



Title: Standard Operating Procedure for Environmentally protected Beta Attenuation Monitor (E-BAM)		
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1. INTRODUCTION AND SCOPE

The Environmentally protected Beta Attenuation Monitor (E-BAM) provides real time mass measurement of selected size particles in ambient air samples. This instrument is used in national and local air monitoring networks to provide continuous data on the mass concentrations of various potential measurements including total suspended particulates (TSP), particulate matter (PM) of 10µm, 2.5µm, or 1µm aerodynamic diameter and less in ground level ambient air.

The procedure described in this document is for the operation of E-BAM samplers reporting data to the NAPS and AENV network.

The operating manual supplied by the instrument manufacturer (Met One document no. E-Sampler-9800 rev F) provides detailed installation and operating procedures. Those procedures are part of this operating method.

2. PRINCIPLE OF THE METHOD

This method is a continuous mass measurement of PM present in ambient air. Air is drawn through a PM sizing selective inlet at 16.67 LPM. The dichotomous nature of the sizing inlet will allow through all PM at or less than 10 µm in diameter. A secondary inlet will further break down any PM less than 2.5 µm if required. The draw of the controlled flow is pulled through a sample tape for analysis.

Beta attenuation is the count of beta particles through a traversed medium; in this case the sample tape. A Carbon¹⁴ source emits a consistent 60 microcurie signal and is detected by a scintillation detector. The tape is measured prior to sampling to determine the background coefficient of the signal. The tape is then shuttled and sealed into sample position for a user determined period of time for sampling. Post sample time, the shuttle returns the tape position back to the detector and a second count of beta particles through the medium is determined. The beta particles or degree of attenuation should be less than the background count due to deposited material on the filter. The degree of attenuation of the beta signal will determine the mass concentration of particulate matter deposited on the filter tape. Further calculations will determine the air volume of the sample period and this is divided by the mass concentration for data presented in µg/m³. Relative humidity above 50% in the air sample does have an influence on the measurement so a controlled heated inlet is incorporated with an internal RH probe to measure sample stream humidity. This ensures high humidity does not cause influence to the data and prevents condensation on the filter tape.

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3. MEASUREMENT RANGE AND SENSITIVITY

The manufacturer states that the minimum detectable limit for the mass transducer is $1 \mu\text{g}/\text{m}^3$. Met One further states that the analyzer has an operational range of up to 65 milligrams per cubic meter.

4. EQUIPMENT AND APPARATUS

The following models are used in this method.

- Met One E-BAM

The instrument is enclosed in a weather tight case with a weather tight inlet tube connected to the top. The system is made up of seven primary parts: E-BAM console, ambient temperature probe, inlet adaptor tube, sample head, filter tape, tripod, battery/power supply and in some configurations data transmitter module.

5. INTERFERENCES

Ambient Temperature

The EBAM sampler contains a heater for cold weather operations however experience has shown that ambient temperatures below the -25 to -30 degrees centigrade range causes the sampler to go into a general fault halting data collection. Data collection resumes once temperature goes above this lower operational limit.

Moisture

The Met One E-BAM 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.

Inlet and Sample Tube Losses

The particle size-selective inlets have a stable cut-point as long as they are routinely maintained and remain free of significant particle accumulation. Inlets that become dirty may allow particle re-entrainment or bounce, leading to an inaccurate measurement of the actual PM concentration. Many inlets show a shift in cut point when they are dirty, which would lead to incorrect measurement of the actual PM concentration.

Excessive particle build up on the inner walls of the down tube can affect PM concentration measurements.



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System Leaks

Air leaks in the sample system can affect the measured PM concentrations. The E-BAM monitor must pass the leak check as described in the manual to produce valid data.

6. PRECISION AND ACCURACY

The performance of the E-BAM is dependent on particle composition. This is in turn influenced by site location and temporal events that impact on the site. The accuracy and precision are consistent with US-EPA requirements for Class III designation for PM_{2.5}, although to date the E-BAM has not been tested under the Environmental Technology Verification Program. Approvals for this technology have been obtained under the Met One BAM 1020 analyzer designate.

4.1 Accuracy

The listed accuracy rating for PM_{2.5} is 2.5 µg in a 24 hour period. ± 10% of indication (one hour mode).

4.2 Precision

No US EPA documentation is available on precision for the E-BAM. Please refer to BAM 1020 precision statistics for reference.

7. SITE REQUIREMENTS

The E-BAM monitor has specific physical requirements that should be considered prior to installation. In addition, all E-BAM monitors (PM_{2.5}, PM₁₀ and TSP), should be deployed following the Siting Criteria outlined in the AMD.

1) Inlet radius clearance: The E-BAM inlet must have a one (1) meter radius free of any objects that may influence airflow characteristics, including the airflow radius of another instrument. For example, if a E-BAM is to be installed nearby another E-BAM or another similar sampler, the inlets of each sampler must be no less than 2 meters apart from each other.

2) Inlet height: The height of the inlet should be at least 1 metre above the roof of the structure (if so sited) and between 1 to 5 metres from the ground.

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Equipment Assembly

1. Lift the tripod and remove the three lock pins. Spread the tripod legs and re-insert the three locking pins.
2. Lift up the E-BAM enclosure with the aerosol inlet oriented upwards. Slide the slot on the back of the cabinet down over the tab of the tripod. Bolt the cabinet to the tripod with the provided ¼ inch nut and bolt.
3. After removing the plastic end caps from the inlet adaptor tube, push it into the E-BAM inlet. The tube must pass through two O-rings by pushing and twisting the tube into the enclosure until it stops. Hand tighten the large black screw at the top of the E-BAM enclosure.
4. Place the sampling head (PM₁₀ or PM₁₀ equipped with sharp cut cyclone for PM_{2.5}) onto the inlet adaptor tube. Push and twist the sampling head down all the way until it stops. The head must pass through two O-rings. The O-rings are factory lubricated but with frequent removal/replacement of parts they will need to be re-lubricated with silicon grease.
5. Install the cross arm on the pipe at the top of the tripod and tighten. Clip the temperature sensor onto one arm of the tripod and plug the signal cable into the 5-pin plug under the E-BAM enclosure.
6. Attach the power cable to the power supply and plug the other end of the power cable into the receptacle at the bottom of the enclosure.
7. Connect transmitter module cables, if the installation includes transmitter module.

8. INSTALLATION REQUIREMENTS

The installation procedures of the E-BAM are detailed in the Met One Operating Manual; all the steps outlined therein must be followed closely.

Probe Location Criteria

The location of the E-BAM inlet must conform to the probe location criteria below.

- | | |
|---------------------------------|---|
| Height above ground | 1 to 15 metres |
| Distance from support structure | > 2 metre |
| Distance from trees | > 20 metres or twice the height of tree above the inlet whichever is greater. |



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Distance from any air flow obstacle, i.e. buildings	> 2xheight of obstacle above the inlet
Airflow Restrictions	unrestricted in at least 3 of the 4 wind quadrants
Local Source Influences	Local source influences must be considered in locating the site for ambient

9. OPERATIONAL REQUIREMENTS

When the E-BAM is powered up it quickly runs through a minimum of eight screens. These screens verify that the time, date, and averaging period are correct. The E-BAM also checks for filter tape and proper operation of vital subsystems.

Prior to sampling, the E-BAM must be leak checked and flow, temperature and pressure audits performed. See calibration section of the Met One E-BAM manual for the procedures to be followed.

Following start up the E-BAM will display the default screen which is the sampling screen. This screen is 13 lines long and due to the size of the display only 4 lines are displayed at a time. Use the down arrow to move the window to see other lines. Each line must be reviewed and edited to meet the sampling events requirements. The displayed lines are as follows:

- 1. Date and Time** – the date and time are displayed as the DAY-MONTH-YEAR. If the date was not corrected during start up, press the MENU key. From the MENU screen, using the arrow keys highlight SETUP and press MENU/SELECT. The first SETUP screen is the DATE/TIME screen. Press the right/left arrow keys to highlight the digits to modify and the up/down keys to change the digit. When the correct date and time are displayed, press SET and then continue until the main menu is displayed.
- 2. Real-Time Concentration** – displays the REAL-TIME AVE selected during instrument setup. To modify this setting press MENU/SELECT and highlight SETUP with the curser and press MENU/SELECT again. Press CONTIUNE until the Location Averaging screen is displayed. Modify the settings by highlighting the value and incrementing the reading with the UP/DOWN keys. Press SET and then continue until the main menu is displayed.
- 3. Hourly Concentration** – Displays the hourly concentration. This line can not be modified.



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4. **E-BAM Status** – This line shows the current E-BAM operation. If the line is displaying UNIT OFF, press the hot key directly under the message to turn on the unit.

5. **Sample Flow Rate** – This line displays the instantaneous flow rate. To modify press MENU/SELECT and highlight SETUP with the curser and then press MENU/SELECT. Press CONTINUE until the FLOW RATE screen is displayed. Modify settings by highlighting the value(s) and incrementing the reading with the UP/DOWN keys. Press SET and then continue until the main menu is displayed. (NOTE: For the 130 Liberty Street ambient air program, the desired flow rate is 16.7 liters per minute.)

6. **Wind Speed and Direction** – If the E-BAM is connected to a wind sensor this line will display the wind speed and direction. This line is not modified.

7. **Ambient Temperature** – Displays ambient temperature. This line is not modified.

8. **Filter Temperature** - Displays filter temperature. This line is not modified.

9. **Relative Humidity Internal and Filter Temperature** – This line displays the sensor readings used to control the inlet heater. (The inlet heater is used to control condensation on the filter paper). To modify press MENU/SELECT and highlight SETUP with the curser and then press MENU/SELECT. Press CONTINUE until the HEATER screen is displayed. Modify settings by highlighting the value(s) and incrementing the reading with the UP/DOWN keys. Met One recommends using an RH setpoint of 45% and a DELTA-T setpoint of 8 degrees Celsius with the RH Control set to ON. Press SET and then continue until the main menu is displayed.

10. **Relative Humidity External** – If E-BAM is equipped with the sensor, the relative humidity is displayed. This line is not modified.

11. **Battery Voltage** – Displays the measurement of incoming power. This line is not modified.

12. **Secondary Flow** – This line is displayed only when the E-BAM flow is selected as STANDARD flow. This line is not modified.

The following activities must be performed when operating a semi-continuous E-BAM monitor in Alberta. The maintenance schedules such as filter change and cyclone inlet cleaning are for a typical site. There are sites with heavy PM concentrations that require more frequent service and an alternate schedule must be used.



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All operational activities conducted at any ambient monitoring station, must be documented in the station logbook, and/or station checklists. This allows other operators to access a history of the station if the regular technician is not available. The following documentation must be available to the operators on site: operational and maintenance manual(s), and station site documentation.

Daily Check:

Review station datalogger or transmitter, data if so equipped, values for correct operation of the E-BAM.

Routine Checks:

Check the E-BAM filter tape and replace when necessary.

Monthly Checks:

- 1) Flow check: Perform an inlet flow verification to ensure a flow rate of 16.67 VLPM (+/- 2 percent).
- 2) Leak check: Perform a Leak check. An E-BAM display of less than 1.0 LPM passes the manufacturers leak check specifications.
- 3) Thoroughly clean the PM2.5 Sharp Cut Cyclone (SCC) and the PM10 FRM inlets, as well as inspection and/or cleaning of the inlet nozzle.

Semi-Annual Checks: Perform semi-annual E-BAM verification/calibration of the external ambient temperature, internal pressure, leak check, volumetric flow measurement, and calibration plate audit.

10. CALIBRATION

A flow system must be audited following initial setup of the E-BAM and prior to sampling and periodically, as defined by the QAP, during the sampling event. The flow system audit consists of two checks, a leak check and flow audit.

10.1 Leak Check

To perform a valid leak test, perform the following:

1. Press MENU/SELECT and highlight FIELD CALIBRATION/PUMP TEST and select LEAK CHECK.
2. Remove the sampling head and replace with a leak test valve (Met One part No.: BX-305).
3. Close leak test valve.
4. The flow rate on the display should drop to under 1.5 LPM. If flow drops to less than 1.5 LPM, leak check passed; open and remove valve and replace sampling head. If leak check fails, refer to Section 3.3.1.3 of the manual for fixing a leak.

---THIS DOCUMENT MUST NOT BE PHOTOCOPIED---

Additional copies are available from the Air Monitoring Manager or designate

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10.2 Flow Audit

To perform the flow audit, attach the flow standard to the E-BAM inlet. Let the E-BAM pull through the standard for 1 minute until stabilization and then check the E-BAM flow rate. The flow reading from the E-BAM must be within 4% of the flow reading of the flow standard device and the flow reading from the E-BAM must be within 5% of the designated flow rate of 16.67 LPM. If the E-BAM does not agree with the standard, then a flow calibration must be performed.

10.3 Flow Calibration

Three parameters (temperature, pressure, and flow) must be verified/calibrated to perform a flow calibration on the E-BAM. Perform the following steps to perform a flow calibration.

1. Press MENU/SELECT and highlight FIELD CALIBRATION and press MENU/SELECT again.
2. From the FIELD CALIBRATION display, highlight and select TEMPERATURE.
3. The TEMPERATURE display will show three parameters; the set point (POINT:) which is either HIGH (ambient) or LOW (ice bath), E-BAM temperature reading (E-BAM), and the reference temperature (REF:) which the E-BAM uses to calculate its temperature. Select POINT to HIGH and let E-BAM and reference thermometer come to equilibrium.
4. Compare the reference temperature with the E-BAM display. If the readings are within 0.5 degrees Celsius or 1 degree F, no recalibration is required. If not, highlight the REF: line and enter the reference temperature and press CALIBRATE.
5. Repeat calibration procedure for the second point.
6. From the FIELD CALIBRATION display, highlight and select PRESSURE.
7. Compare the E-BAM pressure reading with a reference pressure. If the pressure values are within 2 mm Hg no recalibration is needed. If not, enter the reference pressure in the REF: line and press CALIBRATE.
8. From the FIELD CALIBRATION display, highlight and select FLOW.
9. The FLOW display will show three parameters; flow set point (FLOW SP:), E-BAM flow rate (E-BAM:), and the reference flow rate (REF:). The flow set point is selectable with three points (14.0, 16.7, and 17.5 LPM). The 16.7 LPM set point should be selected.
10. Remove sampling cap and place the reference flow audit device on the inlet tube. Wait for 5 minutes for the flow to equilibrate.

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11. Compare reference flow to the E-BAM flow. If the flows are within 4% no calibration is required and go to step 16. If not, highlight REF: and enter audit device flow rate and press CALIBRATE.
12. Highlight FLOW SP: and select one of the other two selectable flow rates. The E-Bam will automatically turn the pump and regulate to the flow setpoint.
13. Wait for 5 minutes for the flow to equilibrate.
14. Highlight REF: and enter audit device flow rate and press CALIBRATE.
15. Perform steps 13 and 14 with the remaining selectable flow setpoint.
16. Remove the flow audit device and replace sampling cap.

The E-BAM flow rate is now calibrated and ready for sampling.

10.4 Calibration Verification

Calibration verification of the E-BAM measuring system should be done at a frequency specified in the QAP. Verification is accomplished using two calibration plates that represent ZERO and SPAN factory calibration points. The set of calibration plates are unique to each E-BAM and have the same serial number as the E-BAM. **Make sure the proper calibration plates are used.** The following steps are to be used to perform the calibration verification:

1. Press MENU/SELECT and highlight FIELD CALIBRATION and press MENU/SELECT again.
2. Highlight MEMBRANE TEST and press START. The filter tape will advance, the nozzle will lower and the E-BAM will take a four-minute blank zero count. Press CANCEL to re-start the test.
3. When the nozzle moves up, insert the ZERO membrane calibration plate.
4. After the four-minute sample, the nozzle will move up and the display will state: REMOVE MEMBRANE, remove zero calibration plate.
5. The E-BAM will then perform a four-minute blank SPAN count and the nozzle will then move up and wait for the SPAN calibration plate to be inserted. The display will read: INSERT SPAN MEMBRANE, insert SPAN calibration plate.
6. The nozzle will lower and perform a SPAN count. The test results will then be displayed on the screen. Record the test results in log book. IF ZERO or SPAN fails, repeat the test.
7. IF E-BAM continues to fail calibration, clean the detector (refer to Section 3.3.2.2 of manual) and re-run the test.

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11. APPLICABLE DOCUMENTS

- **EM-005a** Met One Instruments E-BAM Operations Manual
- Alberta Environment Air Monitoring Directive 1989
- 3.0 Environment Canada Manual

12. LITERATURE REFERENCES

- 1.0 Met One E-BAM Standard Operating Procedures, Ambient Air Monitoring Program for the 130 Liberty Street Deconstruction Project, Lower Manhattan Development Corporation, Met One E-BAM Particulate Monitor, TRC Corporation, Lowell MA.

13. REVISION HISTORY

Revision 0 (new document)

Revision 1.0 January 17, 2011 Section 5 Add low ambient temperature interference

14. APPROVAL



Approved by: Harry Benders
Title: Air Monitoring Team Leader

Date: January 17, 2011