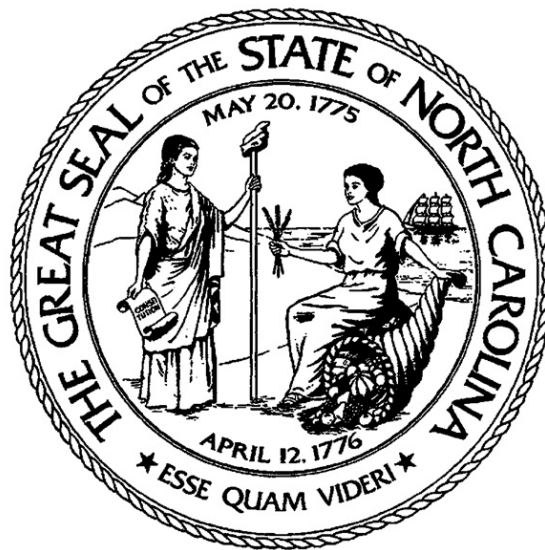


**Standard Operating Procedure 2.46**  
**Section 2:**  
**Met One BAM 1022 Standard Procedures for Operators**



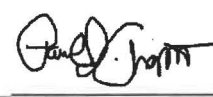
**Revision 2020**



## Standard Operating Procedure Approval

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### Department of Environmental Quality

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Air Quality Division Director
2. Signature:  Date 12-3-2019  
Quality Assurance Manager  
(Ambient Monitoring Section Chief)
3. Signature:  Date 12/3/2019  
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4. Signature:  Date 12/3/19  
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## **1.0 SCOPE AND PURPOSE**

The U.S. Environmental Protection Agency (EPA) began regulating fine particles in July 1997. The regulation established the gravimetric based federal reference method (FRM) in the Code of Federal Regulations (CFR) at 40 CFR Part 50, Appendix L. On August 26, 2015, the EPA designated a new federal equivalent method (FEM) in the Federal Register (EQPM-1013-209). The new FEM was approved for measuring the concentration of fine particles in the ambient air using beta ray attenuation. This document has been prepared to assist the field operators with the North Carolina Division of Air Quality (NCDAQ) to use the EPA equivalent method to monitor the ambient atmosphere for particles with an aerodynamic diameter of  $2.5\text{ }\mu\text{m}$  or less ( $\text{PM}_{2.5}$ ), known as fine particles. Fine particles are formed in the atmosphere from gases such as sulfur dioxide, reactive oxides of nitrogen, and volatile organic compounds. Sources include power plants, diesel trucks, wood stoves, and industrial processes.

The following document describes the operation and field technician responsibilities for the Met One Instruments Beta Attenuation Monitor (BAM) Model 1022. The BAM 1022 automatically measures and records the airborne  $\text{PM}_{2.5}$  concentration using the principle of beta ray attenuation. The hourly concentration recorded by the instrument is later compared to the National Ambient Air Quality Standards (NAAQS) for annual and 24-hour average.

The objective of this Standard Operating Procedure (SOP) is to familiarize the station operator with the activities used in the collection of air monitoring data. The accuracy of data obtained from any instrument depends upon the instrument's performance and the operator's skill. It is important that the station operator become familiar with both this SOP as well as the manufacturer's operation manual in order to achieve a high level of data quality.

## **2.0 SAMPLER DESCRIPTION AND ASSEMBLY**

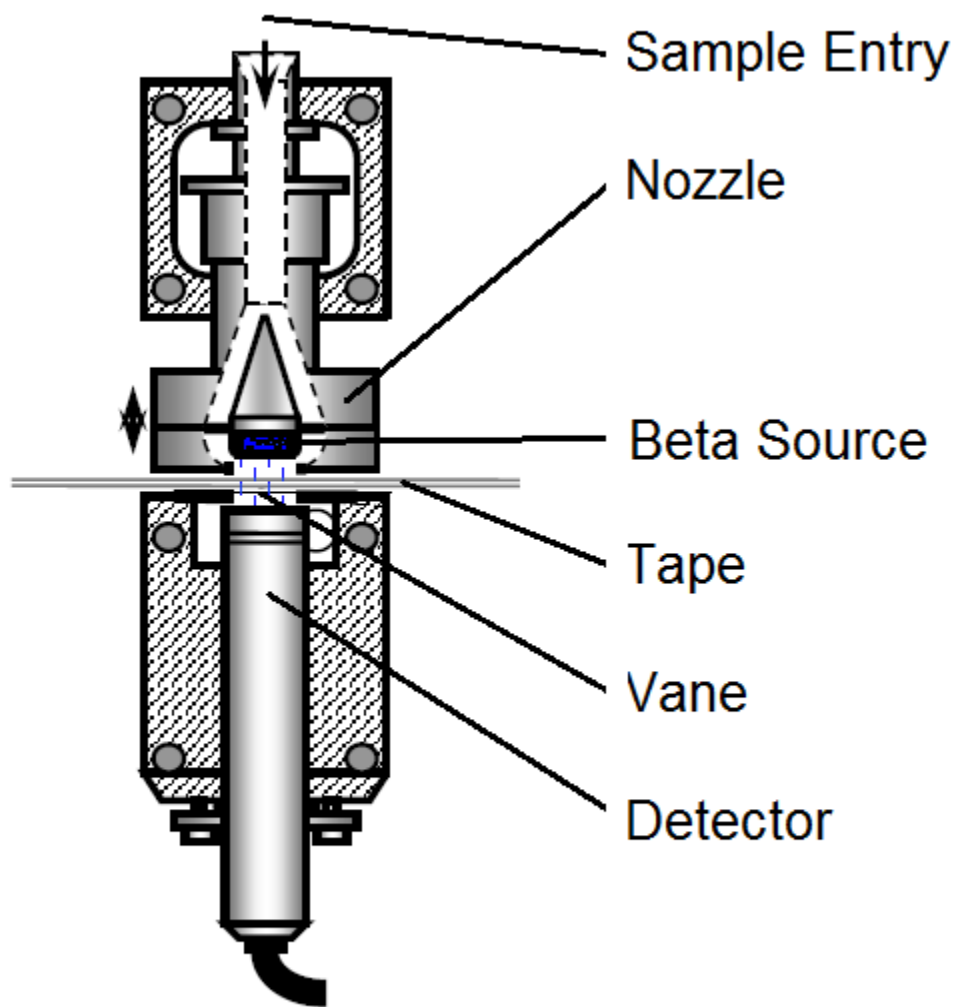
### **2.1 Description of Met One 1022 Monitor**

The Met One Instruments Model BAM 1022 Continuous PM Monitoring System utilizes the principal of beta ray attenuation to accurately measure and report the concentration of airborne particulate matter (PM) in ambient air at local conditions of temperature and atmospheric pressure. The centerpiece of the measurement system is a small, Carbon 14 ( $^{14}\text{C}$ ) source that emits a consistent supply of electrons, in the energy of the Beta spectrum to the mass to be measured, and a sensitive detector that counts the incident electrons.

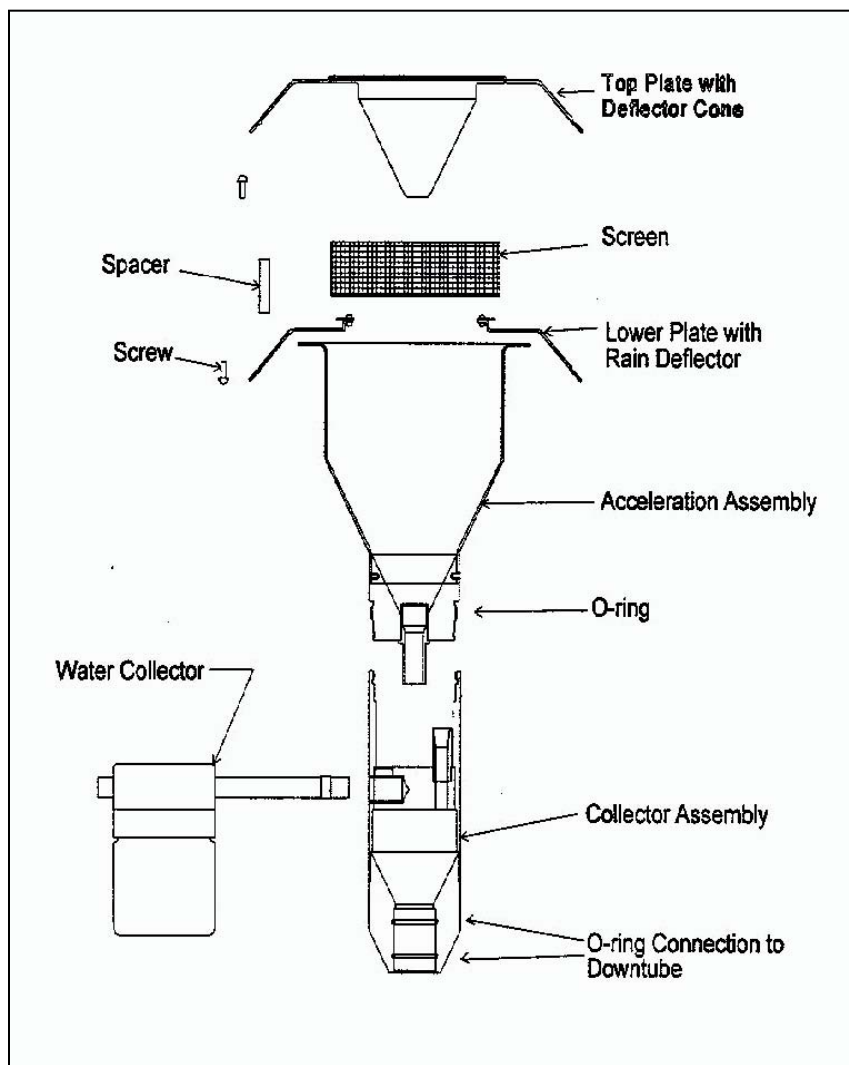
A vacuum pump draws air, at a rate of 16.7 liters per minute (LPM), through a size selective inlet, down the inlet tube, and deposits the airborne particulate on a filter tape that is located between the beta source and detector. The accumulation of mass onto the filter tape increasingly attenuates beta ray transmission through the media.

Beta attenuation through the filter tape is continuously monitored throughout the measurement cycle. The degree of beta ray attenuation is used to determine the mass of particulate matter deposited on the filter tape. During sampling, the flow rate is precisely controlled.

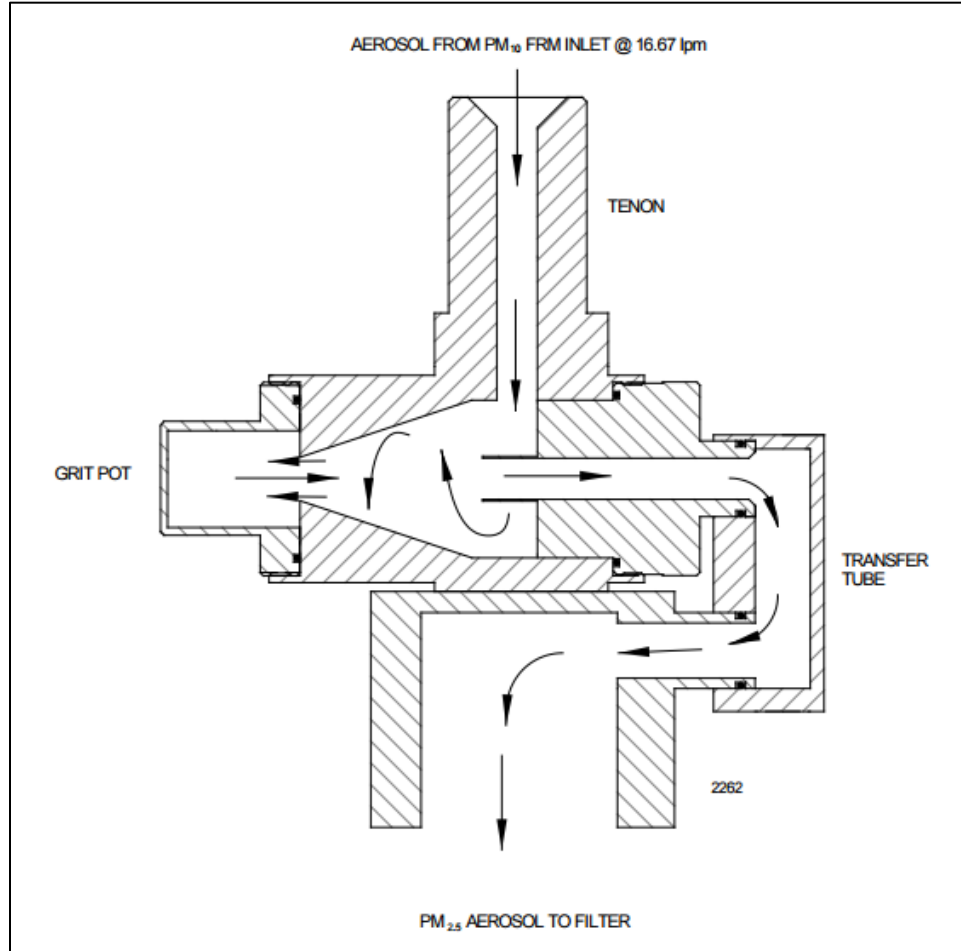
Having determined both mass and sample volume, the BAM 1022 calculates and reports the ambient PM concentration, expressed as micrograms (one-millionth of a gram,  $1\text{e}+6$ ) per cubic meter of air ( $\mu\text{g}/\text{m}^3$ ). Figure 1 below demonstrates the BAM 1022 measurement system. Appendix A contains a diagram that outlines the BAM 1022 system.



**Figure 1. BAM 1022 Measurement System.**



**Figure 2. Exploded Cross-Sectional View of PM10 Sampler Inlet Head.**



**Figure 3. Operation of the VSCE.**

## 2.2 Assembly

Upon installation of the BAM-1022 at the site by ECB, visually inspect it to ensure that all components are accounted for. Inspect the instrument for external physical damage due to transport, such as scratched or dented panel surfaces and broken knobs or connectors. Open the instrument cover and inspect the interior of the instrument for damage, such as broken components or loose circuit boards. If no damage is evident, the monitor is ready for installation, calibration and operation. Notify ECB immediately if any equipment is missing or damaged.

### **3.0 SUMMARY INFORMATION SPECIFIC TO THE INSTRUMENT**

#### **3.1 Safety Precautions**

The Met One Instruments BAM 1022 contains a small  $^{14}\text{C}$  (Carbon 14) beta radiation-emitting source. The nominal activity of the source is  $60\ \mu\text{Ci} \pm 15\ \mu\text{Ci}$  (microcuries), which is below the “Exempt Concentration Limit” as defined in USC 10 CFR Section 30.71 – Schedule B (100  $\mu\text{Ci}$ ). Under no circumstances should anyone but factory technicians attempt to remove or access the beta source. The beta source has a half-life of about 5,730 years, and should never need to be replaced unless it becomes damaged or corroded. Neither the  $^{14}\text{C}$  source nor the beta ray detector are serviceable in the field. Should these components require repair or replacement, the BAM 1022 must be returned to the factory for service and recalibration. The BAM 1022 is manufactured in compliance with the U.S. NRC safety criteria in 10 CFR 32.27.

If the BAM 1022 is operated in a manner not specified by the manufacturer, the performance and protection provided by the equipment may be impaired.

- Any repairs or adjustments made to the BAM 1022 that are not outlined within this document must be carried out only by factory-trained personnel. Under no circumstances should repairs be attempted by personnel not qualified to service electronic instrumentation.
- Disconnect power to the BAM 1022 power before working on electrical components. Failure to do so may result in an electrical hazard and could damage the equipment.
- Grounding and antistatic procedures must be followed when handling any internal components. Internal circuitry of the BAM 1022 may be damaged by static electricity.
- Do not operate the BAM 1022 in potentially explosive environments.
- The BAM 1022 should be secured against accidental tipping. Anchoring holes are provided in the feet at the base of pump box assembly for this purpose.

#### **3.2 Siting Criteria**

The installation of the 1022 should follow the siting criteria requirements in 40 CFR Part 58, Appendix E in order for the sampled filters to be considered valid. General siting criteria include:

1. Being >20 meters from a tree, and at least 10 meters from a tree drip line,
2. Being >1 meter horizontally away from another probe,
3. Having the probe inlet located 2-15 meters above ground,

4. And being twice the distance from a structure or tree that acts as an obstruction, as the structure or tree protrudes above the inlet.

## 4.0 LOGBOOK SET-UP, SITE VISIT PROCEDURES AND CHECKS

### 4.1 Logbook Setup

An electronic logbook (e-log) must be created for each site at the beginning of the calendar year or upon setup. The BAM e-log consists of the spreadsheets listed in Table 1. The most current e-log version can be obtained from the IBEAM documents module, the Ambient/Documents/PM Monitoring SharePoint folder or by contacting the RCO particulate matter lead.

**Table 1. Description of E-Log Spreadsheets.**

| <b>E-Log Spreadsheet</b> | <b>Description</b>   |
|--------------------------|--|
| Instructions             | Setup of site information (Site Name, AQS ID, SiteID2). Provides a summary of operational evaluations and sampler maintenance for users.   |
| Event Summary            | Table for users to track dates of verifications, audits, and maintenance.  |
| Site Visit               | Log of every site visit including monitor information, operational parameters, and site activities.  |
| Calibration              | Table for documenting sampler calibrations.  |
| Maintenance Log          | Table for documenting monthly, quarterly, and annual maintenance activities, as well as tape changes, leak checks, clock verifications, etc.   |
| Verification Audit       | Table for documenting all verifications and audits.  |
| Background               | Calculates the background coefficient for the BAM and determines if the zero background test passes or fails. (Note: there are three background spreadsheets in case multiple tests need to be performed.) |
| AQS Upload               | This spreadsheet is for RCO use. Formulas on this page generate the AQS upload files for all verifications and audits.   |

Initial setup of the e-log requires selecting the site name from a pull down menu on the “Instructions” tab of the e-log. The AQS ID, pollutant, and BAM type field will automatically populate based on the site name.

#### **4.1.1 Guidance for Useful Logbook Documentation**

EPA has been providing guidance on record keeping requirements for QA/QC programs. In particular, EPA has discussed the role that logbooks play in providing proof that QAPPs and SOPs are being followed. According to EPA, logbooks should, at a minimum, provide the following to be a useful tool for documenting the operations conducted at a monitoring site:

1. Purpose – Define the purpose of this site visit. Tell why you are there. Is it to replace a filter? Did you note something in the previous data download that is indicating a problem? Are you experiencing data drops and want to see if anything is wrong? In a couple of sentences, tell what you intend to do. Don't say routine maintenance, say instead: "noted fluctuations in flow while reviewing the 5-minute average data". Be specific.
2. Appearance – Tell how you found the site. If the site was secure, say so. If you noted a problem, or a changed condition, then document it in a couple of sentences: "construction has taken place in the vacant lot next to the site since my last visit".
3. Action – Tell what you did. In a few short sentences describe the actions you took at the site: "cleaned the PM10 head and replaced one of the two gaskets". In particular, you might want to document any site computer updates that were run. Just things like that.
4. Results – Were you successful? Did you accomplish your goals? If so, then say so: "completed the monthly and quarterly maintenance and returned the monitor to "Wait" mode". If not, then say so: "failed as-left leak check, contacted ECB".
5. Response – Is the equipment operating within specifications set in SOP? If so, then great, note that fact in the logbook and you are done. If not, then what did you do? If something is wrong then reach out for help and document it: "contacted Scott at ECB, he will be here presently with a new FRM."
6. Reviewers should add their comments: "reviewed above, approved operator action." Or: "upon review noted deviation from SOP".



## **4.2 Site Visit Procedures and Checks**

### **4.2.1 Site Inspection**

Before entering the station, the perimeter should be inspected for damage. Extreme weather conditions, neglect of station maintenance or vandalism that may have resulted in damage to the site since the operator's last visit. Once the operator has approached the site, she/he should first:

1. Check for any obvious sampler malfunctions. For example, check to see that the equipment is running, the pumps are operating and the instrument is cycling properly.
2. Note any unusual odors or noise. An unusual odor may indicate a point source of a pollutant or a strange new noise can indicate a malfunction in the equipment.

These observations should be recorded in the station log book and may prove to be invaluable if the data is challenged. The station operator is responsible for making several observations during the station inspection. Any of the above described observation must be thoroughly detailed in the site log book.

It is the operator's responsibility to maintain the monitoring site. Routine maintenance includes keeping site clean and being observant of potential problems. Examples of potential problems include:

1. Accumulation of dirt and debris.
2. Infestation by rodents or insects.
3. Overgrowth of vegetation around the site.

### **4.2.2 Site Logbook**

A station log book must be maintained at each monitoring site and should accurately reflect site operations. The log book will be identified with the station name and station number. All entries shall include the date, time, operator, maintenance on equipment and equipment changes. Additional information should include: maintenance performed on the station, abnormal traffic patterns or nearby construction. If the data is challenged, the information recorded in the logbook is invaluable. A written record of observations concerning abnormal operations or localized occurrences is critical if a violation of ambient air standards were recorded during this period.

### **4.2.3 Equipment Inspection**

There are several routine duties that must be performed each time an air monitoring station is inspected. These duties include equipment inspection, performing calibrations, assisting during audits, documentation, and making necessary adjustments or repairs to the instruments.

It is suggested that each station operator consult the newest versions of the Met One 1022 Particulate Monitor Operation Manual and compile personal notes on troubleshooting as they gain experience with the instruments. The operator is encouraged to contact ECB or the manufacturer when attempting any repairs.

**The operator's manual is the best resource the station operator has for the information on the operation and maintenance of the 1022 monitors.**

## 5.0 MONITOR SETUP

### 5.1 User Interface

The BAM 1022 uses a touchscreen display to control the features and functionality of the BAM. The center screw of the mounting bracket hinge adjusts the amount of force necessary to reposition the bracket.

#### 5.1.1 Main Operating Screen

1. The main operating screen displays the last hourly concentration reading, the current real time values, the current flow, and the current ambient temperature (Figure 4). Press the three horizontal lines (≡) in the top left corner of the main screen to wake up the touchscreen display. You may then tap the up or down arrow keys in the lower left corner of the display to navigate between the two screens shown below. The secondary screen will show relative humidity, barometric pressure, filter temperature, and filter relative humidity.

| ≡ BAM 1022 2014-10-29 13:54:19 |          |
|--------------------------------|----------|
| Conc HR                        | 3 ug/m3  |
| Status                         | SAMPLING |
| Conc RT                        | 4 ug/m3  |
| Flow                           | 16.7 LPM |
| AT                             | 24.4 C   |
| ▼                              |          |

| ≡ BAM 1022 2014-10-29 14:50:32 |          |
|--------------------------------|----------|
| Conc HR                        | 3 ug/m3  |
| RH                             | 22 %     |
| BP                             | 736 mmHg |
| FT                             | 24.6 C   |
| FRH                            | 15 %     |
| ▲                              |          |

**Figure 4. Main Operating Screen (Left) and Secondary Operating Screen (Right).**

To access the various main menus, press the three horizontal lines (≡) in the top left corner. A drop down menu will appear (Figure 5) to allow selection of any of the four main menus. This option is available on all main menu screens and on the main operating screen.

| BAM 1022 2014-10-29 14:58:37 |             |
|------------------------------|-------------|
| > Operate                    | 99999 ug/m3 |
| > Test                       | STOPPED     |
| > Setup                      | 99999 ug/m3 |
| > Alarms                     | 0.0 LPM     |
|                              | 24.7 C      |
| ▼                            |             |

**Figure 5. Main Menus Drop Down.**


### 5.1.2 Operate Menu Screen

| Operate Menu       |  |
|--------------------|--|
| > Start Sample     |  |
| > Load Filter Tape |  |
| > Transfer Data    |  |
| > About            |  |
|                    |  |


**Figure 6. Operate Menu Screen.**



**Table 2. Operating Menu Navigation.**

| Sub Menu Options | Overview  |
|------------------|---|
| Start Sample     | Begin or resume monitoring                                    |
| Load Filter Tape | Load and properly tension the filter tape                     |
| Transfer Data    | Download stored data to a USB memory stick                    |
| About            | Details the current BAM 1022 firmware type and version number |

To return to the main operating screen, press the home icon (  ) located in the upper right corner of all main menu screens. This icon can clearly be seen in the Setup Menu image shown above (see Figure 6).

### 5.1.3 Test Menu Screen

The Test Menu (Figure 7) provides a means of testing and calibrating individual sensors. Because these settings directly impact flow and concentration values, most of these tests are password protected. Note that the display has a limited amount of space and cannot show all options on one screen. Tap the “> More...” and “> Back...” keys in the lower right corner of the display to navigate. To return to the main operating screen, press the home icon (  ) located in the upper right corner.


| ≡ Test Menu  |                   | ≡ Test Menu  |                |
|---|-------------------|---|----------------|
| > Leak Test   | > Parameters      | > Nozzle/Count Test   | > Input Test   |
| > Ambient Temperature   | > Filter Sensors  | > Analog Output Cal   | > Digital Link |
| > Ambient Pressure  | > Span Mass Audit | > Analog Output Test  |                |
| > Flow Calibration  | > Tape Test       | > Inlet Heater  |                |
| > Run Self-Test   | > More...         | > Relay Test  | > Back...      |

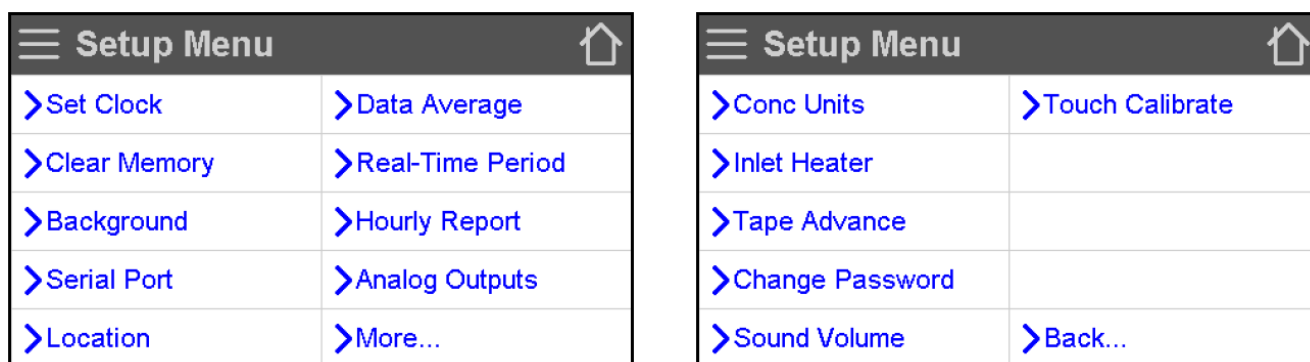
**Figure 7. Test Menu Screens.**

**Table 3. Test Menu Navigation.**

| Sub Menu Options    | Overview   |
|---------------------|--|
| Leak Test           | Perform the leak test  |
| Ambient Temperature | Calibrate ambient temperature or restore default settings            |
| Ambient Pressure    | Calibrate ambient pressure or restore default settings               |
| Flow Calibration    | Calibrate flow rate or restore default settings                      |
| Run Self-Test       | Run the BAM 1022 Self-Test   |
| Parameters          | Review current settings  |
| Filter Sensors      | Calibrate filter temp, pressure, and restore default settings for RH |
| Span Mass Audit     | Run the zero and span foil tests                                     |
| Tape Test           | Verify tape travels expected distance                                |
| Nozzle/Count Test   | Test nozzle operation and verify beta counting                       |
| Analog Output Cal   | Calibrate the analog output  |
| Analog Output Test  | Test the analog output   |
| Inlet Heater        | Manually turn the inlet heater on and off                            |
| Relay Test          | Manually open and close the alarm relay                              |
| Input Test          | Test the digital clock sync input                                    |
| Digital Link        | Test digital communications  |

### 5.1.4 Setup Menu Screen

The setup menu (Figure 8) allows for the configuration of the majority of the operating parameters for the BAM. The most commonly used menu options are typically Set Clock and Background. Note that the display has a limited amount of space and cannot show all options on one screen. Tap the “> More...” and “> Back...” keys in the lower right corner of the display to navigate. To return to the main operating screen, press the home icon (  ) located in the upper right corner.




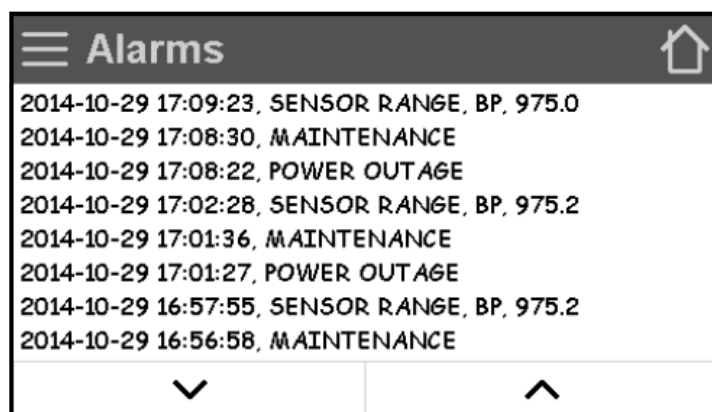
**Figure 8. Setup Menu Screens.**

**Table 4. Setup Menu Navigation.**

| Sub Menu Options    | Overview   |
|---------------------|--|
| Set Clock           | Set the date and time  |
| Clear Memory        | Clear all stored data  |
| Background          | Change the concentration offset  |
| Serial Port         | Set the baud rate and connection type for serial communications            |
| Location            | Set the location number used to identify the BAM 1022                      |
| Data Average        | Set the averaging interval for collecting other than hourly data (non-FEM) |
| Real-Time Period    | Set the averaging interval for collecting real time data                   |
| Hourly Report       | Set the type of time stamp to use for the hourly report                    |
| Analog Outputs      | Set the parameters for both analog outputs                                 |
| Concentration Units | Set the concentration units  |
| Inlet Heater        | Set the RH threshold for the inlet heater to activate                      |
| Tape Advance        | Set the differential pressure threshold for advancing the filter tape      |
| Change Password     | Change the master password   |
| Sound Volume        | Adjust the volume of the touchscreen sounds                                |
| Touch Calibrate     | Calibrate the touch screen sensitivity                                     |

### 5.1.5 Alarm Menu Screen

This screen is used to view time-stamped alarm events with the most recent alarm displayed first. Use the up and down arrow keys located at the bottom of the screen to scroll through the alarm log. To return to the main operating screen, press the home icon (  ) located in the upper right corner.

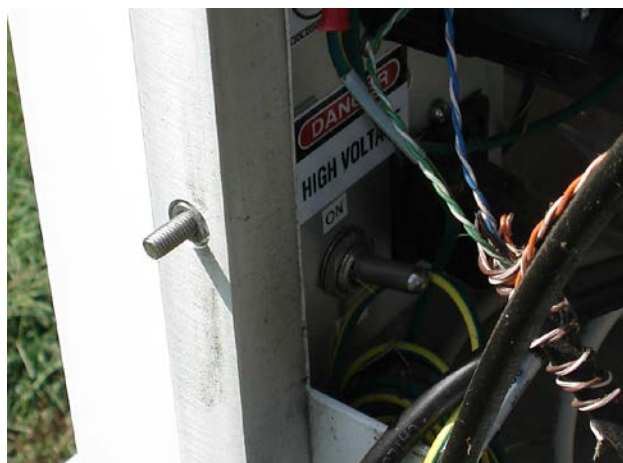


**Figure 9. Alarms Menu Screen.**

## 5.2 Monitoring

### 5.2.1 Powering Up and Warm-Up Period

The BAM 1022 power switch is located inside the back panel of the BAM. When the power is switched on, the main menu screen should appear after a few seconds.



**Figure 10. BAM 1022 Power Switch.**

If the BAM 1022 has been switched off for more than a few moments, the mass monitor must warm up for at least one hour before accurate PM measurements can be obtained. This is because the beta detector contains a photomultiplier vacuum tube that must stabilize every time the unit is powered up.

This also allows the electronics to stabilize for optimal operation. This applies any time the unit is powered up after being off for more than one minute or due to a power outage. Users are encouraged to disregard the first two hourly PM data sets after power is restored. During the warm up period, maintenance, programming (setup) changes, tests, and data downloads can be performed.

### 5.2.2 Time and Date Setup

The BAM clock time must agree with the Envidas DAS time to within  $\pm 1$  minute, Eastern Standard Time. The BAM clock may drift as much as a minute or two per month. To set the date and time on the BAM:

1. Assuming that the monitor is sampling, press the three horizontal lines (≡) in the top left corner. Press “Operate” and then select “Stop Sample”. A message of “**Warning! Stop Current Sample?**” should appear. Press the grey <STOP> button to cease sampling.
2. Press the three horizontal lines (≡) in the top left corner of the main screen.
3. Select “Setup”.
4. Select “Set Clock”. A menu with fields for the year, month, day, hour, minute, and second will appear (Figure 11).

The screenshot shows a 'Set Clock' dialog box. At the top, there is a green bar with a white checkmark icon and the text 'Set Clock', and a grey bar with a white 'X' icon. Below this, there are six input fields arranged horizontally, labeled 'Year', 'Month', 'Day', 'Hour', 'Minute', and 'Second'. The values entered in these fields are 2016, 2, 22, 12, 46, and 3 respectively. Below the input fields is a large grey button labeled 'Set'.

| Year | Month | Day | Hour | Minute | Second |
|------|-------|-----|------|--------|--------|
| 2016 | 2     | 22  | 12   | 46     | 3      |

Set

**Figure 11. Time and Date Setup Screen.**

5. Select the field that needs to be modified. A visual keypad will open up and allow you to input a value.
6. Press <OK> to accept the changes, or press the grey <CANCEL> button to return to the previous screen.
7. Repeat steps 4 and 5 to modify all necessary date and time features.

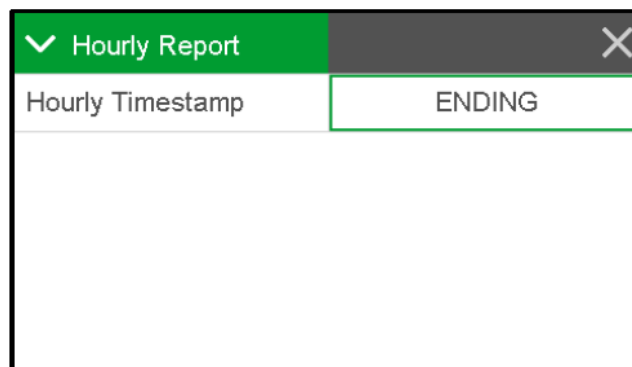


8. To save all date and time changes, press the grey <SET> button on the Set Clock Menu. You will be returned to the Setup Menu. Press the <X> icon in the upper right corner if no changes are made.

### 5.2.3 Hourly Report Set-Up

Check to make sure the BAM 1022 is putting the correct time stamp on the hour. The hourly report time stamp should be set to mark the data with the time from the ending of the hour. To check or set the hourly report on the BAM:

1. Assuming that the monitor is sampling, press the three horizontal lines (≡) in the top left corner. Press “Operate” and then select “Stop Sample”. A message of “**Warning! Stop Current Sample?**” should appear. Press the grey <STOP> button to cease sampling.
2. Press the three horizontal lines (≡) in the top left corner of the main screen.
3. Select “Setup”.
4. Select “Hourly Report”.
5. Press the green bordered value box and a list of the settings available will be displayed. Note: The factory default setting for this option is “Ending” (Figure 12). Press <ENDING> to select, then press the grey <OK> button to accept, or the grey <CANCEL> button to return to the previous screen.
6. Press the <X> icon in the upper right corner to return to the Setup Menu.



**Figure 12. Hourly Report Screen.**

#### **5.2.4 Other Important Settings for Reference**

The ECB will have setup many of the more obscure functions of the 1022 before deployment. It is still the operator's responsibility to assure that these settings remain as left, and to investigate unwanted changes from one download to the next. Below (Figure 13) is an example settings report for use to compare with the downloaded setting file. Some of the more important settings are:

- Averaging time (Data average in the report): 1 hour.
- Smart heater turn-on set point of 45% RH (FT Set Point in the report).
- Hourly timestamp of "ENDING".
- Background setting.

```

BAM 1022 Settings Report
2019-01-02 10:22:44

    Firmware, 81650, R1.0.7
      CPLD, 81699, R1.0.0
    Serial Number, T22314
      Location, 1
        Baud Rate, 9600
    Ethernet FlowControl, NONE
      Data Average, 1 HR
    RealTime Period, 60
      Tape Period, 1 HR
    Tape Pressure, 250
      K, 1.054
    Background, 0.0006
      Usw, 0.285
    Audit Span, 0.807
    Conc Units, ug/m3
    USB Days, 30
    USB Files, ALL
    Analog Range 1, 0-5.0 V
    Analog Range 2, 0-5.0 V
      Conc Span, 1000 ug/m3
      Conc Offset, 0 ug/m3
    Hourly Timestamp, ENDING
      FT Set Point, 45.0
        FT P-Gain, 0.500
        FT I-Gain, 0.300
    RealTime Alpha, 0.2316
    RealTime Gamma, 0.1500
      Beep Volume, 10
    ModBus Address, 1
      Byte Order, 512
    Factory Mode, OFF

    Name, Offset, Slope
    FLOW, 0.389, 0.970
      AT, -0.480
      BP, -2.090
      FT, -2.400
    UPPER, -3.380
    LOWER, -3.275
      FRH, 0.000
      BOX, 0.000
    ENCL1, 0.000

    DAC Cal 1, 0.0, -80, 5.0, 52687
    DAC Cal 2, 0.0, -123, 5.0, 52752

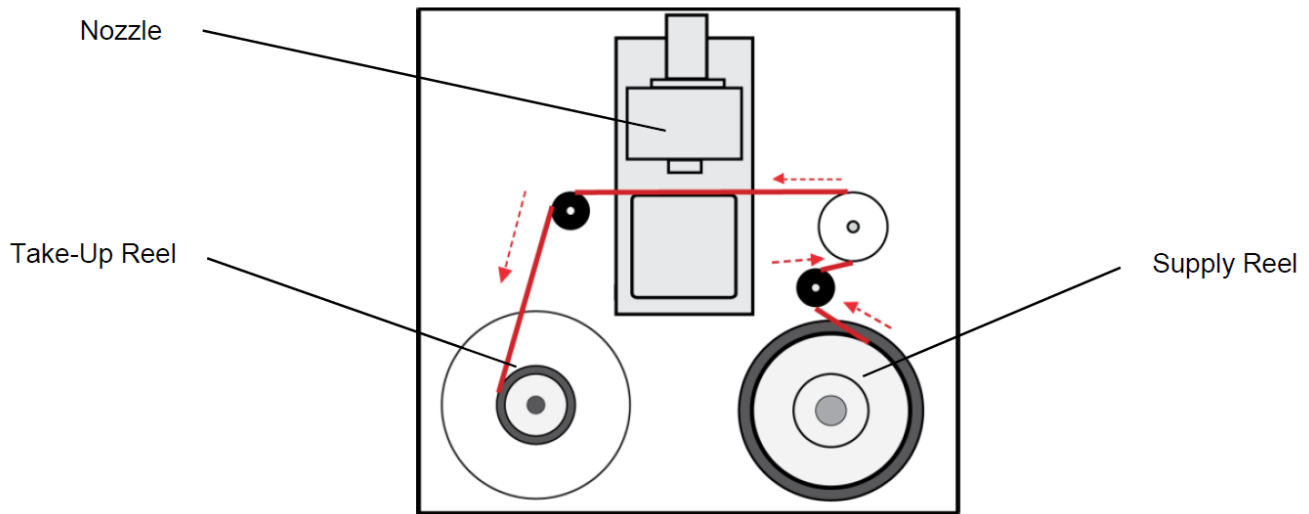
    Factory Settings
      Cal Span, 0.807
  
```

**Figure 13. Setting File.**

### 5.2.5 Filter tape Installation

A roll of Met One glass fiber filter tape must be loaded into the BAM 1022 for sampling. A roll of filter tape can last between 45 and 60 days under normal operation. Operators should store spare rolls of filter tape at the site to avoid sampling interruptions. The tape should never be flipped over or reused. This will result in invalid measurements. Use the following steps (see Figure 14) to load an initial roll of filter tape:

1. Assuming that the monitor is sampling, press the three horizontal lines (≡) in the top left corner. Press “Operate” and then select “Stop Sample”. A message of “**Warning! Stop Current Sample?**” should appear. Press the grey <STOP> button to cease sampling.
2. Press the three horizontal lines (≡) in the top left corner. Select “Operate” and then “Load Filter Tape”. Entering this screen will cause the nozzle to raise.
3. Remove the Plexiglas cover by pulling out at the bottom to release the Velcro holding strip, and then lifting the cover off of the two alignment pins at the top
4. Unscrew and remove the two clear plastic reel covers. Retrieve onto the take-up reel any leftover tape. Remove from monitor and dispose of the tape responsibly.
5. Label the tape and box with the current date and time. Return the tape to the Raleigh Central Office Lab at a later date.
6. Make sure the BAM nozzle and vane are completely clean of debris. Cleaning procedures are detailed in Section 6.4 of this manual.
7. Slide an empty tape spool core on to the take-up reel (on the left). You may use an empty cardboard spool core or a grey core tube (part number 8150) supplied with the instrument.
8. Unbox a new roll of filter tape. Place the full roll on the supply reel and route the tape through the nozzle and vane as directed in the figure below. A guide for tape alignment, which is also used to align the span mass audit foils, is provided on either side of the block that houses the detector.




**Figure 14. Tape Installation and Direction.**



**Figure 15. Tape Alignment Guide.**

9. Fasten the loose end of the new filter tape to the take-up spool with a piece of cellophane tape. Rotate the take-up spool two revolutions in order to firmly secure the new tape connection.
10. Rotate the supply reel by hand to remove any slack in the tape while also checking for tape alignment.
11. Replace the two clear plastic reel covers and fasten the screws tightly by hand.
12. Press the grey <MOVE> button to advance the tape and verify it has been properly loaded.

13. If the tape is correctly installed, the display will report “**TAPE IS OK!**”.
14. If there is a problem, “**TAPE FAIL**” will be displayed.
15. If this occurs, verify the tape is properly routed.
16. Next, remove any slack by rolling up loose tape on the tape spools.
17. Select the grey <MOVE> button again to take out any additional slack and verify the tape is loaded correctly.
18. Press the <X> icon in the upper right corner to return to the Operate Menu and then (  ) to return to the Main Operating Screen.

## 6.0 CALIBRATION

A full monitor calibration consists of a beginning “as found” external leak check, the calibration of ambient temperature and pressure sensors, a three-point flow calibration, a one-point flow verification and a final “as left” leak external leak check. It is a good practice to complete all outstanding maintenance activities prior to initiating a full calibration. *Note: A flow verification (see Section 7.0) must be completed prior to a calibration if the sampler was previously operating at the site.* New samplers installed at a site do not need a flow verification prior to a calibration because there is no collected data to envelope. Annual calibrations are required within 365 days of the prior calibration.

### 6.1 Calibration Requirements

A calibration is required under the following circumstances:

- Upon initial sampler set up.
- Annually (no more than 365 days from the last calibration and each calendar year).
- After a sampler is replaced.
- After a sampler is moved or relocated, no matter the distance.
- After the pump or flow controller is replaced.
- If flow check or a flow audit are not within specifications (after appropriate troubleshooting to ensure that the failed value was due to drift or other instrument problems).
- If the flow device once used for flow calibration needs to be used as the audit device.
- If the sampler is without power for longer than 48 hours and the flow verification fails.

## 6.2 Calibration Equipment



**Figure 16. BGI Tetra Cal with Optional Temperature Probe.**

All device certifications must be current within 365 days of use. Listed below is the necessary equipment needed for completing a calibration:

- A leak check device or flow audit adapter for performing leak checks.
- A certified Tetra Cal unit or Streamline Flow Transfer Standard (FTS).
- If using a FTS, a digital, water or oil manometer, capable of measuring to a tenth of an inch of water.
- If using a FTS, a 12-18" piece of 1/4" diameter Tygon<sup>®</sup> tubing to connect the FTS to the manometer.
- A glass mineral thermometer capable of measuring to the nearest half a degree Celsius, that is traceable to a National Institute of Standards and Technology (NIST) standard, or the thermistor probe included with a certified Tetra Cal unit.
- A digital barometer, that is NIST traceable, or the barometer that is part of a certified Tetra Cal unit.
- The most recent revision of the BAM electronic logbook.



*Note: If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet. Allow all devices, whether a Tetra Cal or digital barometer, to equilibrate for approximately 10 minutes, making sure to keep them out of direct sunlight.*

### **6.3 Warm-up Period**

If the BAM 1022 has been switched off for more than a few moments, the mass monitor must warm up for at least one hour before accurate PM measurements can be obtained. This is because the beta detector contains a photomultiplier vacuum tube that must stabilize every time the unit is powered up. This also allows the electronics to stabilize for optimal operation. This applies any time the unit is powered up after being off for more than one minute or due to a power outage. Users are encouraged to disregard the first two hourly PM data sets after power is restored. During the warm up period, maintenance, programming (setup) changes, tests, and data downloads can be performed.

### **6.4 Calibration E-Log Setup**

1. Open the most recent scrolling e-log for the site. If this is a new site or the first visit of the calendar year, obtain the proper e-log from the IBEAM documents module, the Ambient/Documents/PM Monitoring SharePoint folder or contact the RCO PM lead.
2. Select the "Calibration" tab of the e-log.
3. Enter in the information for all of the white boxes under the Visit Information, Thermometer information, Manometer Information, Barometer Information, Tetra Cal or FTS information sections.
4. Do not proceed if any of the devices fail the certification requirement (certified within 365 days of use).

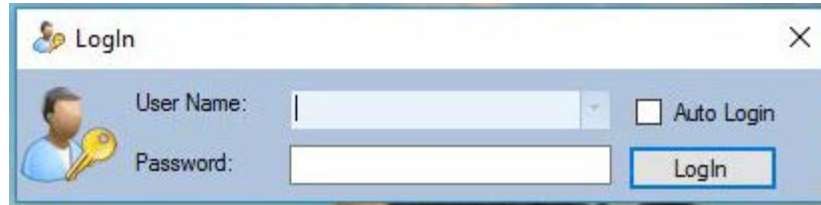
### **6.5 Calibration Setting the Envidas Channel to Off-Scan**

1. From the site computer, select the Envidas Ultimate Viewer icon and open the program.



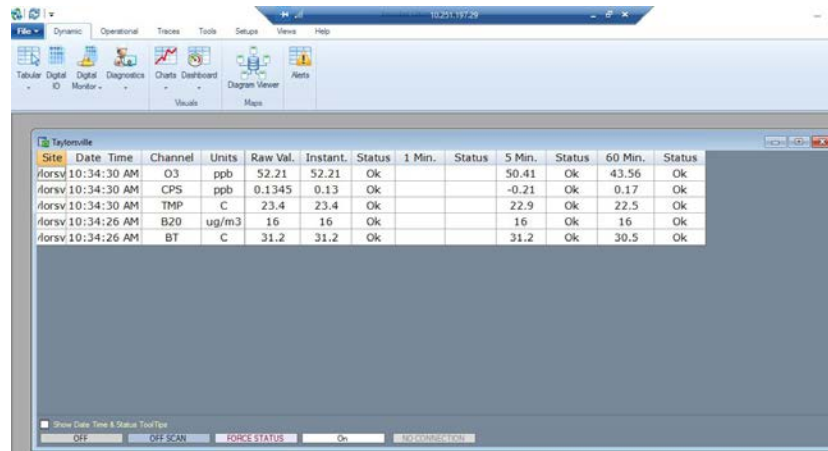
**Figure 17. Envidas Ultimate Viewer Icon.**

2. A login window will appear. Select your user name from the dropdown menu and enter your password.



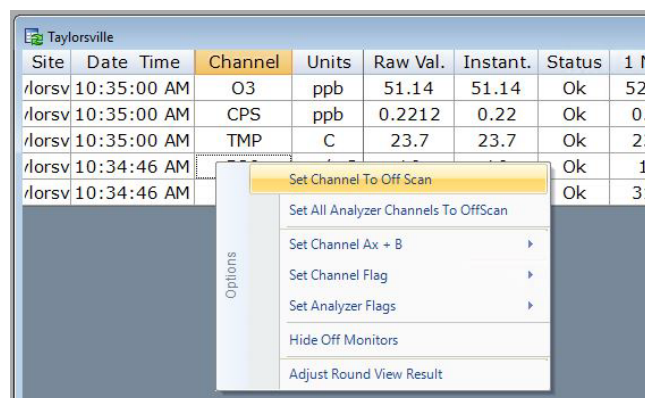
**Figure 18. Envidas Viewer Login.**

3. Envidas Viewer will open and the parameters at the site will made visible in a window like the one below. If the window does not automatically open, select “Tabular” from the taskbar and then select your site for viewing.



**Figure 19. Tabular Display of Site Parameters.**

4. Right click on the channel name to access the options menu. Select “Set Channel To Off Scan”.



**Figure 20. Channel Options Menu.**

- The channel line will be greyed and the status will change to “OffScan”.

| Site   | Date Time   | Channel | Units | Raw Val. | Instant. | Status  | 1 Min. | Status | 5 Min. | Status | 60 Min. | Status |
|--------|-------------|---------|-------|----------|----------|---------|--------|--------|--------|--------|---------|--------|
| rlorsv | 10:36:40 AM | O3      | ppb   | 51.33    | 51.33    | Ok      | 50.59  | Ok     | 51.71  | Ok     | 43.56   | Ok     |
| rlorsv | 10:36:40 AM | CPS     | ppb   | -0.1179  | -0.11    | Ok      | 0.11   | Ok     | 0.24   | Ok     | 0.17    | Ok     |
| rlorsv | 10:36:40 AM | TMP     | C     | 23.6     | 23.6     | Ok      | 23.8   | Ok     | 22.1   | Ok     | 22.5    | Ok     |
| rlorsv | 10:36:26 AM | B20     | ug/m3 | 16       | 16       | OffScan | 16     | Ok     | 16     | Ok     | 16      | Ok     |

**Figure 21. Channel Off Scan.**

## 6.6 Calibration “As Found” Leak Check

Take the following steps to perform an “as found” leak check:

- Assuming that the monitor is sampling, press the three horizontal lines (≡) in the top left corner. Press “Operate” and then select “Stop Sample”. A message of “**Warning! Stop Current Sample?**” should appear. Press the grey <STOP> button to cease sampling.
- Press the three horizontal lines (≡) in the top left corner. Select “Test” and then “Leak Test”.
- Remove the PM10 head from the sampling tube.
- Install a leak check adapter onto the inlet of the Very Sharp Cut Cyclone (VSCC). *Note: the Tetra Cal flow audit adapter may be used for leak checks as well.*



**Figure 22. Leak Check Adapter.**

| ✓ Leak Test                          |            | ✕ |
|--------------------------------------|------------|---|
| Flow                                 | 0.0 LPM    |   |
| Lower                                | 758.0 mmHg |   |
| <div>PUMP ON</div> <div>NOZZLE</div> |            |   |

**Figure 23. Leak Test Menu.**

5. Turn the valve to the OFF position to prevent any air from entering the inlet tube.
6. Ensure that the nozzle is in the down position and that filter tape is in place. Press the grey <NOZZLE> button if it is in the raised position.
7. Press the grey <PUMP ON> button. You should hear the pump engage.
8. The leak check is passing if the leak flow value is < 1.0 LPM. Record the value in the e-log on the “Calibration” page under the “As Found Leak Check” section.
9. The nozzle and vane must be cleaned if the leak flow value is  $\geq 1.0$  LPM. Repeat the leak check after cleaning. If there is still a leak present, perform a lower and upper system leak check as outlined in Appendix B.
10. Press the grey <PUMP OFF> button to turn the pump off.
11. Slowly open the leak check adapter to release the pressure.
12. The operator may remove the leak check adapter from the sample tube, or leave it on to protect the monitoring inlet from foreign objects during the calibration of ambient temperature and pressure.
13. Press the <X> key in the upper right corner to return to the Test Menu.

## 6.7 Ambient Sensor Calibration

The temperature and pressure must be calibrated prior to the flow because the actual flow is calculated using both ambient temperature and pressure. Field operators do not calibrate or verify any of the inline temperature or pressure sensors inside the BAM.

*Note: A sensor calibration always requires a flow calibration afterwards.*

### 6.7.1 Ambient Temperature and Ambient Pressure Sensor Calibration



**Figure 24. Proper Shaded Inlet Location.**



**Figure 25. Proper Shaded Solar Shield Location.**

1. If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet (Figures 18 and 19). Allow all devices, whether a Tetra Cal or digital barometer, to equilibrate for approximately 10 minutes, making sure to keep them out of direct sunlight.
2. Press the three horizontal lines (≡) in the top left corner. Select "Test" and then "Ambient Temperature". The "BAM 1022" row is the BAM 1022 real time ambient temperature measurement. The "Standard" row is where the values from the temperature reference standard will be entered (Figure 21).

| ✓ Ambient Temp |        |
|----------------|--------|
| BAM 1022       | 17.4 C |
| Standard       | +17.4  |

DEFAULT CALIBRATE

**Figure 26. Ambient Temperature Calibration Screen.**

3. Read and record the stated ambient temperature (°C) given by the BAM 1022 in the e-log on the "Calibration" page under the "Ambient Temperature Calibration" section
4. Read and record the actual ambient temperature (°C) given by your NIST thermometer to the nearest half degree in the e-log on the "Calibration" page under the "Ambient Temperature Calibration" section
5. Press inside the green box encircling the standard temperature. A new screen with a keypad will appear.
6. Enter the value from the thermometer into the standard field using the keypad. Press <OK> to return to the AMBIENT TEMPERATURE screen.
7. Press the <CALIBRATE> button to save the new calibration offset for the ambient temperature. The BAM and Standard values should now be the same.

8. If the BAM 1022 temperature sensor exceeds the criteria of  $\pm 2$  °C of the transfer standard, repeat steps 3 through 7 again after pressing the <DEFAULT> button to remove any previous offsets.
9. Press the <X> key in the upper right corner to return to the Test Menu.
10. Select “Ambient Pressure” (Figure 22). The “BAM 1022” row is the BAM 1022 real time pressure measurement. The “Standard” row is where the values from the NIST pressure standard will be entered.

| ✓ Ambient Pressure |          |
|--------------------|----------|
| BAM 1022           | 757 mmHg |
| Standard           | +757     |

DEFAULT CALIBRATE

**Figure 27. Ambient Pressure Calibration Screen.**

11. Read and record the stated ambient pressure (mm Hg) given by the BAM 1022 in the e-log on the “Calibration” page under the “Ambient Pressure Calibration” section.
12. Read and record the actual ambient pressure (mm Hg) given by your NIST barometer, rounding to the nearest whole number, in the e-log on the “Calibration” page under the “Ambient Pressure Calibration” section.
13. Press inside the green box encircling the standard pressure. A new screen with a keypad will appear.
14. Enter the value from the NIST barometer into the standard field using the keypad. Press <OK> to return to the AMBIENT PRESSURE screen.
15. Press the <CALIBRATE> button to save the new calibration offset for the ambient pressure. The BAM and Standard values should now be the same.

16. If the BAM 1022 pressure sensor exceeds the criteria of  $\pm 10$  mm Hg of the NIST standard, repeat steps 11 through 15 again after pressing the <DEFAULT> button to remove any previous offsets.
17. Press the <X> key in the upper right corner to return to the Test Menu.

## 6.8 Flow Calibration



**Figure 28. Flow Audit Adapter for Tetra Cal.**





**Figure 29. FTS with Manometer.**

1. Make certain that the BAM 1022 has warmed up for at least 60 minutes prior to performing calibrations.
2. If using a Tetra Cal, place the Tetra Cal flow audit adapter on top of the VSCC. Connect the Tetra Cal to the flow adapter with the provided tubing. If a FTS is used, place the FTS on top of the VSCC and connect the manometer to the FTS with your Tygon® tubing.
3. Zero the Tetra Cal or manometer.
4. From the Test Menu select “Flow Calibrate” (Figure 25). The pump will start automatically and adjust flow to the 16.7 LPM test point.
5. Press the green bordered value box in the “Set Point” row. The flow rate test set point selection will appear.
6. Select the first set point of “14.0” LPM and then press the grey <OK> button. The display will return to the Flow Calibrate screen and adjust the flow to the new set point.

| ✓ Flow Calibrate |          | ✕         |
|------------------|----------|-----------|
| Set Point        | 16.7     |           |
| BAM 1022         | 16.6 LPM |           |
| Standard         | +16.7    |           |
| DEFAULT          |          | CALIBRATE |


**Figure 30. Flow Calibrate Screen.**

7. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 14.0 LPM.
8. Read and record the stated flow rate (LPM) given by the BAM 1022 in the “Calibration” page of the e-log.
9. Read and record the actual flow rate (LPM) given by your certified Tetra Cal, or calculate the flow from your FTS using the given pressure drop in inches of water from the manometer and the formula on the corresponding FTS certification, in the “Calibration” tab of the e-log.
10. Press the green bordered value box in the “Standard” row and the numerical entry keypad will be displayed. Enter the actual flow value in the field, and press the grey <OK> button to return to the Flow Calibration screen.
11. Press the grey <SET> button to enter the actual flow rate.
12. Repeat steps 5 through 11 above for the second set point of 17.5 LPM.
13. Repeat steps 5 through 10 above for the third and final set point of 16.7 LPM. Note: when setting the 16.7 LPM flow rate, the grey <SET> button will have changed to <CALIBRATE>.
14. Press the grey <CALIBRATE> button to finalize the calibration. The BAM 1022 now internally adjusts the monitor flow rate for all three points based on the actual flow rates entered.
15. Press the <X> key in the upper right corner to return to the Test Menu.

16. The slope of a calibration curve is used as a diagnostic tool to determine the stability of the instrument, specifically the pump or mass flow controller. The e-log will automatically calculate the slope of the calibration curve in the “Calibration Status” section. The slope of the calibration curve should be within 10% of the expected values (within an acceptable range of 0.9 to 1.1). **If the slope is outside of these parameters, a second calibration must be completed even if the post-calibration flow verification passes.** If the slope fails a second time, this indicates a possible defect in the mass flow controller or pump. The operator must inform the RCO particulate matter chemist and ECB.

## 6.9 Post Calibration Flow Evaluation

The calibration must be verified by performing a single point evaluation using the same certified flow device the monitor was just calibrated with. *Reminder: A post calibration flow evaluation is not interchangeable with a monthly verification. The two processes are not the same.*

1. Zero the Tetra Cal or manometer (the Tetra Cal or FTS should still be in place from your flow calibration).
2. From the Test Menu select “Flow Calibrate”. The pump will start automatically and adjust flow to the 16.7 LPM test point.
3. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 16.7 LPM. *Do not press the <CALIBRATE> button.*
4. Read and record the stated flow rate (LPM) given by the BAM 1022 in the “Calibration” tab of the e-log.
5. Read and record the actual flow rate (LPM) given by your certified Tetra Cal, or calculate the flow from your FTS using the given pressure drop in inches of water from the manometer and the formula on the corresponding FTS certification, in the “Calibration” page of the e-log under the “Post-Cal Flow Evaluation” section.
6. Using the automatic calculation in the e-log, verify that the flow is +/- 2% of the current flow (%A) and +/- 2% of the theoretical flow (%AD) of 16.7 LPM. **The monitor must be recalibrated if these specifications are not met.**
7. Press the <X> icon in the upper right corner to return to the Operate Menu and then (  ) to return to the Main Operating Screen.
8. Remove the Tetra Cal flow audit adapter or FTS from the VSCC.



## 6.10 Calibration “As Left” Leak Check

1. Install a leak check adapter onto the inlet of the VSCC. *Note: the Tetra Cal flow audit adapter may be used for leak checks as well.*
2. Turn the valve to the OFF position to prevent any air from entering the inlet tube.
3. From the Test Menu select “Leak Test”.
4. Ensure that the nozzle is in the down position and that filter tape is in place. Press the grey <NOZZLE> button if it is in the raised position.
5. Press the grey <PUMP ON> button. You should hear the pump engage.
6. The leak check is passing if the leak flow value is  $< 1.0$  LPM. Record the value in the e-log on the “Calibration” page under the “As left Leak Check” section.
7. The nozzle and vane must be cleaned if the leak flow value is  $\geq 1.0$  LPM. Repeat the leak check after cleaning. If there is still a leak present, perform a lower and upper system leak check as outlined in Appendix B.
8. Press the grey <PUMP OFF> button to turn the pump off.
9. Slowly open the leak check adapter to release the pressure.
10. Remove the leak check adapter from the sample tube.
11. Replace the PM10 head on top of the VSCC.
12. Press the <X> key in the upper right corner to return to the Test Menu.

## 6.11 Performing a Self-Test

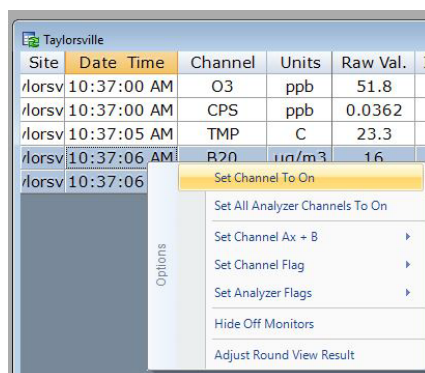
After any action taken by the operator that interrupts the sampling cycle of the BAM 1022, a self-test must be performed. The self-test checks the movement of tape, nozzle movement and presence of flow.

1. Assuming that the monitor is at the Main Operating Screen, press the three horizontal lines (≡) in the top left corner of the screen.
2. Select the Test Menu and press “Run Self-Test”.
3. The test will start automatically, give messages such as “Moving Tape”, “Moving Noz Down”, “Counting . . .” and “Waiting Flow”. The full test will take approximately 30 seconds.

4. When the passing test is finished the display will change to **SELF-TEST COMPLETE**. If there are any displayed errors, troubleshoot the issues and repeat the self-test.
5. Press the <X> icon in the upper right corner to return to the Test Menu and then (  ) to return to the Main Operating Screen.
6. Record the self-test result in the “Site Visit” spreadsheet.
7. The BAM 1022 is ready for sampling. Press the three horizontal lines (  ) in the top left corner of the main screen.
8. Select “Operate and then press “Start Sample”. The monitor will prompt you to begin a new sample with “**Warning! Start a New Sample?**” Select the grey <START> button. The monitor’s pump will automatically turn on and begin a new sampling cycle.

## 6.12 Calibration Setting the Envidas Channel to Ok

1. In Envidas Viewer, select the channel you would like to bring up by right clicking on the name of the channel. The options menu will appear.



**Figure 31. Setting the Channel to On**

2. Select “Set Channel To On”. At the top of the minute, the channel will appear un-greayed and the status will read “Ok”.
3. Shut down Envidas Viewer.

## 7.0 QUALITY CONTROL

A **Flow Verification** must be performed once every thirty days (a.k.a. Monthly Verification). It is a test of the monitor's sensors against certified standards. It is preferred, **but not required**, that the verification be completed with devices that are different from the devices used for the calibration. A flow verification is also required before any action that requires the operator to envelope the data (e.g. moving the monitor, performing maintenance that will break the sampling pathway or shutdown). A flow verification is also required after a power outage lasting more than 48 hours. A monthly flow verification cannot be completed on the same day as a calibration unless it is the final day of the calendar month.

A **Mid-Month Verification** is a test of the monitor's sensors against certified standards. The mid-month verification was implemented to avoid invalidating large amounts of data if a monthly flow verification fails. The mid-month verification must follow a verification by 14 to 18 days. The mid-month verification process is the same as the monthly verification procedure. The audit replaces the mid-month verification in the second month of each calendar quarter.

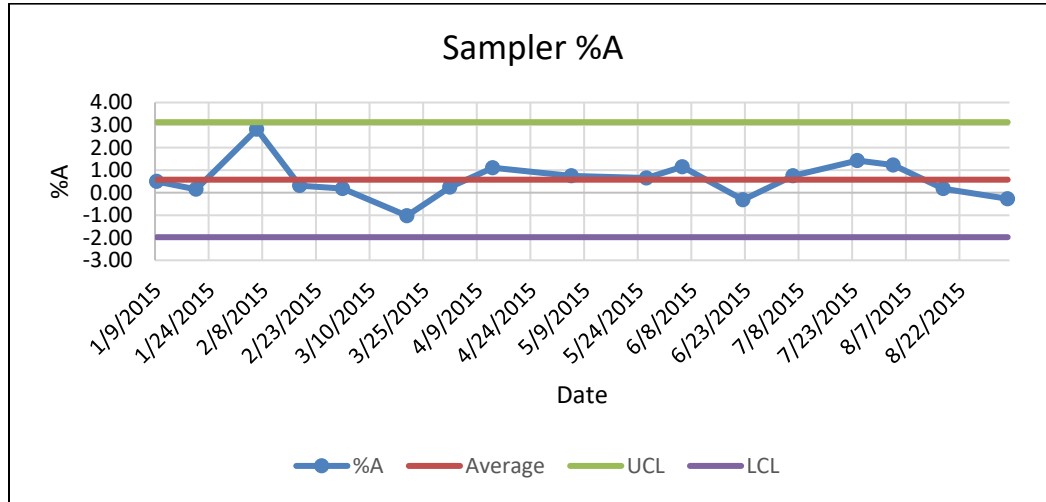
An **Audit** must be performed every quarter. It should be performed in the second month of each calendar quarter if possible. It is a test of the monitor's sensors against certified standards **that were not used** for the previous calibration, monthly verifications or mid-month verifications. Standards that have been recently recertified (having been used for calibrations/verifications and not used since) are candidates for becoming audit equipment. Audits are also to be performed by personnel other than the normal site operator. If the audit cannot be performed during the second month due to abnormal circumstances (such as the monitor being inoperable or extreme weather events), the mid-month verification must be completed instead. The audit should then be performed in place of the mid-month verification during the third month, before the quarter ends.

After each verification or audit, operators must analyze the Flow Rate Accuracy (%A) and the Flow Rate Accuracy vs. Design (%AD) control charts (Figure 27) in the e-log to determine if there are any unfavorable trends on the same sampler including, but not limited to:

- Four or more consecutive decreasing points.
- Four or more consecutive increasing points.
- Differences of  $\pm 3\%$  between points.
- Any points falling outside of the upper confidence level (UCL) or the lower confidence level (LCL).

Operators should consider repeating a verification or audit if it is outside of the LCL or UCL. Changes in the sampler, mass flow controller, or pump might distort the control charts and do not require additional investigation. Report any abnormal trends in the control charts to the RCO particulate matter lead. *Note: the control charts are generated based on flows from a calendar year (per the annual e-*

*log). The first few flows of the year will not produce a valid control chart due to the limited data. The previous year's flow data can be imported into the e-log if desired.*



**Figure 32. Example E-log Control Chart.**

All device certifications must be current within 365 days of use. Listed below is the necessary equipment needed for completing a verification or audit:

- A leak check device or flow audit adapter for performing leak checks.
- A certified Tetra Cal unit or Streamline Flow Transfer Standard (FTS).
- If using a FTS, a digital, water or oil manometer, capable of measuring to a tenth of an inch of water.
- If using a FTS, a 12-18" piece of 1/4" diameter Tygon® tubing to connect the FTS to the manometer.
- A glass mineral thermometer capable of measuring to the nearest half a degree Celsius, that is traceable to a National Institute of Standards and Technology (NIST) standard, or the thermistor probe included with a certified Tetra Cal unit.
- A digital barometer, that is NIST traceable, or the barometer that is part of a certified Tetra Cal unit.
- The most recent revision of the BAM electronic logbook.

*Note: If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet. Allow all devices, whether a Tetra Cal or digital barometer, to equilibrate for approximately 10 minutes, making sure to keep them out of direct sunlight.*

## 7.1 Tolerances and Corrective Actions for Verifications, Checks, and Audits

If any parameter fails the tolerance listed in Table 5, corrective action is required as indicated. **Do not perform a calibration until after you have verified, checked or audited all of the parameters.**

**Table 5. Operation Evaluations.**

| CRITERIA                                  | TOLERANCES   | FREQUENCY  | CORRECTIVE ACTION   |
|---|--|--|---|
| External Leak Check                       | <1.0 LPM   | <ol style="list-style-type: none"> <li>Before and after any flow verification.</li> <li>During each quarterly audit.</li> <li>Each time the VSCC is removed.</li> <li>Each time the tape is changed.</li> <li>Each time the nozzle/vane is cleaned.</li> </ol> | <ol style="list-style-type: none"> <li>Clean nozzle and vane.</li> <li>Make sure tape is seated.</li> <li>Check seating and assembly of VSCC (O-rings).</li> <li>Perform internal leak check.</li> <li>If unit fails to pass, call ECB</li> </ol> |
| Ambient Temperature Verification or Audit | $\pm 2$ °C of NIST Thermometer   | <ol style="list-style-type: none"> <li>During each monthly and mid-month check.</li> <li>During each quarterly audit.</li> </ol>   | Perform a flow verification prior to an ambient temperature adjustment. Follow with complete calibration.   |
| Ambient Pressure Verification or Audit    | $\pm 10$ mm Hg of NIST Barometer   | <ol style="list-style-type: none"> <li>During each monthly and mid-month check.</li> <li>During each quarterly audit.</li> </ol>   | Perform a flow verification prior to an ambient pressure adjustment. Follow with complete calibration.  |
| Post Calibration Evaluation               | %A $\pm 2\%$<br>%AD $\pm 2\%$  | After each monitor calibration   | Calibrate again. If unit fails, call ECB and Particulate Lead.  |
| Monthly Verification                      | %A $\pm 3\%$ and<br>%AD $\pm 4\%$ are DAQ action limits<br>( $\pm 4\%$ and $\pm 5\%$ are EPA voiding limits) | <ol style="list-style-type: none"> <li>Each calendar month.</li> <li>Power outage &gt; 48 hours</li> </ol>   | Investigate the cause for the failure. If no other cause is identified other than monitor drift, perform a calibration. If unit fails to pass, call ECB and Particulate Lead.   |
| Mid-Month Verification                    | %A $\pm 3\%$ and<br>%AD $\pm 4\%$ are DAQ action limits<br>( $\pm 4\%$ and $\pm 5\%$ are EPA voiding limits) | 14-18 Days after Flow Rate Verification<br>(in non-audit months)   | Investigate the cause for the failure. If no other cause is identified other than monitor drift, perform a calibration. If unit fails to pass, call ECB and Particulate Lead.   |
| Quarterly Audit                           | %A $\pm 3\%$ and<br>%AD $\pm 4\%$ are DAQ action limits<br>( $\pm 4\%$ and $\pm 5\%$ are EPA voiding limits) | Quarterly<br>(preferably the second month)   | Investigate the cause for the failure. If no other cause is identified other than monitor drift, perform a calibration. If unit fails to pass, call ECB and Particulate Lead.   |
| Span Audit                                | $\pm 5\%$ of Standard  | Quarterly (preferably with the quarterly maintenance).   | Repeat the cleaning procedure and test. If unit fails to pass, call ECB and Particulate Lead.   |
| Background Test                           | $\geq 48$ hours of uninterrupted readings with a passing E-log statistical review                            | Upon sampler setup and then annually in the spring or fall.  | Repeat the test in another window of suitable weather. If unit fails to pass, call ECB and Particulate Lead.  |



## 7.2 Verification or Audit: E-Log Setup

1. Open the most recent scrolling e-log for the site. If this is a new site or the first visit of the calendar year, obtain the proper e-log from the IBEAM documents module or contact the RCO PM lead.
2. Select the “Verification Audit” tab of the e-log.
3. Enter in the information for all of the white boxes under the Visit Information, Thermometer information, Manometer Information, Barometer Information, Tetra Cal or FTS information sections.
4. Do not proceed if any of the devices fail the certification requirement (certified within 365 days of use).

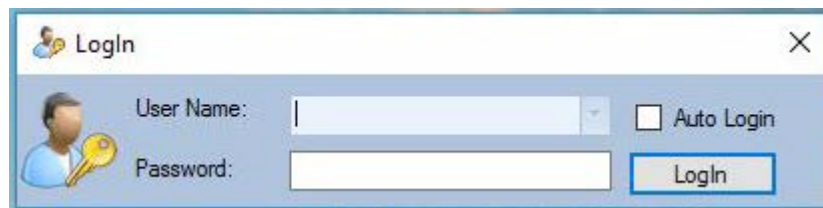
## 7.3 Verification or Audit: Setting the Channel to Off-Scan

1. From the site computer, select the Envidas Ultimate Viewer icon and open the program.



**Figure 33. Envidas Ultimate Viewer Icon.**

2. A login window will appear. Select your user name from the dropdown menu and enter your password.



**Figure 34. Envidas Viewer Login.**

3. Envidas Viewer will open and the parameters at the site will be made visible in a window like the one below. If the window does not automatically open, select “Tabular” from the taskbar and then select your site for viewing.

| Site   | Date Time   | Channel | Units | Raw Val. | Instant. | Status | 1 Min. | Status | 5 Min. | Status | 60 Min. | Status |
|--------|-------------|---------|-------|----------|----------|--------|--------|--------|--------|--------|---------|--------|
| /lorsv | 10:34:30 AM | O3      | ppb   | 52.21    | 52.21    | Ok     |        |        | 50.41  | Ok     | 43.56   | Ok     |
| /lorsv | 10:34:30 AM | CPS     | ppb   | 0.1345   | 0.13     | Ok     |        |        | -0.21  | Ok     | 0.17    | Ok     |
| /lorsv | 10:34:30 AM | TMP     | C     | 23.4     | 23.4     | Ok     |        |        | 22.9   | Ok     | 22.5    | Ok     |
| /lorsv | 10:34:26 AM | B20     | ug/m3 | 16       | 16       | Ok     |        |        | 16     | Ok     | 16      | Ok     |
| /lorsv | 10:34:26 AM | BT      | C     | 31.2     | 31.2     | Ok     |        |        | 31.2   | Ok     | 30.5    | Ok     |

**Figure 35. Tabular Display of Site Parameters.**

- Right click on the channel name to access the options menu. Select “Set Channel To Off Scan”.

| Site   | Date Time   | Channel | Units | Raw Val. | Instant. | Status | 1 Mi |
|--------|-------------|---------|-------|----------|----------|--------|------|
| /lorsv | 10:35:00 AM | O3      | ppb   | 51.14    | 51.14    | Ok     | 52.3 |
| /lorsv | 10:35:00 AM | CPS     | ppb   | 0.2212   | 0.22     | Ok     | 0.3  |
| /lorsv | 10:35:00 AM | TMP     | C     | 23.7     | 23.7     | Ok     | 23.  |
| /lorsv | 10:34:46 AM |         |       |          |          | Ok     | 16   |
| /lorsv | 10:34:46 AM |         |       |          |          | Ok     | 31.  |

**Figure 36. Channel Options Menu.**

- The channel line will be greyed and the status will change to “OffScan”.

| Site   | Date Time   | Channel | Units | Raw Val. | Instant. | Status  | 1 Min. | Status | 5 Min. | Status | 60 Min. | Status |
|--------|-------------|---------|-------|----------|----------|---------|--------|--------|--------|--------|---------|--------|
| /lorsv | 10:36:40 AM | O3      | ppb   | 51.33    | 51.33    | Ok      | 50.59  | Ok     | 51.71  | Ok     | 43.56   | Ok     |
| /lorsv | 10:36:40 AM | CPS     | ppb   | -0.1179  | -0.11    | Ok      | 0.11   | Ok     | 0.24   | Ok     | 0.17    | Ok     |
| /lorsv | 10:36:40 AM | TMP     | C     | 23.6     | 23.6     | Ok      | 23.8   | Ok     | 22.1   | Ok     | 22.5    | Ok     |
| /lorsv | 10:36:26 AM | B20     | ug/m3 | 16       | 16       | OffScan | 16     | Ok     | 16     | Ok     | 16      | Ok     |

**Figure 37. Channel Off Scan.**

#### 7.4 Verification or Audit: Disable Parameter in Envidas and “As Found” Leak Check

Take the following steps to perform an “as found” leak check:

1. Down the BAM concentration channel in Envidas at the site.
2. Assuming that the monitor is sampling, press the three horizontal lines (≡) in the top left corner. Press “Operate” and then select “Stop Sample”. A message of “**Warning! Stop Current Sample?**” should appear. Press the grey <STOP> button to cease sampling.
3. Press the three horizontal lines (≡) in the top left corner. Select “Test” and then “Leak Test”.
4. Remove the PM10 head from the sampling tube.
5. Install a leak check adapter onto the inlet of the VSCC. *Note: the Tetra Cal flow audit adapter may be used for leak checks as well.*



**Figure 38. Leak Check Adapter.**

| ✓ Leak Test |            | ✕      |
|-------------|------------|--------|
| Flow        | 0.0 LPM    |        |
| Lower       | 758.0 mmHg |        |
| PUMP ON     |            | NOZZLE |

**Figure 39. Leak Test Menu.**

6. Turn the valve to the OFF position to prevent any air from entering the inlet tube.
7. Ensure that the nozzle is in the down position and that filter tape is in place. Press the grey <NOZZLE> button if it is in the raised position.
8. Press the grey <PUMP ON> button. You should hear the pump engage.
9. The leak check is passing if the leak flow value is < 1.0 LPM. Record the value in the e-log on the “Verification Audit” page under “As Found Leak Check”.
10. The nozzle and vane must be cleaned if the leak flow value is  $\geq 1.0$  LPM. Repeat the leak check after cleaning. If there is still a leak present, perform a lower and upper system leak check as outlined in Appendix B.
11. Press the grey <PUMP OFF> button to turn the pump off.
12. Slowly open the leak check adapter to release the pressure.
13. The operator may remove the leak check adapter from the sample tube, or leave it on to protect the monitoring inlet from foreign objects during the evaluation of ambient temperature and pressure.
14. Press the <X> key in the upper right corner to return to the Test Menu.

## 7.5 Verification or Audit: Ambient Temperature and Ambient Pressure



**Figure 40. Proper Shaded Inlet Location.**



**Figure 41. Proper Shaded Solar Shield Location.**

1. If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet. Allow all devices, whether a Tetra Cal or digital barometer, to equilibrate for approximately 10 minutes, making sure to keep them out of direct sunlight.

2. From the Test Menu select “Ambient Temperature”. The “BAM 1022” row is the BAM 1022 real time ambient temperature measurement.

| ✓ Ambient Temp |        | X         |
|----------------|--------|-----------|
| BAM 1022       | 17.4 C |           |
| Standard       | +17.4  |           |
| DEFAULT        |        | CALIBRATE |

**Figure 42. Ambient Temperature Calibration Screen.**

3. Read and record the stated ambient temperature (°C) given by the BAM 1022 in the e-log on the “Verification Audit” worksheet under the “Ambient Temperature Check”.
4. Read and record the actual ambient temperature (°C) given by your NIST thermometer to the nearest half degree, in the e-log on the “Verification Audit” worksheet under the “Ambient Temperature Check”.
5. Using the automatic calculation in the e-log, verify that the temperature is within  $\pm 2$  °C of the transfer standard. The monitor must be recalibrated if this specification is not met.
6. Press the <X> key in the upper right corner to return to the Test Menu.
7. Select “Ambient Pressure”. The “BAM 1022” row is the BAM 1022 real time pressure measurement.

| ✓ Ambient Pressure |          | X         |
|--------------------|----------|-----------|
| BAM 1022           | 757 mmHg |           |
| Standard           | +757     |           |
| DEFAULT            |          | CALIBRATE |

**Figure 43. Ambient Pressure Calibration Screen.**

8. Read and record the stated ambient pressure (mm Hg) given by the BAM 1022 in the e-log on the “Verification Audit” worksheet under the “Pressure Check” section.
9. Read and record the actual ambient pressure (mm Hg) given by your NIST barometer, rounding to the nearest whole number, in the e-log on the “Verification Audit” worksheet under the “Pressure Check” section.
10. Using the automatic calculation in the e-log, verify that the pressure is within  $\pm 10\%$  of the transfer standard. The monitor must be recalibrated if this specification is not met.
11. Press the <X> key in the upper right corner to return to the Test Menu.

## 7.6 Verification or Audit: Flow



**Figure 44. Flow Audit Adapter for Tetra Cal.**



**Figure 45. FTS with Manometer.**

1. If using a Tetra Cal, place the Tetra Cal flow audit adapter on top of the VSCC. Connect the Tetra Cal to the flow adapter with the provided tubing. If a FTS is used, place the FTS on top of the VSCC and connect the manometer to the FTS with your Tygon® tubing.
2. Zero the Tetra Cal or manometer.
3. From the Test Menu select “Flow Calibrate”. The pump will start automatically and adjust flow to the 16.7 LPM test point.



4. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 16.7 LPM. *Do not press the <CALIBRATE> button.*
5. Read and record the stated flow rate (LPM) given by the BAM 1022 in the “Verification Audit” page of the e-log under the “Flow Calculations” section.
6. Read and record the actual flow rate (LPM) given by your certified Tetra Cal, or calculate the flow from your FTS using the given pressure drop in inches of water from the manometer and the formula on the corresponding FTS certification, in the “Verification Audit” page of the e-log under the “Flow Calculations” section.
7. Using the automatic calculation in the e-log, verify that the flow is +/- 3% of the current flow (%A) and +/- 4% of the theoretical flow (%AD) of 16.7 LPM. The monitor must be recalibrated if these specifications are not met.
8. Press the <X> icon in the upper right corner to return to the Test Menu.
9. Remove the Tetra Cal or FTS from the VSCC.





#### **7.7 Verification or Audit: “As Left” Leak Check**

1. Install a leak check device onto the inlet of the VSCC. *Note: The Tetra Cal flow audit adapter may be used for leak checks as well.*
2. Turn the valve to the OFF position to prevent any air from entering the inlet tube.
3. From the Test Menu, select “Leak Test”.
4. Ensure that the nozzle is in the down position and that filter tape is in place. Press the grey <NOZZLE> button if it is in the raised position.
5. Press the grey <PUMP ON> button. You should hear the pump engage.
6. The leak check is passing if the leak flow value is < 1.0 LPM. Record the value in the e-log on the “Verification Audit” page under “As Left Leak Check”.
7. The nozzle and vane must be cleaned if the leak flow value is  $\geq$  1.0 LPM. Repeat the leak check after cleaning. If there is still a leak present, perform a lower and upper system leak check as outlined in Appendix B.
8. Press the grey <PUMP OFF> button to turn the pump off.

9. Slowly open the leak check device to release the pressure.
10. Remove the leak check device from the sample tube.
11. Replace the PM10 head on top of the VSCC.
12. Press the <X> key in the upper right corner to return to the TEST MENU.

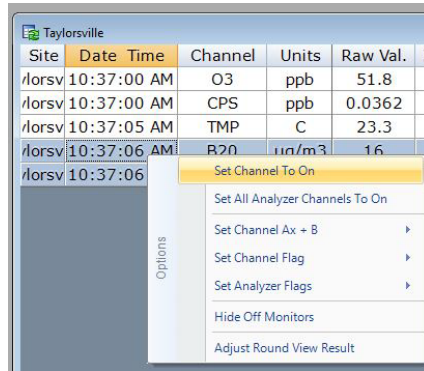
## 7.8 Verification or Audit: Self-Test and Enable Parameter in Envidas

After any action taken by the operator that interrupts the sampling cycle of the BAM 1022, a self-test must be performed. The self-test checks the movement of tape, nozzle movement and flow.

1. Assuming that the monitor is at the Main Operating Screen, press the three horizontal lines (  ) in the top left corner of the screen.
2. Select the Test Menu and press “Run Self-Test”.
3. The test will start automatically, give messages such as “Moving Tape”, Moving Noz Down”, “Counting . . . “and “Waiting Flow”. The full test will take approximately 30 seconds.
4. When the passing test is finished the display will change to SELF-TEST COMPLETE. If there are any displayed errors, troubleshoot the issues and repeat the self-test.
5. Press the <X> icon in the upper right corner to return to the Test Menu and then (  ) to return to the Main Operating Screen.
6. Record the self-test result in the “Site Visit” spreadsheet.
7. The BAM 1022 is ready for sampling. Press the three horizontal lines (  ) in the top left corner of the main screen.
8. Select “Operate and then press “Start Sample”. The monitor will prompt you to begin a new sample with “Warning! Start a New Sample?” Select the grey <START> button. The monitor’s pump will automatically turn on and begin a new sampling cycle.
9. Press the <X> icon in the upper right corner to return to the Operate Menu and then (  ) to return to the Main Operating Screen.
10. Up the BAM concentration channel in Envidas at the site.

## 7.9 Verification or Audit: Setting the Envidas Channel to Ok

1. In Envidas Viewer, select the channel you would like to bring up by right clicking on the name of the channel. The options menu will appear.



**Figure 46. Setting the Channel to On**

2. Select "Set Channel To On". At the top of the minute, the channel will appear un-greayed and the status will tread "Ok".
3. Shut down Envidas Viewer.

## 7.10 Span Membrane Test



**Figure 47. Zero Foil.**



**Figure 48. Span Foil.**

The Span Membrane Test is used to verify the performance of the BAM 1022 beta attenuation system. Since it is very important that the upper nozzle, nozzle and vane be clean to ensure valid results, the test must be performed by the primary operator once a quarter following the completion of quarterly maintenance and cleaning. A zero and span foil card (included in the BAM 1022 accessory kit) will be required to complete this procedure. Take the following steps to complete the process:

1. Assuming that the monitor is sampling, down the parameter in Envidas.
2. Press the three horizontal lines (≡) in the top left corner of the view screen. Press “Operate” and then select “Stop Sample”. A message of “**Warning! Stop Current Sample?**” should appear. Press the grey <STOP> button to cease sampling.
3. Press the three horizontal lines (≡) in the top left corner. Select “Test” and then “Span Mass Audit”.
4. The filter tape must be loaded for this test. Insert the zero card above the filter tape, staying between the two card guides on either side, with the label facing up. Take care to minimize tape movement by applying slight reverse pressure on the supply reel.
5. The notch on the left side of the zero foil will slide into the monitor. The notch enables the monitor to detect the card and will automatically lower the nozzle. The four-minute measurement will commence.




**Figure 49. Proper Zero Foil Placement.**



**Figure 50. Foil Guides and Notch Entrance.**

6. After four minutes, the nozzle will be raised and the screen will instruct you to remove the zero card.
7. Remove the zero card. Take care to minimize tape movement.
8. Once removed, the display will change to list the current span foil card setting. Compare this value to the value listed on the span foil card, calibration certificate or sampler door. If the values do not match, tap the green bordered “Span Value” field and enter the proper value. Press the grey <CONTINUE> button. The value is now saved for future span membrane tests.

9. The display will now instruct you to insert the span foil card. Insert card above the filter tape, staying between the two card guides on either side, with the label facing up. Take care to minimize tape movement by applying slight reverse pressure on the supply reel. The notch on the left side of the span foil card will slide into the monitor.
10. When the span foil card is in place, select the grey <CONTINUE> button. The four-minute measurement will commence.
11. After four minutes the display will change to list the results of the audit. The measured mass will be listed on the top, the programmed span value will be in the middle and the error between the two will be listed on the bottom.
12. Read and record these values in the “Membrane Span Check” section of the “Verification Audit” page of the E-log.
13. If the error is greater than +/- 5%, the audit has failed. The error is usually caused by tape movement during the insertion and removal of the zero and span foil cards. Repeat the test while paying attention to minimizing tape movement.
14. If the test continues to fail, perform the upper nozzle, nozzle and vane cleaning once again to ensure valid results. If the test still continues to fail, contact ECB and the RCO particulate lead for assistance.
15. If the test passes, press the <X> icon in the upper right corner. The nozzle will raise and you will be instructed to remove the span foil card. Remove the card and the display will automatically return to the Test Menu.
16. To return to the main operating screen, press the home icon (  ) located in the upper right corner.

## **7.11 Zero Background Test**

The operator must perform a zero background test on the BAM 1022, after the initial installation and calibration, as soon as the weather conditions meet the minimum weather requirements: 48-72 hours of clear weather with no precipitation forecasted. A zero background test may also be performed indoors before the monitor is installed by the Electronic and Calibrations Branch: weather requirements are waived in this circumstance, yet the smart heater still must be used. This test corrects the background value to compensate for minor variations caused by local conditions such as grounding and shelter characteristics. Subsequent background tests will be performed on an annual basis in early Spring (March/April/May) or Fall (September/October/November) when dew points are generally at a low point. The test collects data for 48-72 consecutive hours having the PM10 and PM2.5 inlets replaced with a HEPA filter on a flow audit adapter. At the end of a completed 48 to 72-hour period, the data must be downloaded and statistically analyzed using a spreadsheet template. After the new background value has been calculated and compared with the factory zero, it is recommended that the new coefficient be audited for 24 hours prior to resuming normal data collection; especially if the BAM is close to failing the background test. Specific EPA guidance is provided in Appendix C.

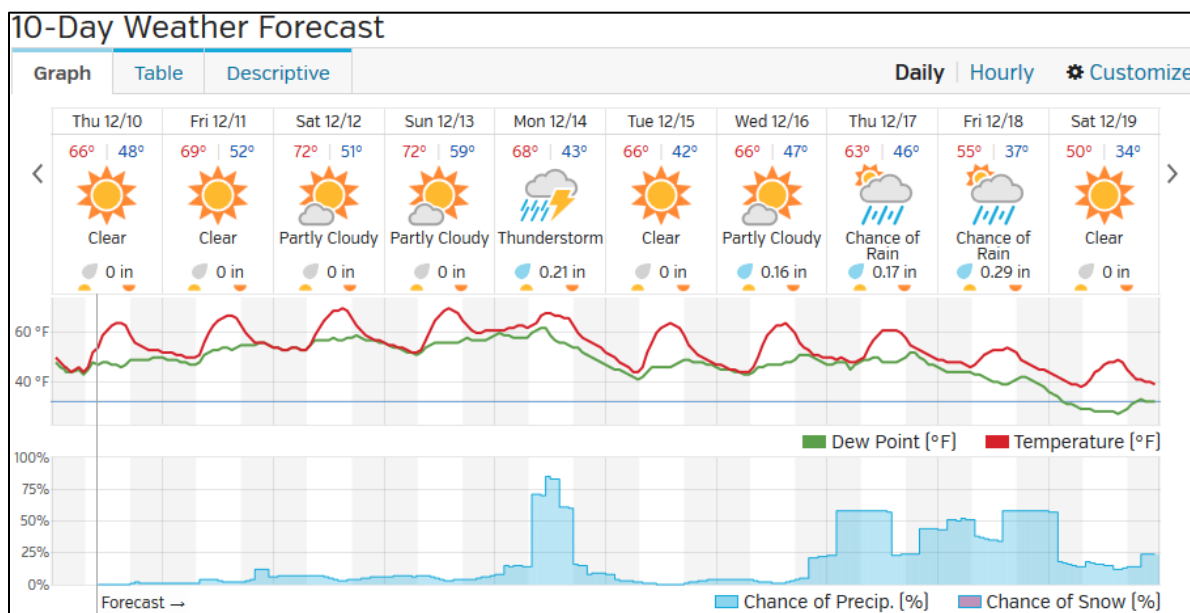
### **7.11.1 Materials**

The following materials are needed to complete a background test:

- The latest revision of the BAM Operators SOP and Met One BAM 1022 Manual
- BAM down tube cleaning kit
- All devices necessary to complete a calibration or verification
- All tools necessary to complete all BAM cleanings and maintenance
- A high-efficiency particulate air (HEPA) filter assembly with a flow audit adapter
- Most recent version of the BAM e-log

### **7.11.2 Zero Background Procedure**

1. Watch the weather forecast watching for 4-5 days of clear weather: no major fronts coming through, relatively low dew points and no precipitation forecasted. Weather Underground ([www.weatherunderground.com](http://www.weatherunderground.com)) can supply detailed forecasts over multiple days. Isolated thunderstorms are often unavoidable and should not be a deterrent from starting the zero background test. In the example below, 12/10 through 12/13 is an ideal time for a background test. A background test should not be completed on 12/17 or 12/18.



**Figure 51. Example Weather Forecast.**

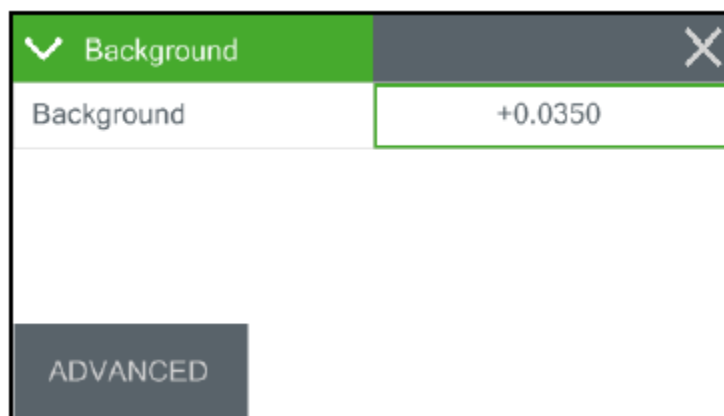
2. The test must run for a minimum of 48 consecutive hours, otherwise the test is invalid. Tests should run for more than 48 hours because the first 5 hours of the test, when the detector is equilibrating, may need to be discarded.
3. It is recommended that the Envidas data channels **remain enabled** so that the data can be monitored during the test period.
4. Notify the RCO particulate matter lead at the start of the test. This is important to ensure that the background test data do not post to the public website!
5. If this is not an initial zero background test, complete a full verification (see Section 7.0) prior to setting up the monitor for the test. **This will envelope the data to prevent invalidation.**
6. Complete all monitor maintenance (see Section 8.0) prior to the start of the test, **including cleaning the upper and lower nozzle, vane, rollers, downtube, VSCC and the PM10 head.**
7. Complete a full calibration of the monitor (see Section 6.0).





**Figure 52. HEPA Filter Assembly.**

8. Inspect the zero filter cartridge. The zero filter cartridge should be replaced if there are any obvious signs of discoloration due to aging or the aspiration of water.
9. Screw the cartridge onto the leak check adapter and attach the rain shield line to the top. A small amount of Teflon tape may be used to guarantee a tight seal for both connections.
10. With the PM10 head and VSCC removed, place the HEPA filter assembly. Verify that the zero filter leak valve is in the open position.
11. From the Main Operating Screen, press the three horizontal lines (≡) in the top left corner of the screen.
12. Select the “Setup Menu” and select “Background”.



**Figure 53. Background Screen.**

13. Record the current background value in the next available “Background” tab of the E-log.
14. Although it is not necessary to reset the existing BKGD value to 0 for the purpose of conducting the zero-test, doing this will minimize the chance of a miscalculation. Press the green bordered value box on the row labeled “Background” and the numerical entry keypad will be displayed. Change the background value to 0.0000 and press <OK>. Regardless of the concentration units setting, the background is always entered in mg/m<sup>3</sup>.
15. Press the <X> icon in the upper right corner to return to the Setup Menu. Then select “Background” to ensure that the background value has been set to 0.0000.
16. Press the <X> icon in the upper right corner to return to the Setup Menu. Press the three horizontal lines (≡) in the top left corner of the Main Operating Screen.
17. Select “Operate and then press “Start Sample”. The monitor will prompt you to begin a new sample with “**Warning! Start a New Sample?**” Select the grey <START> button. The monitor’s pump will automatically turn on and begin a new sampling cycle.
18. Press the <X> icon in the upper right corner to return to the Operate Menu and then (⏏) to return to the Main Operating Screen.
19. After no less than 53 hours (5 hours to ensure monitor stability and 48 hours of sampling), download the BAM 1022 hourly concentration data. Confirm that the monitor ran without disruption.
20. If any disruptions occurred during the test (e.g. data errors, power outages or maintenance), the assessment must be extended until a full 48 to 72 hours of continuous data is obtained.

### 7.11.3 Calculating the Background Coefficient

1. Open the E-log and navigate to the “Background” tab. Fill out the “Test Information” section. Add any comments in the comments section.
2. Copy the 48 to 72-hour period of data from the data BAM 1022 data download (use the ConcHR ( $\mu\text{g}/\text{m}^3$ ) column) and paste it directly in the “Test Data” section of the Background spreadsheet.

|                  |                       |               |           |
|------------------|-----------------------|---------------|-----------|
| Data Report      |                       |               |           |
| 11/9/2016 9:25   |                       |               |           |
| Location         | 1                     | T17002        |           |
|                  |                       |               |           |
| Time             | ConcRT( $\mu\text{g}$ | ConcHR( $\mu$ | Flow(lpm) |
| 11/4/2016 14:00: | 10                    | 7             | 16.6      |
| 11/4/2016 14:00: | 4                     | 3             | 16.7      |
| 11/4/2016 14:00: | 2                     | -1            | 16.7      |
| 11/4/2016 14:00: | 1                     | 0             | 16.7      |
| 11/4/2016 14:00: | -1                    | 0             | 16.7      |
| 11/4/2016 14:00: | 0                     | 0             | 16.6      |
| 11/4/2016 14:00: | 0                     | 0             | 16.7      |
| 11/4/2016 14:00: | 0                     | 0             | 16.7      |
| 11/4/2016 14:00: | -2                    | 0             | 16.7      |
| 11/4/2016 14:00: | 1                     | 1             | 16.7      |

**Figure 54. Hourly Concentration Column.**

| Test Data       |  |
|-----------------|--|
| Time            | Concentration ( $\mu\text{g}/\text{m}^3$ ) |
| 11/4/2015 14:00 | 7  |
| 11/4/2015 15:00 | 3  |
| 11/4/2015 16:00 | -1   |
| 11/4/2015 17:00 | 0  |
| 11/4/2015 18:00 | 0  |
| 11/4/2015 19:00 | 0  |
| 11/4/2015 20:00 | 0  |
| 11/4/2015 21:00 | 0  |
| 11/4/2015 22:00 | 0  |
| 11/4/2015 23:00 | 1  |

**Figure 55. Background Test Data E-Log.**

3. Check the “Dataset Statistics” section of the background worksheet to determine if all parameters pass. The e-log will automatically calculate the necessary statistics and label each with a pass/fail indicator. If a failing test occurs, repeat the test in another window of suitable weather. If unit fails to pass, call ECB and Particulate Lead.

4. From the Main Operating Screen, press the three horizontal lines (≡) in the top left corner of the screen.
5. Select the “Setup Menu” and select “Background”.
6. Press the green bordered value box on the row labeled “Background” and the numerical entry keypad will be displayed. Enter the new background value obtained from the E-log and press <OK>. Regardless of the concentration units setting, the background is always entered in mg/m<sup>3</sup>.
7. Press the <X> icon in the upper right corner to return to the Setup Menu. Then select “Background” to ensure that the background value has been set to the desired value.
8. It is recommended, especially if the BAM is close to failing the background test, to complete a background audit as described in the next section. If a background audit is not to be done, remove the background test HEPA filter assembly and replace the PM10 head.
9. The BAM 1022 is ready for sampling. Press the three horizontal lines (≡) in the top left corner of the main screen.
10. Select “Operate and then press “Start Sample”. The monitor will prompt you to begin a new sample with “**Warning! Start a New Sample?**” Select the grey <START> button. The monitor’s pump will automatically turn on and begin a new sampling cycle.
11. Press the <X> icon in the upper right corner to return to the Operate Menu and then (⏏) to return to the Main Operating Screen.

#### **7.11.4 Zero Background Audit**

1. With the newly calculated background value entered in the 1022, and the HEPA filter assembly remaining on the downtube, continue collecting data for an additional 12 to 24 hours.
2. Download the data from the BAM.
3. The background coefficient passes the audit if the hourly data is centered around zero ( $\pm 2$   $\mu\text{g}/\text{m}^3$ ). Discuss these results with the RCO particulate matter lead prior to ending the test.
4. If the background test passes, remove the HEPA filter assembly and replace the PM10 head and VSCC. Resume normal sampling. If a failing test occurs, Repeat the test in another window of suitable weather. If unit fails to pass, call ECB and Particulate Lead.

## **8.0 MAINTENANCE**

All sampler maintenance must be recorded on the “Maintenance Log” tab of the e-log. It is recommended that operators carry the following items in their field maintenance kit:

- Can of compressed air with tube
- Cotton Tipped Applicators
- Phillips Head Screwdriver
- Allen Wrench (5/64”)
- Vacuum grease (silicone based)
- 91% Isopropyl Alcohol for cleaning the VSCC and PM10 head
- Distilled water
- Cotton cloth or Shop Towels
- Kimwipes
- O-rings for the VSCC
- Downtube cleaning kit
- BAM tape
- Scotch tape
- Flashlight

**Table 6. Summary of Sampler Maintenance.**

| <b>Maintenance Activity</b>  | <b>Frequency</b>   |
|--|--------------------|
| <ul style="list-style-type: none"> <li>• Clean nozzle, vane and rollers</li> <li>• Check BAM clock (see Section 5.2.2.)</li> <li>• Check smart heater (touch to see if warm)</li> <li>• Download data, settings, and alarm files (see Section 9.0)</li> </ul>      | Every 14 – 18 days |
| <ul style="list-style-type: none"> <li>• Clean VSCC and inspect O-rings</li> <li>• Clean PM10 head and inspect O-rings</li> <li>• Wipe down interior and exterior of the BAM 1022</li> <li>• Clean fan filters</li> <li>• Empty water collection bottle</li> </ul> | Every 30 days      |
| <ul style="list-style-type: none"> <li>• Verify BAM settings</li> <li>• Clean Temperature Probe Solar Shield</li> <li>• Clean Internal Nozzle</li> <li>• Clean Downtube</li> <li>• Inspect downtube O-rings</li> <li>• Span Mass Audit</li> </ul>                  | Every 91 days      |

## 8.1 Cleaning the PM10 Inlet

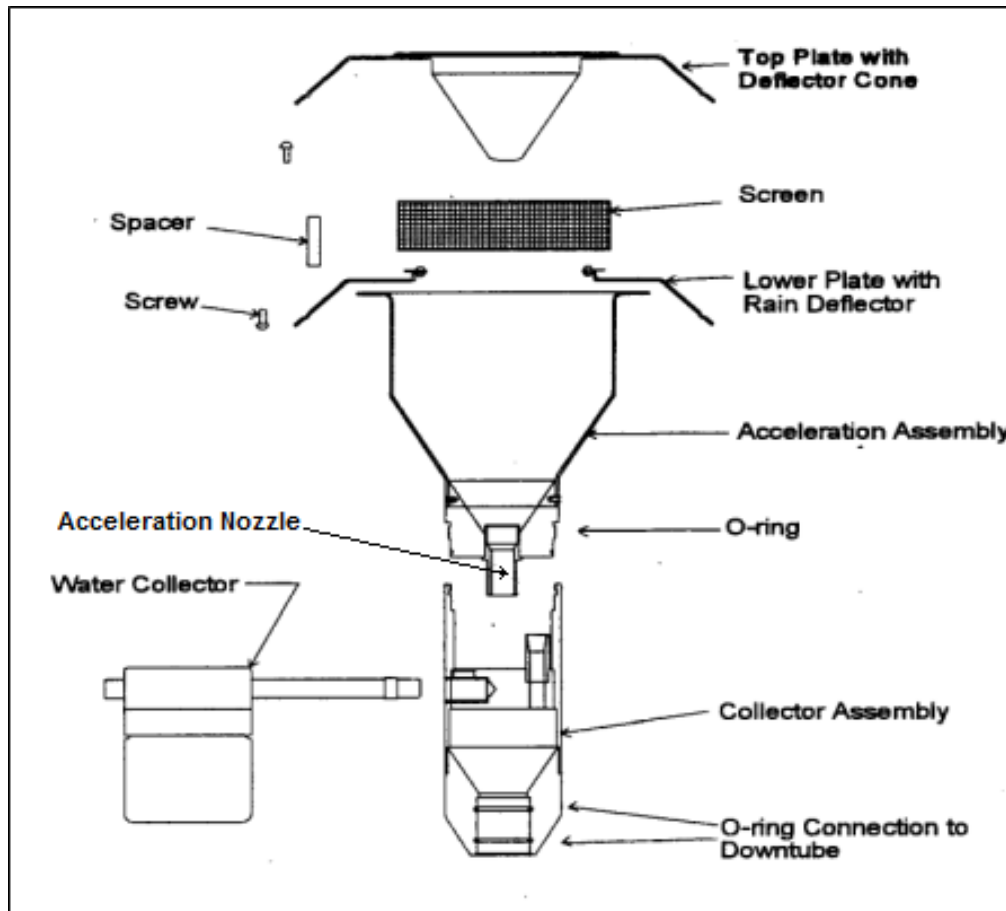
The PM10 inlet has two primary components: The Acceleration Assembly and the Collector Assembly. These components must be disassembled and cleaned every 30 days.



**Figure 56. The PM10 Inlet Components.**

### 8.1.1 Disassembling the Inlet

1. Remove the PM-10 head by lifting the inlet up and off the sample tube.
2. Using Figure 57 as a guide, unscrew the collector assembly from the accelerator assembly by turning the top portion counterclockwise.



**Figure 57. Exploded view PM-10 Inlet Assembly.**

### 8.1.2 Cleaning and Maintaining the PM10 Accelerator Assembly

1. Remove four Philip head screws from the top and remove the top plate.
2. Clean the top plate with a lint-free cloth and water (or alcohol).
3. Remove the insect screen from the lower plate and clean.
4. Clean the lower plate with a lint free cloth and water (or alcohol) with particular attention to the internal sides of the acceleration chamber.

5. Use water (or alcohol) and a cotton swab to clean the acceleration nozzle.
6. Inspect the large O-ring between the accelerator and collection assembly. Lightly lubricate with the vacuum grease if necessary.
7. Reinstall the insect screen and screw the top plate back onto the bottom plate of the Acceleration Assembly.

### **8.1.3 Cleaning and Maintaining the PM10 Collector Assembly**

1. Clean the threads of the Collector Assembly to ensure smooth separation and assembly.
2. Clean the Collector Assembly walls, bottom plate and three vent tubes using a cloth, water (or alcohol) and cotton swab.
3. Clean the hole in the collector plate where the condensate runs to the moisture trap with a cotton swab.
4. Remove the rain jar and clean with a cloth. Inspect the brass nipple. Replace rain jar and lightly coat the threads with grease.
5. Inspect the two inlet tube O-rings for wear and lightly grease if necessary.
6. Reassemble the collector assembly by hand tightening.
7. Place the reassembled PM10 head back onto the sampler tube.

## **8.2 Cleaning the VSCC**



**Figure 58. Disassembling the VSCC for Cleaning.**



The VSCC is an essential component of the inlet system. It needs to be diligently maintained or it will corrode. The VSCC must be cleaned every 30 days. A spare O-ring kit should be kept on hand. Disassemble and clean the VSCC following these steps:

1. Remove the PM10 head from the sampler tube and VSCC.
2. Remove the VSCC from its installed position in the instrument.
3. Pull off the side transfer tube. Care should be taken to avoid damaging the two O-ring seals.
4. Unscrew the top cap and the grit chamber.
5. Use alcohol, or if unavailable, water, along with a cotton swab to remove all visible deposits. These deposits are most likely to be found at the bottom of the cone (located beneath the grit chamber) and inside the grit chamber.
6. Inspect all O-rings for shape and integrity. If at all suspect, replace the O-rings.
7. Assemble in reverse order and reinstall on the sampler tube.

### **8.3 Inlet Downtube Cleaning**

The inlet downtube must be cleaned quarterly and before every zero background test. Each regional office has been provided with Met One's BX-344 Inlet Cleaning Kit. The kit contains the following downtube cleaning items

- Lint-free washable microfiber rags for cleaning the inside of the vertical inlet tube. Generic shop rags or cleaning cloths may be used as well.
- A 10' Pull Rope Assembly for pulling the rags or tube brush through the inlet tube. The brass weight allows the rope to feed through the tube.
- A Nylon Tube Brush to remove any debris inside the inlet tube before using the cleaning rags.
- An Allen Wrench, (5/64", not included in the kit) will also be needed.

The procedure for cleaning the inlet downtube is as follows:

1. Stop the sampling cycle if the BAM is in operation.
2. Remove the PM10 head and the VSCC from the vertical inlet tube.
3. Disconnect the ambient temperature cable from the probe.

4. Loosen the waterproof flange around the inlet tube where it enters the enclosure so that the inlet tube can be turned.



**Figure 59. Inlet Tube Flange.**



**Figure 60. Smart Heater Set Screws.**

5. Rotate the downtube counter clockwise so that the smart heater set screws become accessible. Loosen, but do not remove, the hex screws on the smart heater of the BAM.

6. Slowly advance the downtube up out of the unit, allowing the smart heater to slide off below in the process. Cover the BAM inlet to prevent debris from falling into the hole during the cleaning (a red plastic cap should be provided with each unit for this purpose).



**Figure 61. Pull Rope Assembly.**

7. Feed the weighted end of the pull rope assembly down through the inlet tube until it comes out the bottom. Use the rope to pull the brush through the inlet tube. Repeat as needed.
8. Insert a cleaning rag through the looped end of the pull rope assembly and slip the loop up tight around the rag. **Note: Do not use paper towels or Kimwipes.**
9. Feed the weighted end of the pull rope assembly down through the inlet tube until it comes out the bottom.
10. Use the rope to pull the rag through the inlet tube. The rag should fit snugly, but it should not be difficult to pull through. The rag may be dampened with water if needed.
11. Visually inspect to determine if the down tube is clean.
12. Reinsert the inlet tube into the inlet tube flange and the smart heater, making sure that the inlet tube is seated correctly in the sampling inlet receiver.



**Figure 62. Proper Smart Heater Clearance.**

13. Adjust the position of the smart heater, allowing 1-1.5 inches of clearance between the smart heater and the sampling inlet receiver. Tighten the smart heater screws.
14. Rotate the inlet tube, along with the smart heater, to its original position and then tighten the inlet tube flange.
15. Reattach the VSCC and PM10 head.

#### **8.4 Internal Nozzle Cleaning**

The inside of the sample nozzle should be cleaned to remove particulate which may have settled on internal surfaces. This cleaning prevents a buildup of debris, which could fall out of the nozzle and on to the tape (causing undesired positive concentration spikes). The internal nozzle should be cleaned every 91 days and prior to a span membrane test and zero background test. The following cleaning items will be needed:

- Canned Air (a.k.a. Compressed Air Duster) with Tube
- Allen Wrench, (5/64")
- Kimwipes

Use the following steps to clean the nozzle's internal surfaces:

1. Stop the sampling cycle if the BAM is in operation.
2. Remove the PM10 head and the VSCC from the vertical inlet tube.
3. Loosen the waterproof flange around the downtube where it enters the enclosure so that it can be turned.
4. Rotate the downtube counter clockwise so that the smart heater set screws become accessible. Loosen, but do not remove, the hex screws on the smart heater of the BAM.
5. Loosen the hex screws on the smart heater.
6. Slowly raise the downtube, removing the smart heater, and tighten the waterproof flange to hold the downtube in place as shown in Figure 63.
7. Remove the collar of the sampling inlet receiver exposing the internals of the nozzle.



**Figure 63. Sample Tube Held in Place by Flange.**

8. Press the three horizontal lines (≡) in the top left corner. Select the Test Menu and then “Tape Test”. Entering this screen will cause the nozzle to raise.

9. Gently slide the canned air tube down the inlet receiver on top of the BAM 1022. Supply multiple short blasts of air, while moving the canned air tube from side to side to blow on all surfaces inside the inlet. You may also swab the visible insides of the nozzle with Kimwipes.
10. Inspect the tape below for debris. If debris is still present, repeat steps 7 through 12.

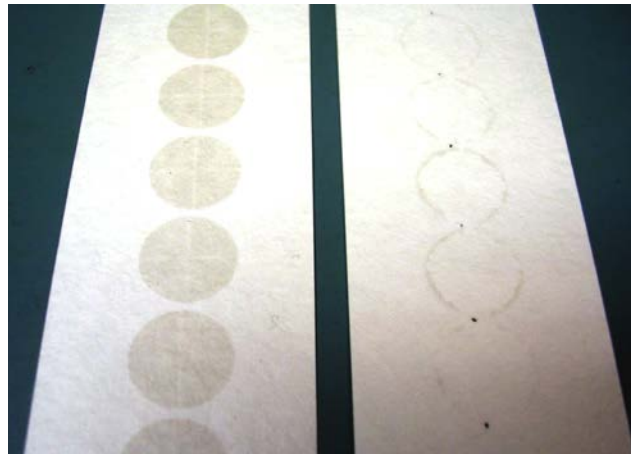


**Figure 64. Sampling Inlet Receiver Collar.**

11. Clean the collar of the sampling inlet receiver, taking care to inspect all O-rings for shape and integrity. If at all suspect, replace the O-rings.
12. Reinstall the sampling inlet receiver collar making sure it is seated correctly.
13. Reinsert the inlet tube into the inlet tube flange and the smart heater, making sure that the inlet tube is seated correctly in the sampling inlet receiver.
14. Adjust the position of the smart heater, allowing 1-2 inches of clearance between the smart heater and the sampling inlet receiver. Tighten the smart heater screws.
15. Rotate the inlet tube, along with the smart heater, to its original position and then tighten the inlet tube flange.
16. Reattach the VSCC and PM10 head.

## 8.5 Cleaning the Nozzle, Vane and Rollers

The nozzle and vane (located under the nozzle) must be cleaned regularly to prevent leaks and measurement errors. The cleaning must be done at least once every 14 – 18 days from the last cleaning and each time the filter tape is changed. Some sites may require more frequent cleaning as determined by visual inspection of the filter spots that have previously collected sample. Figure 36 shows the difference between acceptable and inferior sampling areas. The tape on the left is from a properly operated BAM 1022 with a clean nozzle and vane. The particulate sampling areas have very crisp edges, are perfectly round, and are evenly distributed. The tape to the right is from a unit that has not been properly maintained. A spot of debris has built up on the vane and is punching a hole on the edge of the sample area. **These holes can allow beta particles to get through un-attenuated and negatively affect accuracy even if the nozzle is not leaking.** The spots also show a “halo” effect due to air leaking in around the edge. Debris has built up to the extent that the nozzle no longer seals correctly. These faults are easily corrected and prevented by keeping the nozzle and vane clean.



**Figure 65. Hourly Filter Samples.**

Other parts along the filter tape routing within the BAM 1022 must also be cleaned regularly to reduce debris accumulation. Over time, a gradual build-up of filter tape debris and particulate may form on the nozzle and vane sealing surfaces. The following cleaning items will be needed:

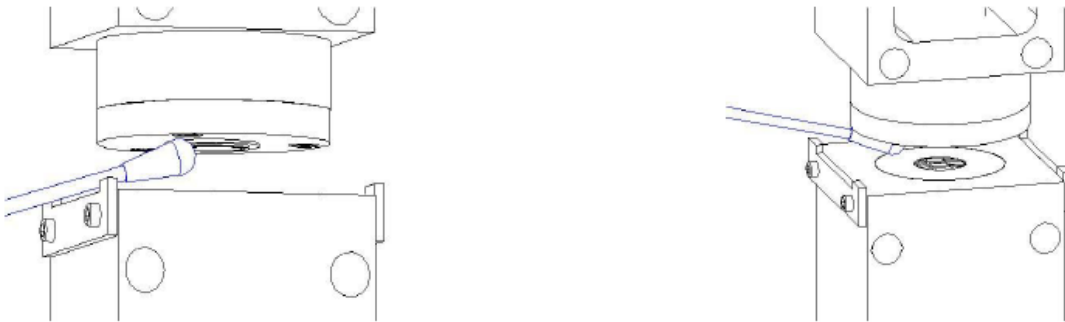
- Cotton Tipped Swabs
- 91% Isopropyl Alcohol
- Canned Air (a.k.a. Compressed Air Duster) with Tube
- Cleaning Brush



**Figure 66. Cleaning Brush.**

Use the following steps to clean the nozzle, vane and roller assembly:

1. Down the channels on the data logger.
2. Complete an "As Found" leak check.
3. Navigate to the Test>Leak Test menu and raise the nozzle, if needed.
4. Remove the BAM 1022 filter tape.



**Figure 67. Nozzle Cleaning.**

5. Thoroughly clean the nozzle seal and vane with a clean swab soaked in alcohol. Allow the alcohol to dissolve any deposits. Since the beta detector is located beneath the vane, try to prevent debris from falling through the holes.
6. If heavy debris remains on the vane or nozzle, loosen it with the cleaning brush. Do not use any sharp tools.



7. If debris falls through or is found beneath the vane, carefully clean the cavity with a blast of compressed air.
8. Inspect and clean rollers with Kimwipes.
9. Re-install the BAM 1022 filter tape.
10. Perform an “as left” leak check along with a Self-Test.
11. Return the BAM to the sampling mode.
12. Bring the BAM 1022 channels back online.

## 8.6 Cleaning the Ambient Temperature Probe and Solar Radiation Shield



**Figure 68. Ambient Temperature Probe.**

In order for the ambient temperature to read correctly, the temperature probe and solar radiation shield need to be cleaned quarterly. This assures that the probe and shield are not behaving as an unintentional heat sink, building up debris or harboring insect nests that may influence readings.

1. Locate the locking screw on the back of the solar radiation shield. Unscrew it enough to allow the temperature probe to rotate in the housing one quarter turn. The probe should drop freely from the shield.



**Figure 69. Ambient Temperature Probe Lock Screw.**

2. Inspect the probe for wear or damage, especially around the data cable connection. Clean the probe with water and a clean shop towel or Kim Wipe.
3. Inspect the solar shield for debris or insects. Clean the solar shield vanes with water and a clean shop towel. Periodic disassembly is recommended on occasion for hard to reach areas of the shield.
4. Reassemble by inserting the temperature probe back into its housing and holding it in place with the locking screw.

## **8.7 Cleaning the Fan Filters**

1. One of the air intake filters is located in the pump compartment of the sampler.
2. Snap off the cover to the air intake filter.
3. Remove the filter and shake clean or use a soft brush. If it is sticky, clean with mild detergent and water. Rinse and repeat as needed.
4. Reinstall the filter and cover.
5. Now, locate the intake fan in the sampling compartment, remove and clean filter as described above.

## 9.0 DATA HANDLING

Each BAM is supplied with a free copy of the Met One Comet software. Comet is a communications terminal program that can retrieve data from the BAM 1022 either directly via a RS-232 cable, USB serial cable, USB Flash Drive or remotely through a modem. The BAM 1022 can store up to 11,827 records (1.4 years' worth of data at one record per hour, 8 days' worth of data at 1 record per minute).

### 9.1 Downloading Data via Flash Drive

A USB flash drive is all that is needed to download the internal data from the BAM-1022. The flash drive is inserted in the USB port located on the front of the unit, in the upper left corner of the tape transport.



**Figure 70. USB Download Port.**

1. To download the data, plug a USB flash drive into the port. Press the three horizontal lines (≡) in the top left corner. Select "Operate" and then "Transfer Data".
2. There are two fields in this screen. The first is the "Days" field. Press the green bordered box next to the Days. Enter the number of days of data to download (between 001 and 999) and press <OK>.
3. The second field is the "Files" field. There are two file types. The "User" files are for all routine data collection purposes. The "All" files type contains additional encrypted factory diagnostic data. Select "All" and press <OK>.

4. Press the grey <COPY> button in the bottom left corner to copy the selected data to the USB flash drive. Copying is complete when the display reads “Copy Complete”.

## 9.2 Downloading Data via Comet and RS232

Each BAM 1020 is supplied with a free copy of **Comet**<sup>™</sup> utility software from Met One Instruments. Comet is a communications terminal program which can retrieve data from the BAM 1022 using either a direct local connection or a remote connection via various modem types or even an IP address. The CD contains complete instructions.

Install the program on your computer, then run it from the programs directory. You will have the option to select a previously saved station, or to create a new one. **Note: The BAM 1022 display must be on the main menu in order to establish communications.** To create a new station in Comet, complete the following.

1. Connect the RS-232 port on the back of the BAM to your computer or laptop using the appropriate (supplied) cable. Connect to the COM1 serial port.
2. Open the “Comet” program (Start>Programs>Met One>Comet). The program will ask “New Station” or “Existing”. For a new station, click “Create” and then under “Manual Set-Up” click “Set-Up”.
3. Under **Station Name** enter a name such as “Millbrook” or “ML”.
4. Under **Product** select “BAM 1022”.
5. Under **Port** select “COM 1”.
6. Under **Baud** select “9600”.
7. Under **Phone Number** leave blank.
8. Click “OK”. **Note:** After a “New Station” has been set-up, subsequent data downloading is performed by clicking on “Existing”.
9. The next screen will display two optional “Tabs”. Select the “Data” tab. Under “Data Options” click “Retrieve Current”.
10. In the next screen under “Retrieve Files” click “All” and under “Data Range” click “New”. (“All” allows three files to be automatically downloaded; settings, alarms and data. “New” allows all data since the last download to be downloaded).
11. Click “Retrieve” to download all data since the last download. The download status screen will display progress and indicate when download is complete.

12. By default, the data is automatically stored to the “My Documents” directory. To change the data storage directory, first create a new file directory under the Met One directory, giving it a name such as “BAM Downloads”.
13. In the Comet main menu program click on “File” and then on “Settings”. This opens the file settings dialog box. In the dialog box, either manually type in the desired directory (such as “C: Program Files>Met One>BAM Downloads”) or use the “Browse” feature to locate the desired directory and click “OK”.
14. When the download is complete, “Comet” automatically saves the downloaded files and assigns a unique file name to each file using the following convention:

**Filename = station name\_file\_YYmmdd\_HHMMss.Extension**

- **Station Name** = Millbrook or Bryson City or .... (named during set-up);
  - **File** = either “data”, “alarm” or “settings”;
  - **YY** = year file was retrieved;
  - **mm** = month file was retrieved;
  - **dd** = day file was retrieved;
  - **HH** = Hour file was retrieved;
  - **MM** = Minute file was retrieved;
  - **ss** = second file was retrieved; and
  - **Extension** = .txt for alarm and settings files and .csv for the data file.
15. Go to the “My Documents” or “BAM Downloads” directory and open the files to make sure they were successfully saved. Review the data for any anomalies.
  16. Once the station is set up in Comet, the data can be downloaded from the BAM using the “Retrieve Current” BAM.

### **9.3 Downloading Data Remotely**

Data can be downloaded from the BAM remotely (i.e. from home or the office) by using the site’s IP address and corresponding BAM port. In the “Create New Station” setup menu, select the TCP/IP option. Enter the IP address for the site modem and use Port 9885. *Note: This remote download option often does not work at the NC DAQ offices because of firewall settings. Contact your local IT administrator for more information.*

## **9.4 Types of Data Files**

### **9.4.1 Data File**

The data file contains all of the raw data recorded on the internal hard drive of the BAM 1022. The data file can store 11,827 data records and will start to overwrite the oldest file when full.

### **9.4.2 Settings File**

The settings contain a list of the BAM 1022 settings and calibration values. This is useful for verifying the setup parameters, ensuring that the slope of the calibration is between 0.9 to 1.1 and confirming that settings have changed after calibration.

### **9.4.3 Alarms File**

The alarms file is a log of the date, time, and alarm code of the BAM 1022. Alarms can be grouped into twelve different categories: external reset, telemetry fault, maintenance, internal error, power failure, reference error, nozzle error, flow error, pressure drop, deviant membrane, count error, or filter tape error. The alarm file can store 200 events and will start to overwrite the oldest file when full.

## 10.0 QUALITY ASSURANCE AND DATA HANDLING

### 10.1 Daily Data Review

Each regional office should set up their Envista Air Resources Manager (ARM) to distribute automated reports each morning. Contact ECB or the Data Acquisition Manager for more information. An example daily report is shown in Figure 71.

| Station         | HICKORY HK | HICKORY HK |
|-----------------|------------|------------|
| Monitor         | 1022BAM    | PM2.5A     |
| 9/10/2019 00:00 | 15.00      | 14.00      |
| 9/10/2019 01:00 | 16.00      | 17.00      |
| 9/10/2019 02:00 | 15.00      | 12.00      |
| 9/10/2019 03:00 | 16.00      | 14.00      |
| 9/10/2019 04:00 | 15.00      | 16.00      |
| 9/10/2019 05:00 | 16.00      | 10.00      |
| 9/10/2019 06:00 | 13.00      | 16.00      |
| 9/10/2019 07:00 | 14.00      | 28.00      |
| 9/10/2019 08:00 | 20.00      | 25.00      |
| 9/10/2019 09:00 | 23.00      | 25.00      |
| 9/10/2019 10:00 | 27.00      | 26.00      |
| 9/10/2019 11:00 | 24.00      | 31.00      |
| 9/10/2019 12:00 | 27.00      | 24.00      |
| 9/10/2019 13:00 | 28.00      | 26.00      |
| 9/10/2019 14:00 | 26.00      | 19.00      |
| 9/10/2019 15:00 | 22.00      | 30.00      |
| 9/10/2019 16:00 | 29.00      | 18.00      |
| 9/10/2019 17:00 | 22.00      | 17.00      |
| 9/10/2019 18:00 | 21.00      | 24.00      |
| 9/10/2019 19:00 | 22.00      | 18.00      |
| 9/10/2019 20:00 | 23.00      | 22.00      |
| 9/10/2019 21:00 | 25.00      | 25.00      |
| 9/10/2019 22:00 | 24.00      | 29.00      |
| 9/10/2019 23:00 | 25.00      | 30.00      |
| Average         | 21.16      | 21.50      |
| Min Value       | 13.00      | 10.00      |
| Max Value       | 29.00      | 31.00      |

**Figure 71. Example Daily Report from Envista.**

The polled BAM data must be reviewed on a daily basis (preferably in the morning) by the regional office staff. The BAM concentration should be reviewed. It is at the discretion of the regional ambient monitoring coordinator (RAMC) as to how this process should be executed. At a minimum, each BAM operator should review their site data on a daily basis and report abnormalities to either the RAMC or the RCO particulate matter lead.

If the average daily PM<sub>2.5</sub> concentration exceeds 35 µg, alert the Regional Office Chemist (ROC) and the RCO particulate matter lead immediately. The daily maximum PM<sub>2.5</sub> concentrations should be below 30 µg/m<sup>3</sup>.

A negative concentration is likely, especially during periods of extended precipitation. Repeating concentrations of -5 µg/m<sup>3</sup> is indicative of either a monitor or an onsite Envistas malfunction. The cause of this must be investigated immediately.

## **10.2 Field Operator Quality Assurance**

Upon arriving at the site, the field operator is responsible for ensuring that the monitor has collected what appears to be valid data since the previous site visit. This includes reviewing the alarms and collected data. Below is a suggested list of items that operators should be verifying during each site visit:

- Possible changes near the site that could bias the data (fires, construction, etc.)
- Encroachment of wildlife or vegetation
- Vandalism
- Obstructions of the inlet
- Alarms on the screen of the BAM
- Abnormalities in the BAM downloads:
  - Ensuring that there are no gaps in the data
  - Investigating repetitive patterns of numbers (especially repeating -5's)
  - Ensuring that the filter relative humidity is different than the ambient relative humidity if above 45% (Contact ECB and the RCO Particulate Matter Lead if this is the case. A new smart heater might be needed immediately)
  - Corresponding alarm flags are investigated and corrective action taken when needed

## **10.3 Regional Office Quality Assurance**

The Field Operator and RAMC are responsible for reviewing all Envista 1022 data and logbooks prior to submitting the data to RCO. The specific QA duties for the regional offices are described in the following sections.

### **10.3.1 BAM Download Review**

The Field Operator and RAMC are responsible for reviewing the 1022 download data, alarms, and settings to ensure that there are no abnormalities, similar to those described in Section 10.2:

- Ensuring that there are no gaps in the data



- Ensuring that repetitive patterns of numbers (especially repeating -5's) have been addressed
- Verifying that the filter relative humidity is not greater than 35% (Contact ECB and the RCO Particulate Matter Lead if the relative humidity is greater than 35%. A new smart heater might be needed immediately.)
- Checking the ambient temperature data (no abnormal trends, repeating values)
- Corresponding alarm flags are investigated and corrective action taken when needed
- Concentration values of 995 match alarms and void codes

### **10.3.2 Electronic Logbook Review**

The e-logs are an additive yearly scrolling document. The Field Operator and RAMC must review the e-log for each site on a monthly basis. E-log reviews are recommended, but not required, to be conducted every 15 days to ensure the operators and the monitors are meeting the necessary requirements.

1. The staff must review all e-logs for completeness, verifications, audits, calibrations, and monitor problems. Specifically, the RAMC must verify that:
  - There is a monthly and mid-month verification (or audit) for each calendar month.
  - All devices used were within certification dates.
  - Audit devices were different from the monthly verification devices.
  - %A and %AD are within the limits.
  - All leak checks passed.
  - All monitor issues and missing data are clearly documented in the comments.
  - VSCC, monthly, and quarterly maintenance items were completed.
  - There is downloaded data (alarms, data, and settings) for all collected data.
2. The RAMC and the operator should discuss any discrepancies, errors, concerns or questions before the e-log is submitted to RCO.
3. The RAMC must sign and date each e-log record before submission to the RCO. There are RAMC review spaces on the "Maintenance", "Calibration", "Site Visit", and "Verification Audit" pages. The RAMC should only make corrections in the comments section of the e-log to preserve the initial documentation of the operator.
4. The RAMC must bring any problem or suspect problem that affects the validity of the data to the attention of the RCO particulate matter lead by e-mail or telephone within 5 business days of discovery. It is recommended that the RAMC alert the RCO particulate lead as soon as possible to discuss corrective actions.

5. After e-log approval, the RAMC must post the reviewed e-logs at P:\Ambient\Incoming\RegOffices.NC\ (your region) within fifteen days from the start of each month.

## 10.4 Monthly Envista Data Validation

Below are the steps for reviewing and validating the 1022 Envista data:

1. Open Envista ARM and select the <Reports> tab. Click on <Station>. A box like the one below will appear.

The screenshot shows the 'Station Report' dialog box. On the left, under the 'Primary' tab, there are dropdown menus for Purpose (set to 'All'), Region (set to 'All'), City (set to 'All'), and Organization (set to 'All'). Below these is a 'Station' section with a checkbox for 'All Stations' and a dropdown for 'BDED'. Further down are checkboxes for 'All' (checked) and 'On Monitors'. A list of monitors is shown with 'PM25' selected. On the right, the 'Output' section has radio buttons for 'Tabular', 'Graph', and 'Excel' (selected). The 'Duration' section has radio buttons for 'Daily', 'Weekly', 'Monthly' (selected), and 'Period'. The 'Date And Time' section has dropdowns for 'Start Date' (7/1/2018), 'Start Time' (00:00), 'Stop Date' (7/31/2018), and 'Stop Time' (23:00). Below this is a 'Type' section with tabs for 'Criteria', 'Status', and 'Add Features'. Under 'Criteria', there are settings for 'Average Type' (AVG), 'From Time Base' (1 Hour), 'Time Base' (1 Hour), and checkboxes for 'Partial', 'Use Raw', 'Accumulate', 'Round Data', 'Summary Only', and 'Seperate Monitors'. At the bottom right is a 'Display Monitor Unit As' dropdown set to 'Default Units'. At the very bottom are 'OK' and 'Cancel' buttons.

**Figure 72. Station Report Screen.**

2. Select the correct monitoring station, parameter, monthly date range and time base (1 hour).  
Select the output as <Excel> and click on <OK>.
3. The system should then promulgate an Excel sheet with the corresponding monthly data.  
Using this spreadsheet, take note of the highest and lowest data point for the month and when it occurred. This can be found in the monthly summary at the end of the report.
4. Highlight all 1022 values that are less than -5. Save this spreadsheet for the next step.
5. Open Envista ARM and select the <Edit> tab. Click on <Station>. A box like the one below will appear.

The screenshot shows a software window titled "Edit Table - BDED Edit Level: Final". It contains several configuration options for data retrieval. On the left, there are dropdown menus for "Purpose", "Region", "City", "Organization", and "Station", all set to "All". Below these are checkboxes for "All" and "On Monitors", and a list box with "PM25" selected. On the right, the "Output" section has "Tabular" selected. The "Duration" section has "Monthly" selected. The "Date And Time" section shows a date range from "7/1/2018" to "7/31/2018" with a time range from "00:00" to "23:00". The "Type" section has "View Style" set to "Standard", "Time Base" set to "1 Hour", and "Use EPA Statuses" checked. At the bottom are "OK" and "Cancel" buttons.

**Figure 73. Edit Table Screen.**

6. The system should then promulgate a monthly tabular report sheet with the corresponding monthly data.
7. Using the saved spreadsheet, locate all values that are less than -5. Select the value and right click. Click on <Enter/Change Explanation/Comment>. The following screen should appear.

**Figure 74. Comment Screen.**

8. Using the dropdown menu, select the flag “MD – Value less than MDL” for all values from -6 to -10  $\mu\text{g}/\text{m}^3$ . For all values less than -10, void by using the null code “BR – Sample Below Acceptable Range”. Click on <Add/Change>.
9. Using the saved spreadsheet, locate all values that are outliers, meaning four to five times greater than the other readings surrounding it. Select the value and right click. Click on <Enter/Change Explanation/Comment>.
10. If the outlier has been investigated and no unusual cause has been found for the reading, using the dropdown menu, select the flag “5 – Outlier” and then check “V – Validated value”. Click on <Add/Change>.
11. Verify the 1022 Envista data with the 1022 download data.
  - a. Pick three random days in the month and select the highest concentrations for review.
  - b. Open the 1022 data download for the corresponding days and verify that the 1022 download concentration is within 1  $\mu\text{g}/\text{m}^3$  of the concentration in the 1022 Envista data.
  - c. If the values are not within 1  $\mu\text{g}/\text{m}^3$ , alert the RAMC and RCO particulate matter lead. In the event that the concentrations are not within the desired range, the 1022 downloaded data should be used in place of the 1022 Envista data.
12. Go through the data report and add the null data codes (Appendix A) for all documented site activity. This includes audits, verifications, maintenance, site visits, power outages, etc. Each hour must have either a valid data point or a null data code.

13. Confirm these void hours in the report with the verification, audit and maintenance events recorded in the 1022 E-log. Save your changes.
14. Once finished, select <Validation settings> from the Edit tab.
15. Select the monitoring site and parameters you wish to validate.
16. Select the appropriate data and time range. Click on <Add>. Your approval has been recorded and time/date stamped.

## 11.0 TROUBLESHOOTING AND CORRECTIVE ACTIONS

The following list contains information on some of the more common problems that may be encountered, and some steps to identify and remedy the problems. If the solution cannot be found in the following points, then contact ECB or the RCO Particulate Chemist.

### 11.1 Basic Problems and their Causes/Solutions

#### *The monitor won't start a measurement cycle.*

- The monitor will not start a measurement cycle if it detects a hardware failure, such as low beta count signal, nozzle failure, pressure sensor failure, or pump failure.
- The mass monitor will not start a cycle if the ambient temperature sensor is not connected.
- The monitor will not start a cycle if the filter tape is not installed correctly.
- The monitor will usually display an error message on the display if it cannot start a cycle.
- If the monitor is left in a SETUP or FIELD CALIBRATION screen, it should still try to start a cycle after several minutes of inactivity, unless a failure is detected.

#### *The monitor records frequent "Tape Advance" errors.*

- This usually indicates that the filter tape is automatically advancing in response to being clogged due to heavy particulate loading.
- If frequent tape advance errors are encountered, try setting the TAPE ADVANCE setting to a higher value. When hourly PM readings repeatedly exceed 100  $\mu\text{g}/\text{m}^3$  more frequent tape advance intervals may be required.

#### *The concentration indicates negative values.*

- It is possible for the monitor to occasionally record negative hourly values if the actual particulate concentration is very low, such as below 3  $\mu\text{g}/\text{m}^3$ . This is because the mass monitor has an hourly random noise band of several micrograms.
- If the mass monitor is reading large, negative numbers hour after hour, it is probably punching holes in the filter tape. These holes can be very small and hard to see. This is almost always caused by debris on the nozzle or vane. Clean the parts.
- The real-time averages of the mass monitor are considerably noisier than the hourly measurements. These noise spikes may indicate negative concentrations unless the true concentrations are high.

- The noise performance of the mass monitor may be audited. Met One Instruments supplies the BX-302 zero filter kit for auditing the zero readings of the mass monitor.

***The airflow won't regulate at the correct rate of 16.7 LPM.***

- This usually indicates that the air pump is losing vacuum capacity due to wear.
- Check for leaks at the nozzle. This will often cause the inlet flow to be low even though the flow sensor is measuring the correct flow rate. This is because the flow sensor is downstream of the filter tape and nozzle. Clean the nozzle and vane.
- Perform a flow calibration. If the flow regulates at the lower calibration point, but not the higher point, the pump is probably worn out or there is a leak.
- The gray plastic pump mufflers used on the vacuum pump can clog up. Replace it if necessary.
- Check the inlet and PM heads for obstructions.

***The mass monitor has flow leaks, even after cleaning the nozzle and vane.***

- The nozzle may be sticking. Verify that the nozzle up/down motion is smooth and complete. If the nozzle is sticky or gritty, it will not seal properly.
- Check the O-rings on the sharp-cut cyclone (if used). These frequently leak.
- Check for bad O-rings on the inlet receiver.
- Check all of the push-in air fittings inside the mass monitor.

***The mass monitor will not pass the span membrane test.***

- This often just indicates the membrane foil surface is dirty or damaged. It can be cleaned with distilled water. Damaged membranes must be replaced.
- If the membrane is in good condition, but the mass monitor fails span tests, then the most common problem is debris on the beta detector window. Carefully blow through the vane with canned dusting air to blow debris off of the detector window and try again.
- If the detector is clean and the membrane is in good condition, then failed span tests can indicate that the detector is wearing out. Contact ECB.

## 11.2 Alarms

In the event a measured parameter or sequence is not within design specification, the BAM 1022 will generate an alarm. These alarms can be monitored via the alarm log, output files or the alarm relay. A list of alarms is detailed below.

*Note:* An alarm is indicated and logged at the time it occurs. The resolution time is not recorded.

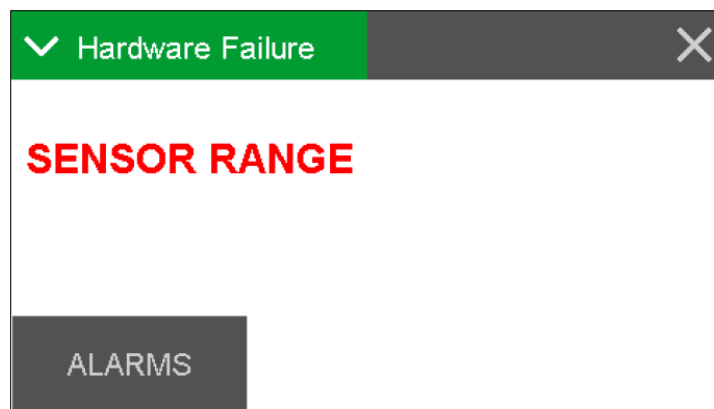
| Code | Description          | Cause  |
|------|----------------------|--|
| 1    | Tape Break           | No tape movement was detected during the tape move process.  |
| 2    | Beta Detector        | The event occurs when the Beta detector count rate is less than 500 Hz during the sampling cycle.  |
| 4    | Sensor Range         | The event occurs when an analog sensor reading (AT, RH, BP, UPPER, LOWER, FT, FRH) is outside the designated limits.   |
| 8    | Tape Advance         | The event occurs when the pressure drop across the tape exceeded the Tape Advance Pressure setting.  |
| 16   | Flow Failure         | The event occurs when the sample flow is less than 1.0 SLPM for greater than 1 minute.<br>The event occurs when the sample flow is +/-10% out of regulation for 1 minute.<br>The event occurs when the sample flow is +/-5% out of regulation for 5 minutes. |
| 32   | Nozzle Failure       | The event occurs when the nozzle failed to move and stop at the up or down position.<br>The event will also will occur when the foil device is still inserted at start of operation.   |
| 64   | Digital Link Failure | The event occurs when communication with the 597 sensor has ceased for greater than 10-seconds.  |
| 128  | Power Failure        | The event occurs for a power cycle or a micro-processor reset.   |
| 256  | Short Sample         | The event occurs when the first sample cycle is less than 1-hour.  |
| 512  | Maintenance          | The event occurs when the user stops normal operation.   |

**Figure 75. Alarm Codes and Causes.**

## 11.3 Hardware Failure Screen

This screen is presented to the user when a hardware failure occurs with the type of alarm (Tape Break, Sensor Range, Flow Failure, Nozzle Failure, Digital Link Failure) indicated in red text. Pressing the grey ALARMS button will present the View Alarms screen.





**Figure 76. Failure Screen.**

#### 11.4 Sensor Out of Range Event

The sensor outside range alarm event occurs when one of the sensors listed in the table below is reading outside of its designated limit. Each sensor, along with its limits, is shown in the following table.

*Note:* Stop column indicates whether or not the error will cause the BAM 1022 to stop sampling.

| Sensor | Minimum | Maximum | Stop |
|--------|---------|---------|------|
| AT     | -50     | 70      | Yes  |
| RH     | 0       | 100     | No   |
| BP     | 375     | 825     | Yes  |
| UPPER  | 228     | 818     | Yes  |
| LOWER  | 228     | 818     | Yes  |
| FT     | -40     | 60      | Yes  |
| FRH    | 0       | 98.9    | No   |
| BOX    | -40     | 60      | No   |
| BETA   | 500     | 20000   | Yes  |

**Figure 77. Range Limits.**

## **12.0 REVISION HISTORY**

None noted.

## **13.0 REFERENCES**

Met One Instruments, Inc., (2012) BAM 1022 Particulate Monitor Operation Manual. Prepared by Met One Instruments, Inc., Grants Pass, OR

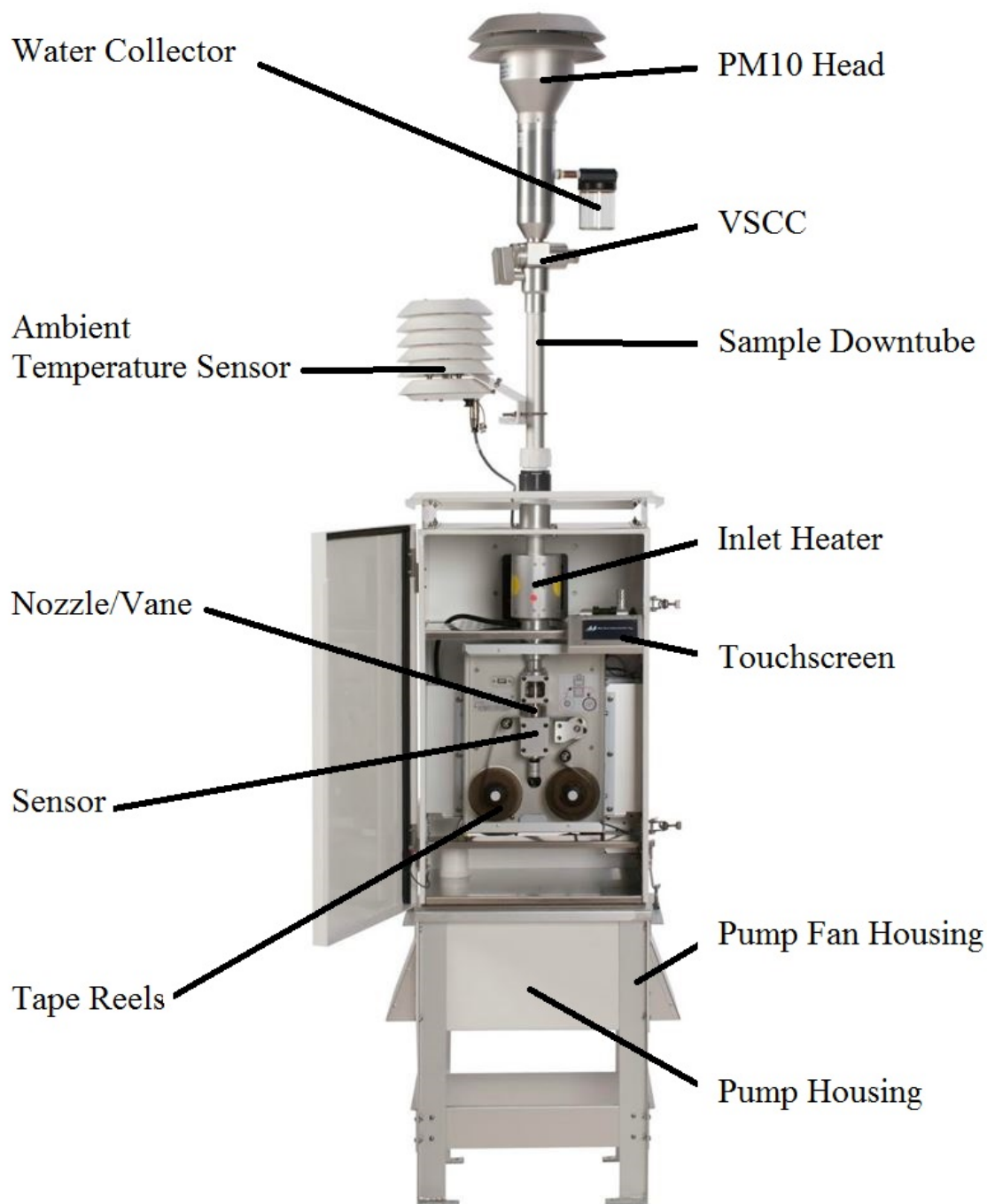
United States Code of Federal Regulations, (2006) Title 40 Part 50 Appendix L, Reference Method for the Determination of Fine Particulate Matter as PM<sub>2.5</sub> in the Atmosphere. Prepared by the US Government Publishing Office

United States Code of Federal Regulations, (2013) Title 40 Part 50 Appendix N, Interpretation of the National Ambient Air Quality Standards for PM<sub>2.5</sub>. Prepared by the US Government Publishing Office

United States Code of Federal Regulations, (2013) Title 40 Part 58 Appendix E, Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring. Prepared by the US Government Publishing Office

## Appendix A: Diagram of BAM 1022 System

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**Figure 78. BAM Unit Diagram.**

## Appendix B: Advanced Leak Checks

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If the basic leak check persistently fails, and the location of the leak cannot be identified, the following procedures will help isolate the problem.

**Required Tools:** Leak Check Valve (Met One Instruments Part No. BX-305 or BX-302) and Nozzle Seal Tool (Part No. 7440)

### Lower System Leak Test

Use this procedure to identify leaks between the vane and flow sensor.

1. Assuming that the monitor is sampling, press the three horizontal lines (≡) in the top left corner. Press “Operate” and then select “Stop Sample”. A message of “**Warning! Stop Current Sample?**” should appear. Press the grey <STOP> button to cease sampling.
2. Press the three horizontal lines (≡) in the top left corner. Select “Test” and then “Leak Test”.
3. Remove the PM10 head from the sampling tube.
4. Install a leak check adapter onto the inlet of the Very Sharp Cut Cyclone (VSCC). *Note: the Tetra Cal flow audit adapter may be used for leak checks as well.*
5. Turn the valve to the OFF position to prevent any air from entering the inlet tube.
6. If the nozzle is down, press the grey <NOZZLE> button to raise the nozzle and remove the tape.
7. Insert the Nozzle Seal Tool without the hole between the nozzle and vane. Note the proper alignment in the photo below (Figure 67).
8. Press the grey <NOZZLE> button to lower the nozzle.
9. Press the grey <PUMP ON> button. You should hear the pump engage.
10. Monitor the flow rate on the BAM 1022 display. If the flow rate falls below 0.2 LPM, the leak is not in the lower system. Turn off the pump and proceed to the upper system leak check.



**Figure 79. Leak Isolation Shim Position for Lower System Leak Test.**

11. If the flow rate does not fall below 0.2 LPM, there is a leak located in the tubing or fittings between the vane and flow sensor.
12. If the source of the leak cannot be identified, contact ECB or the RCO particulate matter lead immediately.

A leak can be further isolated by using the part of the seal without the hole. This allows a leak test to be performed only on the system below the filter tape junction. The leak test procedure using the rubber seal is as follows:

### **Upper System Leak Test**

A leak can be further isolated by using the part of the seal with the hole. This allows a leak test to be performed only on the system above the filter tape junction. **The lower system leak test above should be performed first.** The leak test procedure using the rubber seal with the hole is as follows:

1. Insert the Nozzle Seal Tool with the hole between the nozzle and vane. Note the proper alignment in the photo below (Figure B2).
2. Press the grey <NOZZLE> button to lower the nozzle.
3. Press the grey <PUMP ON> button. You should hear the pump engage.



**Figure 80. Leak Isolation Shim Position for Upper System Leak Test.**

3. Monitor the flow rate on the BAM 1022 display. If the flow rate falls below 1.0 LPM, the leak check is successful. Turn off the pump.
6. If the flow rate does not fall below 1.0 LPM (and the lower system leak test in the section above was successful), there is a leak located above the nozzle. Inspect/replace the “O” rings in the VSCC, inspect the inlet tube connection and perform the test again. If the source of the leak cannot be identified, contact ECB or the RCO particulate matter lead immediately.

## Appendix C: EPA Memo Regarding Zero Tests

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**October 5, 2012**

**To:** Met One BAM Users

**From:** Tim Hanley, U.S. EPA, OAQPS

**RE:** Zero Tests on the Met One BAM 1020

### **Introduction:**

Over the last few months a number of monitoring agencies have shared their Met One BAM zero test data with me (IN, MD, NC, NH, Albuquerque NM, BAAQMD, Cherokee, Hamilton County OH). I have been reviewing these data and have identified a relationship between ambient dew point and the zero test results of the Met One BAM at most, but not all sites.

The relationship is such that when dew point goes down (as we expect coming off the summer into fall; at least in the East and Mid-West), the BAM zero test data goes up. The magnitude of the BAM 1020 zero response is somewhat variable; however, data indicate that a 5 to 10 C drop in dew point corresponds to a 1 to 3  $\mu\text{g}/\text{m}^3$  increase in the mass concentration. While we still learning the specifics of how this is happening, this issue can potentially be explained due to the changes in moisture affecting the tape during zero tests, which would also affect the tape during normal operation. We are evaluating this issue and are also working with Met One on possible ways to use the information we have to improve use of the zero tests.

While we intend to investigate this further, we are sending this note to Met One BAM users now since many areas of the country are in the middle of a seasonal change in dew point and our recommendations may be of use to a number of those monitoring agencies.

### **Recommendations:**

1. **Perform Zero test.** For those locations with seasonal changes in ambient dew point and especially for those locations impacted by high summer dew points (e.g., where the ambient dew point may be expected to be within several degrees centigrade of the stations internal temperature) we are recommending a zero test be performed and if appropriate a new zero set-point entered in the BAM 1020. For many locations early fall may be an appropriate time to perform a zero test to represent the expected dew points over the coming months. In late Spring, if there are seasonal changes to dew point for your network, it may be necessary to run another set of zero tests for your sites to ensure the zero is representative of conditions at your

sites for that time of year. As a reminder, please follow Met One's instructions for performing a zero test. There are three key things to keep in mind in performing a successful zero test:

- a. Ensure a stable response of the zero concentration. Met One has a spreadsheet on their web site to test this. ([http://www.metone.com/bam\\_user.php](http://www.metone.com/bam_user.php)).
  - b. Per instructions in the BAM 1020 Manual (BAM-1020-9800, Revision G) page 57. The zero test "should not be performed during a period of rapidly changing weather".
  - c. Ensure that the background level (labeled as BKGD under the SETUP>CALIBRATE menu) entered in the Met One BAM is the negative of the average from the valid 72-hour test. For example, an average from the sample period of -2.0 µg/m<sup>3</sup> is entered as 0.0020.
2. **Datalog Delta-T.** Per the Met One Presentation at the National Monitoring Conference in Denver this past May (<http://www.epa.gov/ttn/amtic/files/2012conference/1B02BAM.pdf>), page 9; set the Datalog Delta-T: to "YES". This will log the Delta-T (the increase in filter temperature of the BAM 1020 over ambient temperature) to Channel 5.
  3. **Log Met One BAM temperature and RH data to your data logger.** If the station data logger is capable of recording relative humidity, Delta T, and ambient temperature from the BAM 1020, configure the data logger to record these values. These data will enable your staff to track changes in dew point (which requires a calculation) and how they may affect the zero data at your site. If you are unable to log these data directly, include these data when retrieving the digital data from the instrument during maintenance.

### **Follow-Up:**

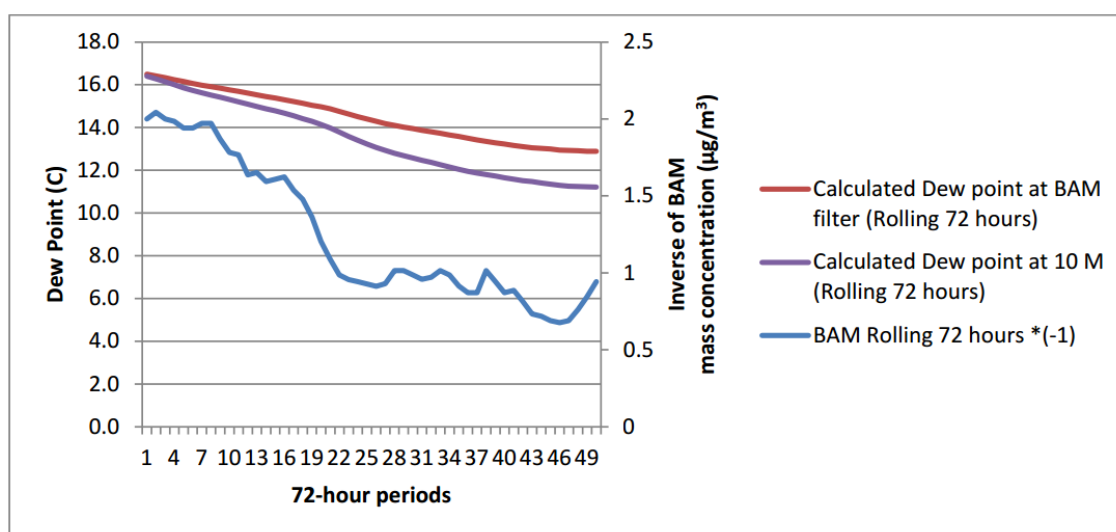
As mentioned above, I am sending this technical note now as a large portion of the country is transitioning from relatively higher to lower dew points. As you incorporate these changes, we are interested in hearing from you on your experiences and results of incorporating these more frequent zero tests. If you or your monitoring agency has information or results you think others may be interested in, please share that information with the applicable technical contact on monitoring from your EPA Regional Office. We may potentially refine these procedures at a later date, based on additional testing and/or what we learn from experiences in the field.

### **Additional Background:**

Here is some background on a recent extended zero test in RTP, NC:



In September, when we knew the RTP, NC area was to be impacted by the remnants of a tropical storm, a zero test was performed on our Met One BAM 1020 over five days (a total of 121 hours). I have 3 A calculation for dew point: TD = temperature of the dew point in degrees C; f = relative humidity in percent; and T = the ambient temperature in degrees C. October 5, 2012 3 plotted results of that test by taking 72 hour averages of available dew points and the inverse of the 72 hour BAM zero data. This results in 49 rolling 72 hour periods. As you can see from the figure below, as the area went from relatively higher dew points at the beginning of the test to lower dew points at the end of the test there is a noticeable change in the response of the BAM zero data. Note, since these are 72 hour averages, there is a lag in the change from the impact of the warm moist air during the storm to the relatively drier period at the end of the test. So as you can see if we were to take the one of the first few 72 hour periods, the dew point would have been above 16C and the zero value about 2.0 µg/m<sup>3</sup>. If we had taken one the 72 hour periods from towards the end of the test the dew point would have been around 12C and the zero test data less than 1.0 µg/m<sup>3</sup>.



**Figure 81. Met One BAM zero data in RTP, NC from September 7th to 12th, 2012.**

<sup>1</sup>During both normal operation and zero tests, a beta count is taken over the first few minutes of an hourly sample (I0) and again at the end of the hourly sample (I3). In most cases the tape is relatively dry during the initial beta count. If there is a large amount of moisture moving through the tape during a sample; even if no condensation occurs as the smart heater is functioning correctly and keeping the filter relative humidity below 35% RH, the tape may still undergo a slight change in size due to the additional moisture. This change can result in a decrease in the final beta count, which will be subsequently be reported as a larger mass concentration for that hour. Again, this is the case when the ambient air has high dew points relative to a tape that is initially dry.

<sup>2</sup>For example, if the ambient dew point reaches 18C at a station with an interior temperature near the bottom of the 20 to 30 C station temperature criteria.

<sup>3</sup> A calculation for dew point: TD = temperature of the dew point in degrees C; f = relative humidity in percent; and T= the ambient temperature in degrees C.

$$T_D = \left( \frac{f}{100} \right)^{\frac{1}{5}} (112 + 0.9T) + 0.1T - 112$$

## Appendix D: Frequently Used BAM Data Validation Codes

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**Table 7. Frequently Used BAM Data Null Codes (Void Codes).**

| Code | Qualifier Description                |
|------|--------------------------------------|
| AA   | Sample Pressure out of Limits        |
| AB   | Technician Unavailable               |
| AC   | Construction/Repairs in Area         |
| AD   | Shelter Storm Damage                 |
| AE   | Shelter Temperature Outside Limits   |
| AF   | Scheduled but not Collected          |
| AG   | Sample Time out of Limits            |
| AH   | Sample Flow Rate or CV out of Limits |
| AI   | Insufficient Data (cannot calculate) |
| AJ   | Filter Damage                        |
| AK   | Filter Leak                          |
| AL   | Voided by Operator                   |
| AM   | Miscellaneous Void                   |
| AN   | Machine Malfunction                  |
| AO   | Bad Weather                          |
| AP   | Vandalism                            |
| AQ   | Collection Error                     |
| AR   | Lab Error                            |
| AS   | Poor Quality Assurance Results       |
| AT   | Calibration                          |
| AV   | Power Failure                        |
| AW   | Wildlife Damage                      |
| AX   | Precision Check                      |
| AZ   | Q C Audit                            |
| BA   | Maintenance/Routine Repairs          |
| BB   | Unable to Reach Site                 |
| BC   | Multi-point Calibration              |
| BE   | Building/Site Repair                 |
| BI   | Lost or damaged in transit           |
| BJ   | Operator Error                       |
| BK   | Site computer/data logger down       |
| BN   | Sample Value Exceeds Media Limit     |
| BR   | Below Acceptable Range               |
| SA   | Storm Approaching                    |
| SV   | Sample Volume out of limits          |

**Table 8. Frequently Used BAM Data Qualifier Codes (Flags).**

| Code | Qualifier Description                                 |
|------|---|
| 1    | Deviation from a CFR/Critical Criteria Requirement    |
| 2    | Operational Deviation                                 |
| 3    | Field Issue   |
| 4    | Lab Issue   |
| 5    | Outlier   |
| 6    | QAPP Issue  |
| CB   | Values have been Blank Corrected                      |
| CC   | Clean Canister Residue                                |
| CL   | Surrogate Recoveries Outside Control Limits           |
| FB   | Field Blank Value Above Acceptable Limit              |
| FX   | Filter Integrity Issue                                |
| HT   | Sample pick-up hold time exceeded                     |
| LB   | Lab blank value above acceptable limit                |
| MD   | Value less than MDL                                   |
| NS   | Influenced by nearby source                           |
| QP   | Pressure Sensor Questionable                          |
| QT   | Temperature Sensor Questionable                       |
| QX   | Does not meet QC criteria                             |
| SQ   | Values Between SQL and MDL                            |
| SS   | Value substituted from secondary monitor              |
| SX   | Does Not Meet Siting Criteria                         |
| TB   | Trip Blank Value Above Acceptable Limit               |
| TT   | Transport Temperature is Out of Specs.                |
| V    | Validated Value                                       |
| VB   | Value below normal; no reason to invalidate           |
| W    | Flow Rate Average out of Spec.                        |
| X    | Filter Temperature Difference or Average out of Spec. |
| Y    | Elapsed Sample Time out of Spec.                      |