U.S. EPA
Technical Systems Audit
Supplementary Checklist for $PM_{2.5}$ Continuous Monitors

Introduction and Overview:

This checklist is intended to support EPA Regional staff conducting Technical Systems Audits of $PM_{2.5}$ continuous monitors operated by State, local, or Tribal monitoring agencies. This checklist supplements Appendix H of the QA Handbook Volume II (http://www.epa.gov/ttn/amtic/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf). The checklist attempts to address the most important aspects of ensuring a $PM_{2.5}$ continuous monitor is set-up, operating, and reporting data to meet the intended monitoring objectives (e.g., NAAQS and AQI). This checklist does not attempt to redundantly capture the activities already addressed in the Appendix H checklist; however, there are a few places where an item already addressed in Appendix H is further detailed to ensure the auditor has the key information to conduct the audit.

The audit is performed by looking at a number of documents and assessments in advance of travelling to a site and then by inspecting how the monitor is set-up, operated, maintained, and reporting data at the site to ensure the method can appropriately support its intended monitoring objectives.

While this checklist is fairly detailed, it attempts to balance calling attention to the best practices without having so much detail that the auditor might not be able to successfully complete addressing all parts of the checklist. Additionally, and where appropriate, illustrations and images are included to provide a reference for the auditor. If there is a need for a visual to illustrate a setting or practice that is not included, please ask so that we can continue to improve this checklist.

This checklist is organized into three basic areas that cover the Technical Systems Audit (TSA):

1. ***Preparation and Planning***: In advance of travelling to an agency, the auditor should review the agency's annual monitoring network plan, assessments of data, and other documentation (e.g., list of designated reference and equivalent methods) to determine if the monitor is meeting its stated objectives and producing data that meets the needs of the data users. (i.e., meeting DQOs). This preparation and planning should be very similar regardless of the specific method being run by the monitoring agency.

2. ***On-Site Technical Systems Audit:*** While on site the auditor should spend time reviewing the set-up, operation, maintenance, and reporting of data to ensure the method is functioning appropriately. If there are items observed during the audit that can be addressed while on-site without compromising data quality (e.g., cleaning the VSCC during the period of time the monitor is not pulling air), then these should be communicated immediately to the agency staff. The on-site audit activities are organized in a method-specific checklist.

3. ***Follow-Up and Review:*** The auditor should ensure a written report is provided in a timely manner to the monitoring agency. Audit findings should be grouped into either: a. Significant Findings, or b. Observations. Significant findings should address those items that appear to affect data quality in an adverse way. Observations should include items that help ensure the method is operating appropriately and efficiently. Additionally, for Significant Findings, the auditor should request that the agency provide documentation to the EPA Regional office that the items are addressed. For example, zero test data could be provided to document that a new zero test was conducted.

1. Preparation and Planning:

Regional staff should prepare for a TSA in advance of travelling to meet with an agency and their sites by reviewing several documents, assessments, and reports of data. This preparation will help to ensure the auditor becomes familiar with the method and use of the data as well as to help inform areas that should be focused on during the TSA.

Below find a table with recommended documents, assessments, and data-bases that should be reviewed prior to going into the field.

Table 1 – Preparation Table:

Document or Assessment or To Do	Where or who to find	What to look for or Document or Data?	Comments
Annual Monitoring Network Plan.	Agency's current and/or planned annual Monitoring Network Plan	Review and identify the sites you will visit that have $PM_{2.5}$ continuous monitors; whether they are pre-FEM or FEM; and their stated monitoring objectives.	Note any FEMs that are either already approved for exclusion or requested for exclusion from the $PM_{2.5}$ NAAQS due to not meeting performance requirements.
Review latest copy of "List of Reference and Equivalent Methods" and compare to annual plan.	http://www.epa.gov/ttn/amtic/files/ambient/criteria/reference-equivalent-methods-list.pdf	Read method designation description for $PM_{2.5}$ continuous FEMs that are at sites you will visit. Document method designation number and minimum firmware requirements in descriptions.	
Instrument company web site	Look on line for the instrument company	Look for latest version of instrument manual and firmware for FEMs; however, you should not need to download these.	Notes: 1. Some instrument company web sites may be password protected. 2. In cases where a Pre-FEM monitor is being run, but the latest manual is specific to the FEM version, the agency may not need the latest version of the manual.
Run AQS reports (e.g., AMP450NC) and ensure all $PM_{2.5}$ continuous monitors identified in Annual Plan are reporting to AQS.	Use AQS if you have an active user login and password. Alternatively, use AirData (http://www.epa.gov/airdata/) if you do not have ready access to AQS. All ambient PM data in AirData originates from AQS via the DataMart.		Monitors reporting to parameter code 88101 will be used in NAAQS and AQI. Monitors reporting to parameter code 88502 will be used in the AQI.
$PM_{2.5}$ continuous monitor comparability assessment tool	http://www.epa.gov/airquality/airdata/ad_rep_frmvfem.html	For sites that will be visited, run assessment and identify any performance issues. (primarily focus on additive and multiplicative bias)	Note: a collocated FRM is required for the assessment to run.
Run an hourly data report for the $PM_{2.5}$ continuous monitor	AMP 350 or download data	Verify the following: 1. What is the lowest hourly reading recorded to AQS? There should be some data less than 0. If not, note and review data farther back in time 2. What is the highest hourly value recorded to AQS? There should be no data at 985 (or close to it if using analog)	An absence of any slightly negative (down to -10 ug/m^3) data may be biasing the 24-hour averages high. Among $PM_{2.5}$ FEMs, only the GRIMM is known to never have a negative hourly value. Significantly high data at or near 985 ug/m^3 indicate that the instrument has gone to full scale. This is usually associated with an error code and should not have been reported.

Document or Assessment or To Do	Where or who to find	What to look for or Document or Data?	Comments
		Also, the hourly data record is a good way to check that the instrument was off line during period of zero test.	
Assessment of collocated FRM data. Where appropriate, this will help to determine whether the issue with the $PM_{2.5}$ data is the continuous FEM monitor or FRM sampler.	AMP 256	Where there are comparability issues between the FRM and continuous FEM, we would like to verify that the FRM to FRM collocation meets DQOs. Look to see that the FRM to FRM CV UB is less than or equal to the 10% CV?	In cases where the "Collocated Detail Report" is providing the CV UB for the PM2.5 continuous monitor collocated with an FRM, the calculation is often relatively higher than the FRM to FRM collocation, even in cases where the additive and multiplicative bias statistic are met.
Reports of flow verifications and audits	AMP 251	Are flow rate verifications and audits acceptable?	Flow audits are required to be reported to AQS. Flow verifications are not required to be reported to AQS, but they can be.
Interview Data Users in Region; find out what is working well or any concerns.	e.g., ESAT PEP field scientist	Ask if there are any known or potential issues in the set-up, operation, maintenance, or reporting of the $PM_{2.5}$ continuous monitors?	
Review AIRNow reporting and ensure $PM_{2.5}$ continuous monitors identified in Annual Plan are reporting to AIRNow and available for public reporting of data. Note: AIRNow reporting is not technically "required"; however, participating in AIRNow fulfills the requirements of Appendix G for AQI reporting.	www.AirNowTech.org If you do not have access, you can request it or check with colleagues who may already have access.	Ensure monitors are being publically reported.	Public Maps (without needing to log in) are available at: http://www.airnow.gov/index.cfm?action=airnow.pointmaps These maps, while national in scale, may be able to provide a quick visual assessment if a site is reporting $PM_{2.5}$ continuous data publically.
SOP	Ask agency in advance	1. Adherence to method requirements prescribed in instrument company manual (e.g., settings in firmware)	

Document or Assessment or To Do	Where or who to find	What to look for or Document or Data?	Comments
		2. Incorporation of best practices (e.g., are more frequent zero tests performed, where appropriate?)	

2. On-site Technical Systems Audit of Met One BAM 1020

Conducting the on-site audit of the Met ONE BAM 1020 involves evaluating several aspects of the set-up, operation, maintenance, and reporting of the monitor. For this checklist we have grouped the questions into four areas:

a. Items to review at the monitor
b. Items to review in the firmware and data logger
c. Items to review at the inlet.
d. Maintenance and QC records to review

This checklist can be applied to either pre-FEM or FEM Met One BAM 1020 monitors. Pre-FEM Met One BAM 1020 monitors will be set up and operated nearly identical to an FEM, except that they may use a Sharp Cut Cyclone (SCC) rather than a VSCC and that the version of firmware may be prior to version 3.2.4. There may be other engineering differences between a pre-FEM and FEM Met One BAM 1020; however, these will likely be unnoticeable to the user or auditor. To the extent that any differences exist, it does not necessarily mean that the pre-FEM version is not being run appropriately.

Typical Met One BAM 1020 Set-up:

Note: Dimensions are typical and not necessarily part of a requirement.

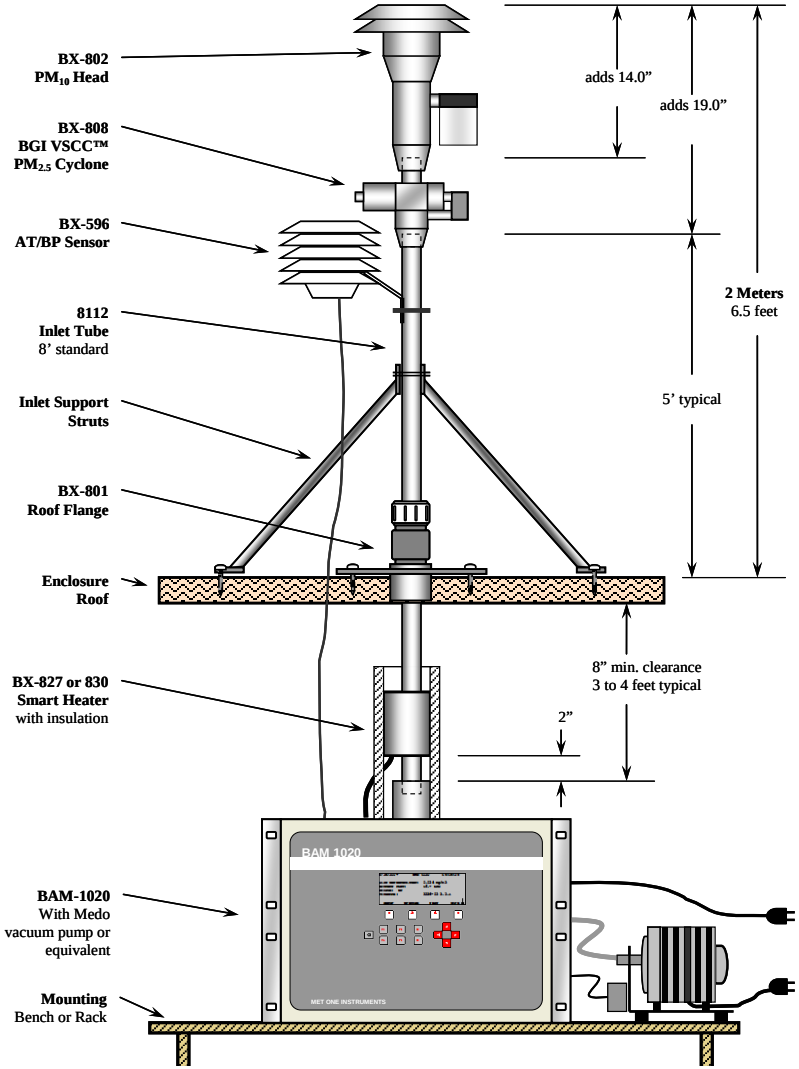
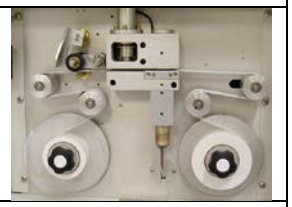
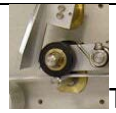
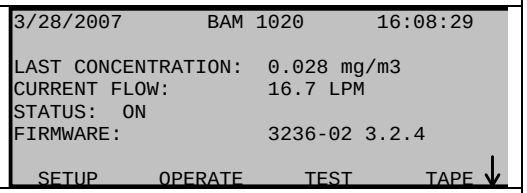
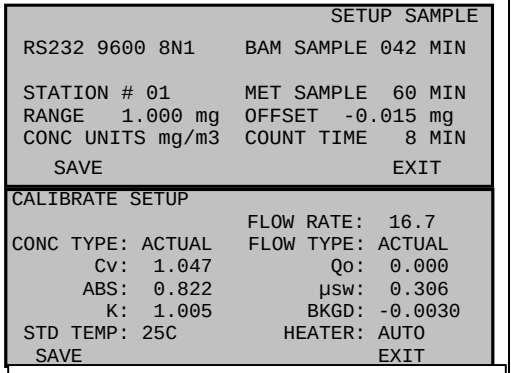


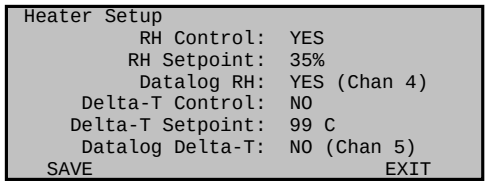
Table 2 – Audit Questions for the Met One BAM 1020 $PM_{2.5}$ Continuous Monitor:

Question #	Item	Response	Comments
Items to review at the Monitor:			
1	Confirm the make and model of the $PM_{2.5}$ continuous monitor?		
2	Does this make and model match what is identified in the annual plan and reported to AQS?	☐ Yes ☐ No	
3	If expected, is there an FEM sticker on the $PM_{2.5}$ continuous Monitor?	☐ Yes ☐ No	*Automated Equivalent Method: EQPM-0308-170*
4	Are there any concerns about the location of the monitor inside the shelter?	☐ Yes ☐ No	This is largely professional judgement. Items of concern might include: substantial vibration where monitor is set-up; AC blowing directly on down tube; or poor access to monitor.
5	Is the latest SOP and Instrument manual for the $PM_{2.5}$ continuous monitor available at the station?	☐ Yes ☐ No	The latest instrument manual version is Revision K.
6	Is the SOP current? Identify approval date.	☐ Yes ☐ No	If practicable, look for approval before trip.
7	How far is the sampling pump placed away from the BAM? Is the pump isolated so as to minimize vibration to the monitor?	☐ Yes ☐ No	Distance between the BAM and pump will help to minimize vibration. Even placed a few feet away isolated on foam or rubber mat will help.
8	Is the chassis of the monitor ground to an earth ground? How is this grounded?	☐ Yes ☐ No	This is in addition to the ground associated with the electrical cord. Grounding of the pump is also recommended. Photo at right illustrates green/yellow ground line leading from back of chassis. 
9	Is the inlet down tube grounded with two set screws at the receiving collar of the monitor?	☐ Yes ☐ No	Ask operator if they have tested down tube grounding. While not required, this can be confirmed by testing continuity between the down tube and monitor chassis; however, a small

Question #	Item	Response	Comments
	This should be done by cranking hard on the set screws to pierce the aluminum anodizing , then back out and gently tighten. Over-tightening will cause leaks.		section of anodized aluminum would need to be scratched off on the down tube to test this. A down tube that is not grounded may be susceptible to electrical static build up, which can lead to a noisier concentration output.
10	Describe any heat on or near the smart heater? Does it appear the smart heater is operating? Is the downtube insulated? (although not required, this may help the smart heater perform better)	☐ Yes ☐ No	The smart heater has two power levels: a high level and a low level. Even at the low level there should be a small amount of noticeable heat at the down tube near the smart heater. A smart heater that is not working may have a cold down tube.
11	Ask operator to open door of monitor. Observe tape set-up; has the tape run out or are there any other visible issues?	☐ Yes ☐ No	The nozzle sits on the tape during sampling right in the center of the unit. 
12	Observe the tape that has already sampled; if applicable, describe any pin holes that may appear on the tape?	☐ Yes ☐ No	Pinholes are a symptom of the nozzle pinching down on the tape. Pinholes will result in excessively lower negative readings in the data.
13	Observe the nozzle as it sites on the filter tape. If applicable, describe any visible debris on the bottom of the nozzle?	☐ Yes ☐ No	The nozzle and vane are to be cleaned at regular intervals (typically monthly) to ensure debris does not build up on bottom of nozzle.
14	Is there build-up on the capstan rollers?	☐ Yes ☐ No	 The capstan roller is located to the left of the nozzle.

Question #	Item	Response	Comments
15	Inspect the inlet receiver where the downtube meets the unit. Look for any signs of water marks. Another sign of water may be found on the serial name plate at the bottom just inside the door.	☐ Yes ☐ No	If water marks are found, this maybe an indication that the shelter seal around the downtube is leaking and either needs to be tightened or replaced.
16	Describe any other issues with the monitor?	☐ Yes ☐ No	
Items to review in the Firmware and data logger:			
17	What version of software is identified on the monitor?		Firmware is listed on the main menu screen. 
18	Is this version of software compliant with firmware requirements for the method identified in the "List of Reference and Equivalent Methods"?	☐ Yes ☐ No	Approved firmware includes: $PM_{2.5}$ – 3.2.4 or higher; PM_{10} – 2.0 or higher. Latest versions of firmware as of Spring 2015 are: Non-touch BAM – 3236 – 2 R3.7.1 (this is the unit on page 5) Touch BAM – 3236-55 R2.3.1 (this has a touch screen) Coarse BAM – 3236-6 R3.7.1 Note: it is not always necessary to upgrade to the latest firmware; check manufacturer's web site for details.
19	Review the most recent zero test data and verify that the zero value entered in the firmware is the opposite of the average of that zero test data.	☐ Yes ☐ No	The zero setting is entered in the field "BKGD". This is located in the "CALIBRATE SETUP" screen, which is illustrated in the center screen shot in question 24. Note: it is critical that the value entered in this field is the <u>negative</u> of the average from the most recent zero test. For example, if the zero test produces an average of 1.2 ug/m^3, then the value entered is "-0.0012".

Question #	Item	Response	Comments
20	In reviewing the most recent zero test, was the standard deviation of the test data < 2.4 ug/m^3?	☐ Yes ☐ No	
21	Observe the last hour reported on the LCD screen and compare this to data reported at the station data logger; are they the same?	☐ Yes ☐ No	Note: The last hour reported may not be available for a couple minutes after the top of the hour; however, this data point represents the previous hour at the start of the hour. For example an updated value first posted at 10:02 am should represent hour 09:00.
22	Is the clock on the BAM 1020 set to run on local standard time (i.e., not day light savings time)?	☐ Yes ☐ No	
23	Compare time on BAM1020 to time of data logger; is there any difference in time and if so how many minutes?	☐ Yes Min: _____ ☐ No	Note: in some cases Met One BAM 1020 Monitors are purposefully set to have an offset in the time reading. This is acceptable to ensure the latest BAM reading is interpreted by the data system to represent the previous hour.
24	Verify firmware settings and note any discrepancies. From main screen select: 1. >SETUP >SAMPLE 2. >SETUP >CALIBRATE 3. >SETUP >HEATER Note 1: **Sample will stop to verify settings.** An as found leak test is recommended prior to stopping flow. Note 2: For PM_{10} only (i.e., not $PM_{10-2.5}$) measurements, CONC TYPE	1. Items in "SAMPLE" screen: Yes No ☐ ☐ BAM SAMPLE: 042 MIN ☐ ☐ OFFSET: -0.015 mg ☐ ☐ COUNT TIME: 8 MIN 2. Items in "CALIBRATE" screen: ☐ ☐ CONC TYPE: ACTUAL ☐ ☐ FLOW TYPE: ACTUAL ☐ ☐ FLOW RATE: 16.7 lpm ☐ ☐ HEATER: AUTO 3. Items in "HEATER" screen:	 *Note: Cv, ABS, and K are set at the factory and will vary from monitor to monitor.*

Question #	Item	Response	Comments
	is set to "STD" and STD TEMP is set to "25C."	☐ ☐ RH Control: YES%, ☐ ☐ RH Setpoint 35%, ☐ ☐ Datalog RH: YES (Chan 4) ☐ ☐ Delta-T Control: NO ☐ ☐ Delta-T Setpoint: 99 C,Datalog Delta-T log: This can be set to either YES or NO. Since it's only the log, it does not affect operation of the monitor.	
25	If applicable, describe any other issues in the firmware or data logger?		
Activities to review at monitors' inlet:			
26	Is the PM_{10} inlet a "pie pan" design?	☐ Yes ☐ No	 Note: All $PM_{2.5}$ continuous monitors nominally operating at 16.7 lpm should use the pie-pan inlet design. Only the GRIMM uses an inlet design different than the pie pan inlet for $PM_{2.5}$. Some PM_{10} continuous FEM monitors and older TEOMs (pre-FEM) may use the flat head inlet design.
27	Open the inside of the PM_{10} inlet. Describe the cleanliness of the inlet well.		The PM_{10} inlet can be inspected near the top of the hour without disrupting on-going operations as the flow runs for 42

Question #	Item	Response	Comments
			minutes. Flow is typically off from minute 50 to minute 8 each hour.
28	If expected, is the $PM_{2.5}$ second stage separator an approved VSCC?	☐ Yes ☐ No	 Notes: **1.** VSCC's and SCC's look very similar in design. **2.** Also, there are two designs of the VSCC; however, all $PM_{2.5}$ continuous monitors should use the design on the left. The other VSCC design is used with BGI samplers.
29	Open the VSCC. Describe the cleanliness of the inside of the VSCC.		The VSCC can be inspected near the top of the hour without disrupting on-going operations as the flow runs for 42 minutes. Flow is typically off from minute 50 to minute 8 each hour.
30	Is there a gill screen or similar near the inlet that is also connected to the $PM_{2.5}$ continuous monitor to provide an ambient temperature reading?	☐ Yes ☐ No	 BAM-1020 $FEM_{2.5}$ requires BX-596 (AT,BP) BAM-1020 FEM_{10} requires BX-592 (AT)
31	Do the Inlet and down tube appear perpendicular to the ground?	☐ Yes ☐ No	Best judgement is fine.
32	Describe any other issues at the monitors' inlet?	☐ Yes ☐ No	
Maintenance and QC Records to review:			
33	Does the agency use an audit sheet for regular maintenance and verifications? Or logbook?	☐ Yes ☐ No	Review audit sheets and/or logbook while on site to ensure maintenance and verifications are performed at expected frequencies.
34	<u>Monthly and quarterly checks:</u> Is there a record documenting that the following checks are being	<u>Yes</u> <u>No</u> ☐ ☐ Flow check ☐ ☐ Temperature check ☐ ☐ Barometric Pressure	

Question #	Item	Response	Comments
	performed at least monthly or quarterly, where identified?	☐ ☐ Leak check ☐ ☐ Nozzle and vane cleaning ☐ ☐ PM_{10} inlet is cleaned (at least quarterly) ☐ ☐ VSCC is cleaned	
35	12 month checks: Is there a record documenting that the following checks are being performed at least every 12 months?	Yes No ☐ ☐ Perform 72 hour zero test (note: more frequent zero tests [e.g., seasonally] are recommended, but not required). If an assessment indicates the monitor is meeting the additive bias requirement, seasonal zero tests may not be necessary. Nozzle cleaning/rebuild is recommended prior to zero test. ☐ ☐ Clean down tube ☐ ☐ Analog voltage audits, if applicable	

While on site, also perform the following:

a. Interview the operator and have routine procedures described.
b. Ask for documentation providing evidence that the flow standards being utilized by the operator and the agency's own auditor (these are required to be separate devices) are NIST traceable and within certification. The Agency office may need to be contacted for these.
c. Communicate any items that can be addressed in the field without compromising data quality.

3. Follow-Up and Review:

These activities are suggestions to help ensure the TSA leads to actionable improvements in the operation of the method, where appropriate. Regions that have their own polices for how TSA's are shared should follow those policies as directed by their management.

a. Review your notes and checklist within 24 hours of leaving the site to ensure you completely document any activities of note.

b. Write a draft TSA report of the audit findings within 5 working days of completing travel to the agency. It is important to get the TSA fully documented while it is fresh in your mind as well as to benefit the monitoring agency if there are issues that need to be addressed quickly.

c. In the draft report, group findings into two distinct categories as follows:
   I. Significant Findings - should address those items that appear to affect data quality in an adverse way. The TSA report should request that the agency provide documentation that these items are addressed. For example, zero test data could be provided to document that a new zero test was conducted.
   II. Observations - should address items that help to ensure the method is operating appropriately and efficiently.

d. Share a draft electronic report with the appropriate manager(s) in the monitoring agency. Ask if there are any items that appear unclear in how to address or which they may disagree with, including a rationale as to why they disagree. Also, provide a recommended date for the monitoring agency to respond by (e.g., 4 weeks).

e. With any comments received and/or actionable improvements already made by the agency, draft a final report for distribution to the agency. Include a recommended timeline to address any remaining significant findings.