

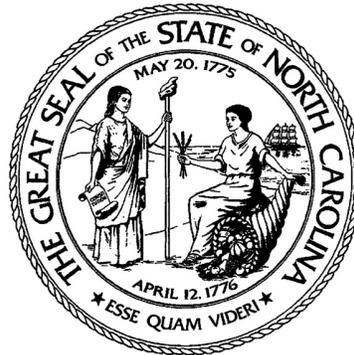
North Carolina Department of Environmental Quality Division of Air Quality

Standard Operating Procedure 2.37

Section 2:

Met One BAM 1020 Standard Procedures for Operators (Touch Screen and Touch Key Versions)

Revision 2020

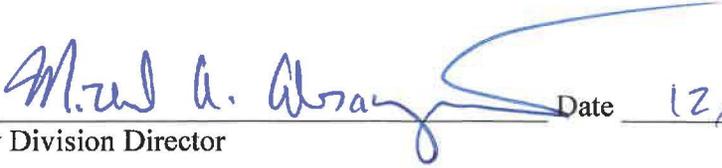


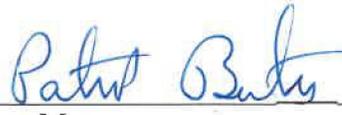
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Division of Air Quality
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1.0 SCOPE AND PURPOSE

The following document describes the operation and field technician responsibilities for the Met One Instruments Beta Attenuation Monitor (BAM) Model 1020. Depending on the setup, the BAM 1020 can automatically measure and record hourly airborne $PM_{2.5}$, PM_{10} and $PM_{2.5-10}$ concentrations 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 averages.

In order for the BAM 1020 to maintain FEM status, the instrument must be operated as detailed in the instruction manual and as outlined in the procedures provided in this standard operating procedure by a trained operator.

2.0 SAMPLER DESCRIPTION AND SETUP

2.1 Description of the Met One 1020 Monitor

The BAM 1020 can automatically measure and record airborne particulate matter (PM) concentrations in $\mu\text{g}/\text{m}^3$, at local or standard conditions of temperature and atmospheric pressure, using the principle of beta ray attenuation. A small, Carbon 14 (^{14}C) source emits a constant source of high-energy electrons known as beta particles, which are detected and counted by a sensitive scintillation detector. The degree of attenuation of the beta particles is used to determine the mass concentration of PM in the ambient air.

The BAM is configured to operate on 1-hour cycles. During this one-hour cycle, the unit makes two 8-minute beta measurements (one for the background or blank and one for the sample) and collects one 42-minute sample for a combined total of 58 minutes. The remaining 2-minutes of each hour are used for filter tape and nozzle movements. At a preset clock time (time 00 for this discussion), the BAM advances the filter tape forward one “window” (next unused spot) where the tape is positioned between beta source and the detector. The BAM begins counting beta particles for exactly 8-minutes. At the end of minute 08, the BAM stops counting the clean spot and advances the tape exactly four windows forward, positioning that same spot under the sampling nozzle. The nozzle is lowered into position, the pump turns on and the sample is collected for exactly 42-minutes at a flow rate of 16.67 LPM. At the end of minute 50, the pump stops, the nozzle is raised and the tape moves backwards exactly four windows. The spot that was just loaded with PM is now positioned between the beta source and the detector. The BAM begins counting beta particles for exactly 8-minutes. At the end of minute 58, the BAM stops counting and calculates the PM concentration. At the end of minute 60, the BAM records the concentration to memory, provides a corresponding analog output signal to the data logger and advances the filter tape to a fresh spot and the cycle begins over at minute 00.

During each 42-minute sampling period, the BAM automatically performs quality control checks of system performance. A span check is performed by automatically inserting a calibrated membrane between the source and the detector. The response is compared to the factory determined value. The BAM also checks for instrument drift caused by varying external parameters such as temperature, barometric pressure and relative humidity.

The small, ^{14}C element is a sealed source with a sufficiently low activity as to be below the Federal “Exempt Concentration Limit” and poses no health hazard. The source has a very long half-life (5000 + years) and should never need replacing.

Under no circumstances should anyone but factory technicians attempt to remove or access the beta source.

The sample inlet system is equipped with a PM₁₀ head which is used to remove the PM fraction that is equal to or larger than 10 micrometers in diameter and a PM_{2.5} very sharp cut cyclone (VSCC) which is used to further separate out PM larger than 2.5 micrometers in diameter. The BAM 1020 received the designation as a Federal Equivalent Method (FEM) for measuring PM_{2.5} in the ambient air from the EPA on March 12, 2008. The instrument may be operated in FEM or non-FEM depending on instrument settings. Consult the operators manual and this SOP to determine the appropriate settings for a given application.

2.2 Assembly

The BAM 1020 is US-EPA designated for PM₁₀, PM_{2.5} and PM_{10-2.5} under the following designation numbers:

- Designation Number: EQPM-0798-122 (PM₁₀)
- Designation Number: EQPM-0308-170 (PM_{2.5} with BGI/Mesa Labs VSCC™ or Tisch Cyclone)
- Designation Number: EQPM-0715-266 (PM_{2.5} with URG Cyclone)
- Designation Number: EQPM-0709-185 (PM_{10-2.5} with BGI/Mesa Labs Cyclones)

Details concerning USEPA designated configurations of the BAM 1020 may be found on the US-EPA website:

<https://www.epa.gov/amtic/air-monitoring-methods-criteria-pollutants>

Upon installation of the BAM-1020 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.

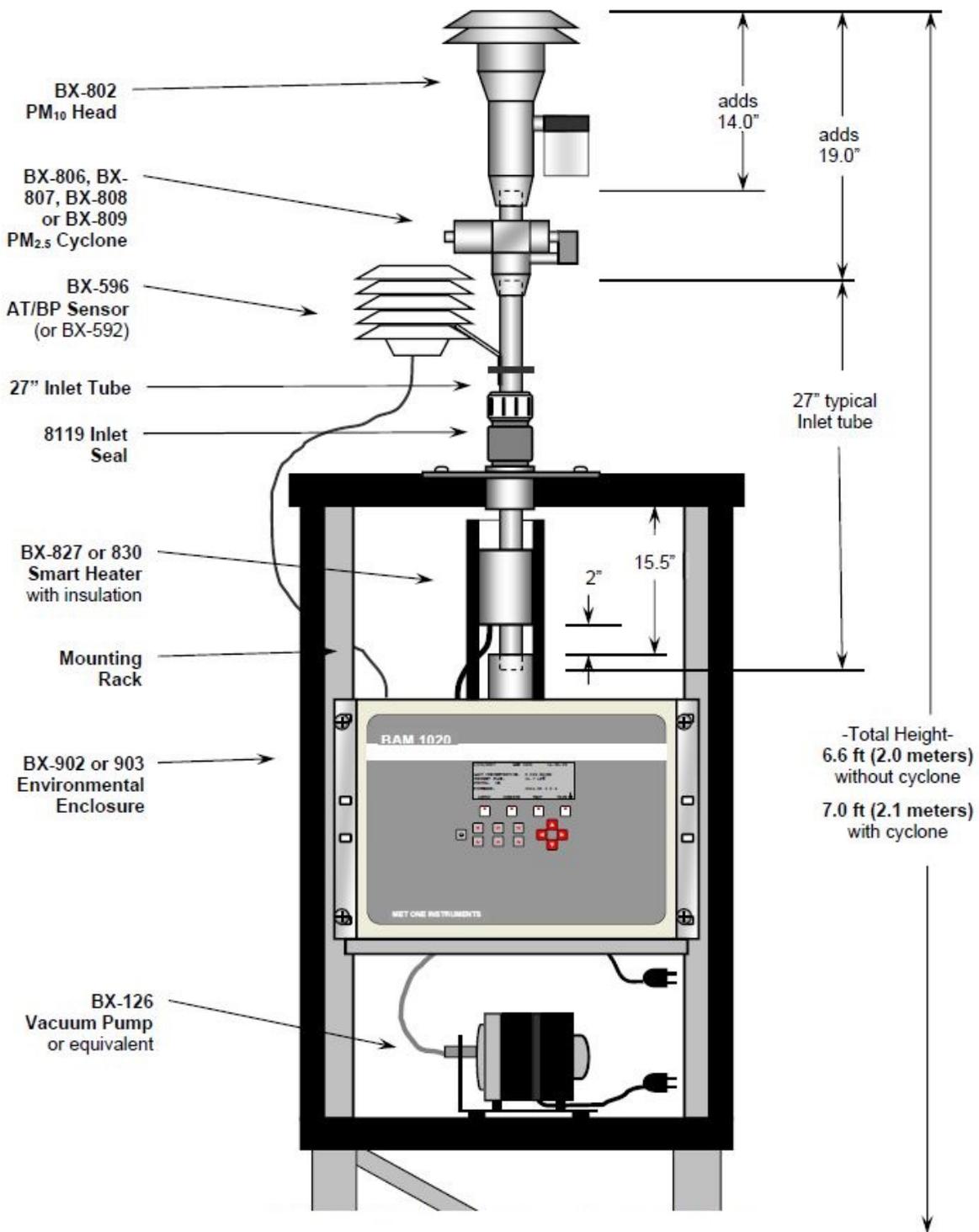


Figure 1. Typical BAM 1020 Installation Arrangement

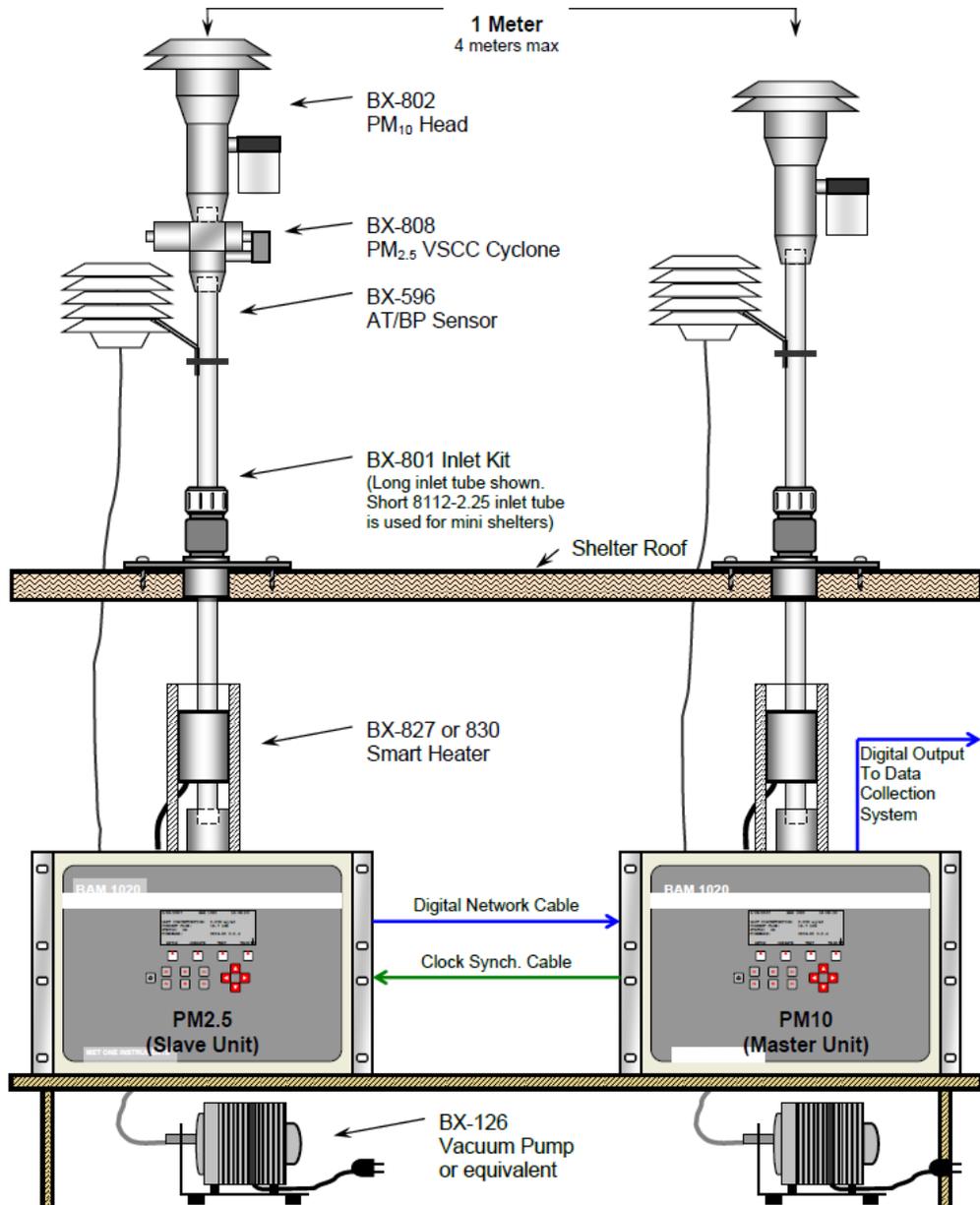


Figure 2. Typical BAM 1020 Coarse Installation Arrangement.

3.0 SUMMARY INFORMATION SPECIFIC TO THE INSTRUMENT

3.1 Safety Precautions

The Met One Instruments BAM 1020 contains a small ^{14}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 μCi). 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}C source nor the beta ray detector are serviceable in the field. Should these components require repair or replacement, the BAM 1020 must be returned to the factory for service and recalibration. The BAM 1020 is manufactured in compliance with the U.S. NRC safety criteria in 10 CFR 32.27.

If the BAM 1020 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 1020 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 1020 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 1020 may be damaged by static electricity.
- Do not operate the BAM 1020 in potentially explosive environments.
- The BAM 1020 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 1020 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.

3.3 Inferences and Limitations

3.3.1 Moisture

The Met One BAM-1020 is a mass analyzer, and therefore any component that is suspended on the filter tape and attenuates beta rays will subsequently affect the average mass value for that hour. Moisture in the ambient air can affect both monitor performance and hourly average mass values. A smart heater is essential for most BAM-1020 applications throughout the State of North Carolina.

3.3.2 The Smart Heater

The smart heater resembles a small aluminum can, rated at 200 Watts. The smart heater requires specific firmware, hard cards and other configurations to operate properly. Unlike heat tape, the smart heater is controlled using both %RH and temperature. These set points can be adjusted using the BAM-1020 firmware.

4.0 LOGBOOK SETUP, 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.

E-Log Spreadsheet	Description
Instructions	Setup of site information (Site Name, AQS ID, Site ID2). Provides a summary of operational evaluations and sampler maintenance for users.
Event Summary	Table for users to track dates of verifications, audits, and maintenance.
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, cleaning, 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 1020 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 1020 monitors.

5.0 MONITOR SETUP

5.1 User Interface (Touch Key)

The BAM 1020 uses either a touch key or touch screen display to control the features and functionality of the BAM.

5.1.1 Home Screen

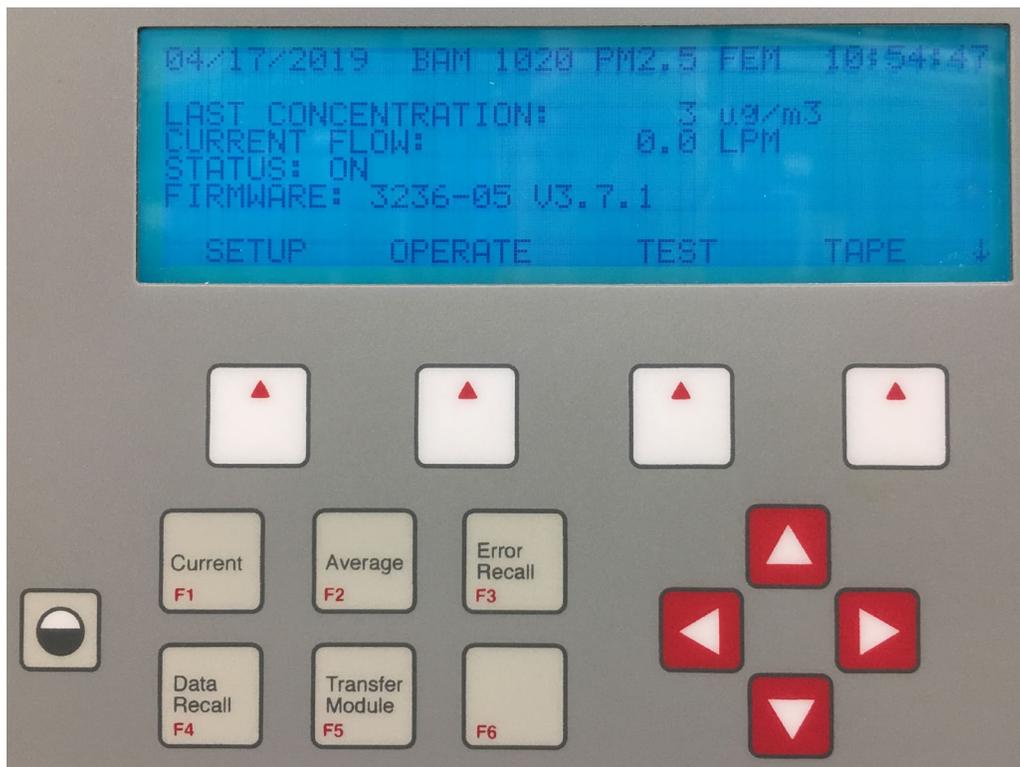


Figure 3. BAM 1020 Touch Key Main Menu and Keyboard.

Soft Keys: Directly beneath the display are four white buttons called “soft keys” or “hot keys”. These are keys where the function changes in response to a menu option displayed directly above each key on the bottom row of the display. Whatever menu option is displayed above one of these keys is the function which that key will perform in that particular menu. These are used throughout the entire menu system for a variety of functions. For example, modifications made within a menu are usually not saved unless a <SAVE> soft-key is pressed. <EXIT> is also another common soft-key function.

Arrow (Cursor) Keys: The four red arrow keys are used to scroll up, down, left, and right to navigate in the menu system, and to select items or change fields on the screen. The arrow keys are also often used to change parameters or increment/decrement values in the menu system.

Contrast Key: The key with a circular symbol on it is for adjusting the light/dark contrast on the LCD display. Press and hold the key until the desired contrast is achieved.

Function Keys F1 to F6: The function keys serve as shortcuts to commonly used menu screens. The F keys are only functional from the main menu screen, or for entering passwords. **The factory default password is F1, F2, F3, F4.**

F1 “Current”: This key is a shortcut to the OPERATE > INST screen, used to display instantaneous data values being measured by the BAM 1020.

F2 “Average”: This key is a shortcut to the OPERATE > AVERAGE screen, used to display the latest average of the data recorded by the BAM 1020.

F3 “Error Recall”: This key allows the user to view the errors logged by the BAM 1020. The errors are sorted by date. The last 12 days which contain error records are available, and the last 100 errors can be viewed.

F4 “Data Recall”: This key allows the user to view the data stored in the BAM 1020, including concentrations, flow, and all six external channels. The data is sorted by date, and the user can scroll through the data hour-by-hour using the soft-keys. Only the last 12 days which contain data records are available for viewing in this menu.

F5 “Transfer Module”: This key is used to copy the memory contents to an optional data transfer module. The transfer module option is obsolete and no longer used.

F6: This key is not assigned a data function.

5.1.2 Setup Menu



Figure 4. Setup Screen.

The BAM 1020 uses a comprehensive system of setup menus which contain all of the settings and parameters needed to perform the measurement and operation of the BAM 1020. Once set, most of the

values in the setup menus will not need to be changed. The setup values will not be lost if the BAM 1020 is unplugged or powered down.

WARNING: Some of the settings in the setup menus are unit-specific calibration constants which must not be changed, or the accuracy and proper operation of the BAM 1020 may be affected.

WARNING: Entering the setup menu system requires stopping the sample cycle. Older versions of firmware will not warn you before stopping the sample!

1. Press the <SETUP> soft-key to enter the menu as shown in figure 3. The setup menu provides a choice of operations. Use the arrow keys to navigate to the desired field, then press the <SELECT> soft-key to enter. A brief description of each sub-menu shown in the table below. Detailed information is provided in the following subsections.

Table 2. Setup Menu Definitions.

Menu	Settings
CLOCK	BAM 1020 real-time clock date and time settings.
SAMPLE	Range, Offset, Sample Time, Count Time, Conc Units, Avg Period, Unit ID, and RS-232 settings.
CALIBRATE	Factory Calibration Values, (C _v , Q ₀ , ABS, μsw, K, BKGD) Flow rate, Flow type, Conc Type.
EXTRA1	Low concentration clamp, e1 – e4, Rarely used.
ERRORS	Analog error selections, Flow limits, Pressure drop limit.
PASSWORD	Password change screen.
INTERFACE	Cycle Mode early/standard, alarm relay polarity.
SENSOR	Meteorological sensor scaling and configuration screens, Channels 1 – 6.
HEATER	RH set-point for Smart Heater.
QUERY	Configuration for the custom Query data output file, and the European Bayern-Hessen protocol.
REPORTS	Daily data report hours, BP and Reference Membrane logging options
HJ 653	Data format compliance with Chinese HJ 653-2013 standard

5.1.3 Date and Time Setup



Figure 5. Date and Time Setup Screen.

The date and time setup screen allows for the setting of the time and date. Time is a 24-hour clock only. Use the arrow keys to select and increment/decrement the desired field, then press the <SAVE> soft-key. The lithium battery backup keeps the clock running during power down. NCDAQ recommends a monthly check of the clock.

5.1.4 Sample Setup



Figure 6. Sample Setup Screen.

The sample setup screen is used to set the BAM 1020 sampling and averaging periods, and some other important settings. The fields can be edited with the arrow keys, then saved with the <SAVE> soft-key.

RS-232: This allows you to set the baud rate of the RS-232 serial port. The default setting is 9600 baud.

BAM SAMPLE: This value sets the number of minutes per sample hour that the pump is on. The BAM sample time must be set in response to the count time value, since current versions of the BAM 1020 allow the option of setting the count time to 4 or 8 minutes. **Note:** *If the BAM 1020 is used for PM2.5 FEM or PM10-2.5 (coarse) monitoring, the BAM sample must be set to 42 minutes with 8-*

minute count time. PM10 monitors are usually set for 50-minute sample time with 4-minute count time, but may be set for 42/8 if the installed firmware allows it.

INLET TYPE: This setting helps users identify whether the BAM 1020 is collecting TSP, PM10, or PM2.5 data. Whichever option is selected sets the corresponding label to be displayed at the top of the main menu screen. This setting is for providing indication on the display only and does not impact any of the actual data collection or reports.

STATION #: This is a station identification number. This number has a range of 001-254, and will be included in the data reports. The default value is 01.

MET SAMPLE: This value is the averaging period for the built-in met sensor data logger. It sets how often the data array is averaged and written to memory, and can be set to 1, 5, 15, or 60 minutes. For example, if an optional wind speed sensor is attached to the BAM 1020, the MET sample period could be set to 1 or 5 minutes. This value applies to all parameters and sensors attached to the BAM 1020, except for the dust concentration data which is always an hourly average regardless of this setting.

Warning: This setting will affect how long the memory will last before getting full!

There are **4369 records** available in the memory. The default MET sample period of 60 minutes (1 record per hour) will result in 182 days of memory capacity, but a 1-minute average period would fill up these memory records in only 3 days. When the memory gets full the BAM 1020 overwrites the oldest data. It is recommended that the MET SAMPLE period set at the default value of 60 minutes

Table 3. MET Data Capacity.

MET SAMPLE	Data Capacity
60 min	182 days
15 min	45 days
5 min	15 days
1 min	3 days

RANGE: The RANGE setting sets the full-scale range of the concentration measurement system of the analog voltage output. The RANGE value is usually kept at the default setting of 1.000 mg, with a default OFFSET (lower limit of the range) of -0.015 mg. This means that the BAM measures a

maximum full-scale range of $-0.015 \text{ mg} + 1.000 \text{ mg} = 0.985 \text{ mg}$ by default. **Note:** *Changing the range setting will affect past data already stored to memory. Always download any old data before changing settings, then clear the memory.*

OFFSET: The offset value is used to set the lower end of the BAM 1020 concentration range for both the analog output and internal digital ranges. The factory default value for OFFSET is -0.015 mg , which is the recommended setting. When set this way the BAM 1020 can report from -0.015 mg (0.0 V) to $.985 \text{ mg}$ (1.0 V). **Note:** *Changing the offset setting will affect past data already stored to memory. Always download any old data before changing settings, then clear the memory.*

CONC UNITS: This setting determines the concentration units which the BAM 1020 displays and stores in memory. This can be set to $\mu\text{g}/\text{m}^3$ (micrograms) or mg/m^3 (milligrams) per cubic meter. **Note:** $1.000 \text{ mg} = 1000 \mu\text{g}$.

COUNT TIME: This is the time the BAM 1020 takes to perform the I0 and I3 counts at the beginning and the end of the sample hour. *When used for PM2.5 FEM or PM10-2.5 (coarse) monitoring, the count time must be set to 8 minutes.* For PM10 measurement count time may be set to 4, 6 or 8 minutes. See the BAM sample setting description above. The BAM 1020 will prompt you to change the BAM sample time setting if you change the count time to an incompatible value.

5.1.5 Calibrate Setup



Figure 7. Calibrate Setup Screen.

The calibrate setup screen is where most of the factory-determined calibration parameters for the BAM 1020 are stored. These values are unit-specific, and can also be found on the calibration certificate for the BAM 1020. Most of these settings will never be changed without specific information from ECB. It is good practice to periodically audit the calibration values to verify that they have not been altered.

5.1.6 Password Setup



Figure 8. Password Setup Screen.

The password setup allows the user to change the password required to enter many of the test or setup menus. The password prevents users without the password from changing critical settings or calibrations on the BAM 1020. The password can be any 4-key combination of the six function keys, F1 to F6. **The default password is F1, F2, F3, F4.** ECB does not recommend changing the default password unless necessary. Contact ECB for instructions if the password is lost or forgotten.

5.2 User Interface (Touch Screen)

5.2.1 Home Screen

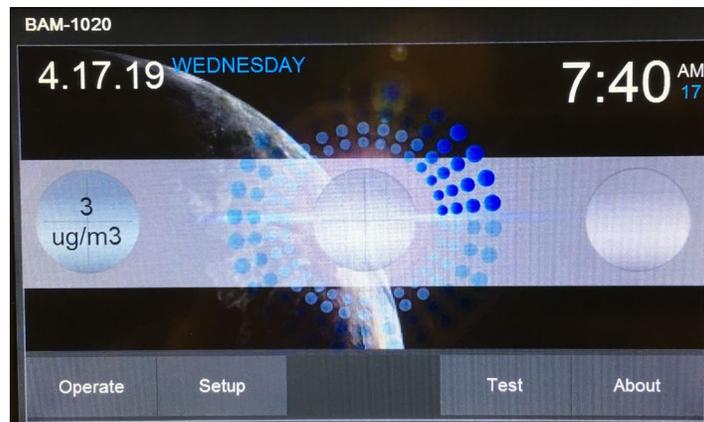


Figure 9. BAM 1020 Touch Home Screen.

5.2.2 Operational Menu

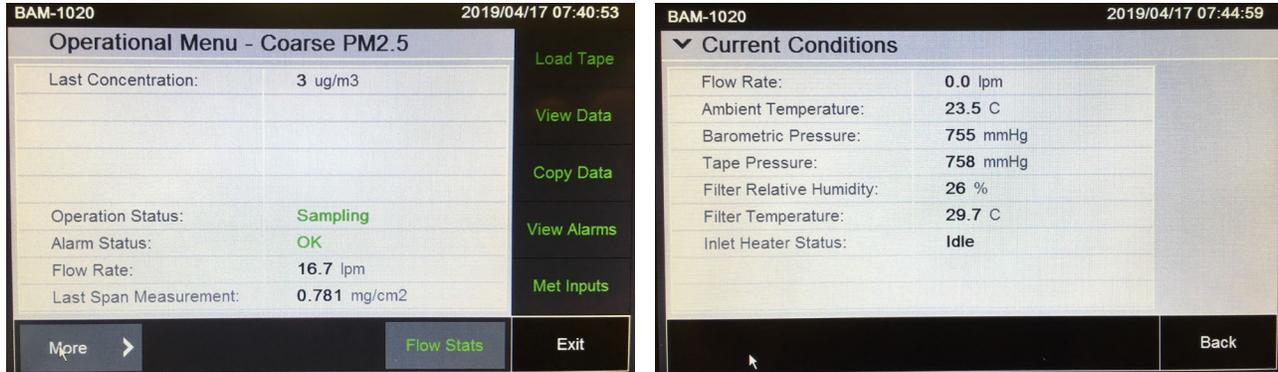


Figure 10. Operate Screen.

The <Operate> key can be pressed at any time during the sample cycle to enter the Operational Menu screen as seen above. This menu allows the user to view the current status of the measurement cycle and the alarm status, as well as the last hourly concentration, span, and flow values. The <More> button can be pressed to access the current operational conditions as shown. And really, who wouldn't want more. The green buttons on the right side allow access to the data log memory and additional met and flow values as described in the following sections. All of these menus can be accessed without interrupting the sample cycle, except for the Load Tape sub-menu.

5.2.2.1 Load Tape

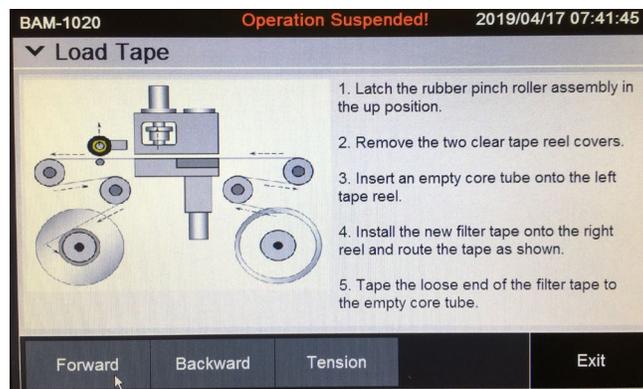


Figure 11. Load Tape Screen.

5.2.2.2 View Data and View Alarms

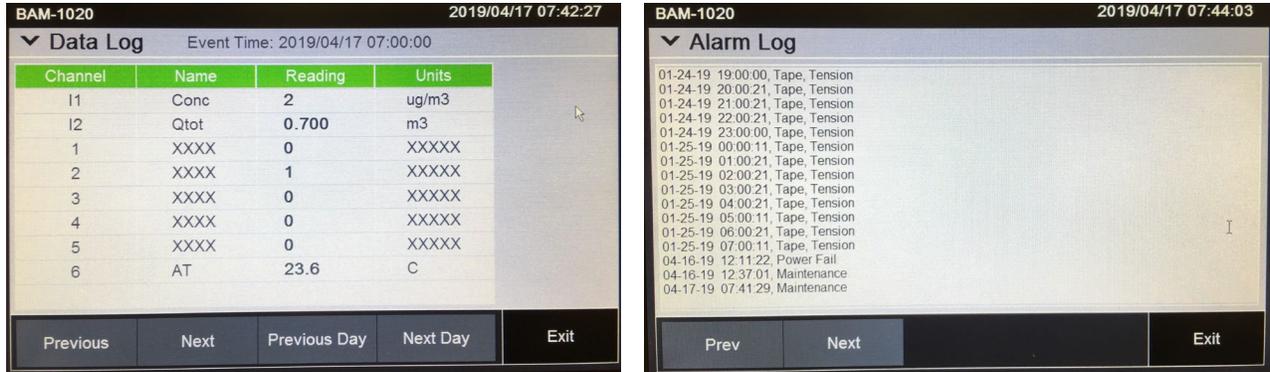


Figure 12. Data and Alarm Screens.

These screens allow the user to view previous BAM-1020 data and alarms in memory. The data is sorted by day and by hour. The Previous Day and Next Day buttons are used to select the day. The Previous and Next buttons select which hour of the day is viewed. Each hourly record contains the format shown below. Conc is the hourly concentration, and Qtot is the hourly flow sample volume. The six met sensor channels also appear even if some of the met channels are unused. The alarm screen shows the alarm events in date/time order. If numerous alarms are recorded, the <Next> and <Prev> buttons can be used to scroll through the pages.

5.2.2.3 Copy Data

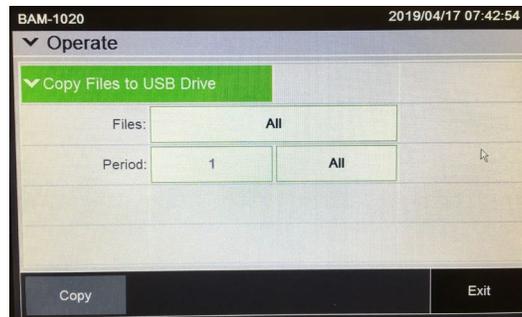


Figure 13. Copy Data Screen.

This screen is used to copy BAM-1020 data to a USB flash drive. **A USB drive must be inserted into the top USB port on the display module inside of the front door.** The screen allows the option of selecting All or Standard files. The Standard file set includes the data log, error log, and settings files only. The All file set includes the standard files, along with the flow statistics and 5-minute flow files. The Period setting fields can be set to Months or All. After the desired file set and period are selected, press the Copy button at the bottom of the screen to copy the data to the drive. A status screen will

appear during the transfer. Wait for the monitor to tell you that all files have been downloaded before proceeding.

5.2.2.4 Flow Statistics Screen

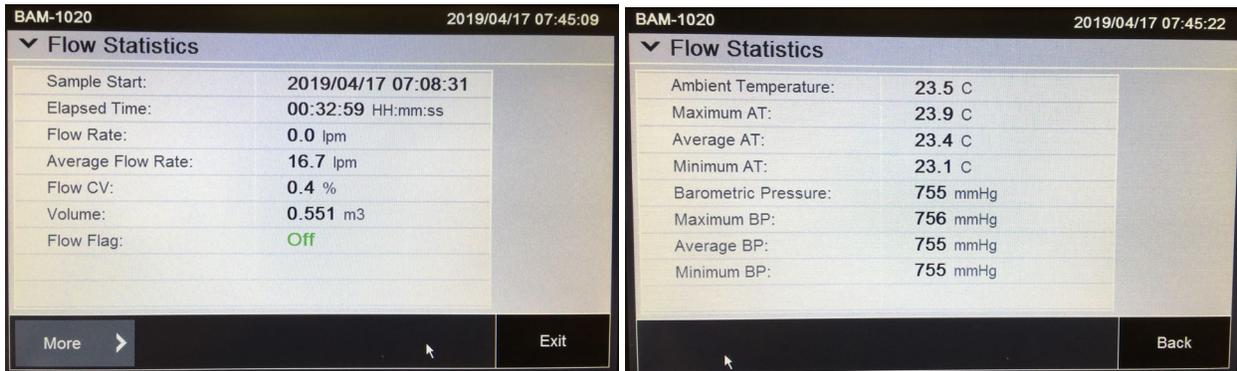


Figure 14. Flow Statistics Screens.

These screens can be accessed during the sample cycle, and displays the real-time flow statistics for the current measurement cycle. The <More> button can be pressed to view the current, min, max, and average temperature and pressure values.

5.2.3 Setup

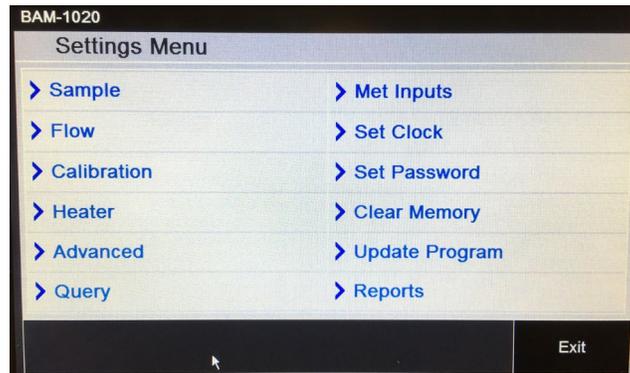


Figure 15. Setup Screen.

The BAM-1020 uses a comprehensive system of setup menus which contain all of the settings and parameters needed to perform the measurement and operation of the unit. Most of these settings are set at factory default values which will be correct for most applications. Some settings may be altered by the operator to suit the specific needs of your monitoring program. This section describes the settings menu in detail, and should be reviewed when the instrument is put into service to ensure desired operation. Once set, most of the values in the settings menus will not need to be changed by the site operator. The setup values will not be lost if the unit is unplugged or powered down.

WARNING: Some of the settings in the settings menus are unit-specific calibration constants which must not be changed, or the accuracy and proper operation of the unit may be affected. Entering the settings menu system requires stopping the sample cycle.

Press the <Settings> button on the main menu to enter the setup menu. The default password of **1234** is required. The Setup Menu provides a choice of operations. Press the blue text button of the desired sub-menu on the touch screen display.

5.2.3.1 Sample Setup Screen

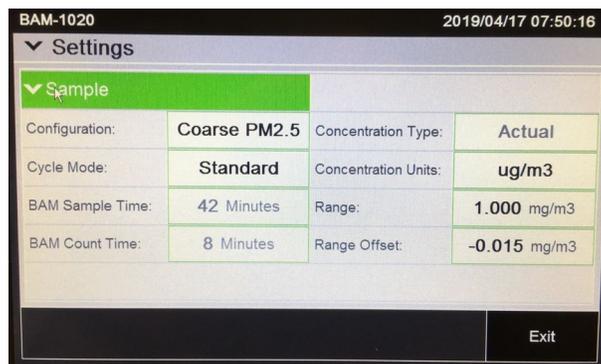


Figure 16. Sample Setup Screen.

This screen is used to set the BAM-1020 sample timing, range/offsets, and some other important settings. Review each of these settings carefully. The settings are edited by pressing the button showing the desired parameter. The value for that parameter is then edited by either selecting the desired setting from a pop-up pick-list, or by entering a new value with the pop-up numeric keypad. Press the <Save> button when finished.

Configuration: This single setting allows the user to quickly preset all of the required settings for EPA designated FEM monitoring by simply setting up the desired configuration type. This will automatically set the BAM sample time, count time, flow type, concentration type, and flow rate settings. The possible configuration values are listed below.

Table 4. Configuration Options.

Configuration	Description
PM2.5 FEM	Sets the required settings for PM2.5 FEM monitoring.
PM10 FEM	Sets the required settings for PM10 FEM monitoring.
COARSE PM2.5	Sets the unit as the PM2.5 slave unit in a coarse paired set.
COARSE PM10	Sets the unit as the PM10 master unit in a coarse paired set.
CUSTOM	Allows the user to set all sample settings manually.

Cycle Mode: The Cycle Mode can be set to Standard or Early. If you are not using the analog output voltage of the BAM-1020, leave this set to Standard. The Cycle Mode setting must be reviewed and understood if the analog output is being used.

BAM Sample Time: This value sets the amount of minutes per sample hour that the vacuum pump is on. The BAM Sample Time must be set in response to the Count Time value, since current versions of the BAM-1020 allow the option of setting the count time to 4 or 8 minutes. *If the unit is used for PM2.5 FEM or EU PM2.5 monitoring, the BAM Sample must be set to 42 minutes with 8-minute count time.* PM10 monitors are usually set for 50-minute sample time with 4-minute count time, but may be set for 42/8 if the firmware allows the count time to be set to 8 minutes.

BAM Count Time: This is the amount of time the unit takes to perform the I0 and I3 counts at the beginning and the end of the sample hour. *When used for PM2.5 FEM, EU PM2.5, or PM10-2.5 (coarse) monitoring, the COUNT TIME must be set to 8 minutes.* The unit will prompt you to change the BAM Sample time setting if you change the Count Time to an incompatible value.

Concentration Type: This sets the way that the concentration values are reported, and can be set to either Actual or Standard. *The Concentration Type must be set to Actual for all PM2.5 monitoring, and is almost always set to Standard for PM10 monitoring.* If set to Actual, then the concentration is calculated and reported based on the volume of the air at local ambient conditions. An ambient temperature sensor is required. If set to Standard, the concentration is calculated and reported based on the standard values for temperature and pressure (760 mmHg and usually 25C), even if a temperature sensor is available.

Concentration Units: This setting determines the concentration units which the BAM-1020 displays and stores in memory. This can be set to µg/m³ (micrograms) or mg/m³ (milligrams) per cubic meter. Older revisions of firmware were fixed at mg/m³ only, and this is still the default setting. **Note:** 1.000 mg = 1000 µg.

Range: The Range setting sets the full-scale range of the concentration measurement system, including the digital system and the analog voltage output. The Range value is rarely ever changed from the default setting of 1.000 mg, with a default Range Offset (lower limit of the range) of -0.015 mg.

High Concentrations: The Range setting may be set higher than 1.000 mg in high concentration areas. It is very unlikely that PM2.5 levels will exceed 1000 µg without first clogging the BAM filter tape, but some PM10 areas can see dust loading that exceeds 1000 µg without clogging the tape spot. *However, setting the Range to 5.000 or 10.000 mg reduces the digital resolution of the BAM-1020 in low concentrations, so don't use these two range settings unless necessary.*

Note: Changing the range setting will affect past data already stored to memory. Always download any old data before changing settings, then clear the memory.

Range Offset: The Range Offset value is used to set the lower end of the BAM-1020 measurement range, and is sometimes simply called the “offset”. It can be set to values of -0.015, -0.005, or 0.000 mg. The factory default value for Range Offset is -0.015 mg. This shifts the range of the BAM-1020 down slightly so that it can read from -0.015 to 0.985 mg (with the default range of 1.000 mg). This simply allows the unit to measure slightly negative concentration numbers near zero, which is necessary to differentiate between normal noise and a failure such as punctured filter tape.

Note: The Offset value is often misunderstood, and should not be confused with the BKGD (zero correction factor) value. Be sure you understand all three of these settings!

Note: Changing the offset setting will affect past data already stored to memory. Always download any old data before changing settings, then clear the memory.

5.2.3.2 Flow Setup

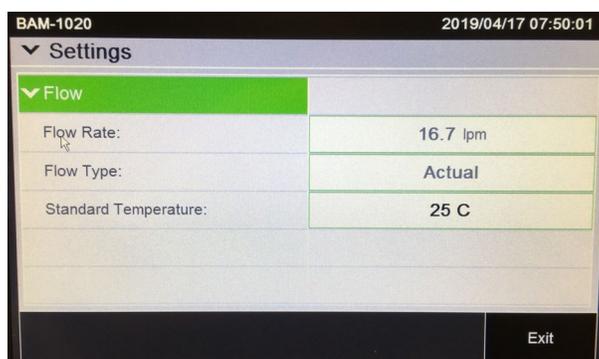


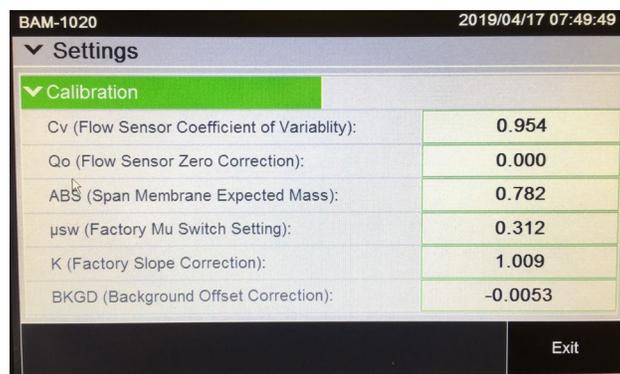
Figure 17. Flow Setup Screen.

Flow Rate: This sets the air flow rate for the BAM-1020, and the unit will continuously regulate the flow to this value during sampling. The Flow Rate is always set for **16.7 liters per minute**, as this is required for all PM2.5 and PM10 monitoring. The range of the setting is 10 to 20 L/min.

Flow Type: This setting selects the flow control scheme used by the BAM-1020. The options are Actual or Standard. This is an important parameter to understand. At sea level and moderate temperatures, the difference between actual and standard flow will be minimal, but at high elevations or varied temperatures, the flow rate can be greatly affected by this setting. *The Flow Type must be set to Actual on all PM2.5 and PM10-2.5 (coarse) units.* The flow is controlled based on actual, local ambient temperature and pressure conditions. Actual flow type is also recommended for all newer PM10 units with firmware revision 3.0 or later, since the separate Concentration Type setting can be set to Standard for standard PM10 reporting, even though the flow is controlled volumetrically. Actual flow requires an ambient temperature sensor. If the Flow Type is set to Standard on a unit with revision 3.0 or later firmware, the BAM-1020 will control the flow based on standard temperature and pressure values, even if a temperature sensor is connected.

Standard Temperature: This is the value of standard air temperature, used only for standard flow control or standard concentration calculations. In the U.S. the value of standard temperature is always 25 degrees C as mandated by the U.S. EPA.

5.2.3.3 Calibration Setup



The screenshot shows the 'Calibration' settings screen for the BAM-1020. The screen title is 'BAM-1020' and the date/time is '2019/04/17 07:49:49'. The 'Settings' menu is expanded to show 'Calibration'. The calibration parameters are listed in a table with their corresponding values.

Parameter	Value
Cv (Flow Sensor Coefficient of Variability):	0.954
Qo (Flow Sensor Zero Correction):	0.000
ABS (Span Membrane Expected Mass):	0.782
μsw (Factory Mu Switch Setting):	0.312
K (Factory Slope Correction):	1.009
BKGD (Background Offset Correction):	-0.0053

An 'Exit' button is located at the bottom right of the screen.

Figure 18. Calibration Setup Screen.

This screen is where the factory-determined calibration parameters for the BAM-1020 are stored. These values are unit-specific, and can also be found on the calibration certificate for the BAM-1020. Most of these settings will never be changed without specific information from ECB. It is good practice to periodically audit the calibration values to verify that they have not been altered.

Cv: This value is a factory-set scaling slope for the internal mass flow sensor. All units with flow controllers and ambient temperature sensors never need to have this value altered, because the flow calibrations are done in the Flow Calibrations Screen.

Qo: This value is the factory-set zero correction offset for the internal mass flow sensor, and is almost always simply zero.

ABS: The ABS value is the factory-set expected mass of the reference membrane foil used during the automatic hourly span check. Each unit's ABS value is different, but is typically near 0.800 mg/cm². **The ABS value is never changed by the operator unless the span membrane foil is replaced due to damage.**

μsw: This is called the Mu-switch value, and is the factory-set mass absorption coefficient used by the BAM-1020 in the concentration calculations. The value varies for different units, but is typically near 0.305.

Warning: This is a unit-specific calibration value which may significantly affect the accuracy of the unit. Never change this value without specific instruction from ECB.

K: The K-factor is the factory-set calibration slope correction (multiplier) for the BAM-1020 concentrations. The K-factor value is determined by dynamic testing of the BAM-1020 in the factory smoke chamber. This will always be a value between 0.9 to 1.1.

Warning: This is a unit-specific calibration value which may significantly affect the accuracy of the unit. Never change this value without specific instruction from ECB.

BKGD: The BKGD (background) value is the zero correction (offset) for the BAM-1020 concentrations. This is determined by running the unit for at least 72 hours with a zero filter on the inlet. The concentration values over this time are averaged, and the BKGD is the negative of this average. All of the stored and displayed data contains this offset correction.

5.2.3.4 Advanced Setup

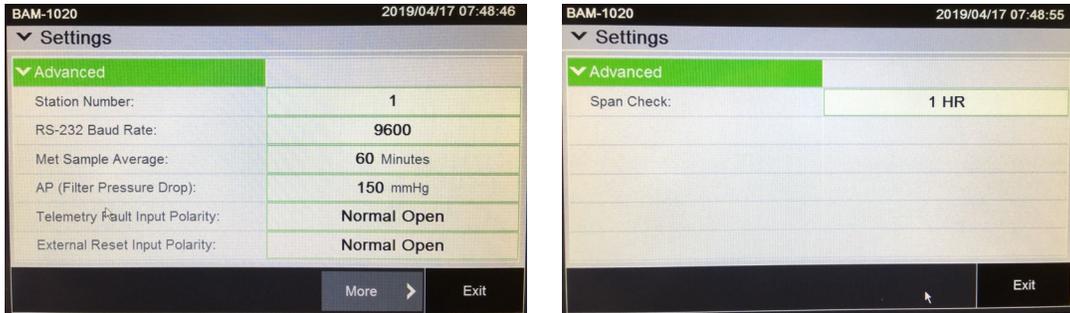


Figure 19. Advanced Setup Screens.

Met Sample Average: This value is the averaging period for the built-in met sensor data logger. It sets how often the data array is averaged and written to memory, and can be set to 1,5,15, or 60 minutes. For example, if an optional wind speed sensor is attached to the BAM, the Met Sample period could be set to 1 or 5 minutes. **Warning: This setting will affect how long the memory will last before getting full!** There are **4369 records** available in the BAM memory. The default Met Sample period of 60 minutes (1 record per hour) will result in 182 days' worth of memory capacity, but a 1 minute average period would fill up these memory records in only 3 days. When the memory gets full the unit over-writes the oldest data.

Table 5. Memory Capacity Settings.

MET SAMPLE	Data Capacity
60 min	182 days
15 min	45 days
5 min	15 days
1 min	3 days

Span Check: This setting determines how often the BAM-1020 performs the automatic span membrane check. If the value is set to 1HR, the BAM measures and displays the span each hour as normal. If this value is set to 24HR, then the BAM will only perform the span check once during the sample hour beginning at midnight, or during any sample hour following a power failure. The resulting value will be displayed throughout the rest of the day. If this value is set to Off, the span check will be disabled entirely.

5.2.3.5 Clock Setup

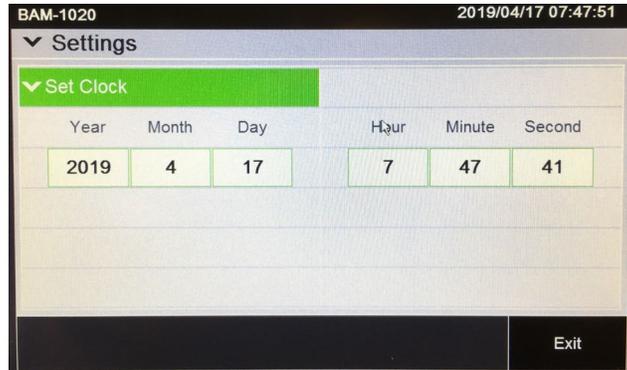


Figure 20. Clock Setup Screen.

This screen allows for the setting the time and date. Time is a 24-hour clock only. Set the clock by selecting one of the parameters, then entering a new value using the pop-up numeric keypad. Press the <Save> button when finished.

5.2.3.6 Password Setup

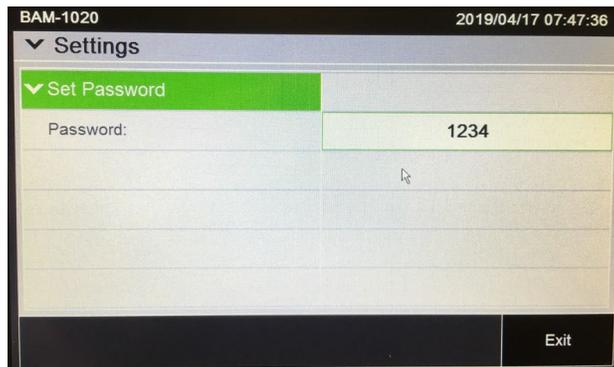


Figure 21. Password Setup Screen.

This screen allows the program administrator to change the password required to enter many of the Test or Settings menus. The password prevents untrained users from accidentally changing critical settings or calibrations on the unit. The password can be any four-digit numeric value. **The default password is always “1234”.** ECB does not recommend changing the default password unless necessary. Contact ECB for instructions if the password is lost or forgotten.

5.2.4 Test Menu

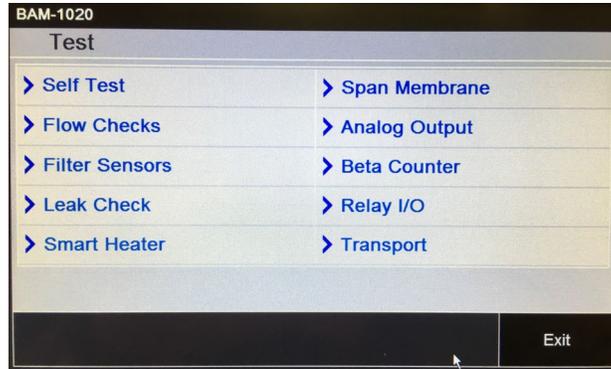


Figure 22. Test Screen.

The following sub-sections provide information for performing diagnostic checks on the BAM-1020 sub-systems using the test menus. Most of these tests are used for troubleshooting purposes only, and are not necessary on properly functioning units. The test menu system is accessed by the test button from the main menu. These screens are used to perform calibrations and audits of various sensors, as well as some advanced diagnostics to resolve failures and errors.

5.2.4.1 Self-Test Screen

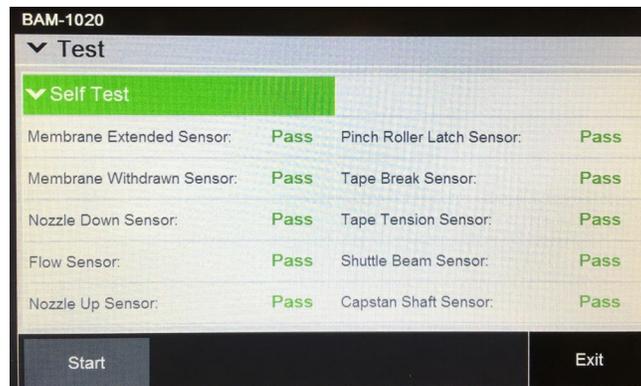


Figure 23. Self-Test Screen.

The BAM-1020 has a built-in self-test function which automatically tests most of the tape control and flow systems of the unit. The self-test should be run after each time the filter tape is changed, and it can also be used if the operator suspects a problem with the unit. The tests will take a couple of minutes, and the BAM-1020 will display the results of each tested item with a **Pass** or a **Fail** tag.

5.2.4.2 Flow Checks Test Screen

Flow Checks	BAM Reading	Reference
> Ambient Temperature	23.6 C	23.6 C
> Barometric Pressure	755 mmHg	755 mmHg
> 15.0 lpm Flow Rate	0.0 lpm	15.0 lpm
> 18.4 lpm Flow Rate	0.0 lpm	18.4 lpm
> 16.7 lpm Flow Rate	0.0 lpm	16.7 lpm

Figure 24. Flow Checks Test Screen.

The “BAM Reading” column displays what the BAM-1020 measures for each parameter. The “Reference” column is where you can enter the correct values from your traceable reference standard device. The current selected parameter can be changed by pressing the blue text button of the desired parameter. When a parameter is selected, the Reference field will become active and a <Calibrate> and a <Default> button will appear at the bottom of the screen. No calibration changes are made to the selected parameter unless the <Calibrate> or <Default> key is pressed.

5.2.4.3 Filter Sensor Test Screen

Filter Sensors	BAM Reading	Reference
> Filter Temperature	31.1 C	31.1 C
> Filter RH	25 %	25 %
Pump On	Nozzle:	Moving Up
Pump Off	Pump:	Off
	Flow:	0.0 lpm

Figure 25. Filter Sensor Test Screen.

This screen is used to check or calibrate the filter temperature and RH sensors located in the air stream beneath the filter tape. The RH sensor measures the humidity of the sample air to control the Smart Heater system, which turns up or down as needed to maintain the sample near or below the RH setpoint value.

5.2.4.4 Leak Check Test Screen

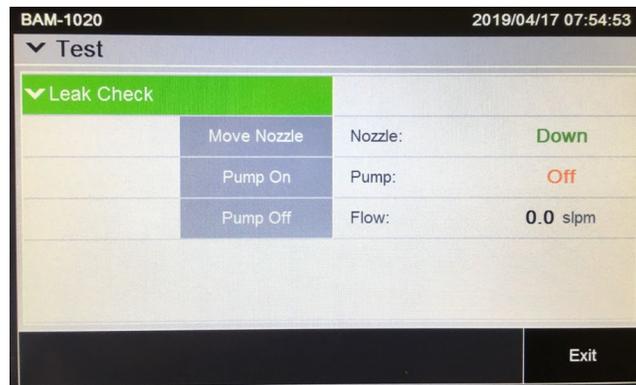


Figure 26. Leak Check Test Screen.

This screen is used to perform leak checks. It can also be used to manually force the pump on and off, or to manually move the nozzle. **Note:** *The BAM will regulate the flow to the 16.7 L/min setpoint, but the flow rate shown on this screen is uncorrected and always in standard conditions, even if the BAM operates in actual flow mode.* For this reason, no flow audits should be performed using this screen!

5.2.4.5 Heater Test Screen

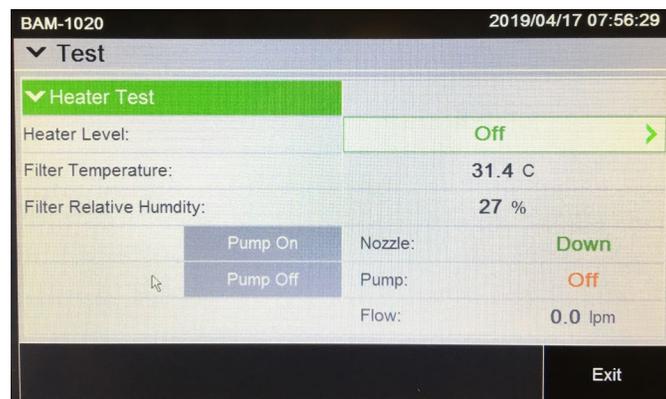


Figure 27. Heater Test Screen.

This screen is used to force the Smart Inlet Heater on or off for testing purposes. The Heater Level field can be set to Off, On, or Idle. The On mode will turn the heater up to full power of 200 watts. The Idle mode will set the heater to low power mode at the default of 40 watts (20%) or whatever the idle mode wattage is set to. The heater takes several minutes to heat up or cool down noticeably.

5.2.4.6 Membrane Test Screen

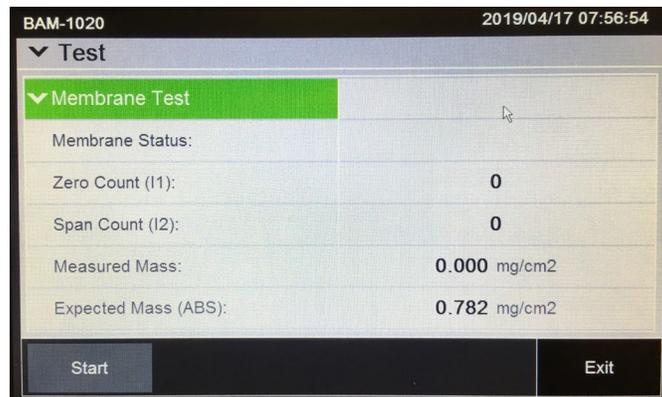


Figure 28. Span Membrane Test Screen.

This screen is used to perform tests of the reference membrane span check which occurs automatically every sample cycle. This test can be run if the BAM-1020 has been logging **D** errors. Each BAM-1020 has an individually weighed membrane, and this mass is measured and displayed during this test. Compare the value from this test with the ABS value on the calibration sheet for your unit. The values must match within 5%, and will typically match within just a few micrograms. If not, the most common cause is a dirty membrane foil, which can be carefully cleaned with canned air or clean water rinse. Alcohol is not used because it leaves a film. CD cleaner works well for badly soiled membranes. **Caution: The span membrane foil is a thin sheet of polyester and is fragile.** It must be replaced if damaged. Contact ECB for replacement instructions.

5.3 Monitoring

5.3.1 Monitoring Timeline

The BAM 1020 is almost always configured to operate on 1-hour cycles. In the example timeline below the BAM 1020 makes an 8-minute beta measurement at the beginning and the end of each hour, with a 42-minute air sample period in between, for a total of 58 minutes. The other two minutes of the hour are used for tape and nozzle movements during the cycle.

When running the BAM 1020 as a US-EPA designed equivalent method for PM₁₀, the Count Time may be set to 4, 6, 8, or 10 minutes. The NCDAQ sets the count time for all PM₁₀ BAMS to 8 minutes.

5.3.2 Powering Up and Warm-Up Period

The BAM 1020 power switch is located on the back of the unit, above the power cord. When the power is switched on, the main menu screen should appear after a few seconds.

The BAM 1020 must warm up for at least one hour before valid data 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 a power outage. It may be necessary to discard the first two hours of data after the BAM is turned on, or after the BAM is downed for maintenance.

5.3.3 Time and Date Setup

Touch Key

The BAM clock time must agree with the data logger to within ± 1 minute, Eastern Standard Time. The BAM 1020 clock may drift as much as a minute or two per month. To set the clock on the BAM:

1. From the main menu, press the <Set-Up> touch key.
2. Press the <Clock> key to enter the clock menu.
3. The BAM 1020 time is a 24-hour clock only. Use the arrow keys to select and increase or decrease the desired field, then press the <Save> touch key.
4. From the main menu, press the <Set-Up> soft key.
5. Press the <Date> key to enter the clock menu.
6. Use the arrow keys to select and increase/decrease the desired field, then press the <Save> touch key.



Figure 29. Touch Key Clock Screen.

Touch Screen

The BAM clock time must agree with the data logger to within ± 1 minute, Eastern Standard Time. The BAM 1020 clock may drift as much as a minute or two per month. To set the clock on the BAM:

1. Time is a 24-hour clock only. Set the clock by selecting one of the parameters, then entering a new value using the pop-up numeric keypad.
2. Press the <Save>button when finished. The BAM-1020 clock may drift as much as a minute or two per month.

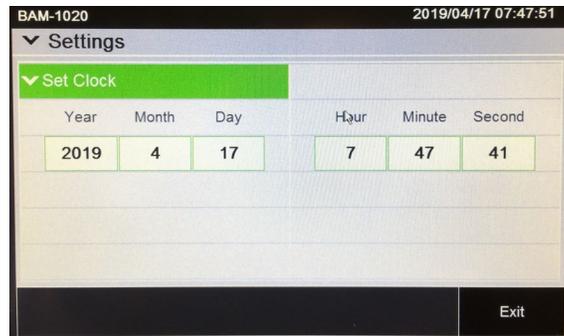


Figure 30. Touch Screen Clock Screen.

5.3.4 Sample Parameter Set-Up

The BAM sample parameter is the amount of time that the vacuum pump is on per sample cycle. To meet FEM requirements, it is mandatory that this setting is 42 minutes. The Count Time parameter is the amount of time the unit takes to perform the before sampling I0 and the after sampling I3 counts. The Count Time must be set to 8 minutes to meet FEM requirements. If either of these parameters are not set accordingly, the collected data cannot be used for attainment purposes.

Note: If a stand-alone BAM unit is being used to sample PM₁₀, only the Conc Type Parameter must be set to Standard. Flow will remain set to Actual.

Upon initial setup of a monitor at the site and quarterly thereafter, check to ensure that the sampling setup parameters are being met.

Table 6. Required BAM Settings for FEM Operation.

Screen	Parameter	Required Default PM2.5	Required Default PM10
SETUP > SAMPLE	BAM SAMPLE	42 min	42 min
	RANGE	1.000 mg	1.000 mg
	CONC UNITS	µg	µg
	COUNT TIME	8 MIN	8 MIN
SETUP > CALIBRATE	FLOW RATE	16.7 LPM	16.7 LPM
	CONC TYPE	Actual	Standard
	FLOW TYPE	Actual	Actual
	STD TEMP	25 C	25 C
	HEATER	AUTO	AUTO
SETUP > ERRORS	AP	150	150
	FR1	10	10
	FRh	20	20
SETUP > HEATER	RH Control	YES	YES
	RH Setup	35%	35%

In addition, the following settings must be verified in the menus of both BAMs used in the coarse configuration. Except for the Operation setting, these are the same as the PM_{2.5} FEM settings.

Table 7. Required BAM Settings for Coarse Operation.

Menu	Setting	PM10 Master	PM2.5 Slave
SETUP > SAMPLE	OPERATION	COARSE PM10	COARSE PM2.5
	BAM SAMPLE	42 MIN	42 MIN
	COUNT TIME	8 MIN	8 MIN
SETUP > CALIBRATE	CONC TYPE	ACTUAL	ACTUAL
	FLOW TYPE	ACTUAL	ACTUAL
	STD TEMP	25C	25C
	HEATER	AUTO	AUTO
SETUP > HEATER	RH Control	YES	YES
	RH Setpoint	35%	35%

5.3.5 Filter tape Installation

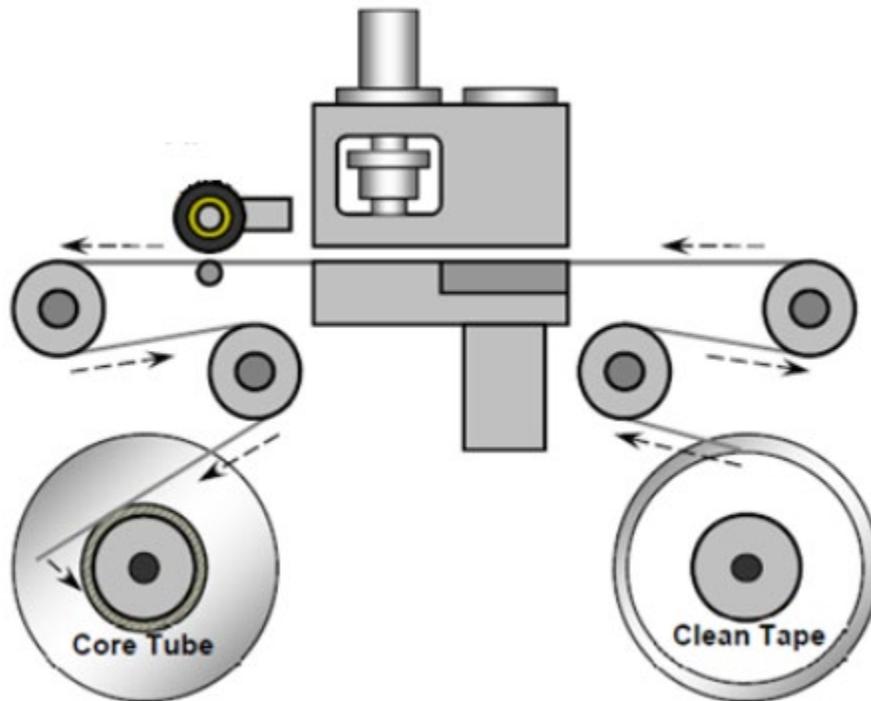


Figure 31. Filter Tape Pathway.

A roll of Met One glass fiber filter tape must be loaded into the BAM 1020 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 to load an initial roll of filter tape.

Touch Key

1. Turn on the BAM 1020. The BAM 1020 should automatically raise the sample nozzle.
2. Lift the rubber pinch roller assembly and latch it in the up position.
3. Unscrew and remove the two clear plastic reel covers.
4. An empty core tube **MUST** be installed on the left (take-up) reel hub. This provides a surface for the used tape to spool upon. Met One supplies a plastic core tube to use with the first roll of tape. After that, you can use the empty core tube left over from the previous roll. **Never fasten the filter tape to the aluminum hub.**

5. Load the new roll of filter tape onto the right (supply) reel, and route the tape through the transport assembly as shown in the drawing above. Attach the loose end of the filter tape to the empty core tube with adhesive cellophane tape or equivalent.
6. Rotate the tape roll by hand to remove excess slack, then install the clear plastic reel covers. The covers must be tight in order to properly clamp the tape in place and prevent slipping.
7. Align the filter tape so that it is centered on all of the rollers. Newer units have score marks on the rollers to aide in visually centering the tape.
8. Unlatch and lower the pinch roller assembly onto the tape. **The BAM 1020 cannot automatically lower the rollers, and the BAM 1020 will not operate if the pinch rollers are left latched in the up position!**



Figure 32. Tape Tension Screen.

9. Press the <Tension> touch key in the Tape menu. The BAM 1020 will set the tape to the correct tension and alert you if there was an error with the process. Exit the menu.

Touch Screen

1. Turn on the BAM-1020 and enter the Operate > Load Tape menu as shown below. The unit should automatically raise the sample nozzle.



Figure 33. Load Tape Screen.

2. Perform steps 2 – 8 of the Touch Key BAM installation process.
3. Press the <Tension> button. The BAM-1020 will set the tape to the correct tension and alert you if there was an error with the process. The <Forward> and <Backward> buttons can be used to manually feed the tape. Feed the tape forward several times to ensure that a complete turn of tape is wound around the take up reel, then exit the menu.

5.3.6 Self-Test Function

The BAM-1020 has a built-in self-test function which automatically tests most of the tape control and flow systems of the unit. The self-test should be run after each time the filter tape is changed, and it can also be used if the operator suspects a problem with the unit.

Touch Key



Figure 34. Touch Key Self-Test Screen.

The self-test feature is located in the TAPE menu. Press the SELF TEST soft-key to start the test. The tests will take a couple of minutes, and the BAM 1020 will display the results of each tested item with an **OK** or a **FAIL** tag. If all of the test items are OK, the status will show SELF TEST PASSED as shown in the drawing below. If any item fails, the status will show ERROR OCCURRED.

Touch Screen

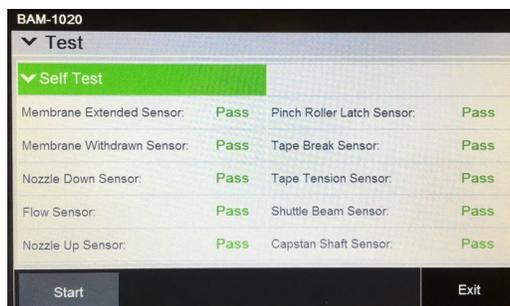


Figure 35. Touch Screen Self-Test Screen.

The self-test feature is located in the TEST > SELF TEST menu. Press the START button to start the test. The tests will take a couple of minutes, and the BAM-1020 will display the results of each tested item with a **PASS** or a **FAIL** tag. Press EXIT when finished.

5.3.7 Shelter Temperature Control

The shelter temperature in the freestanding Ekto configuration must be maintained at 28-32 °C. Due to the changing seasons, it is expected that operators may need to fine-tune the temperature twice a year: once in the spring and once in the fall. The thermostat is accessed by removing the three screws on the HVAC panel. Upon opening the door, the thermostat is visible at the top center of the unit (Figure 28).



Figure 36. HVAC Panel.

The temperature can be adjusted up or down by tuning the temperature adjustment knob (Figure 53). The thermostat adjustment knob provides a relative temperature change; the temperatures listed on the knob are not exact. The exact temperature of the unit is determined by monitoring the thermocouple connected to the DAS.



Figure 37. HVAC Adjustment Knob.

If the thermostat knob in Figure 29 is maxed out as high as it can go, yet the temperature on the thermocouple still cannot reach a tight 28-32 °C window, open the thermostat housing and adjust the “spread” knob in order to decrease the length between turning on to cool, and turning off once the desired temperature has been reached (Figure 54).



Figure 38. Spread Control.

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” external leak check. It is a good practice to complete all outstanding maintenance activities (see Section 8.0) 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 once each calendar year and 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 and within 365 days of the prior calibration.
- After a sampler is replaced.
- After a sampler is moved or relocated, no matter the distance.
- When the BAM has been removed from the Ekto shelter for any type of maintenance.
- After the pump or flow controller is replaced.
- If flow check or a flow audit are not within specifications.
- If the flow calibration device needs to be changed.
- If the sampler is without power for longer than 48 hours and the flow verification fails.

6.2 Calibration Equipment



Figure 39. 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[®] 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 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 contacting 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).

6.4 Calibration Setting the Envidas Channel to Off-Scan

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



Figure 40. Envidas Ultimate Viewer Icon.

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



Figure 41. 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 42. Tabular Display of Site Parameters.

4. 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 43. Channel Options Menu.

5. 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
r/orsv	10:36:40 AM	O3	ppb	51.33	51.33	Ok	50.59	Ok	51.71	Ok	43.56	Ok
r/orsv	10:36:40 AM	CPS	ppb	-0.1179	-0.11	Ok	0.11	Ok	0.24	Ok	0.17	Ok
r/orsv	10:36:40 AM	TMP	C	23.6	23.6	Ok	23.8	Ok	22.1	Ok	22.5	Ok
r/orsv	10:36:26 AM	B20	ug/m3	16	16	OffScan	16	Ok	16	Ok	16	Ok

Figure 44. Channel Off Scan.

6.5 Calibration “As Found” Leak Check



Figure 45. Leak Check Adapter

Almost all air leaks in the BAM system occur at the nozzle where it contacts the filter tape. The BAM-1020 has no way of automatically detecting a leak at this interface because the airflow sensor is located downstream of the filter tape. A poor seal at this point lets an unknown amount of air enter the system from a location other than through the inlet. This will cause the flow to be incorrect. **Leak check with the filter tape in place.** Take the following steps to perform an “as found” leak check.

Touch Key

1. Go to the Test>Pump menu. This will stop the current sample, if one is in progress.
2. Remove the PM10 size selective inlet from the sample tube and install the leak check adapter. If a PM2.5 cyclone is being used, it should be left in place and included in the leak check.
Verify that the leak valve is in the open position.
3. Press the <Pump> button. The BAM-1020 will automatically lower the nozzle (if needed) and start the pump.
4. Allow sufficient time for the flow to stabilize at 16.7 LPM on the BAM-1020 display and then press the <Leak> button. Verify the status changes to indicate “Leak On”.

5. Turn the leak check device to the closed position.
6. The pump flow rate should drop below 1.0 LPM. Record the “as found” results. If the flow rate is 1.0 LPM or less, the leak check has passed. If the flow rate is greater than 1.0 LPM, the leak check has failed.
7. If the leak check fails, investigate the cause for the failure. If no cause is identified, perform another leak check. If unit fails to pass, call ECB and the Particulate Lead.
8. Slowly open the leak check valve to restore normal flow through the BAM-1020.
9. Press the PUMP button to turn off the pump and then go to the Test >Tape menu.
10. Advance the tape forward seven windows by pressing the <Up arrow> to set the Windows field to 7 and then pressing <FWD>. The nozzle should raise automatically and then advance the tape.

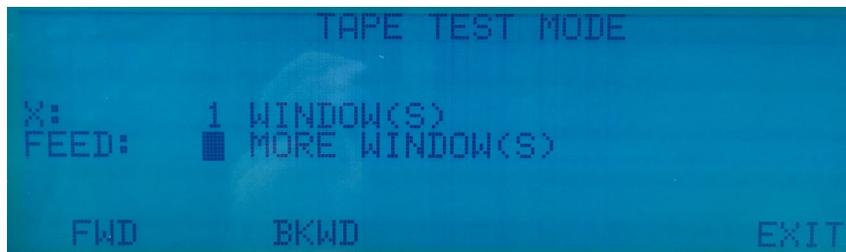


Figure 46. Tape Test Screen.

11. Exit to the Main Menu.
12. Remove the leak check adapter and replace the PM10 size selective inlet.
13. Resume normal sampling operations.

Touch Screen

1. Enter the Test > Leak Check menu on the BAM. This will stop the operation cycle of the unit.
2. Remove the PM10 head from the inlet tube and install the leak check adapter onto the inlet tube. If a PM2.5 cyclone is used, install the leak check valve on top of the cyclone, since the cyclone is a possible source of leaks and should be tested.
3. Turn the valve to the off position to prevent any air from entering the inlet tube.

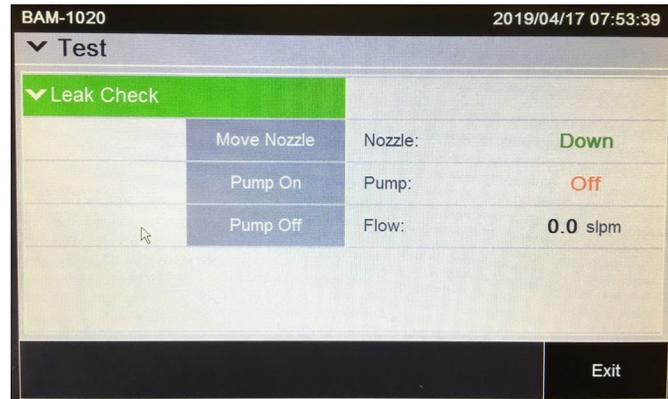


Figure 47. Leak Check Screen.

4. If the nozzle is not already in the down position, press the <Move Nozzle> field to make it so.
5. Press the <Pump On> field. The standard flow rate shown on the BAM display should stabilize at less than 1.0 L/min in about 20 seconds. Record the as-found results. If the flow rate is 1.0 LPM or less, the leak check has passed. If the flow rate is greater than 1.0 LPM, the leak check has failed.
6. If the leak check fails, investigate the cause for the failure. If no cause is identified, perform another leak check. If unit fails to pass, call ECB and the Particulate Lead.
7. Slowly open the leak check valve to restore normal flow through the BAM-1020.
8. Turn the pump off and remove the leak test valve. Exit to the Main Menu.

6.6 Ambient Sensor Calibration

The temperature and pressure must be calibrated prior to the flow because the actual flow is calculated based on ambient temperature and the ambient pressure. Field operators do not calibrate or verify any of the inline temperature or pressure sensors. **A sensor calibration always requires a flow calibration afterwards.**

6.6.1 Ambient Temperature and Ambient Pressure Sensor Calibration

Touch Key

1. If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet (Figure 64). 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.



Figure 48. Proper Shaded Inlet Locations.

2. Enter the Test > Flow menu. The nozzle will automatically lower when this screen is entered. The “BAM” column is the BAM-1020 measurement for each parameter. The “STD” column is where the values from the reference standard will be entered.
3. Position the <CAL> symbol next to AT using the <NEXT> touch key.

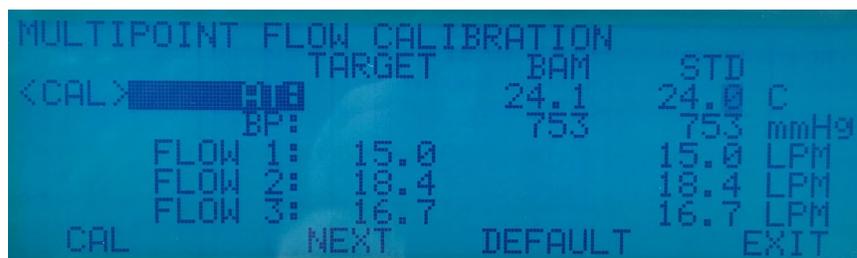


Figure 49. Calibration Screen.

4. Read the ambient temperature (° C) with your reference thermometer to the nearest tenth.
5. Enter the value from the thermometer into the “STD” field using the arrow keys.
6. Record the value in the e-log on the Calibration page under the “Ambient Temperature Calibration” section. There is no pass/fail requirement.

7. Press the <CAL> touch key to correct the BAM reading. The BAM and STD values should now be the same.
8. Press the <Next> touch key to move the <CAL> indicator to the BP field.
9. Read the ambient pressure (mm Hg) with your reference barometer to the nearest whole number.
10. Enter the value from the barometer into the “STD” field using the arrow keys. The BAM and STD values should now be the same.
11. Record the value in the e-log on the Calibration page under the “Ambient Pressure Calibration” section.
12. Exit the calibration menu.

Touch Screen

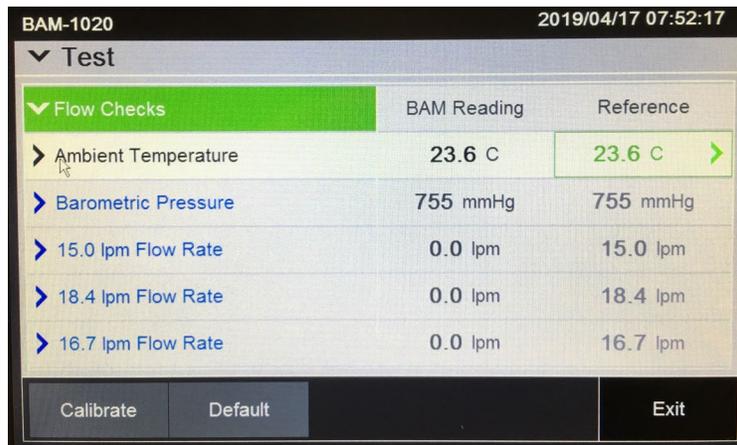


Figure 50. Temperature and Pressure Calibration Screen.

1. Enter the Test > Flow Checks menu as shown above. The nozzle will lower automatically when this screen is entered.
2. Select the Ambient Temperature parameter. The reference value will become greenly active.

3. Measure the ambient temperature with your reference standard device. Record the value in the e-log on the Calibration page under the “Ambient Temperature Calibration” section. There is no pass/fail requirement.
4. Press the green reference field and a keypad will appear. Use the keypad to enter the value from your reference standard and press the OK field.
5. The reference field should now contain the correct value. Press the <Calibrate> button to calibrate the BAM reading to match.
6. Select the Barometric Pressure parameter. The reference value will become greenly active.
7. Measure the ambient pressure with your reference standard device. Record the value in the e-log on the Calibration page under the “Ambient Pressure Calibration” section. There is no pass/fail requirement.
8. Enter the barometric pressure value from your reference standard into the reference field using the same process as temperature, then press the <Calibrate> button to attune the BAM reading to match.
9. Exit the test menu screen.

6.7 Flow Calibration

Touch Key

1. Make certain that the BAM 1020 has warmed up for at least 60 minutes prior to performing calibrations.
2. Remove the PM10 head from the inlet tube and install your reference flow meter onto the inlet in its place.
3. 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.



Figure 51. FTS with Manometer.

4. Zero the Tetra Cal or manometer.
5. Press the <NEXT> touch key to move the <CAL> indicator to the 15.0 LPM flow point. The pump will turn on automatically.

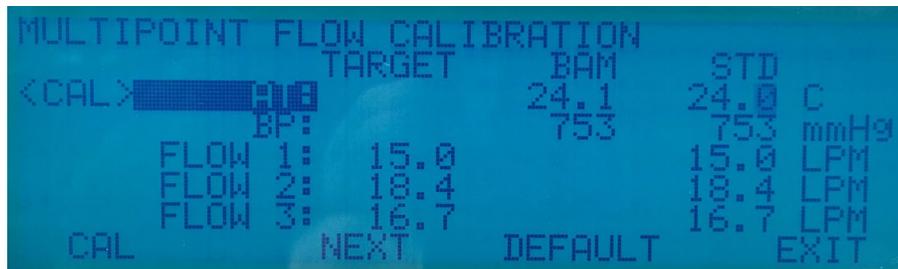


Figure 52. Flow Calibration Screen.

6. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 15.0 LPM.
7. Read and record the stated flow rate (LPM) given by the BAM 1020 in the “Calibration” page of the e-log.
8. 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.
9. Enter the actual flow rate from the e-log into the STD field on the BAM using the arrow keys.

10. Press the <CAL> touch key. **Note: the BAM reading will not change to match the STD until after all three calibration points have been entered.**
11. Press the <NEXT> touch key to move the <CAL> indicator to the 18.3 LPM flow point.
12. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 18.3 LPM.
13. Read and record the stated flow rate (LPM) given by the BAM 1020 in the “Calibration” page of the e-log.
14. 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.
15. Enter the actual flow rate from the e-log into the STD field on the BAM using the arrow keys.
16. Press the <CAL> touch key. **Note: the BAM reading will not change to match the STD until after all three calibration points have been entered.**
17. Press the NEXT hot key to move the <CAL> indicator to the 16.7 LPM flow point.
18. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 16.7 LPM.
19. Read and record the stated flow rate (LPM) given by the BAM 1020 in the “Calibration” page of the e-log.
20. 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.
21. Enter the actual flow rate from the e-log into the STD field on the BAM using the arrow keys.
22. Press the <CAL> touch key. The BAM 1020 will now internally adjust the monitor flow rate for all three points based on the actual flow rates entered.
23. 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. 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. *Per Met One's advice, the second, failing calibration should not be used even if the post-calibration flow verification passes.* The operator must inform the RCO particulate matter lead and ECB.

Touch Screen

1. Make certain that the BAM 1020 has warmed up for at least 60 minutes prior to performing calibrations.
2. Remove the PM10 head from the inlet tube and install your reference flow meter onto the inlet in its place.
3. Enter the Test > Flow Checks menu. The nozzle will lower automatically when this screen is entered.
4. 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.
5. Zero the Tetra Cal or manometer.

Flow Checks	BAM Reading	Reference
Ambient Temperature	23.6 C	23.6 C
Barometric Pressure	755 mmHg	755 mmHg
15.0 lpm Flow Rate	0.0 lpm	15.0 lpm
18.4 lpm Flow Rate	0.0 lpm	18.4 lpm
16.7 lpm Flow Rate	0.0 lpm	16.7 lpm

Figure 53. Flow Calibration Screen.

6. Select the “15.0 lpm Flow Rate” field. The pump will turn on automatically. Allow the unit to regulate the flow until the BAM Reading stabilizes at the target flow rate.
7. Read and record the stated flow rate (LPM) given by the BAM 1020 in the “Calibration” page of the e-log.
8. 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.

9. Select the reference field for the 15.0 lpm flow point and enter the flow value from your standard device into the reference field using the pop-up keypad and press OK. Then press the <SET> button at the bottom of the screen. **Note: The BAM flow reading will not change to match the Reference value until after you have entered all three flow calibration points.**
10. Select the “18.4 lpm Flow Rate” field. Allow the flow to stabilize again.
11. Read and record the stated flow rate (LPM) given by the BAM 1020 in the “Calibration” page of the e-log.
12. 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.
13. Select the reference field for the 18.4 lpm flow point and enter the flow value from your standard into the reference field and press the <SET> button. **Note: If the BAM-1020 is unable to achieve flow regulation at the 18.4 L/min point, this could be an early indication that the pump needs to be serviced.**
14. Select the “16.7 lpm Flow Rate” field. Allow the flow to stabilize.
15. Read and record the stated flow rate (LPM) given by the BAM 1020 in the “Calibration” page of the e-log.
16. 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.
17. Select the reference field for the 16.7 lpm flow point and enter the value from your standard device into the reference field. Press the <Calibrate> field.
18. After this third flow point is calibrated, the BAM Reading for the 16.7 lpm flow rate will change to show the corrected flow, then the BAM-1020 will quickly re-regulate the flow to 16.7 lpm based on the new calibration. The BAM-1020 flow reading should now match your flow standard device at 16.7 ± 0.1 lpm. Exit the calibration screen.

19. 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. 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. *Per Met One’s advice, the second, failing calibration should not be used even if the post-calibration flow verification passes.* The operator must inform the RCO particulate matter lead and ECB.

6.8 Post Calibration Flow Verification

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.*

Touch Key

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. If starting from the main menu, press the <TEST> touch key to enter the flow menu. Press the <NEXT> touch key to move the <CAL> indicator to the 16.7 lpm flow point. The pump will turn on automatically. **Do not press the <CAL> touch key!**
4. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 16.7 lpm.
5. Read and record the stated flow rate (lpm) given by the BAM 1020 in the “Calibration” page of the e-log.
6. Read and record the actual flow rate (lpm) given by your certified Tetra Cal, or calculate the flow from your flow standard 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.
7. Remove the flow standard from the VSCC.
8. Exit the test menu.

Touch Screen

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. If starting from the main menu, Enter the Test > Flow Checks menu. The nozzle will lower automatically when this screen is entered.
4. Press the <16.7 lpm Flow Rate> field. The pump will turn on automatically. **Do not press the <Calibration> field!**
5. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 16.7 lpm.
6. Read and record the stated flow rate (lpm) given by the BAM 1020 in the “Calibration” page of the e-log.
7. 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.
8. Remove the flow standard from the VSCC.
9. Exit the test menu.

6.9 Calibration “As Left” Leak Check

Touch Key

1. Go to the Test>Pump menu. This will stop the current sample, if one is in progress.
2. Remove the PM10 size selective inlet from the sample tube and install the leak check adapter. If a PM2.5 cyclone is being used, it should be left in place and included in the leak check. **Verify that the leak valve is in the open position.**
3. Press the <Pump> button. The BAM-1020 will automatically lower the nozzle (if needed) and start the pump.
4. Allow sufficient time for the flow to stabilize at 16.7 LPM on the BAM-1020 display and then press the <Leak> button. Verify the status changes to indicate “Leak On”.

5. Turn the leak check device to the closed position.
6. The pump flow rate should drop below 1.0 LPM. Record the “as found” results. If the flow rate is 1.0 LPM or less, the leak check has passed. If the flow rate is greater than 1.0 LPM, the leak check has failed.
7. If the leak check fails, investigate the cause for the failure. If no cause is identified, perform another leak check. If unit fails to pass, call ECB and the Particulate Lead.
8. Slowly open the leak check valve to restore normal flow through the BAM-1020.
9. Press the PUMP button to turn off the pump and then go to the Test >Tape menu.
10. Advance the tape forward seven windows by pressing the <Up arrow> to set the Windows field to 7 and then pressing <FWD>. The nozzle should raise automatically and then advance the tape.

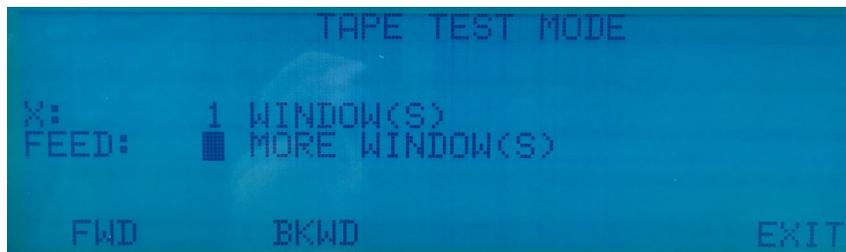


Figure 54. Tape Test Screen.

11. Exit to the Main Menu.
12. Remove the leak check adapter and replace the PM10 size selective inlet.
13. Resume normal sampling operations.

Touch Screen

1. Enter the Test > Leak Check menu on the BAM. This will stop the operation cycle of the unit.
2. Remove the PM10 head from the inlet tube and install the leak check adapter onto the inlet tube. If a PM2.5 cyclone is used, install the leak check valve on top of the cyclone, since the cyclone is a possible source of leaks and should be tested.
3. Turn the valve to the off position to prevent any air from entering the inlet tube.

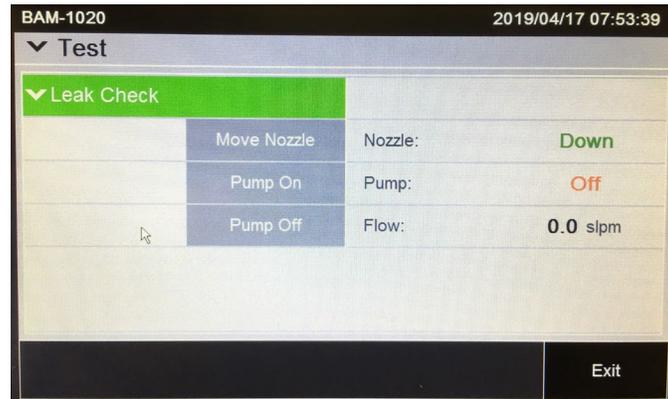


Figure 55. Leak Check Screen.

4. If the nozzle is not already in the down position, press the <Move Nozzle> field to make it so.
5. Press the <Pump On> field. The standard flow rate shown on the BAM display should stabilize at less than 1.0 L/min in about 20 seconds. Record the as-found results. If the flow rate is 1.0 LPM or less, the leak check has passed. If the flow rate is greater than 1.0 LPM, the leak check has failed.
6. If the leak check fails, investigate the cause for the failure. If no cause is identified, perform another leak check. If unit fails to pass, call ECB and the Particulate Lead.
7. Slowly open the leak check valve to restore normal flow through the BAM-1020.
8. Turn the pump off and remove the leak test valve. Exit to the Main Menu.

6.10 Self-Test and Operation

The BAM-1020 has a built-in self-test function which automatically tests most of the tape control and flow systems of the unit. The self-test should be run after each time the filter tape is changed, and it can also be used if the operator suspects a problem with the unit.

Touch Key



Figure 56. Touch Key Self-Test Screen.

The self-test feature is located in the TAPE menu. Press the SELF TEST soft-key to start the test. The tests will take a couple of minutes, and the BAM 1020 will display the results of each tested item with an **OK** or a **FAIL** tag. If all of the test items are OK, the status will show SELF TEST PASSED as shown in the drawing below. If any item fails, the status will show ERROR OCCURRED. If the self-test fails, investigate the cause for the failure. If no cause is identified, perform another self-test. If unit fails to pass, call ECB and the Particulate Lead.

Touch Screen

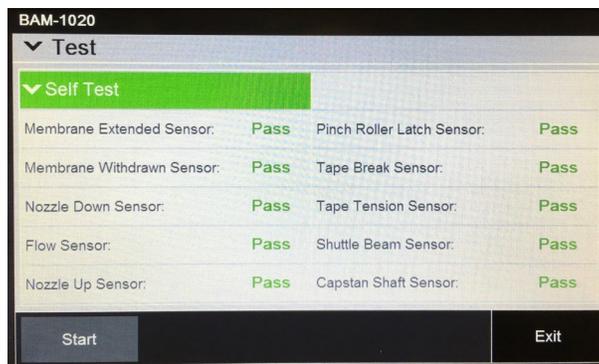


Figure 57. Touch Screen Self-Test Screen.

The self-test feature is located in the TEST > SELF TEST menu. Press the START button to start the test. The tests will take a couple of minutes, and the BAM-1020 will display the results of each tested item with a **PASS** or a **FAIL** tag. Press EXIT when finished. If the self-test fails, investigate the cause for the failure. If no cause is identified, perform another self-test. If unit fails to pass, call ECB and the Particulate Lead.

6.11 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.

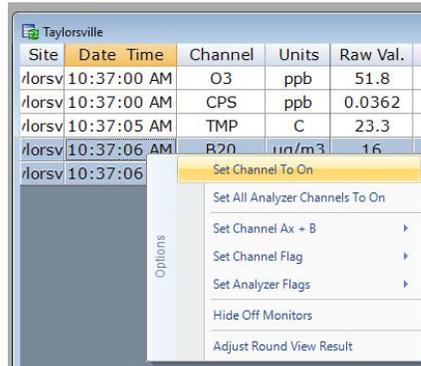


Figure 58. Setting the Channel to On

2. Select "Set Channel To On". At the top of the minute, the channel will appear un-greyled 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), and at least 14 days from the previous 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 for every quarter that a monitor operates. It should be performed in the second month of each calendar quarter if possible, unless the monitor is being shut down before the second month of the quarter, in which case the audit should be performed prior to an ending verification and subsequent shut down. 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.*

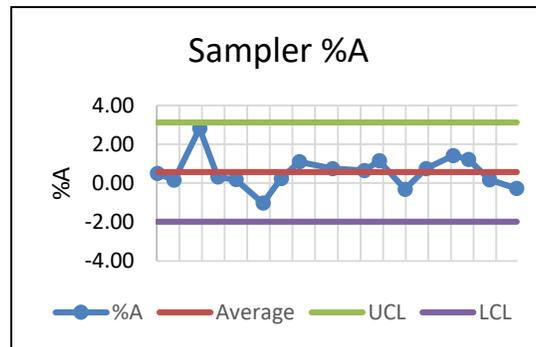


Figure 59. Example E-log Control Chart.

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 is not within the tolerance listed in

Table 8, corrective action is required as indicated. Do not perform a calibration until after you have verified, checked, or audited all of the parameters. The relative humidity is not recorded or checked against a standard.

Table 8. Operation Evaluations

CRITERIA	TOLERANCES	FREQUENCY	CORRECTIVE ACTION
External Leak Check	≤ 1.0 LPM	<ol style="list-style-type: none"> 1. During each monthly and mid-month check. 2. During each quarterly audit. 3. Each time the VSCC is removed. 4. Each time the tape is changed. 5. Each time the nozzle/vane is cleaned. 	<ol style="list-style-type: none"> 1. Clean nozzle and vane. 2. Make sure tape is seated. 3. Check seating and assembly of VSCC (o-rings). 4. Perform internal leak check. 5. If unit fails to pass, call ECB
Ambient Temperature Verification or Audit	± 2 °C of NIST Thermometer	<ol style="list-style-type: none"> 1. During each monthly and mid-month check. 2. During each quarterly audit. 	Perform a flow verification prior to an ambient temperature adjustment. Follow with complete calibration.
Pressure Verification or Audit	± 10 mm Hg of NIST Barometer	<ol style="list-style-type: none"> 1. During each monthly and mid-month check. 2. During each quarterly audit. 	Perform a flow verification prior to an ambient pressure adjustment. Follow with complete calibration.
Post Calibration Verification	%A $\pm 2\%$ %AD $\pm 2\%$	After each monitor calibration.	Calibrate again. If unit fails, call ECB and Particulate Lead.
Monthly Verification	%A $\pm 3\%$ and %AD $\pm 4\%$ are DAQ action limits ($\pm 4\%$ and $\pm 5\%$ are EPA voiding limits)	<ol style="list-style-type: none"> 1. Each calendar month. 2. After power outage longer than 48 hours. 	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 %AD $\pm 4\%$ are DAQ action limits ($\pm 4\%$ and $\pm 5\%$ are EPA voiding limits)	14-18 Days after Flow Rate Verification (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 %AD $\pm 4\%$ are DAQ action limits ($\pm 4\%$ and $\pm 5\%$ are EPA voiding limits)	Quarterly (preferably the second month of each quarter)	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.
Background Test	≥ 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 Envidas Channel to Off-Scan

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



Figure 60. Envidas Ultimate Viewer Icon.

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

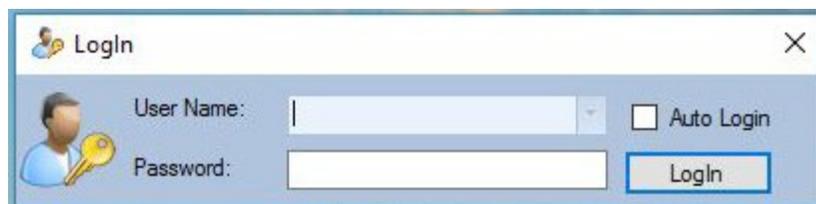


Figure 61. Envidas Viewer Login.

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 62. 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 Min.
/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	B20	ug/m3	16	16	Ok	16
/lorsv	10:34:46 AM	BT	C	31.2	31.2	Ok	31.

Figure 63. 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 64. Channel Off Scan.

7.4 Verification or Audit “As Found” Leak Check



Figure 65. Leak Check Adapter

Almost all air leaks in the BAM system occur at the nozzle where it contacts the filter tape. The BAM-1020 has no way of automatically detecting a leak at this interface because the airflow sensor is located downstream of the filter tape. A poor seal at this point lets an unknown amount of air enter the system from a location other than through the inlet. This will cause the flow to be incorrect. **Leak check with the filter tape in place.** Take the following steps to perform an “as found” leak check.

Touch Key

1. Go to the Test>Pump menu. This will stop the current sample, if one is in progress.
2. Remove the PM10 size selective inlet from the sample tube and install the leak check adapter. If a PM2.5 cyclone is being used, it should be left in place and included in the leak check.
Verify that the leak valve is in the open position.
3. Press the <Pump> button. The BAM-1020 will automatically lower the nozzle (if needed) and start the pump.
4. Allow sufficient time for the flow to stabilize at 16.7 LPM on the BAM-1020 display and then press the <Leak> button. Verify the status changes to indicate “Leak On”.
5. Turn the leak check device to the closed position.
6. The pump flow rate should drop below 1.0 LPM. Record the “as found” results. If the flow rate is 1.0 LPM or less, the leak check has passed. If the flow rate is greater than 1.0 LPM, the leak check has failed. See Table 8 for corrective actions for a failed leak check.
7. Slowly open the leak check valve to restore normal flow through the BAM-1020.
8. Press the PUMP button to turn off the pump and then go to the Test >Tape menu.

9. Advance the tape forward seven windows by pressing the <Up arrow> to set the Windows field to 7 and then pressing <FWD>. The nozzle should raise automatically and then advance the tape.



Figure 66. Tape Test Screen.

10. Exit to the Main Menu.
11. Remove the leak check adapter and replace the PM10 size selective inlet.
12. Resume normal sampling operations.

Touch Screen

1. Enter the Test > Leak Check menu on the BAM. This will stop the operation cycle of the unit.
2. Remove the PM10 head from the inlet tube and install the leak check adapter onto the inlet tube. If a PM2.5 cyclone is used, install the leak check valve on top of the cyclone, since the cyclone is a possible source of leaks and should be tested.
3. Turn the valve to the off position to prevent any air from entering the inlet tube.

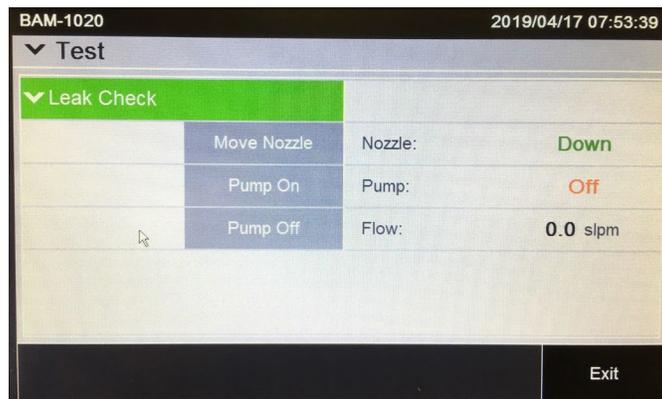


Figure 67. Leak Check Screen.

4. If the nozzle is not already in the down position, press the <Move Nozzle> field to make it so.

5. Press the <Pump On> field. The standard flow rate shown on the BAM display should stabilize at less than 1.0 L/min in about 20 seconds. Record the as-found results. If the flow rate is 1.0 LPM or less, the leak check has passed. If the flow rate is greater than 1.0 LPM, the leak check has failed. See Table 8 for corrective actions for a failed leak check.
6. Slowly open the leak check valve to restore normal flow through the BAM-1020.
7. Turn the pump off and remove the leak test valve. Exit to the Main Menu.

7.5 Ambient Temperature and Ambient Pressure Verification or Audit

Touch Key

1. If using a glass thermometer, hang the thermometer from the shaded side of the ambient temperature probe's solar shield or sampling inlet (Figure 73). 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.



Figure 68. Proper Shaded Inlet Locations.

2. Enter the Test > Flow menu. The nozzle will automatically lower when this screen is entered. The “BAM” column is the BAM-1020 measurement for each parameter.

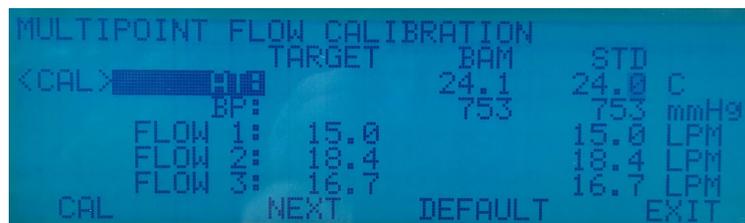


Figure 69. Calibration Screen.

3. Read the ambient temperature (°C) with your reference thermometer to the nearest tenth. Record the value in the e-log on the “Verification_Audit” page under the “Ambient Temperature” section.
4. Read the ambient temperature (°C) from your BAM 1020. Record the value in the e-log on the “Verification_Audit” page under the “Ambient Temperature” section.
5. Read the ambient pressure (mm Hg) with your reference barometer to the nearest whole number. Record the value in the e-log on the “Verification_Audit” page under the “Ambient Pressure” section.
6. Read the ambient pressure (mmHg) from your BAM 1020. Record the value in the e-log on the “Verification_Audit” page under the “Ambient Pressure” section. See Table 8 for corrective actions for a failed temperature verification or audit.
7. Exit the calibration menu.

Touch Screen



Figure 70. Temperature and Pressure Calibration Screen.

1. Enter the Test > Flow Checks menu as shown above. The nozzle will lower automatically when this screen is entered.
2. Read the ambient temperature (°C) with your reference thermometer to the nearest tenth. Record the value in the e-log on the “Verification_Audit” page under the “Ambient Temperature” section.

3. Read the ambient temperature (°C) from your BAM 1020. Record the value in the e-log on the “Verification_Audit” page under the “Ambient Temperature” section.
4. Read the ambient pressure (mm Hg) with your reference barometer to the nearest whole number. Record the value in the e-log on the “Verification_Audit” page under the “Ambient Pressure” section.
5. Read the ambient pressure (mmHg) from your BAM 1020. Record the value in the e-log on the “Verification_Audit” page under the “Ambient Pressure” section. See Table 8 for corrective actions for a failed temperature verification or audit.
6. Exit the test menu screen.

7.6 Flow Verification or Audit

Touch Key

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. If starting from the main menu, press the <TEST> touch key to enter the flow menu. Press the <NEXT> touch key to move the <CAL> indicator to the 16.7 lpm flow point. The pump will turn on automatically. **Do not press the <CAL> touch key!**
4. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 16.7 lpm.
5. Read and record the stated flow rate (lpm) given by the BAM 1020 in the “Verification_Audit” page under the flow section.
7. Read and record the actual flow rate (lpm) given by your certified Tetra Cal, or calculate the flow from your flow standard 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 under the flow section. See Table 8 for corrective actions for a failed flow verification or audit.
6. Remove the flow standard from the VSCC.
7. Exit the test menu.

Touch Screen

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. If starting from the main menu, Enter the Test > Flow Checks menu. The nozzle will lower automatically when this screen is entered.
4. Press the <16.7 lpm Flow Rate> field. The pump will turn on automatically. **Do not press the <Calibration> field!**
5. Allow the unit to regulate the flow until the BAM reading reaches the target flow rate of approximately 16.7 lpm.
6. Read and record the stated flow rate (lpm) given by the BAM 1020 in the “Verification_Audit” page of the e-log.
7. 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” tab of the e-log. See Table 8 for corrective actions for a failed flow verification or audit.
8. Remove the flow standard from the VSCC.
9. Exit the test menu.

7.7 Verification or Audit “As Left” Leak Check

Touch Key

1. Go to the Test>Pump menu. This will stop the current sample, if one is in progress.
2. Remove the PM10 size selective inlet from the sample tube and install the leak check adapter. If a PM2.5 cyclone is being used, it should be left in place and included in the leak check. **Verify that the leak valve is in the open position.**
3. Press the <Pump> button. The BAM-1020 will automatically lower the nozzle (if needed) and start the pump.
4. Allow sufficient time for the flow to stabilize at 16.7 LPM on the BAM-1020 display and then press the <Leak> button. Verify the status changes to indicate “Leak On”.

5. Turn the leak check device to the closed position.
6. The pump flow rate should drop below 1.0 LPM. Record the “as found” results. If the flow rate is 1.0 LPM or less, the leak check has passed. If the flow rate is greater than 1.0 LPM, the leak check has failed. See Table 8 for corrective actions for a failed leak check.
7. Slowly open the leak check valve to restore normal flow through the BAM-1020.
8. Press the PUMP button to turn off the pump and then go to the Test >Tape menu.
9. Advance the tape forward seven windows by pressing the <Up arrow> to set the Windows field to 7 and then pressing <FWD>. The nozzle should raise automatically and then advance the tape.
10. Exit to the Main Menu.
11. Remove the leak check adapter and replace the PM10 size selective inlet.
12. Resume normal sampling operations.

Touch Screen

1. Enter the Test > Leak Check menu on the BAM. This will stop the operation cycle of the unit.
2. Remove the PM10 head from the inlet tube and install the leak check adapter onto the inlet tube. If a PM2.5 cyclone is used, install the leak check valve on top of the cyclone, since the cyclone is a possible source of leaks and should be tested.
3. Turn the valve to the off position to prevent any air from entering the inlet tube.
4. If the nozzle is not already in the down position, press the <Move Nozzle> field to make it so.
5. Press the <Pump On> field. The standard flow rate shown on the BAM display should stabilize at less than 1.0 L/min in about 20 seconds. Record the as-found results. If the flow rate is 1.0 LPM or less, the leak check has passed. If the flow rate is greater than 1.0 LPM, the leak check has failed. See Table 8 for corrective actions for a failed leak check.
6. Slowly open the leak check valve to restore normal flow through the BAM-1020.
7. Turn the pump off and remove the leak test valve. Exit to the Main Menu.

7.8 Verification or Audit Self-Test and Operation

Touch Key

The self-test feature is located in the TAPE menu. Press the SELF TEST soft-key to start the test. The tests will take a couple of minutes, and the BAM 1020 will display the results of each tested item with an **OK** or a **FAIL** tag. If all of the test items are OK, the status will show SELF TEST PASSED as shown in the drawing below. If any item fails, the status will show ERROR OCCURRED. If unit fails to pass, call ECB and the Particulate Lead.

Touch Screen

The self-test feature is located in the TEST > SELF TEST menu. Press the START button to start the test. The tests will take a couple of minutes, and the BAM-1020 will display the results of each tested item with a **PASS** or a **FAIL** tag. Press EXIT when finished. If unit fails to pass, call ECB and the Particulate Lead.

7.9 Verification or Audit Setting the Envidas Channel to Ok

4. 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.

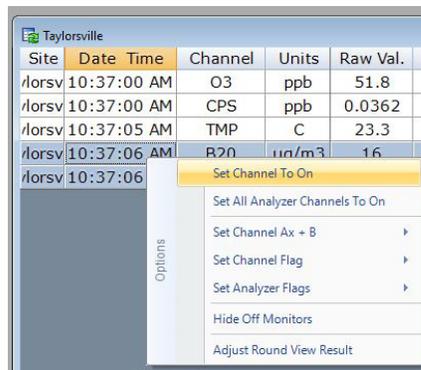


Figure 71. Setting the Channel to On

5. Select "Set Channel To On". At the top of the minute, the channel will appear un-greyed and the status will read "Ok".
6. Shut down Envidas Viewer.

7.10 Zero Background Test

The operator must perform a zero background test on the BAM 1020, 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.

7.10.1 Materials

The following materials are needed to complete a background test:

- BAM Operators SOP and the latest revision of the Met One BAM 1020 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

7.10.2 Zero Background Procedure

Both Models

1. Watch the weather forecast watching for 4-5 days of clear weather: no major fronts coming through, relatively low dew points (with regards to the earlier days) and no precipitation forecasted. Weather Underground (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 competed on 12/17 or 12/18.

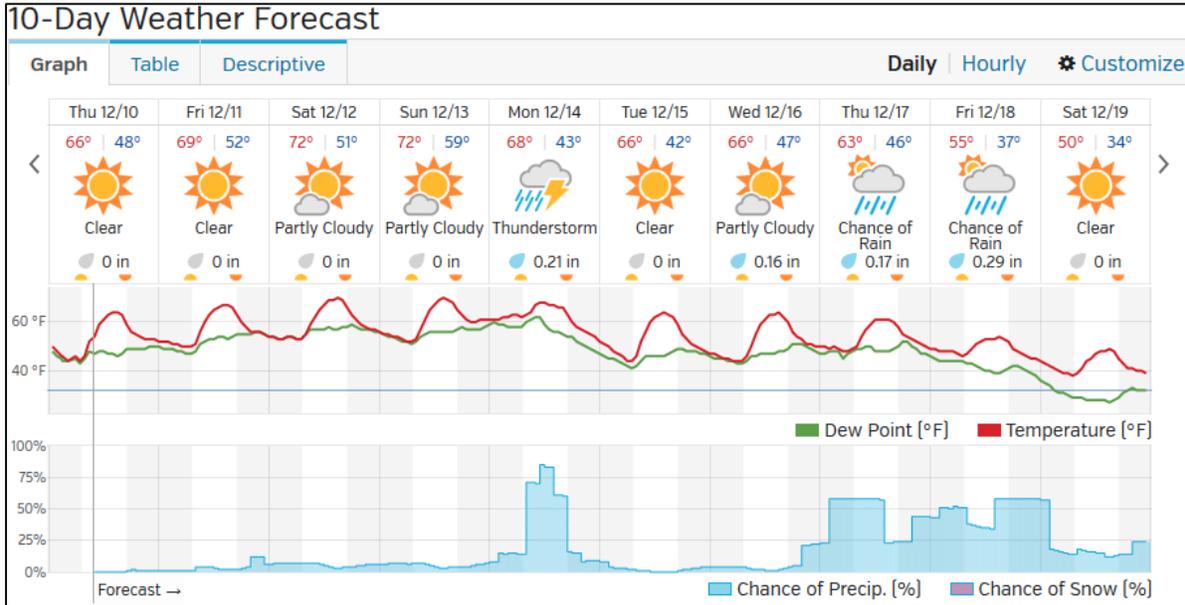


Figure 72. Example Weather Forecast.

2. The test must run between 48 and 72 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 DAS 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 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.**
7. Complete a full calibration of the monitor.



Figure 73. 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.

Touch Key

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.



Figure 74. Touch Key Background Constant Screen.

1. Press the <SETUP> and <CALIBRATE> touch keys.
2. Record the existing BKGD value in the e-log. Change the stated BKGD in the BAM 1020 to 0.0000 by using the arrow keys (optional).

3. Note the concentration type and set it to “Actual” if it is not. For PM10 monitoring, this should be set to “Standard”.
4. Note the flow type and set it to “Actual” if it is not already so (for both PM2.5 and PM10 monitoring).
5. Press the <SAVE> touch key and exit back to the main menu.

Touch Screen

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.

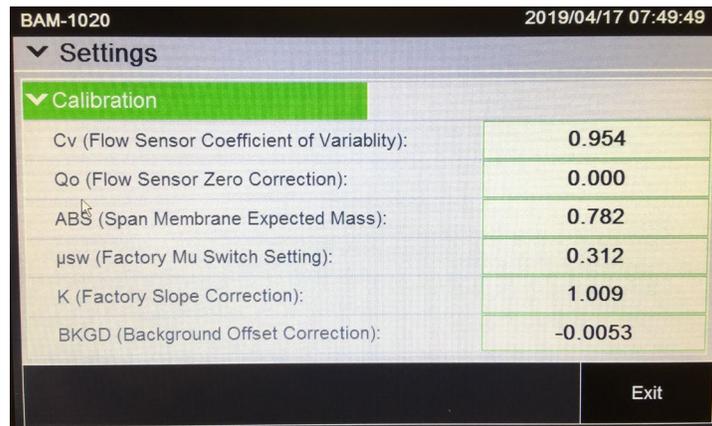


Figure 75. Touch Screen Background Constant Screen.

1. Enter the settings menu and then the calibration menu.
2. Record the existing BKGD value in the e-log. Change the stated BKGD in the BAM 1020 to 0.0000 by selecting the BKGD field and using the virtual keypad provided.
3. Save and exit back to the main menu.

Both Models (Cont.)

11. After no less than 53 hours (5 hours to ensure monitor stability and 48 hours of sampling), download the BAM 1020 hourly concentration data. Confirm that the monitor ran without disruption.
12. 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.

7.10.3 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 hourly 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 (Figure 81).

Data Report			
11/9/2016 9:25			
Location	1 T17002		
Time	ConcRT(μg	ConcHR(μ	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 76. 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 77. 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. See Table 8 for corrective action if the test does not pass.
4. Enter the new background calculated by the e-log into the BAM 1020.
5. 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 VSCC and PM10 head.

7.10.4 Zero Background Audit

1. With the newly calculated background value entered in the 1020, 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. If the test fails, see Table 8 for corrective actions.
4. If the background test passes, remove the HEPA filter assembly and replace the VSCC and PM10 head. Resume normal sampling.

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 and PM10 head
- Downtube cleaning kit
- BAM tape
- Scotch tape
- Flashlight

Table 9. Summary of Sampler Maintenance

Maintenance Activity	Frequency
<ul style="list-style-type: none"> • Clean nozzle, vane and rollers • Check BAM clock (see Section 5.0) • Check smart heater (touch to see if warm) • Download data, settings, and alarm files (see Section 9.0) 	Every 14 – 18 days
<ul style="list-style-type: none"> • Clean VSCC and inspect O-rings • Clean PM10 head and inspect O-rings • Wipe down interior and exterior of the BAM 1020 • Clean HVAC filter • Empty water collection bottle 	Every 30 days
<ul style="list-style-type: none"> • Verify BAM settings • Clean temperature probe and solar shield • Clean internal nozzle • Check seals on shelter doors • Clean downtube • Inspect downtube O-rings 	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 78. The PM10 Inlet Components.

8.1.1 Removing and Disassembling the Inlet

1. Remove the PM-10 head by lifting the inlet up and off the sample tube.
2. Using Figure 95 as a guide, unscrew the collector assembly from the accelerator assembly by turning the top portion counterclockwise.

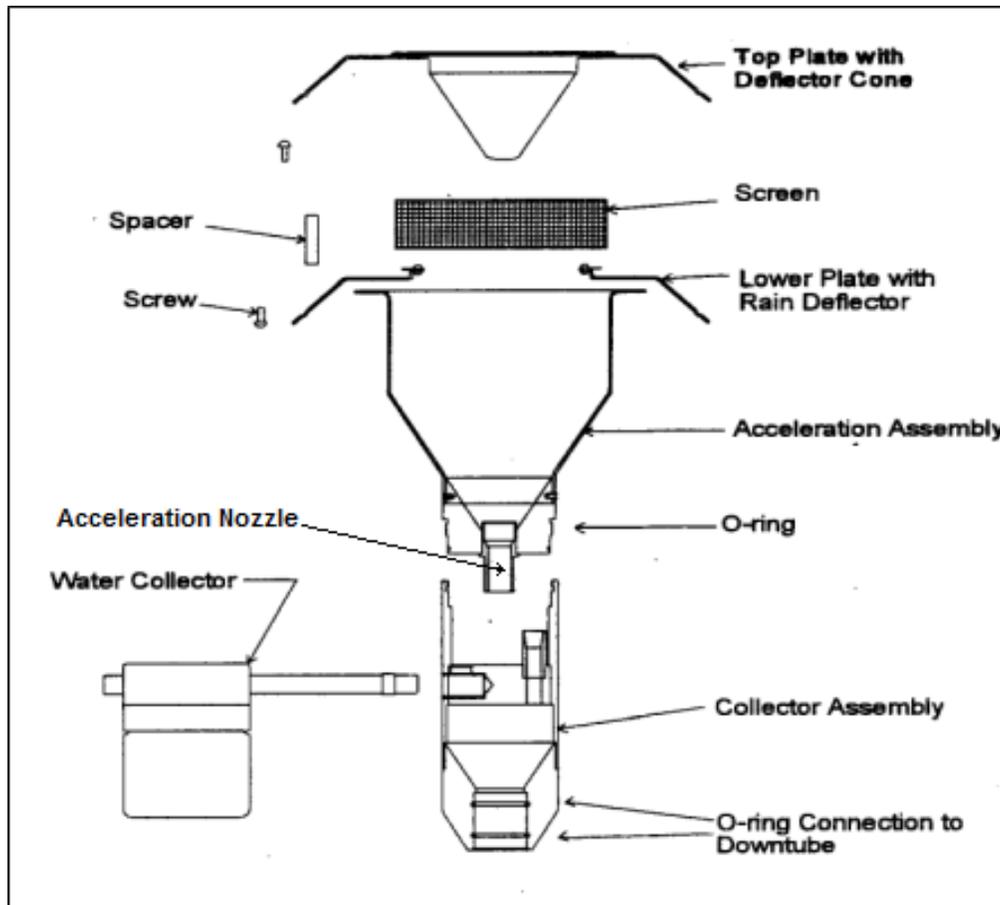


Figure 79. Exploded view PM-10 Inlet Assembly.

8.1.2 Cleaning and Maintaining the PM10 Accelerator Assembly

1. Remove the 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.

1. Use water (or alcohol) and a cotton swab to clean the acceleration nozzle.
2. Inspect the large O-ring between the accelerator and collection assembly. Lightly lubricate with the vacuum grease if necessary.
3. 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 80. Disassembled VSCC.

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 a 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 and unscrew the two grounding bolts at the base of the sampling inlet receiver.
5. Raise the tube enough to expose the sampling inlet receiver and tighten the inlet tube flange to hold the tube in place.



Figure 81. Inlet Tube Flange.

6. 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.
7. 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.***
8. Feed the weighted end of the pull rope assembly down through the inlet tube until it comes out the bottom.
9. 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.
10. Visually inspect to determine if the down tube is clean.
11. Loosen the inlet tube flange and lower the inlet tube, making sure that the inlet tube is seated correctly in the sampling inlet receiver.

12. If needed, adjust the position of the smart heater, allowing 1-1.5 inches of clearance between the smart heater and the sampling inlet receiver.
13. Rotate the inlet tube, along with the smart heater, to its original position and then tighten the inlet tube flange and the two grounding bolts.
14. 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 inlet tube flange around the downtube where it enters the enclosure so that the downtube can be raised.
4. Loosen, but do not remove, the hex screws that ground and hold the downtube in place
5. Slowly raise the downtube and tighten the waterproof flange to hold the downtube in place.
6. Inspect the upper inlet.
7. Gently slide the canned air tube down the inlet receiver on top of the BAM 1020. 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.
8. Inspect the tape below for debris. If debris is still present, repeat step 7.
9. Clean the collar of the downtube receiver, taking care to inspect all O-rings for shape and integrity. If at all suspect, replace the O-rings.

10. Loosen the inlet tube flange and lower the inlet tube, making sure that the inlet tube is seated correctly in the sampling inlet receiver.
11. If needed, adjust the position of the smart heater, allowing 1-1.5 inches of clearance between the smart heater and the sampling inlet receiver.
12. Rotate the inlet tube, along with the smart heater, to its original position and then tighten the inlet tube flange and the two grounding bolts.
13. 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 91 shows the difference between acceptable and inferior sampling areas. The tape on the left is from a properly operated BAM 1020 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.

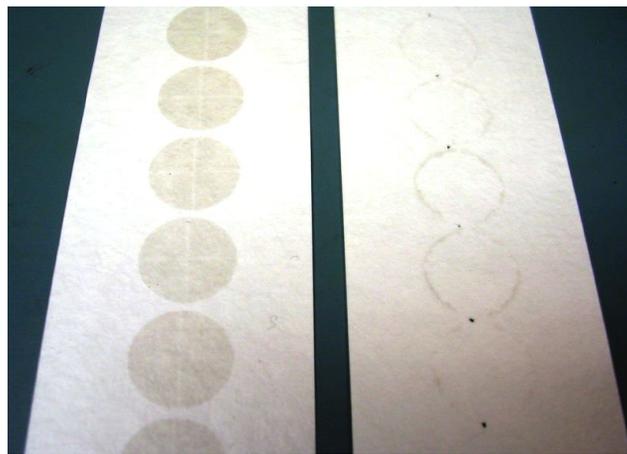


Figure 82. Hourly Filter Samples.

Other parts along the filter tape routing within the BAM 1020 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
- Distilled water
- Canned Air (a.k.a. Compressed Air Duster) with Tube

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

1. Complete an “As Found” leak check.
2. Raise the nozzle, if needed.
3. Lift the pinch roller and latch it into the “up” position.
4. Carefully remove the filter tape from the nozzle area. The tape just needs to be moved enough to access the nozzle. It is unnecessary to remove the tape completely from the unit, however, it might be helpful to slightly loosen the take-up and supply spools. The tape just needs to be moved enough to access the nozzle.
5. With the nozzle in the up position, inspect the nozzle and vane for any burrs that may cause leaks or tape damage. A small flashlight can aid in this observation.
6. Clean the vane with a cotton-tipped applicator and 90% isopropyl alcohol. Hardened deposits may have to be carefully scrapped off using the wooden end of the cotton-tipped applicator.
7. Lower the nozzle.
8. Manually lift the nozzle with your finger and insert another clean cotton-tipped applicator with alcohol between the nozzle lip and vane.
9. Carefully release the nozzle, letting the nozzle press down onto the swab with its spring pressure.
10. User your fingers to rotate the nozzle while keeping the swab in place. A few rotations should clean the nozzle’s lip.
11. Lift the nozzle with your finger and remove the cotton-tipped applicator.
12. Clean the capstan shaft using a cotton swab and isopropyl alcohol.

13. Clean the pinch rollers of any filter debris using either a dry, clean cotton swab or a swab with distilled water.
14. Reposition the filter tape between the nozzle and vane, making sure that the tape is centered. Adjust the tape to the point where it just touches the engraved line on all of the metal rollers.
15. Return the pinch roller to the “down” position.
16. Perform an “As Left” leak check.
17. Perform a Self-Test.
18. Return the BAM to the sampling mode.
19. Bring the BAM 1020 channels back online.

8.6 Cleaning the Ambient Temperature Probe and Solar Radiation Shield



Figure 83. Ambient Temperature Probe.

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

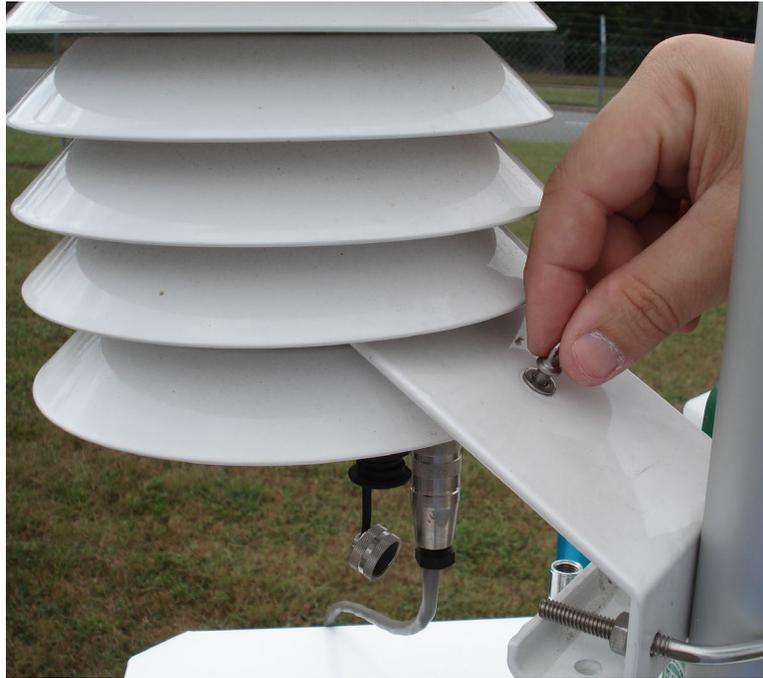


Figure 84. Ambient Temperature Probe Lock Screw.

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. Now, locate the intake fan in the sampling compartment, remove and clean filter as described above.

9.0 DATA HANDLING

This section describes the methods, other than using Envidas or Envista ARM, to retrieve digital data files through the RS-232 serial communications system on the BAM 1020. The BAM 1020 has one or more two-way RS-232 serial ports which may be used with a computer, laptop, modem, or digital data logger. The data can be accessed through the serial ports with a terminal program and a simple menu driven interface, or by using the free Comet software that comes with the BAM.

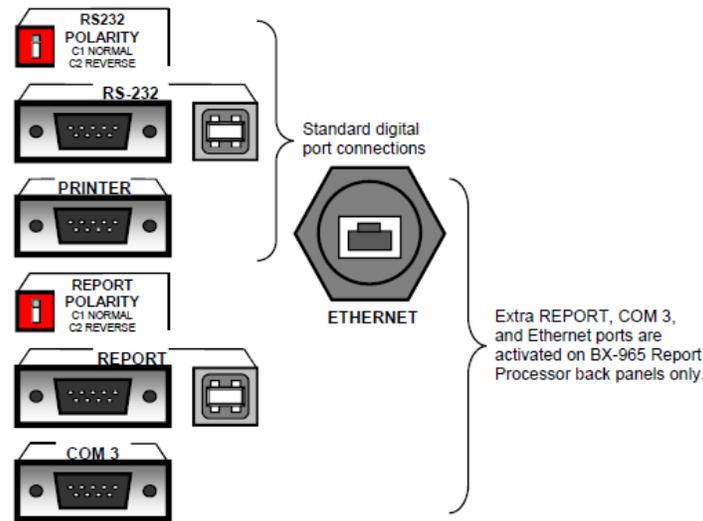


Figure 85. BAM 1020 Back Pane Connections.

9.1 Direct Serial Port Connections and Settings

The “RS-232” serial port on the back of the BAM 1020 handles data transfer directly from the BAM CPU, and can be used for less intensive digital collection systems. Units with the newer Report Processor back panel option also have a second REPORT serial port and USB serial converters. The REPORT port has its own file service system which can’t be interrupted or ignored by the BAM sample cycle, and should be used whenever available. Both the RS-232 and REPORT ports contain the same data files and are accessed in the same manner. The PRINTER port is output-only and is rarely used. The COM3 port is for connecting two BAMs together in PM-coarse systems only.

9.1.1 RS -232 Connections

Most older desktop and laptop computers have a standard 9-Pin serial port available for communications. In these circumstances, the BAM 1020 RS-232 or REPORT port can be directly connected to the serial port. Connect the port on the back of the BAM 1020 to the COM port connector

on the computer with the supplied BAM serial cable. **CAUTION: Do not confuse the parallel printer port or video adapter port on your computer with a serial port.**

9.1.2 USB Connections

Most newer computers no longer have the 9-Pin serial communications port. In these situations, BAM 1020 monitors may still be connected to the computers by using a USB to serial converter. Of the converters commonly available in local electronics and office supply stores, Met One Instruments, Inc. has seen the most reliable performance from those manufactured by Belkin.

Newer BAM 1020 monitors (or older models with the optional Report Processor installed) will have an active USB port available on the back panel. Contact ECB to obtain the necessary drivers for the computer to allow it to communicate with the BAM in this manner.

9.1.3 Communication Settings

The BAM 1020 communicates at 9600 Baud, 8 data bit, no parity, one stop bit, and no flow control. The default 9600 baud rate may be changed to a faster setting for downloading large BAM data files, but in any case, the terminal program baud rate must match the BAM baud setting. If unable to establish communications, try changing the RS-232 Polarity switch on the back of the BAM 1020. This swaps the polarity of the TX and RX lines (pins 2&3) and functions as a null modem. **NOTE: The BAM 1020 user interface must be in the main top-level menu or operate menu before any communication can be established through the RS-232 port.** The LCD display and keypad on the BAM 1020 are disabled whenever RS-232 communication with the CPU is in progress. The optional report port does not have these limitations.

9.2 Downloading Data via Comet and RS232

Each BAM 1020 is supplied with a free copy of **Comet™** utility software from Met One Instruments. Comet is a communications terminal program which can retrieve data from the BAM 1020 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 1020 display must be on the main menu in order to establish communications.** To create a new station in Comet, complete the following.

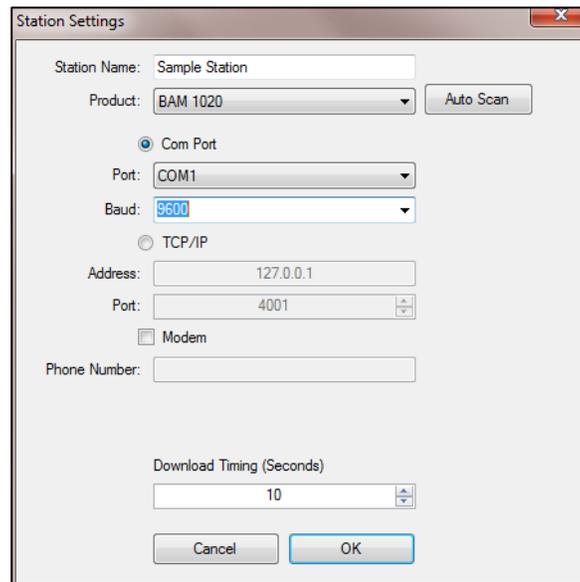


Figure 86. Example RS-232 BAM 1020 Setup in Comet.

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 1020”.
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 via Flash Drive (Touch Screen)

The newer versions of the BAM 1020 data can be downloaded onto a flash drive without using Comet. On the inside of the BAM door, there is a USB interface. Simply insert a flash drive into the USB port and navigate to the “Transfer Data” selection of the BAM “Operate” menu.

9.4 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 (Figure 8791). *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.*

The screenshot shows a 'Station Settings' dialog box with the following configuration:

- Station Name: Sample Station Remote
- Product: BAM 1020
- Com Port: COM1
- Baud: 300
- Connection Type: TCP/IP (selected)
- Address: 127.0.0.1
- Port: 9885
- Modem: unchecked
- Phone Number: (empty)
- Download Timing (Seconds): 10

Figure 87. Example Remote BAM 1020 Setup in Comet.

9.5 Downloaded Data Files

9.5.1 Data File

The data file contains all of the raw data recorded on the internal hard drive of the BAM. The first column is the time and date. The second column is the concentration. The Qtot column is the total flow volume for the hour. With a flow rate of 16.7 L/min and a sample time of 42 minutes, this value will be about 0.701 m³/hr. The remaining six columns are the six data logger inputs on the BAM including but not limited to: relative humidity, ambient temperature, and filter temperature.

9.5.2 Settings File

The settings file will contain a list of the BAM 1020 settings and calibration values. This is useful for verifying the setup parameters and ensuring that the slope of the calibration is between 0.9 to 1.1.

9.5.3 Alarms File

The alarms file is a log of the date, time, and alarm code of the BAM. 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.

10.0 QUALITY ASSURANCE AND DATA HANDLING

10.1 Daily Data Review

Each regional office should set up Envista to send out automated reports each morning. Contact the Data Acquisition Manager for more information.

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 88. 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 and the corresponding BAM shelter temperature should be reviewed. It is at the discretion of the RAMC 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_{2.5} concentration exceeds 35 µg/m³, alert the Regional Ambient Monitoring Coordinator and the RCO particulate matter lead immediately. The daily maximum PM_{2.5} concentrations should be below 30 µg/m³.

A negative concentration is likely, especially during periods of extended precipitation. Repeating concentrations of -5 µg/m³ is indicative of either a monitor or an onsite Envistas malfunction. The cause of this must be investigated immediately.

It is mandatory that the BAM shelter temperature be maintained between 28 to 32 °C. It is expected that the thermostat will need to be adjusted in the fall and spring because of wide variations in ambient conditions. If a temperature event (outside of the acceptable range) continues to reoccur, corrective action is necessary. If you are not sure if corrective action is necessary, contact RCO particulate matter lead or ECB.

10.2 Field Operator Quality Assurance

Upon arriving at a site, the field operator is responsible for ensuring that the monitor has collected 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 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 (audits, verifications, audits)

10.3 Regional Ambient Monitoring Coordinator Quality Assurance

The regional ambient monitoring coordinator (RAMC) is responsible for reviewing all raw data and logbooks prior to submitting the data to RCO. The specific QA duties for the regional ambient monitoring coordinator are described in the following sections.

10.3.1 BAM Download Review

The RAMC is responsible for reviewing the BAM 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 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 RAMC 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. 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 Verification

Below are the steps for reviewing and verifying the 1020 Envista data:

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

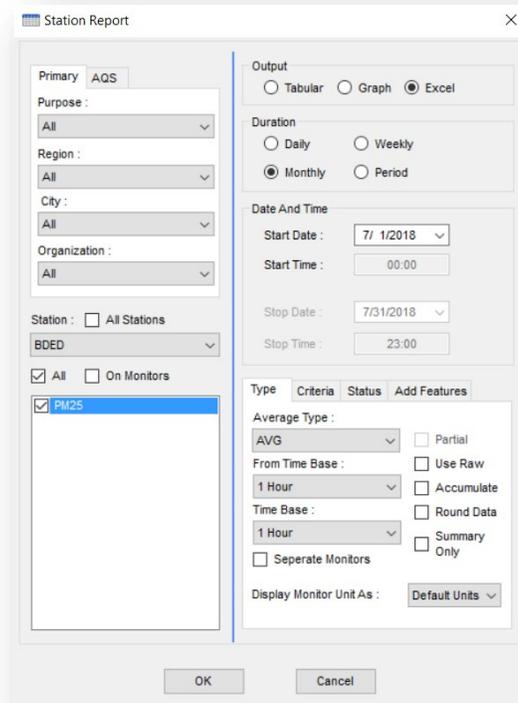


Figure 89. Station Report Screen.

2. Select the correct monitoring station, parameter (channel for the BAM 1020 and BAM Temp), monthly date range and time base (1 hour). Select the output as <Excel> and click on <OK>.

- 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.
- Using conditional formatting, highlight all 1020 BAM values that are less than $-5 \mu\text{g}/\text{m}^3$.
- Using conditional formatting, highlight all 1020 BAM temperature values that are not between 28 and 32°C. Save this spreadsheet for the next step.
- Open Envista ARM and select the <Edit> tab. Click on <Station>. A box like the one below will appear.

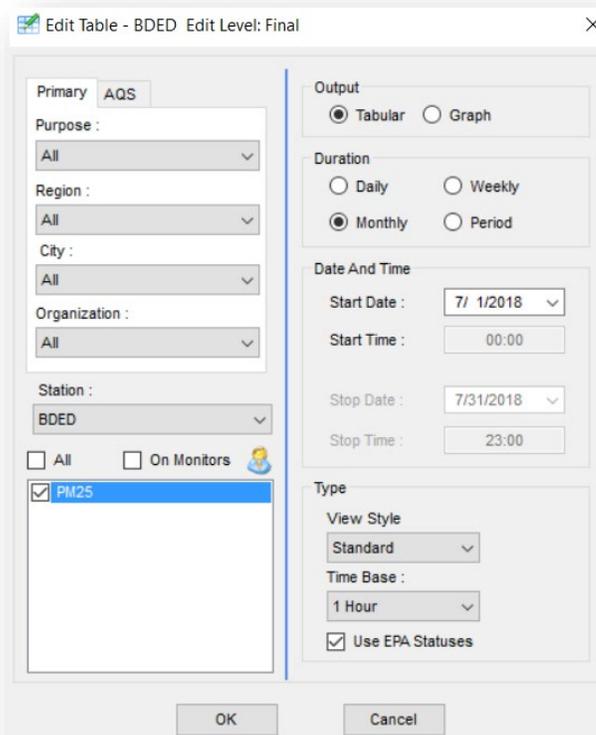


Figure 90. Edit Table Screen.

- Select the correct monitoring station, parameter (channel for the BAM 1020 and **no** BAM Temp), monthly date range and time base (1 hour). Select the output as <Tabular> and click on <OK>.The system should then promulgate a monthly tabular report sheet with the corresponding monthly data.
- Using the saved spreadsheet, locate all hourly BAM PM values that correspond to an hour that had temperatures **not** between 28 and 32. Select the **value** and right click. Click on

<Enter/Change Explanation/Comment> in the menu that appears. The following screen should appear.

The screenshot shows a dialog box titled "Enter Explanation/Comment". On the left, there is a dropdown menu for "Explanation" with "(None)" selected, and a text area for "Comment". On the right, there is a section for "Additional Explanations (Max 9)" with a counter showing "0". Below this is a list of checkboxes for various explanation codes: 1. Deviation from a CFR Critical Criteria Requirement, 1C. 1-Point QC check exceeds, evidence data is v..., 1V. Data reviewed and validated (ALL), 2. Operational Deviation (ALL), 3. Field Issue (ALL), 4. Lab Issue (ALL), 5. Outlier (ALL), 6. QAPP Issue (ALL), 7. Below Lowest Calibration Level (ALL), 9. Negative value detected - zero reported (ALL), CB. Values have been Blank Corrected (ALL), CC. Clean Canister Residue (ALL), and CL. Surrogate Recoveries Outside Control Limits (ALL). At the bottom of the dialog are "Add / Change" and "Cancel" buttons.

Figure 91. Comment Screen.

9. Using the dropdown menu, select the flag “6 – QAPP Issue” for all values having been taken during an hour when the temperature was out of range. Click on <Add/Change>.
10. Using the saved spreadsheet, locate all values that are less than -5. Select the value and right click. Click on <Enter/Change Explanation/Comment>.
11. 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 “AN – Invalid”. Click on <Add/Change>.
12. 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>.
13. 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>.
14. Verify the 1020 Envista data with the 1020 download data.
 - a. Pick three random days in the month and select the highest concentrations for review.

- b. Open the 1020 data download for the corresponding days and verify that the 1020 download concentration is within $1 \mu\text{g}/\text{m}^3$ of the concentration in the 1020 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 1020 downloaded data should be used in replacement of the 1020 Envista data.
15. Go through the data report and add the null data codes (Appendix C) 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.
16. Confirm these void hours in the report with the verification, audit and maintenance events recorded in the 1020 E-log. Save your changes.
17. Once finished, select <Validation settings> from the Edit tab.
18. Select the monitoring site and parameters you wish to verify.
19. 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 unit is programmed not to start a sample cycle until the beginning of an hour. Make sure the clock is set correctly.
- The unit will wait until the beginning of a new hour before it starts, even if the operation mode is set to ON.
- Don't expect the pump to turn on until the clean tape count is finished, about 8 minutes after the start of the hour.
- The unit cannot start if the pinch rollers are latched in the up position. The unit cannot lower them.
- Make sure the filter tape is installed correctly.
- The unit will never start a cycle if the display is left in a TEST or SETUP menu. The main screen menu must be displayed.
- The unit will usually display an error if it cannot start a new sample cycle.

The filter tape keeps breaking during normal operation.

- The photo sensors which watch the tape transport motion may be out of alignment. Check the photo sensors using the instructions in the operations manual.
- This is sometimes caused by misalignment of the "SHUTTLE" photo sensor or the interrupter flag on the end of shuttle beam inside the BAM. Contact ECB.

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 nozzle and vane as outlined in Section 8.0.
- 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 (see Section 7) of the mass monitor.
- The BKGD zero correction offset value may have been incorrectly entered, or may need to be audited. Met One supplies the BX-302 zero filter kit for auditing the zero average and noise floor of the unit. Set the BKGD value to 0.000 during the test.
- Look for sources of electrical noise, such as bad grounding. Any source of noise will show up in the zero filter test.
- Verify that the inlet tube is grounded to the chassis of the BAM-1020.

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 as outlined in Section 8.0.
- 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.
- Checking the 18.4 L/min point during the regular 3-point flow audits verifies the pump capacity.
- 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.
- Check the zero of the flow sensor in the BAM: Perform another leak check, but disconnect the tubing between the pump and the BAM, so there can be no air flow through the unit. Verify that the flow reading on the BAM reads less than 0.2 L/min. If not, the flow sensor **Q0** zero offset setting may need to be adjusted in the SETUP > CALIBRATION menu. The Q0 setting is usually very close to zero.

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 1020 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.

E – External Reset or Interface Reset

This alarm indicates that an external data logger sent a clock synchronization signal to the BAM on the EXT RESET input, but the BAM was unable to reset its clock, because it occurred outside of the allowable time window. Hourly clock reset signals will be ignored by the BAM from minutes 5-54 (standard cycle) or minutes 0-49 (early mode). The alarm will also be generated if the synch signal occurs within the acceptable window near the end of the hour, but before the BAM has finished the previous concentration calculation. The digital error log will indicate which of these two conditions have occurred. If an external clock reset event is successful, then no alarm is logged. These alarms do

not prevent the BAM from storing a valid data record for the sample hour. Manually set the BAM 1020 clock to match the data logger clock initially. This should cause subsequent clock synch events to succeed. Make sure the BAM lithium battery is functional by using a multi-meter or exchanging the battery with a new one.

M – Maintenance Alarm

This alarm almost always indicates that the sample cycle was stopped because someone entered a SETUP or TEST menu for calibration or testing purposes. Maintenance flags always cause the digital concentration value to go full-scale for that hour, because the sample cycle was not finished.

I – Internal Error or Coarse Link Down

In BAM 1020 units configured as the PM10 master unit in a PM-coarse pair, the “I” alarm indicates that the digital link between the two units is down, and the master unit could not obtain the PM2.5 value from the slave unit and thus could not calculate a coarse value. The coarse and PM2.5 values will be full-scale. Contact ECB if this occurs.

L – Power Failure or Processor Reset

This error occurs if AC input power is lost even momentarily, or if the power switch is turned off. Frequent “L” errors usually indicate poor quality AC power. If frequent power errors occur even when the BAM 1020 is connected to a UPS backup system, contact ECB for instructions on possible power supply upgrades. Anything that causes the microprocessor to reset will also result in an “L” error, such as low voltage on the 5.25V Vcc bus, bad connections on the internal DC power harness, or in rare cases electrical interference. All power failure errors cause the digital concentration value to go full-scale.

N – Nozzle Error

This error indicates that the nozzle motor is not operating correctly. The error is triggered if photo sensors S4 and S5 never change state within 12 seconds, despite drive commands to nozzle motor. The concentration value is set to full-scale if the nozzle motor or sensors have failed. The digital error log will indicate which photo sensor timed out. Contact ECB if this occurs.

F – Flow Error

Flow errors can occur due to a fault with the flow controller, the flow sensor, or the vacuum pump. See section 7.5 for troubleshooting suggestions. The digital error log contains the exact subcategory which generated the alarm. The following minor flow alarms occur when a parameter was out of bounds, but the sample was not stopped.

P – Pressure Drop Alarm or Delta-Pressure Alarm

This error indicates that the pressure drop across the filter tape has exceeded the limit set by the “AP” value and is often due to heavy particulate loading. Current firmware will stop the sample early when this occurs, and make the concentration calculation based on the partial volume, then wait for the next hour. This feature is designed to stop the sample early if the vacuum capacity of the pump is about to be exceeded, before flow errors occur. Contact ECB if this occurs.

T – Tape System Error or Filter Tape Error

The tape error usually indicates that the filter tape is has run out or broken. It occurs if the right spring-loaded tensioner (tape roller nearest to the detector) is at the far left limit of its travel. In this case, tape break photo sensor S6 is ON continuously, despite drive commands to the tape reel motors and the capstan motor. The tape error is also generated if the pinch rollers are latched in the up position when a new sample hour starts, preventing the cycle. Contact ECB if this occurs.

12.0 REVISION HISTORY

13.0 REFERENCES

Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, Part 1, Ambient Air Quality Monitoring Program Quality System Development Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II- Ambient Air Specific Methods, EPA-454/B-08-003, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C. 27711, 2008.

Guideline on the Meaning and Use of Precision and Bias Data Required by 40 CFR 58, Appendices A, U. S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Research Triangle Park, N.C. 27711, 2007.

Title 40 Code of Federal Regulations Part 50, 2014

Title 40 Code of Federal Regulations Part 58- Ambient Air Quality Surveillance. 2008.

Operations Manual (Revision L). BAM-1020-9803 Particulate Monitor Operations Manual (Touch Screen). Met One Instruments, Inc.

Operations Manual (Revision W). BAM-1020-9800 Particulate Monitor Operations Manual (Touch Key). Met One Instruments, Inc.

6- EPA Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G- 6. Office of Environmental Information. Washington, D.C. April 2007.

EPA Quality Assurance Guidance Document Method Compendium Addendum A. Andersen RAAS2.5-200 Audit Sampler. Field Standard Operating Procedures for the PM2.5 Performance Evaluation Program. Office of Air Quality Planning and Standards. Research Triangle Park, NC. March 2009.

Appendix A: Internal Leak Check Procedures

The filter tape is removed and the rubber seal is inserted with the hole centered under the nozzle (Figure A 1). The seal allows the leak check to be performed similar to the external leak check (from the VSCC through the entire system), but without any leakage through the filter tape.



Figure A 1. Leak Isolation Shim.

The leak value should drop to 0.2 LPM or less with this method. 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. If the nozzle and vane are thoroughly clean, but a leak persists, inspect/replace the O-rings in the VSCC and perform the test again. If the source of the leak cannot be identified, contact the ECB. The leak test procedure using the rubber seal is as follows:

1. From the “Main Menu”, press the <TEST> soft key to enter the TEST MODE screen.
2. Using the red <ARROW> keys, scroll to PUMP and press the <SELECT> key.
3. If the pump is running, press the <PUMP OFF> key. If the nozzle is in the down position, press the <MOVE NOZZLE> key to move it to the up position.
4. Lift the pinch roller until the latch automatically locks it in the up position. Carefully slide the filter tape out of position. This may require unwinding a very small amount of filter tape from the roll to provide some slack in the tape without causing damage to the tape.
5. Insert the provided rubber nozzle seal (Part #7440 with a ¼” hole and center it under the nozzle. Make sure the surfaces of the rubber seal are clean and dust free. Cleaning can be accomplished by using water and a lint free wipe.

6. Remove the PM₁₀ head only from the inlet tube. Install a BX-305 or BX-302 leak test valve (or equivalent valve for auditing FRM samplers) onto the cyclone inlet and turn the valve to the OFF position to prevent any air from entering the inlet tube.
7. Press the <MOVE NOZZLE> key to lower the nozzle and press the <PUMP ON> key to start the pump.
8. Observe the flow reading on the screen, which should be dropping toward zero. After 2-3 minutes, or when the reading has become stable, record the value in the comments section of the e-log. A value of 0.2 LPM or less indicates an acceptable leak test. If the leak test fails, this may mean that the nozzle and vane are dirty and must be cleaned. After completion of the cleaning procedure, repeat the leak test, making sure that all rubber “O” rings (cyclone/leak check device) are in place and are not damaged. If the source of the leak cannot be identified, contact ECB.
9. Upon completion of the leak test, press the <PUMP OFF> key. Release the vacuum and remove the audit test device. Replace the PM₁₀ head.
10. Press the <MOVE NOZZLE> key to move the nozzle to the up position and remove the rubber nozzle seal.
11. Carefully place the filter tape back into position under the nozzle, advance the filter tape approximately six inches to provide a clean filter spot and rewind the filter tape to remove any slack.
12. Move the latch to release the pinch roller.
13. Press the <EXIT> soft key as necessary to return to the MAIN MENU.
14. The BAM 1020 will return to normal sample operation at the beginning of the next hour. Record all results on the e-log.

Appendix B: EPA Memo Regarding Zero Tests

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 operation¹. 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 temperature²) 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)
 - 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 $-2.0 \mu\text{g}/\text{m}^3$ 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 calculation³) 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:

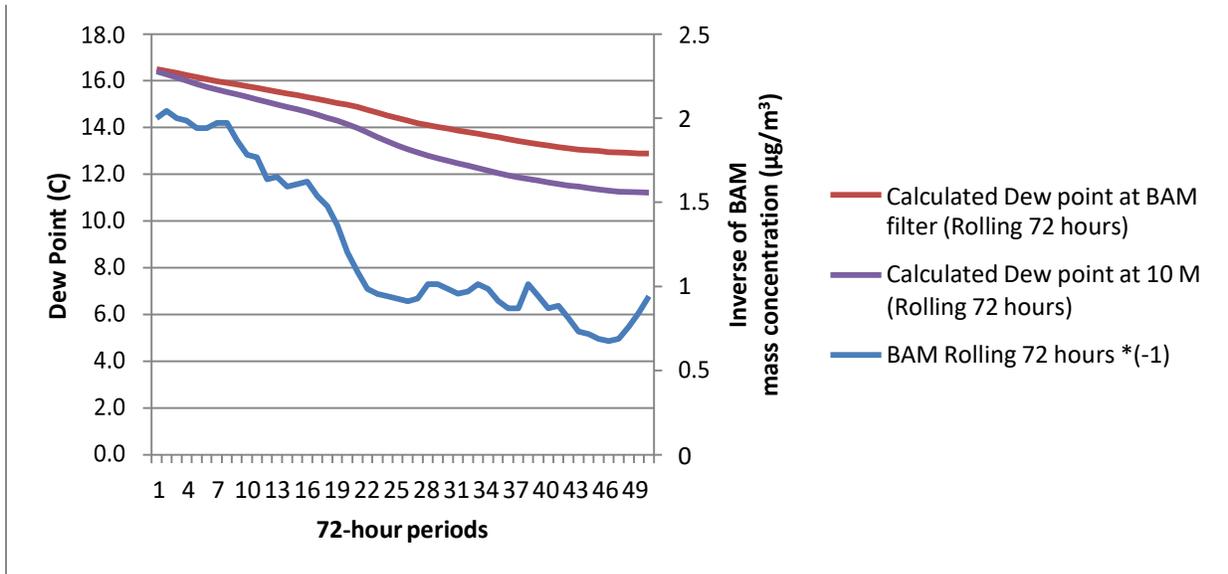
As mentioned above, I am sending this technical note now as a large portion of the country is transitioning from relatively higher to lower dew points. As you incorporate these changes, we are interested in hearing from you on your experiences and results of incorporating these more frequent zero tests. 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 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 $2.0 \mu\text{g}/\text{m}^3$. 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 $1.0 \mu\text{g}/\text{m}^3$.

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



¹During 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.

²For 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.

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.

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

Appendix C: Frequently Used BAM Data Validation Codes

Table C 1. 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
SA	Storm Approaching
SV	Sample Volume out of limits

Table C 2. 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.

Appendix E: BAM Coarse Units

1.0 SAMPLER DESCRIPTION

The BAM coarse system allows for the collection of PM₁₀, PM_{2.5}, and PM_{10-2.5} measurements. The system consists of two separate BAMS: a PM₁₀ monitor (master unit) and a PM_{2.5} monitor (slave unit). The PM_{2.5} monitor measures, stores, and displays PM_{2.5} concentrations similar to that of a standalone unit. The PM₁₀ unit measures PM₁₀ concentrations and collects the PM_{2.5} data from the slave unit. The PM₁₀ master unit also calculates the PM coarse value (PM₁₀-PM_{2.5}), stores and displays all three concentration values for each hour, synchronizes the clock timing between the two units, and monitors both units for errors and alarms.

The BAM 1020 Coarse consists of two separate BAMS: a PM₁₀ monitor and a PM_{2.5} monitor. Individually, each unit works like a single BAM unit with a few differences:

1. The PM₁₀ BAM does not use a VSCC.
2. Both BAMS must undergo a zero test and calibrations at the same time.
3. A total of four PM data sets are recorded: PM_{2.5}, PM₁₀, PM Coarse, and PM₁₀ standard data.

2.0 MENUS AND SETUPS

All BAM 1020 coarse units must have a special firmware installed by ECB. Most of the user interface screens and menus are the same as the normal PM_{2.5} BAM 1020.

3.0 CALIBRATION

Calibration of the BAM coarse unit is the same as that described in Section 6.0 of the BAM 1020 Operator's SOP. The PM₁₀ BAM and the PM_{2.5} BAM of the coarse unit must be calibrated at the same time in addition to any other collocated particulate matter samplers at the site.

4.0 VERIFICATIONS, CHECKS, AND AUDITS

Verifications, checks, and audits of the BAM coarse unit is the same as that described in Section 7 of the BAM 1020 Operator's SOP. Complete the required verifications, checks, and audits on both the PM₁₀ BAM and the PM_{2.5} BAM.

5.0 ZERO BACKGROUND TEST

The zero background test for the BAM coarse unit is the same as that described in the BAM 1020 Operator's SOP. The PM10 BAM and the PM2.5 BAM of the coarse unit must undergo background tests at the same time.

6.0 MAINTENANCE

Maintenance of the BAM coarse unit is the same as that described in the BAM 1020 Operator's SOP. Maintenance of the PM10 BAM and the PM2.5 BAM should be performed at the same time. As noted previously, the PM10 BAM does not have a VSCC and therefore does not need any routine maintenance.

7.0 DOWNLOADING DATA

Downloading data from the BAM coarse unit is the same as that described in Section 9.0 of the BAM 1020 Operator's SOP. Data (alarms, settings, and data) is all downloaded from the BAM 1020 PM10 (master) unit. Operators should ensure that the downloaded data contains the PM2.5, PM10, and PM Coarse values. The PM10 Standard concentrations are calculated using a math setting in the data logger.

8.0 QUALITY ASSURANCE AND DATA HANDLING

Quality assurance of the BAM coarse unit is similar as that described in Section 10.0 of the BAM 1020 Operator's SOP. Operators and the Regional Ambient Monitoring Coordinators are responsible for the quality assurance of the PM2.5, PM10, PM Coarse, and PM10 Standard data. There are two deviations from the main SOP involving the use of void codes:

- If a null code is used for the PM10 BAM, an "AI" void code should be used for the PM10 Standard value, for that same period, to indicate that there is insufficient data to calculate the standard concentration.
- If a null code is used for either the PM2.5 or PM10 BAM, an "AI" void code should be used for the PM Coarse value, for that same period, to indicate that there is insufficient data to calculate the coarse concentration.