This SOP is subject to
review and revision in 2015.

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

TECHNICAL SERVICES DIVISION

QUALITY ASSURANCE PROJECT PLAN

STANDARD OPERATING PROCEDURE

AIRMON SOP 207

MET ONE BAM 1020 $PM_{2.5}$

REVISION 207.2.00 06/27/2012

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1. PURPOSE

This Standard Operating Procedure (SOP) describes the BAAQMD (Bay Area Air Quality Management District) procedures for the installation, setup, general operation, calibration, maintenance, data collection, troubleshooting and repair of the Met One Instruments Inc. Model 1020 BAM (Beta Attenuation Mass Monitor). This includes both the FEM (Federal Equivalent Method) and the non-FEM BAM 1020. This SOP supplements the procedures located in the BAM 1020 Particulate Monitor Operation Manual.

2. SUMMARY OF METHOD

The BAM 1020 automatically measures and records airborne particulate concentration levels in units of ug/m3 using the principle of beta ray attenuation. Please refer to the appropriate BAM Operation's Manual for a further explanation.

BAAQMD staff operate both the older non- FEM BAM 1020's and the newer FEM BAM 1020 $PM_{2.5}$ which is designated as an equivalent method for $PM_{2.5}$ monitoring in accordance with 40 CFR Part 53 by the United States Environmental Protection Agency (EPA) as of March 12, 2008.

3. DEFINITIONS

BAAQMD	Bay Area Air Quality Management District
BAM	Beta Attenuation Mass Monitor
CARB	California Air Resources Board
DAS	Data Acquisition System
DMS	Data Management System
EPA	Environmental Protection Agency
FEM	Federal Equivalent Method
FRM	Federal Reference Method
NIST	National Institute of Standards and Technology
PM10	Particulates < 10 microns in diameter
PM2.5	Particulates < 2.5 microns in diameter
SCC	Sharp Cut Cyclone
SOP	Standard Operating Procedure
VSCC	Very Sharp Cut Cyclone

4. HEALTH AND SAFETY WARNINGS

NOTE: Please refer to the appropriate BAM 1020 Operation's Manual for information.

5. CAUTIONS

NOTE: Please refer to the appropriate BAM 1020 Operation's Manual for information.

6. INTERFERENCES AND LIMITATIONS

The BAM 1020 inlet must not be installed near any flue, fan, exhaust (from an HVAC unit), blower, dusty environments such as a dirt roadway, or any other source that might bias PM2.5 concentration measurements; the interior of the BAM 1020 and the inlet system should be kept clean and free of debris

For FEM BAMs:
Lower Detection Limit: < 4.8 ug/m^3 from 0.000 – 0.100 mg/m^3 (1 Hour)
Lower Detection Limit: < 1.0 ug/m^3 (24 Hour)

7. PERSONNEL QUALIFICATIONS AND RESPONSIBILITIES

Installation, operation, maintenance, repair or calibration of the instrument and all support equipment should only be performed by properly trained personnel. Personnel should meet all minimum BAAQMD requirements and qualifications for an Air Quality Instrument Specialist (AQIS) I or II, Senior Air Quality Instrument Specialist, and/or Supervising Air Quality Instrument Specialist.

The station operator AQIS is responsible for the operation and oversight of the instrument and all support equipment. The operator shall complete any required or recommended maintenance, minor repairs and/or occasional calibration of the instrument and all support equipment. The station operator AQIS is responsible for all DMS data review and validation. The station operator AQIS may occasionally install or replace an instrument or support equipment. The Senior AQIS and Supervisor AQIS complete major installations, repairs and calibrations.

BAAQMD MQA personnel manage the DMS and complete all final data review and submittal.

BAAQMD PEG staff may conduct periodic performance and/or system's audits.

CARB staff may conduct periodic performance and/or system's audits.

EPA staff may conduct periodic performance and/or system's audits.

8. EQUIPMENT AND SUPPLIES

The BAM 1020 is installed and operated with the following equipment:

- BAM 1020 monitor and accessories
- BX-596 ambient temperature and barometric pressure combination sensor (FEM BAM 1020)
- BX-592 ambient temperature sensor (non-FEM BAM 1020)
- BX-827 (110V) Smart Inlet Heater
- Standard glass fibers filter tape.
- Vacuum pump including tubing and wiring
- Inlet tubing
- Inlet support brackets
- PM10 FRM inlet
- PM2.5 VSCC cyclone (FEM BAM 1020)
- PM2.5 SCC cyclone (non-FEM BAM 1020)

The following equipment may be used for a BAM 1020 installation inside a station:

- Pump box with internal 120 VAC outlet
- BX-823 eight foot inlet tube extension
- BX-801 roof flange mounting kit and plate
- 4 lag screws for roof mounting plate.
- Weather proof silicon or roof sealant

The following equipment may be used for BAM 1020 installation in a weatherproof enclosure:

- Rack mounting screws
- AC unit
- Heater
- Cabinet temperature sensor

The following equipment is required or recommended for BAM 1020 installation, calibration and maintenance:

- Certified NIST (National Institute of Standards and Technology) traceable flow standard such as a Delta Cal;
- Certified NIST traceable pressure standard such as a Druck;
- Certified NIST traceable temperature standard such as a TEGAM;
- BX-302 zero filter calibration kit
- methanol, cleaning aids such as wipes and cotton tipped swabs

- extra glass fiber filter tapes
- vacuum grease
- Assorted tools such as Allen wrenches, Philips screwdriver's, socket set, Hole-saw 2 1/4"), etc.

9. PROCEDURES

9.1 INITIAL SETUP

NOTE: Please refer to the appropriate BAM 1020 Operation's Manual for further information

NOTE: The following should be considered when planning an installation.

- BAM 1020 monitors should be deployed following all 40 CFR 58 Appendix E sitting requirements for PM2.5. This includes the inlet height, distance, distance to other PM2.5 or PM10 samplers, distance from roadways, trees, walls, etc.;
- The BAM 1020 must not be installed near any flue, fan, exhaust (from an HVAC unit), blower, dusty environments such as a dirt roadway, or any other source that might bias PM2.5 concentration measurements;
- The BAM 1020 must be installed on a level solid surface capable of supporting its weight;
- In a typical BAAQMD air-monitoring station, the vacuum pump is normally installed into a separate pump box;
- Separate AC power outlets must be available for the monitor, the vacuum pump and the Smart Heater. A GFI protected circuit is required for a rooftop shelter installation.

NOTE: If prompted for a password**,** the factory default password is **F1, F2, F3, and F4**.

1. Complete all roof modifications (for a new install);
2. If using a weatherproof enclosure, install the enclosure following the instructions supplied by Met One.
3. Install BAM;
4. Install the inlet tube; **NOTE**: Proper alignment is very critical!
5. Install the BAM 1020 Smart Heater**;**
6. Install the BX-596 (temperature and pressure, FEM BAM 1020) sensor or the BX-592 (temperature only non-FEM BAM 1020) sensor;
7. Install the $PM_{2.5}$ VSCC (FEM BAM 1020) or the SCC (non-FEM BAM 1020) onto the top of the inlet tube. Use o-ring lubricant as needed.
8. Install the PM_{10} head on top of the VSCC (or SCC). Use o-ring lubricant as needed.
9. Complete all electrical and pneumatic connections**;**
10. For weatherproof enclosure installation:
    a. Install the cabinet temperature sensor in a suitable location inside the enclosure;

b. Connect a suitable length of 2-wire cable from the cabinet temperature sensor to the back of the BAM 1020 channel 1;
c. Plug in the cabinet temperature sensor power supply cable into an AC outlet;

11. Plug the BAM 1020 into a grounded AC power supply;
12. Switch on the power switch located on the back of the unit directly above the power cord. When power is switched on the main menu screen should appear after a few seconds. The unit will probably flash an error indicating that there is no filter tape installed.
13. Install tape (**NOTE**: Section 9.5.2 of this SOP)
14. Press the **SETUP** soft-key to enter the various setup menus. Use the arrow keys to navigate to the desired field, and then press the **SELECT** soft-key to enter.
15. Allow BAM to warm up at least 1 hour.

9.2 ACCEPTANCE TESTING

NOTE: Please refer to the appropriate BAM 1020 Operation's Manual for further information.

Staff will conduct acceptance testing on new instruments prior to deployment in the field. Setup BAM following the steps in Section 9.1 of this SOP.

1. Calibrate BAM (Section 9.3 of this SOP);
2. Complete a Leak Check and SELF TEST;
3. Setup to operate for a minimum of 1 week in a simulated station;
4. Check 5-minute and hourly data and parameters for stability, repeatability, flags and/or alarms, or any other atypical performance; Check tape for pinholes, debris on nozzle, etc.
5. Enter any pertinent information into the appropriate DMS instrument e-log;
6. New instruments should have a BAAQMD S/N assigned.

9.3 CALIBRATION AND VERIFICATION

NOTE: Please refer to the appropriate BAM 1020 Operation's Manual for further information.

NOTE: Met One recommends performing a leak check and nozzle cleaning before flow calibrations, as a leak can affect the flow.

NOTE: When calibrating the BAM 1020, a password may be required. The default password is **F1 F2 F3 F4**.

9.3.1 Procedure: Calibration of a FEM BAM

A FEM BAM 1020 must be calibrated upon installation, after major repairs, etc., and whenever required thereafter.

1. Press the **OPERATE** soft-key at the main menu to enter the operate menu;
2. To stop sampling, toggle the up/down arrows and select OFF.

3. Remove the PM10 inlet from the BAM 1020. All calibrations should be completed with the PM2.5 VSCC inlet in place.
4. Place a certified flow transfer standard (Delta Cal) onto the PM2.5 VSCC inlet. Turn the Delta Cal power switch on with no flow being pulled through the BAM 1020.
5. Place the temperature transfer standard (TEGAM) probe into a suitable location near the BAM 1020 temperature/pressure sensor (locate inside the temperature/BP radiation shield without touching the probe against any other surface). Turn on the TEGAM.
6. Place the pressure standard (DRUCK) in a suitable location avoiding direct sunlight if possible. Turn on the DRUCK. Allow all standards to equilibrate
7. Enter the **TEST > FLOW** menu
8. Measure the ambient temperature with your reference standard positioned near the ambient temperature probe. Enter the value from the reference temperature standard into the STD field using the arrow keys. Press the **CAL** hot key to correct the BAM 1020 reading. The BAM and STD values should now be the same.
9. Press the **NEXT** hot key to move the <CAL> indicator to the BP field, and repeat the same steps for barometric pressure.
10. After the temperature and pressure readings are correct, press the **NEXT** hot key to move the <CAL> indicator to the first flow point of 15.0 lpm. The pump will turn on automatically. Allow the unit to regulate the flow until the BAM 1020 reading stabilizes at the target flow rate. Enter the flow value from the flow standard into the STD field using the arrow keys. Press the **CAL** hot key to correct the BAM 1020 reading. **NOTE:** The BAM 1020 reading will not change to match the STD until after you have entered all three calibration points.
11. Press the **NEXT** hot key to move the <CAL> indicator to the second flow point of 18.3 lpm and repeat the process.
12. Press the **NEXT** hot key to move the <CAL> indicator to the third flow point of 16.7 lpm and repeat the process. Enter the flow value and press <**CAL**>.
13. When all of the calibrations are complete, the BAM 1020 flow readings should match the traceable flow standard reading at 16.7 lpm, +/- 0.1 lpm.
14. Exit the calibration menu.
15. Place the BAM 1020 into normal operation mode.
16. Record all pertinent information into the instrument e-log.

9.3.2 Procedure: Calibration of a non-FEM BAM

A BAM 1020 must be calibrated upon installation, after major repairs, etc., and whenever required thereafter.

1. Press the **OPERATE** soft-key at the main menu to enter the operate menu.
2. To stop sampling, toggle the up/down arrows and select OFF.
3. Remove the PM10 inlet from the BAM 1020. All calibrations should be completed with the PM2.5 SCC inlet in place.
4. Place a certified flow transfer standard (Delta Cal) onto the PM2.5 SCC inlet. Turn the Delta Cal power switch on with no flow being pulled through the BAM 1020.

5. Place the temperature transfer standard (TEGAM) probe into a suitable location near the BAM 1020 temperature sensor (locate inside the temperature radiation shield without touching the probe against any other surface). Turn on the TEGAM.
6. Place the pressure standard (DRUCK) in a suitable location avoiding direct sunlight if possible. Turn on the DRUCK. Allow all standards to equilibrate.
7. Enter the **TEST > FLOW** menu.
8. Measure the ambient temperature with your reference standard positioned near the ambient temperature probe. Enter the value from the reference temperature standard into the STD field using the arrow keys. Press the **ADJUST/SAVE** hot key to correct the BAM 1020 reading. The BAM and STD values should now be the same.
9. Press the **NEXT** hot key to move the <CAL> indicator to the BP field, and repeat the same steps for barometric pressure.
10. After the temperature and pressure readings are correct, press the **NEXT** hot key to move the <CAL> indicator to the Volumetric Flow-rate line. The pump will turn on automatically. Allow the unit to regulate the flow until the BAM 1020 reading stabilizes at the target flow rate. Enter the flow value from the flow standard into the STD field using the arrow keys. Press the **ADJUST/SAVE** hot key to correct the BAM 1020 reading.
11. When all of the calibrations are complete, the BAM 1020 flow readings should match the traceable flow standard reading at 16.7 lpm, +/- 0.1 lpm.
12. Exit the calibration menu.
13. Place the BAM 1020 into normal operation mode.
14. Record all pertinent information into the instrument e-log.

9.3.3 Procedure: Bi-weekly Verification of a FEM BAM

The FEM BAM 1020 flow and its sensors must be verified bi-weekly.

1. Press the **OPERATE** soft-key at the main menu to enter the operate menu;
2. To stop sampling, toggle the up/down arrows and select OFF.
3. Remove the PM10 inlet from the BAM 1020. All verifications should be completed with the PM2.5 VSCC inlet in place.
4. Place a certified flow transfer standard (Delta Cal) onto the PM2.5 VSCC inlet. Turn the Delta Cal power switch on with no flow being pulled through the BAM 1020.
5. Place the temperature transfer standard (TEGAM) probe into a suitable location near the BAM 1020 temperature/pressure sensor (locate inside the temperature/BP radiation shield without touching the probe against any other surface). Turn on the TEGAM.
6. Place the pressure standard (DRUCK) in a suitable location avoiding direct sunlight if possible. Turn on the DRUCK. Allow all standards to equilibrate
7. Enter the **TEST > FLOW** menu
8. Measure the ambient temperature with your reference standard positioned near the ambient temperature probe. Compare the reference temperature standard value to the BAM 1020 reading. Take 3 consecutive readings.
9. Press the **NEXT** hot key to move the <CAL> indicator to the BP field; Compare the reference barometric pressure standard value to the BAM 1020 reading.

10. After the temperature and pressure readings are verified, press the **NEXT** hot key to move the <CAL> indicator to the last flow point of 16.7 lpm. The pump will turn on automatically. Allow the unit to regulate the flow until the BAM 1020 reading stabilizes at the target flow rate. Compare the reference flow standard value to the BAM 1020 reading. Take 3 consecutive readings; Re-calibrate and re-verify if any parameters (temperature, pressure, flow) are outside of the BAAQMD acceptance criteria;
11. Complete a leak check, clean the nozzle; complete a SELF-TEST;
12. Place the BAM into normal operation mode.
13. Record all pertinent information into the instrument e-log.

ITEM	ACCEPTANCE CRITERIA	ACTION
Time	+/- 2 min	Reset clock
Leak Check	≤ 1.0 lpm	Find source of leak and correct
Temperature	+/- 2 ‘C	Recalibrate if necessary
Pressure	+/- 10 mmHg	Recalibrate if necessary
Flow	16.7 l/m +/- 3% (16.2 – 17.2)	Recalibrate if necessary

Figure 1: BAM acceptance criteria

9.3.4 Procedure: Bi-weekly Verification of a non-FEM BAM

The BAM 1020 flow and its sensors must be verified bi-weekly. Re-calibrate if any parameters (temperature, pressure, flow) are outside of the BAAQMD acceptance criteria;

1. Press the **OPERATE** soft-key at the main menu to enter the operate menu.
2. To stop sampling, toggle the up/down arrows and select OFF.
3. Remove the PM10 inlet from the BAM 1020. All calibrations should be completed with the PM2.5 SCC inlet in place.
4. Place a certified flow transfer standard (Delta Cal) onto the PM2.5 SCC inlet. Turn the Delta Cal power switch on with no flow being pulled through the BAM 1020.
5. Place the temperature transfer standard (TEGAM) probe into a suitable location near the BAM 1020 temperature sensor (locate inside the temperature radiation shield without touching the probe against any other surface). Turn on the TEGAM.
6. Place the pressure standard (DRUCK) in a suitable location avoiding direct sunlight if possible. Turn on the DRUCK. Allow all standards to equilibrate.
7. Enter the **TEST > FLOW** menu.
8. Place the temperature transfer standard (TEGAM) probe into a suitable location near the BAM 1020 temperature/pressure sensor (locate inside the temperature/BP radiation shield without touching the probe against any other surface). Turn on the TEGAM.
9. Place the pressure standard (DRUCK) in a suitable location avoiding direct sunlight if possible. Turn on the DRUCK. Allow all standards to equilibrate
10. Enter the **TEST > FLOW** menu

11. Measure the ambient temperature with your reference standard positioned near the ambient temperature probe. Compare the reference temperature standard value to the BAM 1020 reading. Take 3 consecutive readings.
12. Press the **NEXT** hot key to move the <CAL> indicator to the BP field; Compare the reference barometric pressure standard value to the BAM 1020 reading.
13. After the temperature and pressure readings are verified, press the **NEXT** hot key to move the <CAL> indicator to the Volumetric Flow-rate line. The pump will turn on automatically. Allow the unit to regulate the flow until the BAM 1020 reading stabilizes at the target flow rate. Compare the reference flow standard value to the BAM 1020 reading. Take 3 consecutive readings; Re-calibrate and re-verify if any parameters (temperature, pressure, flow) are outside of the BAAQMD acceptance criteria;
14. Complete a leak check, clean the nozzle; complete a SELF-TEST;
15. Place the BAM into normal operation mode.
16. Record all pertinent information into the instrument e-log.

9.3.5 Procedure: Leak Check

Leak checks should be performed after a calibration, bi-weekly thereafter, and whenever the filter tape is changed. Perform an as-found leak checks (before cleaning the nozzle and vane). Investigate and correct any leak check result > 1.0 lpm.

1. Remove the PM10 head (or the Delta Cal flow transfer standard) from the inlet tube. Do not remove the VSCC or SCC. Install a BX-305 or BX-302 leak test valve (or equivalent valve for auditing FRM samplers) onto the inlet tube. Turn the valve to the OPEN position.
2. In the **TEST > TAPE** menu, advance the tape to a fresh, unused spot.
3. In the **TEST > PUMP** menu, turn on the pump. Slowly close the valve. The indicated flow rate should drop below **1.0 lpm**. If the leak flow value is 1.0 lpm or greater, then the nozzle and vane need cleaning, or there may be another small leak in the system.
4. Remove the leak test valve, and re-install the PM10 inlet head.
5. Press the **OPERATE** soft-key at the main menu to enter the operate menu screen. To start sampling, toggle the up/down arrows and select ON.
6. Press **EXIT** to return to the Main screen.
7. Place the BAM 1020 into normal operation mode.
8. Record all pertinent information into the instrument e-log.

9.3.6 Procedure: SELF-TEST

The self-test should be completed after each filter tape change, after any flow or leak checks, after cleaning the nozzle, and can also be used if the operator suspects a problem with the unit.

1. The self-test feature is located in the TAPE menu. Press the **TAPE** hot key.
2. Press the **SELF TEST** soft-key to start the test. The tests will take a couple of minutes, and the BAM 1020 will display the results of each tested item with an **OK** or a **FAIL** tag. If all of the test items are OK, the status will show SELF TEST PASSED as shown in the drawing above. If any item fails, the status will show ERROR OCCURRED.

3. Exit back to the Main screen
4. Place the BAM 1020 into normal operation mode.
5. Record all pertinent information into the instrument e-log.

9.4 AUTO-CALIBRATION, 'AUTO-CALS'

This section is left intentionally blank and is not applicable.

9.5 SERVICE AND MAINTENANCE

The operator shall perform all recommended or required diagnostic checks, service and maintenance. The following table is a suggested general guideline for service and maintenance.

NOTE: Please refer to the appropriate BAM 1020 Operation's Manual for further information.

Maintenance Item	Suggested Period	SOP Section
Flow/Temperature/Pressure Verification and/or calibration	Bi-weekly	9.3.1, 9.3.2, 9.3.3, 9.3.4
Leak Check	Bi-weekly	9.3.5
Run SELF-TEST Function	Bi-weekly	9.3.6
Nozzle and Vane Cleaning	Bi-weekly	9.5.1
Clean Capstan Shaft and Pinch Roller Tires*	Monthly	BAM Manual
Clean PM10 Head/PM2.5 Inlet	Monthly	BAM Manual
Load/Replace Filter Tape	2 Months	9.5.2
Replace or Clean Pump Muffler (if used)	6 months	BAM Manual
Perform 72 hour BKGD (BX-302 zero filter) test	12 months	9.5.3
Clean Radiation Shield	12 Months	9.5.4
Clean Internal Debris Filter	12 Months	BAM Manual
Check Membrane Span Foil	12 Months	BAM Manual
Clean Inlet Tube	12 months	BAM Manual
Rebuild Vacuum Pump*	24 months	BAM Manual
Replace Nozzle O-ring	24 months	BAM Manual
Replace Pump Tubing	24 Months	BAM Manual

*****These items may be performed more often as required.

9.5.1 Procedure: Nozzle and Vane Cleaning

The nozzle and vane (located under the nozzle) must be cleaned regularly to prevent leaks and measurement errors or even punching small holes in the filter tape. The cleaning must be done at least each time the filter tape is changed, though bi-weekly cleaning is highly recommended. Some sites will require more frequent cleaning.

1. Raise nozzle in the **TEST > PUMP** menu; release caption roller assembly; Remove filter tape from the nozzle area;
2. With the nozzle up, use a small flashlight to inspect the cross-hair vane.
3. Clean the vane with a cotton-tipped applicator and alcohol. Hardened deposits may have to be carefully scraped off with the wooden end of the applicator or a dental pick or similar tool.
4. Lower nozzle in the **TEST > PUMP** menu. Lift nozzle with your finger and insert another cotton swab with alcohol between the nozzle and the vane. Let the nozzle press down onto the swab with its spring pressure.
5. Use your fingers to rotate the nozzle while keeping the swab in place. A few rotations should clean the nozzle lip.
6. Repeat the nozzle cleaning until the swabs come out clean.
7. Inspect the nozzle lip and vane for any burrs which may cause leaks or tape damage.
8. Replace tape; engage roller caption assembly;
9. Run a SELF TEST;
10. Place the BAM into normal operation mode.
11. Record all pertinent information into the instrument e-log.

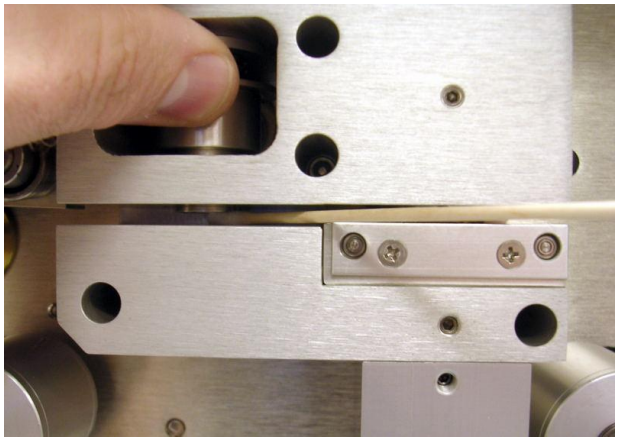

Figure 2: Nozzle Cleaning

NOTE: The figure below shows the difference between good and bad filter tape spots. The tape on the left is from a properly operated BAM with a clean nozzle and vane. Notice the particulate spots have very crisp edges, are perfectly round, and are evenly distributed.

The tape on the right is from a unit which has not been properly maintained. A spot of debris has built up on the vane, and is punching a pin-hole at the edge of each spot. These holes can allow

beta particles to get through un-attenuated which negatively may affect accuracy even if the nozzle is not leaking. The spots also show a “halo” effect due to air leaking in around the edged because the debris has built up to the extent that the nozzle no longer seals correctly. These faults are easily corrected and prevented by keeping the nozzle and vane clean.

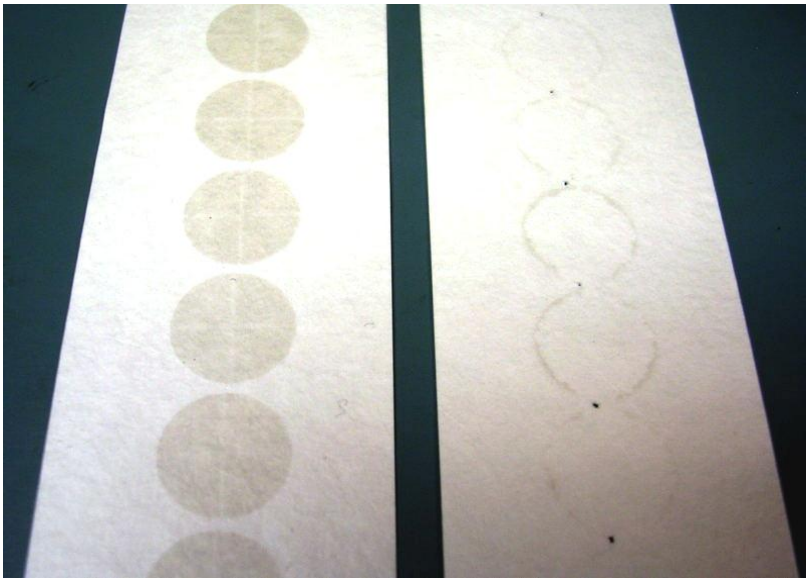

Figure 3: BAM Tape pin-holes

9.5.2 Procedure: Load/Replace Filter Tape

Follow these steps to load filter tape:

1. Raise nozzle in the **TEST > PUMP** menu; release caption roller assembly;
2. Unscrew and remove both clear plastic spool covers.
3. Remove remainder of old tape;
4. Install an empty core tube on the left (take-up) reel hub.
5. Load the new roll of filter tape onto the right (supply) reel, and route the tape through the transport assembly as shown in the drawing. Attach the loose end of the filter tape to the empty core tube with cellophane tape or equivalent.
6. Rotate the tape roll by hand to remove excess slack, and then install the clear plastic spool covers. The covers will clamp the rolls to the hubs to prevent slipping.
7. Align the filter tape so that it is centered on all of the rollers. Newer units have score marks on the rollers to aide in visually centering the tape.
8. Engage roller caption assembly;
9. Run a SELF TEST;
10. Place the BAM into normal operation mode.
11. Record all pertinent information into the instrument e-log.

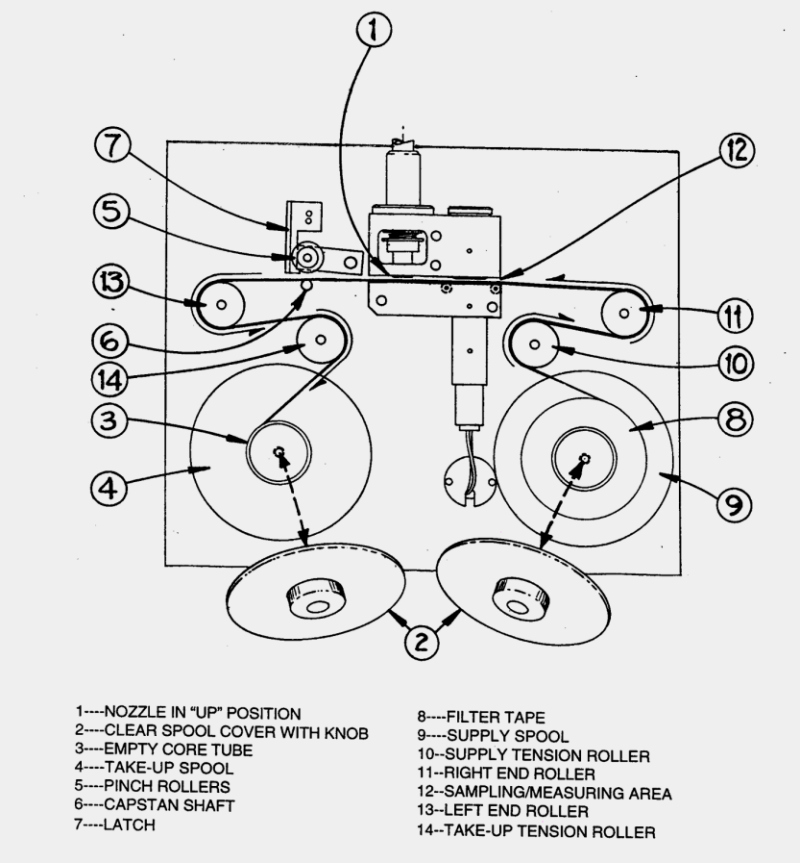

Figure 4: Tape Loading Schematic

9.5.3 Procedure: 72-Hour Zero-Filter BKGD Test

The BAM 1020 must pass a 72-hour zero-filter test upon initial installation and annually thereafter. This is determined by running the unit for at least 72 hours with a 0.2 micron zero-filter on the inlet. The concentration values over this time period are averaged, and entered as a new BKGD which is the negative of this average.

The BKGD value is typically between 0.000 and -0.005 mg/m^3. The test corrects the BKGD value to compensate for minor variations caused by local conditions such as grounding and shelter characteristics. This results in optimum accuracy at lower concentrations typical of $PM_{2.5}$ levels. The test also provides information about the zero noise levels of the unit being tested. The test should not be performed during a period of rapidly changing weather. A complete set of instructions for the test are included with the BX-302 kit.

WARNING: This is a unit-specific calibration value which may significantly affect the accuracy of the unit!

NOTE: The BKGD value is not to be confused with the OFFSET (range offset) value in the SETUP > SAMPLE menu.

1. Stop operation of the BAM;
2. Disable the appropriate DAS channel;
3. Select the **SETUP > CALIBRATE** screen. Record the current BKGD setting. Change the BKGD setting = 0.000. Press **SAVE** and then **EXIT**.
4. Complete a full calibration of the BAM;
5. Clean BAM nozzle;
6. Remove the PM10 inlet. Place a clean BX-302 filter onto the PM2.5 VSCC inlet or PM2.5 SCC;
7. Complete a leak check using the valve on the BX-302 filter;
8. Place the BAM into normal operation for a minimum of 76 hours. **NOTE**: The first four hours of data will be discarded;
9. Record all pertinent information into the instrument e-log.
10. After at least 76 hours, download the appropriate BAM 1020 concentration data for the DMS;
11. Open EXCEL; open the file of the downloaded data;
12. Calculate the following. Repeat if the following criteria are not met:

    NEW BKG: +/- 0.0020 FROM PREVIOUS
    STDEV < 0.0024
    MIN: < -0.015 (FEM BAM) < -0.005 (non-FEM BAM)
    MAX: < 0.020
    DIFF: < 0.015

13. After the completion of a passing 72-hour filter test, select the **SETUP > CALIBRATE** screen. Enter the new BKGD setting. Press **SAVE** and then **EXIT.**
14. Remove the BX-302 filter; place the PM10 inlet back onto the PM2.5 VSCC (or SCC).
15. Place the BAM 1020 back into normal operation;
16. Enable the appropriate DAS channel;
17. Flag all DMS BAM 1020 concentration data for the appropriate 72-hour period data QC Code as Valid;
18. Change all valid DMS BAM 1020 concentration data for the appropriate 72-hour period data OP Code = 100
19. Record all pertinent information into the instrument e-log.
20. Save and place a copy of the raw data onto the District server;

9.6 SAMPLE COLLECTION

NOTE: This SOP section is non-applicable and is left intentionally blank

9.7 SAMPLE HANDLING AND PRESERVATION

NOTE: This SOP section is non-applicable and is left intentionally blank

9.8 SAMPLE PREPARATION AND ANALYSIS

NOTE: This SOP section is non-applicable and is left intentionally blank

9.9 TROUBLESHOOTING

NOTE: Please refer to the appropriate BAM Operation Manual troubleshooting guide for further information.

NOTE: The operator should utilize the DMS to track and record various parameters (parametric data) which may be helpful for troubleshooting.

NOTE: 1-hour DMS data also includes instrument flags. For diagnostic flag codes, please refer to Appendix A of this SOP.

The operator should be aware of the following:

- Abnormal or out-of-range concentration values on instrument front display;
- 'Alarm' or alarm icon present on the front display;
- Abnormal DAS or DMS instrument diagnostic flags;
- Abnormal or unusual calibration results;
- Unusual sounds or changes in sounds over time (pump)

The operator should take the appropriate steps to resolve any instrument issue:

- Troubleshoot to identify faulty component or support equipment;
- Repair instrument or support equipment;
- Check and verify instrument's performance; re-calibrate if needed;
- Review and invalidate any data that does not meet the criteria in Section 11 of this SOP;
- Review and validate or invalidate any questionable data as 'suspect';

- Maintain the appropriate DMS instrument and/or station e-log. The operator must enter the appropriate information after the completion of any repairs, maintenance, or adjustments. The operator should note any data gaps.
- In cases of instrument failure or inability to repair on-site, the operator should contact the Senior AQIS and/or the Supervising AQIS in order to coordinate replacement of the instrument.

9.10 COMPUTER HARDWARE AND SOFTWARE

The BAM is connected to a BAAQMD station DAS via its Serial RS-232 Port. The DAS collects 5-minute and hourly data. All BAM parameters must be set accordingly. No further data calculations or reduction are required.

- DAS: The operator should be familiar with operation of the station's DAS and the DAS manual calibration script files
- DMS: Operator should be familiar with the operation of the DMS software including data review, auto-cal response data review, e-log entry, etc.

9.10.1 Procedure: Configuring Bam 1020 Serial Ports

The BAM 1020 RS-232 serial ports must be set up to communicate with the DAS:

NOTE: The BAM 1020 display must be on the Main Menu in order to establish communications.

1. Temporarily remove any other connection to the BAM 1020 RS-232 Port on the back of the monitor.
2. Connect the RS-232 port on the back of the BAM 1020 to your computer or laptop using the appropriate cable. Connect to the Com1 serial port if available.
3. Open HyperTerminal or ProComm and connect to the BAM 1020. Press the computer's return button a couple times. An asterisk (*) should appear. If not, depress the small white and red polarity toggle switch located next to the RS232 connector on the back of the BAM 1020.
4. Once communication is established, press the **h** key. The **> BAM 1020 < System** menu should appear;
5. Press the **8** key. The **> BAM 1020 < Utility Commands** menu should appear;
6. Press the '**a'** key. **NOTE**: This command is NOT shown in the BAM 1020 Utility Commands menu. The **RS-232 Port #2 Function S**elect menu should appear;
7. Press the '**4'** key. The message "RS-232 set as Comma Separated Data Port" should appear;
8. Next, again press the '**H'** key. The **> BAM 1020 < System Menu** should appear.
9. Press the '**8'** key to re-enter the **> BAM 1020** < Utility Commands menu.
10. Press the '**z**' key. This enables the Printer port it to output a fixed-width concentration report at the end of the sample period, which can be used to interface to a serial data logger.
11. The message "Concentration report enabled" should appear;

12. Next, again press the '**H'** key. The > **BAM 1020 < System Menu** should appear. Select Transfer > Capture Text from the HyperTerminal drop-down menu. Select a location for the file, and then click the "Start" button.
13. Next, press the '**4**' key. **File 4: Display System Configuration**. This file will contain a list of most of the BAM 1020 settings and calibration values as shown on the next page. This is useful for verifying the setup on a remote BAM 1020, and to send to the factory if service is required. The setting report has been updated and reformatted.
14. Retrieve the desired files, and HyperTerminal will automatically store them to the text file.
15. When completed, exit HyperTerminal.
16. Reconnect the DAS serial connection.
17. Check for DAS 5-minute BAM meta data updates
18. Check for DAS hourly BAM concentration data updates

10. DATA AND RECORDS MANAGEMENT

Hourly concentration ($\mu g/m^3$) and sampling volume data is collected by the station's DAS. The station DAS pushes new data to the BAAQMD DMS every hour where it is reviewed by AirMon staff. Five-minute instrument parametric data are also collected by the station's DAS and used for quality control purposes.

BAM parametric data may include various instrument operating parameters such as flow volume, RH, cabinet temperature, ambient temperature and instrument flags (**NOTE**: please refer to the appropriate BAM Operation manual and Appendix A of this SOP for an explanation of diagnostic flags). The operator is encouraged to use the instrument parametric data as an aid to data review and validation and for troubleshooting

District staff are responsible for data and records management including oversight of data capture into a station DAS, data ingestion into the District DMS, data review and validation, and data retention.

The operator is responsible for the following:

- Review and validate or invalidate any data that does not meet the criteria in Section 11 of this SOP;
- Review and validate or invalidate any questionable data as 'suspect';
- Maintain the appropriate DMS instrument and/or station e-log. The operator must enter the appropriate information after the completion of any repairs, maintenance, or adjustments. The operator should note any data gaps. The operator may elect to manually collect data from the analyzer in the event of a DAS data collection error

11. QUALITY CONTROL AND QUALITY ASSURANCE

Quality Control (QC) procedures include the completion of any required calibrations, service and maintenance. Quality Assurance (QA) procedures include the completion of any required audits.

11.1 QUALITY CONTROL

- The operator will adjust the BAM if bi-weekly verification results are outside of the acceptable BAAQMD QC limits. QC limits are developed to provide an early warning of instrument problems prior to the exceedance of a Measurement Quality Objective (MQO). If a QC measurement is outside the specified quality control limit, the source of the problem is to be investigated and corrected.
- Violation of a QC limit does not require data action as long as an MQO is not also exceeded.
- If any MQO's are exceeded, the source of the problem is to be investigated and corrected and the operator shall invalidate all suspect or questionable DMS data **unless** the error is a result of other equipment (i.e., power-failure, etc.) **and** the operator has demonstrated that the instrument is functioning within its specified operating parameters.
- The operator shall perform all recommended or required diagnostic checks, service and maintenance. Please refer to Section 9.5 of this SOP and the appropriate instrument manual for more information.

$PM_{2.5}$ Beta Attenuation	Flow Rate Verification	Biweekly	≤ ± 3% of std. ≤ ± 4% of design
	Leak Check	Biweekly	≤ 1.0 L/min
	Pressure Verification	Biweekly	≤ ± 10 mmHg
	Temperature Verification	Biweekly	≤ ± 2 °C

Figure 5: BAAQMD QC Limits for BAM

$PM_{2.5}$ Beta Attenuation [2]	Flow Rate Verification	Biweekly	≤ ± 4% of std. ≤ ± 5% of design
	Leak Check	Biweekly	≤ 1 L/min
	Pressure Verification	Biweekly	≤ ± 10 mmHg
	Temperature Verification	Biweekly	≤ ± 2 °C
	Precision (flow rates)	Annual	≤ 10%
	Bias (flow rates)	Annual	≤ ± 10%

Figure 6: BAAQMD MQO's for BAM

11.2 QUALITY ASSURANCE

Quality Assurance activities include the following:

- District staff shall conduct performance and system's audits on a regular basis.
- CARB staff may conduct performance and/or systems audits
- EPA staff may conduct performance and/or systems audits

12. AUTHORS

- Original Author: Robert Shusteritsch, BAAQMD AQIS, 7/26/2005
- Revised By: Stan Yamaichi, BAAQMD Supervising AQIS, 5/30/2008
- Revised by: Christopher Rumm, BAAQMD AQIS, 1/12/2011, New SOP for FEM BAM 1020
- Revision to AM validation procedures by S Randall, BAAQMD Supervising AQIS, Jan. 2011
- Revised by: Christopher Rumm, BAAQMD AQIS, 06/27/2012, final formatting; minor changes to 72 hour test procedure

13. REFERENCES

- Met One BAM 1020 Particulate Monitor Manual, Rev G and H
- Met One website: http://www.metone.com/

APPENDIX A: BAM 1020 ERROR CODES

ERROR CODE	TYPE	CAUSE	SOLUTION
E	**EXTERNAL RESET**	**System clock reset error**	Check the DAS
U	**TELEMETRY FAULT**	external DAS has sent an error	Check the DAS
M	**MAINTENANCE**	Calibration or testing was performed during the flagged hour.	**N/A**
I	**INTERNAL CPU**	error in the mass concentration calculation	Contact the Service department if these errors occur frequently
L	**POWER FAIL**	Even a split second power failure will cause an "L" error. This will interrupt the sample cycle until the top of the next hour. Power is cycled or lost, even momentarily. Frequent "**L**" errors usually indicate internal voltage too low	The 5 volt DC power supply output must be set to 5.25 volts. Contact the Service dept. for instructions to check or adjust this. The CHASSIS terminal needs to be connected to a good earth ground. Plug BAM 1020 into a computer-style UPS. Local high power RF fields must be avoided if possible.
R	**REFERENCE MEMBRANE**	assembly is not physically extending and retracting properly	**Test operation; Clean assembly, Check** photo sensors S2 and S3;
N	**NOZZLE STUCK TIMEOUT**	nozzle motor is not operating or Delta-T exceeded	**Test operation, Check nozzle alignment**
F	**FLOW ERROR** **or** **BX-596 TEMP/BP SENSOR ERROR**	**Low or high flow** **Sensor failure**	**Check pump, vacuum tubing, flow controller flow sensor** **Test sensor, cable, replace sensor/cable**
P	**PRESSURE DROP**	vacuum beneath the filter tape has exceeded the limit	**Check flow system**

ERROR CODE	TYPE	CAUSE	SOLUTION
	EXCESSIVE	set by the **AP** value; high concentrations, or certain types of particulate clogging the filter tape	
D	**DEVIANT MEMBRANE DENSITY**	Reference membrane span check measurement (**m)** for that hour was out of agreement with the expected value (**ABS**) by more than ±5%.	Check operation, check for a dirty or damaged membrane
C	**COUNT ERROR**	beta particle counting system error or failure	Check for stuck membrane; Run Count Test; Contact met One
T	**TAPE BREAK**	filter tape is broken or has run out; pinch roller assembly has been left latched	Check tape and pinch roller latch
AP	**PRESSURE-DROP LIMIT ACROSS THE FILTER TAPE**	See the PRESSURE DROP EXCESSIVE	See the PRESSURE DROP EXCESSIVE
FRl	**FLOW RATE LOWER LIMIT**	The default setting is **10** lpm	See the FLOW OUT OF LIMITS
FRh	**FLOW RATE HIGHER LIMIT**	The default setting is **20** lpm	See the FLOW OUT OF LIMITS

APPENDIX B: EXAMPLE OF A BAM 1020 CONFIGURATION REPORT

```
BAM Settings Report
01/10/2011  09:39:17

     Station ID, 1

       Firmware, 3236-05 V3.6.1

              K, 00.991
           BKGD, 0.0034
            usw, 00.309
            ABS, 00.868
          Range, 1.000
         Offset, -0.015
          Clamp, -0.015
     Conc Units, mg/m3
      Conc Type, ACTUAL
     Count Time, 8

             Cv, 00.989
             Qo, 00.000
      Flow Type, ACTUAL
     Flow Setpt, 0016.7
       Std Temp, 25
High Flow Alarm, 20
 Low Flow Alarm, 10

      Heat Mode, AUTO
   Heat OFF (%), 20
        RH Ctrl, YES
       RH SetPt, 35
         RH Log, YES
        DT Ctrl, NO
       DT SetPt, 99
         DT Log, NO

     BAM 1020 Sample, 42
     MET Sample, 5
     Cycle Mode, EARLY
 Fault Polarity, NORM
 Reset Polarity, NORM
    Maintenance, OFF

   EUMILRNFPDCT
   111111111111

             AP, 000150
      Baud Rate, 9600
 Printer Report, 5
             e3, 00.000
             e4, 15.000
```

```
      Channel,       1,       2,       3,       4,       5,       6,
    Sensor ID,     255,     255,     255,     255,     255,      35,
   Channel ID,     255,     255,     255,     255,     255,     254,
         Name,        ,        ,        ,   RH   ,   Delta,     AT ,
        Units,        ,        ,        ,     %  ,     C  ,     C  ,
         Prec,       0,       0,       0,       0,       1,       1,
    FS Volts,   1.000,   1.000,   1.000,   0.500,   2.500,   2.500,
         Mult,       1,       1,       1,      32,  -147.1,    95.0,
       Offset,       0,       0,       0,     -26,    95.8,   -40.0,
  Vect/Scalar,       S,       S,       S,       S,       S,       S,
    Inv Slope,       N,       N,       N,       N,       N,       N,

  Calibration,   Offset,    Slope,
         Flow,   -0.322,    1.020,
           AT,   -0.987,
           BP,   -1.000,
           RH,    7.412,
           FT,    0.000,

        QUERY,        1,     CONC,
  Daily Range, 00:00 - 23:00
X2138
```