SANTA BARBARA COUNTY AIR POLLUTION CONTROL DISTRICT

STANDARD OPERATING PROCEDURES

FOR

METONE BAM 1020
FOR PM10 AND PM2.5 FEM MONITORING

August 2017
SANTA BARBARA COUNTY AIR POLLUTION CONTROL DISTRICT

Approval of Standard Operating Procedures (SOP)
METONE BAM 1020
FOR PM10 AND PM2.5 FEM MONITORING

| APPROVALS |
|------------------|------------------|------------------|
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FOR PM10 AND PM2.5 FEM MONITORING

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1.0 GENERAL INFORMATION

1.1 Introduction
This Standard Operating Procedure (SOP) describes procedures used by the Santa Barbara County Air Pollution Control District (SBCAPCD) to operate the MetOne Beta Attenuation Monitor, Model 1020 for the measurement of PM10 or PM2.5 in ambient air. This monitor will be referred to as “the instrument” unless otherwise required. This procedure is designed to supplement the instruction manual by describing hardware or operating procedures as implemented by the SBCAPCD for monitoring of PM10 or PM2.5 in the District’s ambient air monitoring network. It is not the intent of this SOP to duplicate or replace the instruction manual.

1.2 Principle of Operation
The BAM-1020 uses beta ray attenuation to calculate collected particle mass concentrations in units of ug/m3. A 14C element (60 μCi +/- 15 μCi) emits a constant source of low-energy electrons, also known as beta particles. The beta rays are attenuated as they collide with particles collected on a filter tape. The decrease in signal detected by the BAM-1020 scintillation counter is inversely proportional to the mass loading on the filter tape.

The BAM-1020 operates with an hourly cycle, where the instrument tape mechanism moves the tape between the sampling position and the mass measurement position. This cycle allows for a “mass measurement” by beta attenuation of the filter tape prior to sampling, followed by sampling for 50 minutes for PM10 and 42 minutes for PM2.5, followed by a final “mass measurement by beta attenuation of the filter tape after sampling. Hourly concentration of particulate (PM10 or PM2.5) is calculated by the instrument from the difference in mass between the post and pre sampling mass measurements and the volume of air sampled during the sampling period. Additionally, while the instrument is sampling, the mass verification of a membrane of known mass is performed to confirm proper operation of the mass measurement system of the instrument.

Each BAM 1020 is equipped with automated reference membranes. The BAM is configured so that the reference membrane values generated during each hourly cycle (older firmware) or one cycle every 24 hours (newer firmware) are instrument drift values, not to be confused with span values. The Met One BAM-1020 monitors include an eighty percent full scale reference membrane (approximately .800 mg/cm2). Each BAM-1020 monitor is deployed with a Met One BAM-1020 Operation Manual that is unique to that instrument. Appendix B of the BAM-1020 manual lists the calibration and membrane values specific to the serial number of the instrument indicated. The density of the reference membrane for the BAM-1020 can also viewed in the instruments set-up file, and from the set-up mode on the front panel as “ABS”, a value typically between 0.800 to 0.850 mg/cm2. Each hour, this membrane is automatically positioned in the beta path and analyzed for instrument drift. The analysis of this membrane is integrated and displayed on the BAM-1020 display screen as “LAST m:” during the following hour.
The “LAST m:” value should not be used or confused with instrument span values. The BAM-1020 does not have the capability to analyze or report any span value information. Factory default settings should flag any hourly mass data when the “LAST m:” value differs more than +/- 5% from expected. If the "Last m:" value is less than 0.5% from the expected "ABS" number, it is an indication that the analytical aspects of the BAM-1020 are working properly.

1.3 PM10 and PM2.5 Configurations of the BAM 1020
BAM 1020 instruments configured for PM10 and PM2.5 are essentially equivalent in all analytical aspects. Both use the same underlying technologies. The only significant difference between the two configurations is that PM2.5 instruments utilize a PM2.5 very sharp cut cyclone under the PM10 inlet to exclude all particles with an aerodynamic diameter greater than 2.5 micron and the PM2.5 sampling period is 42 minutes where the PM10 sampling period is 50 minutes. The shorter sample period for the PM2.5 instrument allows for longer count time in the measurement portions of the analytical cycle to provide greater precision for the lower PM2.5 mass measurements.

Both the PM10 and PM2.5 configured instruments must be configured in accordance with their respective EPA equivalent method description. The PM10 instrument EPA equivalent method designation is EQPM-0798-122. The PM2.5 instrument EPA equivalent method designation is EPA EQPM-0308-170. The specific equivalent method configuration requirements are specified in the instrument manual, Sections 1.5 and 1.6.

All BAM instruments utilized in the SBCAPCD network have the optional BX-965 Report Processor installed to allow data acquisition at all times and to provide Ethernet port capabilities.

1.4 Personnel Qualifications
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 requirements and qualifications commensurate with their position or title. All air monitoring staff at SBCAPCD are hired as Air Quality Specialist I, II, III, or Monitoring/IT Supervisor positions. Qualifications for the respective staff functions are typically first established through the successful completion of a probationary period with supervisory oversight. Successive levels of responsibility are achieved via internal and external training classes, experience and a demonstrated display of abilities until a “journey level” is attained.

1.5 Equipment and Supplies
Instrumentation, spare parts, and consumables such as filter tape, tubing, and other material used in air monitoring activities are stored in the SBCAPCD laboratory for use by monitoring staff.
Standard site installation requires analyzers, calibration systems, and data acquisition systems to be properly integrated to allow for automated calibrations and acquisition of data. Calibration systems are maintained and certified by the station operator.

Consumable supplies, required for regular scheduled maintenance are also stored at the respective sites as needed. Supplies are ordered by the Monitoring Supervisor or his designee with consideration for adequate lead times. Station operators are required to notify the Monitoring Supervisor as stock of consumables are depleted to the point where new purchases are required.

Some of the specific items critical to the successful operation of the MetOne BAM1020 PM10 and PM2.5 FEM samplers are listed below with the vendor where the items are typically purchased:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Tape</td>
<td>Rolled quartz fiber filter tape designed specifically for MetOne BAM1020</td>
<td>MetOne, Inc.</td>
</tr>
<tr>
<td>Tubing</td>
<td>Vacuum tubing to connect pump to BAM 1020</td>
<td>MetOne, Inc.</td>
</tr>
<tr>
<td>Power and most Cables</td>
<td>3 prong AC cable and most cables utilized with sampler are provided upon initial purchase.</td>
<td>MetOne, Inc.</td>
</tr>
<tr>
<td>Ethernet Cable</td>
<td>CAT5e or better Ethernet Cable</td>
<td>Compuwave</td>
</tr>
<tr>
<td>Calibration Standard</td>
<td>Delta Cal flow, temperature, and pressure standard, certified as NIST traceable.</td>
<td>Mesa Labs, Inc.</td>
</tr>
</tbody>
</table>

1.6 Safety Precautions
Prior to cleaning the analyzer or performing any maintenance on the instrument, place the MAIN power switch to the OFF position, and unplug the power cord. Avoid the use of chemical agents which might damage components. Always use a three-prong, grounded plug on this analyzer.

The Met One Instruments BAM-1020 contains a small 14C (Carbon 14) beta radiation-emitting source. The activity of the source is 60 μCi ±15μCi (microcurries), which is below the “Exempt Concentration Limit” as defined in 10 CFR Section 30.70 – Schedule A. The owner of a BAM-1020 is not required to obtain any license in the United States to own or operate the unit. The owner of a BAM-1020 may elect to return the entire unit to Met One Instruments for recycling of the 14C source when the unit has reached the end of its service life, although the owner is under no obligation to do so. Under no circumstances should anyone but factory technicians attempt to remove or access the
beta source. The beta source has a half-life of about 5730 years, and should never need to be replaced. Neither the 14C source nor the beta particle detector are serviceable in the field. Should these components require repair or replacement, the BAM-1020 must be returned to the factory for service and recalibration.

1.7 Interference/Limitations
The Met One BAM-1020 is a mass analyzer, and therefore any component that is suspended on the filter tape and attenuates beta rays will subsequently affect the average mass value for that hour. Moisture in the ambient air can affect both monitor performance and hourly average mass values.

All BAM-1020 samplers utilized by SBCAPCD are equipped with a “smart heater” to minimize moisture interferences. The “smart heater” is controlled using both %RH and temperature. These set points can be adjusted using the BAM-1020 firmware.

2.0 INSTALLATION PROCEDURE

2.1 General Information:
The instrument is designed and has received EPA equivalency with an operating temperature range between 0º and 50ºC. To provide added assurance of stable operating temperature, a stable shelter temperature between 20-30 ºC is preferred. Additionally, shelter temperature is maintained at as constant a value as possible, avoiding any hourly changes in shelter temperature greater than 2 ºC. Care should be taken to install the instrument in a standard 19” instrument rack or bench mounted such that it can be accessed for maintenance, repair work and troubleshooting etc. The standard 19” instrument racks should be bolted to the floor and properly grounded.

The BAM-1020 pump requires a standard external 120 VAC outlet. Plugging the BAM-1020 pump into the same power source as the BAM-1020 monitor may help reduce potential problems. If the BAM-1020 monitor is in normal sampling operation mode, a flow of 16.7 LPM is expected. If the BAM-1020 pump fails to operate during the sampling period, the monitor will acknowledge a flow error. Flow errors can be difficult for an operator to detect and the BAM-1020 can not pin point the fault. Therefore, do NOT plug only the BAM-1020 monitor into an uninterruptible power supply (UPS). Plug in both the pump and monitor into an UPS, or neither. The BAM-1020 is designed to resume normal operation after any power failure. There is not enough information at this time to determine whether using an UPS with a BAM-1020 is significantly beneficial.

A 'good' station ground and an adequate surge protector are highly recommended with all monitoring equipment, and are especially significant for proper operation of the BAM-1020. A poor or absent BAM-1020 chassis ground and/or surge protection can cause temporary or permanent damage to the BAM-1020 monitor. Using an UPS will not provide a chassis ground and most likely will not provide adequate surge protection. The inlet tube should also be grounded to the BAM-1020 chassis. To ground the inlet tube, be sure to firmly tighten the two hexagonal head screws to the inlet tube. The two
hexagonal head screws are located at the top inlet connection area of the BAM-1020 monitor.

2.2 Physical Inspection:
The instrument is normally shipped with the following standard equipment:

1. Power cord
2. Instruction manual or CD
3. Inlet tube and mounting flange/supports
4. PM10 head and VSCC for PM2.5
5. Smart heater assembly
6. Sample pump
7. Assorted tools and cables necessary for typical set up

Upon receiving the instrument, confirm that the instrument is in good working order and inspect for damage. If any damage is observed, contact the IT/monitoring supervisor. Prior to installation of the instrument, check the following:

1. Verify no apparent shipping damage.
2. Check that all connectors are fully inserted.
3. Check that all mechanical connections are tight.
4. Open front panel and remove the internal foam “doughnuts” and the Teflon sheet between the nozzle and vane assembly.

2.3 Instrument Siting
The instrument should be sited in accordance with the United States Environmental Protection Agency (U.S. EPA) Title 40, Code of Federal Regulations Part 58 Appendix E “Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring” and USEPA Designated Equivalent Method EQPM-0798-122 and EQPM-0308-170. Care must be taken to ensure the correct distance between all sample inlets at each monitoring station. As SBCAPCD only utilizes low flow inlets/samplers, there must be at least 1 meter separation between all inlets.

2.4 Electrical Connections
There are a variety of analog electrical connections on the rear panel of the instrument that are described in Section 2.6 of the instrument manual. The PM10 instrument requires the use of an external temperature sensor and the PM2.5 instrument utilizes an external temperature and barometric pressure sensor. These sensors are mounted external to the shelter on the instruments sample inlet tube. The real-time primary data acquisition for these analyzers is via Ethernet or serial communications, therefore analog data connections are not utilized for this instrument. Over 6 months of back-up data records are stored in the instrument and can be manually retrieved as needed following the procedures outlined in the instrument manual Section 9.
2.5 Ethernet Connections and Settings

The primary data acquisition method utilized for particulate concentration and instrument operational data is via Ethernet connection utilizing the system menu system described in Section 9.4 of the instrument manual.

Each monitoring station utilizes an internal Ethernet network that connects each instrument to the station broadband modem through an Ethernet switch or hub. The BAM 1020 is configured for static IP communications following the procedures outlined in the BX-965 Report Processor Interface Option manual, section 6 using the appropriate IP address (192.168.xxx.x), Gateway IP (192.168.xxx.1), and Subnet Mask (255.255.255.0) as configured in the data system for this instrument. The instrument is polled for both concentration and operational data directly each hour via modem by the Districts central AirVision software.

Following making the above IP configurations on the instrument, and connecting the instrument to the station LAN, ensure that the AirVision is gathering data from the instrument. If not already configured, AirVision for the appropriate channels to gather concentration as well as all operational parameters following the AirVision manual’s procedures. Once AirVision is properly configured, confirm that all channels are correctly gathering data from the instrument.

2.6 Operation Verification

**NOTE:** Prior to operation of the instrument, operators must read the respective instruction manual to familiarize themselves with the operation of the instrument.

Prior to operating the BAM 1020, ensure that the proper connections have been made. In summary, at most SBCAPCD monitoring locations this involves the following connections:

- Connect the electrical connections as outlined in Section 2.4 of this SOP
- Connect the pump power to AC source.
- Connect the power cord to a well-grounded and appropriate power outlet.
- Connect and configure LAN connections on the rear panel.
- Load filter tape in the instrument following the procedure outlined in Section 3.4 of the instrument manual

After proper connections have been made, turn on the power switch.

At initial power on and boot up of the instrument, perform a self-test following the procedure outlined in Section 3.5 of the instrument manual.

2.7 Acceptance Testing

Prior to field deployment, all new instruments are tested in the SBCAPCD laboratory to ensure proper operation prior to collecting data for record. The instrument is set up in
the SBCAPCD laboratory following the same procedures outlined in this SOP for setting an instrument up in a monitoring station, with the exception that the inlet tube utilized is short allowing for the sampler to sample room air through the BX-302 Zero Filter Kit. The SBCAPCD laboratory is equipped with a connection to the central AirVision server mimicking the station set up. After the instrument has been set up, configured following the procedures in Section 3 of this SOP, and warmed up for a minimum on one hour, a full calibration is performed following the procedures described in Section 5 of this SOP. The instrument is maintained in the laboratory mock station set up for one week sampling particulate free air with the use of the BX-302 Zero Filter Kit. During this one week period, daily QC verifications (weekday only) are performed to track flow, temperature, and pressure drift as well as ensure the sampling system maintains a leak free condition for the testing period. At the end of the week long acceptance test period, the final 72 hours of hourly concentration data sampling through the BX-302 Zero Filter Kit is loaded into the MetOne Excel sheet for evaluation of the 72 hour background test. The 72 hour background test spreadsheet and the results of the daily verification tests the instrument is evaluated to ensure the following criteria are met:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pass Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum flow deviation (@16.7l/m)</td>
<td>+/- 2%</td>
</tr>
<tr>
<td>Maximum temperature deviation</td>
<td>+/-1 DegC</td>
</tr>
<tr>
<td>Maximum pressure deviation</td>
<td>+/- 5 mm Hg</td>
</tr>
<tr>
<td>Maximum leak test result</td>
<td>0.5 l/m</td>
</tr>
<tr>
<td>Standard Deviation of final 72 hours data</td>
<td>&lt;0.002 mg/m3</td>
</tr>
<tr>
<td>sampling through BX-302 Zero Filter Kit</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 – Acceptance Test Criteria

Note that the background test performed as part of the Acceptance Test, is not utilized in setting the background value, but is utilized to evaluate the noise level of the instrument. Another background test will be performed following deployment to the field that will again measure noise level, but also determine the correct setting for the background value of the instrument. If the results of the testing is within allowable criteria, the instrument can be deployed to the field for operation. The calibration/verification results, 72 hour background test, and records of operational parameters recorded by the central AirVision DAS are copied and permanently stored in the Instrument Records section of the District’s SharePoint intranet site. Should the testing results not meet one or more criteria, the instrument is not deployed to the field and either returned to the vendor or corrective action is taken by Monitoring staff, followed by a repeat of the week long acceptance testing procedure until all criteria are met.
3.0 CONFIGURATION

3.1 Instrument Configuration
Prior to initiating monitoring for record, the instrument configuration is properly configured prior to field use. Refer to Section 6 of the instrument manual for descriptions of all configuration settings. First, confirm that all settings required for EPA equivalency as specified in Section 1.5 and 1.6 of the instrument manual are correctly configured. For all BAM instruments in the SBCAPCD network, the flow type and conc type is set to Actual. PM2.5 instruments will report concentration data under only actual conditions. However, the PM10 instruments need to report data under both actual and standard conditions in order to provide concentration data comparable to both the California PM10 standard (actual conditions) and the PM10 NAAQS (standard conditions). For PM10, the instrument reports concentration data to the data system as actual conditions and a second math channel is utilized that converts the reported PM10 concentrations from actual to standard conditions.

3.2 AirVision Data System Configuration:
The AirVision central data acquisition system acquires instrument concentration and operational data (flow, temp, RH, bad status, etc) once each hour via broadband modem using the file menu commands. Instructions on AirVision configuration are provided in the AirVision instrument manual. Following configuration, the site operator will monitor the instrument and data system to ensure the configuration has resulted in the correct acquisition of data.

For PM10 instruments, in addition to the primary concentration channel, configured to record concentrations under actual conditions, a second math calculations channel is configured. The second calculated concentration channel converts the concentration from actual conditions to standard conditions using the following equation:

\[ C_{std} = C_{amb} \times \left( \frac{P_{std}}{P_{amb}} \right) \times \left( \frac{T_{amb}}{T_{std}} \right) \]

Where:
\( C_{std} = \) Concentration converted to standard conditions (25 degC, 760 mm Hg)
\( C_{amb} = \) Concentration from instrument in actual conditions
\( P_{std} = 760 \) mm Hg
\( P_{amb} = \) actual barometric pressure mmHg
\( T_{amb} = \) actual temp in Kelvin (=degC+273)
\( T_{std} = 298 \) deg K

As barometric pressure is not always available at each monitoring station, a standardized pressure based on site elevation is utilized for the \( P_{amb} \) value. Standardized pressure adjusted for site elevation is calculated by:

\[ P_{amb} = 760 - [(\text{Elevation in meters}) \times 0.0097] \]
3.3 Data Management
Data acquisition, data calculations, and data storage/transmittal are described in the SBCAPCD Data Review and Validation SOP.

4.0 CALIBRATION INFORMATION

4.1 Calibration Introduction:
A calibration is a procedure for aligning or checking the output of an instrument to a known “true” standard. To ensure the quality of the data provided by the BAM 1020, in general the instrument must be calibrated in accordance with recommendations stated in this SOP.

Each BAM 1020 is calibrated by the factory prior to shipment, by a process where the instrument is collocated with a manual filter sampler in an artificially generated particulate atmosphere. Data from this colocation is utilized to calculate the μsw and K-factor settings that are set by the factory and never should be changed other than the result of the factory calibration. The calibration of the mass measurements by beta attenuation is verified automatically each hour by the instrument with the utilization of a reference membrane with a known mass.

On site calibration of the flow, temperature, pressure, and background values are necessary prior to monitoring for record. A multi-point flow calibration is performed, with a single point temperature and pressure calibration. The background setting is determined from a 72 hour background test performed on site. While PM2.5 instruments have a regulatory requirement for the 72 hour background test to be performed, SBCAPC performs the 72 hour background test on both PM10 and PM2.5 instruments to improve overall accuracy.

4.2 Calibration Overview:
Calibrations for flow, temperature, and pressure must be performed utilizing flow, temperature, and pressure standards that have been certified as traceable to NIST standards within the past year.

A full calibration (flow, temperature, pressure) and 72 hour background check is performed prior to initiating monitoring. The full calibration will adjust the BAM 1020 flow, temperature, and pressure readings to match the readings from the certified authoritative standard utilized in performing the calibration and can be considered a “final” calibration. A full calibration is performed every 6 months thereafter and whenever calibration verifications show an out of tolerance or approaching out of tolerance condition. The 72 hour background check is performed annually to adjust background settings and confirm the instrument noise level is within tolerance.

A calibration verification is performed every two weeks to verify the flow, temperature, and pressure calibration are within allowable tolerance and to confirm there are no significant leaks in the inlet apparatus. These verifications are all performed under “as
is" conditions, without any adjustments or maintenance performed prior to the verification. The allowable tolerance for these verifications are listed in the table below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Allowable Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference between BAM1020 Flow and Flow Standard</td>
<td>+/- 4%</td>
</tr>
<tr>
<td>Difference between Flow Standard and design flow (16.7 l/m)</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>Difference between BAM 1020 temperature and Temp. Standard</td>
<td>+/- 2 DegC</td>
</tr>
<tr>
<td>Difference between BAM 10201 pressure and Pressure Standard</td>
<td>+/- 10 mm Hg</td>
</tr>
<tr>
<td>Leak Test Results</td>
<td>&lt;1.0 l/m</td>
</tr>
</tbody>
</table>

Table 2 – Instrument verification and leak criteria

4.3 Calibration Apparatus:
Field flow, temperature, and pressure calibrations are performed utilizing a BGI (Mesa Labs) DeltaCal. The DeltaCal is certified as traceable to NIST standards annually. A valve assembly for performing leak checks is supplied by MetOne with each instrument. The MetOne BX-302 zero filter kit is utilized for performing the 72 hour background check.

5.0 CALIBRATION PROCEDURES

To ensure the quality of the data collected within the SBCAPCD’s air monitoring network, ALL instruments used in the network must receive a full flow, temperature, pressure calibration

• during initial field installation and every 6 months thereafter,
• following physical relocation,
• after a calibration verification with out of tolerance or approaching out of tolerance conditions.
• after any major maintenance or repair that could potentially influence flow, pressure, or temperature calibration.

ALL instruments used in the network must receive a 72 hour background check

• during initial field installation and every annually thereafter,
• following physical relocation,
• after any major maintenance or repair that could potentially influence background settings and/or instrument noise.

An “as is” verification is performed bi-weekly to confirm that the flow, temperature, and pressure calibrations are within allowable tolerance.
Instrument calibrations at all stations within the SBCAPCD network shall be performed in a consistent manner, so that all network monitoring stations are calibrated in a similar fashion. **Instruments must be calibrated in accordance with the appropriate SOP and/or appropriate instruction manual.**

Results of the Bi-Weekly verifications are documented on the monthly QC Checksheet. Results of the 6 month full calibrations are documented on the BAM Calibration worksheet. Results of the 72 hour background check are documented on the standardized MetOne Excel workbook. Any other calibration details for calibrations and background check are recorded in the station log.

### 5.1 Calibration at Altitude
Calibrating the instrument at altitude requires no special adjustments because it compensates for changes in temperature and pressure. The flow calibrations are all performed under actual conditions, so no adjustments for altitude are required.

### 5.2 Full Calibration With Adjustment
A full calibration is performed at set up, every 6 months, and whenever a verification shows an out of tolerance or approaching out of tolerance condition. In the full calibration, a leak check is performed first to confirm a leak free inlet assembly prior to any calibration adjustments. Next the temperature is calibrated, setting the BAM temperature reading to the authoritative standard’s reading, followed by the setting of the BAM pressure to the standard’s reading. The BAM flow sensor is calibrated/adjusted based on the flow standard at three flow points (15.0 l/m, 18.4 l/m, 16.7 l/m), followed by an as is check of the flow at the operational flow of 16.7 l/m. The step by step procedures is listed below:

1. Ready a Delta Cal and confirm the certification is valid (within the past year).
2. Ready a BAM 1020 Calibration Form.
3. Enter the date and operator initials on the calibration form.
4. Enter the Delta Cal serial number and certification date on the form.
5. Press the test key on the BAM, then select “flow”
6. If the nozzle is not already in the down position (look at BAM display to see nozzle position), lower the nozzle using the “move nozzle” key.
7. In the site, press the select key until the cursor is in the 16.7 flow field.
8. On the roof, remove the PM10 inlet from tube and install closed valve on inlet tube (if PM2.5 keep the VSCC installed on the inlet tube).
9. In the site, watch the flowrate display on the BAM.
10. When the flowrate display reaches the lowest value, record this value in the “Leak test as Found” field on the form. This value must be 1.0 or less to pass the leak check and should be <0.5 for a fully leak free inlet.
11. If the value in number 10 above was 0.5 or less enter N/A in the “Leak test Final” field and proceed to step 20.
12. If the leak check value in step 10 above is greater than 0.5, exit the “flow” screen and enter the “pump” screen.
13. Move the nozzle to the up position using the move nozzle key.
14. Move the capstan to the up position. Remove the filter tape from the nozzle/detector assembly.
15. Lower the nozzle using the move nozzle key.
16. Using a Q-tip and isopropyl alcohol, lift the nozzle up, setting it down on the nozzle edge, rotate the nozzle one or two revolutions so that the nozzle edge slides across the Q-tip to clean the nozzle.
17. Hold the nozzle up, remove the Q-tip.
18. Hold the nozzle up, and clean the vane assembly with a new Q-tip and alcohol.
19. Re-install the filter tape, ensuring that unused portion of the tape is installed under the nozzle assembly.
20. Repeat steps 5-10 to perform another leak check, record the final leak check value in the “Leak check Final” field on the form.
21. If the second leak check is >0.5, contact the IT/Monitoring Supervisor to take further corrective action to fix the leak.
22. Set the BAM to the TEST>Flow screen and enter select until the cursor is on the 15.0 flow field.
23. On the roof, install the Delta Cal standard. Note that the Delta Cal must boot up completely prior to installing on the BAM inlet tube.
24. Record ambient temperature (Ta), barometric pressure (Pa), and actual flow (Qa) from the Delta Cal standard on the form after all readings have stabilized.
25. Enter Ta, Pa, and Qa in the Atmospheric Temperature, Barometric Pressure, and Flow from the BAM display (center column) “as found” fields on the form.
26. Starting with Temperature, using the select and arrow keys to move to the correct field on the BAM display, enter the Ta, Pa, and Qa values from the Delta Cal in the calibration column (far right column) in the BAM flow screen. Press “cal” after each entry. Note: enter the flow Qa in the corresponding flowrate being tested, starting with 15.0.
27. After each “cal” entry, allow the BAM display to stabilize and record the corresponding final BAM value on the appropriate field on the calibration form.
28. Using the select key, move the cursor to the 18.4 flow setting.
29. Repeat steps 22-27 omitting the temperature and pressure portions of these steps.
30. Using the select key, move the cursor to the 16.7 flow setting.
31. Repeat steps 22-27 omitting the temperature and pressure portions of these steps.
32. Exit the flow screen and then re-enter the flow screen.
33. Using the select button, move the cursor to the 16.7 flow field.
34. On the roof, record the actual flow (Qa) from the Delta Cal standard.
35. Record the actual flow from the above step in the Delta Cal Final Actual field in the workbook.
36. Remove the Delta Cal and re-install the PM10 head on the inlet tube.
37. Calculate the differences for all fields and enter on the calibration form.
38. Review the calibration form paying special attention to the calculated differences fields. All final % difference fields should be close to 0%, if not, investigate and
take corrective action as needed. If the calibration results meet the criteria listed on the form, indicate the calibration passed with a Y, if any criteria was not met, indicate the calibration did not pass with an N and investigate, take corrective action, and repeat the calibration until all criteria is met.

39. Place the BAM back in normal operation mode and note the calibration in the site log.

40. Note in the site log that a full calibration was performed on this instrument.

5.3 Flow, Temperature, Pressure Verification and Leak Test

1) Ready the SBCAPCD BAM Monthly QC Checksheet and Delta Cal Standard.
2) Enter the date in the first open Bi-weekly check field.
3) Enter or confirm the previous entry Make/Model, S/N and the certification date for the Delta Cal standard.
4) Press the test key on the BAM, then select “flow” (you may need to enter the password of F1,F2,F3,F4 to exit sampling and enter the test screen). Press the select button until the cursor is on the 16.7 flow field.
5) On roof, remove the PM10 head from the inlet tube and install the Delta Cal standard. Be sure to allow the Delta Cal to boot up prior to placing on the BAM inlet tube.
6) After the Delta Cal reading has stabilized, record ambient temperature (Ta), barometric pressure (Pa), and actual flow (Qa) from the Delta Cal standard on the QC checksheet.
7) In the site, record the BAM flow reading in the BAM flow field, record the BAM temperature reading in the BAM temp field, and record the BAM pressure reading in the BAM pressure field on the QC checksheet. Note that all BAM readings are displayed by the flow calibration screen in the center column.
8) On the roof, remove the Delta Cal and install closed valve on inlet tube.
9) In the site, watch the flow display drop.
10) When the flowrate display reaches the lowest value, record this value in the as the “Leak Check” field on the QC checksheet. This value must be 1.0 or less to pass the leak check.
11) On the roof, remove the valve from the inlet tube. Note that the valve should be removed prior to shutting off the BAM pump or reverse flow may damage BAM components.
12) If the result to step 10 above was less than 1.0 the leak check passes and the nozzle/vane assembly does not need cleaning and you can skip steps 13-22. If the result to step 8 was greater than 1.0, proceed to steps 13-22.
13) Exit out of the flow test screen and enter the pump screen.
14) Move the nozzle to the up position using the move nozzle key.
15) Move the capstan to the up position. Remove the filter tape from the nozzle/detector assembly.
16) Lower the nozzle using the move nozzle key.
17) Using a Q-tip and isopropyl alcohol, lift the nozzle up, setting it down on the nozzle edge, rotate the nozzle one or two revolutions so that the nozzle edge slides across the Q-tip to clean the nozzle.
18) Hold the nozzle up, remove the Q-tip.
19) Hold the nozzle up, and clean the vane assembly with a new Q-tip and alcohol.
20) Re-install the filter tape, ensuring that unused portion of the tape is installed under the nozzle assembly.
21) Repeat steps 8-11 above to perform another leak check to ensure that the cleaning solved the leak problem.
22) Repeat the above procedure to perform a second bi-weekly verification.
23) Review the results of the bi-weekly check performed, if any fields exceed allowable criteria, perform a full calibration as outlined in Section 5.2.
24) Place the BAM in the normal operate mode, with PM10 head installed.
25) Note the bi-weekly check was performed in the site log.

6.0 ROUTINE SERVICE CHECKS

6.1 General Information
The following routine service checks are to be performed in accordance with the maintenance schedule (Table 3). Perform the routine service checks at least at the prescribed intervals. Some site operators may need to perform these checks more frequently. Detailed routine maintenance procedures can be found in Chapter 7 of the instruction manual.

<table>
<thead>
<tr>
<th>Task</th>
<th>Daily*</th>
<th>Bi-Weekly</th>
<th>Monthly</th>
<th>6 Month</th>
<th>Annual</th>
<th>As Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check power and warning messages</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review operational and concentration data</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verification of temp, pressure, and flow</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leak Test</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean Inlet/VSCC</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check Pump Tube, replace as needed</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Download back up data from BAM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Perform full Calibration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Perform 72 hour Background test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Clean inlet Tube</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Replace/rebuild pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Replace/rebuild nozzle assembly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Table3: Maintenance Schedule
* Daily indicates that for each working day the site technician should perform these checks remotely or locally when the station is visited.
6.2 Daily (or Each Visit) Checks
Daily (or each site visit) review instrument operational and concentration data, for any indication of analyzer malfunction. Check the instruments for any error/fault messages.

6.3 Bi-Weekly Checks
Perform verification and leak check as outlined in Section 5.3 of this SOP.

6.4 Monthly Checks
Clean PM10 inlet and VSCC (PM2.5 only). Check pump tubing for wear, replace as needed. Complete monthly QC checksheet and file.

6.5 Six Month Checks
Perform full calibration following the Section 5.2 in this SOP.

6.6 Annual Checks
Clean the inlet tube. Perform 72 hour background check following procedure in Section 7.7 of the instrument manual. Load data into MetOne Excel workbook for background check statistical calculations and evaluation.

6.7 As Needed
Replace or rebuild the sample pump when flow fluctuates or unable to maintain stable 16.7 l/m flow. Rebuild the nozzle assembly when the nozzle sticks or nozzle errors are reported by BAM data string. Download back-up data from BAM using comet software as needed to maintain a back-up data source.

7.0 MAINTENANCE AND PROCEDURES

7.1 General Information
The instrument is designed to operate unattended for long periods of time. Other than the routine service checks outlined in section 6.0 of this SOP, the instrument needs very little maintenance. However, preventative maintenance requirements may vary from instrument to instrument, thus operators should refer to the instrument instruction manual to become familiar with maintenance requirements.

If station operators cannot repair an instrument using procedures stated in the instruction manual, contact the IT/Monitoring Supervisor.

8.0 TROUBLESHOOTING

8.1 General Information
The BAM 1020 instruments have been designed to rapidly detect possible problems and allow for their quick evaluation and repair. During operation, the instrument continuously performs self-test diagnostics and provides bad status indicators in the data string.
Should instrument malfunctions occur and troubleshooting is required to determine the problem, operators should refer to Section 7 of the instrument manual.

**9.0 QUALITY CONTROL/QUALITY ASSURANCE**

Quality control checks are performed as outlined in Section 5.0 of this SOP as well as the Santa Barbara County APCD Particulate Pollutant Quality Assurance Project Plan. The results of these checks are used in validating data from BAM particulate samplers. The procedures for handling data associated with out of tolerance quality control checks are outlined in detail in Section 6 of the SBCAPCD Data Review and Validation SOP.

In general, whenever data is bracketed in time by one or more calibration/verification checks outside of allowable tolerances (sample flowrate +/-4%), that data must be invalidated and corrective action to bring the sampler back into tolerance must be taken.

In addition to calibration/verification checks being used to validate data from BAM particulate samplers, the operational parameters and visual checks (punching of tape) of the sampler are reviewed to ensure that these variables are within operational tolerance for all valid data.

Quality Assurance checks, such as bi-annual performance audits are also utilized to assist in the validation of particulate data. Whenever a performance audit shows an out of tolerance condition, the issue is immediately investigated by the site operator and documented in the site log. Should this investigation show the sampler in an out of tolerance condition, data is invalidated for the out of tolerance period.

If a problem or issue is encountered where the cause of the problem, solution to the problem, and/or the data implications are unclear, the CARB Corrective Action Notification (CAN) process is implemented. The CAN process allows for a more thorough review of the problem, ensuring that the problem, potential solutions, and impacts to data are thoroughly reviewed and considered. See References for a link to the CARB CAN SOP for further details.

**REFERENCES**

- Primary Quality Assurance Organization (PQAO) website http://www.arb.ca.gov/aaqm/qa/qa.htm
- SBCAPCD Data Review and Validation SOP, First Revision
- MetOne BAM 1020 Instruction Manual, version K
- MetOne BX-965 Instruction Manual, version B
- CARB Corrective Action Notification SOP https://www.arb.ca.gov/aaqm/qa/pqao/can/can_sop.pdf
• SBCAPCD Particulate Pollutants QAPP
  http://apcd.sbcapcd.org/Business/Mit/MonitoringPrivate/Air Monitoring SOP/PMQAPP
• Monthly QC BAM Checksheet-Attached as Appendix A
• BAM Full Calibration Worksheet-Attached as Appendix A
APPENDIX A – FORMS

SBCAPCD BAM Full Calibration Form
SBCAPCD BAM Monthly QC Check Sheet
# Santa Barbara County APCD

## BAM 1020 Full Calibration Form

<table>
<thead>
<tr>
<th>Site Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Tech.</td>
<td></td>
</tr>
<tr>
<td>BAM S/N</td>
<td></td>
</tr>
<tr>
<td>PM10 or PM2.5</td>
<td></td>
</tr>
<tr>
<td>Delta Cal S/N</td>
<td></td>
</tr>
<tr>
<td>Delta Cal Cert. Date</td>
<td></td>
</tr>
</tbody>
</table>

## Leak Check Flow (<1.0 lpm)

<table>
<thead>
<tr>
<th>As Found lpm</th>
<th>Final lpm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Atmospheric Temp. (+/- 2.0 deg. C)

<table>
<thead>
<tr>
<th>BAM 1020 As Found</th>
<th>Delta Cal Actual</th>
<th>Difference (Deg. C)</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Was the difference &gt; +/-2.0 deg. C?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Did you adjust?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BAM 1020 Final</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delta Cal Final</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Difference (Deg. C)</td>
<td>0</td>
</tr>
</tbody>
</table>

## Barometric Pressure (+/- 10mm Hg)

<table>
<thead>
<tr>
<th>BAM 1020 As Found</th>
<th>Delta Cal Actual</th>
<th>Difference (mm Hg)</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Was difference &gt; +/-10?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Did you adjust?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BAM 1020 Final</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delta Cal Final</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Difference (mm Hg)</td>
<td>0</td>
</tr>
</tbody>
</table>
## Flow Calibration (+/- 2%)

<table>
<thead>
<tr>
<th></th>
<th>BAM 1020</th>
<th>Delta Cal</th>
<th>Difference (%)</th>
<th>Was difference &gt; 2%?</th>
<th>Did you adjust?</th>
<th>BAM 1020 Final</th>
<th>Delta Cal Final</th>
<th>Final Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As Found</td>
<td>15.0 l/m</td>
<td>15.0 l/m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>Actual</td>
<td>15.0 l/m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#DIV/0!</td>
</tr>
<tr>
<td></td>
<td>18.4 l/m</td>
<td>18.4 l/m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#DIV/0!</td>
</tr>
<tr>
<td></td>
<td>16.7 l/m</td>
<td>16.7 l/m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#DIV/0!</td>
</tr>
</tbody>
</table>
SANTA BARBARA COUNTY APCD
MONTHLY QUALITY CONTROL MAINTENANCE CHECK SHEET
Met One BAM-1020 AIR SAMPLER
PM 2.5 FEM [ ] PM 10 FEM [ ]

Site Name: Goleta
Serial #: T21301
Month-Year: March-17
Operator: SBCAPCD

Operator Instructions:
1) Daily checks: Review station data system values for correct operation of BAM-1020.
2) Weekly checks: Check filter tape & replace when necessary (approx. 2 months per roll).
3) Bi-weekly checks: Perform BAM-1020 flow and leak check.
4) Monthly checks: Complete and submit this Monthly Quality Control Maintenance Check Sheet.
   - Thoroughly clean both PM 2.5 SCC/VSCC and PM10 FRM inlets.
   - Check pump exit exhaust tubing and replace when needed.
   - Download and submit data from BAM-1020.
5) Semi-annual calibration last performed:
6) Annual:
   • Value of Zero BKG: -0.0021
   • Inlet tube cleaning: 6/4/2016
   • Date last performed: 11/17/2016

Transfer Standard Used:

<table>
<thead>
<tr>
<th>Make/Model</th>
<th>Serial Number</th>
<th>Certification Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta Cal</td>
<td>320</td>
<td>10/12/2016</td>
</tr>
</tbody>
</table>

Bi-Weekly Sampler Flow Rate, Ambient Temp, and Pressure Check Results:

**Date: 3/6/17**

<table>
<thead>
<tr>
<th></th>
<th>Sampler</th>
<th>Standard</th>
<th>Difference</th>
<th>Control Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Rate</td>
<td>16.7</td>
<td>16.7</td>
<td>0</td>
<td>16.00 to 17.34 (±0.67 L/min)</td>
</tr>
<tr>
<td>Ambient Temp</td>
<td>17.8</td>
<td>17.8</td>
<td>0</td>
<td>±2 °C</td>
</tr>
<tr>
<td>Ambient Press</td>
<td>764</td>
<td>764</td>
<td>0</td>
<td>±10 mm Hg</td>
</tr>
<tr>
<td>Leak Check</td>
<td>0</td>
<td></td>
<td>&lt; 1.0 L/min</td>
<td></td>
</tr>
</tbody>
</table>

**Date: 3/27/17**

<table>
<thead>
<tr>
<th></th>
<th>Sampler</th>
<th>Standard</th>
<th>Difference</th>
<th>Control Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Rate</td>
<td>16.7</td>
<td>16.6</td>
<td>0.1</td>
<td>16.00 to 17.34 (±0.67 L/min)</td>
</tr>
<tr>
<td>Ambient Temp</td>
<td>23.4</td>
<td>23.8</td>
<td>-0.4</td>
<td>±2 °C</td>
</tr>
<tr>
<td>Ambient Press</td>
<td>760</td>
<td>760</td>
<td>0</td>
<td>±10 mm Hg</td>
</tr>
<tr>
<td>Leak Check</td>
<td>0.4</td>
<td></td>
<td>&lt; 1.0 L/min</td>
<td></td>
</tr>
</tbody>
</table>

If subsequent leak checks also exceed limits, initiate a course of action to troubleshoot the source of the leak, remedy, and if required, request a re-calibration.

Operator Comments: