



# Met One BAM 1022 Operating Procedure

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By

Christopher Atherly

For the

**Air Quality Program**

Washington State Department of Ecology  
Olympia, Washington

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## Contact Information

### Air Quality Program

P.O. Box 47600  
Olympia, WA 98504-7600  
Phone: 360-407-6800

**Website**<sup>1</sup>: [Washington State Department of Ecology](http://www.ecology.wa.gov)

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<b>Headquarters</b>	Across Washington	PO Box 46700 Olympia, WA 98504	360-407-6000

# BAM 1022 Operating Procedure

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Air Quality Program  
Washington State Department of Ecology  
Olympia, WA

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DEPARTMENT OF  
**ECOLOGY**  
State of Washington

**Approved by:**

Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
Arati Kaza, Ecology Quality Assurance Officer

Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
Rob Dengel, Air Quality Deputy Program Manager

Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
Sean Lundblad, Technical Services Section Manager

Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
Jill Schulte, Air Monitoring Coordinator

Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
Scott Dubble, NWRO/SWRO & Air Quality Operations Unit Supervisor

Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
Christopher Atherly, Air Quality Program Quality Assurance Coordinator

Signatures are not available on the Internet version.



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## Acronyms and Abbreviations

AD	Aerodynamic diameter
AQP	Air Quality Program
AQS	Air Quality System
BAM	Beta Attenuation Monitor
<sup>14</sup> C	Radioactive isotope of carbon
CFR	Code of Federal Regulations
Comet	Software program for interfacing with BAM units
Ecology	Washington State Department of Ecology
Envista ARM	Envista Air Resources Manager
EPA	Environmental Protection Agency
Ecology	Washington State Department of Ecology
FEM	Federal Equivalent Method
FRM	Federal Reference Method
FTLT	Filter Tape Leak Test
LSLT	Lower System Leak Test
LPM	Liters per minute
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Radiation Commission
PM	Particulate Matter
PM <sub>2.5</sub>	PM with an aerodynamic diameter 2.5 µm or less
PM <sub>10</sub>	PM with an aerodynamic diameter 10 µm or less
QA	Quality Assurance
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
RH	Relative humidity
SCC	Sharp cut cyclone

SIMS	Site Information Management System
SOP	Standard operating procedure
TSLT	Total System Leak Test
μCi	Microcuries
μg/m <sup>3</sup>	Micrograms per cubic meter
User's Manual	BAM 1022 Particulate Monitor Operation Manual
VSCC	Very sharp cut cyclone

# 1. Introduction

This document describes Ecology's procedures for operating a Met One Instruments BAM 1022 (BAM) to measure ambient air PM. Any BAM 1022 operated within the Washington State Ambient Air Monitoring Network (Washington Network) must be operated in accordance with this Standard Operating Procedure.

The BAM 1022 uses beta attenuation technology to measure hourly PM mass concentrations. In 2015, it earned FEM designation from the EPA for measurement of PM<sub>2.5</sub> for regulatory purposes.

Meeting FEM requirements for PM<sub>2.5</sub> monitoring involves:

- Using a glass fiber tape roll
- Maintaining a flow rate of 16.67 liters per minute (LPM) through:
  - An approved PM<sub>10</sub> inlet that adheres to [40 CFR Part 50 Appendix L](#) specifications
  - A Mesa Labs PM<sub>2.5</sub> Very Sharp Cut Cyclone (VSCC)
- Employing a BX-597A ambient temperature/barometric pressure/relative humidity sensor
- Operating and maintaining the instrument according to revision B or later of the [BAM 1022 Particulate Monitor Operation Manual](#) (User's Manual).

For non-regulatory PM<sub>2.5</sub> monitoring, the same requirements apply, except the VSCC can be replaced with a Sharp Cut Cyclone (SCC).

Note that the BAM 1022 is not approved for FRM or FEM for measurement of PM<sub>10</sub>. When operated as a non-FRM/FEM for measuring PM<sub>10</sub>, the instrument is configured without the PM<sub>2.5</sub> cyclone and set to report concentrations in standard conditions. All other operational procedures are identical to those for FEM PM<sub>2.5</sub>.

A photo of the BAM 1022 is provided in Figure 1-1 for reference.

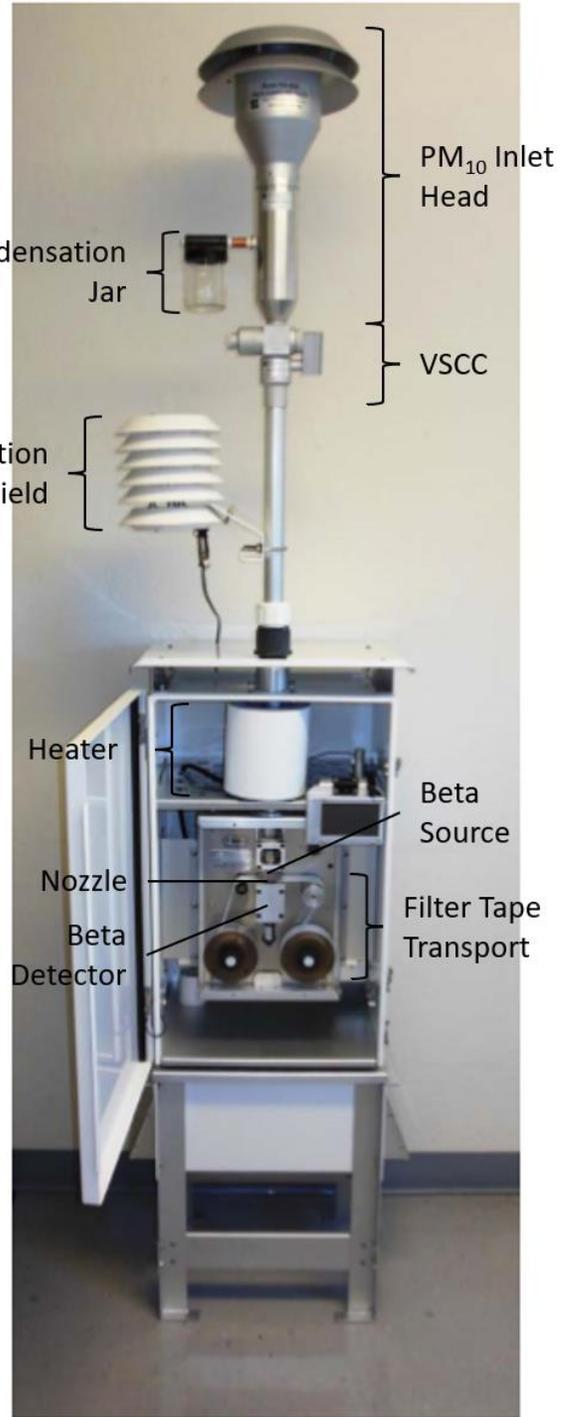


Figure 1-1: Photo of BAM 1022

## 2. Safety Considerations

### 2.1. Beta radiation

The BAM 1022 contains a small, sealed capsule containing Carbon-14 ( $^{14}\text{C}$ ), which emits beta radiation. The radiation level is extremely low - only 60  $\mu\text{Ci}$ , below the U.S. Nuclear Regulatory Commission's (NRC) "Exempt Concentration Limit" of 100  $\mu\text{Ci}$  (10 CFR 30.71 - Schedule B). Nevertheless, to minimize the likelihood of any exposure, the requirements below must be followed:

- Never attempt to remove or access the beta source. Only factory technicians are allowed handle it.
- Both the beta source and detector are not field-serviceable. Return the BAM 1022 to the factory for any repairs or replacements.

The BAM 1022 meets U.S. NRC safety regulations (10 CFR 32.27). Radiation safety is described further in Section 1.4.1 of the User's Manual.

The beta source has a long half-life (5,730 years) and will not need replacement unless damaged.

### 2.2. Operational safety

Operating the BAM 1022 outside of manufacturer specifications can compromise its performance and safety features.

- Always consult this document or the manufacturer's instructions before making any adjustments or repairs. Only factory-trained personnel should handle complex repairs.
- Disconnect power before working on electrical components to avoid electrocution and equipment damage.
- Follow grounding and antistatic procedures when handling internal components. Static electricity can damage sensitive circuitry.
- Do not operate the BAM 1022 in potentially explosive environments.
- Secure the BAM 1022 against tipping using the provided anchoring holes at the base of the pump box assembly. If bolting is not feasible, use sandbags, cinderblocks, or similar methods to secure the unit against tipping.

## 3. Principles of Operation

The BAM 1022 uses beta ray attenuation to measure the mass concentration of PM in ambient air. This technique relies on the interaction of beta particles (high-energy electrons emitted by the Carbon-14 source) with the collected PM on the filter tape. As the mass of PM increases, a greater number of beta particles are scattered or absorbed, leading to a decrease in the intensity of the detected radiation.

### 3.1. Sample acquisition and flow determination

An external pump draws ambient air at a precisely controlled flow rate of 16.67 LPM through a PM<sub>10</sub> size-selective inlet, separating particles with an aerodynamic diameter (AD) exceeding 10 µm. To sort particles over 2.5 µm AD, the air stream then enters a Very Sharp Cut Cyclone (VSCC) (FEM) or Sharp Cut Cyclone (SCC) (non-regulatory). Particles with AD ≤ 2.5 µm are captured as air flows through the moving glass fiber filter tape.

Precise flow control and monitoring are crucial for calculating the sampled volume and the subsequent ambient PM<sub>2.5</sub> concentration. The BAM 1022 employs a mass flow controller to maintain the constant sampling rate, allowing total air volume to be calculated based on elapsed time.

A BAM 1022 PM<sub>2.5</sub> inlet and measurement system is shown in Figure 3-1.

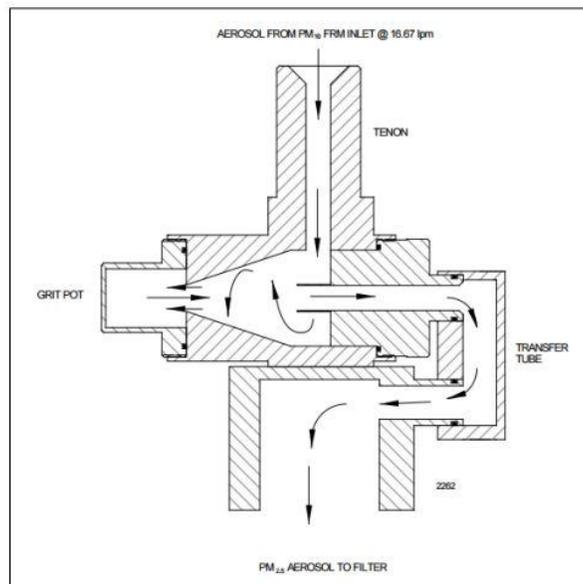


Figure 3-1: Schematic diagram of BAM 1022 VSCC

### 3.2. Beta ray transmission and signal detection

A sealed <sup>14</sup>C source positioned above the filter tape continuously emits beta particles through the air gap and filter tape. Their trajectory and energy are altered by captured PM on the filter tape.

A scintillation detector located beneath the filter tape measures the intensity of the transmitted beta radiation. The detector converts the beta particles into light pulses, which are subsequently converted into electrical signals for quantification.

The measurement system's configuration is shown in Figure 3-2.

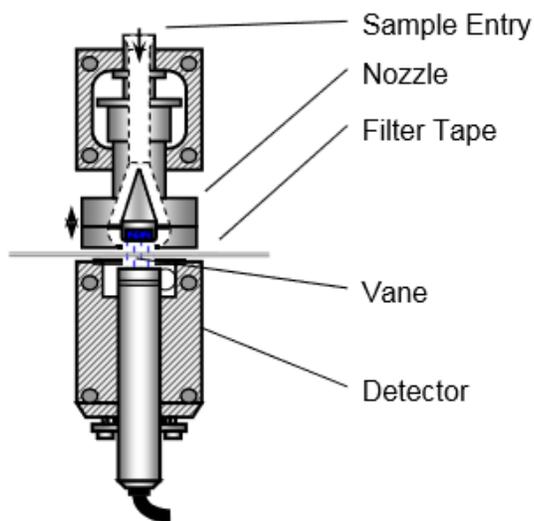


Figure 3-2: Schematic diagram of BAM 1022 measurement system

### 3.3. Concentration calculation

The decrease in beta ray intensity is directly proportional to the mass of PM accumulated on the filter tape. The BAM 1022 has a pre-calibrated relationship between this attenuation and the corresponding PM mass concentration.

The total volume of air flowed through the instrument is determined using the constant flow rate of 16.67 LPM over time. Final volume calculations incorporate temperature and pressure measurements to compensate for variations in air density.

By dividing the recorded mass by the calculated volume within the sample time, a concentration value in units of  $\mu\text{g}/\text{m}^3$  is determined.

## 4. Equipment and Supplies

The diagnostic tools, parts, and supplies necessary to operate and maintain the BAM 1022 are summarized in Table 4-1 below.

Table 4-1: Summary of BAM 1022 standard hardware, tools, routine parts, and supplies

Category	Equipment	Purchase Schedule
Tools and equipment	Approved, certified, NIST-traceable flow standard	Once
	Flow audit adapter	Once
	Tygon® tubing	Once
	NIST-traceable thermometer	Once
	NIST-traceable handheld barometer	Once
	Digital multi-meter	Once
	Rubber shim (part 7440 in tool kit)	Once
	Various hand tools (screwdriver, hexagonal wrench, etc.)	Once
Consumables	Filter tape (Sibata; Met One 460180)	Every 60 days, or as needed
	Zero test filter	Initial setup, as needed
	Cleaning swabs	As needed
	Cotton-tip applicators	As needed
	Rubbing alcohol	As needed
	Lint-free lab wipes	As needed

## 5. Installation Procedure

### 5.1. Siting

Proper siting is essential to collecting data that are representative and at the appropriate scale. Most monitoring in the Washington Network is done at the neighborhood scale, meaning the monitor represents a relatively uniform land use such as a residential area (0.5 to 4 km).

Siting criteria for neighborhood-scale PM monitoring sites are described extensively in 40 CFR Part 58, Appendices D and E. The primary considerations are summarized in Table 5-1 below.

If you're planning to monitor at a different scale (e.g., regional, urban), refer directly to Appendices D and E for specific siting requirements. Always confirm the intended scale and FEM configuration with the Air Monitoring Coordinator before settling on a location.

Table 5-1: Summary of PM siting criteria (adapted from Vaughn, 2009)

Parameter	Category	Siting Requirement
Inlet height	General	2-15 m above ground
	On rooftop	2 m above roof
	Collocated samplers	Within 1 vertical m of each other
	Inlet tube length	≤ 16 ft (4.9 m)
Inlet radius clearance	General	≥ 1 m radius clearance
	Collocated samplers	1-4 m between inlets
	Near small obstructions (fences, walls, etc.)	≥ 2 m
	Near large obstructions (buildings, sound walls, billboards, etc.)	Distance ≥ 2x height of obstruction
	Near overhanging trees	≥ 10 m from dripline; ≥ 20 m from dripline is recommended
	Arc of air flow	Unrestricted 270° arc that includes prevailing direction of high concentrations
Nearby air sources	General	As far away as possible from vents
Distance from roadways	< 3,000 vehicles per day	≥ 5 m from nearest traffic lane
	Elevated roadway (> 25 m high)	≥ 25 m away
	Unpaved roads	As far away as possible

Operators should refer to [Ecology's Air Monitoring Site Selection and Installation](#) Procedure for further information on site selection. Once a site is selected, the operator must enter the monitor's parameters and site information (if a new monitoring location) in the Site Information Management System.

The BAM 1022 is a weatherproof unit and must be deployed as a freestanding unit outside of any enclosures to maintain its FEM status. The housing of the BAM has been designed to

maintain a nearly constant internal temperature. This is required to account for differences in beta attenuation due to variations in pressure and temperature.

Operators must read and become familiar with the current version of the User's Manual prior to installation and operation.

## 5.2. Installation

Follow the detailed instructions found in section **2.3 BAM 1022 Installation for FEM Monitoring Applications** of the User's Manual when installing a new instrument.

Take the following special precautions when installing the BAM 1022:

- Make sure that the black sealing ring is tightened sufficiently around the downtube. Failure to do so can result in water entering and damaging the BAM.
- If installed as a FEM, ensure that the proper PM<sub>10</sub> inlet and PM<sub>2.5</sub> VSCC are used. If using as a non-regulatory PM<sub>2.5</sub> monitor, use a PM<sub>10</sub> inlet followed by a PM<sub>2.5</sub> SCC.
- If installed as a non-regulatory PM<sub>10</sub> monitor, exclude the PM<sub>2.5</sub> cyclone altogether.
- Secure the BAM feet with bolts if possible. Otherwise use sandbags, cinderblocks, or similar means to safely secure and prevent equipment from tipping.
- When closing the door, be sure that the touch screen is tucked away so that it and its cable are not damaged by the door.
- Verify the BAM 1022 is connected to the cell modem or site data logger and that the BAM 1022 and cell modem, if used, are plugged into a power outlet.

After installing the instrument, conduct the following steps to begin operation:

Table 5-2: Summary of post-installation steps

Step	Section
Verify settings	5.3
Install filter tape	5.4
Perform Self-Test	5.5
Perform leak check	5.6
Calibrate ambient temperature, ambient pressure, and flow	5.7
Perform span check	5.8
Perform 72-hour zero test	5.9

## 5.3. Cellular connection setup

The BAM 1022 can be configured to run with a data logger or a cellular connection to transmit data. Due to the ease of deployment (no data logger required), most Washington Network BAM 1022s will be deployed with a cell modem and antennae, as shown in Figure 5-1.



Figure 5-1: BAM 1022 stand-alone setup with cellular modem

An ethernet cable connects the BAM 1022 to the cell modem. The Calibration and Repair Lab will work with AQP IT and Telemetry Unit to configure the ethernet connection. For reference, the Ethernet screen should look like Figure 5-2. To check or change values, or to set up the cellular data connection, follow the instructions in Section 9.2 of this document.



Figure 5-2: BAM 1022 Ethernet screen

Both the BAM 1022 and the modem need standard 120V power. As the distance to an outlet can differ from site to site, work with the Calibration and Repair lab to acquire appropriate power cables. The box fan and modem should be plugged into a surge protector that is plugged into the pump box fan outlet using the configuration shown in Figure 5-3.



Figure 5-3: BAM 1022 surge protector strip configuration

## 5.4. Verify settings

Upon startup, the BAM 1022 will give a 60s countdown to beginning a sample. First, you will need to check the verify that all instrument settings are correctly set.

To access the Setup menu, select **STOP** on the lower left of the touch screen. Then access the settings menu by touching the 3 bars in the upper left corner and selecting **Setup**. The BAM 1022 will prompt you for the password, which is **1 2 3 4**.

Navigate through each sub-menu in Table 5-3, and confirm that all listed settings are correct on the instrument. Then, return to the main operating screen by pressing the **Home** icon in the upper right corner.

Table 5-3: BAM 1022 Setup Menu parameters to review upon installation

Menu	Sub-Menu	Selection	Setting
SETUP	CLOCK		Verify clock is same as data logger clock
	SAMPLE	Data Average	1 HR or whatever is specified by Calibration and Repair Lab
		RealTime Period	60
		Conc Units	µg/m <sup>3</sup>
	INLET HEATER	FT Set Point	+45.0
	REPORTS	Time Stamp	ENDING
	SERIAL PORT	RS-232	9600
		Flow Control-232	NONE
	STATION ID		1
	TAPE ADVANCE	Tape Period	1 HR
		Tape Pressure	PRESSURE = +250

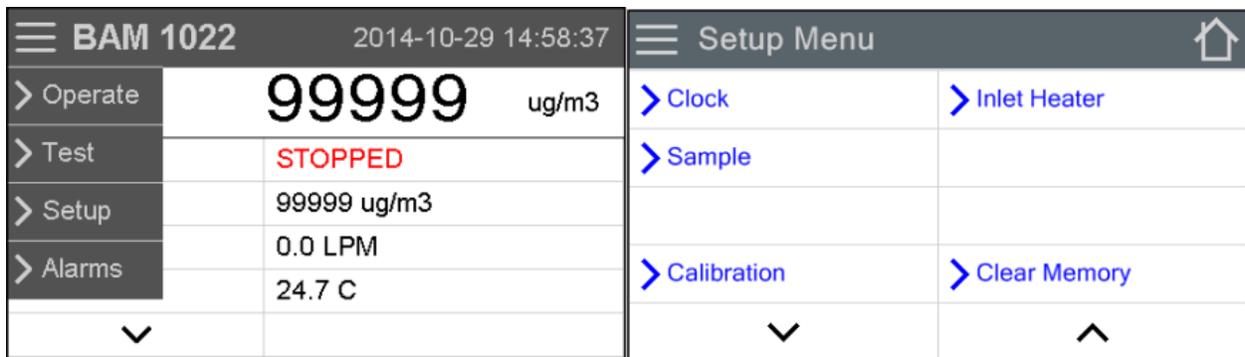


Figure 5-4: BAM 1022 main operating screen (left) and Setup menu (right)

## 5.5. Install filter tape

1. **Operate Menu > Load Filter Tape.**
2. Remove the clear plastic box that covers the tape, nozzle, and emitter/detector.
3. Remove the plastic reel covers.
4. Install an empty plastic core on the take-up (left) reel.
5. Load the new roll of filter tape on the supply (right) reel and guide the tape into the transport assembly as shown in the drawing just right of the nozzle.
  - a. Handle the filter tape only by its edges to avoid contaminating the sampling surface.

- b. **Note:** the 1022's tape routing is different than the BAM 1020.
6. Use adhesive tape to fasten the loose end of filter tape to the empty core on the take-up reel.
7. Rotate the reels by hand until the filter tape is taut.
8. Install the plastic reel covers. Tighten them until the metal plates behind the reels just begin to turn.
9. Align the filter tape so that it is centered under the nozzle.
10. Press **MOVE**.
11. If the tension is ok, green text "TAPE IS OK!" will appear.
12. Exit the Load Filter Tape menu.

## 5.6. Self-Test

The BAM 1022's built-in Self-Test function automatically tests the tape, counting and flow systems to ensure that the BAM is ready to enter sampling mode. The Self-Test should be run initially and after any interruption to sampling, such as a quality control check, filter tape change, or performance evaluation.

1. **Test Menu > Run Self-Test.**
2. The password is **1 2 3 4**.
3. The Self-Test will run. You will hear mechanical noises and then the pump will turn on.
4. When it is done, a passing result will display "SELF-TEST COMPLETE" in blue letters.
5. If the Self-Test fails, it will display a failure and will take you to the Alarms menu. Use this information along with the User's Manual and the Calibration and Repair Lab to troubleshoot the issue.
6. When you have resolved the issue repeat the Self-Test until you get a passing result or determine that the instrument needs more in-depth repairs.

## 5.7. Leak check

1. **Test Menu > Tape Test.** Press **MOVE TAPE** 5 times to advance the tape to a clean, unsampled spot.
2. Remove the PM<sub>10</sub> head from the end of the sample inlet.
3. Install the flow audit adapter in place of the PM<sub>10</sub> head, above the VSCC. Turn the flow audit adapter valve to the closed position (perpendicular to the inlet).
4. **Test Menu > Leak Test.**
5. Make sure that the nozzle is down by pushing **NOZZLE DOWN**.
6. Turn the pump on. The displayed lower pressure is an important diagnostic and should be read before opening the valve on your filter. Note the ambient pressure when the pump is off.
7. Allow the pump to stabilize for 20-30 seconds.
8. Read the flow rate on the BAM display and record it in the As-Found Leak Check section of the BAM 1022 QC form. The flow rate must be  $\leq 1.5$  LPM for the leak check to pass. If the leak check does not pass, see Section 6.4 to perform an advanced leak check.
9. Turn off the pump.

10. **Important:** Allow the Lower Pressure value to return to ambient. This will take a minute or so.

Once the pressure has returned to ambient, open the flow audit adapter and remove it. Waiting for equilibration is very important, because the detector in a 1022 is directly in line with the flow path. **Opening the valve before equilibration of the pressure can push debris from the filter into the detector.**

## 5.8. Calibrate temperature, pressure, and flow

The ambient temperature, ambient pressure, and flows must be calibrated upon installation and relocation of the BAM 1022. It is recommended that the user default to factory settings before calibrating. Temperature, pressure, and then multipoint flow should be calibrated in order. The default password is 1 2 3 4.

1. **Test Menu > Ambient Temp.**
2. Press **DEFAULT**.
3. Measure the actual ambient temperature inside the radiation shield using a certified, NIST-traceable thermometer. Allow the temperature standard to equilibrate.
4. Enter the temperature value from the standard into the BAM's Reference field.
5. Press **Calibrate** and exit to the Test Menu.
6. Select Ambient Pressure.
7. Press **DEFAULT**.
8. Measure the actual BP at the BAM inlet using a certified BP standard.
9. Enter the reading from the standard into the Reference box on the BAM.
10. Press **Calibrate** and exit to the Test Menu.
11. Remove the PM<sub>10</sub> head and install a certified flow transfer standard in the correct direction of flow.
12. Select **Flow Calibration** to enter the flow calibration screen. The pump will start.
13. Press **DEFAULT**.
14. Select **Set Point** and choose **14.0**.
15. Once the flow equilibrates, enter the value from the flow standard in the Reference box.
16. Push **CALIBRATE**
17. Repeat this for values of 17.5 and 16.7 LPM.
18. If done, return to the home screen.

✓ Flow Calibration		✕
Set Point	16.7	
BAM 1022	6.6 LPM	
Reference	+16.7	

Figure 5-5: Flow Calibration screen

## 5.9. Span mass audit

The Span Mass Audit checks the stability and performance of the BAM 1022's beta particle detection system. To do this insert two "foils", a "zero foil" and a "span foil" over the filter tape. Each set of foils are instrument-specific, and not interchangeable. It is important to make sure that the filter tape is loaded and to be careful not to tear the filter tape or introduce dust when inserting and removing the foils.

**Note:** Once the foils are properly loaded, the nozzle will automatically lower. Once the measurement is done, and you have advanced the screen, the nozzle will raise. If the span mass audit fails, repeat it, and make sure that the foils are properly centered when the nozzle lowers. Small movements after you place it in can result in large reported mass changes. Sometimes the foils move when you remove your fingers from them, so it is best to hold it in place until the nozzle is lowered.

1. **Test Menu > Span Mass Audit.**
2. The screen will prompt you to load the zero foil. Once it is properly inserted the nozzle will automatically lower and a 240 second countdown will begin.
3. When it finishes the nozzle will raise and the screen will prompt you to remove the foil.
4. When the screen shows the span value, record it in the station log (see Section 6.2) and press **CONTINUE**.
5. The screen will prompt you to insert the Span Foil above the tape. Again, the nozzle will lower when the foil has been inserted correctly.
6. A 240 second countdown will begin.
7. Once complete the test will display the calculated mass (Mass), the recorded value (Span), and the percent error. Record this in the station log.
8. Exit the test.
9. The nozzle will raise and prompt you to remove the span foil.
10. Remove it, place it in the sleeve and store it safely.

## 5.10. 72-hour zero test

To meet EPA requirements for federal equivalency and for obtaining a site-specific background, all PM<sub>2.5</sub> BAM 1022s must undergo a 72-hour zero background test when first deployed and annually thereafter. Each BAM has a programmable background value (BKGD) to compensate for site-specific characteristics such as grounding, radon, or radio-frequency interference. This test should be performed during dry, stable weather when clean (not during wildfire smoke or other major particulate matter events) air is expected.

The 72-hour zero test should be performed when the BAM 1022 is installed in its permanent location and fully configured for sampling. Before performing the 72-hour zero test, contact the Calibration and Repair Laboratory.

The following is a brief set of instructions for performing the 72-hour zero test. For additional information, operators should refer to the detailed instructions that accompany the BX-302 Zero Filter Kit included with all BAM units.

1. Before performing the 72-hour zero test, retrieve the current settings file using Comet software (see Section 9.1.1) or you can download the settings in Hyperterminal or equivalent using the 1 command (see Section 7.5.1 of the User's Manual).
  - a. For a standalone setup, because there is no logger, the data, alarms, and settings file should be retrieved using a USB drive (Section 7.2 of User's Manual). The USB port is in the upper right corner above the tape transport.
  - b. If connected to a logger, Met One's Comet software can be used to connect to the BAM 1022.
2. Copy and paste the settings file into the site's Envidas electronic logbook.
3. **Setup Menu > Background.** Record the current BKGD setting in the logbook entry alongside the settings file.
4. Touch **Background** value to bring up the background entry screen and enter 0.00000. press **OK**.
5. Remove the PM<sub>10</sub> inlet head.
6. Inspect the BX-302 for signs of discoloration or obvious water damage.
7. Install the BX-302 0.2 µm filter kit above the VSCC.
8. In Envidas Ultimate, right-click the BAM channel and set the analyzer flag to Zero.
9. Allow the BAM to warm up with the BX-302 kit installed for 24 hours before starting the 72-hour zero test.
10. Allow the BAM to sample for at least 72 continuous hours, not including the 24-hour warm-up period. If any error flags are shown, the results are invalid, and the test must be restarted.
11. Record the standard deviation of the 72-hour zero. It should be less than 0.0024 mg/m<sup>3</sup>. If the standard deviation is not less than 0.0024 mg/m<sup>3</sup>, contact the Calibration and Repair Lab.
12. Record the mean hourly concentration recorded during the 72-hour zero test in mg/m<sup>3</sup> and subtract this number from 0. This value should normally be within ± 0.002 mg/m<sup>3</sup> of prior BKGD values on the same instrument. If it is not contact the Calibration and Repair Lab.

13. In the **Setup > Background** menu, program the resulting value (the negative of the mean 72-hour concentration in mg/m<sup>3</sup>) into the BKGD field.
14. Remove the BX-302 filter, reinstall the PM<sub>10</sub> head, return to the home screen, and if connected to a logger, remove the flags from the BAM channel to enter normal sampling mode.
15. Record the new BKGD value and calculated standard deviation in the site Envidas electronic logbook.

Contact the Calibration and Repair Laboratory for assistance with analyzing and interpreting 72-hour zero test data.

## 6. Quality Control and Maintenance

To ensure proper operation of the BAM 1022, routine QC maintenance must be conducted at regular intervals. If the BAM 1022 is to be used as a regulatory PM<sub>2.5</sub> monitor, it must have a VSCC installed and meet the requirements of 40 CFR, Part 58, Appendix A. For additional guidance refer to the [EPA Quality Assurance Handbook for Air Pollution Measurement Systems Volume II Appendix D](#).

Additional maintenance must be performed every 6 and 12 months. The 12-month maintenance should be performed by the Calibration and Repair Laboratory.

### 6.1. Quality control and maintenance

Operators are required to perform a QC check and monthly maintenance every 30 days. This consists of the tasks in Table 6-1.

Table 6-1: Quality control and maintenance steps

Procedure	Minimum Frequency	Section
As found leak check	Every 30 days or as needed	5.7, 6.3
Filter tape inspection	Every 30 days or as needed	6.5
Nozzle and vane cleaning	Every 30 days	6.6
Filter tape change	Every 60 days or as needed	6.7
Clean the PM <sub>10</sub> inlet	Every 30 days	6.8
Clean the VSCC	Every 30 days or as needed	BX-808 Manual 4.0
As-left leak check	Every 30 days	6.10
Ambient temperature and pressure verification	Every 30 days	6.11
Three-point flow verification	Every 30 days	6.12
Temperature/pressure flow calibration	As needed	6.13, 5.7
Clock verification	Every 30 days	6.15
Self-Test	Every 60 days	6.16
Span mass audit	Every 30 days (weather permitting)	5.9

All operators of a BAM 1022 in the Washington Network are required to record the results of monthly QC checks on the appropriate Washington State Department of Ecology BAM 1022 Quality Control Check Results form (Appendix A).

## 6.2. Logbook entries

For stand-alone BAM 1022s using a cellular telemetry connection, all site activities are documented through the Envista Air Resources Manager (Envista ARM), which includes tools to visualize and review data, create logbook entries, and set data validation flags. To install and gain access to Envista ARM, contact the AQP IT and Telemetry Unit.

A logbook entry must be created each time the site is visited, a QC or maintenance is performed, or environmental concerns that could affect data quality are observed.

To create a logbook entry:

1. Open the Envista ARM from your laptop.
2. Under the **Operational** tab, in the **Log Book** section, click **Add**.
3. A popup will open like the one shown in Figure 6-1.

The screenshot shows a 'Log Book' window with the following details:

- Log Book Record Details**
- Date And Time**: Start Date: 2/ 6/2024, Start Time: 09:52:00
- Station**: Aberdeen-Division St
- Generic List**: BlackCarbon
- Maintain Type**: Scheduled - weekly
- Technician Name**: (empty dropdown)
- Invalid Data
- Manufacturer**: API
- Analyzer**: API-T100
- All Parts
- ORIFICE, 3 MIL, IZS
- CD, ORIFICE, .004 BLUE
- ORIFICE, 012 MIL, RXCELL
- LENS, UV
- LENS, PMT
- FILTER, PMT OPTICAL, 330 NM
- ASSY, THERMISTOR
- Description**: (empty text area)
- Buttons**: Save, Cancel

Figure 6-1: Log book entry screen in Envista ARM

4. Select your site from the **Station** dropdown.
5. Choose **PM2.5** from the **Generic List** dropdown.
6. Enter your entry into the Description box.
7. Click **Save** and close the popup.

### 6.3. As-found leak check

The most common cause of invalid data from the BAM is a leak where the nozzle contacts the filter tape. Particularly in wet and humid conditions, debris can build up on the nozzle and cause a leak at the contact point. Frequent leak checks detect small leaks as they develop. At sites where leak check failures are common, it is recommended that operators increase the frequency of the leak check and nozzle and vane cleaning.

1. **Test Menu > Tape Test.**
2. Press **TEST TAPE 2** or 3 times to advance the tape to a clean spot.
3. Examine the last sampled spot for signs of an irregular sample, abnormal deformations, or holes. If you find something odd, do not fix it here. Note it in the logbook and continue with the test.
4. Remove the PM<sub>10</sub> head and replace it with the flow audit adapter (BX-302 or BX-305). Do not remove the VSCC. Turn the flow audit adapter valve to the open position (parallel to the direction of flow).
5. Exit the Test Tape menu.
6. Confirm that the Nozzle is down. If not press **NOZZLE DOWN**.
7. Before turning the pump on, note the lower pressure with no vacuum in the logbook.
8. Press **PUMP ON** and allow the flow to stabilize at 16.7 LPM on the BAM display (~30s).
9. Close the valve on the flow audit adapter.
10. The flow rate should drop. Once it has stabilized (~30s) read the flow rate on the BAM and record it in the As-Found Leak Check section of the BAM 1022 QC form. The flow rate must be  $\leq 1.5$  LPM for the leak check to pass.
  - a. If it doesn't pass, clean the nozzle/vane interface, and retest it.
  - b. If it fails again consult Section 6.4 to start an advanced leak check.
11. Press **Pump Off**.
12. Allow the lower pressure to return to the noted value.
13. You may now open the BX-305 valve. **It is very important that you do not open the valve while under vacuum.** Doing so can result in debris from the filter being blown into the detector. If you suspect that you have blown sample tape into the detector, contact the calibration and repair laboratory.
14. Remove the BX-305 and replace the PM<sub>10</sub> inlet. Return to the Home screen.

### 6.4. Advanced leak check

If the result of the leak check is greater than 1.5 LPM, and cleaning doesn't fix the leak, an advanced leak check is required. Full details regarding the advanced leak check procedure are available in Section 6.3 of the User's Manual. To locate leaks, the advanced leak check consists of 3 parts: Total System Leak Test (TSLT), Lower System Leak Test (LSLT), and Filter Tape Leak Test (FTLT).

**You will need the Leak Check Valve (BX-305) and Nozzle Seal Tool (7440) for the advanced leak check.**

### 6.4.1. Total system leak test

This tests the entire flow system from the inlet to the flow controller, excluding the nozzle. To check this the entire system must be under vacuum. The TSLT is covered in Section 6.3.1 of the User's Manual.

1. Stop the pump if it is running by pressing **PUMP OFF**. Raise the nozzle by pressing **NOZZLE UP**.
2. Remove the filter tape, insert the Nozzle Seal Tool with the hole beneath the nozzle.
3. Verify that the BX-305 is in place and the valve is closed.
4. Press **LEAK ON**. The pump will start and stabilize.
5. Enter the TSLC flow into the logbook. A passing test is below 0.3 LPM.
  - a. If the test passes the leak is at the nozzle. If cleaning the nozzle again does not improve this, contact the Calibration and Repair Laboratory. The system may need a new nozzle or an adjustment to nozzle alignment.
  - b. If the flow is greater than 0.3 LPM, follow the steps in Sections 6.4.2 and 6.4.3 to locate the leak.

### 6.4.2. Lower system leak test

This tests the system downstream of the nozzle/vane interface. The LSLT is covered in Section 6.3.2 of the User's Manual.

1. Stop the pump if it is running by pressing **PUMP OFF**. Raise the nozzle by pressing **NOZZLE UP**.
2. Insert the Nozzle Seal Tool with the hole beneath the nozzle. Press **NOZZLE DOWN**.
3. Press **LEAK ON** to start the pump.
4. Enter the LSLT flow into the logbook. A passing test is below 0.3 LPM.
  - a. If the test passes the leak is above the nozzle. All the connections above the nozzle should be investigated.
  - b. If the test fails, the leak is downstream from the nozzle. The fittings in the lower portion of the flow system should be investigated for leaks.
  - c. Once you have resolved the lower system leak, you will need to repeat the LSLT. If it passes, repeat the as found / as left leak check.

### 6.4.3. Filter tape leak test

The FTLT determines the leak rate at the nozzle tape interface. Leak rate is determined by subtracting the flow through a flow calibration transfer standard with tape from the flow without tape.

1. Remove the PM<sub>10</sub> inlet and install the flow calibration transfer standard.
2. **Test Menu > Leak Test**.
3. Insert the Nozzle Seal Tool with the hole beneath the nozzle. Press **NOZZLE DOWN**.
4. Press **PUMP ON**. The LEAK status should remain in LEAK OFF.
5. Allow the flow to equilibrate for 2-3 minutes.
6. Record the flow as the "Without Tape" value.

7. Stop the pump and raise the nozzle.
8. Remove the nozzle sealing tool.
9. Install a 3" section of tape under the nozzle and lower it.
10. Press **PUMP ON**. The LEAK status should remain as LEAK OFF.
11. Once the flow rate has stabilized, write the value down as the "With Tape" value.
12. Stop the pump and raise the nozzle.
13. Remove the strip of tape.
14. Calculate the tape leak rate (Without Tape – With Tape)
15. If the tape leak rate is less than 0.3 LPM, the test passes. If the test fails, clean the nozzle, and try again. If the test still fails after a thorough cleaning, contact the calibration and repair laboratory.

## 6.5. Filter tape inspection

Examine the spent filter tape for holes. Holes in the filter tape usually indicate a spot of hard debris on the nozzle punching into the tape.

Figure 6-2 shows spent filter tape from a BAM with a clean nozzle and vane on the left, and from a leaking nozzle and vane on the right. The leaking BAM likely has a buildup of debris on the nozzle causing the pinholes visible in the photo.

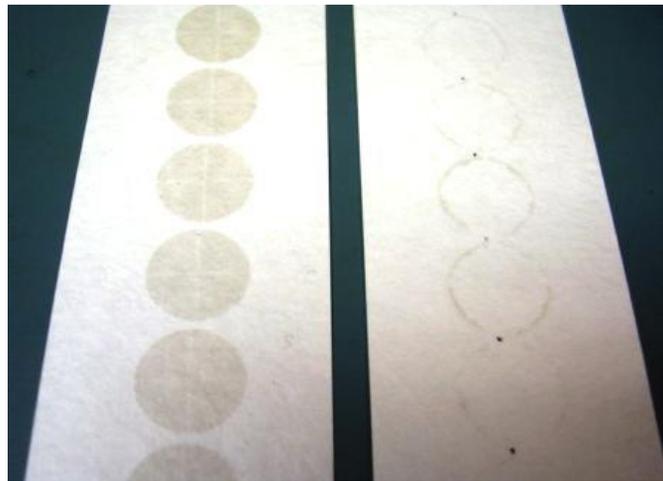


Figure 6-2: Spent filter tape from clean nozzle/vane (left) and leaking nozzle/vane (right)

## 6.6. Nozzle and vane cleaning

Nozzle and vane cleaning is required every 30 days, or more frequently in particularly dusty or humid environments or at sites with a history of leak check failures. Regular cleaning reduces the likelihood of leak check failures and minimizes data loss when they do occur.

You will need 90% isopropyl alcohol, lint-free chamois and compressed air.

**Note:** Although the User's Manual recommends cotton-tip applicators for nozzle and vane cleaning, these can leave lint debris in the nozzle and vane, causing leaks. Operators should

instead use lint-free swabs designed for cleaning electronic equipment. The Calibration and Repair Laboratory can provide these.

1. **Test Menu > Leak Test** and select **NOZZLE UP** to raise the nozzle.
2. Remove the tape.
3. Inspect the vane with a flashlight and clean any debris with a swab dipped in rubbing alcohol. Take care to prevent debris from falling through as the detector is directly below the vane.
4. Press **NOZZLE DOWN**.
5. Use a finger to raise the nozzle and insert an alcohol-dipped swab. Release the nozzle and allow it to press down on the swab.
6. Rotate the nozzle several times with the swab in place.
7. If the swab is visibly dirty, repeat with a fresh swab until the swab comes out clean.
8. Replace the tape or change with a new roll as described in Section 5.5.

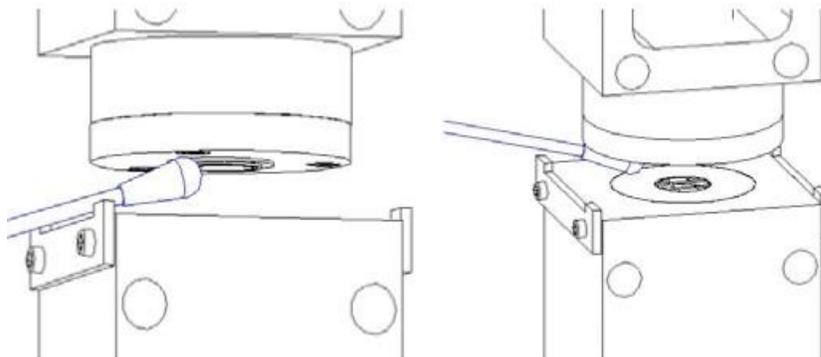


Figure 6-3: Close-up view of nozzle and vane cleaning.

## 6.7. Filter tape change

Changing the filter tape is described in Section 4.2 of the User's Manual.

1. **Operate Menu > Load Filter Tape**.
2. Enter **1 2 3 4** for the password and press **OK**.
3. Remove the Plexiglas cover.
4. Remove the plastic reel covers by unscrewing the knobs.
5. Remove the filter tape and dispose of it in the garbage.
6. Place the empty plastic or cardboard spool core on the receiver.
7. Open a new roll of filter tape and place it on the supply reel.
8. Route the tape through the transit, nozzle and vane as shown on the diagram on the transit.
9. Secure the end of the filter tape to the receiver spool core with a piece of tape.
10. Rotate the spools by hand to remove any slack.
11. Replace the spool covers and tighten the screws only until the covers engage the spool core and hold it in place.
12. Press the **Move** button.

13. If the tape is installed correctly, it will display "TAPE IS OK!" in green letters.

**Note:** It is strongly recommended that operators change the filter tape during every other QC check in the sequence described here. However, if it is necessary to change the filter tape outside of a normal QC check, the filter tape change should always be followed by an as-left leak check (Section 6.10) and Self-Test (Section 6.16).

## 6.8. Clean the PM<sub>10</sub> inlet

1. Remove the PM<sub>10</sub> inlet and condensation jar.
2. Unscrew the collector assembly from the acceleration assembly (Figure 6-4), being careful to avoid damage to the acceleration assembly O-ring.
3. Remove the four screws on the underside of the top plate of the acceleration assembly and separate the top plates from the insect screen and assembly body.
4. Clean using brushes, a lint-free cloth, and/or compressed air. Water can be used if all parts are thoroughly dry before reassembly.
5. Clean the collector plate and the walls around the three vent tubes. Run a wet cloth through the three vent tubes.
6. Wipe out the bottom of the collector assembly where the O-rings are located.
7. Grease the O-rings with silicone grease (never use other types of grease) and inspect for damage. Replace if necessary.
8. Wipe out the condensation jar and lid. Grease the seal inside the lid.
9. Reassemble inlet, being careful not to pinch the O-rings.

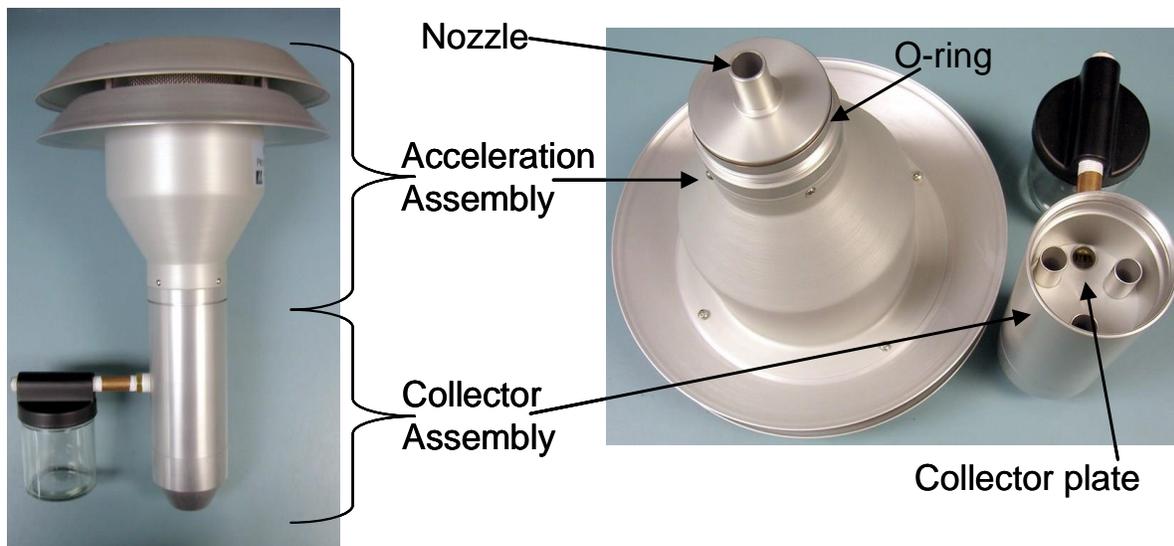


Figure 6-4: Diagram of PM<sub>10</sub> head inlet components (Vaughn, 2009)

## 6.9. Clean the VSCC or SCC

1. Remove the VSCC or SCC from the inlet tube.
2. Remove the top cap and the emptying cup as shown in Figure 6-5.
3. Use a damp, lint-free wipe or cotton swab to remove visible dirt and debris, paying special attention to the emptying cup and the cone inside the top cap. Make sure it is dry before putting back together.
4. Inspect the O-rings for damage and adequate lubrication. Replace O-rings and/or apply silicone grease if necessary.
5. Reinstall the VSCC or SCC on the inlet tube.

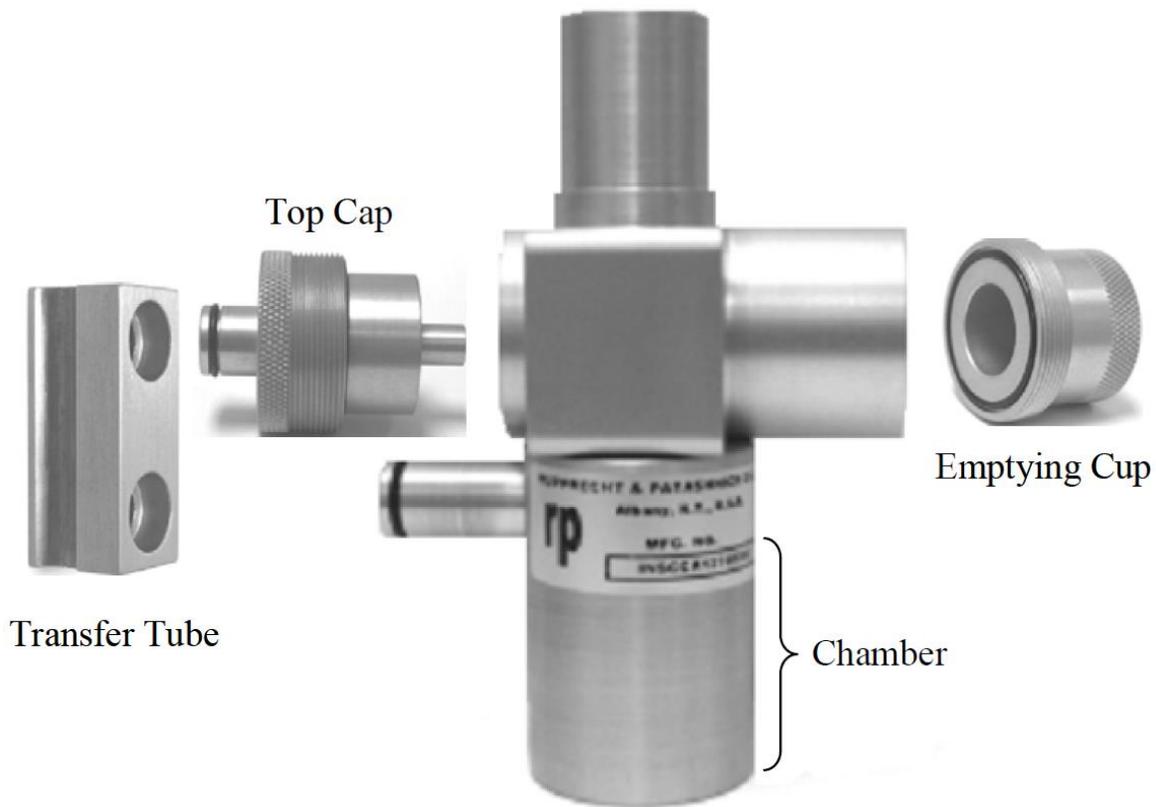


Figure 6-5: Exploded view of VSCC components (Vaughn, 2009)

## 6.10. As-left leak check

The leak check must be repeated after the nozzle and vane cleaning (and filter tape change, if applicable) to ensure that any debris at the vane/nozzle was successfully removed and that no new leaks were introduced.

1. Repeat the leak check procedure in Section 6.3.
2. Record the results in the As-Left Leak Check section of the BAM 1022 QC form.

If a leak greater than 1.5 LPM persists, repeat the nozzle and vane cleaning procedure in Section 6.6.

## 6.11. Ambient temperature and pressure verification

As temperature and pressure change, so does the density of air. They are measured to correct flow (and by extension concentration) to a value that can be compared across meteorological conditions.

The Ambient Temp and Ambient Pressure screens (Figure 6-6) allow the user to view and calibrate the probes used to measure ambient conditions. For each parameter, the BAM shows the instrument's indicated value. The STD column is whatever was last entered for a calibration.

1. Insert the tip of a certified, NIST-traceable thermometer into the radiation shield and allow it to equilibrate for five minutes.
2. Record the temperature reported by the thermometer on the QC form.
3. **Test Menu > Ambient Temp.**
4. The screen will show the ambient temperature measured by the BAM 1022.
5. Record the BAM 1022 temperature in the QC form.
6. If the temperature verification passes ( $\pm 2^{\circ}\text{C}$ ) no further action is needed. If it fails, you will need to calibrate it as described in Section 5.8.
7. Press **X** to exit.
8. Measure the ambient pressure with your NIST-Traceable pressure sensor and record it in the QC form.
9. **Test Menu > Ambient Pressure.**
10. Record the BAM 1022 pressure the QC form.
11. If the pressure verification passes ( $\pm 10$  mmHg) no further action is needed. If it fails, you will need to calibrate it as described in Section 5.8.

Ambient Temp		Ambient Pressure	
BAM 1022	22.5 C	BAM 1022	739 mmHg
Reference	+22.5	Reference	+739

DEFAULT      CALIBRATE      DEFAULT      CALIBRATE

Figure 6-6: Ambient Temp (left) and Ambient Pressure (right) screens

**Note:** Operators should complete a full initial QC before making any changes to the STD column. If calibration is needed, record the results of the initial QC, and label the QC form “as found.” Calibrate the necessary parameters following the steps in Section 5.8 then repeat the QC check and record the results in a separate QC form labeled “as left.”

## 6.12. Three-point flow verification

Although the BAM 1022 operates at a flow rate of 16.7 LPM, the QC check also tests the BAM 1022 at flows of 14.0 and 17.5 LPM. Testing three flows ensures not only that the operating and

design flows are accurate but also that the slope of the BAM's mass flow sensor is properly calibrated.

1. Ensure that the flow audit adapter is installed above the VSCC or SCC and in the open position.
2. Connect a certified flow transfer standard on the sample tube in line with the flow.
3. **Test > Flow Calibration.** The pump will start, and the flow will equilibrate at 16.7 LPM.
4. Once the flow has stabilized, record the BAM flow and the flow observed by the standard in the QC form (Flow 1).
5. Touch the **Set Point** box, select the **17.5** LPM flow and press **OK**.
6. Once the flow has equilibrated at 17.5 LPM record the BAM flow and standard flows in the QC form (Flow 2).
7. Touch the **Set Point** box again, select **14.0** and press **OK**.
8. Allow the flow to equilibrate to 14.0 LPM before entering the BAM and Standard flows in the QC form (Flow 3).

### 6.13. Temperature/pressure/flow calibration (as needed)

Prior to calibrating any values in the STD column, perform a complete initial QC according to Sections 6.3 through 6.12. This will establish baseline measurements and create a record of the instrument's function for future diagnosis.

The acceptable ranges for each parameter are:

- **Ambient Temperature:**  $\pm 2^{\circ}\text{C}$
- **Ambient Pressure:**  $\pm 10$  mm Hg
- **Flow:**  $\pm 4\%$  of reference standard and  $\pm 5\%$  of design flow (16.7 LPM)

If any parameter falls outside of these ranges, document the observed value in the "as found" column on a QC form, and proceed with calibration as described in Section 5.8. After calibration, repeat the QC check and record the results in the "as left" column. Record all calibration activities in the site log.

### 6.14. Span mass audit

The Span mass audit is described in Section 5.9 as a part of the setup procedure. This tests the BAM's ability to accurately determine a known mass and should be performed during each QC if the weather permits it, and at least annually.

1. **Test Menu > Span Mass Audit.**
2. Enter **1 2 3 4** when prompted for the password.
3. The screen will prompt you to load the zero foil. Once it is properly inserted the nozzle will automatically lower and the zero will begin counting down from 240 s.
4. When it finishes the nozzle will raise and the screen will prompt you to remove the foil.
5. When screen shows you the span value, record it in the station log and press **CONTINUE**.
6. The screen will prompt you to insert the Span Foil above the tape. Again, the nozzle will lower when the foil has been inserted correctly.

7. The detector will begin counting down from 240 s.
8. Once complete the test will display the calculated mass (Mass), the recorded value (Span), and the percent error. If the error is greater than  $\pm 5\%$ , the audit has failed. The error is usually caused by tape movement during the insertion and removal of the zero and span foils. If a large error occurs, redo the test while minimizing tape movement.
9. Press **X** to exit the test.
10. The nozzle will raise and prompt you to remove the span foil.
11. Remove it, place it in the sleeve and store it safely.

If the span mass audit fails, follow the cleaning steps in Section 6.8 of the User's Manual. If the span mass audit continues to fail, contact the Calibration & Repair laboratory for further troubleshooting steps.

## 6.15. Clock verification

1. Verify that the BAM clock is the same time as the data logger clock. If not connected to a logger, time should be set to the time reported by an internet-connected device.
2. Record the data logger time and as-found BAM time in the Clock Verification section of the BAM 1022 QC form.
3. If the BAM does not report the same time as the data logger, adjust the BAM clock in **Setup Menu > Set Clock**. Record the results on the QC form as the "as left" BAM time.

## 6.16. Perform Self-Test

The BAM's built-in Self-Test function automatically tests the tape and flow systems to ensure that the BAM is ready to return to sampling mode. The Self-Test should be run after every QC check and any other interruption to sampling, such as a filter tape change or performance evaluation.

1. If the leak check adapter is installed, ensure the valve is open.
2. **Test Menu > Run Self-Test**.
3. Read the "Status" line when the Self-Test is complete. If it displays SELF TEST PASSED, select **EXIT** to return to the home screen.
4. If the status displays ERROR OCCURRED, look for an error in the individual test parameters on the BAM screen. Resolve the error and repeat the Self-Test until it passes. If you are unable to resolve the failure, contact the calibration and repair lab.
5. Remove the leak check adapter.

## 6.17. Final checks

Before leaving the site, always verify that the flow audit adapter is removed, the SCC or VSCC and PM<sub>10</sub> head are installed, the BAM displays the home screen, and the results of all QC checks and maintenance are recorded in the electronic logbook.

## 7. Six-Month Maintenance

### 7.1. Clean/replace the pump muffler

The BAM's standard Medo pump has a gray plastic muffler, which may clog with dust and debris over time. Clean or replace this muffler after every 6 months of use or if the pump is unable to draw 16.7 LPM. The Calibration and Repair Lab recommends replacing the muffler with a 30-inch length of Tygon tubing, which will not clog and improves pump performance.

### 7.2. Test the filter temperature sensor

1. **Test Menu > Filter Sensors > TEMPERATURE.** This will raise the nozzle and turn on the pump.
2. Allow the pump to warm up for 5 minutes and the reference thermometer to equilibrate to room temperature. If the Smart Heater has recently been running, allow additional time for the inlet to cool to room temperature.
3. Compare the filter temperature displayed to the ambient room temperature on the reference thermometer. Place the reference temperature probe as close as possible to the nozzle opening. The acceptance limit is  $\pm 1^{\circ}\text{C}$ .
4. If necessary, calibrate the sensor by pressing **DEFAULT** and then entering (if necessary) the ambient temperature from the reference thermometer in the Standard field, then select **CALIBRATE**.
5. Select **X** to return to the Test menu.

### 7.3. Test the upper and lower pressure

1. **Test Menu > Filter Sensors > UPPER/LOWER PRES > OK.**
2. The pump should be off, and the nozzle raised so that the pressure in the vacuum system is at ambient pressure.
3. Compare the Upper/Lower Pressure reading to the pressure transfer standard.
4. If the Upper/Lower Pressure reading needs calibration, press **DEFAULT**.
5. If the default calibration is within  $\pm 5$  mm Hg of the pressure transfer standard, no further calibration is needed.
6. If further calibration is needed, enter the pressure reading on the standard in the Standard box and press **CALIBRATE**.

### 7.4. Test the smart heater

1. **Test Menu > Inlet Heater.**
2. If the heater is on, select **OFF** and allow it to equilibrate to room temperature.
3. Select **ON** and verify that the heater warms to the touch after several minutes.
4. Select **X** to return to the home screen. The heater will automatically turn off.

Record the maintenance steps completed in the electronic logbook.

## 8. Twelve-Month Maintenance

The BAM 1022 requires annual maintenance. This is normally conducted by the Calibration and Repair Laboratory. The Laboratory maintains records of all completed 12-month maintenance.

Unlike the BAM 1020, accessing the 1022's internal components for maintenance is challenging. Therefore, 12-month maintenance involves a field instrument swap.

The annual maintenance includes the following tasks:

- Inspect/replace the internal debris filter.
- Check the membrane span foil.
- Span mass audit.
- Test the filter RH sensor.
- Test the beta detector count rate and dark count.
- Clean the inlet tube.
- Test/replace lithium battery on circuit board.
- Rebuild the vacuum pump.
- Replace the nozzle O-ring.
- Replace the pump tubing.
- Repeat the 72-hour zero test.

The Calibration and Repair Laboratory will work with operators to arrange the annual 72-hour zero test at the operating site and update the BKG value as necessary.

## 9. Data Collection and Storage

### 9.1. Communication software setup (data logger)

Comet software enables downloading data, settings, and diagnostic information from the BAM 1022 via Ethernet or serial connection. Coordinate with the Calibration and Repair Laboratory and the IT and Telemetry Unit to install Comet version 2.0.4 or later, either from the CD that came with the BAM, or downloaded from: <https://metone.com/products/comet/>.

#### 9.1.1. New monitor setup

To connect a BAM to Comet for the first time, users must configure its connection:

1. Select **Add New Station**. You should see the station setup screen shown in Figure 9-1.
2. Select **BAM** and click **Next**.
3. Select **BAM1022** and click **Next**.
4. For ethernet connections:
  - a) Select **TCP/IP** and click **Next**.
  - b) Enter the IP address and port number.
5. For serial connections:
  - a) Select **Serial** and click **Next**.
  - b) Identify and enter the communications port.
6. If successful, the station will now appear in the main Comet window.
7. Test the connection and download settings file:
  - a) Open the station and click **Retrieve** to download the settings file.
  - b) Verify successful download by checking the file path displayed at the bottom of the screen (Figure 9-2).
8. Open the downloaded settings file and copy and paste its contents into the site's logbook.
  - a) This provides a record that can be referenced if any settings are incorrectly changed.
  - b) It also facilitates troubleshooting and understanding of instrument behavior.

#### 9.1.2. Accessing data

Select **Retrieve Current** in Comet to download the following:

- **Data:** PM measurements and associated time stamps.
- **Settings:** Current configuration parameters of the BAM 1022.
- **Diagnostic Information:** Insights into instrument performance and potential issues.
- **Alarm History:** Records of past alarms and their associated details.
- **Factory (Internal Diagnostic) Data:** Comprehensive internal diagnostic information for troubleshooting and maintenance.

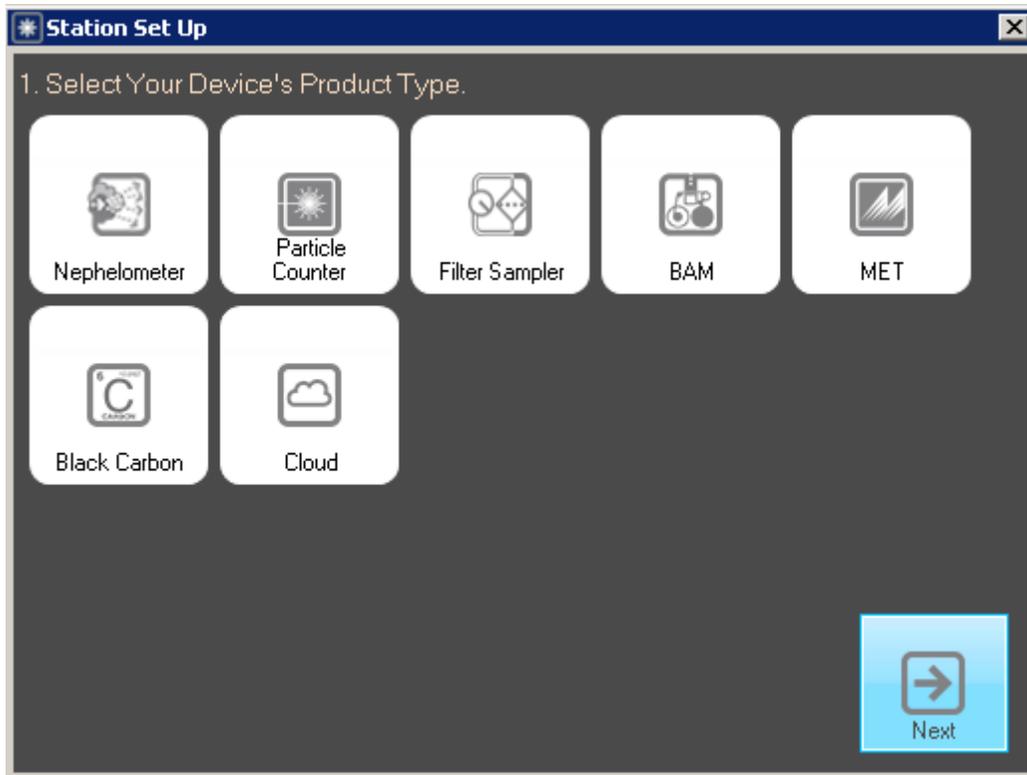


Figure 9-1: Comet station setup screen

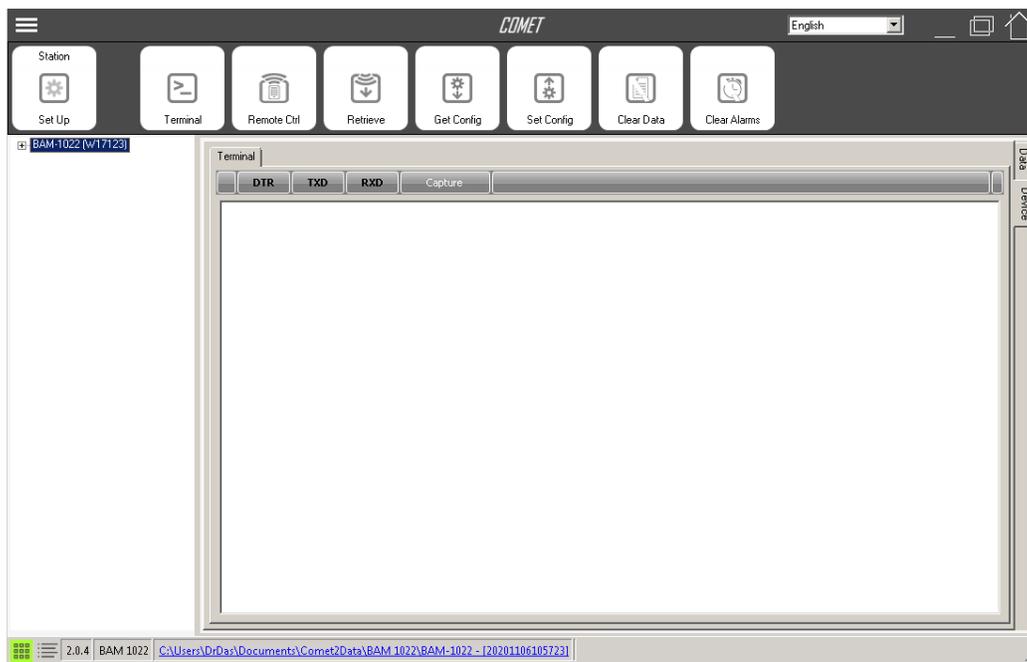


Figure 9-2: Comet user interface

## 9.2. Communication setup (cellular)

Generally, the IT and Telemetry Unit will configure both the BAM and its modem prior to deployment. If settings need to change, or if you need to set up communications for a new instrument, work with the IT and Telemetry Unit using the steps in this section.

Configure the BAM static IP:

1. Enter the **Setup** menu from the home screen.
  - a. The password is **1 2 3 4**.
  - b. Not all options will be visible at once. Use the up and down arrows to scroll through options.
2. From the **Setup** menu, select **Ethernet**.
3. Enter values provided by IT for IP Address, Subnet Mask, and Gateway.

Set up the router:

1. Upon activating a new service line, a static IP address must be requested from the service provider.
2. Once the router is activated, turn off its Wi-Fi functionality by setting the dropdown box under **Wi-Fi AP** to **OFF**.
3. Set up port forwarding:
  - a. Navigate to **Advanced > Advanced – Port Forwarding > Add Service**.
  - b. Check **Enable** to allow port forwarding. Enter the **Port** and **Map to** values provided by IT.
  - c. Note that Envidas connects on port 444 and the BAM 1022 always connects on port 7500.
4. Set up the firewall:
  - a. Navigate to **Advanced > Firewall – Access Rules > Add Rule**.
  - b. Enter the **Source** and **Destination** values provided by IT.
5. Install the router according to the instructions in Section 5.2.

## 9.3. Site Information Management System (SIMS)

The Air Quality Program uses the Site Information Management System (SIMS) as the repository for all site and parameter information. SIMS is updated by station operators when a site is established or discontinued and as monitored parameters or physical conditions at the site change. IT and Calibration & Repair staff maintain the Equipment Inventory portion of SIMS.

SIMS encompasses:

- **Site Information:** Address, physical location, type of monitoring site, probe information, monitored parameters.
- **Geographical Information:** Latitude, longitude, elevation.
- **Monitor/Station Type:** SLAMS, NCore, Near-road, SPMS, etc.
- **Instrumentation and Methods:** Pollutants measured, equipment make and model, etc.
- **Measurement Scale:** Micro, middle, neighborhood, etc.

- **Land Use:** Industrial, commercial, etc.
- **Location Setting:** Urban or rural.
- **Monitoring Objective**
- **Telemetry and Telecommunication Information:** Central setup, data logger channel mapping.
- **Probe Location:** Top of building, ground level, etc.
- **Equipment Inventory**

## 9.4. Data verification and quality assurance

Operators are responsible for ongoing review of measured parameters. Issues must be reported to the Quality Assurance Unit and documented in the site logbook as soon as possible. The Quality Assurance Unit is responsible for final data verification.

Data validity is evaluated using several criteria, including the results of quality control checks and performance audits and examination of diagnostic parameters. Table 9-1 summarizes the tolerance limits for critical and operational criteria. Criteria that trigger invalidation outside of tolerance limits are marked with a ✓. The validity of data outside of the remaining limits is evaluated using a weight-of-evidence approach. The full table of critical and operational criteria can be found in EPA’s Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II.

Table 9-1: Summary of critical and operational criteria used to verify data

Criteria	Frequency	Tolerance limits	Invalid
Flow check	Monthly QC; semi-annual audit	± 4% actual flow; ± 5% design flow	✓
Leak check	Monthly QC; semi-annual audit	≤ 1.5 LPM	✓
Temperature verification	Monthly QC; semi-annual audit	± 2°C	Weight-of-evidence
Pressure verification	Monthly QC; semi-annual audit	± 10 mm Hg	Weight-of-evidence
Span Mass Audit	Monthly QC; semi-annual audit	± 5% factory value	✓
Clock verification	Monthly QC; semi-annual audit	2-3 minutes ahead	✓
Status	Hourly	Error flag	✓

## 9.5. Error flags

Table 9-2 summarizes possible error flags, their associated codes, and their causes. Operators should consult the User’s Manual for more detailed diagnostic and troubleshooting information regarding error flags. Alarms can be viewed via the alarm log on the BAM as well as in output files. If multiple errors occur in the same period, the alarm code will be the sum of the codes.

To determine which codes are being summed, note the largest code number that is less than the summed value. This will be the first code being summed. Subtract that from the summed value to determine the second code. Repeat this process until all codes are known.

Table 9-2: BAM 1022 error flags (User's Manual, BAM 1022-9805 REV D, page 62)

Code	Description	Cause
1	Tape Break	No tape movement was detected during the tape move process.
2	Beta Detector	Beta detector count rate was less than 500 Hz during the sampling cycle.
4	Sensor Range	An analog sensor reading (AT, RH, BP, UPPER, LOWER, FT, FRH) was outside the designated limits.
8	Tape Advance	Pressure drop across the tape exceeded the Tape Advance Pressure setting.
16	Flow Failure	Sample flow was less than 1.0 SLPM for greater than 1 minute. Sample flow was $\pm 10\%$ out of regulation for 1 minute, or sample flow was $\pm 5\%$ out of regulation for 5 minutes.
32	Nozzle Failure	Nozzle failed to move and/or stop at the up or down position, or the foil device was still inserted at start of operation.
64	Digital Link Failure	Communication with the BX-597A sensor was interrupted for greater than 10 seconds.
128	Power Failure	Power cycle or micro-processor reset.
256	Short Sample	Sample cycle was less than 1-hour.
512	Maintenance	User stopped normal operation.

## 10. References

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Ambient Air Monitoring Reference and Equivalent Methods: Designation of Five New Equivalent Methods. Federal Register (12 November 2013) pp. 67360 – 67361. Met One Instruments, Inc. BAM 1022 Real Time Beta Attenuation Mass Monitor PM<sub>2.5</sub> FEM configuration Automated Equivalent Method: EQPM-1013-209.

Met One Instruments, Inc. *BAM-1022 Continuous Particulate Monitor Operation Manual*. Grants Pass, OR: Met One Instruments, 2020 (BAM1022-9805 REV D).

Met One Instruments, Inc. *BX-302 Zero Filter Calibration Kit Manual*. Grants Pass, OR: Met One Instruments, 2007 (BX-302-9800 Manual REV F).

“Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring.” *Code of Federal Regulations* Appendix E to 40 CFR Part 58.

U.S. Environmental Protection Agency. Center for Environmental Measurements & Modeling Air Methods & Characterization Division. “List of Designated Reference and Equivalent Methods.” [https://www.epa.gov/system/files/documents/2023-12/list\\_of\\_frm\\_fem\\_-\\_december\\_2023\\_final.pdf](https://www.epa.gov/system/files/documents/2023-12/list_of_frm_fem_-_december_2023_final.pdf)

U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. *Quality Assurance Handbook for Air Pollution Measurement Systems Volume II: Ambient Air Quality Monitoring Program*. Research Triangle Park, 2017 (EPA-454/B-17-001).

# Appendix A: BAM 1022 QC Form

Use of the BAM 1022 QC form below is required for all operators in the Washington Network. Contact the Ecology Quality Assurance unit for a spreadsheet copy of this form. QC forms are stored on the QA unit's server indefinitely, and also available upon request.

AQS No. _____	Date _____
Location _____	Operator _____
Sampler Serial No. _____	QC Start Time _____ PST
State Tag No. _____	QC Stop Time _____ PST
Flow Std. Model _____	Temp Std. Serial No. _____
Flow Std. Serial No. _____	Temp Std. Cert. Date _____
Flow Std. Cert. Date _____	Pressure Std. Serial No. _____
	Pressure Std. Cert. Date _____

### As-Found Leak Check

Indicated flow (<1.5 lpm)	
Pass/Fail	

### Clock Verification

BAM 1022 time	
BAM time adjusted?	

### Temperature QC

Ambient Temp  ±2°C	Act:		°C
	Ind:		°C
	Diff:		°C

### Pressure QC

Barometric Pressure  ±10mmHG	Act:		mmHg
	Ind:		mmHg
	Diff:		mmHg

### Flow QC

Sampler Design Flow Rate	Indicated Flow Rate lpm	Actual Flow Rate lpm	% Difference (±4%)
Flow 1			
Flow 2			
Flow 3			
Design Flow Difference (±5%)			

Mass Span Check	Mass	Span	% Error
Design Mass Span Difference (±5%)			

### Post QC Leak Check

Indicated flow (<1.5 lpm)	
Pass/Fail	

**QC Result:**

**Comments:**