Appendix G

Standard Operating Procedures for

MetOne 1020

Beta Attenuation Particulate Monitor

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Met One 1020 BAM Particulate Monitor

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1.0 GENERAL INFORMATION

1.1 Introduction:

The goal of this SOP is to formalize BAM-1020 installation, configuration and operation procedures in order to ensure comparability among all BAM-1020 data, and to describe supplemental information and modifications to the Met One BAM-1020 Operation Manual necessary to successfully integrate the BAM-1020 into the District's ambient air monitoring network. The Met One Instrument's BAM-1020 Operation Manual contains a significant source of information pertinent to the operation, maintenance and understanding of this instrument, and therefore it is highly recommended that it be thoroughly reviewed.

1.2 Principle of Operation

The BAM-1020 measures and records hourly particulate mass concentrations in ambient air. The monitor consists of three basic components; the central unit, the sampling pump and the sampling inlet hardware. Each component is self-contained and may be easily disconnected for servicing and replacement.

The BAM-1020 uses beta ray attenuation to calculate collected particle mass concentrations in units of ug/m3. A ^{14}C element (60 μCi +/- 15 μC) 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 inlet of the BAM-1020 can be configured for either PM-10 or PM-2.5 measurement. For PM-10 measurements a 10 micron inertial impactor is installed on the top of the inlet. For PM2.5 measurements, a 2.5 micron very sharp cyclone is installed inline between the 10 micron inertial impactor and the inlet tube.

1.3 Safety Precautions:

Only properly trained personnel should perform BAM-1020 testing, installation, operation, maintenance and calibration procedures. As with all monitoring equipment, precautions should be taken when working around electricity, power tools and above ground elevations.

The ^{14}C radioactive source should never be dismantled, removed or tampered with. It will never be necessary for any field personnel to adjust, replace or touch the ^{14}C source. All ^{14}C issues will be handled by the manufacturer. When working with the BAM-1020 door open and in the immediate vicinity of the ^{14}C beta source, the wearing of long sleeves and laboratory gloves may help reduce possible exposure to ^{14}C beta rays.

The US EPA Code of Federal Regulations (CFR) and the Code of California Regulations (CCR) allows no more than ten (10) BAM-1020 units at any one facility at one time. There are NO restrictions or special requirements (such as licenses or permits) to ship, receive or operate a BAM-1020 monitor within the State of California.

1.4 Interferences/Limitations:
Moisture: 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. The Smart heater has been shown to be most effective in dealing with moisture issues and is used on all BAM1020 samplers used by the District.

Power Supply: 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 cannot 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 a UPS, or neither. The BAM-1020 is designed to resume normal operation after any power failure

2.0 INSTALLATION PROCEDURE

The BAM-1020 Installation procedure has been separated into the following ten (10) areas. Each area is described in further detail.
1) List of tools/supplies.
2) Physical Inspection.
3) Siting.
4) Installing BAM-1020 Central Unit.
5) Drilling Inlet Tube Hole.
6) Attaching Inlet Support Hardware.
7) Tape Loading.
8) Pump Connection.
9) Outside Temperature/Pressure Connections.
10) ESC 8816 / ESC 8832 Data Logger Connection.

2.1 List of Tools/Supplies
1) Hole saw/bits (1 3/8” and 2 1/4”).
2) Weather proof silicon or roof sealant.
3) 2 conductor cable (min. AWG 20 gauge).
4) Tape (i.e. Scotch or masking).
5) 4 lag screws adequate for roof mounting plate.
6) Rack mounting screws.
7) Tools that include drill, screwdriver and socket set.
8) Certified flow, temperature, and pressure standard (delta cal).

2.2 Physical Inspection

Upon receipt of a BAM-1020, inspect equipment and accessories for completeness and for shipping damage. If shortage or damage is found, immediately notify your supervisor.

NOTE: The BAM-1020 should never be moved unless the two hard foam packing rings (referred to as donuts) are placed around the transport rollers. Failure to install the donuts can cause severe damage to the tape advance mechanism.

List of BAM-1020 Components:
1) BAM-1020 central unit.
2) Vacuum pump.
3) Inlet Tubing.
4) PM10 FRM Inlet.
5) PM2.5 Very Sharp Cut Cyclone (VSCC) Inlet (for PM2.5 operation).
6) Smart Heater Kit.
7) Inlet Support Brackets.
8) Pump tubing and wiring.
9) Outside Temperature Sensor (PM-10) or Temperature/Barometric Pressure Sensor (PM2.5).

2.3 Siting
The BAM-1020 monitor has specific physical requirements that should be considered prior to installation. Additionally, the siting requirements listed in 40 CFR 58 Appendix A must be followed in siting any PM-10 or PM2.5 monitor used for regulatory purposes.

The BAM-1020 central unit and pump is neither waterproof nor water-resistant and must be protected from moisture. The BAM-1020 was designed to operate in a temperature-controlled enclosure (between 0° C and 50° C), and where the relative humidity is not condensing and does not exceed 90 percent. All District BAM-1020 monitors will be deployed inside a weather proof and temperature controlled structure. While the BAM-1020 has a wide range of temperature where it can successfully be operated, rapid changes of temperature can influence the data and should be avoided.

In general, when choosing the location for BAM-1020 monitor, it may help to consider the following items:

1) Inlet radius clearance: The BAM-1020 inlet must have a one (1) meter radius free of any objects that may influence airflow characteristics, including another instrument. For example, if a BAM-1020 is to be installed at a station with another BAM-1020 or a PM2.5 FRM filter sampler, the inlets of each sampler must be no less than 1 meters apart from each other. If installing near a PM10 SSI HiVol sampler, then the distance between the inlets of the BAM-1020 and the HiVol must be no less than two (2) meters. These distances are Federal EPA requirements (40 CFR Part 58), and are designed to limit inlet airflow interference.

2) Inlet height: The height of the inlet should be equal to the height of the federal reference method filter samplers such as the PM10 inlet on the PM2.5 FRM or the large round PM10 impactor on the SSI HiVol.

3) Distance between BAM-1020 and station ceiling: A minimum distance of at least eight (8) inches is required between the top of the BAM-1020 and ceiling. This distance is necessary to safely accommodate the smart heater.

4) Heater Kit: The Smart Heater resembles a small aluminum can and when installed, should be located around the lower end of the inlet tube, just where the BAM-1020 and the inlet tube intersect (about 0.5 to 1.0" above). The smart heater will cover approximately four (4) inches in length of the inlet tube. The heating device should be a minimum of two (2) inches away from any object, such as the instrument rack or ceiling.

5) Inlet: The straight, vertical inlet tubing of the BAM-1020 limits the placement of the BAM-1020 central unit. The BAM-1020 inlet tubing is a 1 5/16” OD, 8’ long rigid aluminum tube. The lower end of the inlet tube inserts directly into the top of the BAM-1020 housing, the other end points vertically upward through all roofing material and above the roofline. The selected particle size inlet(s) are mounted on the upper end of the inlet tube. The BAM-1020 FRM PM10 head should be installed so that its height is equal the same inlet height of the PM2.5 FRM or HiVol SSI filter sampler heads (approximately four to six feet above the roof line). Provisions must be made during installation to allow future removal, maintenance and re-installation of all equipment. Total inlet tube length should not exceed more than sixteen (16) feet (two 8' lengths with coupling).

6) Specifications: Specifications for siting a BAM-1020 will mirror the Federal EPA PM2.5 criteria listed in the Code of Federal Regulations (40 CFR, Part 58).

2.4 Installing BAM-1020 Central Unit

The BAM-1020 can be rack mounted, placed on a table, shelf or other flat surface. As with all instrumentation installations, the racks, table or fixture must be secure and the overall installation must protect both the instrument and personnel.

Because the BAM-1020 connector fitting for the inlet tube is located on top of the BAM-1020 central unit, installation of the BAM-1020 does not allow for other instruments to be mounted above it. Wherever the BAM-1020 is installed, space for the vertical position of the inlet tube, inlet hardware and heater must be taken into account.

2.5 Drilling Inlet Tube Hole

Applications may vary due to structural and material makeup. Forethought may help alleviate problems and frustration. After locating a suitable place for the BAM-1020 monitor, the holes for the BAM inlet tube can be drilled. Protect instruments from falling debris. The inlet support hardware includes a rooftop mounting plate for stations with a flat roof. The mounting plate has a circular ridge that protrudes beneath the surface and therefore a 2¼” diameter recess must be made on top of the roof in order to

accommodate the ridge. Inside station ceiling hole: The hole on the inside of the station should only be large enough to accommodate the outside diameter of the inlet tube. Use a 1 3/8” diameter hole saw. A plumb bob can help locate the best position on the ceiling of air monitoring stations. Drill a 1 3/8” hole vertically through the ceiling DIRECTLY ABOVE the BAM-1020 monitor inlet spout. STOP drilling when the tip of the guide bit just begins to poke through the top of the roof. The drill bit hole will be used as a guide when drilling from above and therefore DO NOT drill a 1 3/8” hole all the way through the roof.

Outside roof top hole: Relocate to the topside of the roof after drilling the 1 3/8” inside ceiling hole from underneath (remember to only drill until the hole saw bit just pokes through the roof top). Using the hole created by the guide drill of the 1 3/8” hole saw bit, drill downward with a 2¼” hole saw until the hole is deep enough to accommodate the roof mounting plate.

2.6 Attaching Inlet Support Hardware:
Affix the inlet mounting plate to the top of the roof with plenty of weatherproof sealant and four adequate lag bolts. Attach the supplied inlet coupler to the mounting plate. Slide the inlet tube through the coupler, plate, roof and ceiling. From inside the station, gently insert and seat the bottom end of the inlet tube into the top of the BAM-1020 central unit. Leak test sealing of the roof jack with water. Two (2) additional lag screws, the two supplied inlet brackets and the single (1) supplied hose clamp can be used to help support the inlet tube. The inlet(s) can now be attached to the top end of the inlet tube. Be sure to firmly tighten both BAM-1020 hexagonal inlet screws to the inlet tube.

2.7 Tape Loading: Refer to Figure 1 (below), for photo of installed filter tape. Loading the tape must be performed before accessing other BAM-1020 functions. Begin by lifting the pinch roller (the pin with the black roller located in the upper front of the BAM) and lock the roller into position with the latch (located immediately to the left of the pinch roller). Remove both clear spool caps by unscrewing the black knobs (bottom left and bottom right spools). Unroll approximately 2 to 3 feet of tape and slide the roll on to the bottom right spool (supply spool) of the BAM-1020. Position the supply spool so that as the tape unwinds on the spool, the roll turns counter-clockwise. The tape will ‘S’ around the two center rollers by feeding around the left supply tension roller located just above and to the left of the supply spool, then around the right side of the right end roller located slightly above and to the right of the tension roller. The tape slides in the slit located between the source and detector, and between the pinch roller and capstan shaft (the thin metal shaft located just below the pinch roller). ‘S’ the tape around the left side of the left end roller (roller on the upper left), around the right side of the take-up tension roller (just below and to the right), then tape onto to the take-up spool (located bottom left). Make sure there’s enough extra tape to wrap the tape approximately 1½ times around the take-up spool. The left side tape configuration should be a mirror image of the right side. Lift up on the pinch roller (the latch will automatically unlock) andgently lower the pinch roller until it completely touches the filter tape against the capstan roller. Visually check tape for binding, tears or other obvious problems. Wherever the tape comes in contact with the rollers, the entire width of the tape should

be on the roller with a little bit of the roller's edge showing. **It is highly recommended to perform a 'SELF TEST' following the BAM-1020 installation, after routine filter tape change, when troubleshooting and after correcting any problem**.

The BAM-1020 'SELF TEST' is performed by the following steps:
1. In the BAM-1020 main menu, press the "**TAPE**" soft key.
2. Next, press the "**SELF TEST**" soft key.
3. If all BAM-1020 checks pass, the display will read 'Status: SELF TEST PASSED'. If the display reads 'FAILED', remedy the problem and rerun 'SELF TEST'. Most likely, the condition that caused the 'SELF TEST' failure will be indicated on the display.
4. At the completion of the BAM-1020 'SELF TEST', press the "**EXIT**" soft key to return to the main menu. The BAM-1020 tape is now loaded and adjusted. Figure 1 picture below represents a properly loaded BAM-1020 filter tape.

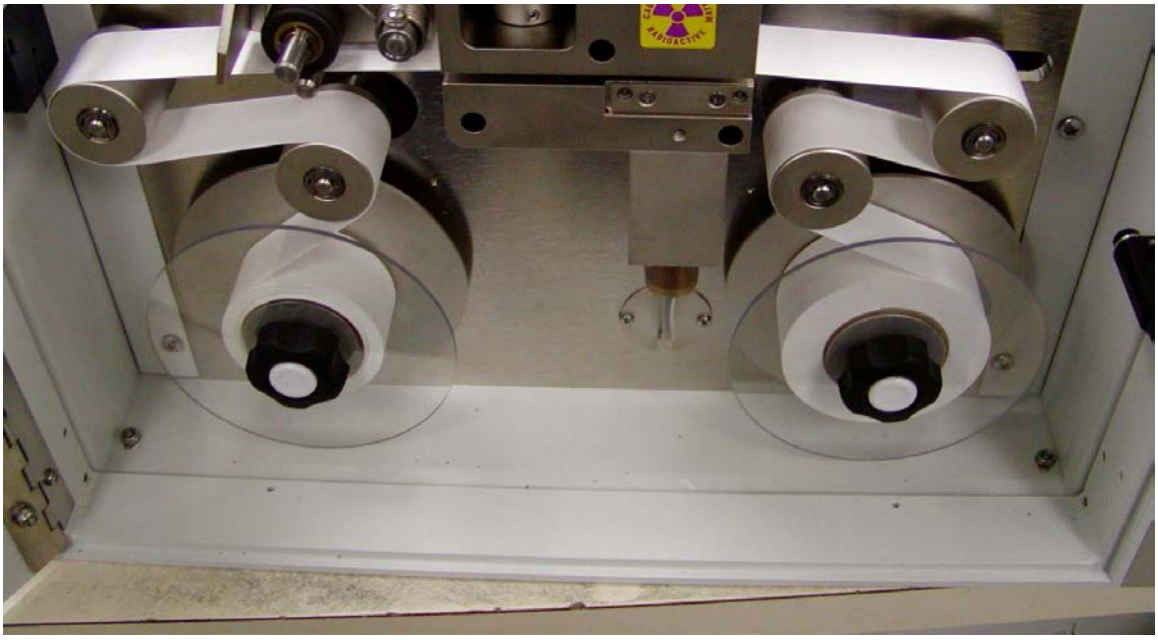

FIGURE 1 – Picture of Loaded Filter Tape

2.8 Pump Connection: The pump connects to the BAM-1020 with the supplied clear vacuum tube and 2-lead wire.

Pump tubing: Insert one end of the supplied clear tubing to the only flow 'inlet' connector of the pump, and the other end of the tubing to the only tube connector located to the lower rear of the BAM unit. Push in each end of the tubing all the way in, then pull back slightly to ensure a good seal. The tubing should remain at least 6 feet in length to help reduce any possible flow fluctuations caused by the pump.

Pump wiring: Attach one end of the supplied 2 lead wire to the two inside terminals on the pump, the other end to the terminals on the rear of the BAM unit labeled 'PUMP CONTROL'.

2.9 Outside Temperature/Pressure Sensor Connection
Both PM-10 and PM2.5 Federal Equivalent Method samplers require the installation of either the supplied temperature sensor (PM-10) or the supplied combination temperature/pressure sensor (PM-2.5). Connect the sensors per the following tables:

Termal Name	BX-592 Sensor (PM-10)	BX-596 Sensor (PM2.5)
Channel 6 SIG	Yellow or White	Yellow
Channel 6 COM	Black/Shield	Black/Shield
Channel 6 POWER	Red	Red
Channel 6 ID	Green	Green
Channel 7 SIG	No connection	White

2.10 ESC **8816 / 8832** Data Logger Connection:
When using an ESC 8816 data logger, two separate data logger channels are required. One channel is configured as the raw BAM-1020 input and the other is configured for a math averaging function. The ESC 8816 contact closure commands are independent of channel configurations. A hard wire connection must be installed for the BAM-1020 raw data and the clock contact closure function. No hard wiring is necessary for the 'math averaging' channel.

A) Raw data channel connection: Attach one end of a shielded 2 wire cable (not-supplied) to the (+) and (-) connectors at rear of the BAM monitor labeled ‘VOLT OUT’. Attach the other end of the (+) and (-) lead to the next open ESC 8816/8832 “Analog In” channel.

B) Contact closure channel connection: A contact closure connection is required to sync the BAM monitor clock with the ESC 8816 data logger. Again, the importance of syncing the two clocks together is due to the tight time frame in which BAM-1020 data is available from the samper and the necessity that the ESC data logger collect it before the sampling hour is ended. Attach one end of a shielded 2-wire cable (not supplied) to the connectors at rear of the BAM monitor labeled ‘EXT RESET N.V.’. Attach the other end of the 2- wire cable to the ESC 8816/8832 next available “Digital Out”.

3.0 CONFIGURATION

3.1 Configure BAM-1020: Each BAM-1020 is calibrated at the factory and therefore has unique calibration settings. The correct factory calibration settings for BAM-1020 are included on the factory calibration sheet with a new instrument in the manual.

When configuring or calibrating the BAM-1020, it is important to exit out to the main menu before proceeding to the next parameter. This will ensure that each change has been saved and that the BAM-1020 has updated it’s memory to the new configuration or set point. The BAM-1020 is in the main menu when the bottom of the display reads the words “SETUP”, “OPERATE”, “TEST” and “TAPE”.

Clock Set: When setting up the BAM-1020, it is crucial that the BAM-1020 clock is set to the ESC data logger clock (within 30 seconds). If the clocks are not set to within 30 seconds of each other, then the clock syncing program will not work and the data will be flagged.

To set the clock:
1) Press the "**SETUP**" soft key.
2) Ensure that the cursor is in the word 'CLOCK and press the "**SELECT**" soft key.
3) Use the cursor arrows to adjust the BAM-1020 date and time.
4) Press the "**SAVE**" soft key when BAM and datalogger times are in synch.
5) Press the "**EXIT**" soft key.
6) Confirm BAM-1020 date and time display in main menu.

Early Cycle Mode: There are two different configurations for the BAM-1020 analog output; the 'Standard' mode and the 'Early' cycle mode. The BAM-1020 MUST be configured in the 'Early' cycle mode to correctly interface with the ESC 8816/8832 data logger.

To configure the BAM-1020 to "EARLY' cycle mode:
1) Press the "**SETUP**" soft key.
2) Use the arrow keys to move the cursor to the word 'INTERFACE' and press the "**SELECT**" soft key.
3) The word 'EARLY' should be displayed to the immediate right of 'Cycle Mode:'.
4) If the word 'STANDARD" is displayed, press the up arrow key once. The word 'EARLY' should appear.
5) Change 'STANDARD' to 'CYCLE' by pressing the down arrow key once.
6) Press the "**SAVE**" soft key.
7) Press the "**EXIT**" soft key.
8) Confirm 'EARLY' cycle mode configuration by performing steps 1 through 3.

BAM-1020 'offset' voltage output configuration: All District BAM-1020 monitors are configured with a negative offset of -0.015 VDC. This offset works in combination with the ESC data logger configurations listed in section 3.2 and only affects the voltage output to the ESC data logger. With this negative offset, the data logger has the capacity of calculate and store negative values. The ability for the ESC data logger to collect negative values has proven essential when trying to determine if a BAM-1020 monitor is working correctly.

To configure the BAM-1020 monitor with the correct offset:
1) Press the "**SETUP**" soft key.
2) Use the arrow keys to move the cursor over to the word 'sample' and press the key under the word "**SELECT**".
3) Using the side arrow keys, move the cursor down to the bottom right (offset). With the up and down arrow keys, change the offset value to -0.015.
4) Press the "**SAVE**" soft key.

5) Press the “**EXIT**” soft key.
6) Confirm offset configuration by performing steps 1 through 3.

Differences in ESC and BAM-1020 data logger values should consistently read no more than 1.0 ug/m3 from each other. After collecting several hourly data points, adjust either the ESC or BAM-1020 offset voltage output so that the ESC data is always equal to or 1.0 ug/m3 less than the BAM-1020 data set. The BAM-1020 data set expresses the hourly average of the ending time. For example, the averages logged by the BAM-1020 at 9:00 am were actually collected during the 8:00 hour. Data collected during the 8:00 am hour will be logged by the ESC data logger as 8:00 am data. The relationship between ESC and BAM-1020 data is checked by the BAM data screening workbook during each monthly data set review.

Volumetric flow mode configuration: For Federal Reference Method (FRM) PM2.5 and PM10 BAM operation the BAM-1020 monitors are configured for 'ACTUAL' flow control. To check that the BAM-1020 is correctly configured:
1) Press the “**SETUP**” soft key.
2) Use the arrow keys to move the cursor over to the word ‘Calibrate’ and press the “**SELECT**”.
3) The word 'ACTUAL' should be displayed to the immediate right of ‘FLOW TYPE’. If not, use the arrow keys to set correct flow type.
4) Press the “**SAVE**” soft key.
5) Press the “**EXIT**” soft key.
6) Confirm 'ACTUAL' flow control configuration by performing steps 1 through 3.

3.2 Configure ESC 8816/8832 data logger
Configuring the ESC 8816/8832 to the BAM monitor requires initializing two data channels and one digital output configuration. The next available analog channel on the logger will be initialized as the input data cannel and is named RAW25 for a PM-2.5 monitor and RAW10 for a PM-10 monitor. The second channel is configured as an Average Math Channel and is named BAM25 for a PM-2.5 monitor and BAM10 for a PM-10 monitor. During normal operation, the RAW channel will continuously calculate minute average data from the BAM-1020. This minute average data will not be stored anywhere. The BAM channel will continuously look at the RAW minute averages and calculate ug/m3 values, but the BAM channel will only store the last minute of each hour that is generated by the RAW channel. Therefore, the last minute average of each hour generated by the RAW channel is calculated and stored on the BAM channel and reported as the hourly average.

```
60 : COM1:9600,N,8,1
Exit
ESC 8816 v5.31   ID:60        Standard Channel Config.

     Instrument Name              :  RAW25
     Analog Input Number          :  07
     Report Channel Number        :  15
     Volts Full Scale             :  1
     High Input                   :  1 V
     Low Input                    :  0 V
     High Output (E.U.s)          :  985
     Low Output (E.U.s)           :  -15
     Units                        :  ug/m3
     Base Avg. Interval, Storage  :  1m  , 0s
     Average #1 Interval, Storage:  15m , 0s
     Average #2 Interval, Storage:  1h  , 0s
     Use 40CFR75 Validation (Y/N):  N
     FINISHED (Configure Now)      03/10/11 10:15:04
```

Above is the typical standard channel configuration for the RAW channel. In this case the BAM analog output is connected to the data logger's #7 analog input. Note that no minute or hourly data for this channel is stored, rather the base average validation screen sets the minute average to be continuously written to the math constant K1. For sites with only one BAM K1 is used as the math constant. For sites with both PM-2.5 and PM-10 BAM's the RAW25 channel is written to K1 and the RAW10 channel is written to K2. The validation screen for the base average is accessed by placing the cursor over the base average storage field and pressing <control "V">. After the appropriate K value is entered into the "Average to Math Constant" field on the validation screen, <escape> is entered to return to the main channel configuration screen. In order to save the validation screen entry and the main screen entries the cursor must be placed over the FINISHED (Configure Now) field and a <return> entered. Below is an example of the validation screen for a PM-2.5 BAM.

```
60 : COM1:9600,N,8,1
Exit
ESC 8816 v5.31   ID:60        Average Validation Config.

     High-High Alarm Limit (H)   :  1E+10
     High Alarm Limit      (h)   :  1E+10
     Low Alarm Limit       (l)   :  -1E+10
     Low-Low Alarm Limit   (L)   :  -1E+10
     High ROC Alarm Limit  (J)   :  1E+10
     Low ROC Alarm Limit   (j)   :  1E+10
     Floor Limit           (f)   :  -1E+10
     Floor Value                 :  0
     Ceiling Limit         (c)   :  1E+10
     Ceiling Value               :  0

     Percent for valid average   :  Default (100)
     Average to Math Constant    :  K1
```

The BAM channel is configured as a Math Average channel. The typical configuration is shown below.

```
60 : COM1:9600,N,8,1
Exit
ESC 8816 v5.31   ID:60        Average Math Channel Config.

     Instrument Name                 :  BAM25
     Report Channel Number           :  17
     Equation                        :  K1=



     Units                           :  ug/m3
     Base Avg. Interval, Storage     :  1m  , 0s
     Average #1 Interval, Storage:   15m , 0s
     Average #2 Interval, Storage:   1h  , 9d 14h
     Round Constituents: (Y/N)       :  N
     Use 40CFR75 OOC (Y/N)           :  N
     FINISHED (Configure Now)          03/10/11 10:15:45
```

The final configuration needed for the data logger is the digital event contact closure configuration to synchronize the time in the data logger and BAM. This synchronizing contact closure is to occur at exactly 55 minues into each and every hour. The typical digital event configuration is shown below.

```
60 : COM1:9600,N,8,1
Exit
ESC 8816 v5.31   ID:60        Config. Dig. Event Program

     Dig. Event Program Name         :  BAM25
     Starting Time                   :  07/19/11 14:55:00
     Repeat Interval                 :  1h
     Output Line(s)                  :  1,
     Output Duration                 :  5s
     Disable During Cal(s)           :  (none)



     FINISHED (Configure Now)          03/10/11 10:22:21
```

In this example, the wiring between the BAM and the relay output card of the data logger was connected to output #1.

4.0 SELF TEST

Performing the BAM-1020 ‘SELF TEST’ checks both the current operational status and resets any error codes that may exist. The BAM-1020 can generate an error code whenever an expected set point cannot be maintained, as when a low flow condition occurs or when the filter tape runs out. **It is highly recommended to perform a ‘SELF TEST’ following the BAM-1020 installation, after the routine filter tape change, when troubleshooting and after correcting any problem**.

The BAM-1020 self test is performed by the following steps:
1. In the BAM-1020 main menu, press the “**TAPE**” soft key.
2. Next, press the “**SELF TEST**” soft key.
3. If all BAM-1020 checks pass, the display will read ‘Status: SELF TEST PASSED’. If the display reads ‘FAILED’, remedy the problem and re-run ‘SELF TEST’. Most likely, the condition that caused the ‘SELF TEST’ failure will be indicated on the display.
4. At the completion of the BAM-1020 ‘SELF TEST’, press the “**EXIT**” soft key to return to the main menu.

5.0 CALIBRATION INFORMATION

5.1 Calibration Introduction: The purpose of this section is to outline the Met One Beta Attenuation Mass Monitor, model 1020 (BAM-1020) verification and calibration procedures used by the District. The Met One Instrument’s BAM-1020 Operation Manual is an important resource of information for BAM-1020 calibrations, and therefore the District highly recommends a thorough review of the BAM-1020 Operation Manual.

5.2 Calibration Overview: The BAM-1020 requires the calibration of the outside temperature sensor (OT), the pressure sensor and the volumetric flow controller. When configuring or calibrating the BAM-1020, a password is required. The default password is F1 F2 F3 F4.

Met One BAM-1020 is calibrated using the following steps:
1. Leak Check
2. Outside temperature (OT) calibration/verification.
3. Pressure calibration/verification.
4. Volumetric flow calibration/verification.

It is important to exit back to the main menu following calibration of each parameter. As with most software driven monitoring equipment, returning to the main menu between calibrations can be imperative when adjustments are made to specific components that ultimately impact the calibration and/or operation of the instrument’s other components. Exiting out of the calibration screen and returning to the main menu after calibrating each component allows the BAM-1020 to completely update any configurations or changes made. Temperature and pressure changes are especially critical with respect to the BAM-1020’s volumetric flow control.

5.3 Apparatus for BAM-1020 Calibration

1. NIST-traceable mass flow transfer standard*
2. NIST-traceable temperature meter*
3. NIST-traceable pressure meter*
4. Leak check apparatus
5. Site workbooks to document calibration/verification

***Note**: The R&P FTS Streamline Calibration Kit requires an additional temperature and pressure standard while the Delta Cal has all three standards together in one unit.

6.0 CALIBRATION PROCEDURE

Calibration of the BAM involves the calibration of each sensor that influences the sample flow rate. Before the sensors are calibrated, a leak check is performed to ensure that there are no leaks in the sampling inlet and nozzle assembly. The order that the sensors are calibrated is important and must be performed in the following order:

1) Temperature Sensor – one point
2) Pressure Sensor – one point
3) Flow Sensor – three points

6.1 Calibration Transfer Standards and Equipment

All calibration transfer standard equipment must possess up-to-date certification. Certified temperature and pressure sensors are required for both BAM-1020 outside temperature and pressure calibrations. A certified fixed orifice device will be required for flow calibrations. The Delta Cal provides all of these standards in one unit and is therefore most often used. However, calibration/verification worksheets are configured to allow the use of independent temperature and pressure standards and the FTS streamline as the flow standard.

6.2 Step by Step Calibration Procedure

The following procedure is written for calibrations using the delta cal, if the FTS streamline standard is used the delta P from the FTS streamline must be manually converted to true actual flow using the FTS streamline certification equation.

1) Place the Delta Cal standard outside near the BAM inlet and allow it to equilibrate to ambient temperature.
2) Open the site mpcal workbook and access the BAM tab to display the calibration worksheet.
3) Enter the date, your initials, the Delta Cal serial number,and Delta Cal certification date in the header for the first open column.
4) Press the "**TEST**" soft key.
5) Use the arrow keys to select the **"PUMP"** press the select soft key.
6) On the roof, remove the PM-10 head and install the leak check fixture with the valve in the open mode.
7) Press the **"PUMP ON"** soft key.
8) On the roof, close the valve on the leak check fixture.
9) Once the flow has stabilized record the flow display on the BAM on the calibration worksheet as the "as found" leak check. The flow display on the BAM-1020 must read less than **1.0** LPM with the inlet capped off to pass the

manufacturers recommended leak check specifications. The leak check flow value on the display screen of the BAM-1020 should stabilize in less than 20 seconds to within two to three tenths of a liter per minute (0.2 – 0.3 lpm). Ensure that the leak check flow value remains stable for a minimum of fifteen (15) to twenty (20) seconds. It is recommended NOT to leave the BAM-1020 capped off in the leak check mode for any period of time longer than necessary. A leak check value between 0.7 and 1.0 LPM still passes but indicates the potential of a leak check failure in the near future and should be investigated.

10) If the leak check fails or is marginal, clean the inlet nozzle and vane assembly with swabs and alcohol and repeat steps 8 and 9 until a passing leak check is achieved.
11) Open the valve on the leak check fixture and remove. Do not shut off the pump prior to opening the leak check fixture as this can cause a flow reversal and damage the BAM.
12) Turn off the pump in the Pump test screen.
13) Exit the Pump test screen.
14) Select the “Flow” test screen. The pump should be off now. The flow calibration screen will look similar to the figure below:

MULTIPOINT FLOW CALIBRATION				
		TARGET	BAM	STD
<CAL>	AT:		23.8	24
	BP:		760	760
	FLOW1:	15.0	15.0	15.0
	FLOW2:	18.4	18.4	18.4
	FLOW3:	16.7	16.7	16.7
CAL	NEXT		DEFAULT	EXIT

15) Install the Delta Cal on the inlet and turn it on.
16) Wait until the temperature on the Delta Cal has stabilized and record the temperature and pressure from the Delta Cal in the worksheet under “as found” actual temperature and pressure.
17) Using the arrow keys, adjust the STD temperature on the display to the temperature value recorded from the delta cal. Press the CAL soft key. Note that prior to pressing the CAL soft key the <cal> symbol will be to the left of AT and after pressing the CAL soft key it will move down so it is to the left of the BP row.
18) Using the arrow keys, adjust the STD temperature (AT) on the display to the temperature value recorded from the delta cal. Press the CAL soft key. Note that prior to pressing the CAL soft key the <cal> symbol will be to the left of AT and after pressing the CAL soft key it will move down so it is to the left of the BP row.
19) Using the arrow keys, adjust the STD barometric pressure (BP) on the BAM display to the pressure value recorded from the delta cal. Press the CAL soft key. Note that prior to pressing the CAL soft key the <cal> symbol will be to the left of BP and after pressing the CAL soft key it will move down so it is to the left of the Flow 1 row. The pump will now turn on.

20) Read and record on the worksheet the actual flow as measured by the delta cal.
21) Using the arrow keys, adjust the STD flow 1 on the BAM display to the flow 1 value recorded from the delta cal. Press the CAL soft key. Note that prior to pressing the CAL soft key the <cal> symbol will be to the left of flow 1 and after pressing the CAL soft key it will move down so it is to the left of the Flow 2 row.
22) Read and record on the worksheet the actual flow as measured by the delta cal.
23) Using the arrow keys, adjust the STD flow 2 on the BAM display to the flow 2 value recorded from the delta cal. Press the CAL soft key. Note that prior to pressing the CAL soft key the <cal> symbol will be to the left of flow 2 and after pressing the CAL soft key it will move down so it is to the left of the Flow 3 row.
24) Read and record on the worksheet the actual flow as measured by the delta cal.
25) Using the arrow keys, adjust the STD flow 3 on the BAM display to the flow 3 value recorded from the delta cal. Press the CAL soft key. This completes the calibration.
26) Exit the flow screen, then select the flow screen again.
27) Press the NEXT soft key until the <CAL> symbol is to the left of the Flow 3 row (16.7 l/m).
28) Allow the flow to stabilize, read and record on the worksheet the actual flow as measured by the delta cal. This provided conformation that the calibration was successful and the operational flow of the sampler is well within tolerance.
29) Remove the Delta Cal standard and re-install the PM-10 inlet.
30) Place the sampler in the normal operational mode.
31) Note in the site log errata the offline period for the sampler.

7.0 VERIFICATION PROCEDURE

Every 14 days the BAM temperature, barometric pressure, and flow measurements are verified to ensure the sampler is operating within required tolerance. Should verification show the sampler flowrate to be out of tolerance, all data back to the last valid verification or calibration must be invalidated, corrective action taken as needed, and a full re-calibration (see section 6 above) performed.

7.1 Verification Transfer Standards and Equipment

All verification transfer standard equipment must possess up-to-date certification. Certified temperature and pressure sensors are required for both BAM-1020 outside temperature and pressure calibrations. A certified fixed orifice device will be required for flow calibrations. The Delta Cal provides all of these standards in one unit and is therefore most often used. However, calibration/verification worksheets are configured to allow the use of independent temperature and pressure standards and the FTS streamline as the flow standard.

7.2 Step by Step Verification Procedure

The following procedure is written for verifications using the delta cal, if the FTS streamline standard is used, select the streamline option on the worksheet dropdown for “type of standard”. The verification worksheet automatically blacks out the fields not used for one type of standard versus another. You will need to enter the FTS streamline certification equation and current temp and pressure in the column header.

1) Place the Delta Cal standard outside near the BAM inlet and allow it to equilibrate to ambient temperature.
2) Open the site log workbook and access the BAM verification tab to display the verification worksheet.
3) Enter the date, your initials, the Delta Cal serial number, and Delta Cal certification date in the header for the first open column.
4) Select the “Flow” test screen. The pump should be off now. The flow calibration screen will look similar to the figure below:

MULTIPOINT FLOW CALIBRATION				
		TARGET	BAM	STD
<CAL>	AT:		23.8	24
	BP:		760	760
	FLOW1:	15.0	15.0	15.0
	FLOW2:	18.4	18.4	18.4
	FLOW3:	16.7	16.7	16.7
CAL	NEXT		DEFAULT	EXIT

5) Install the Delta Cal on the inlet and turn it on.
6) Because this is verification, not a calibration be very careful to never press the CAL soft key in this procedure. To move to the next field press the NEXT soft key.
7) Press the NEXT soft key until the <CAL> symbol is to the left of the FLOW 3 row. Watch the BAM display until the flow in the BAM column of FLOW 3 stabilizes at 16.7.
8) Wait until the temperature, pressure, and actual flow on the Delta Cal has stabilized and record the temperature, pressure, and actual flow from the Delta Cal in the verification worksheet. The temperature and pressure are recorded in the ambient temp. and barometric pressure true fields. The actual flow is recorded in the “as is sampler flow delta”.
9) Record the temperature and pressure values from the BAM (from the BAM column, not the STD column on the BAM display) in the verification worksheet in the ambient temp. indicated and barometric pressure indicated fields.
10) Remove the Delta Cal and install the leak check fixture. Close the valve on the leak check fixture.
11) Record the flow value from the BAM display (Flow 3 row, BAM column) on the verification worksheet under “as is leak check flow”.
12) Open the leak check fixture and remove. Re-install the PM-10 inlet.
13) Exit the flow calibration screen on the BAM.
14) Compare the time on the BAM screen and the site computer (or site logger) time. Record on the verification worksheet.
15) Review the verification results. The leak check must be <=1.0l/m to pass and should be <0.6 under most cases. The temperature must be within +/-2 degC and the pressure must be within +/-10 mmHg to pass. The actual flow rate must be within +/- 4% to pass. The clock comparison should be within a few seconds and must be within 30 seconds.

16) If the clock comparison was >30 seconds troubleshoot why the clock synchronization is not working. Take necessary corrective action.
17) If the leak check was <0.6, but either the temperature, pressure, or flow was outside tolerance perform a full calibration of the sampler (See Section 6.0)
18) If the leak check was >0.5 l/m, clean the nozzle and vane assembly and repeat steps 10 and 11 above until the leak check value is <0.6 l/m. Repeat steps 4 through 15 above; only do not record the temperature and pressure values and record the actual flow rate value in the “final sampler flow delta” and the leak check in the “final leak check flow” fields.
19) Place the sampler in the normal sample mode; ensure that the PM-10 inlet was replaced on the inlet tube.
20) Note in the site log errata the offline period for the sampler.

8.0 ROUTINE SERVICE CHECKS

8.1 General Information: Perform the following checks on the BAM-1020 at the intervals specified in the service schedule. The checks may be performed more frequently but should be performed at least within the prescribed intervals. Document all check information and maintenance on the site log and mpCal workbooks.

8.2 Daily Check: Review station data logger values for correct operation of the BAM-1020.

8.3 Bi-weekly Checks:
1) Flow, temperature, and pressure Verification with leak check (Section 7.0).
2) Check tape supply. Each roll will last a bit over 60 days.
3) Download Digital Data

8.4 Monthly Checks:
1) Clean PM-10 and PM2.5 VSCC, if used (Section 9).
2) Clean Capstan Assembly (Section 9).
3) Run Self Test if one has not been run in the last 30 days.

8.5 Annual Checks:
1) Perform full calibration (Section 6.0)
2) Perform zero background check (Section 9)

TASK	DAILY	BI-WEEKLY	MONTHLY	ANNUAL
Review Hourly Data	X			
Verification and Leak Check		X		
Check Tape Supply		X		
Download Digital Data		X		
Clean inlet and VSCC			X	
Run Self Test			X	
Perform Full Calibration				X
Perform Zero Background Check				X

Table 1, MetOne 1020 Prescribed Routine Maintenance Table

9.0 MAINTENANCE PROCEDURES

Normal BAM-1020 maintenance requires keeping the BAM-1020 central unit dust free, performing inlet and nozzle cleaning, and checking the zero background of the sampler. Additionally, there are a few long term maintenance checks recommended by the manufacturer.

9.1 PM-10 inlet and PM2.5 Very Sharp Cut Cyclone (VSCC) Maintenance:
The PM-2.5 VSCC and PM-10 inlets requires removal from the inlet tube, disassembly and cleaning. The inlet should be thoroughly cleaned every month. Disassemble the VSCC and PM-10 inlet and wipe clean with lint free cloth and/or swabs with DI water. Ensure that all ‘O’ ring surfaces are in excellent shape and are reinstalled correctly. Replace 'O' rings when needed.

9.2 Nozzle and Vane Assembly Cleaning:
Normal operation causes small particles of fiber and adhesive from the BAM tape to deposit on the sampler nozzle and/or vane assembly. As these particles build up, a leak can develop where the nozzle seals on the BAM tape. Clean these assemblies by placing the sampler offline, removing the tape from the nozzle area, and carefully wiping the sealing portion of the nozzle with a swab and isopropyl alcohol. The vane assembly is cleaned by gently rubbing the assembly with a swab and isopropyl alcohol. Be careful that none of the fibers from the swab are deposited on the assembly.

Occasionally a particular sampler will build up fibers very quickly on the nozzle. This is usually caused by a very small imperfection or burr on the nozzle surface. In these cases placing a small piece of ultra-fine emery cloth under the nozzle while in the down position and rotating the nozzle to allow the emery cloth to smooth out the imperfection or burr has been an effective technique to correct this problem.

9.3 Zero Background Check:
The zero background check involves placing a HEPA filter on the sampler inlet to allow only particulate free air to be sampled by the sampler. The sampler is operated in this

configuration for 72 hours and the data for this period is loaded into a spreadsheet produced by MetOne to evaluate both the zero setting of the sampler and the measurement noise of the sampler. The procedure for this check is provided in the instrument manual, section 7.7 and the instruction with the zero test filter model BX-302.

9.4 Long Term Maintenance Tasks:
A variety of long term maintenance tasks to ensure trouble free sampler operation are specified in the instrument manual, section 7.1 and are documented in the BAM tab of the site log workbook.

10.0 TROUBLESHOOTING

Should the BAM-1020 fail to operate, refer to section 10.3 of the BAM-1020 operating manual. This section contains a troubleshooting guide that outlines symptoms, checkpoints, probable cause and remedies for general problems.

After each download of digital data from the BAM, review of the alarm log will help to identify problems with the sampler. All alarm log entries should prompt immediate investigation and corrective action. Excessive negative values (less than -5 ug/m3) indicate some sort of a problem with the sampler and also require immediate investigation and corrective action.