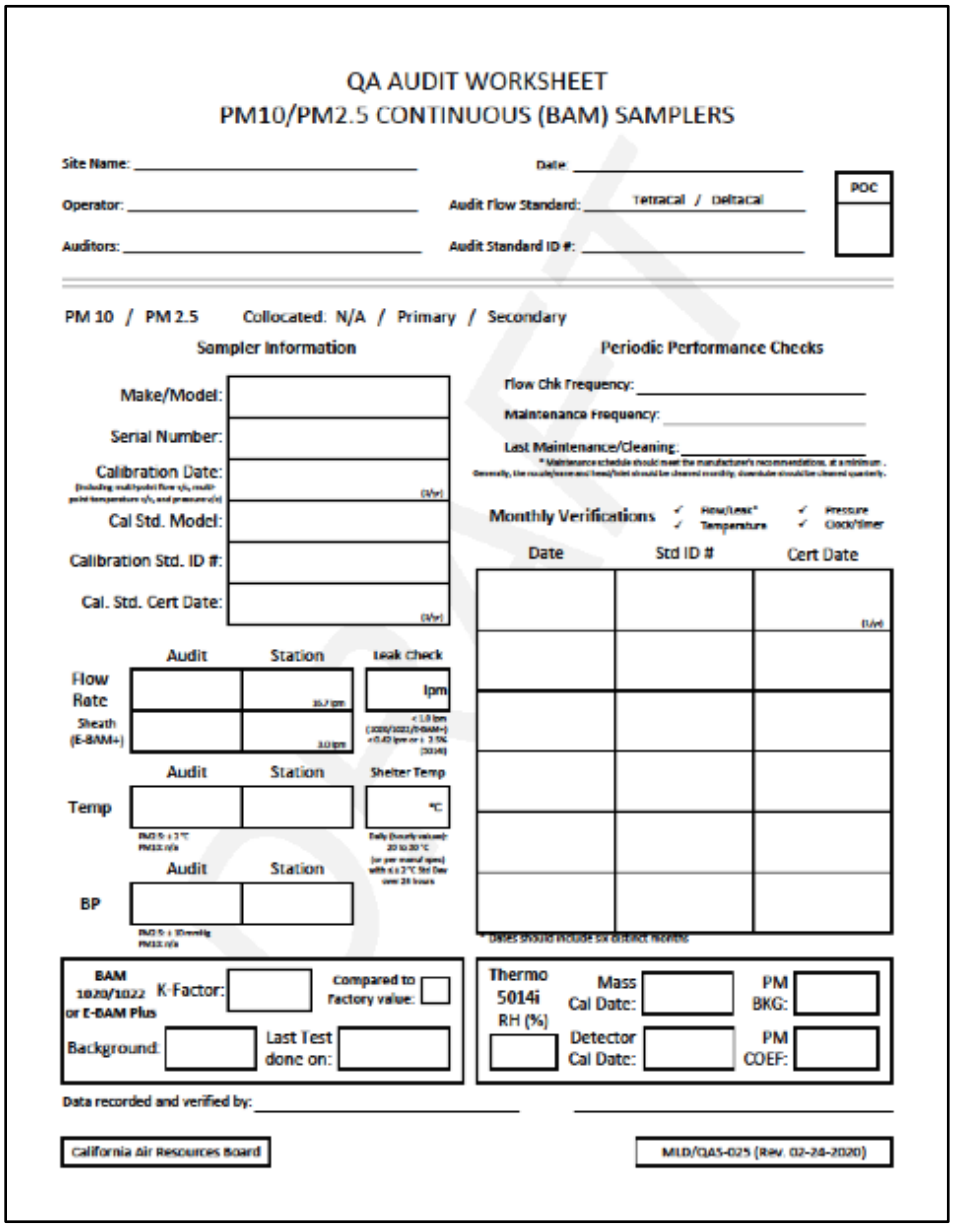


Figure AR-13. Met One BAM 1020

2. Situate audit flow and temperature standards near the sampler inlet, avoiding placement in direct sunlight.

3. Begin recording station and equipment information data on the BAM Audit Worksheet (Figure AR-14).



QA AUDIT WORKSHEET
PM10/PM2.5 CONTINUOUS (BAM) SAMPLERS

Site Name: _____ Date: _____

Operator: _____ Audit Flow Standard: Tetracal / Deltacal

Auditors: _____ Audit Standard ID #: _____

POC

PM 10 / PM 2.5 Collocated: N/A / Primary / Secondary

Sampler Information

Make/Model:
Serial Number:
Calibration Date:
Cal Std. Model:
Calibration Std. ID #:
Cal. Std. Cert Date:

Periodic Performance Checks

Flow Chk Frequency: _____
Maintenance Frequency: _____
Last Maintenance/Cleaning: _____

Monthly Verifications ✓ Flow/Leak* ✓ Pressure ✓ Temperature ✓ Clock/timer

Date	Std ID #	Cert Date

	Audit	Station	Leak Check
Flow Rate			lpm
Sheath (E-BAM+)			

	Audit	Station	Shelter Temp
Temp			°C

	Audit	Station
BP		

BAM 1020/1022 or E-BAM Plus K-Factor: _____ Compared to factory value: ☐
Background: _____ Last Test done on: _____

Thermo 5014i RH (%): _____ Mass Cal Date: _____ PM BKG: _____ Detector Cal Date: _____ PM COEF: _____

Data recorded and verified by: _____

California Air Resources Board

MLD/QAS-025 (Rev. 02-28-2020)

Figure AR-14. BAM Audit Worksheet

4. Verify with the operator that the BAM 1020 is offline or that the data recorder is placed in maintenance/audit mode.

5. When the sampler is running, "OPERATE MODE" appears at the top of the display screen on the sampler (Figure AR-15).

Figure AR-15. Met One BAM 1020 Operate Mode Screen

6. Request the operator to navigate the display panel to the SETUP screen and enter a password (default F1F2F3F4) for display of the CALIBRATE SETUP screen.

   NOTE: The current measurement cycle (if in progress) will stop.

7. Record the displayed K-Factor and BKGD values on the audit worksheet.

8. Verify that this K-Factor value is identical to the factory value, which can be found on the original factory certification provided with the sampler, and should be available at the site.

9. Record the background coefficient on the BAM worksheet. Obtain the date and result of the most recent Background Check from the station operator. This result should match the recorded value.

10. Request operator to start the measurement cycle.

11. Once equilibrated to the ambient conditions, turn on the audit flow and temperature standards and allow them to warm-up until the readings have stabilized.

12. Remove the PM_{10} SSI head from the sample tube and connect the audit flow standard onto the inlet tube. If present, the $PM_{2.5}$ cyclone is to remain in place.

13. Record the Audit Flow Rate and BP values from the audit flow standard on the BAM Audit Worksheet.

14. Remove the audit flow standard from the inlet.

15. Confirm, with operator, the location of the sampler's temperature sensor and placement of the audit temperature standard probe for collocation.

16. Record the audit temperature value from the temperature standard onto the BAM Audit Worksheet.

17. Request the operator to display the sampler TEST> FLOW menu screen.

18. Request the operator to choose the 16.7 LPM flow option.

19. Under the BAM column, obtain and record the AT, BP and Flow values as the Station Temp, BP and Flow Rate, respectively, on the audit worksheet

20. Request the operator to navigate the display panel to the TEST>PUMP menu to perform a leak check.

21. Install the flow audit adapter (Figure AR-5) onto the inlet with the valve in the open position. If present, the $PM_{2.5}$ cyclone is to remain in place.

22. Request the operator to turn on the pump under the pump mode menu.

23. Allow sufficient time for the flow to stabilize. This time will vary depending on current ambient conditions. Proceed once the sampler flow has stabilized at more than 16 LPM.

24. Close the sealing valve on the flow audit adapter (Figure AR-5) to create a vacuum in the sampling line. The sampler flow rate is expected to drop to 1.5 LPM or less.

25. Regardless of where the reading stabilizes, record the sampler flow rate value under Leak Check on the BAM Audit Worksheet. Should the readings not completely stabilize, record an estimated average of the readings observed.

26. Slowly open the sealing valve on the flow audit adapter (Figure AR-5). Allow the sampler flow reading to stabilize before requesting the pump to be turned off.

27. Request operator to perform the Tape Self Test procedure.

28. Return the sampler to the proper operational configuration.

29. Refer to Section AR.3.0 for Post Audit Procedures.

AR.2.5 PERFORMING AN AUDIT ON A MET ONE BAM 1020 WITH TOUCH SCREEN OPTION

The BAM 1020 can be configured with a touch screen display as an optional front door assembly. The display with the main menu is shown in Figure AR-16.

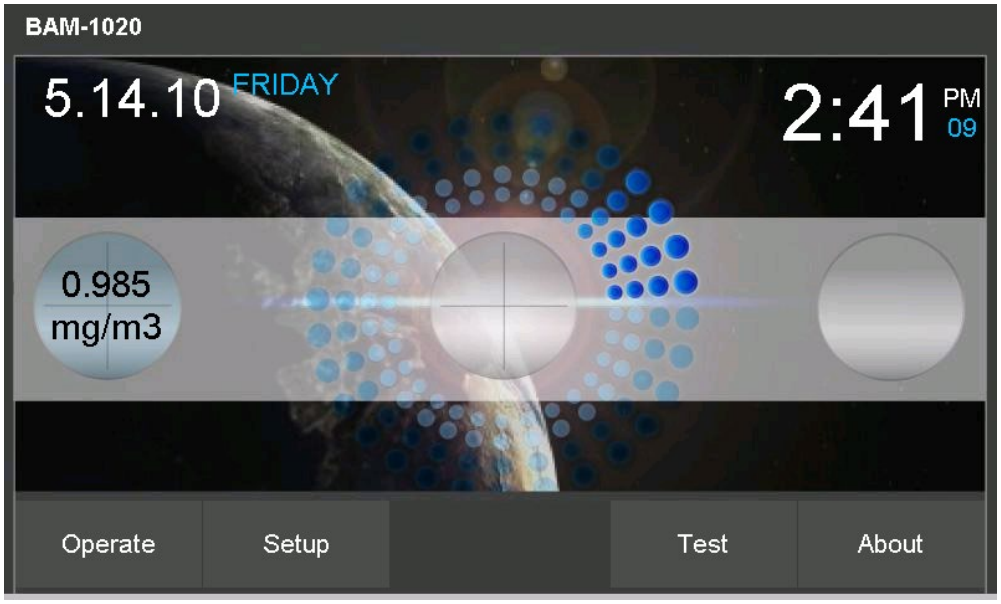


Figure AR-16. Met One BAM 1020 Touch Screen Display

1. Situate audit flow and temperature standards near the sampler inlet, avoiding placement in direct sunlight.

2. Begin recording station and equipment information data on the BAM Audit Worksheet (Figure AR-14).

3. Verify with the operator that the BAM 1020 is offline or that the data recorder is placed in maintenance/audit mode.

4. Request the operator to press the Setup button on the main menu and enter a password (default 1234) for display of the Settings Menu as shown in Figure AR-17.

   NOTE: After password entry, a warning should appear indicating that the current measurement cycle (if in progress) will stop.

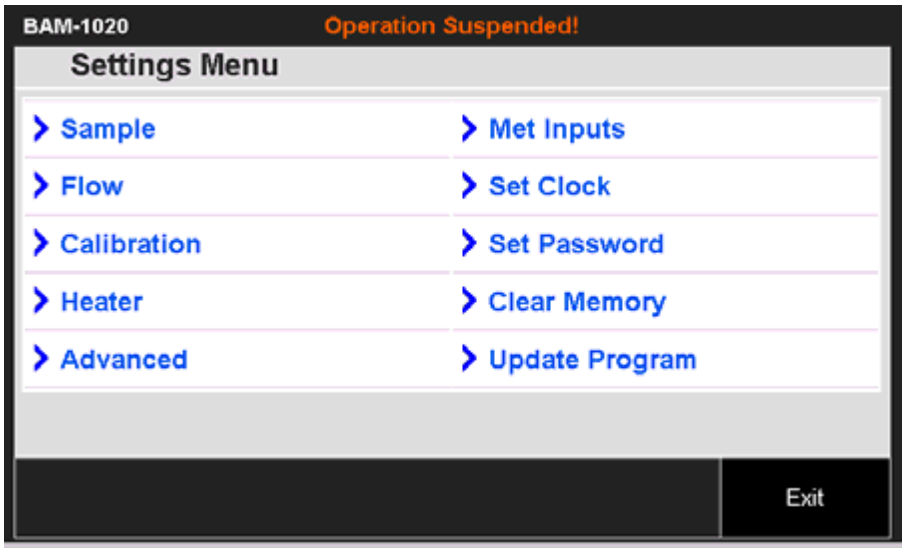


Figure AR-17. BAM 1020 Touch Screen Settings Menu

5. Request the operator to select the Calibration option for display of the Calibration screen (Figure AR-18).

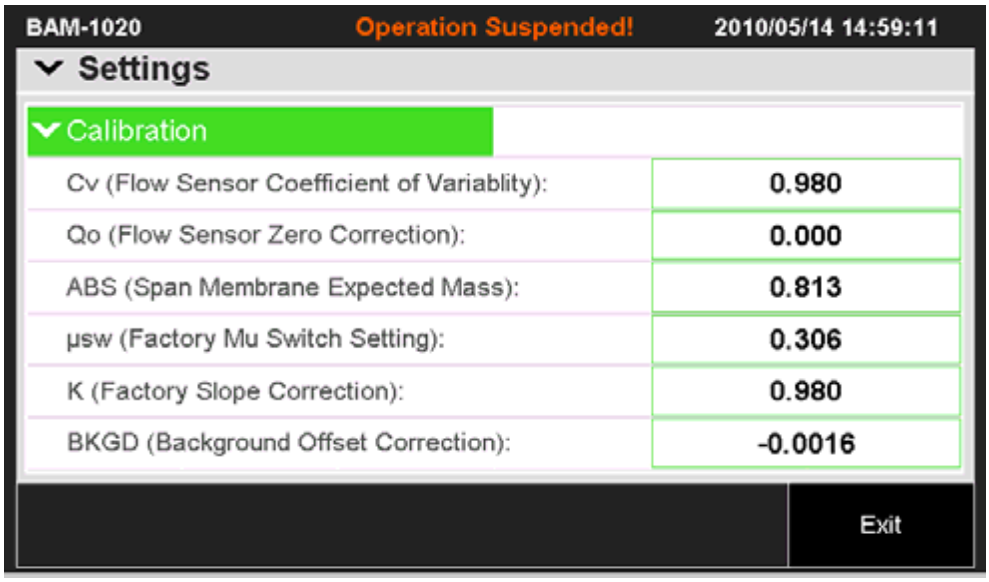


Figure AR-18. BAM 1020 Touch Screen Calibration Menu

6. Record the displayed K-Factor and BKGD values on the audit worksheet.

7. Verify that this K-Factor value is identical to the factory value, which can be found on the original factory certification provided with the sampler, and should be available at the site.

8. Record the Background coefficient on the BAM worksheet. Obtain the date and result of the most recent Background Check from the station operator. This result should match the recorded value.

9. Request operator to start the measurement cycle.

10. Once equilibrated to the ambient conditions, turn on the audit flow and temperature standards and allow them to warm-up until the readings have stabilized.

11. Remove the PM_{10} SSI head from the sample tube and connect the audit flow standard onto the inlet tube. If present, the $PM_{2.5}$ cyclone is to remain in place.

12. Record the Audit Flow Rate and BP values from the audit flow standard on the BAM Audit Worksheet.

13. Remove the audit flow standard from the inlet.

14. Confirm, with operator, the location of the sampler's temperature sensor and placement of the audit temperature standard probe for collocation.

15. Record the audit temperature value from the temperature standard onto the BAM Audit Worksheet.

16. Request the operator to press the Test button on the main menu for display of the Flow Checks screen as shown in Figure AR-19.

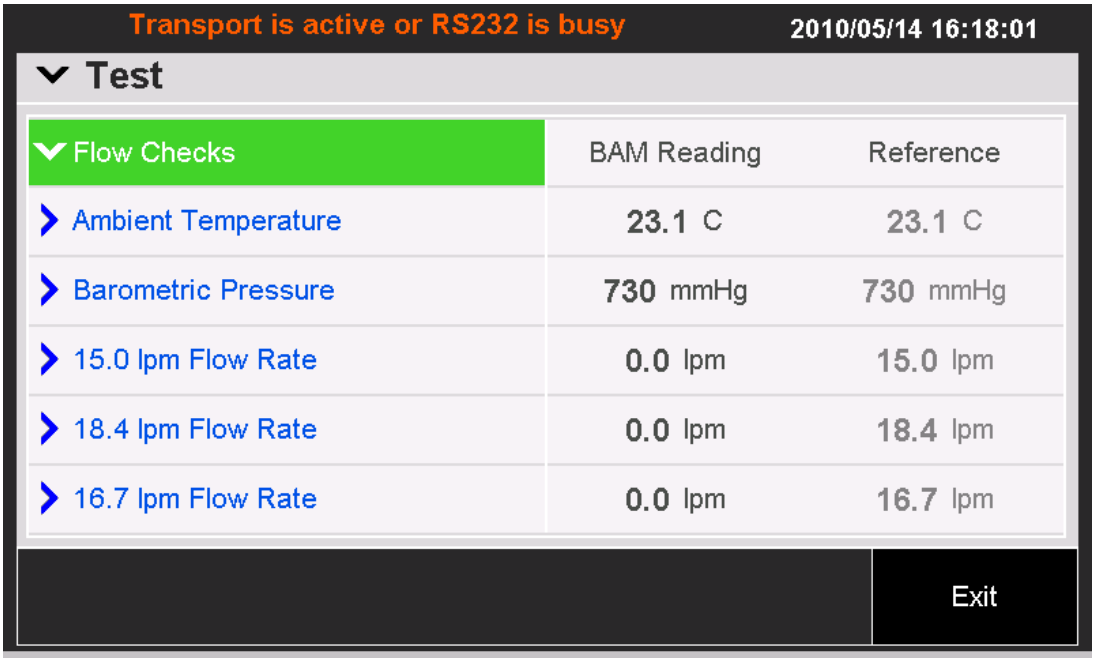


Figure AR-19. BAM 1020 Touch Screen Flow Checks Menu

17. Record, from the BAM Reading column, the Ambient Temperature, Barometric Pressure and 16.7 values as the Station Temp, BP and Flow Rate, respectively, on the audit worksheet

18. Request the operator to navigate the display panel to the Test>Leak Check menu (Figure AR-20) to perform a leak check.

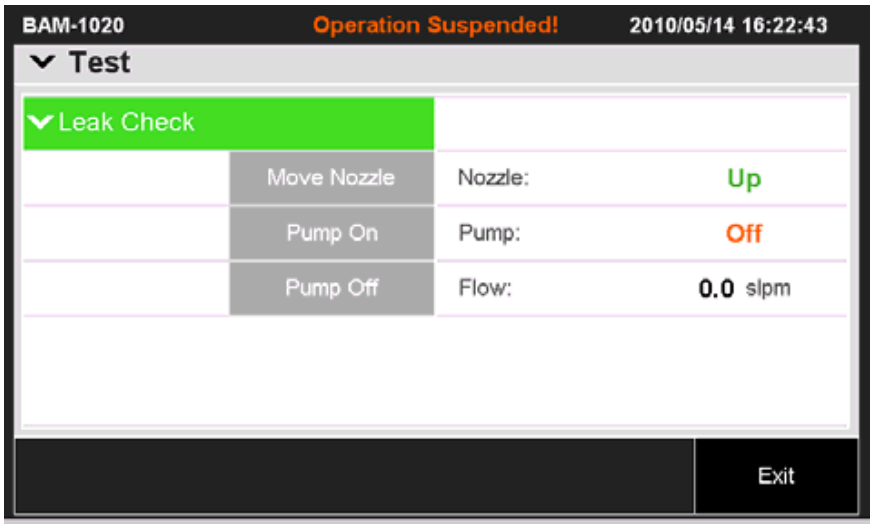


Figure AR-20. AM 1020 Touch Screen Leak Check Menu

19. Install the flow audit adapter (Figure AR-5) onto the inlet with the valve in the open position. If present, the $PM_{2.5}$ cyclone is to remain in place.

20. Request the operator to press the Pump On button on the display.

21. Allow sufficient time for the flow to stabilize. This time will vary depending on current ambient conditions. Proceed once the sampler flow has stabilized at more than 16 LPM.

22. Close the sealing valve on the flow audit adapter (Figure AR-5) to create a vacuum in the sampling line. The sampler flow rate is expected to drop to 1.5 LPM or less.

23. Regardless of where the reading stabilizes, record the Flow value under Leak Check on the BAM Audit Worksheet. Should the readings not completely stabilize, record an estimated average of the readings observed.

24. Slowly open the sealing valve on the flow audit adapter (Figure AR-5). Allow the sampler flow reading to stabilize before requesting the pump to be turned off.

25. Request operator to perform the Tape Self Test procedure.

26. Return the sampler to the proper operational configuration.

27. Refer to Section AR.3.0 for Post Audit Procedures.

AR.2.6 PERFORMING AN AUDIT ON A MET ONE BAM 1022

1. See Figure AR-21 for an illustration of the BAM 1022.

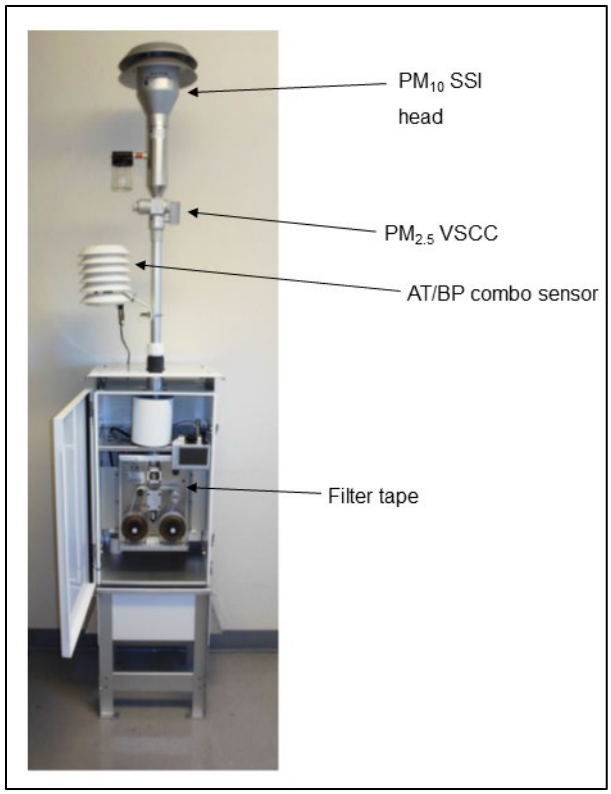


Figure AR-21. Met One BAM 1022

2. Situate audit flow and temperature standards near the sampler inlet, avoiding placement in direct sunlight.

3. Begin recording station and equipment information data on the BAM Audit Worksheet (Figure AR-14)

4. Verify with the operator that the BAM 1022 is offline or that the data recorder is placed in maintenance/audit mode.

5. With the touch screen display, the various main menus are accessed by pressing the three horizontal lines in the top left corner.

6. Request the operator to proceed to the Setup Menu on the display screen. The next screen will display Warning! and Stop current sample? (Figure AR-22).

Figure AR-22. BAM 1022 Stop Operation Screen

7. Request the operator to press the STOP button in the lower left corner of the screen

8. The Setup Menu will display as shown in Figure AR-23. Request the operator to press Background to obtain the coefficient (Figure AR-24)

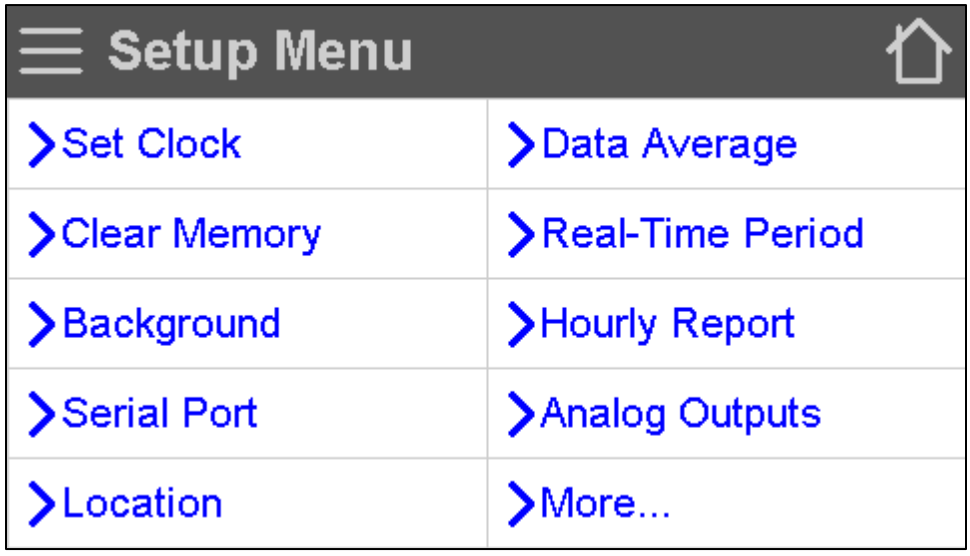


Figure AR-23. BAM 1022 Setup Menu Screen

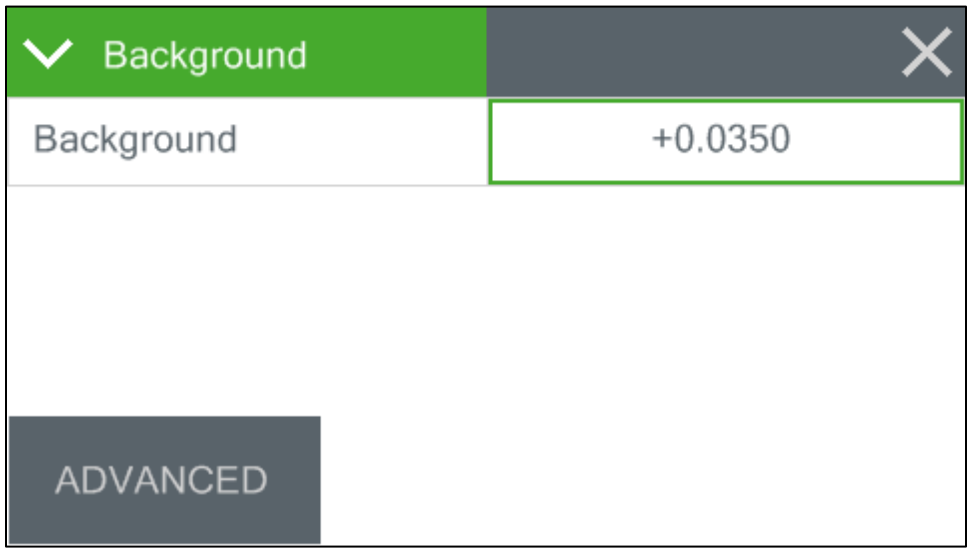


Figure AR-24. BAM 1022 Background Screen

9. Record the Background coefficient on the BAM worksheet. Obtain the date and result of the most recent Background Check from the station operator. This result should match the recorded value.

10. Request the operator to press the ADVANCED button at the bottom of the screen to proceed with obtaining the K-Factor. The following screen, Figure AR-25, will appear.

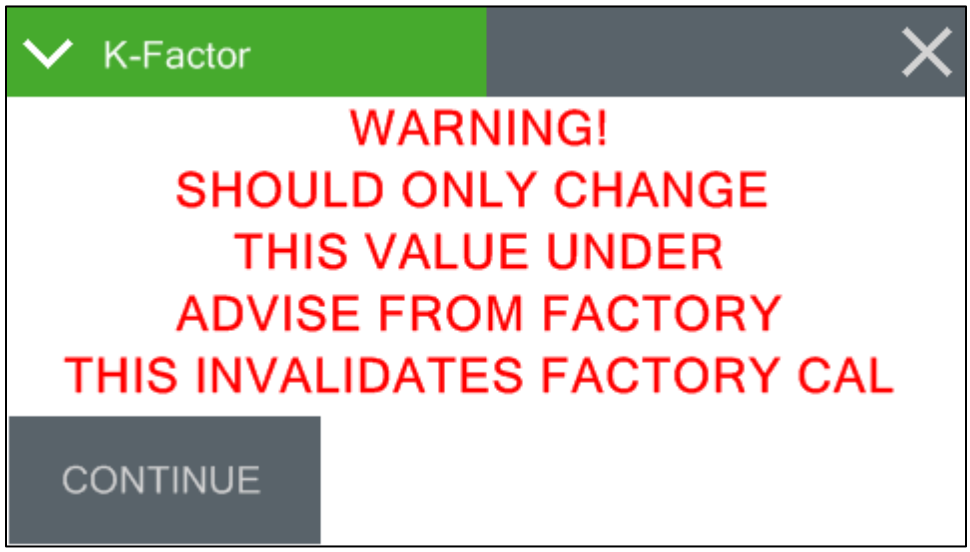


Figure AR-25. BAM 1022 K-Factor Warning

11. Request the operator to press the CONTINUE button for display of the K-Factor (Figure AR-26).

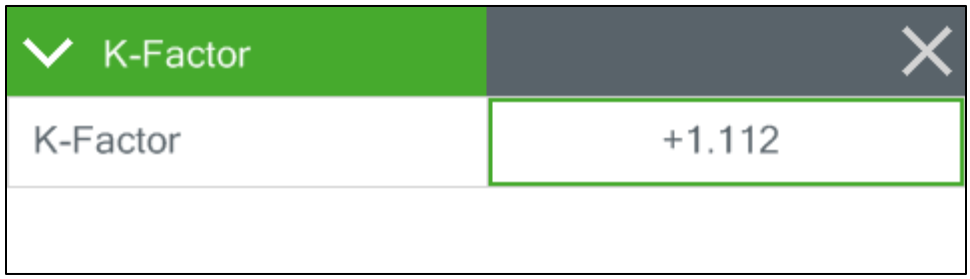


Figure AR-26. BAM 1022 K-Factor Screen

12. Record the K-Factor on the BAM Audit Worksheet (Figure AR-14). Verify that this K-Factor value is identical to the factory value, which can be found on the original factory certification provided with the sampler and should be available at the site.

13. Request operator to start the measurement cycle.

14. Once equilibrated to the ambient conditions, turn on the audit flow and temperature standards and allow them to warm-up until the readings have stabilized.

15. Remove the PM_{10} SSI head from the sample tube, and connect the audit flow standard onto the inlet tube. If present, the $PM_{2.5}$ cyclone is to remain in place.

16. Record the Audit Flow Rate and BP values from the audit flow standard on the BAM Audit Worksheet.

17. Remove the audit flow standard from the inlet.

18. Confirm, with operator, the location of the sampler's temperature sensor and placement of the audit temperature standard probe for collocation.

19. Record the audit temperature value from the temperature standard onto the BAM Audit Worksheet.

20. Request the operator proceed to the temperature and pressure menu on the sampler display.

21. Access one menu and then the other to obtain and record the Station AT and BP values in the appropriate location on the BAM Audit Worksheet (Figure AR-14).

22. Request the operator to return to the main operating screen on the display (Figure AR-27) to obtain and record the Station flow rate onto the BAM Audit Worksheet.

Figure AR-27. BAM 1022 Main Operating Screen

23. Install the flow audit adapter (Figure AR-5) onto the sampler inlet with the valve in the open position. If present, the $PM_{2.5}$ cyclone is to remain in place.

24. Request the operator to navigate to the TEST>LEAK TEST menu.

25. Request the operator to press the PUMP ON button in order to draw a vacuum on the sampling system.

26. Monitor the flow rate on the BAM 1022 display, and allow it to stabilize at 16.7 LPM.

27. Request the operator to press the LEAK ON button.

28. Close the valve on the flow audit adapter.

29. Monitor the sampler flow rate, which is expected to drop to 1.5 LPM or less.

30. Regardless of where the reading stabilizes, record the sampler flow rate value under Leak Check on the BAM Audit Worksheet. Should the readings not completely stabilize, record an estimated average of the readings observed.

31. Request the operator to exit to main menu.

32. Slowly open the flow audit adapter valve to release the vacuum.

33. Return the sampler to the proper operational configuration.

34. Request operator to perform the "Self Tape Test" procedure.

35. Refer to Section AR.3.0 for Post Audit Procedures.

AR.2.7 PERFORMING AN AUDIT ON A MET ONE E-BAM PLUS

1. See Figure AR-28 for illustration of the E-BAM Plus.

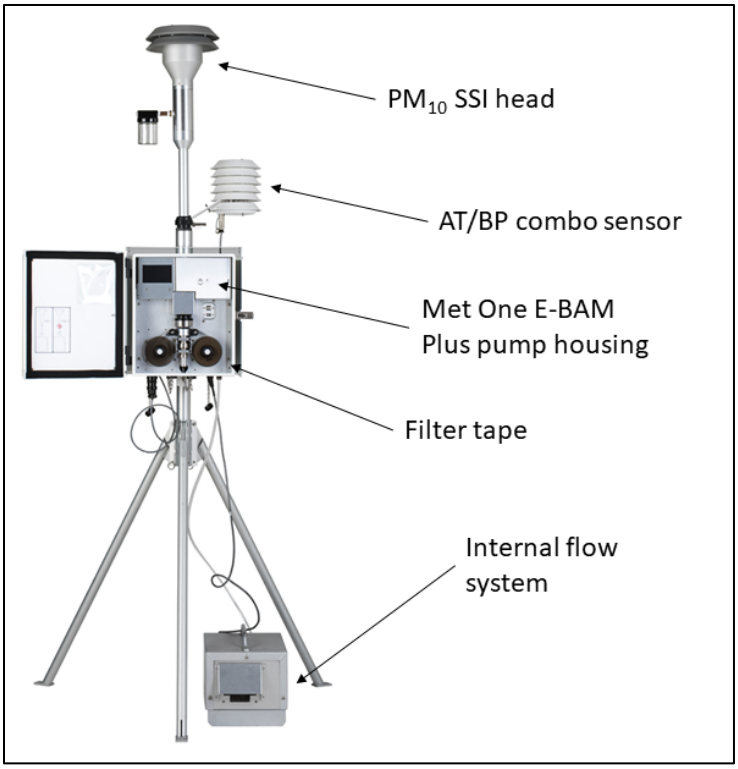


Figure AR-28. Met One E-BAM Plus

2. Situate audit flow and temperature standards near the sampler inlet, avoiding placement in direct sunlight.

3. Begin recording station and equipment information data on the BAM audit worksheet (Figure AR-14).

4. Verify with the operator that the E-BAM Plus is offline or that the data recorder is placed in maintenance/audit mode.

5. The leak, AT, and BP checks must be completed prior to perform a flow test.

6. Remove the PM_{10} SSI head from the sample tube, and install the flow audit adapter (Figure AR-5) with the valve in the closed position.

7. If there is a $PM_{2.5}$ VSCC present, it should be left in place and included in the leak and flow checks. Request operator to navigate to the LEAK TEST menu on the display screen.

8. Request operator to remove the internal flow system cover to expose the various flow filters and sheath air pre-filter inlet (See Figure AR-29 and Figure AR-30).

Figure AR-29. Met One E-BAM Plus Internal Flow System Cover

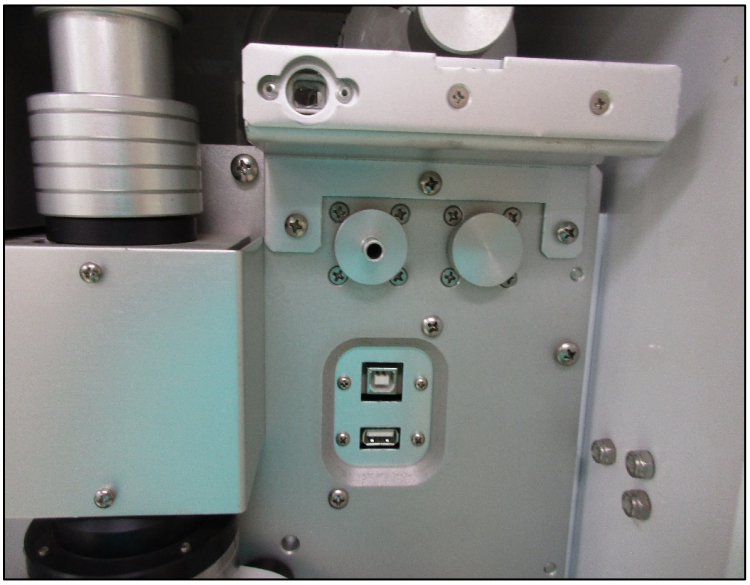


Figure AR-30. Met One E-BAM Plus Internal Flow System Cover Removal

9. Confirm with the operator that the vane is in the up position.

10. Cover the sheath air pre-filter inlet fitting as shown in Figure AR-31.

Figure AR-31. Met One E-BAM Plus Covering of Sheath Air Pre-Filter Inlet

11. Request operator to turn on the pump from the display screen, to begin drawing a vacuum on the sampling system.

12. Monitor the flow rate on the E-BAM PLUS display. It will initially rise and then, as the sampling system is evacuated, it will drop.

13. The displayed flow rate is expected to drop below 1.0 LPM. Regardless of where the reading stabilizes, record the value onto the Audit Worksheet. Should the readings not completely stabilize, record an estimated average of the readings observed.

14. Inform operator to shut off the pump.

15. Remove the flow audit adapter from the sampler.

16. Once equilibrated to the ambient conditions, power on the audit flow standard.

17. Record the pressure measurement from the audit flow standard as the Audit BP onto the audit worksheet.

18. Confirm, with operator, the location of the sampler temperature probe and placement of the audit temperature standard probe for collocation.

19. Record the measurement from the temperature standard as the Audit Temp onto the Audit Worksheet.

20. Request operator to navigate to the Ambient Temperature display screen.

21. Record the value from the sampler display screen as the Station Temp onto the Audit Worksheet.

22. Request operator to navigate to the Ambient Pressure display screen.

23. Record the value from sampler display screen as the Station BP onto the Audit Worksheet.

24. Request the operator to navigate the display panel to the Background screen (Figure AR-32). Record the Background coefficient on the BAM worksheet, and note the completed on date for the Background check. That date should be provided by the station operator.

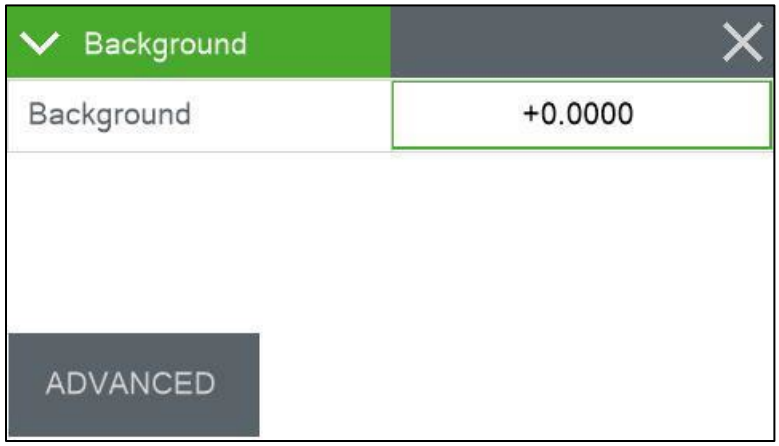


Figure AR-32. Met One E-BAM Plus Background Screen

25. Request the operator to press the ADVANCED button for display of the K-Factor. Record this value onto the Audit Worksheet, and verify that it is identical to the factory value.

26. Request the operator to stop the current sample, and navigate to the Flow Calibrate display screen.

27. Request the operator to press the CONTINUE key to turn on the pump.

28. Install the adapter tubing to the sheath air pre-filter inlet and to the flow audit adapter (Figure AR-33).

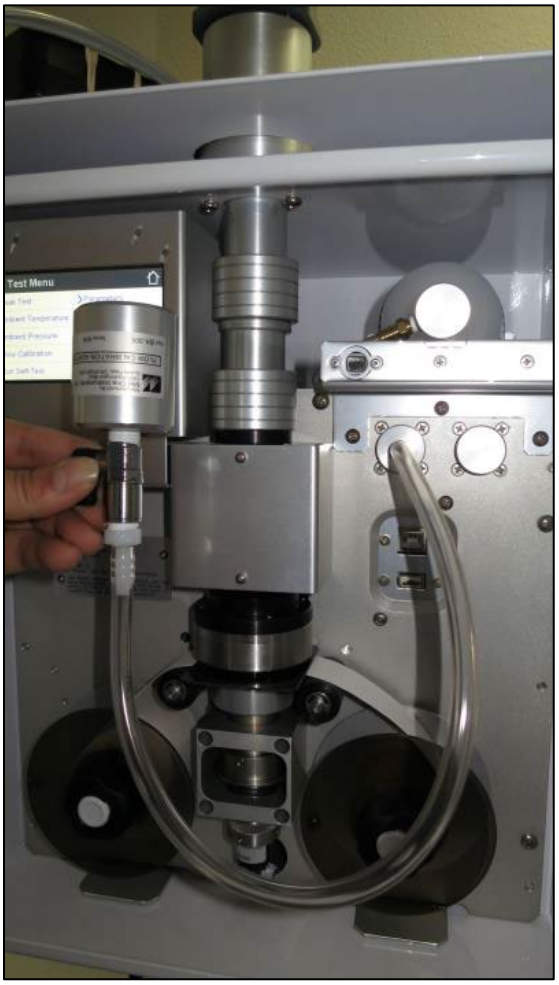


Figure AR-33. Met One E-BAM Plus Installation of Adapter Tubing

29. Connect the audit flow standard and flow audit adapter as shown in Figure AR-34.

Figure AR-34. Met One E-BAM Plus Installation of Flow Audit Adapter and Audit Flow Standard

30. Request operator to navigate through the sampler menu to display the Flow Audit screen (Figure AR-35).

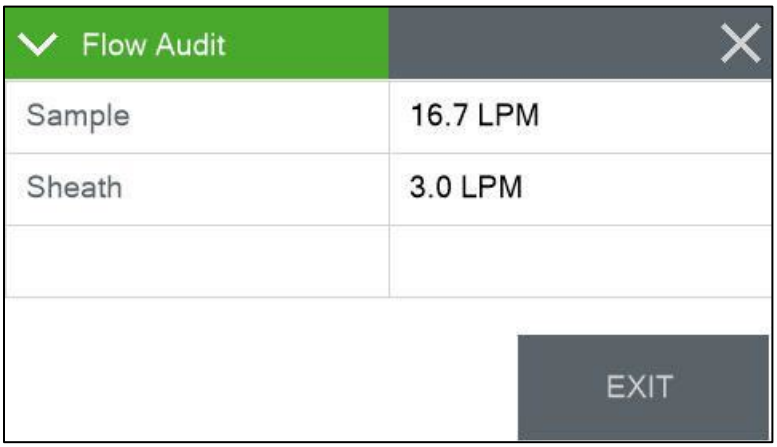


Figure AR-35. Met One E-BAM Plus Flow Audit Screen

31. Record the Sheath flow rate value from the sampler display screen and the flow rate value from the flow audit standard onto the Audit Worksheet.

32. Disconnect the audit equipment from the sheath air pre-filter inlet.

33. Remove the PM_{10} SSI head from the sample tube and replace with the flow audit standard as shown in Figure AR-36.

Figure AR-36. Met One E-BAM Plus Installation of Audit Flow Standard on Main Sample Inlet

34. Allow the sampler and flow audit standard readings to stabilize (about 2-3 minutes) before recording these values onto the Audit Worksheet.

35. Return the sampler to the proper operational configuration.

36. Refer to Section AR.3.0 for Post Audit Procedures.

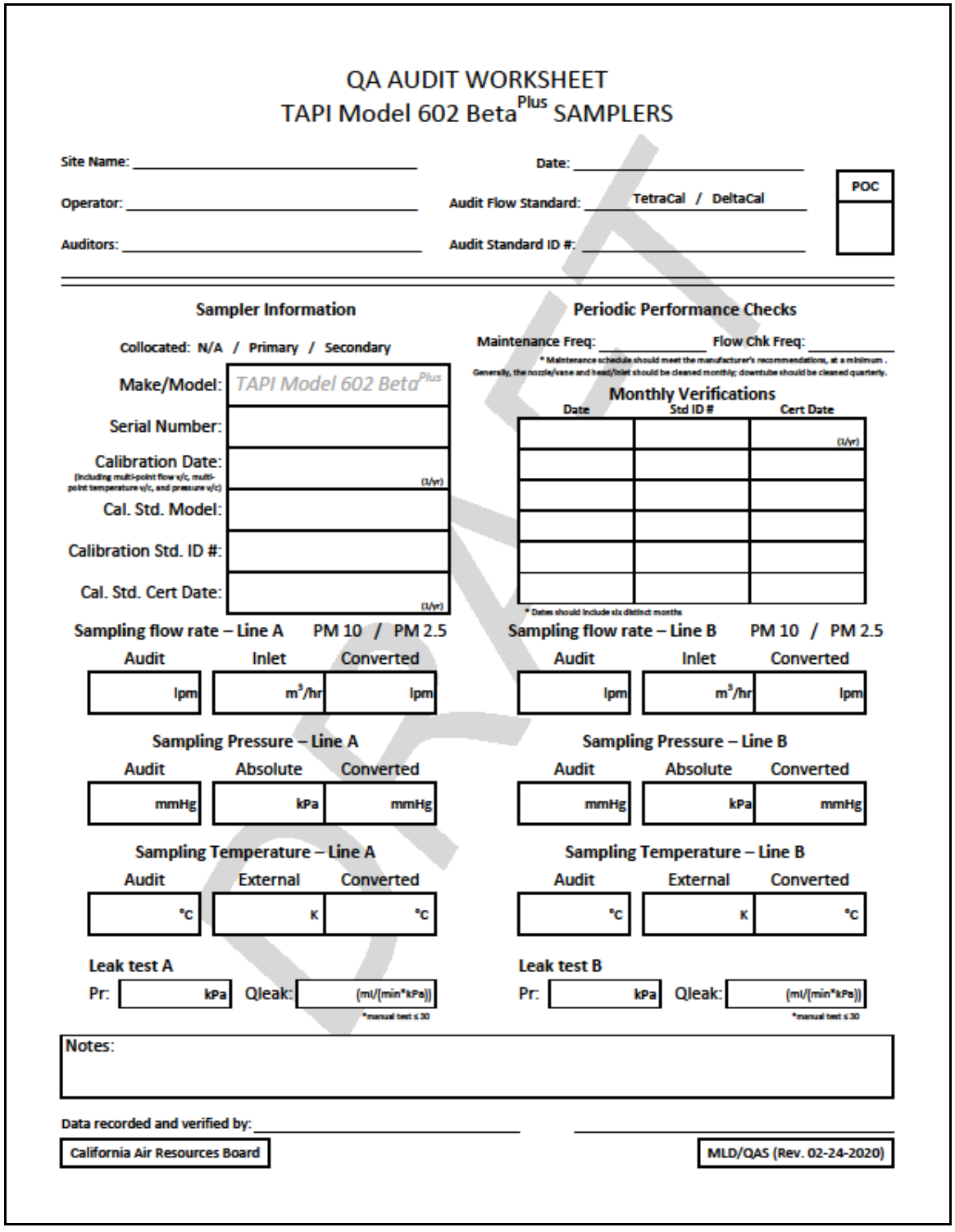
AR.2.8 PERFORMING AN AUDIT ON A TAPI 602 BETA PLUS

The TAPI 602 instrument permits PM sampling and mass measurement on two independent lines simultaneously. This procedure assumes that the instrument is configured in the Dual Channel (Line A & B) Mode with Line A measuring for PM_{10} and Line B measuring for $PM_{2.5}$ (see Figure AR-37).

Figure AR-37. TAPI 602 Beta Plus

1. Situate audit flow and temperature standards near the sampler inlet, avoiding placement in direct sunlight.

2. Begin recording station and equipment information data on the 602 Beta Plus audit worksheet (Figure AR-38). During the audit, the recorded values from the sampler will need to be converted to units (as indicated on the worksheet), to match those needed by AIS to generate comparable results.



QA AUDIT WORKSHEET
TAPI Model 602 Beta^{Plus} SAMPLERS

Site Name: _____ Date: _____

Operator: _____ Audit Flow Standard: TetraCal / DeltaCal

Auditors: _____ Audit Standard ID #: _____

POC

Sampler Information

Collocated: N/A / Primary / Secondary

Make/Model:	TAPI Model 602 Beta^{Plus}
Serial Number:	
Calibration Date: (Including multi-point flow v/c, multi-point temperature v/c, and pressure v/c)	(1/yr)
Cal. Std. Model:	
Calibration Std. ID #:	
Cal. Std. Cert Date:	(1/yr)

Periodic Performance Checks

Maintenance Freq: _____ Flow Chk Freq: _____

* Maintenance schedule should meet the manufacturer's recommendations, at a minimum. Generally, the nozzle/vane and head/inlet should be cleaned monthly; downtube should be cleaned quarterly.

Monthly Verifications

Date	Std ID #	Cert Date
		(1/yr)

* Dates should include six distinct months

Sampling flow rate – Line A PM 10 / PM 2.5

Audit	Inlet		Converted
lpm	m^3/hr		lpm

Sampling flow rate – Line B PM 10 / PM 2.5

Audit	Inlet		Converted
lpm	m^3/hr		lpm

Sampling Pressure – Line A

Audit	Absolute		Converted
mmHg	kPa		mmHg

Sampling Pressure – Line B

Audit	Absolute		Converted
mmHg	kPa		mmHg

Sampling Temperature – Line A

Audit	External		Converted
°C	K		°C

Sampling Temperature – Line B

Audit	External		Converted
°C	K		°C

Leak test A

Pr: kPa Qleak: (ml/[min*kPa]) *manual test ≤ 30

Leak test B

Pr: kPa Qleak: (ml/[min*kPa]) *manual test ≤ 30

Notes:

Data recorded and verified by: _____ _____

California Air Resources Board

MLD/QAS (Rev. 02-24-2020)

Figure AR-38. TAPI 602 Audit Worksheet

3. Confirm that the display panel is indicating that the instrument is in the "Sampling" mode.

4. Confirm that more than 15 minutes are left for sampling within the hour.

5. Request the operator to navigate from the main screen display to the Sampling flow rate - Line A screen display.

6. Record the Inlet Sampling flow rate value for Line A from the sampler display onto the Audit Worksheet (Figure AR-38). (1 m^3/hr = 16.67 LPM)

7. Remove the PM_{10} SSI head from the Line A adaptor.

8. Install the audit flow standard on the Line A adaptor. Allow it to stabilize for not less than 5 minutes after turning on.

9. Record the Line A Audit Sampling flow rate and the Sampling Pressure readings from the audit flow standard onto the audit worksheet. The pressure measurement is common to the two lines.

10. Confirm, with operator, the location of the sampler temperature sensor and placement of the audit temperature standard probe for collocation.

11. Record the Audit Sampling temperature values from the audit standard onto the audit worksheet. The temperature measurement is common to the two lines.

12. Request the operator to navigate through a sequence of menus on the sampler screen until 'Sampling-Temperature-Line A' is displayed.

13. Record the External Sampling Temperature value from the sampler screen onto the audit worksheet. These temperatures are common to the two lines. (^oC = K - 273.15)

14. Request the operator to navigate through the sequence of menus on the sampler screen until 'Sampling-Pressure-Line A' is displayed.

15. Record the Absolute value from the sampler display onto the audit worksheet. This value is common for the two lines. (1 kPa = 7.5 mmHg)

16. Return the sampler Line A to the proper operational configuration.

17. Request the operator to navigate from the main screen display to the Sampling flow rate - Line B screen display.

18. Record the Inlet Sampling flow rate for Line B from the sampler display onto the Audit Worksheet. (1 m^3/hr= 16.67 LPM)

19. Remove PM_{10} Pre-Impactor on Line B while leaving the $PM_{2.5}$ VSCC in place.

20. Install the audit flow standard on Line B above the $PM_{2.5}$ VSCC. Allow it to stabilize for not less than 5 minutes after turning on.

21. Record the Line B Audit Sampler flow rate reading from the audit flow standard onto the audit worksheet.

22. Return the sampler Line B to the proper operational configuration.

23. Request operator to perform the Filter Unloading Procedure for Line A.

24. Remove the PM_{10} Pre-Impactor from the Line A adaptor and replace with a leak check plug.

25. Request the operator to navigate through a sequence of menus on the sampler screen until 'Line A Manual Leak Test' is displayed. Press ENTER.

26. Request the operator to unlock the Loader and place the "complete filter" (the same type used for sampling) inside, then re-lock the Loader and press ENTER to initiate the leak test.

27. The sampler screen will display 'manual leak test in progress'.

28. Wait at least two minutes after pump stops before pressing ENTER.

29. The screen will display values for residual pressure (P_r) and leak (Q_{leak}). Record both values onto the Audit Worksheet.

30. Request operator to end the test.

31. Return the sampler Line A to the proper operational configuration.

32. Request operator to perform the Filter Unloading Procedure for Line B.

33. Remove the PM_{10} SSI head from the Line B adaptor and replace with a leak check plug above the $PM_{2.5}$ VSCC

34. Request operator to navigate through a sequence of menus on the sampler screen until 'Line B Manual Leak Test' is displayed. Press ENTER

35. Request the operator to unlock the Loader and place the "complete filter" (the same type used for sampling) inside, then Re-lock the Loader and press ENTER to initiate the leak test.

36. The sampler screen will display 'manual leak test in progress'.

37. Wait at least two minutes after pump stops before pressing ENTER.

38. The screen will display values for residual pressure (P_r) and leak (Q_{leak}). Record both values onto the Audit Worksheet.

39. Request operator to end the test.

40. Return the sampler Line B to the proper operational configuration.

41. Refer to Section AR.3.0 for Post Audit Procedures.

AR.2.9 PERFORMING AN AUDIT ON A TAPI T640/T640X

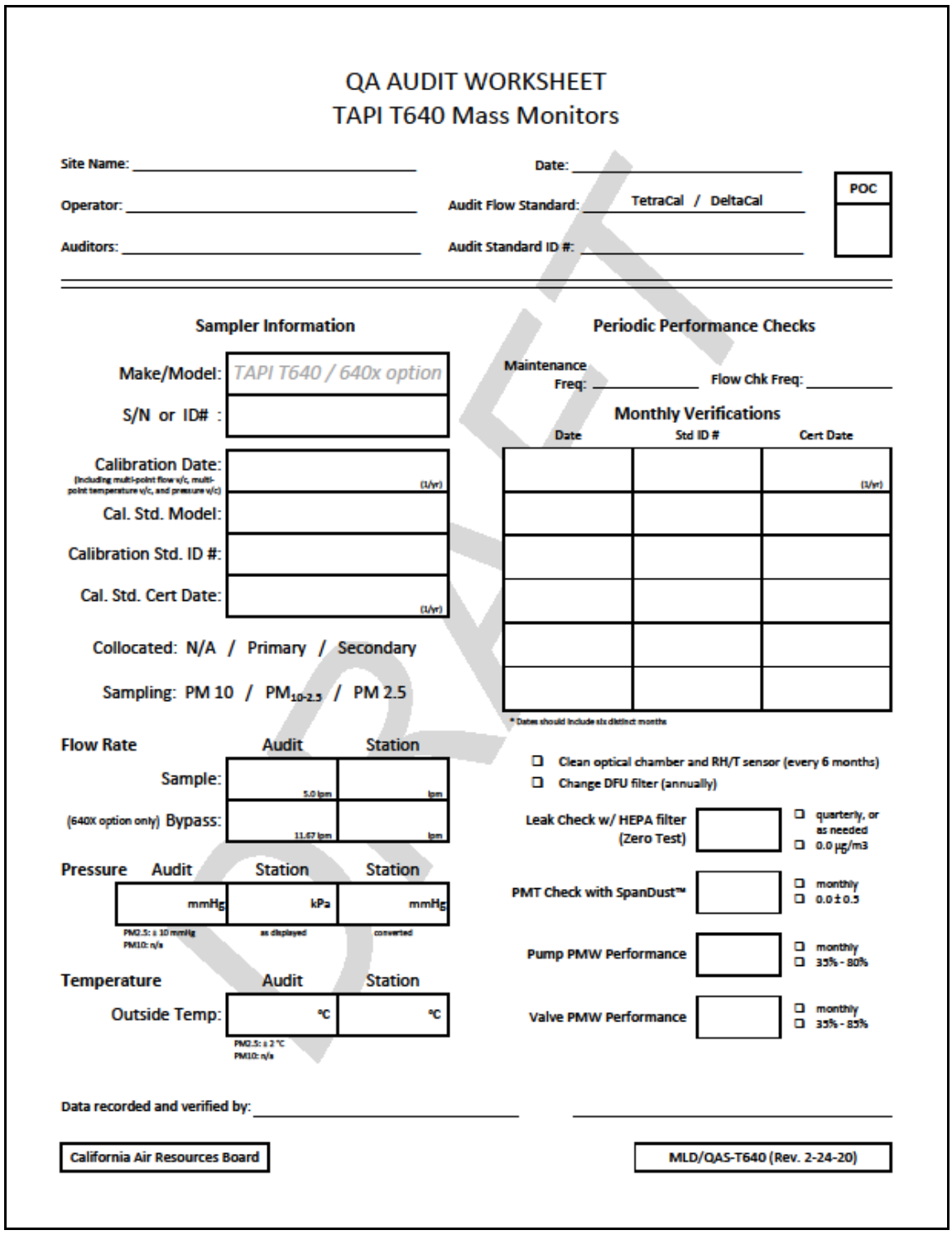
1. See Figure AR-39 for an illustration of the T640.

Figure AR-39. TAPI T640

2. Situate audit flow and temperature standards near the sampler inlet, avoiding placement in direct sunlight.

3. Confirm with the operator the sampler model in operation, T640 or T640X. The T640 samples for $PM_{2.5,}$ while the T640X option samples for $PM_{2.5}$ and PM_{10}.

4. Begin recording station and equipment information data on the TAPI T640 Audit Worksheet (Figure AR-40).



QA AUDIT WORKSHEET
TAPI T640 Mass Monitors

Site Name: _____ Date: _____

Operator: _____ Audit Flow Standard: TetraCal / DeltaCal

Auditors: _____ Audit Standard ID #: _____

POC

Sampler Information

Make/Model: TAPI T640 / 640x option

S/N or ID# :

Calibration Date: (1/yr)
(Including multi-point flow v/c, multi-point temperature v/c, and pressure v/c)

Cal. Std. Model:

Calibration Std. ID #:

Cal. Std. Cert Date: (1/yr)

Collocated: N/A / Primary / Secondary

Sampling: PM 10 / $PM_{10-2.5}$ / PM 2.5

Flow Rate	Audit	Station
Sample:	5.0 lpm	lpm
(640X option only) Bypass:	11.67 lpm	lpm

Pressure	Audit	Station	Station
	mmHg	kPa	mmHg
	PM2.5: ± 10 mmHg PM10: n/a	as displayed	converted

Temperature	Audit	Station
Outside Temp:	°C	°C
	PM2.5: ± 2 °C PM10: n/a	

Periodic Performance Checks

Maintenance Freq: _____ Flow Chk Freq: _____

Monthly Verifications

Date	Std ID #	Cert Date
		(1/yr)

* Dates should include six distinct months

☐ Clean optical chamber and RH/T sensor (every 6 months)
☐ Change DFU filter (annually)

Leak Check w/ HEPA filter (Zero Test) ☐ quarterly, or as needed ☐ 0.0 µg/m3

PMT Check with SpanDust™ ☐ monthly ☐ 0.0 ± 0.5

Pump PMW Performance ☐ monthly ☐ 35% - 80%

Valve PMW Performance ☐ monthly ☐ 35% - 85%

Data recorded and verified by: _____ _____

California Air Resources Board

MLD/QAS-T640 (Rev. 2-24-20)

Figure AR-40. T640 Audit Worksheet

5. Verify with the operator that the T640/T640X is offline or that the data recorder is placed in maintenance/audit mode.

6. The check for leaks does **not** involve pulling a vacuum on the system. The inlet is never to be capped while the instrument pumps are running.

7. Depending on the sampler model, remove the inlet or PM_{10} SSI head and fit a HEPA filter onto the Upper Inlet Tube. Ensure the tubing is not kinked.

8. Open the shelter panel to access the display panel (Figure AR-41).

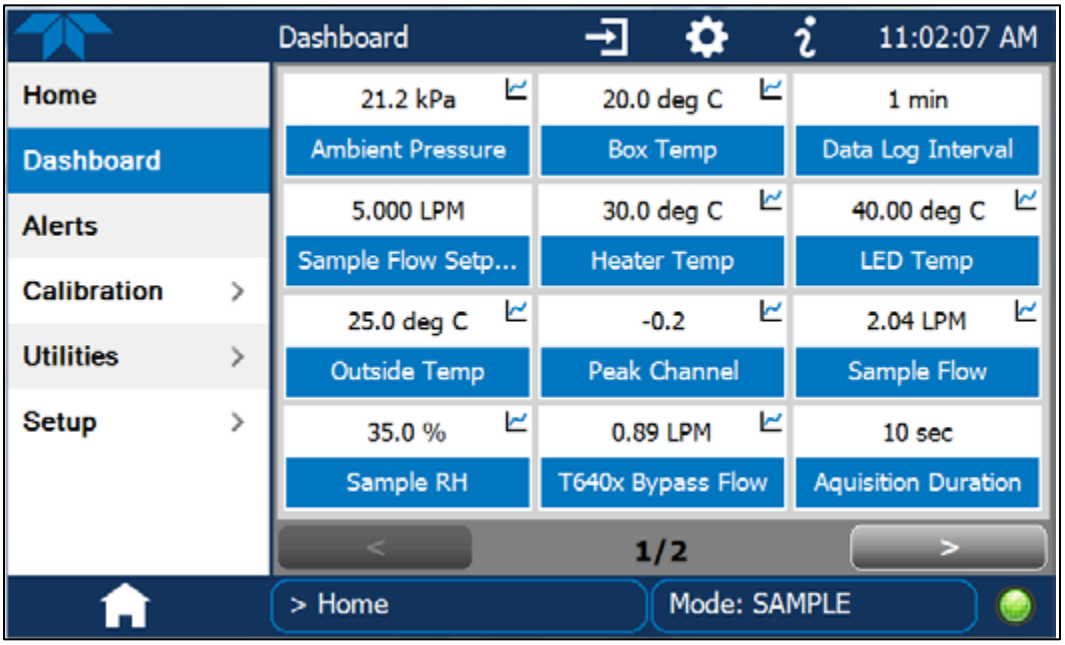


Figure AR-41. TAPI T640 Display Panel

9. Observe the PM values on the home screen of the display. After approximately 10 minutes, the values should read 0.0 for each PM metric.

10. Regardless of where the readings stabilize, record these PM values on the audit worksheet. Once equilibrated to the ambient conditions, power on the audit flow standard.

11. Record the Audit pressure value from the audit flow standard onto the audit worksheet.

12. Confirm, with operator, the location of the sampler temperature probe and placement of the audit temperature standard probe for collocation.

13. Record the Audit temperature from the temperature standard onto the Audit Worksheet.

14. Record the Outside Temp and Ambient Pressure values from the sampler Dashboard page as the Station Temperature and Pressure onto the audit worksheet.

    NOTE: Verify that the pressure reading on the sampler screen is in mmHg. If not, request the operator to change the pressure units displayed by the sampler to mmHg.

15. Gently remove the HEPA filter from the Upper Inlet Tube.

16. The flow audit depends on the sampler model in operation. Proceed to the applicable steps.

17. T640X flow audit:

    i. Remove the Bypass Flow Tube (line) from the Aerosol Sampler Conditioner (ASC) sample tube and cap the Bypass Tube fitting with a Swagelok cap. See Figure AR-42 for component identification.

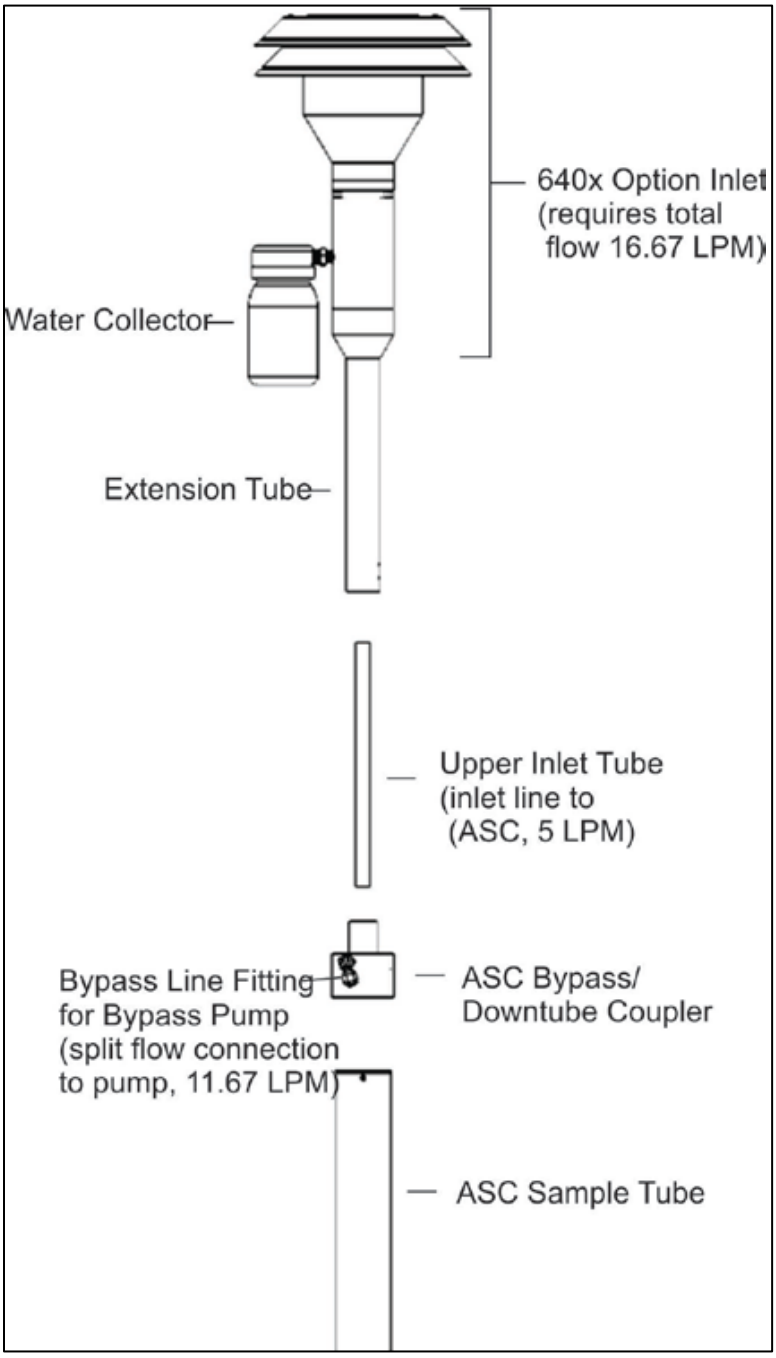


Figure AR-42 TAPI T640X Sample Inlet Configuration

ii. Connect the audit flow standard to the top of the Upper Inlet Tube. Wait at least one minute for the flow to re-stabilize.

iii. Record audit flow standard measurement as the Sample Audit flow rate on the audit worksheet.

iv. With the sampler running, request the operator to display the Calibration>Sample Flow Cal menu.

v. Record the displayed Measured Flow value as the Sample Station flow rate on the audit worksheet.

vi. Remove the audit flow standard from the Upper Inlet Tube.

vii. Connect the audit flow standard device to the Bypass Flow Tube. Wait at least one minute for the flow to re-stabilize.

viii. Record audit flow standard measurement as the Bypass Audit flow rate on the audit worksheet.

ix. With the sampler running, request the operator to display the Calibration>Bypass Flow Cal menu.

x. Record the displayed Measured Flow value as the Bypass Station flow rate on the audit worksheet.

xi. Remove the audit flow standard from the Bypass Flow Tube.

18. T640 Flow Audit:

i. Connect the audit flow standard to the top of the Upper Inlet Tube. Wait at least one minute for the flow to re-stabilize.

ii. Record audit flow standard measurement as the Sample Audit flow rate on the audit worksheet.

iii. With the sampler running, request the operator to display the Calibration>Sample Flow Cal menu.

iv. Record the displayed Measured Flow value as the Sample Station flow rate on the audit worksheet.

v. Remove the audit flow standard from the Upper Inlet Tube.

19. Return the sampler to the proper operational configuration.

20. Refer to Section AR.3.0 for Post Audit Procedures.

AR.3.0 POST-AUDIT PROCEDURES

AR.3.1 COMPILING PRELIMINARY AUDIT RESULTS

1. Review Audit Worksheet for completeness and accuracy, sign. Verify that all audit steps are complete.

2. Input data from the worksheet into AIS to generate preliminary results and report. The second auditor (if present) should review and verify that the worksheet and AIS entries match.

3. Exceedances of established audit criteria or deviation from operational standards may result in corrective action. See Section AR.3.2.

   NOTE: It is highly recommended to repeat a procedure to confirm results that exceed audit criteria.

4. Inform the operator as soon as the sampler can be placed back online.

5. Notify the operator of preliminary audit results and necessary follow up actions.

6. Forward a copy of the preliminary report to the operator upon return from the field.

AR.3.2 AUDIT CRITERIA

The following table (Table AR-2) provides the acceptable criteria for each audited parameter of the continuous PM samplers. Any identified exceedance requires corrective action.

Table AR-2. Control Limits

	TEOM	BAM	TAPI 602	TAPI 640/640x
Flow Rate	$PM_{2.5}$ ± 4% from Flow Audit Standard ± 5% from Design Flow (3.0 LPM) PM_{10} ± 10% from Flow Audit Standard	$PM_{2.5}$ ± 4% from Flow Audit Standard ± 5% from Design Flow (16.67 LPM) PM_{10} ± 10% from Flow Audit Standard	$PM_{2.5}$ ± 4% from Flow Audit Standard ± 5% from Design Flow (16.67 LPM) PM_{10} ± 10% from Flow Audit Standard	T640 Sample Flow ± 4% from Flow Audit Standard ± 5% from Design Flow (5.0 LPM) T640x Total Flow: ± 4% from Flow Audit Standard ± 5% from Design Flow (16.67 LPM) Bypass Flow: ± 4% from Flow Audit Standard ± 5% from Design Flow (11.67 LPM)

	TEOM	BAM	TAPI 602	TAPI 640/640x
Leak check	1400 Main: ≤ 0.15 + main flow NOV (LPM) Auxiliary: ≤ 0.60 + auxiliary flow NOV (LPM) 1405 Main: ≤ 0.15 LPM Auxiliary: ≤ 0.60 LPM	1020/1022 ≤ 1.5 LPM EBAM ≤ 1.0 LPM	≤30 mL/(min*kPa)	≤0.2 µg/m³
Temperature	± 2 °C from Audit Standard			
Barometric Pressure	± 10 mmHg from Audit Standard			

AR.3.3 AIR QUALITY DATA ACTION (AQDA) REQUEST

AQDA Requests are issued when the audit reveals that the station's analyzer(s) are not operating within federal critical criteria or CARB control limits. Refer to the SOP for Air Quality Data Action Requests (Volume V, Appendix AO) for guidance.

AR.3.4 CORRECTIVE ACTION NOTIFICATION (CAN)

CANs are issued to document deficiencies that may potentially impact data quality, completeness, storage, or reporting. Refer to the SOP for Corrective Action Notifications (Volume V, Appendix AN) for guidance.

AR.4.0 CHANGES FROM PREVIOUS SOP

Subject	Revision 0 (2020)
New or Revised Sections	• Replaces SOP Performance Audit Procedures for Continuous PM10 Monitors (Appendix V), issued December, 2009.
Sections Removed (obsolete information)	• N/A

AR.5.0 REFERENCES

CARB Air Monitoring Quality Assurance Manual-Volume V: Audit Procedures for Air Quality Monitoring, "Appendix AN: Corrective Action Notification (CAN)", Revision 3 (October 2014): https://ww3.arb.ca.gov/aaqm/qa/pqao/can/can_sop.pdf

CARB Air Monitoring Quality Assurance Manual-Volume V: Audit Procedures for Air Quality Monitoring, "Appendix AO: Air Quality Data Action Request (AQDA)", Revision 1 (June 27, 2017): https://www.arb.ca.gov/aaqm/qa/qa-manual/vol5/v5apxao.pdf

Met One Instruments BAM 1020 Particulate Monitor Operation Manual, BAM 1020-9800 REV U (2016): https://metone.com/wp-content/uploads/2019/04/BAM-1020-9800-Manual-Rev-U.pdf

Met One Instruments BAM 1022 Particulate Monitor Operation Manual, BAM 1022-9805 REV B (2019): https://metone.com/wp-content/uploads/2019/07/BAM-1022-9805-Rev-B.pdf

Met One Instruments E-BAM PLUS Particulate Monitor Operation Manual, E-BAM PLUS-9800 REV C (2016): https://arb.ca.gov/airwebmanual/instrument_manuals/Documents/EBAM-PLUS-9800_Manual_Rev_C.pdf

Teledyne API Model 602 BETA Plus Particle Measurement System Operation Manual, 07318B DCN6410 (March 2012): http://eservices.teledyne-api.com/manuals/07318B_602.pdf

Teledyne API Model T640 PM Mass Monitor User Manual, 08354 DCN7877 (June 2018): http://www.teledyne-api.com/prod/Downloads/T640%20Manual%20-%2008354.pdf

Thermo Scientific TEOM® 1405 Ambient Particulate Monitor, 42-010976 Revision A.000 (Feb 2008): http://tools.thermofisher.com/content/sfs/manuals/EPM-TEOM1405-Manual.pdf

Thermo Scientific TEOM® Series 1400a Ambient Particulate (PM-10) Monitor Operating Manual, 42-003347 Revision B (Sept 2008): https://assets.thermofisher.com/TFS-Assets/LSG/manuals/EPM-manual-TEOM1400ab.pdf

U.S. EPA Quality Assurance Handbook for Air Pollution Measurement Systems: "Volume II: Ambient Air Quality Monitoring Program" EPA-454/B-17-001, (March 2017): https://www3.epa.gov/ttn/amtic/files/ambient/pm25/qa/Final%20Handbook%20Document%201_17.pdf