BAM 1020
PARTICULATE MONITOR
OPERATION MANUAL

BAM-1020-9800 REV G

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1 INTRODUCTION

1.1 About This Manual

This document is organized with the most important information toward the front of the manual, such as site selection, installation, setups, and field calibrations.

Sections and sub-sections marked with an Information Symbol contain critical information which all BAM-1020 owners and operators should read and understand. Toward the back are sections that provide in-depth information on subjects such as theory, diagnostics, accessories, and alternate settings. These sections provide valuable information which should be consulted as needed. Electronic versions of this manual are also available.

1.2 Technical Service

This manual is structured by customer feedback to provide the required information for setup, operation, testing, maintaining, and troubleshooting your BAM-1020 unit. Should you still require support after consulting your printed documentation, we encourage you to contact one of our expert Technical Service representatives during normal business hours of 7:00 a.m. to 4:00 p.m. Pacific Standard Time, Monday through Friday. In addition, technical information and service bulletins are often posted on our website. Please contact us and obtain a Return Authorization (RA) number before sending any equipment back to the factory. This allows us to track and schedule service work and expedite customer service.

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1.3 BAM: Beta Attenuation Monitor

The Met One Instruments model BAM-1020 automatically measures and records airborne particulate concentration levels using the principle of beta ray attenuation. This method provides a simple determination of concentration in units of milligrams or micrograms of particulate per cubic meter of air. A small ^{14}C (Carbon 14) element emits a constant source of high-energy electrons known as beta particles. These beta particles are detected and counted by a sensitive scintillation detector. An external pump pulls a measured amount of dust-laden air through a filter tape. After the filter tape is loaded with ambient dust, it is automatically placed between the source and the detector thereby causing an attenuation of the beta particle signal. The degree of attenuation of the beta particle signal is used to determine the mass concentration of particulate matter on the filter tape, and hence the volumetric concentration of particulate matter in ambient air. A complete description of the measurement cycle is included in Section 4. In addition, an in-depth scientific explanation of the theory of operation and the related equations is included toward the back of the manual.

1.4 Beta Radiation Safety Statement

The Met One Instruments BAM-1020 contains a small ^{14}C (Carbon 14) beta radiation-emitting source. The activity of the source is **60 μCi** ±15μCi (microcurries), which is below the "Exempt Concentration Limit" as defined in 10 CFR Section 30.70 – Schedule A. The owner of a BAM-1020 is not required to obtain any license in the United States to own or operate the unit. The owner of a BAM-1020 may elect to return the entire unit to Met One Instruments for recycling of the ^{14}C source when the unit has reached the end of its service life, although the owner is under no obligation to do so. 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 5730 years, and should never need to be replaced. Neither the ^{14}C source nor the beta particle 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.

1.5 Model BAM-1020 PM_{10} USEPA Equivalent Method

The Met One Instruments, Inc. Model BAM-1020 is designated as an equivalent method for PM_{10} monitoring by the United States Environmental Protection Agency on August 3, 1998.

Designation Number: **EQPM-0798-122**

The EPA designation applies to G, -1, G-1, and later BAM-1020 PM_{10} Beta Attenuation Monitors, when used in conjunction with the following requirements. Users are advised that configurations that deviate from this specific description may not meet the applicable requirements of 40 CFR Parts 50 and 53.

- The BAM-1020 is operated to obtain a daily average of the hourly measurements, with a filter change frequency of one hour.
- The inlet must be equipped with the standard BX-802 EPA PM_{10} inlet head.
- The unit must be used with standard glass fiber filter tape.
- The unit may be operated with or without any of the following options: BX-823 inlet tube extension, BX-825 heater kit, BX-826 230V heater kit, BX-828 roof tripod, BX-902 exterior enclosure, BX-903 exterior enclosure with temperature control, BX-961 mass flow controller, BX-967 internal calibration device.
- The SAMPLE TIME parameter must be set for 50 minutes.

1.6 Model BAM-1020 $PM_{2.5}$ USEPA Equivalent Method

The Met One Instruments, Inc. Model BAM-1020 Beta Attenuation Mass Monitor - $PM_{2.5}$ FEM Configuration, is designated as an equivalent method for $PM_{2.5}$ monitoring in accordance with 40 CFR Part 53 by the United States Environmental Protection Agency as of March 12, 2008.

Designation Number: **EQPM-0308-170**

All of the following parameters and conditions must be observed when the BAM-1020 is operated as a $PM_{2.5}$ FEM particulate monitor:

- The inlet must be equipped with an EPA-designated $PM_{2.5}$ Very Sharp Cut Cyclone (VSCC™-A by BGI, Inc.). The Met One stock number for the VSCC™ is BX-808.
- The inlet must be equipped with a standard EPA PM_{10} inlet head. Met One BX-802.
- The unit is operated for hourly average measurements. The $PM_{2.5}$ concentration is calculated (external to the BAM) as a daily average of the hourly concentration measurements made by the BAM-1020.
- The unit must be equipped with firmware revision 3.2.4 or later.
- The BAM-1020 must be operated in proper accordance with this operation manual, revision F or later. A supplemental BGI Inc. manual is also supplied with the VSCC™.
- The unit must be equipped with a BX-596 ambient temperature and barometric pressure combination sensor. This is used for flow control and flow statistics.
- The unit must be equipped with the internal BX-961 automatic flow controller, and must be operated in Actual (volumetric) flow control mode.
- The unit must be equipped with a BX-827 (110V) or BX-830 (230V) Smart Inlet Heater, with the heater RH regulation setpoint set to 35%, and Delta-T control disabled.
- The unit must be equipped with the 8470-1 rev D or later tape control transport assembly with close geometry beta source configuration. All BAM-1020 units manufactured after March 2007 have these features standard. Older units will have to be factory upgraded and re-calibrated to the latest specifications.
- The unit must be operated with standard glass fiber filter tape.
- The COUNT TIME parameter must be set for 8 minutes.
- The SAMPLE TIME parameter must be set for 42 minutes.
- The BX-302 zero filter calibration kit is a required accessory. This kit must be used to audit the BKGD (background) value upon unit deployment and periodically thereafter, as described in the BX-302 manual.
- The unit may be operated with or without a BX-823 eight foot inlet tube extension and with or without weatherproof outdoor enclosures BX-902 or BX-903.

1.7 BAM-1020 Specifications

PARAMETER	SPECIFICATION
Measurement Principle:	Particulate Concentration by Beta Attenuation.
US-EPA Existing Designations:	PM_{10}: EPA EQPM-0798-122 $PM_{2.5}$: Class III EPA EQPM-0308-170
Standard Range:	0 - 1.000 mg/m^3 (0 - 1000 μg/m^3)
Optional Ranges:	0 - 0.100, 0.200, 0.250, 0.500, 2.000, 5.000, 10.000 mg/m^3 (special applications)
Accuracy:	Exceeds US-EPA Class III $PM_{2.5}$ FEM standards for additive and multiplicative bias.
Resolution:	± 0.1 μg/m^3
Lower Detection Limit: (2σ) (1 hour)	Less than 4.8 μg/m^3 from 0.000 to 0.100 mg/m^3 (less than 4.0 μg/m^3 typical)
Lower Detection Limit: (2σ) (24 hour)	Less than 1.0 μg/m^3
Measurement Cycle Time:	1 Hour
Flow Rate:	16.7 liters/minute. Adjustable 0-20 LPM range. Actual or Standard flow.
Filter Tape:	Continuous glass fiber filter, 30mm x 21m roll. > 60 days/roll.
Span Check:	Automatic 800ug (typical) span foil verified hourly.
Beta Source:	^{14}C (carbon-14), 60 μCi ±15 μCi (< 2.22 X 10^6 Beq), Half-Life 5730 years.
Beta Detector Type:	Photomultiplier tube with organic plastic scintillator.
Operating Temp. Range:	0 to +50°C
Ambient Temp. Range:	-30° to +60°C
Ambient Humidity Range:	0 to 90% RH, non-condensing.
Humidity Control:	Actively controlled inlet heater module, 10 - 99% RH setpoint.
Approvals:	US-EPA, CE, NRC, TUV, CARB, ISO-9001
User Interface:	Menu-driven interface with 8x40 character LCD display and dynamic keypad.
Analog Output:	Isolated 0-1 VDC output standard. 0-10V, 4-20mA, 0-16mA switch-selectable.
Serial Interface:	RS-232 2-way serial port for PC or modem communications.
Printer Output:	Output-only serial port, data or diagnostic output to a PC or serial printer.
Telemetry Inputs:	Clock Reset (voltage or contact closure), Telemeter Fault (contact closure).
Alarm Contact Closures:	Data Error, Tape Fault, Flow Error, Power Failure, Maintenance.
Compatible Software:	MicroMet Plus®, Comet™, HyperTerminal®, ProComm Plus®.
Error Reporting:	User-configurable. Available through serial port, display, and relay outputs.
Memory:	4369 records (182 days @ 1 record/hr).
Power Supply:	100 - 230 VAC, 50/60 Hz. 0.4 kW 3.4A max.
Weight:	24.5 kg (54 lbs) without external accessories.
Unit Dimensions:	H x W x D = 31cm x 43cm x 40cm (12.25” x 17” x 16”).

*Specifications may be subject to change without notice.

2 SITE SELECTION AND INSTALLATION

2.1 Unpacking and Inspection

If any damage to the shipment is noticed before unpacking, **a claim must be filed with the commercial carrier immediately**. Notify Met One Instruments after notification of the commercial carrier.

Remove the unit and accessories from the shipping boxes and compare the received items to the packing list. Make sure you have all of the required items for the type of installation you plan to perform.

The BAM-1020 is shipped with two white foam rings and a white plastic shim inside the front of the unit, which prevent the moving parts of the tape control assembly from being damaged in transit. Do not remove the foam rings until the BAM-1020 is ready to be installed. These rings must be replaced anytime the unit is being transported in order to avoid damaging the tape control mechanism.

Please keep the special box and foam packing material that the BAM-1020 was shipped in, to re-use in the event that you must return the unit to the factory. Met One is not responsible for any damages to the unit if returned in non-original packaging, or without the foam rings in place. Contact Met One for replacement packing materials if necessary.

2.2 Enclosure Selection

The BAM-1020 unit is not weatherproof or water resistant, and is designed to be mounted in a weatherproof, level, vibration free, dust free, and temperature controlled environment where the operating temperature is between 0^{o} C and +50^{o} C, and where the relative humidity is non-condensing and does not exceed 90%. There are two standard configurations described below for providing a weatherproof location in which to install the unit. Please contact Met One if you plan to have a non-standard mounting or enclosure configuration.

1. **A walk-in building or mobile shelter with a flat roof:** This is often a pre-fabricated shelter, a trailer shelter, or a room in an existing permanent building. The BAM is mounted on a bench-top or in an equipment rack, often with a variety of other instruments installed in the same shelter. The inlet tube of the BAM must extend up through the roof with appropriate hardware. AC power must be available. Instructions for this type of installation are included in this section of the manual.
2. **BX-902/903 environmentally controlled mini enclosure:** Sometimes nicknamed “dog house” enclosures, these small pre-fabricated enclosure are just big enough for the BAM and related accessories, and are installed on the ground or on the roof of a larger building. They are available with a heater (BX-902), or with a heater and air conditioner (BX-903). These enclosures are custom designed by Met One to accept the BAM-1020, and are supplied with a supplemental setup and installation manual.

NOTE: The air temperature inside any enclosure in which a BAM-1020 is installed must be held as constant as possible over the course of the hour. This is important because the unit measures the beta particles through a small gap of air around the filter tape at the beginning and the end of each hour. If the air temperature inside the enclosure has changed by more

than about 2 degrees C during this time, the concentration measurement can be affected on the order of several micrograms. Met One recommends logging the air temperature inside the enclosure to monitor this effect. The exact temperature is not critical as long as it fluctuates as little as possible during any one hour.

2.3 Site Selection

Selection of a proper site for the BAM-1020 is critical for accurate measurements. In many cases, these items must be correctly addressed in order for the collected data to be acceptable for regulatory requirements, such as EPA PM_{10} and $PM_{2.5}$ equivalent methods. Specifications for the site selection can be found in EPA document EPA-450/4-87-007 May 1987 “Ambient Monitoring Guidelines for Prevention of Significant Deterioration”, as well as 40 CFR, Part 58. In any case, the Code of Federal Regulations takes precedence.

Inlet Height:

- The inlet should be located in the “breathing zone”, between 2 and 15 meters above ground level. If the BAM is to be installed in an enclosure at ground level, then the inlet height must two meters or greater above the ground.
- If the inlet is located on (or through) a rooftop, the total height should be no more than 15 meters from the ground level. The inlet height should be two meters above roof surface of the building that the unit is installed in. This matches the specified inlet height of most FRM samplers.
- If the BAM-1020 is to be co-located with other particulate instruments, such as FRM filter-based samplers or other BAM units, then the air inlet must be the same height as the inlet of the other samplers.
- The BX-902 and BX-903 environmental shelters are designed to locate the inlet two meters above whatever surface they are placed on.
- Make sure to account for the height of the PM_{10} and/or $PM_{2.5}$ heads when planning the inlet tube length. Met One can supply a variety of tube lengths up to 8-feet long.
- The maximum allowable total inlet tube length is 16 feet between the BAM-1020 and the bottom of the inlet head.
- If the BAM inlet is the highest point on a building, then lightning rods must be installed to prevent destruction of the BAM during electrical storms.

Inlet Radius Clearance:

- The BAM-1020 inlet must have a one meter radius free of any objects that may influence airflow characteristics, including the inlet of another instrument.
- If a BAM-1020 is to be installed at a station with other BAM or FRM sampler, the inlets of each sampler must be no less than one meter apart from each other.
- If the BAM is to be collocated with another BAM instrument or FRM sampler, then the inlets must be spaced between one and two meters apart. Two meters is recommended where possible.
- If installing near a PM_{10} SSI Hi-Volume sampler, then the distance between the inlet of the BAM-1020 and the Hi-Vol should be no less than three meters.
- The BAM-1020 inlet must be located at least two meters from obstructions such as short walls, fences, and penthouses.
- If located beside a major obstruction (such as a building) then the distance between the unit and the building must be equal to twice the height of the building.

- The inlet must be at least 20 meters from the drip line of any overhanging trees.
- There must be at least a 270 degree arc of unrestricted airflow around the inlet. The predominant direction of concentration movement during the highest concentration season must be included in the 270 degree arc.

Particulate Sources: To avoid possible errors in the concentration measurements, the inlet must be located as far as possible from any artificial sources of particulate, such as blowers, vents, or air conditioners on a rooftop. Especially if any of these types of devices blow air across the inlet of the BAM-1020. Even sources of filtered air must not blow across the inlet.

Spacing from Roadways: The BAM-1020 should usually not be located directly next to a major highway or arterial roadway, as vehicle exhaust will dominate the concentration measurement. This effect can be difficult to predict accurately as shifting winds may direct the plume toward or away from the BAM inlet.

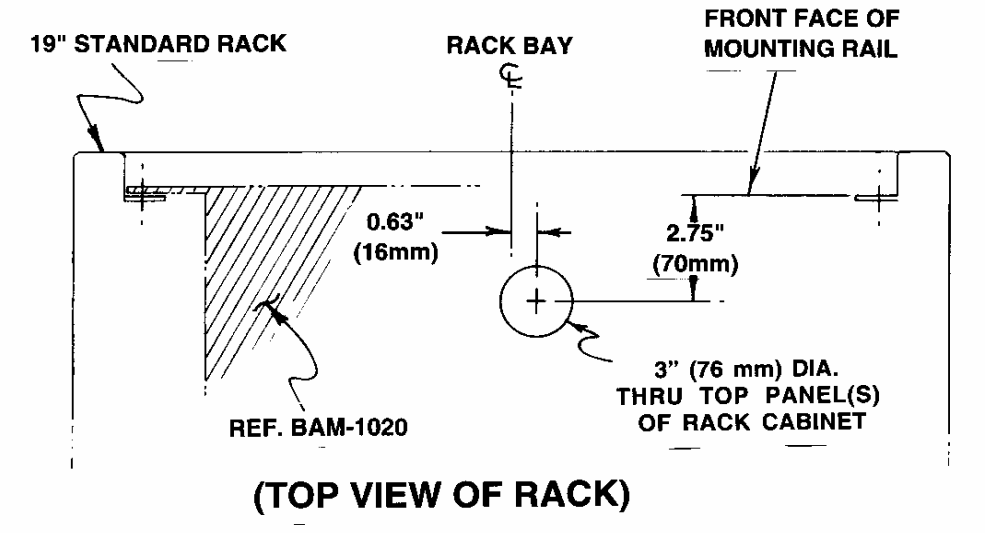
- Roads with a daily traffic volume of less than 3,000 vehicles are generally not considered major sources of pollutants, and in this case the BAM must be located at least five meters from the nearest traffic lane.
- The BAM must be located at least 25 meters from any elevated roadway greater than five meters high.
- The unit should be located as far as possible from unpaved roadways, as these also cause artificial measurements from fugitive dust.
- The unit should not be installed in unpaved areas unless year-round vegetative ground cover is present, to avoid the affects of re-entrained fugitive dust.

2.4 Mounting Options in a Walk-In Shelter

When the BAM-1020 is to be located in a walk-in shelter, the unit will have to be installed either in an equipment rack or on a bench-top. Met One recommends using an equipment rack when possible, as it does a better job of keeping the unit level and in the correct placement. A rack also tends to be a cleaner installation and is more space-efficient. However, either method may be used as long as the mounting is level and allows the inlet tube to be perfectly vertical. Met One supplies brackets standard rack-mount screws with each unit. Take the following into account when planning your mounting:

- **Rear Access:** It is important that your mounting leaves plenty of access to the rear of the BAM-1020 unit for wiring connections and maintenance. At least five inches is required. Full access to the back is recommended whenever possible.
- **Top Access:** It is necessary to have a minimum of eight inches clearance between the top of the BAM inlet receiver and the bottom of the shelter ceiling to accommodate the smart inlet heater which mounts on the inlet tube directly above the BAM.
- **Mobile Shelters:** If the BAM-1020 is being installed into an equipment rack in a mobile shelter or van, the instrument **must** be supported from the bottom <u>in addition</u> to the rack brackets, due to additional strain. The foam shipping rings must also be inserted any time a mobile shelter is moved with the BAM-1020 inside.
- **Rack Modifications:** It is often necessary to modify the top of the equipment rack by cutting a hole to allow the inlet tube to extend through to the ceiling. The drawing below shows the location of the hole. **Note:** The inlet heater is a cylinder which installs

on the inlet tube two inches above the top of the inlet receiver of the BAM-1020. If the BAM unit is to be mounted high in the rack, it may be necessary to make the hole in the top of the rack larger in order to clear the heater diameter. The heater is supplied with an insulation tube cover which may be modified as needed. Make sure these parts are going to fit before installing the BAM-1020.



Rack top modifications for inlet tube clearance

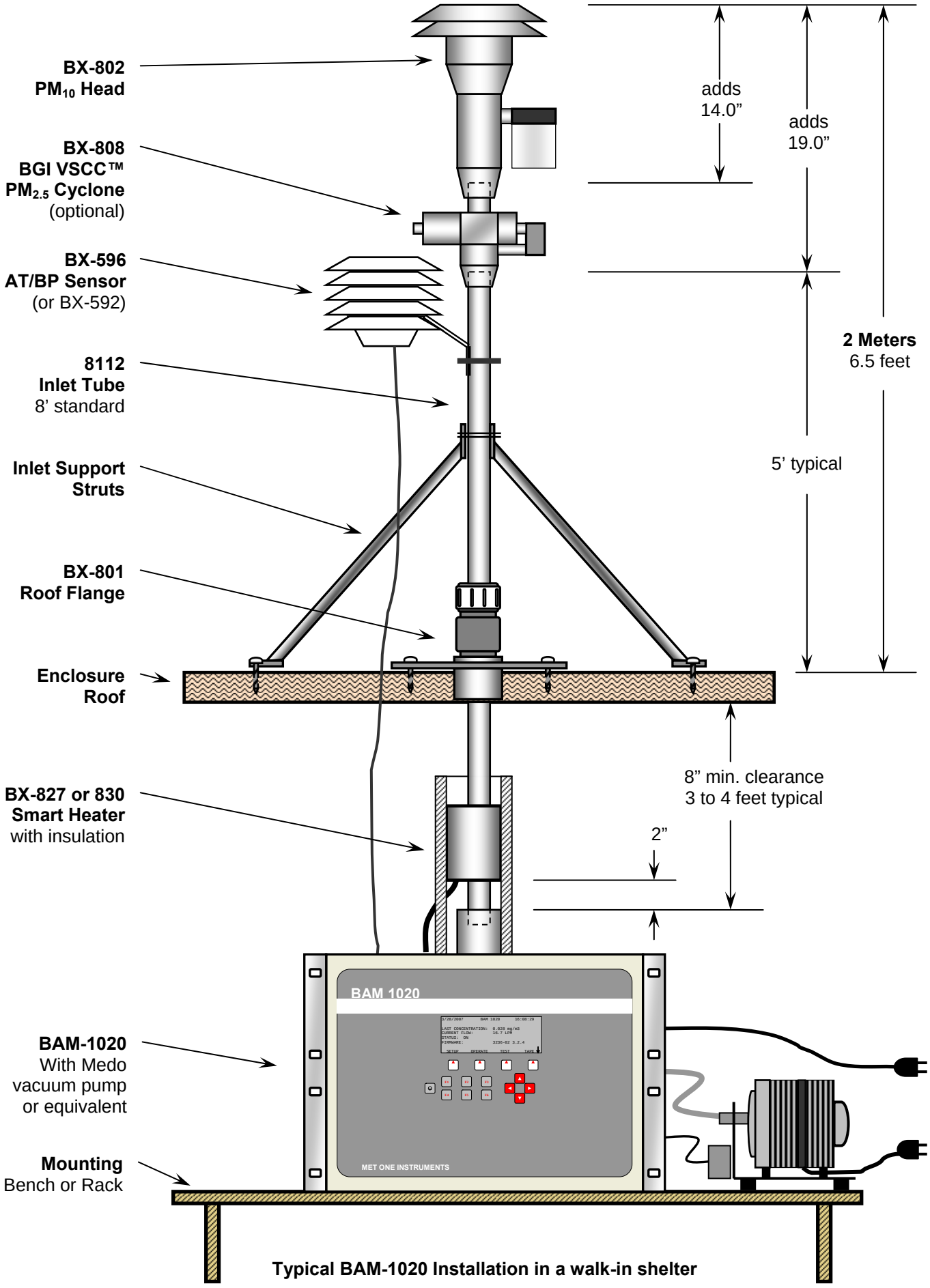
2.5 Installation Instructions in a Walk-In Shelter

Installation of the BAM-1020 should be performed by personnel familiar with environmental monitoring equipment. There are no special precautions or handling concerns except for the normal level of care required for handling scientific equipment. Refer to the diagrams on the following pages.

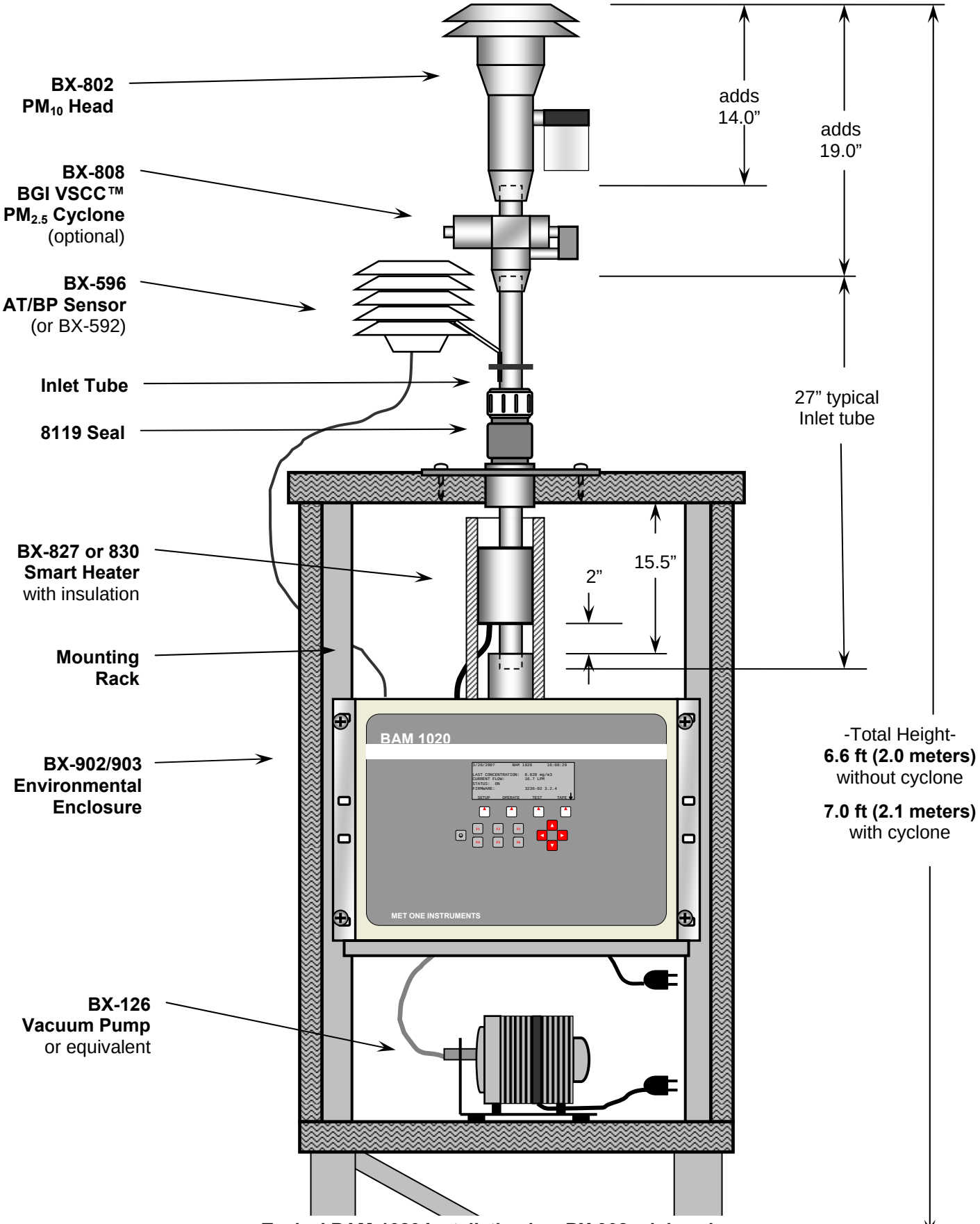
1. **Roof Modifications:** Determine the exact location where the BAM inlet tube will pass through the roof of the enclosure, and drill a 2 ¼" or 2 ½" diameter hole through the roof at that location. Make sure the hole is directly above where the BAM inlet receiver is to be located, as the inlet tube must be perfectly vertical. A plumb-bob is useful for determining where to locate the hole. **Note:** The inlet receiver on the BAM is slightly to the left (0.6 in, 15 mm) of the center line of the unit. See diagrams.
2. **Waterproof Flange:** Apply all-weather caulking around the top of the hole, and install the BX-801 roof flange onto the hole. It is usually best if the threaded barrel of the flange assembly is installed downward, into the hole. Secure the flange in place with four lag bolts or self-tapping screws (not supplied). Caulk around the screws to prevent leaks. Apply Teflon tape to the threads of the gray plastic watertight fitting, and screw it into the roof flange.
3. **Inlet Tube:** Remove the white cap and rubber seal from the flange assembly. This makes it easier to install the inlet tube, as the rubber seal is a tight fit around the tube. Lower the inlet tube through the flange assembly in the roof and into the inlet receiver on the BAM Make sure the inlet tube is fully seated.
4. **Inlet Alignment:** It is very important for the inlet tube to be perpendicular to the top of the BAM. The nozzle may not close properly if there is binding caused by misalignment. A simple check is to rotate the inlet tube back and forth by hand (before

tightening the roof flange seal or the BAM inlet set screws). If the inlet tube is installed straight, then the tube should rotate fairly easily while inserted into the BAM. If it does not rotate, check the inlet tube for vertical alignment or move the BAM slightly.

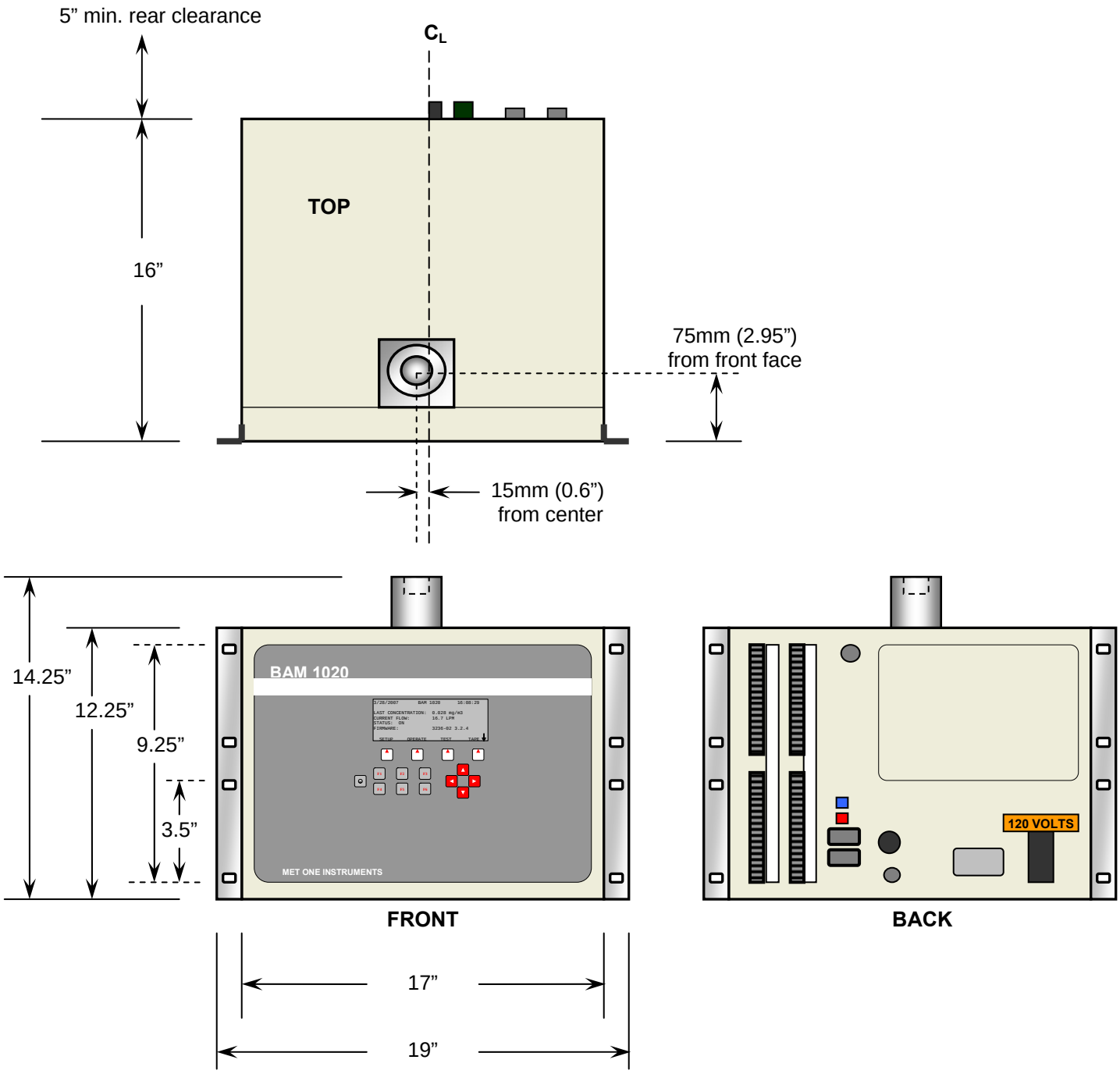
5. **Smart Heater:** Before tightening the inlet tube in place, the BX-827 or BX-830 smart inlet heater (used on most BAM-1020 units) must be installed on the tube. Pull the inlet tube up out of the inlet receiver, and pass the tube through the hole in the heater body (the cable end is the bottom). Then re-insert the inlet tube into the BAM. Position the bottom of the heater unit **two inches** above the top of the inlet receiver on the BAM, and securely tighten the two set screws in the heater to fasten it to the tube. Included with the smart heater is a 12" tube of insulation. The tube is split down its length for easy application. Wrap the insulation around the heater body and peel back the adhesive cover strip to secure in place. The insulation may be cut to fit if needed.
6. **Inlet Tightening:** Slide the black rubber seal and white cap down over the top of the inlet tube and into the roof flange. It is easier if you wet the rubber seal with water or alcohol first. Tighten the white plastic cap.
7. **Support Struts:** The BX-801 inlet kit usually comes with two angled aluminum struts to support the inlet tube above the roof and prevent the inlet from moving in the wind. These struts are typically fastened (about 90 degrees apart) to the inlet tube with a supplied hose clamp. The bottom ends of the struts should be fastened to the roof with lag bolts (not supplied). Note: Some installations may require different methods or hardware for supporting the inlet tube. Support the tube in the best manner available.
8. **Temperature Sensor:** Most BAM-1020 units are supplied with a BX-592 (temperature) or BX-596 (temperature and pressure) sensor, which is attached to the inlet tube above the roof. The sensor cable must feed into the shelter to be attached to the BAM. In some cases it is easiest to simply drill a 3/8" hole through the roof about six inches away from the inlet tube, then feed the cable through the hole and caulk around it to prevent leaks. In some applications there may be a better place to feed the cable into the shelter. Route the cable into the shelter in the best manner. The BX-596 attaches directly to the inlet tube with a supplied U-bolt. If using a BX-592, fasten the aluminum cross-arm to the inlet tube, and clip the temperature probe to the cross-arm.
9. **Inlet Separator Heads:** If the BAM-1020 is to be configured for FEM $PM_{2.5}$ monitoring, then install the $PM_{2.5}$ Very Sharp Cut Cyclone (BGI VSCC™) onto the top of the inlet tube beneath the BX-802 PM_{10} head. For PM_{10} monitoring, the BX-802 is installed on the inlet tube with no cyclone. Use o-ring lubricant as needed.
10. **Inlet Tube Grounding:** Tighten the two ¼"-20 set screws located in the inlet receiver of the BAM to secure the inlet tube. This also creates a ground connection for the inlet tube, as static electricity can build up on the inlet under certain atmospheric conditions and cause errors. This is very important in areas near electromagnetic fields, high voltage power lines, or RF antennas. Check the connection by scraping away a small spot of the clear anodizing near the bottom of the inlet tube, and use a multimeter to measure the resistance between this spot and the "CHASSIS" ground connection on the back of the BAM. It should measure just a couple of Ohms or less if a good connection is made with the set screws. If not, remove the set screws and run a ¼-20 tap through the holes. Then reinstall the screws and check the electrical resistance again. **Note:** Anodized aluminum surfaces are non-conductive.



Typical BAM-1020 Installation in a walk-in shelter



Typical BAM-1020 Installation in a BX-902 mini enclosure



BAM-1020 mounting dimensions

2.6 Electrical Connections

Each BAM-1020 is factory configured to run on either 120 or 230 volt AC power. Your shelter must be wired for power to run the BAM, the pump, and any other AC powered devices such as computers, data loggers, other instruments, etc. A good earth-ground connection point near the BAM unit is highly recommended. Have a qualified electrical contractor provide power according to all local codes. After the BAM unit is installed and power is provided, connect the electrical accessories as follows. Refer to the diagram below.

1. **BAM-1020 Power:** Plug the BAM-1020 into the AC power mains with the provided power cord. Note: There are two fuses located inside the BAM power switch module, which can be accessed by prying open the small cover surrounding the switch. The power cord must be removed in order to open the cover.

   Met One recommends plugging the BAM-1020 unit into a battery back-up UPS (uninterruptible power supply) since even a momentary power outage will reset the BAM and stop an entire hour's worth of data collection. A small computer-style UPS of 300 Watts or greater is usually sufficient. The vacuum pump usually does not need to be connected to the UPS as the BAM can compensate for short pump power outages. If the pump is to be backed up as well, then a much larger UPS is required.
2. **Chassis Ground:** Connect one of the terminals marked "CHASSIS" on the back of the BAM to a ground point as close as possible to the instrument. Use the green/yellow ground wire supplied with the unit. A ground rod is recommended, but a cold water pipe, or junction box safety ground are other possible connection points. Note: the BAM-1020 also uses the standard safety ground line inside the power cord.
3. **Pump Connection:** Decide on a location to place the air pump. The best location is often on the floor under the rack or bench, but it may be up to 25 feet away if desired. Route the air tubing from the pump to the back of the BAM unit, inserting it firmly into the compression fittings on both ends. The tubing should be cut to the proper length and the excess saved for replacements. The pump is supplied with a 2-wire signal cable which the BAM uses to turn the pump on and off. Connect this cable to the terminals on the back of the BAM marked "PUMP CONTROL" The end of the cable with the square black ferrite filter goes to the BAM, but the polarity of the wires is not important. Either the red or black wire can go to either terminal. Connect the other end of the cable to the two terminals on the pump.
4. **Temperature/Pressure Sensor:** The BX-596 or BX-592 temperature sensor should already be installed onto the inlet tube, and the sensor cable routed to the BAM-1020. Connect the cable to the terminals on the back of the BAM as follows:

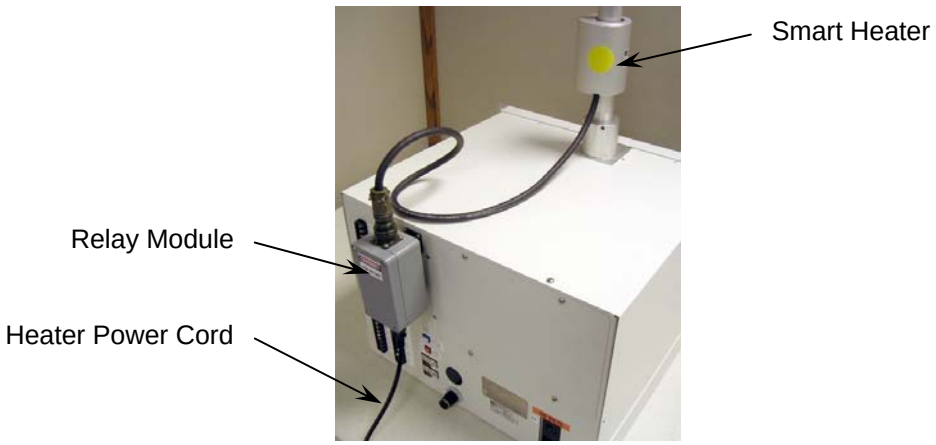
BX-596 AT/BP Sensor	
Wire Color	**Terminal Name**
Yellow	Channel 6 SIG
Black/Shield	Channel 6 COM
Red	Channel 6 POWER
Green	Channel 6 ID
White	Channel 7 SIG

BX-592 AT Sensor	
Wire Color	**Terminal Name**
Yellow or White	Channel 6 SIG
Black/Shield	Channel 6 COM
Red	Channel 6 POWER
Green	Channel 6 ID

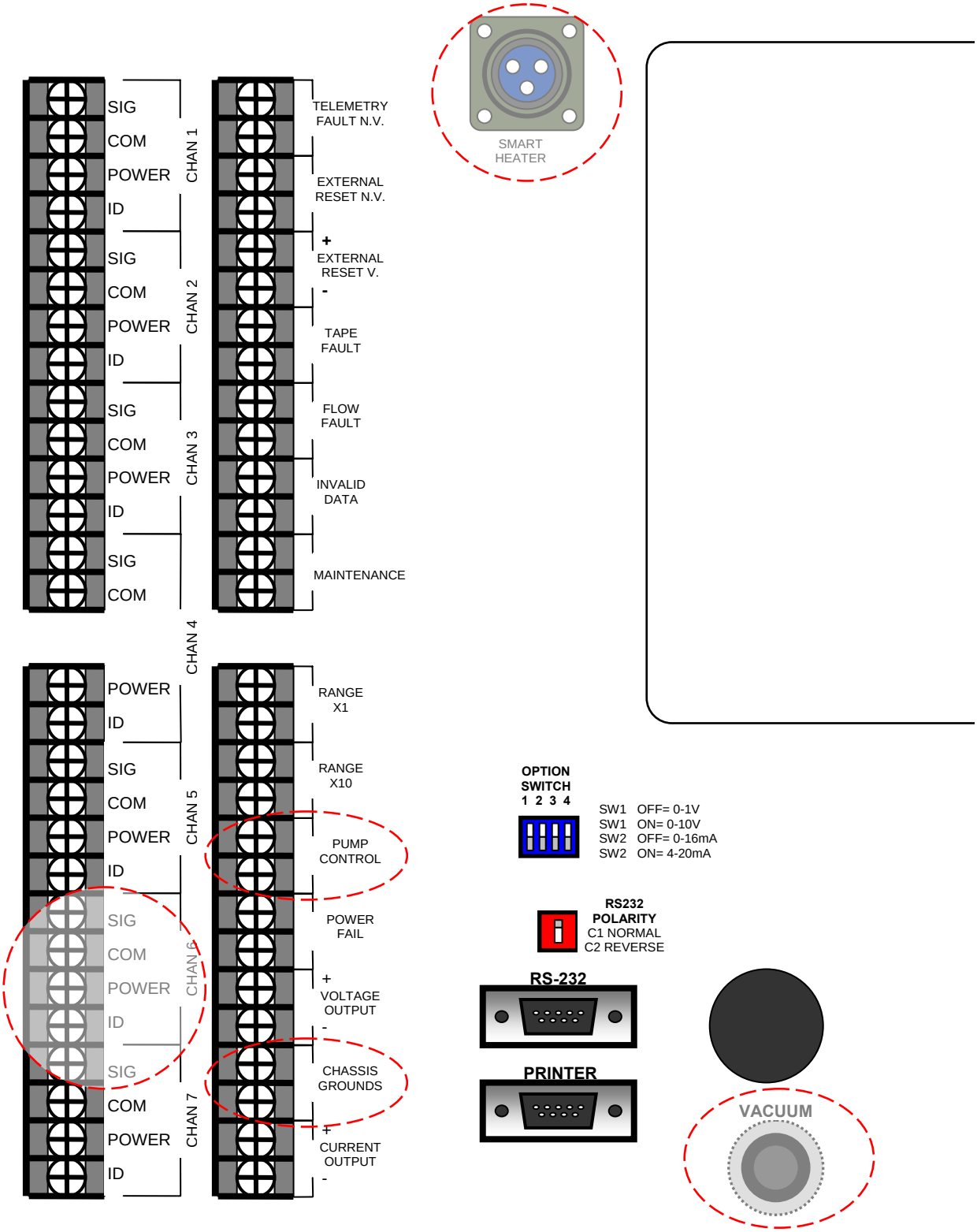
Additional Met One BX-500 series sensors may be connected to BAM channels 1 through 5 to log various other meteorological parameters. Details on these sensor connections are given in Section 10.2 of this manual.

5. **Smart Heater:** There are two possible versions of the BX-827/830 Smart Heater electrical connection. If the Smart Heater kit was supplied with a gray relay module (units built after May, 2008 as shown below), then plug the relay module into the mating control connector on the back of the BAM, and connect the Smart Heater to the green connector on the top of the relay module. The relay module has its own power cord to supply power to the heater. **Note:** The connector on the back of the BAM has been changed to prevent connecting the heater directly to the BAM.

   On previous versions of the kit, the Smart Heater assembly simply plugs directly into the back of the BAM-1020, and power is supplied internally by the BAM. If the BAM is configured like this, then simply plug the heater cable directly into the mating green metal connector on the back of the BAM-1020.



6. **Optional Data Logger Connection:** The BAM-1020 has an analog output which may be recorded by a separate data logger if required. Connect the terminals on the back of the BAM marked ”VOLT OUT +, -“ to the data logger with 2-conductor shielded cable (not supplied). Polarity must be observed. Information on configuring this analog output is provided in Section 8 of this manual. A current loop output is also available.
7. **Other Connections:** The BAM-1020 has a variety of telemetry I/O relays and error relays located on the back of the unit. There are also RS-232 data connections. These items are described in Section 8 and Section 9 of this manual.



BAM-1020 back panel connections

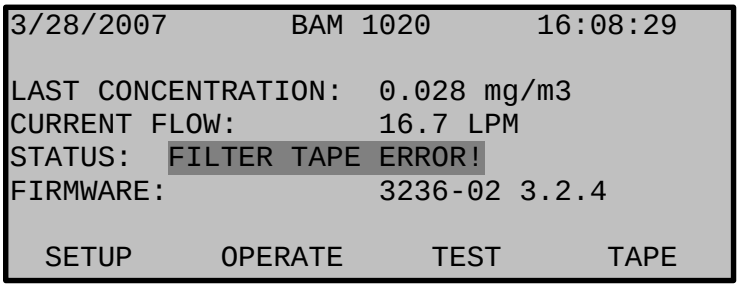
3 INITIAL SETUP OF YOUR BAM-1020

This section describes the process for setting up and configuring your BAM-1020, as well as the basic steps required to put the unit into operation. Some of the topics in this section will direct you to other sections of this manual for more detailed information. It is assumed that the unit is already installed and sited as described in Section 2. In some cases it is useful to first set up the BAM-1020 unit on a test bench before deployment or installation in order to explore the functions of the unit and perform setups. The following steps for starting up your unit are described in this section:

1. **Power on and warm up the unit.**
2. **Familiarize yourself with the user interface.**
3. **Load a roll of filter tape.**
4. **Perform a Self-Test.**
5. **Set the real-time clock, and review your SETUP parameters.**
6. **Perform a leak check and a flow check.**
7. **Return to the top-level menu and wait for automatic start at the top of the hour.**
8. **View the OPERATE menus during the cycle.**

3.1 Power On

The BAM-1020 has a power switch located on the back of the unit directly above the power cord. Verify that the unit is plugged in to the correct AC voltage, and that any electrical accessories are correctly wired before turn the unit on. (Section 2.6) When power is switched on the main menu screen should appear after a few seconds as shown below. The unit will probably flash an error indicating that there is no filter tape installed. Note: Units running revision 3.1 or earlier firmware will display a slightly different main menu screen.



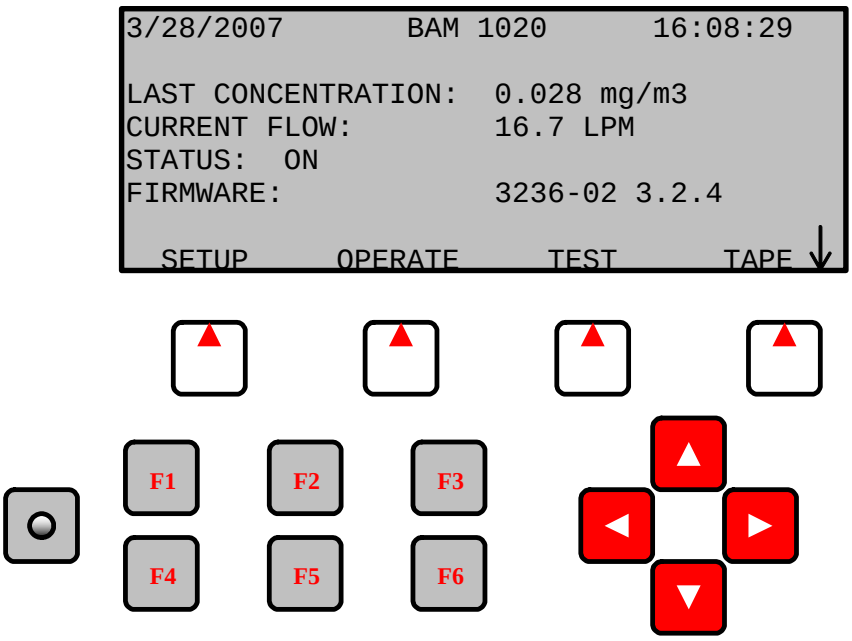
The Main Menu Screen

3.2 Warm-up

The BAM-1020 must warm up for **at least one hour** before an operation cycle is started. This is because the beta detector contains a vacuum tube which 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 a moment. Instrument setups and filter tape installation can be performed during this warm up time. Most agencies choose to discard the first few hours of concentration data after the BAM is powered up.

3.3 Using the Keypad and Display

When the BAM-1020 is powered up it will display the main (top level) menu on the LCD display. This menu is the starting point for all functions of the BAM-1020 user interface.



The BAM-1020 User Interface

Soft Keys:
Directly beneath the display are four white buttons called “soft-keys” or “hot-keys”. These are dynamic keys who’s 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 wide 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. It is possible to overadjust the contrast and make the entire display completely blank or completely dark, so be careful to set it to a visible level or it may appear that the unit is not operating.

Function Keys F1 to F6:
The function keys serve as shortcuts to commonly used menu screens, and can be safely pressed at almost any time without interrupting the sample cycle. The **F** keys are only functional from the main menu screen or for entering passwords. The factory default password is F1, F2, F3, F4.

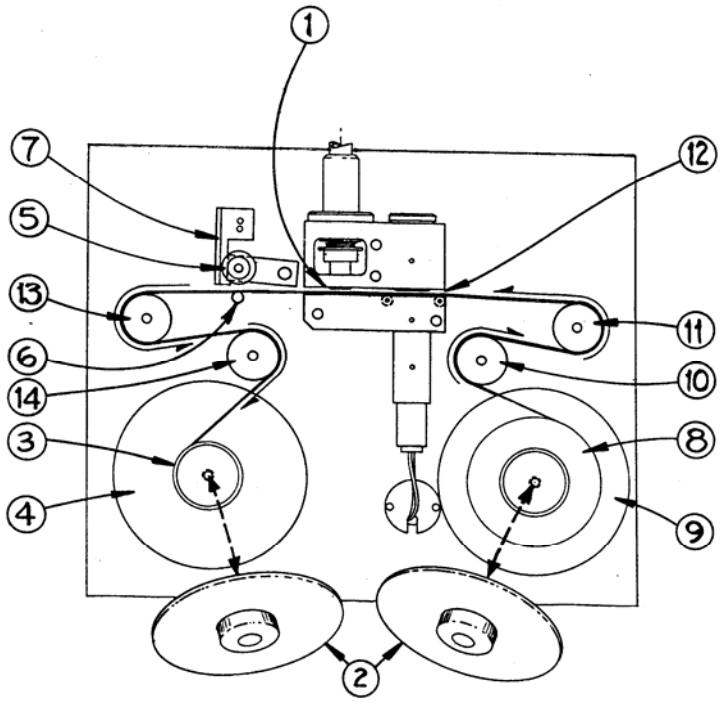
F1 Current: This key is a shortcut to the OPERATE > INST screen, used to display the instantaneous data values that are being measured by the BAM-1020. See section 3.12. The F1 key can be used without interrupting a sample cycle.
F2 Average: This key is a shortcut to the OPERATE > AVERAGE screen, used to display the latest average of the data recorded by the BAM-1020. See Section 3.13. The F2 key can be used without interrupting a sample cycle.
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 up to the last 100 errors can be viewed. The F3 key can be used without interrupting a sample cycle.
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 in this menu. The F4 key can be used without interrupting a sample cycle.
F5 Transfer Module: This key is used to copy the memory contents to an optional transfer storage module to retrieve the digital data without a computer. This function is rarely used. Met One recommends downloading the data with a laptop, computer or modem connection.
F6 (Blank): This key is not assigned a data function.

3.4 Filter Tape Loading

A roll of filter tape must be loaded into the BAM-1020 for sampling. One roll of tape should last more than 60 days under normal operation. It is important to have several spare rolls of tape available to avoid data interruptions. Met One recommends wearing lint-free cotton gloves when handling the tape. Some agencies save the used rolls of tape for post-sampling analysis, although there is no guarantee that the sampled spots have not been contaminated. Used filter tape should never be “flipped over” or re-used! This will result in measurement problems. Loading a roll of filter tape is a simple matter using the following steps:

1. Turn the BAM-1020 on and enter the TAPE menu (Note: This is not the same as the TEST > TAPE menu). If the nozzle is not in the UP position, press the TENSION soft-key to raise the nozzle.
2. Lift the rubber pinch roller assembly and latch it in the UP position. Unscrew and remove the clear plastic spool covers.
3. An empty core tube **MUST** be installed on the left (take-up) reel hub. This provides a surface for the used tape to spool-up on. 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 your last roll to spool-up the new roll. Never fasten the filter tape to the aluminum hub.
4. 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. Attach the loose end of the filter tape to the empty core tube with cellophane tape or equivalent.
5. Rotate the tape roll by hand to remove excess slack, then install the clear plastic spool covers. The covers will clamp the rolls to the hubs to prevent slipping.
6. 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.

7. Unlatch and lower the pinch roller assembly onto the tape. **The BAM will not function if the pinch rollers are latched up, and it has no way of automatically lowering the roller assembly!**
8. Press the TENSION soft-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.



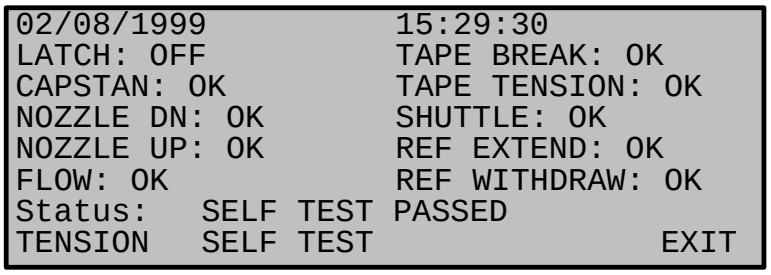
1----NOZZLE IN "UP" POSITION
2----CLEAR SPOOL COVER WITH KNOB
3----EMPTY CORE TUBE
4----TAKE-UP SPOOL
5----PINCH ROLLERS
6----CAPSTAN SHAFT
7----LATCH
8----FILTER TAPE
9----SUPPLY SPOOL
10--SUPPLY TENSION ROLLER
11--RIGHT END ROLLER
12--SAMPLING/MEASURING AREA
13--LEFT END ROLLER
14--TAKE-UP TENSION ROLLER

Filter Tape Loading Diagram

3.5 Self-Test

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 right after each time the filter tape is changed, and it can also be used if the operator suspects a problem with the unit. More detailed diagnostic menus are also available in the BAM, and those are described in the troubleshooting section.

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.



Self-Test Status Screen

LATCH: This will show OFF if the photo interrupter senses that the pinch rollers are unlatched as in normal operation. It will show ON if the roller assembly is latched in the up position. The tape cannot move if the rollers are up!
CAPSTAN: The unit will rotate the capstan shaft forward and backwards and will check if the photo interrupter sees the shaft rotating. The Capstan shaft is what moves the filter tape back and forth.
NOZZLE DN: The unit will attempt to lower the nozzle, and will check if the nozzle motor has moved to the down position with a photo interrupter. It is possible for the nozzle to become stuck in the UP position, even if the nozzle motor has successfully moved to the DOWN position. For this reason, proper inlet alignment and maintenance is necessary.
NOZZLE UP: The unit will attempt to raise the nozzle, and will check if the nozzle motor has moved to the up position with a photo interrupter.
FLOW: The unit will attempt to turn the pump on, and will then look for output on the flow sensor. This test takes about a minute and will fail if the pump is not connected.
TAPE BREAK: The unit will move the supply and take-up motors to create slack in the filter tape, and look for proper operation of the tensioner photo interrupters.
TAPE TENSION: The unit will tension the filter tape, and then check the condition of the tensioner photo interrupters.
SHUTTLE: The unit will attempt to move the shuttle beam left and right, and will check the motion with a photo interrupter.
REF EXTEND: The unit will attempt to extend the reference membrane, and will check the motion with a photo interrupter.
REF WITHDRAW: The unit will attempt to withdraw the reference membrane, and will check the motion with a photo interrupter.

3.6 Initial SETUP Settings Considerations

The BAM-1020 comes pre-programmed with a wide array of default values for the settings which govern the measurement and calibration. Many of these values will not be changed, as the default values are accurate for the majority of applications. You will need to review the Setup Menus in Section 6 of this manual and decide if any values need to be changed. At the very least, review the following parameters:

1. Set the system clock in the SETUP > CLOCK menu. The BAM-1020 clock may drift as much as a couple of minutes per month. It is important to check the clock at least once per month to ensure the samples are performed at the correct times.
2. Review the BAM SAMPLE, COUNT TIME, MET SAMPLE, RANGE, and OFFSET values in the SETUP > SAMPLE menu.

3. Review the FLOW RATE, FLOW TYPE, CONC TYPE, and HEATER CONTROL settings in the SETUP > CALIBRATE menu.
4. Review the scaling of any external sensors in the SETUP > SENSORS menu.
5. Review the Smart Heater control settings in the SETUP > HEATER menu.

3.7 Initial Leak Check and Flow Check

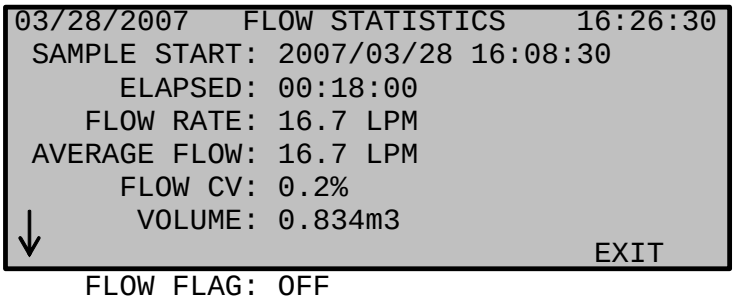
Perform a leak check and flow check/calibration as described in Section 5. Become comfortable with these processes, as they will be performed often.

3.8 Starting a Measurement Cycle

When the preceding steps of Section 3 have been completed, exit out to the main top level menu. The “Status” line should display “ON” (no errors). If so, the unit will start at the top (beginning) of the next hour, and will continuously operate until it is commanded to stop. The unit will stop if the operator sets the Operation Mode to OFF or enters any of the SETUP or TEST menus. The BAM-1020 will also stop itself if a non-correctable error is encountered, such as broken filter tape or failed air flow.

3.9 The Flow Statistics Screen

In the main BAM-1020 menu screen a small arrow has been added to the bottom right corner. When the DOWN ARROW button is pressed the BAM will display the FLOW STATISTICS screen as shown below. This screen displays the flow, temperature and pressure statistics for the current measurement cycle. Pressing the ARROW DOWN key while in this screen will further scroll down to the remaining parameters below the viewable area of the display. This screen will not interrupt the sample. This function is only available with revision 3.2 firmware or later.




```
    FLOW FLAG: OFF
           AT: 23.0
       MAX AT: 23.5
   AVERAGE AT: 23.0
       MIN AT: 22.5
           BP: 760
       MAX BP: 765
   AVERAGE BP: 760
       MIN BP: 755
```

The FLOW STATISTICS Screen

3.10 The OPERATE Screen

Press OPERATE soft-key at the main menu to enter operate menu as shown below. This will not interrupt the sample if already running.

```
11/15/2006   OPERATE MODE       14:13:07

       ↑ = ON
       ↓ = OFF
Operation Mode: ON
        Status: ON

  NORMAL     INST    AVERAGE     EXIT
```

The OPERATE Menu

The DOWN arrow can be used to set the Operation Mode from ON to OFF. This will stop the measurement cycle, but will not power-down the BAM-1020. **NOTE: If the operator sets the Operation Mode to OFF, or the unit stops itself due to an error, it will still automatically set the mode back to ON at the top of the hour, and try to run a new cycle!** The only ways to prevent the unit from automatically starting a cycle are to power off the unit, leave the unit in a TEST or SETUP menu, or leave the pinch rollers latched in the UP position.

The OPERATE menu has three soft-key options for viewing the operating status and sensor measurements while the unit is operating: NORMAL, INST, and AVERAGE.

3.11 The NORMAL Screen

Normal Mode is the primary operation screen which displays most of the important parameters of the sample progress in one place, as shown below. Many operators leave their BAM-1020 in the NORMAL screen whenever the unit is operating, instead of the Main menu.

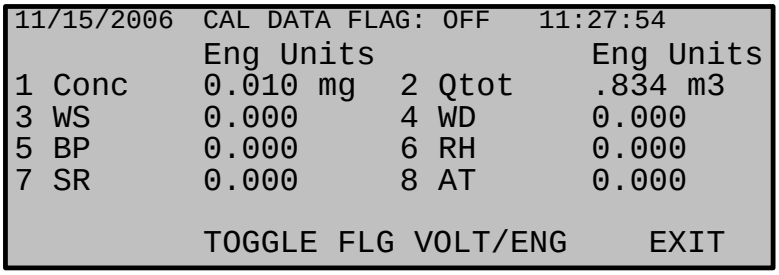
```
11/15/2006         Normal Mode       11:27:54
                                Flow(STD): 16.7 LPM
                             Flow(ACTUAL): 16.7 LPM
LAST C: 0.061 mg/m3                Press: 764 mmHg
LAST m: 0.806 mg/cm2                  RH: 37 %
                                   Heater: OFF
                                  Delta-T: 4.2 C
STATUS: SAMPLING                             EXIT
```

The NORMAL Menu

The **LAST C** value indicates the last concentration record, updated at the end of the cycle. The **LAST m** value indicates the last measured value of the reference span membrane. The value should be very close or equal to the expected value (**ABS**). The other values are instantaneous measurements.

3.12 The INSTANTANEOUS Screen

The INST (Instantaneous) screen displays the instantaneous data values that are being measured by the BAM-1020. This screen is useful for monitoring the current reading of any optional sensors that may be connected to the BAM-1020. All values except **Conc** (concentration) and **Qtot** (total flow volume) are current. The Conc represents the concentration of the last period. Qtot represents total flow volume during the last period.



The Instantaneous Menu

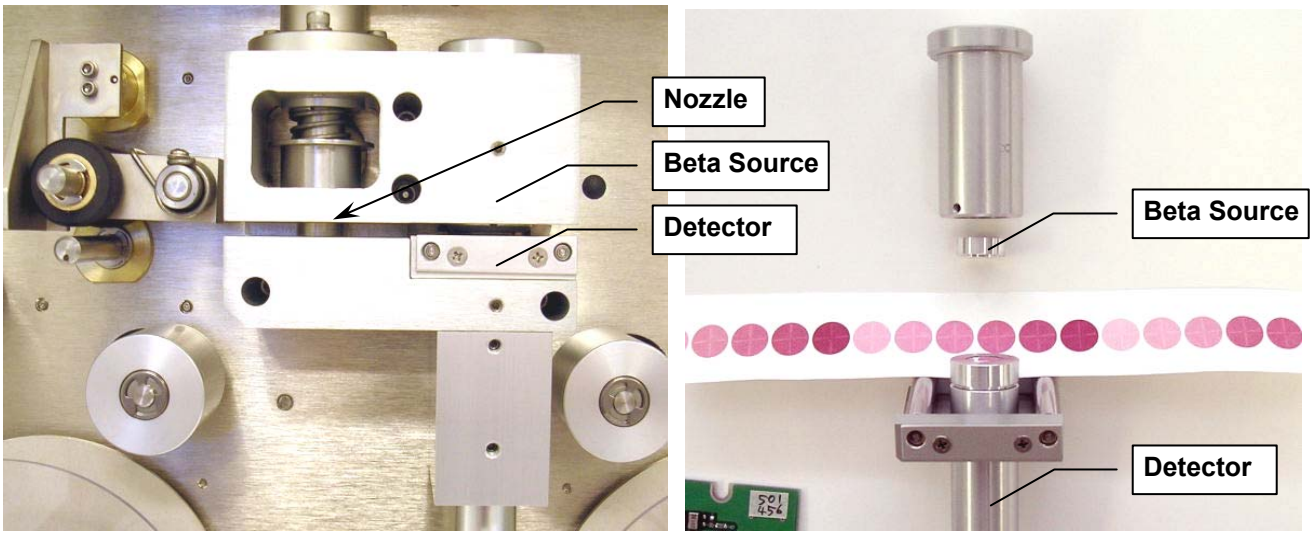
The TOGGLE FLG soft-key in this menu allows the user to set the CAL DATA FLAG value ON or OFF, which marks the data with an **M** flag to indicate a maintenance was performed during that time, such as a flow check. This feature is rarely used, as most maintenance requires stopping the sample anyway. The VOLT / ENG soft-key toggles the displayed values between units and voltages, useful for diagnostic checks on external sensors.

3.13 The AVERAGE Screen

The AVERAGE screen is similar to the INST screen, except that the concentration and flow are presented as the previous hour's average values, and the six external datalogger channels are average values over the average period of the data logger (set by the MET SAMPLE value in the SETUP > SAMPLE menu - usually also 60 minutes).

4 THE MEASUREMENT CYCLE

This section describes the measurement and timing cycle of the BAM-1020 instrument. A clear understanding of the measurement is helpful for the effective operation and maintenance of the unit. For advanced information on the underlying theory and mathematics of the measurement see Theory of Operation, Section 11.



BAM-1020 Sample and Measurement Stations

4.1 The One-Hour Cycle Timeline

The BAM-1020 is almost always configured to operate on 1-hour cycles. The unit has a real-time clock which controls the cycle timing. You will see from the following timeline that the unit makes two 8-minute beta measurements, and one 42-minute air sample, for a total of 58 minutes. The other two minutes are used for tape and nozzle movements during the cycle.

This example shows the timeline if the unit is set for a COUNT TIME of 8 minutes (required for $PM_{2.5}$). If the unit is set for 4 minutes, then the beta counts at the beginning and end of the hour will be only 4 minutes long, with a 50-minute air sample in between. Again, the total adds up to 58 minutes. **Note:** This cycle will be slightly altered if the unit is operated in the special Early Cycle mode with an external datalogger. See Section 8.

1. **Minute 00:** The beginning of an hour. The BAM-1020 immediately advances the filter tape forward one “window” (the next fresh, unused spot on the tape). This takes a few seconds. The new spot is positioned between the beta source and the detector, and the BAM begins counting beta particles through this clean spot for exactly eight minutes. (I_0)
2. **Minute 08:** The BAM-1020 stops counting beta particles through the clean spot (I_0), and moves the tape exactly four windows forward, positioning that same spot directly under the nozzle. This takes a few seconds. The unit then lowers the nozzle onto the filter tape and turns the vacuum pump on, pulling particulate-laden air through the filter tape (the spot in which I_0 was just measured) for 42 minutes at 16.7 liters per minute.
3. **Minute 50:** The BAM-1020 turns the vacuum pump off, raises the nozzle, and moves the filter tape backwards exactly four windows. This takes a few seconds, and puts the spot that was just loaded with particulate back between the beta source and the

detector. The BAM begins counting beta particles through this (now dirty) spot of tape for exactly eight minutes (I_3).

4. **Minute 58:** The BAM-1020 stops counting beta particles through the dirty spot (I_3). The unit uses the I_0 and I_3 counts to calculate the mass of the deposited particulate on the spot, and uses the total volume of air sampled to calculate the concentration of the particulate in milligrams or micrograms per cubic meter of air. The BAM then sits idle and waits a few moments for the remaining time in the hour to expire.
5. **Minute 60:** The beginning of the next hour. The BAM-1020 instantly records the just-calculated concentration value to memory and sets the analog output voltage to represent the previous hour's concentration. The unit advances a new fresh spot of tape to the beta measurement area and the whole cycle starts over…

4.2 Automatic Span Check During The Cycle

While the vacuum pump is on and pulling air through the filter tape, (as described above) the BAM-1020 doesn't have anything else to do, so it performs an automatic check of its calibration (a span check), and checks for instrument drift caused by varying external parameters such as temperature, barometric pressure, and relative humidity. No span corrections are made. This check is performed every hour automatically as follows:

1. **Minute 08:** (When the BAM-1020 has just finished moving the clean spot to the nozzle and turned the pump on) there is another clean spot of filter tape upstream four windows, between the beta source and the detector. This same spot will stay there for the entire time the pump is on (usually 42 minutes), as the tape cannot move with the nozzle down. The BAM begins counting the beta particles through this spot for exactly eight minutes (I_1).
2. **Minute 16:** The BAM-1020 stops counting beta particles through this spot (I_1), and extends the Reference Membrane between the beta source and the detector, directly above the spot of filter tape that was just measured. The Reference Membrane is an extremely thin film of clear Mylar held in a metal tongue. The membrane usually has a mass of about .800 mg. The BAM starts counting beta particles for eight minutes again, this time through the membrane *and* the filter tape spot at the same time (I_2).
3. **Minute 24:** The BAM-1020 stops counting beta particles through the membrane (I_2), withdraws the membrane assembly, and calculates the mass of the membrane **"m"**, as if it were particulate on the filter tape spot.
4. **Minute 42 (typical):** (Eight minutes before the pump stops) The BAM-1020 counts the beta particles through the same spot again (without membrane) for another eight minutes (called $I_{1'}$ or I_1 prime). This checks the ability of the unit to hold a constant output when measuring blank filter tape, and is not otherwise used.

The mass density ***"m"*** (mg/cm^2) of the reference membrane calculated during this automatic process is compared to the known mass of the membrane; the ***"ABS"*** value. During factory calibration, the actual mass of each individual span foil is determined and saved as the ***ABS*** value of the BAM in which it is installed. Each hourly measurement of ***m*** must match the ***ABS*** value within ±5%. If not, the unit records an error for that hour's data. Typically, the hourly value of ***m*** is within just a few micrograms of the expected value. This span check provides a method of internal diagnostics for the measurement system, and for the monitoring of external variables such as temperature variations or pressure changes. The ***ABS*** value is unique to each BAM-1020, and can be found on the calibration sheet.

4.3 Sample Period Description

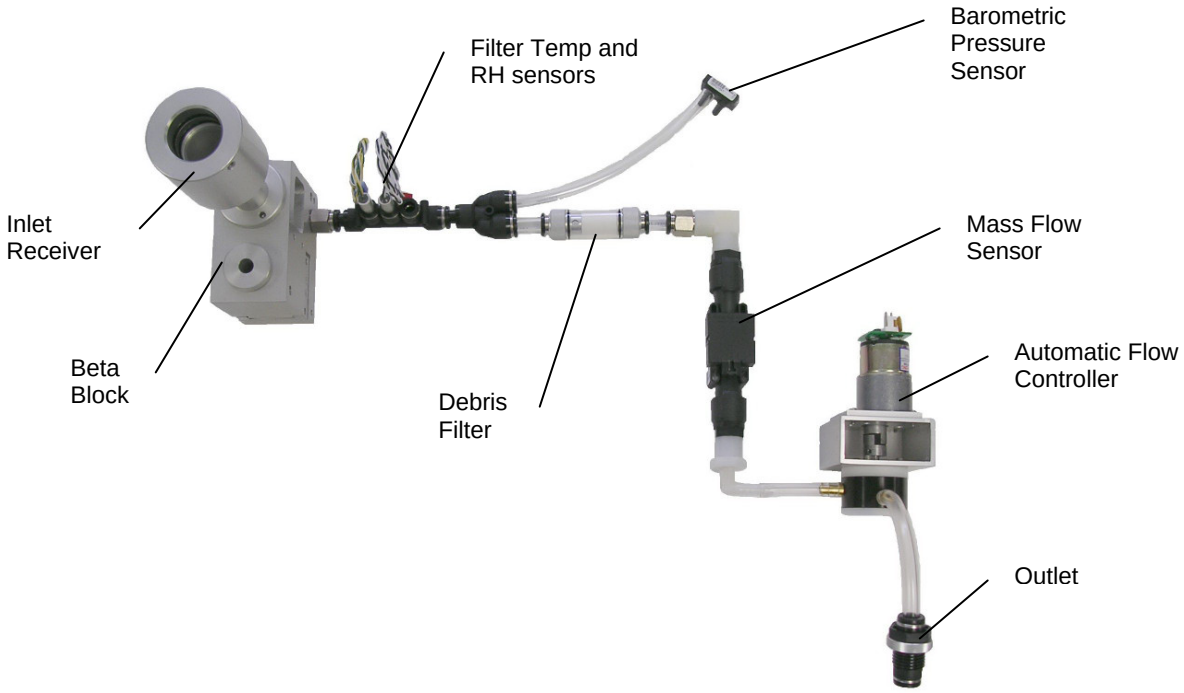
The sample period is the time when the vacuum pump is pulling dust-laden air through the BAM-1020. As the air enters the inlet, it first passes through the external PM_{10} head which has a screen to keep out bugs and debris, and uses inertia to separate out and trap particle larger than 10 microns in size. The air then immediately passes through the Optional $PM_{2.5}$ Very Sharp Cut Cyclone (BGI VSCC™) which further separates out and traps particles larger than 2.5 microns in size.

The air then goes down the inlet and through the filter tape, where the remaining particles are deposited. Some particles smaller than about 0.2 µm may pass through the filter tape and be exhausted. After the sample period is completed and the particulate spot is measured, there is almost always a clearly visible spot of dirt on the filter tape where the particulate was deposited. The BAM-1020 will put the spots very close together on the tape. At exactly midnight, the BAM will skip one spot, leaving a blank spot on the tape. This is a visual aid which separates daily entries on the tape.

5 FLOW SYSTEM and FLOW CALIBRATIONS

5.1 Flow System Diagram

The BAM-1020 airflow control system is very simple and effective, consisting of a few rugged components. Proper operation of the flow system is critical if accurate concentration data is to be obtained from the unit. The key aspects of proper flow system maintenance are **Leak Checks, Flow Checks, and Nozzle Cleaning**. These processes are described in this section. Met One recommends performing a leak check and nozzle cleaning before flow calibrations, as a leak can affect the flow. Flow calibrations require a reference flow meter and a reference standard for ambient temperature and barometric pressure. NIST traceable standards are required in many applications. Met One suggests the BGI DeltaCal® brand (available from Met One as the BX-307 option). It includes flow, temperature and pressure standards in one unit.



BAM-1020 Flow System

5.2 Flow Type Descriptions

The BAM-1020 is designed to operate with an airflow rate of 16.7 liters per minute (lpm). This is important, because the particle separators (PM_{10} inlets, cyclones, and WINS impactors) require this flow rate in order to properly separate the correct sizes of particles from the air stream. All of these separators use the inertia of the particles as they flow through the inlet to sort out the ones above a certain size (cut point) so that they won't be measured by the instrument. If the airflow rate is not maintained within ±5% of the design value flow rate of 16.67 lpm, then particles of the wrong size may be allowed through or sorted out. Periodic BAM-1020 airflow calibrations must be performed to ensure the unit maintains the flow within the EPA specified range of **±5% (±0.83 lpm)** of the design value, and **±4% (±0.67 lpm)** of NIST traceable flow standards.

This section describes the different types of flow control and regulation schemes used in the BAM-1020. The unit can be set to any of three different flow types: Metered, Standard, or Actual (Volumetric), depending on the hardware available and the desired reporting conditions. All BAM-1020 units have a mass airflow sensor and a barometric pressure sensor. The unit also has ***either*** a manual airflow valve on the back of the unit, ***or*** an automatic flow control valve inside the unit. The unit is usually also equipped with an optional BX-592 or BX-596 ambient temperature sensor. Each flow type requires a different process for auditing and calibrating the flow. To verify or set the flow type of the BAM, go to the SETUP > CALIBRATE menu, and check the FLOW TYPE. NOTE: The concentration reporting conditions can now be set independently of the flow type. See section 6.3.

METERED Flow Control:

Neither automatic flow control, nor flow correction for ambient conditions.
Metered flow control is used for BAM units that have a manual (hand-operated) air flow control valve on the back of the unit. These units do not have an automatic flow controller inside, so the unit cannot automatically adjust the flow to compensate for temperature or barometric pressure changes, or for filter loading. The unit does have a mass flow sensor inside. The flow reading from this sensor is stored in EPA conditions, meaning that the volume of air is calculated with the assumption that the ambient temperature is 25 degrees C, and the barometric pressure is 760mmHg (one atmosphere), regardless of the actual temperature and pressure, even if the unit is equipped with a temperature sensor. Due to the lack of automatic flow control, metered units must be frequently flow calibrated and audited, a process which involves a fair amount of math and takes much longer than ACTUAL flow calibrations. Also, metered units must have the flow rate set at a point slightly above the target rate of 16.7 LPM in order to compensate for the fact that the flow rate will drop as the filter becomes loaded with particulate. Note: If a BAM with an automatic flow controller is set to METERED flow control, then the flow will be controlled to EPA STD conditions.

STD (EPA Standard) Flow Control:

Automatic flow control, but usually no flow correction for ambient conditions.
STD (Standard) flow type is often selected when required by specific EPA monitoring regulations, or when no ambient temperature sensor is available. Standard flow control may be selected on any units which have an automatic flow controller instead of the manual valve (almost all BAM-1020 units have the automatic controller anyway). The flow rate is automatically controlled using EPA (standard) conditions, meaning that the volume of air (and thus the flow rate) is calculated with the assumption that the ambient temperature is a

standard value (default is 25 degrees C), and the barometric pressure is 760mmHg (one atmosphere), regardless of the actual temperature and pressure.

NOTE: At low altitudes and moderate temperature, EPA Standard flow will be very close to the actual volumetric flow rate. However, at high altitudes the difference between Standard and Actual flow will be quite significant, due to lower barometric pressure. Carefully consider this effect when deciding on a flow type to implement.

ACTUAL (Volumetric) Flow Control:

Both automatic flow control, and flow correction for ambient conditions.
Actual (also known as volumetric) flow type is the most accurate flow control mode, and is required for all $PM_{2.5}$ monitoring. The actual flow type is also the easiest and fastest to calibrate and audit. The unit always uses actual ambient air temperature and barometric pressure to correct the flow reading, and the flow rate is continuously and automatically adjusted to correct for changes in ambient conditions and filter loading. The flow values will be stored and displayed in actual volumetric conditions. To operate a BAM in actual flow mode, the unit must have a BX-596 or BX-592 ambient temperature sensor on channel six.

5.3 Leak Check Procedure

Leak checks should be performed at least monthly and whenever the filter tape is changed. 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. There will normally be a very small amount of leakage at the tape, but an excessive leak lets an unknown amount of air enter the system through the leak instead of the inlet. This will cause the total air volume calculation (and the concentration) to be incorrect. **Allowing a leak to persist may cause an unknown amount of data to be invalidated!** Perform the following steps to check for leaks:

1. Remove any PM_{10} and $PM_{2.5}$ heads from the inlet tube. Install a BX-305 or BX-302 leak test valve (or equivalent valve for auditing FRM samplers) onto the inlet tube. Turn the valve to the OFF position to prevent any air from entering the inlet tube.
2. In the TEST > TAPE menu, advance the tape to a fresh, unused spot.
3. In the TEST > PUMP menu, turn on the pump. The flow rate should drop below **1.0 lpm**. If the leak flow value is 1.0 lpm or greater, then the nozzle and vane need cleaning, or there may be another small leak in the system.
4. Resolve the leak and perform the check again. A properly functioning BAM with a clean nozzle and vane will usually have a leak value of about **0.5 lpm** or less using this method, depending on the type of pump used.
5. Turn the pump off, remove the leak test valve, and re-install the inlet heads.

NOTES: The reason for the 1.0 lpm leak flow allowance is due to the test conditions. With the inlet shut off the vacuum in the system is very high, about 21 inHg. This is many times greater than the BAM-1020 will encounter during normal sampling. If the leak reading during this test is less than 1.0 lpm, there should not be a significant leak during normal operation.

Some agencies choose to adopt tighter tolerances for the leak test, such as requiring a leak value of 0.5 lpm or less after the nozzle and vane are cleaned. Most agencies perform as-found leak checks (before cleaning the nozzle and vane) for data validation purposes, since it is often necessary to invalidate data from a BAM which is found to have a significant leak, all the way back to the last known good leak test. The typical recommended threshold for invalidating data is an as-found leak value (before cleaning nozzle and vane) of 1.5 lpm or higher. Again, some agencies adopt tighter standards, such as invalidating data if the as-found leak value is greater than 1.0 lpm.

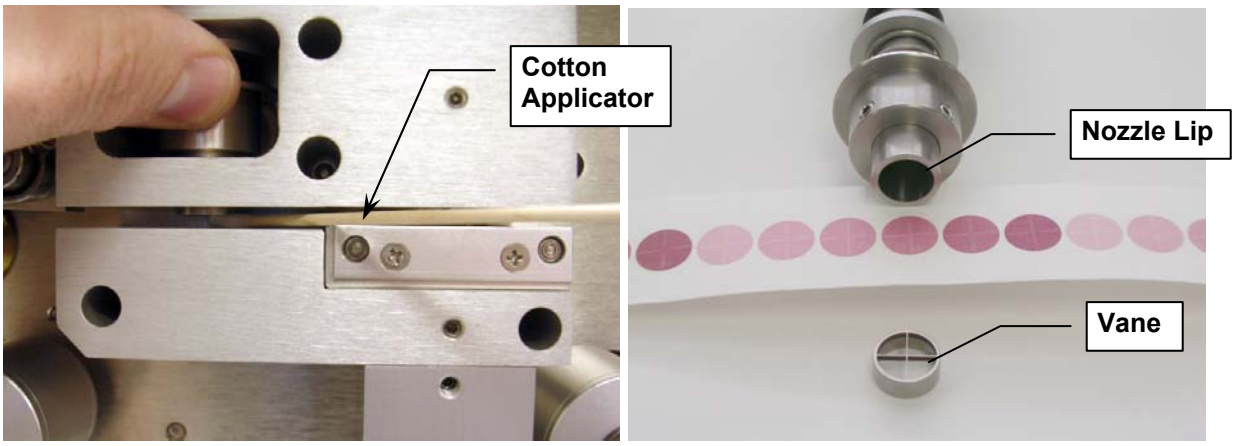
5.4 Leak Isolation and Nozzle Seal Methods

Leaks can be further isolated using a soft rubber sheet with a ¼" hole in it, such as Met One part 7440. The filter tape can be removed and the rubber seal inserted with the hole centered under the nozzle. The seal allows the leak check to be performed as usual, but without any leakage through the filter tape. The leak value should drop to 0.2 lpm or less with this method. A leak can be further isolated by using a part of the seal without a 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, then see Section 7.5 for some troubleshooting steps for leaks in other parts of the flow system.

5.5 Nozzle and Vane Cleaning

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 each time the filter tape is changed, though monthly cleaning is highly recommended. Some sites will require more frequent cleaning as determined by the site administrator. The worst environment for nozzle contamination seems to be hot, humid environments. This is because damp filter tape fibers more easily stick to the nozzle and vane. The fibers can quickly build up and dry out, creating air leaks or even punching small holes in the filter tape. This will cause measurement errors. Use the following steps to clean the parts. Refer to the photos below.

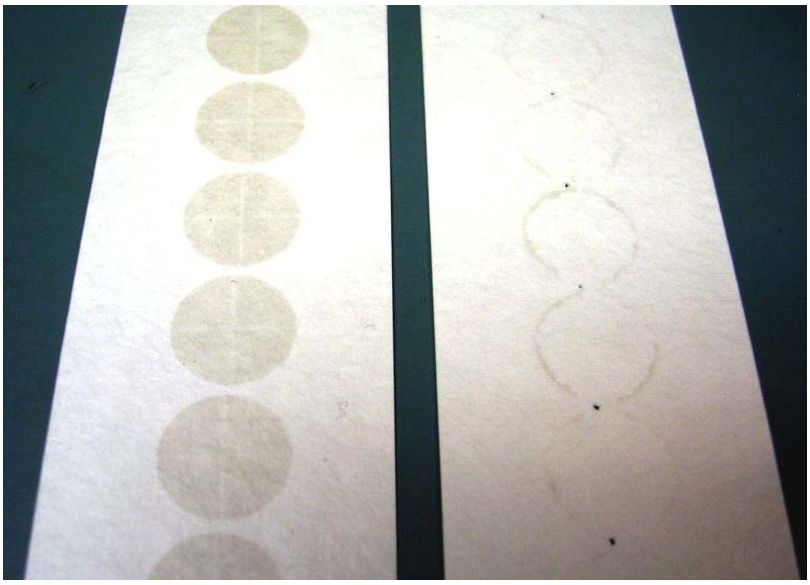
1. Raise the nozzle in the TEST > PUMP menu. Remove the filter tape (if installed) from the nozzle area. It is not necessary to completely remove the tape from the unit.
2. With the nozzle up, use a small flashlight to inspect the cross-hair vane.
3. Clean the vane with a cotton-tipped applicator and isopropyl alcohol. Hardened deposits may have to be carefully scraped off with the wooden end of the applicator or a dental pick or similar tool.
4. Lower the nozzle in the TEST > PUMP menu. Lift the nozzle with your finger and insert another cotton swab with alcohol between the nozzle and the vane. Let the nozzle press down onto the swab with its spring pressure.
5. Use your fingers to rotate the nozzle while keeping the swab in place. A few rotations should clean the nozzle lip.
6. Repeat the nozzle cleaning until the swabs come out clean.
7. Inspect the nozzle lip and vane for any burrs which may cause leaks or tape damage.



Nozzle Cleaning

The figure below shows the difference between good and bad filter tape spots. The tape on the left is from a properly operated BAM-1020 with a clean nozzle and vane. Notice the particulate spots have very crisp edges, are perfectly round, and are evenly distributed.

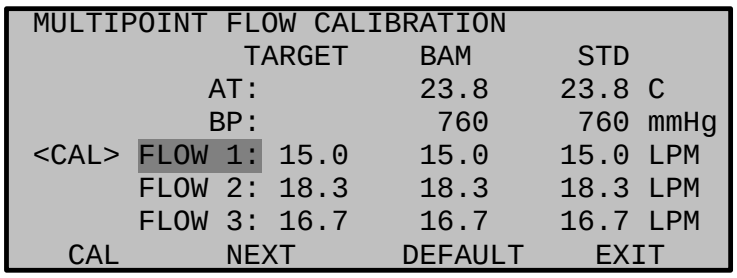
The tape on the right is from a unit which has not been properly maintained. A spot of debris has built up on the vane, and is punching a pin-hole at the edge of each spot. These holes can allow beta particles to get through un-attenuated which negatively affects accuracy even if the nozzle is not leaking. The spots also show a “halo” effect due to air leaking in around the edged because the 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.



BAM-1020 hourly filter tape spots

5.6 Field Calibration of Flow System – Actual (Volumetric) Flow Mode

Actual (volumetric) flow calibration is very fast and easy. This type of calibration can only be performed on BAM units which have an automatic flow controller and a BX-592 or BX-596 ambient temperature sensor on channel 6. The unit must also have the Flow Type set to ACTUAL in the SETUP > CALIBRATE menu or the flow calibration screen will not be visible.



Actual Flow Calibration Screen

1. Enter the TEST > FLOW menu as shown above. The nozzle will lower automatically when this screen is entered. The “BAM” column is what the BAM-1020 measures for each parameter, and the “STD” column is where you will enter the correct values from your reference standard. The <CAL> symbol will appear next to the parameter selected for calibration. The ambient temperature (AT) and pressure (BP) must be calibrated first, as the BAM uses these to calculate the air flow rate in actual mode.
2. Measure the ambient temperature with your reference standard positioned near the BX-592 or BX-596 ambient temperature probe. Enter the value from your reference standard into the STD field using the arrow keys. Press the CAL hot key to correct the BAM reading. The BAM and STD values should now be the same.
3. Press the NEXT hot key to move the <CAL> indicator to the BP field, and repeat the same steps for barometric pressure.
4. After the temperature and pressure readings are correct, remove the PM_{10} and $PM_{2.5}$ heads from the inlet tube and install your reference flow meter onto the inlet. Press the NEXT hot key to move the <CAL> indicator to the first flow point of 15.0 lpm. The pump will turn on automatically. Allow the unit to regulate the flow until the BAM reading stabilizes at the target flow rate. Enter the flow value from your standard into the STD field using the arrow keys. Press the CAL hot key to correct the BAM reading. **NOTE:** The BAM reading will not change to match the STD until after you have entered all three calibration points.
5. Press the NEXT hot key to move the <CAL> indicator to the second flow point of 18.3 lpm and repeat the process.
6. Press the NEXT hot key to move the <CAL> indicator to the third flow point of 16.7 lpm and repeat the process. Enter the flow value and press <CAL>.
7. **When all of the calibrations are complete, the BAM-1020 flow readings should match the traceable flow standard reading at 16.7 lpm, +/- 0.1 lpm. Exit the calibration menu.**

The DEFAULT hot key can be pressed to reset the user calibration from the selected parameter and replace it with a factory setting. If any of the FLOW parameters are selected, the DEFAULT key will reset the calibrations of all three flow points. This feature can be used to start over with a calibration if difficulty is encountered.

Actual flow calibrations in units with older firmware:
BAM-1020 units with previous revisions of firmware (prior to Rev 3.0) have a different format in the TEST > FLOW menu, as shown below. These units are flow calibrated in the same way as described above, except that the flow calibration is performed at only a single point of 16.7 lpm, not a multi-point calibration as in new units. The correct values from your traceable reference standard device must be entered into the "REFERENCE" column, then the "ADJUST/SAVE" button is pressed to correct the BAM reading. The "NEXT" key selects the parameter to be calibrated. AT and BP must be calibrated first, then the pump is turned on.

```
      ACTUAL FLOW CALIBRATION MODE
F1= RESTORE DEFAULT
                        BAM      REFERENCE
AMBIENT TEMPERATURE:   23.8 C    23.4 C
BAROMETRIC PRESSURE:   741 mmHg  742 mmHg
VOLUMETRIC FLOWRATE:   16.7 lpm  16.9 lpm

ADJUST/SAVE   NEXT     PUMP ON    EXIT
```

Previous Format of the Actual Flow Calibration Screen

5.7 Field Calibration of Flow System – EPA Standard Flow Mode

Flow calibration on units operated in EPA STANDARD flow mode can be done a couple of different ways. If the unit has a BX-592 or BX-596 ambient temperature probe installed, the easiest way to calibrate the flow is to temporarily change the FLOW TYPE from STD to ACTUAL in the SETUP > CALIBRATE menu, then perform an Actual flow calibration as described above. If this method is used, be sure to set the unit back to STD flow when done.

If the unit does not have the temperature sensor then you will not have access to the TEST > FLOW screen. Use the following steps to check the flow instead:

1. Attach your flow standard onto the BAM inlet while the pump cycle is running or turn the pump on in the TEST > PUMP screen. Allow the BAM flow to stabilize.
2. If your reference flow meter has a STANDARD flow reading available, that value can be directly compared to the BAM flow reading. If your flow meter only has a volumetric flow reading, then convert the volumetric flow rate to standard flow $\mathbf{Q_s}$ with the following formula:

$$\mathbf{Q_s = Q_a * (P_a / T_a) * (298 / 760)}$$

T_a = Ambient Temperature (Kelvin) (Kelvin = Celsius + 273)
P_a = Ambient Barometric Pressure (mmHg)
Q_a = Actual Volumetric Flow from Reference Meter

3. Compare the reference flow (converted to STD conditions) to the BAM flow reading (also in STD conditions). The two should match within 1% (about 0.17 LPM). If not, a full flow calibration should be performed. Change the FLOW TYPE to METERED and perform a flow calibration using the $\mathbf{C_v}$ and $\mathbf{Q_0}$ values as described in section 5.8. The sections about the manual flow valve do not apply. Set the flow type back to STD when finished.

5.8 Field Calibration of Flow System – Metered Flow Mode

Metered flow calibration is only performed on BAM-1020 units which have a hand-operated manual flow valve on the back (mostly older units). Because these units do not have automatic flow control, the calibration procedure is much more complicated. The flow must also be more frequently checked due to changes in ambient conditions, which these type of units cannot compensate for. Use the following steps for a full Metered flow calibration. The full calibration only needs to be done once in a while, but the flow should be checked and adjusted often. The process is faster if your reference flow meter can provide standard flow.

1. Advance the filter tape to a fresh spot.
2. Enter the SETUP > CALIBRATE menu. Set the $\mathbf{C_v}$ (coefficient of variability) value to **1.000**, and the $\mathbf{Q_0}$ (flow zero correction) value to **0.000.**
3. Disconnect the pump tubing from the back of the BAM, and turn the pump on in the TEST > PUMP menu. There will not be any air flowing through the unit. Record the flow reading from the BAM display. This is the zero flow $\mathbf{Z_f}$ value.
4. Re-enter the SETUP > CALIBRATE menu and set the $\mathbf{Q_0}$ value to equal the negative of the zero flow value $\mathbf{Z_f}$.
5. Go back to the TEST > PUMP menu and turn the pump back on. Verify that the flow reading on the BAM display now reads 0.0 LPM +/-0.1LPM.
6. Reconnect the pump tubing to the back of the BAM. Remove any PM_{10} and $PM_{2.5}$ heads, and connect your reference flow meter to the inlet.
7. Record the ambient temperature $\mathbf{T_a}$ (Kelvin) from your reference standard, and record the barometric pressure $\mathbf{P_a}$ (mmHg) from the OPERATE > NORMAL screen on the BAM.
8. From the TEST > PUMP menu, turn the pump on and allow the flow to stabilize for 5 minutes. Then record the actual flow from your reference flow meter $\mathbf{Q_a}$, and record the standard flow reading from the BAM display $\mathbf{Q_b}$.
8. Convert the volumetric flow rate $\mathbf{Q_a}$ from your reference meter to EPA standard flow $\mathbf{Q_s}$ with the following formula:

$$\mathbf{Q_s = Q_a * (P_a / T_a) * (298 / 760)}$$

T_a = Ambient Temperature (Kelvin) (Kelvin = Celsius + 273)
P_a = Ambient Barometric Pressure (mmHg)
Q_a = Actual Volumetric Flow from Reference Meter

9. Calculate the final value for $\mathbf{C_v}$:

$$\mathbf{C_v = Q_s / Q_b}$$

10. Calculate the final value for $\mathbf{Q_0}$:

$$\mathbf{Q_0 = -C_v * Z_f}$$

11. In the SETUP > CALIBRATE menu, enter the final values for $\mathbf{C_v}$ and $\mathbf{Q_0}$.
12. Turn the pump on in the TEST > PUMP menu again and verify that the flow reading from the BAM display matches $\mathbf{Q_s}$ within 1%. If not, repeat the entire flow calibration.
13. After the flow is calibrated, use the flow adjustment knob on the rear of the BAM-1020 and adjust the flow until the display reads **17.3 LPM**. This level is within the specification of the PM_{10} particle separator, and will allow for filter loading in high concentration areas. In lower concentration areas the flow can be set at 16.7 LPM.
14. Exit the TEST menu.

Quick Flow Check and Adjustment for Metered Flow:
These steps can be used to do a quick flow check on a Metered Flow BAM with a manual valve while it is in operation.

4. Insert your volumetric flow standard onto the BAM inlet, and allow the BAM flow to stabilize.
5. Record the ambient temperature, ambient pressure, and the volumetric flow from the reference.

T_a = Ambient Temperature (Kelvin) (Kelvin = Celsius + 273)
P_a = Barometric Pressure (mmHg)
Q_a = Actual Volumetric Flow

6. Convert the volumetric flow from the reference to EPA standard conditions:

$$\mathbf{Q_s = Q_a * (P_a / T_a) * (298 / 760)}$$

7. Compare the reference flow (converted to STD conditions) to the BAM flow reading (also in STD conditions). The two should match within 1%. If not, a full flow calibration should be performed.
8. If the reference flow (converted to STD conditions) and BAM flow reading match, then adjust the flow adjustment knob on the back of the unit until the BAM flow reading equals **17.3 LPM**.

Manual Flow Compensation for Seasonal Weather Changes:
These steps can be used to periodically adjust the flow rate on a Metered flow BAM with a manual valve to compensate for changes in average local atmospheric conditions. Full flow calibrations should still be performed on a regular basis.

1. Measure the ambient temperature $\mathbf{T_a}$ (Kelvin) at approximately 4:00 PM. This usually represents an average daily temperature.
2. Stop the BAM pump and record the barometric pressure $\mathbf{P_a}$ (mmHg) from the OPERATE > NORMAL screen.
3. Calculate a volume correction term by the following:

$$\mathbf{V = (T_a / P_a)*62.4}$$

4. Divide **V** by 24.47 to determine the ratio of EPA flow to Ambient Flow and record as **CALNUM**.
5. Turn the pump on in the TEST > PUMP menu and allow the flow to stabilize for 5 minutes. Then divide the displayed flow by **CALNUM**.
6. Adjust the flow adjustment knob on the back of the BAM-1020 until the BAM flow reading equals **17.3 / CALNUM**. Exit the TEST menu.

Example:
Temp = **300 Kelvin**
Pressure = **710 mmHg**
V = (300/710) * 62.4 = **26.4**
CALNUM = 26.4/24.47 = **1.08**
Adjusted Flow = 17.3/1.08 = **16.0 LPM**
Adjust flow valve until BAM reads 16.0 LPM.

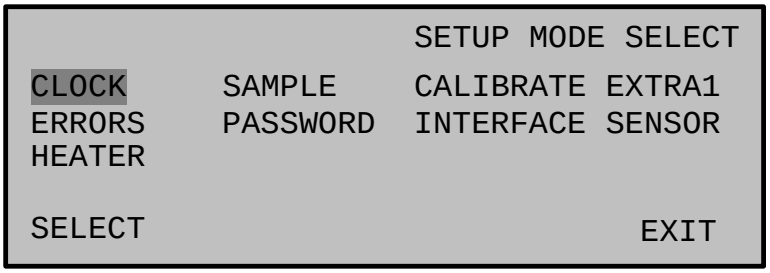
6 SETUP MENU DESCRIPTIONS

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. Some of these settings are set at factory default values which are correct for most applications, but may be altered by the operator to suit the specific needs of your monitoring program. This section describes the SETUP 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 SETUP 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 SETUP menus are unit-specific calibration constants which cannot be changed without affecting the accuracy and proper operation of the unit.

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

Press the SETUP soft-key to enter the menu as shown below. 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.



The SETUP Menu

A brief description of each sub-menu in shown in the table below. Detailed information is provided in the following sub-sections.

Menu	Settings
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, Heater 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 and Delta-T set-points for Smart Heater. Only visible if Heater Control is set to AUTO.

6.1 CLOCK Screen

The SETUP > CLOCK 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 BAM-1020 clock may drift as much as a minute or two per month. Met One recommends checking the clock monthly to ensure correct sample timing.

6.2 SAMPLE Settings Screen – Critical Information

The SETUP > SAMPLE screen is used to set the BAM-1020 sampling and averaging periods, and some other important settings. Review each of these settings carefully. The SAMPLE screen is shown below. The fields can be edited with the arrow keys, then saved with the SAVE soft-key.

```
                                SETUP SAMPLE
RS232 9600 8N1     BAM SAMPLE 042 MIN

STATION # 01       MET SAMPLE  60 MIN
RANGE   1.000 mg   OFFSET  -0.015 mg
CONC UNITS mg/m3   COUNT TIME   8 MIN
   SAVE                          EXIT
```

The SAMPLE Screen

RS-232: This allows you to set the baud rate of the RS-232 serial port. The available values are 300, 600, 1200, 2400, 4800, 9600, 19200, and 38400 baud. Default is 9600. “8N1” means 8 data bits, no parity, 1 stop bit. These handshaking bits cannot be edited.

BAM SAMPLE: This value sets the amount of time that the vacuum pump is on per cycle; the actual sample period (see Section 4.1 for a description of the measurement cycle). The BAM SAMPLE time must be set in response to the COUNT TIME value, since new versions of the BAM-1020 allow the option of setting the count time to 4, 6, or 8 minutes. If the unit is used for $PM_{2.5}$ monitoring, the BAM SAMPLE must be set to 42 minutes with 8 minute count time. PM_{10} monitors are almost always set for 50 minutes.

Count Time	BAM Sample	Used for
4 min	**50 min**	PM10 monitoring
6 min	46 min	not used
8 min	**42 min**	PM2.5 monitoring

The BAM SAMPLE value can be set from 0-200 minutes for custom applications. If set for shorter period, such as 15 minutes, the unit will finish the sampling in 15 minutes and then wait until the end of the hour before beginning a new cycle. This may not leave time for the membrane span check. Only one cycle per hour is allowed, regardless of duration. Setting the value too long may cause the measurement to extend over into the next hour. Contact the Service department before setting this to anything but the values shown in the table.

STATION #: This is a station identification number. This number has a range of 00-99, and will be included in the data reports. When used in a network, every BAM-1020 should be given a different station number. Default value is 01.

MET SAMPLE: This value is the averaging period for the data logger. It sets how often data is written to memory, and can be set to 1,5,15, or 60 minutes. For example, if an external wind speed sensor is attached to the BAM, the MET SAMPLE period could be set to 1 minute. This would cause the BAM to store an average of the WS reading every minute. This value applies to all sensors attached to the unit. **Warning: This setting will affect how long the memory will last before getting full.**

There are **4369 records** available in the BAM memory. A MET SAMPLE period of 60 minutes (1 record per hour) will result in over 182 days worth of memory capacity, but a 1 minute average period will fill up these memory records in only 3 days. When the memory gets full the unit over-writes the oldest data. Met One recommends leaving the MET SAMPLE period set at the default value of 60 minutes unless otherwise required for a particular application. The dust concentration value will always be an hourly average regardless of this setting.

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 almost never changed from the default setting of **1.000 mg**. This means that the BAM measures a maximum full-scale range of 1000 micrograms above whatever the OFFSET value is set to. The table below shows some examples of the RANGE setting interacting with the OFFSET setting to produce the concentration data outputs of the BAM.

OFFSET Setting	**RANGE Setting**	Resulting Digital Data Range	Resulting Analog Output Range
-0.015 mg	1.000 mg	-0.015 to 0.985 mg	0-1V = -0.015 to 0.985 mg
-0.005 mg	1.000 mg	-0.005 to 0.995 mg	0-1V = -0.005 to 0.995 mg
0.000 mg	1.000 mg	0.000 to 1.000 mg	0-1V = 0.000 to 1.000 mg
0.000 mg	2.000 mg	0.000 to 2.000 mg	0-1V = 0.000 to 2.000 mg

In special cases, the RANGE value may be set to 0.100, 0.200, 0.250, 0.500, 2.000, 5.000, or 10.000 mg. Be sure to account for this value if using a separate data logger to record the BAM-1020 analog output.
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. Firmware version 3.2.4 or later will prompt you to clear the memory before letting you change this setting.

OFFSET: The OFFSET value is used to set the lower end of the BAM-1020 measurement range, and could more accurately be called a “range offset”. The new factory default value for OFFSET is now -0.015 mg. This causes the entire range of the BAM-1020 to shift down slightly so that it can read from -0.015 to 0.985 mg, instead of measuring from 0 to 1.000 mg (assuming the RANGE is set to 1.000 mg). This simply allows the unit to measure slightly negative concentration numbers near zero, which is helpful to differentiate between normal noise and a failure such as punctured filter tape.

The previous default was -0.005 mg, and the value may still be set to -0.005 if needed to work with data logging systems structured around the old setting. Some BAM users choose

to set the OFFSET value to 0.000 to avoid confusion, at the expense of not being able to see the true zero noise floor of the unit.

This value also affects the analog output, so that 0 to 1.000 volts equals -0.015 to 0.985 mg, instead of 0.000 to 1.000 mg. This is because the voltage output cannot go negative. You must take this scaling into account if an external data logger is recording the BAM-1020 analog output voltage. Contact the Service department if you plan to set the OFFSET to any value other than -0.000, -0.005, or -0.015 mg.

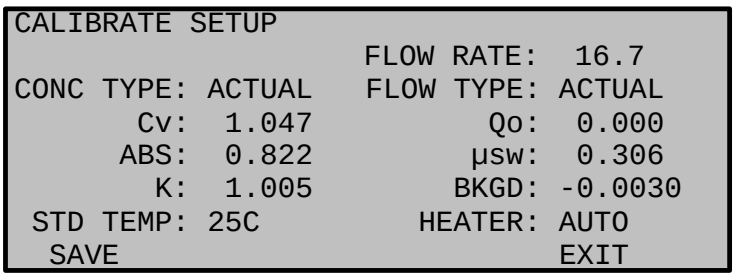
Note: The OFFSET value is often misunderstood, and should not be confused with the BKGD (zero correction factor) or the "e1" (lower concentration limit clamp) values. Be sure you understand all three of these settings!
Note: Changing the offset setting will affect past data already stored to memory. Always download any old data before changing settings, then clear the memory. Firmware version 3.2.4 or later will prompt you to clear the memory before letting you change this setting.

CONC UNITS: This setting determines the concentration units which the BAM-1020 displays and stores in memory. This can be set to ug/m3 (micrograms) or mg/m3 (milligrams) per cubic meter. This is a new option for the BAM-1020. Past versions have always been set for mg/m3. **Note:** 1 mg = 1000 μg.

COUNT TIME: This is the amount of time the unit takes to perform the I_0 and I_3 counts. Past versions of the BAM-1020 have always been fixed at 4 minutes. The new options allow the count time to be set for 4, 6 or 8 minutes. When used to monitor $PM_{2.5}$, this must be set to 8 minutes. This increases the sensitivity of the unit in lower concentrations. Increasing the count time will require decreasing the sample time. For example, a count time of 4 minutes allows a sample time of 50 minutes, while a count time of 8 minutes allows a sample time of only 42 minutes. The unit will prompt you to change the sample time if you change the count time to an incompatible value.

6.3 CALIBRATE Screen – Critical Information

The SETUP > CALIBRATE 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 unit in case a setting is accidentally changed. Most of these settings will never be changed without specific information from Met One Instruments. It is good practice to periodically audit the calibration values to verify that they have not been altered. The CALIBRATE screen is shown below.



The SETUP > CALIBRATE Screen

FLOW RATE: This sets the air flow rate for the BAM-1020 sample period. The BAM will continuously regulate the flow to this value (except manual valve models). The flow rate is almost always set for **16.7 liters per minute**, as this is required for all $PM_{2.5}$ and PM_{10} monitoring. The operator may change this value temporarily in order to test the ability of the pump and flow controller to regulate the flow at different levels. The range of this setting is 10 to 20 LPM.

CONC TYPE: This sets the way that the concentration values are reported. If set to ACTUAL, then the concentration is calculated based on the volume of the air at ambient conditions, and a BX-592 or BX-596 temperature sensor is required. If set to STD, the concentration is calculated based on the standard values for temperature and pressure (usually 25C and 760mmHg), even if a temperature sensor is available. This value is usually set to match the FLOW TYPE setting, and must be set to ACTUAL for $PM_{2.5}$ monitoring. Note: BAM units with firmware prior to rev 3.0 does not have this setting available.

FLOW TYPE: This setting selects the flow control scheme used by the BAM-1020. The three possible settings are METERED, STD, and ACTUAL.

- METERED: Usually used for BAM units with a manual flow valve on the back. Flow is reported in EPA conditions.
- STD: EPA Standard flow. The flow is controlled and reported in EPA standard conditions. Used where required by regulations.
- ACTUAL: Actual Volumetric flow is controlled and reported to ambient temperature and pressure conditions. This is required on $PM_{2.5}$ monitors, and is recommended by Met One whenever possible. BX-596 or BX-592 sensor is required.

This is an important parameter to understand. At sea-level and moderate temperatures the difference between these settings will be minimal, but at high elevations or varied temperatures the flow rate can be greatly affected by this setting. **NOTE:** Section 5.2 contains a detailed description of each of these flow types, and should be studied to ensure proper operation of the unit.

Cv: This value is the factory-set Coefficient of Variability for the internal flow sensor. The value of Cv is only changed by the user when performing a flow calibration on manual valve (metered) or STD flow units. ACTUAL flow controlled units almost never need to have this value altered.

Qo: This value is the factory-set zero correction factor for the internal flow sensor. The value of Qo is only changed by the user when performing a flow calibration on manual valve (metered) or STD flow units. ACTUAL flow controlled units almost never need to have this value altered.

ABS: The ABS value is the factory-set mass of the reference membrane foil used during the automatic span check. This value is compared to the measured value each hour (see section 4.2). Each unit's ABS value is different, but is typically around 0.800 mg. **The ABS value is never changed by the operator unless the span membrane 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. Typical values are about 0.285 to 0.310. **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 Met One Instruments.**

K: The K-factor is the factory-set slope correction (multiplier) for the BAM-1020 concentration. 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. All of the stored and displayed data contains this correction. **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 Met One Instruments.**

BKGD: The BACKGROUND value is the factory-set zero correction (slope offset) for the BAM-1020 concentration. This is determined by running the unit for at least 72 hours with a 0.2 micron 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 correction. The BKGD value is typically between 0.000 and -0.005 mg/m^3. Met One does offer a zero filter kit (BX-302) which may be used to audit this value, and comes with complete instructions. **Warning: This is a unit-specific calibration value which may significantly affect the accuracy of the unit.** Note: The BKGD value is not to be confused with the OFFSET (range offset) value in the SETUP > SAMPLE menu. See section 6.2.

STD TEMP: This is the value of standard temperature, used for standard flow or concentration calculations. In the U.S. the value of standard temperature is usually 25 degrees C as mandated by the USEPA. Some other countries use a standard temperature value of 0C or 20C. This setting is not available on units using firmware prior to rev 3.0.

HEATER: This setting selects which mode the Smart Inlet Heater is used in. When set to AUTO, the Smart Heater will use the filter RH and temperature sensors to control the inlet tube heating. When set to MANUAL, the unit will simply turn the heater on all the time regardless of filter conditions. The actual setup parameters for the Smart Heater are located in the SETUP > HEATER menu, which will not appear unless this value is set to AUTO. The operator may safely set this parameter as required. Met One recommends using the AUTO setting. This value must be set to AUTO for $PM_{2.5}$ monitoring.

6.4 EXTRA1 Screen

The settings in the EXTRA1 screen are special settings that have been installed for special applications and generally will never be changed.

e1 Low Concentration Limit. The lowest concentration value the BAM-1020 is allowed to store or display, despite what it measured. Any measurements below this value will be clamped. The range is -0.015mg to +0.010mg, and the default value is -0.015mg. **Note:** This value is not to be confused with the OFFSET value which sets the lower limit of the measurement range, or the BKGD value which is the zero correction.

e2 Not Used.

e3 Membrane OFF Delay. Hysteresis timer, range is 0.000 to 5.000 seconds. Don't change this value unless instructed to do so by Met One.

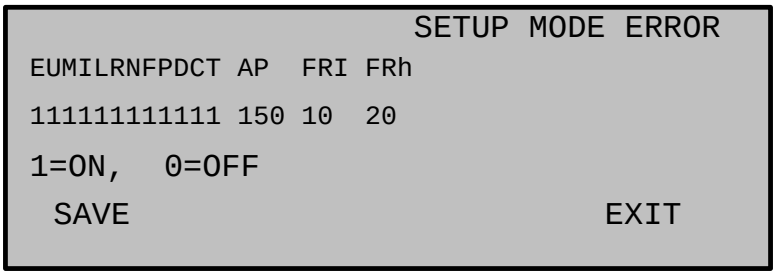
e4 Membrane Time Out. The time the unit allows for the membrane assembly to move before generating an error. Range is 10.00 to 20.00 seconds. Don't change this value unless instructed to do so by Met One.

6.5 ERRORS Screen

This screen allows the operator the option of reporting BAM-1020 errors with the analog output signal. This type of error indication is used when the operator is limited to a single voltage channel for particulate information, such as when the BAM is connected to certain types of data loggers. In this case, the BAM sets the analog output to **full scale voltage** (usually 1.000 volts) when an error occurs. At the beginning of the next hour, the errors are reset and the output functions normally unless another error occurs. The operator can select which errors, if any, are reported in this manner, by selecting each error from the list below and enabling or disabling it (**1=ON, 0=OFF**) in the error setup screen.

Regardless if a particular error is enabled for the analog output in this manner or not, it will always be reported in the BAM-1020 digital memory, and may be viewed with the display or by downloading the data through the serial port. Some of these errors such as P, R, N, and E may be set to cause the analog output to go full scale, even though there may be nothing wrong with that hour's data. In this case, the concentration data can still be downloaded from the BAM. Some (but not all) errors such as M and L cause the digital concentration value to be set to full scale too, usually .985mg.

This scheme is used because it is rare for an actual valid concentration reading to measure full-scale. However, concentrations at or near zero can be common, so leaving the data value at 0.000 during an alarm could be mistaken for valid data.



The ERRORS Screen

E **EXTERNAL RESET:** This error indicates that the system clock time was unable to reset when signaled by an external datalogger. If external reset is successful then no error is logged (see Section 8.2). Sometimes called **INTERFACE RESET**.

U **TELEMETRY FAULT:** This error indicates that an external datalogger has sent an error to the BAM-1020 (on the TELEM FAULT input) indicating that it has encountered a problem. Check the datalogger.

M **MAINTENANCE:** This is a user-set data flag which indicates that calibration or testing was performed during the flagged hour. The "**M**" flag may also be forced ON in the SETUP > INTERFACE menu by setting "Force Maint" to ON, or in the OPERATE > INST screen by pressing the TOGGLE FLG button. M flags cause the digital concentration to read full-scale for that hour.

I **INTERNAL CPU:** This indicates an error in the mass concentration calculation by the central processor. Contact the Service department if these errors begin to occur frequently.

L **POWER FAIL:** This error occurs any time power is cycled or lost, even momentarily. Frequent "**L**" errors usually indicate poor quality AC power. In some cases these errors can be generated by electrical interference (such as large radio antennas or motors) causing an internal reset in the BAM-1020. There are also a variety of power supply upgrades available for some older BAMs which experience frequent L errors. If a BAM experiences frequent L failures even when connected to a UPS, contact Met One for instructions on possible upgrades. This error also causes the digital concentration value to go full-scale.

R **REFERENCE MEMBRANE:** This error indicates that the reference membrane assembly is not physically extending and retracting properly. The error is generated if photo sensors S2 and S3 never change state despite drive commands to the membrane motor, and a timeout of the membrane motion occurred after 15 seconds.

N **NOZZLE STUCK TIMEOUT (or Delta-T exceeded):** This error indicates that the nozzle motor is not operating. The error is triggered if photo sensors S4 and S5 never change state despite drive commands to nozzle motor, and if the sensors do not see the nozzle motor move within 12 seconds of it being turned on. **NOTE:** The nozzle motor lifts the nozzle, but the nozzle is lowered only by its spring. So it is possible for the nozzle to become stuck in the UP position without generating an error! Proper maintenance and inlet alignment prevents this.

The "**N**" error is also used to indicate that the Delta-Temperature set-point was exceeded. This occurs if the sample air temperature (measured below the filter tape) is hotter than the ambient air by at least one degree above the set-point value. This is due to the normal heating of the sample air by the smart heater. In this case, the error is used to simply flag the data. Frequent errors may indicate that the set-point is set too low. In most applications Delta-T control is disabled entirely. See the inlet heater settings instructions in this manual.

F **FLOW ERROR:** This error occurs if the average air flow over the sample period was out of the limits set by the **FRl** (low limit) and **FRh** (high limit) values. The error will also be generated if the flow during any part of the sample period goes out of regulation by more than 5% for more than 5 minutes, or by more than 10% for more than 1 minute. In the later case, the sample is stopped as well. Momentary changes in airflow do not usually trigger the error. This error may begin to occur if the vacuum pump is wearing out, if the muffler is clogged, or due to a fault with the flow sensor, flow controller, or air tubing.

The **"F"** error is also used to indicate if the ambient temperature or barometric pressure sensor has failed or is incorrectly connected (only if the BAM is set for ACTUAL flow or concentration reporting). This applies to auto ID sensors BX-592 and BX-596, the internal filter pressure sensor, and CARB style temperature sensors. The sensor is considered failed if any 1 minute average reading of the sensor is at or beyond the min or max measurement range of the particular sensor.

P **PRESSURE DROP EXCESSIVE:** This error indicates that the vacuum beneath the filter tape has exceeded the limit set by the **AP** value. This is almost always caused by high concentrations, or certain types of particulate clogging the filter tape. When this error occurs, the BAM stops the pump to prevent overheating, completes the measurement early, then waits for the top of the next hour. To increase the amount of particulate which can build up on the tape before this occurs, set the **AP** value higher.

D **DEVIANT MEMBRANE DENSITY:** This error indicates that the reference membrane span check measurement (**m)** for that hour was out of agreement with the expected value (**ABS**) by more than ±5%. If these errors start to occur regularly, it could indicate that the beta detector is beginning to wear out. It can also be caused by a dirty or damaged membrane, or by a membrane assembly that is not extending or retracting fully. Also sometimes called a **BAM CAL** error.

C **COUNT ERROR:** This error indicates that the beta particle counting system is not operating properly, and is activated if the beta count rate falls below 10,000 per 4 minutes. The beta count rate through clean filter tape is usually more than 800,000 per 4 minutes. This error could occur if the beta detector has failed or if something is blocking the beta particles, such as a stuck membrane assembly or debris.

T **TAPE BREAK:** This error indicates that the filter tape is broken or has run out. The error is triggered if photo sensor S6 is ON continuously, despite drive commands to motors M3-M5. Tape supply motor (M3) and tape take-up motor (M4) time out after 10 seconds. Capstan motor (M5) times out after 6 seconds. This error is also generated if the pinch roller assembly has been left latched in the UP position when a measurement cycle starts. Photo sensor S9 is ON any time the latch is set. The BAM-1020 has no way of unlatching and lowering the pinch rollers. It must be done manually. A tape-break error will cause the measurement cycle will stop, and the BAM to repeat the last good concentration value until the filter tape is fixed or replaced.

AP Pressure-drop limit across the filter tape. The default setting is **150** mmHg, and the range is 0-500 mmHg. See the PRESSURE DROP EXCESSIVE error definition above.

FRl Flow Rate Lower Limit. The default setting is **10** lpm, and the range is 0-30 lpm. See the FLOW OUT OF LIMITS error definition above.

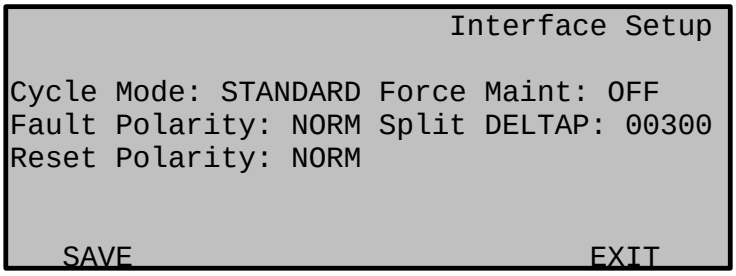
FRh Flow Rate Higher Limit. The default setting is **20** lpm, and the range is 1-38 lpm. See the FLOW OUT OF LIMITS error definition above.

6.6 PASSWORD Screen

The SETUP > PASSWORD screen allows the program administrator to change the password required to enter many of the SETUP menus. The password prevents untrained users from accidentally changing critical settings on the unit. The password can be any 4-key combination of the six function keys, F1 to F6. The default password is **F1, F2, F3, F4**. Met One does not recommend changing the password unless truly necessary. Contact the Met One Service department for instructions if the password is lost or forgotten.

6.7 INTERFACE Screen

The SETUP > INTERFACE screen is shown below. These settings are used to configure the BAM-1020 for operation with an external data logger recording the analog output. Most of these settings are rarely used, but the Cycle Mode setting must be reviewed if the analog output is being used.



The INTERFACE screen

Force Maint: This can be used to manually toggle the maintenance flag ON or OFF to mark the data when the unit is being worked on, such as during a flow check. This also toggles the Maintenance relay to an external data logger. Rarely used.

Fault Polarity: This sets the polarity of the Telemetry Fault Relay. NORM is normally open, INV is normally closed. Rarely used.

Split DELTAP: Not used.

Reset Polarity: This tells the BAM-1020 the incoming polarity of an external clock reset signal, if used. This signal is used to synchronize the BAM clock to an external data logger. NORM is normally open, INV is normally closed.

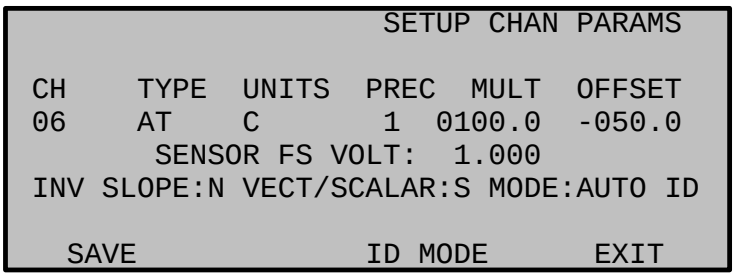
Cycle Mode: The Cycle Mode can be set to STANDARD or EARLY. If you are not using the analog output voltage of the BAM-1020, leave this set to STANDARD. See Section 8.2 for a description of the Cycle Modes.

6.8 SENSOR Screen

The SETUP > SENSOR menu is where configurations and setup parameters are located for the six analog input channels used to log external meteorological sensors. Each channel must be configured to accept the sensor before data can be acquired. Description for the parameters are provided below. There is a separate configurable setup screen for each of the

six external sensor inputs in the SETUP > SENSOR menu. There are also two internal channels (I1 concentration and I2 flow volume) which can be viewed but not modified.

Met One 500 series meteorological sensors have an Auto ID feature which allows the BAM to automatically recognize the sensor and enter all of the setup parameters for any channel the sensor is attached to. Each channel can also be manually configured by the user for other sensors.



The SENSOR Menu

CH: This field selects the channel to be viewed or edited. Use the up/down arrow keys to select the desired channel.

TYPE: This is the channel name. You can enter any desired name here by using the arrow keys to scroll through the alphabet and other characters.

UNITS: This is the measurement units label for the channel. You can enter a value here by using the arrow keys to scroll through the alphabet and other characters.

PREC: This is the precision field, which sets the number of available decimal places for the Multiplier and Offset parameters.

MULT: This is the slope multiplier. Any input on the channel is multiplied by this amount. The **M** factor in **Y=MX+B.**

OFFSET: This is the slope offset value. Any input on the channel has this amount added to or subtracted from it, after the multiplier is applied. The **B** factor in **Y=MX+B.**

FS VOLT: This is the full-scale voltage output of the sensor. The maximum voltage range that can be supplied by the sensor. This value is usually going to be either 1.000 or 2.500 volts. 2.500 is the maximum setting for this field.

INV SLOPE: This setting allows the channel to recognize a sensor with an inverse slope. This is always set to **N** (no) except for use with thermistor temperature sensors with resistance-only outputs.

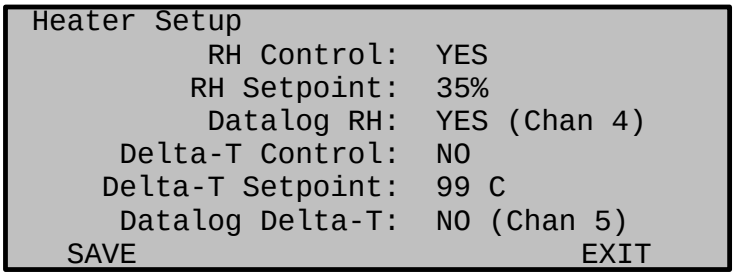
VECT/SCALAR: This value sets the averaging method. **S** (scalar) is used for all measurements except wind direction, which uses **V** (vector).

MODE: This field is toggled by pressing the ID MODE soft-key. The value can be set to either MANUAL or AUTO ID. In MANUAL mode, the user can enter their own

setup parameters for the channel. AUTO ID mode is used with 500 series sensors, and must be selected in order for the unit to recognize the sensor automatically. **NOTE:** Any manually set parameters for that channel will be lost when changing to AUTO ID mode. Channel 6 must be set to AUTO ID for $PM_{2.5}$ monitoring with the ambient temperature sensor BX-596.

6.9 HEATER Screen

The SETUP > HEATER screen is only visible if the HEATER CONTROL value in the SETUP > CALIBRATE menu is set to AUTO. This menu is used to configure the settings used by the BAM-1020 to control the Smart Inlet Heater. The BAM uses an RH and temperature sensor located below the filter tape in the sample air stream to monitor the conditions of the air as it is being sampled. Tests have shown that as the relative humidity of the ambient air exceeds about 50%, the particulate on the filter tape can begin to absorb moisture and the measured mass will increase. The effect gets worse as the RH increases. The Smart Heater minimizes this effect by actively heating the inlet tube to lower the humidity.



The HEATER Setup Screen

RH Control: If YES is selected, the Smart Heater will be automatically turned on full power whenever the humidity of the sample stream exceeds the RH Setpoint. When the RH falls back below the set point, the heater turns down to a low power heat mode (about 30 Watts) which simulates the older style wrap-around heaters. If this is set to NO, The Smart Heater will stay in low power mode and no further RH control will be performed.

RH Setpoint: The RH Setpoint can be a number from 10% to 99%. This is the relative humidity level that will be maintained at the filter. Met One recommends setting this value at **35%**, which is the equilibration value for FRM filters and is required when monitoring $PM_{2.5}$.

Datalog RH: If YES is selected, the filter RH values will be logged on channel 4 of the BAM-1020. Select YES if you do not have any external sensors attached to channel 4.

Delta-T Control: The BAM-1020 can compare the filter temperature to ambient and calculate the difference (Delta-Temperature), if a BX-592 ambient temp sensor is attached to channel 6. If YES is selected, the Smart Heater will be turned down to low power mode whenever the Delta-T Setpoint is exceeded.

Volatile organic compounds (VOCs) may be lost if the Delta-T is excessive. However, this is usually not a problem with the BAM-1020, because each spot of particulate is sampled for less than an hour before being replaced with a new spot. Met One does not recommend

using Delta-T control except in special applications, as it overrides the RH control which has a far greater effect on the concentration measurement. **Note:** Delta-T control must be set to NO for $PM_{2.5}$ FEM monitoring.

Delta-T Setpoint: This can be set from 1 to 99 degrees C. If the filter temperature exceeds the ambient temperature by more than this amount, the Smart Heater will turn down to low power mode, **regardless of the RH level**. An **N** error is logged in the data any time this happens. Note: There is often a few degrees of Delta-T measured even if the heater is OFF, due to mild heating effect of the unit itself. Frequent errors will be logged if the setpoint is too low. Set this value to at least 8 or 10 degrees C if used. Set the value to 99 if not used.

Datalog Delta-T: If YES is selected, the Delta-T values will be logged on channel 5 of the BAM-1020. Select YES if you do not have any external sensors attached to channel 5. **Note:** The measured Delta-T may still be logged even if Delta-T control is set to NO. This is often a useful parameter.

7 MAINTENANCE, DIAGNOSTICS and TROUBLESHOOTING

This section provides information for maintaining your BAM-1020, and for performing diagnostic tests if a problem is encountered. If the unit generates errors on the display or in the data array, first check Section 6.5 to identify the error. Many times there is a simple solution. Persistent errors often signify a failure or impending failure which will require investigation.

7.1 Met One Suggested Periodic Maintenance

Maintenance Item	Suggested Period
Nozzle and Vane Cleaning*	**Monthly**
Leak Check*	**Monthly**
Flow Rate Verification	**Monthly**
Clean Capstan Shaft and Pinch Roller Tires*	**Monthly**
Clean PM10 Head	**Monthly**
Clean PM2.5 Inlet	**Monthly**
Check Error Log*	**Monthly**
Download Digital Data Log*	**Monthly**
Compare BAM-1020 Data to External Datalogger Data (if used)	**Monthly**
Replace Filter Tape	**2 Months**
Run SELF-TEST Function	**2 Months**
Full Flow Audit and Calibration	**2 Months**
Verify BAM-1020 Settings	**2 Months**
Set Real-Time Clock	**2 Months**
Replace or Clean Pump Muffler (if used)	**6 months**
Test Pump Capacity	**6 months**
Test Filter RH and Filter Temperature sensors	**6 months**
Test Smart Heater	**6 months**
Perform 72 hour BKGD (BX-302 zero filter) test	**12 months**
Clean Internal Debris Filter	**12 Months**
Check Membrane Span Foil	**12 Months**
Beta Detector Count Rate and Dark Count Test	**12 Months**
Clean Inlet Tube	**12 months**
Test Analog DAC Output (if used)	**12 Months**
Rebuild Vacuum Pump*	**24 months**
Replace Nozzle O-ring (Special tools required)	**24 months**
Replace Pump Tubing	**24 Months**
Factory Recalibration. Not required except for units sent for major repairs.	**---**

***These items may be performed more often as required.

7.2 Audit Sheet and Test Records

The back of this manual contains a sample of a BAM-1020 Audit Sheet. This is a test record which can be filled out as calibrations, checks, or audits are performed on the unit. The operator is encouraged to make copies of this sample sheet to use as needed. Met One can also supply the original document in a Microsoft Word® format to be modified as needed. Keeping records of calibrations and maintenance is critical for any monitoring program. Most agencies develop their own SOP for maintenance items and test records.

7.3 Self-Test Feature

A primary method of identifying a hardware malfunction in the BAM-1020 is the SELF TEST feature in the TAPE menu. This can identify a large number of the possible mechanical failures in the unit, and is a good place to start if a problem is suspected or if frequent errors are recorded. See Section 3.5 for a description of the self-test process.

7.4 Power-Up Problems

The BAM-1020 must at least be able to power on before any further diagnosis can be performed. There are only a few possible reasons that the unit will fail to power up:

- Make sure that the unit is plugged into the correct AC voltage.
- Check or replace the two fuses (3.15A, 250V) inside the power switch housing. The power cord MUST be removed before the fuse door can be opened, or you will break it. Pry open the top edge of the power switch housing cover to access the fuses.
- It is possible for the display contrast to be set so light that it looks like the unit is OFF when it is really ON. Try holding the contrast key for a few seconds. In rare cases the display may fail completely. If the unit “beeps” when you press the keys, it is ON.
- If the above checks are all OK, there could be a failed power supply inside the unit. Contact Met One for further instructions. Do not attempt to open or repair the power supply assembly unless qualified.

7.5 Basic Problem and Cause/Solution Table

The following table contains information on some of the more common BAM-1020 problems which may be encountered, and some steps to identify and remedy the problems. Met One welcomes customer suggestions for new items to include in this section of future manual revisions! If the solution cannot be found in the following table, then contact one of our expert service technicians for help in resolving your problem.

Problem:	**The BAM won’t start a measurement cycle.**
Cause/Solution:	• The unit is programmed not to start 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, either 4 or 8 minutes after the start of the hour. • The unit cannot start if the pinch rollers are latched UP! The unit cannot lower them. • Make sure the filter tape is installed correctly. • The unit will never start a cycle if the display is not on the main or OPERATE menu. • The unit will usually display an error and “beep” if it cannot start a cycle

Problem:	The analog output voltage and/or digital concentration reading are full-scale.
Cause/Solution:	• The unit will force these values full-scale to indicate an error. Download the error log. Whenever the unit is started or interrupted this will happen until the next hour.

Problem:	The concentration is reading negative values.
Cause/Solution:	• It is possible for the unit to occasionally read negative numbers if the actual particulate concentration is very low, such as below 3 micrograms. This is because the BAM has a "noise band" of several micrograms. This should not happen often. • If the unit is reading negative numbers hour after hour, it is probably punching holes in the filter tape. These holes can be very small and hard to see. This is almost always caused by debris on the nozzle or vane. Clean the parts. • Make sure the SETUP > CALIBRATE values match the calibration sheet, especially the BKGD value. • The BKGD value may need to be field-audited. Met One supplies the BX-302 zero filter kit for auditing the zero reading of the unit.

Problem:	The airflow rate is too low and won't adjust up to 16.7 lpm.
Cause/Solution:	• The gray plastic pump mufflers clog up after several months. Replace it or drill a hole in the end of it for a temporary fix. The brass mufflers can often be cleaned. • Some users replace the pump muffler with a 30 inch length of air tubing. This will not clog and reduces the pump noise as well as the mufflers do. • The pump may need to be rebuilt after about 2 years. • Medo pumps slowly loose flow capacity as the pump wears out. Eventually, the flow capacity drops below 16.7 lpm when connected to a BAM. • Check the inlet and PM heads for obstructions.

Problem:	The airflow is stuck at a particular rate, and will not change.
Cause/Solution:	• The flow controller unit on some older units can become stuck. If your flow controller does not have a small circuit board mounted directly on the motor, it needs to be upgraded. Contact the Service dept. • Set the flow rate in the SETUP > SAMPLE screen to 14.0 and 17.5 lpm, and turn the pump on in the TEST > PUMP screen. The BAM should try to regulate to these values. If the flow does not change, the flow controller is probably stuck. If the flow regulates lower, but not higher than 16.7 lpm, the pump is probably worn out, or there is a leak. Be sure to set the flow back to 16.7 lpm when done.

Problem:	The nozzle gets stuck in the UP position, or won't press down onto the tape fully.
Cause/Solution:	• This is often caused by a misaligned inlet tube. Make sure it is straight up and perpendicular to the top of the unit. • The nozzle o-ring eventually breaks down and needs to be replaced. Contact Met One for detailed instructions. Special shims are required to reinstall the nozzle. • The brass nozzle bushings may have grit in them. Remove the nozzle and clean the parts. Contact Met One for detailed instructions. BX-308 tool kit required. • Lift the nozzle with your fingers and determine if it feels sticky or gritty.

Problem:	The unit has flow leaks, even after cleaning the nozzle and vane.
Cause/Solution:	• The nozzle may be sticking as described above. Verify that the nozzle up/down motion is smooth and complete. If the nozzle feels sticky or gritty, it will not seal properly. Contact Met One for instructions for removing the nozzle and replacing the internal o-ring. • Check the o-rings on the sharp-cut cyclone (if used). These frequently leak. • 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 lpm. If not, the flow sensor $\mathbf{C_v}$ and $\mathbf{Q_0}$ settings may need to be recalibrated as described in Section 5.8 of the BAM manual.

	• Check for bad o-rings on the BAM inlet receiver. • Remove the BAM case cover and inspect all air fittings inside the BAM. These are compression fittings, and must be fully inserted to prevent leaks. • Inspect the internal and external flow system for split or cracked air tubing.

Problem:	**The unit over-measures or under-measures concentrations compared to a collocated FRM filter sampler.**
Cause/Solution:	• The most common cause is moisture getting on the filter tape or being absorbed by the particulate. Review the Smart Heater settings for proper operation. • Test the filter RH sensor calibration, and log the filter RH on channel 4 if possible. RH should be controlled to 35%. • Verify the flow rate and temperature and pressure calibrations. • Make sure that the K-factor setting has not been changed on the BAM. This would appear as a slope error in the BAM concentration data. • Verify the BKGD (background) value is correct, and perform a 72-hour BX-302 zero filter test to verify. If the BKGD value is not correct, it will offset the BAM data by up to several micrograms. • Check for leaks at the nozzle. A leak can cause either a positive or a negative measurement bias depending if the air leaking around the nozzle is cleaner or dirtier than ambient air. • Verify the collocation setup requirements, especially making sure the inlets are spaced correctly and the same height. • If the analog output of the BAM is being logged by an external datalogger, make SURE the logger's scaling of the BAM output is correct! In most cases, a 0.000 volt analog output on the BAM does NOT equal 0.000mg, but rather -0.015 or -0.005mg. See Section 6.2 and Section 8. Periodically verify that the digital data log from the BAM matches the external logger data. • Single event FRM samplers often perform better than multi-channel FRM samplers. If a multi-channel unit is used, then filter collection must still be performed on a daily basis. If the FRM filters are not properly collected and retained every day, then correlation results with the BAM can suffer. • The daily 24-hour average of the BAM hourly values is calculated externally from the BAM. It is important that the 24 hours worth of BAM data used for correlation to the FRM is the same 24 hour period in which the sampler schedule is run. For example, if the FRM is scheduled to stop for filter changes at 9:00 am each day, but BAM data used for that same day is from midnight to midnight, then a bias can result.

Problem:	**The unit logs frequent "L" Power Failure errors.**
Cause/Solution:	• The 5 volt DC power supply output must be set to 5.25 volts. Contact the Service dept for instructions to check or adjust this. • The CHASSIS terminal needs to be connected to a good earth ground. • Try plugging the BAM into a computer-style UPS. • Even a split second power failure will cause an "L" error. This will interrupt the sample cycle until the top of the next hour. • Local high power RF fields must be avoided if possible. • Some vintages of the DC power supply used in the BAM can be prone to oxidization which can cause the unit to reset frequently. Upgrade parts may be available for certain units. Contact the Service department. • Rarely, some older 220 volt units can experience resets caused by the Smart Heater control wiring inside the BAM. Contact the Service department.

Problem:	**The BAM data shows repeated concentration values hour after hour.**
Cause/Solution:	• Certain error flags, such as the "T" (tape broken) flag will cause the BAM to repeat the last known good concentration value until the error is resolved. Check the error log to identify any errors for those hours. • If the RANGE setting on the BAM is set higher than 1.000mg, them the resolution of the A/D system is reduced to 2 micrograms. If the ambient air concentrations do not

	vary much over several hours, then the BAM data may show repeated values due to lost resolution. Leave the RANGE set to 1.000mg unless very high concentrations are expected.

Problem:	Frequent “D” membrane density errors.
Cause/Solution:	• This usually indicates the membrane foil surface is dirty or damaged. It can be cleaned with water rinse. Damaged membranes must be replaced. • The membrane assembly may not be fully extending or retracting properly, which causes the metal part of the assembly to partially or completely block the beta particles. Check the membrane motion.

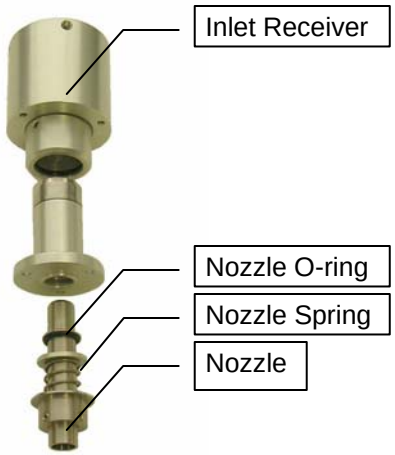
Problem:	The clock settings are lost when the unit is powered down.
Cause/Solution:	• The lithium battery on the 3230 circuit board may need to be replaced after about 10 years. It is normal for the clock to drift as much as 1 minute per month.

Problem:	The filter tape keeps breaking during normal operation.
Cause/Solution:	• The photo sensors which watch the tape transport motion may be out of alignment. Check the photo sensors as described by section 7.16. • This is sometimes caused by misalignment of the “SHUTTLE” photo sensor or the interrupter flag on the end of shuttle beam inside the BAM.

Problem:	The display shows “MISSING TEMP PROBE” message.
Cause/Solution:	• The unit requires a BX-596 or BX-592 ambient temperature sensor if either the CONC TYPE or FLOW TYPE are set to ACTUAL. If no sensor is attached to channel 6 of the BAM, this message will appear. • If the Auto ID line from the temperature sensor is not working, the BAM will not ID the sensor, causing the alarm.

7.6 Nozzle Component Replacement

The nozzle components need periodic inspection, cleaning, and replacement. The nozzle o-ring will need to be replaced every couple of years to prevent the nozzle from starting to stick. The nozzle itself may need to be replaced if it becomes worn or damaged, and should be removed and thoroughly cleaned annually or bi-annually. Complete instructions are available from Met One. A set of shim tools are required for nozzle re-assembly.

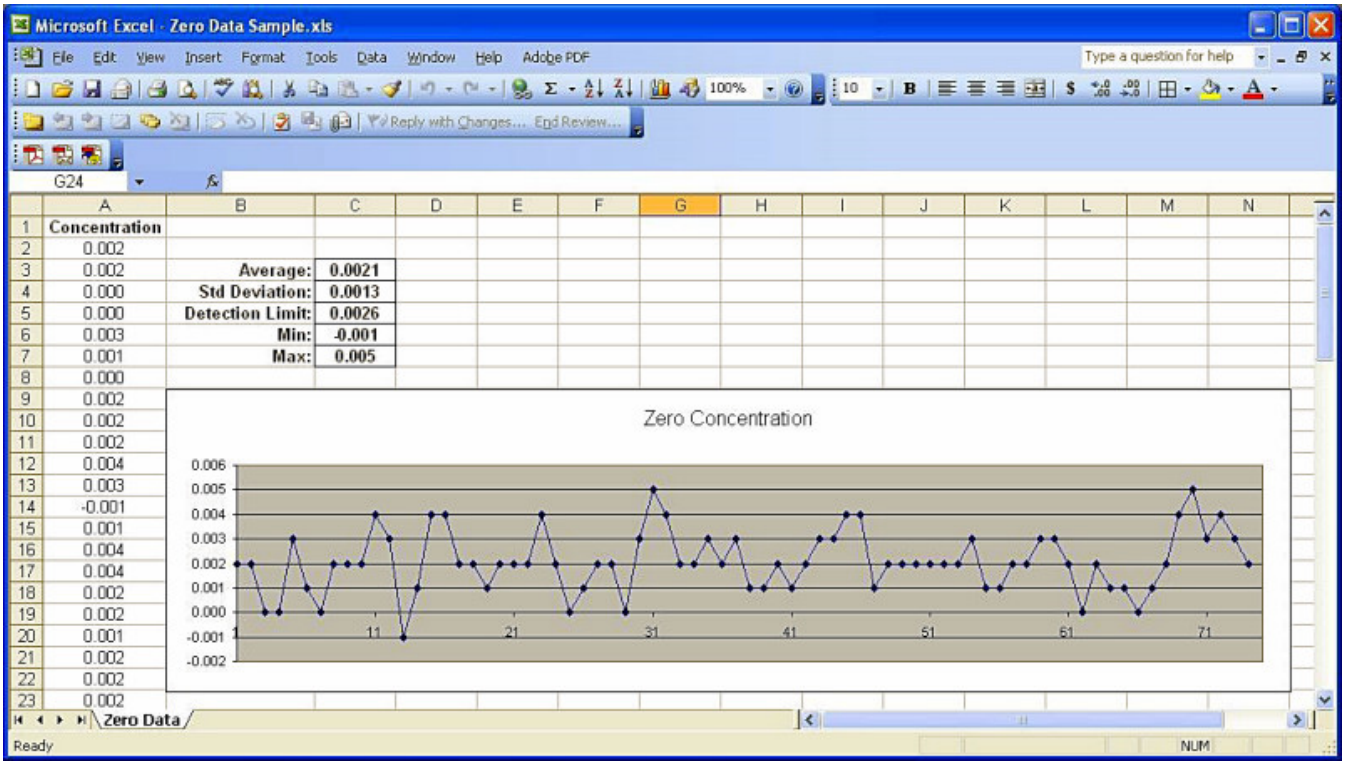


7.7 Field BKGD Zero Background Tests

The Background value is a correction offset for the concentration data collected by the BAM-1020 (see section 6.3 for a description of the BKGD value). This value is factory calibrated for each unit under laboratory conditions, and is typically never changed for PM_{10} monitoring.

BAM-1020 units set up to monitor $PM_{2.5}$ must to have this value field verified (and adjusted if necessary) upon deployment, and at least once per year afterwards using the BX-302 Zero Filter Calibration Kit. The test corrects the BKGD value to compensate for minor variations caused by local conditions such as grounding and shelter characteristics. This results in optimum accuracy at lower concentrations typical of $PM_{2.5}$ levels. The test also provides information about the zero noise levels of the unit being tested.

The test involves running the BAM in its normal operating environment with a zero filter on the inlet for at least 72 hours. The new BKGD will then be calculated and entered into the BAM. The test should not be performed during a period of rapidly changing weather. A complete set of instructions for the test are included with the BX-302 kit.

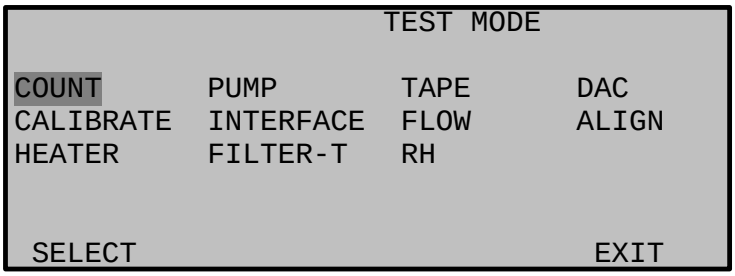


	A	B	C
1	Concentration		
2	0.002		
3	0.002	Average:	0.0021
4	0.000	Std Deviation:	0.0013
5	0.000	Detection Limit:	0.0026
6	0.003	Min:	-0.001
7	0.001	Max:	0.005
8	0.000		
9	0.002		
10	0.002		
11	0.002		
12	0.004		
13	0.003		
14	-0.001		
15	0.001		
16	0.004		
17	0.004		
18	0.002		
19	0.002		
20	0.001		
21	0.002		
22	0.002		
23	0.002		

Typical zero background test results

7.8 Test Menu System

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



The TEST Menu

7.9 COUNT test Screen

The TEST > COUNT screen allows the user to check the function of the beta detector and beta source separate from the rest of the mechanical or flow operations. Each count test will take 4 minutes, and will show the number of beta particles counted as they accumulate. The final count value will stay on the display after the counting is finished, and up to six count tests can be displayed on the screen at once. Count tests are usually performed with a clean section of filter tape between the source and detector, as in normal operation. The test also allows the membrane to be extended between the source and detector as well, if desired.

TIME: This shows the time that the count test is started.

COUNT: This is the total number of beta particles counted during the four-minute test. You will see this count rapidly accruing during the test. Typical four-minute count values are between 600,000 and 1,000,000 counts through clean filter tape. The count total will be lower if the membrane is extended, which simulated adding particulate to the tape. If the count total is less than 500,000 then the beta detector is possibly wearing out.

M: Indicates if the membrane is extended (Y), or not extended (N).

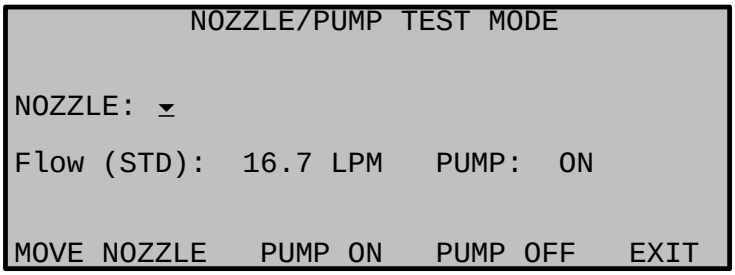
MEMBRN: Press this soft-key to extend the membrane between the source and detector.

NO MEMBRN: This soft-key withdraws the membrane.

GO: This soft-key starts the four minute count test. The counting will immediately begin. After four minutes the counting will stop and wait for the operator to initiate another cycle or EXIT.

7.10 PUMP Test Menu

The TEST > PUMP screen is very useful to test the pump and nozzle, and to perform leak checks and nozzle cleaning. See section 5.3 for the leak check procedure. Note: The BAM nozzle motor drives the nozzle UP, but the nozzle is lowered by only its spring tension. It is possible for the nozzle to become stuck in the UP position even if the motor is working and no errors are generated. It is also possible for the nozzle to not fully seat against the filter tape as well. These faults are usually caused by an inlet tube alignment problem, a disintegrated nozzle o-ring, or grime in the nozzle bearings. A good indication of this problem is an irregularly shaped dust spot on the tape, often with a “halo” around it.



The PUMP Test screen

NOZZLE: Nozzle status. UP (▲) or DOWN (▼).

PUMP: Pump status. ON or OFF.

Flow (STD): The air flow rate, displayed in EPA Standard liters/minute.

MOVE NOZZLE: This soft-key will move the nozzle up or down. The test allows for checking proper nozzle movement. Total elapsed time is about 5 seconds. If the pump is ON this operation is disabled.

PUMP ON: This soft-key will turn ON the vacuum pump. The nozzle will automatically be lowered if necessary.

PUMP OFF: This soft-key will turn the pump OFF.

7.11 TAPE Test Menu

The TEST > TAPE menu allows the user to manually move the filter tape forwards or backwards in increments of 12.5mm “windows”. This is useful to test the tape transport mechanism or to move fresh spots of tape for other tests, such as flow or count tests. The nozzle will be automatically raised if necessary, and the tape will take a couple of seconds to move each window.

X: This is the last number of windows moved. This number will be negative if the last move was backwards.

FEED: This is the number of windows you want to move. Use the arrow up/down keys to select up to 10 windows at a time.

FWD: This soft-key will move the filter tape forward amount of the FEED value.

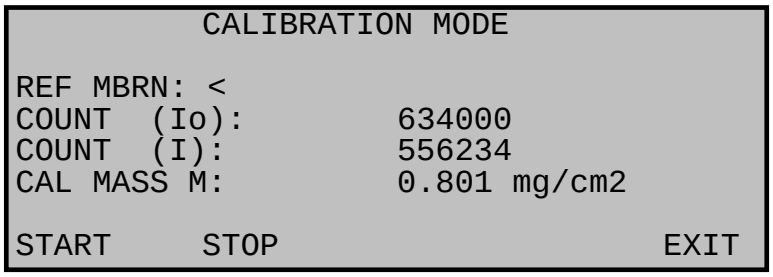
BKWD: This soft-key will move the filter tape backward amount of the FEED value.

7.12 DAC Test Menu – Analog Output Test

The TEST > DAC screen is used to test the function of the analog concentration output voltage and the DAC (digital-to-analog-converter) electronics. Use the up/down arrow keys to set the voltage anywhere from **0.000 to 1.000 volts** in 0.100 increments. Measure the VOLT OUT +/- terminals on the back of the BAM-1020 with a high quality voltmeter and verify that the actual voltage matches the BAM display value within ±0.001 volts at each point. Then attach the voltmeter to the input of your datalogger and repeat the test to verify that the correct voltages get to the input. If the analog output does not match the value on the TEST > DAC screen, contact the Service department for instructions. Note: 1 millivolt = 1 microgram of concentration in most applications. The DAC output cannot go negative.

7.13 CALIBRATE Test Menu

The TEST > CALIBRATE 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 **(m)** 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%. If not, the most common cause is a dirty membrane (dust or lubricant on the foil). The membrane 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 membrane foil is a thin sheet of polyester and is extremely fragile!** It must be replaced if damaged. Contact the Service department for replacement instructions.



The CALIBRATE Test Screen

REF MBRN: This indicates if the reference membrane is extended **(>)** or withdrawn **(<)** from the beta particle path.

COUNT (I_0): The total 4-minute beta count through the filter tape only, no membrane.

COUNT (I): The total 4-minute beta count through both the filter and the membrane.

CAL MASS M: This is the calculated calibration mass **(m)** derived from the two count values, the mass which the unit has just measured for the membrane. An average of several of these values should match the **ABS** value within 5%.

START: This soft-key starts the test cycle. Counting will immediately begin. After 4-minutes the **I_0 count** will stop, the membrane will extend, and the **I count** will begin. At the completion of the test the counting will stop and the mass of the membrane will be calculated. The total elapsed time is about 8.1 minutes per test.

7.14 INTERFACE Test Menu

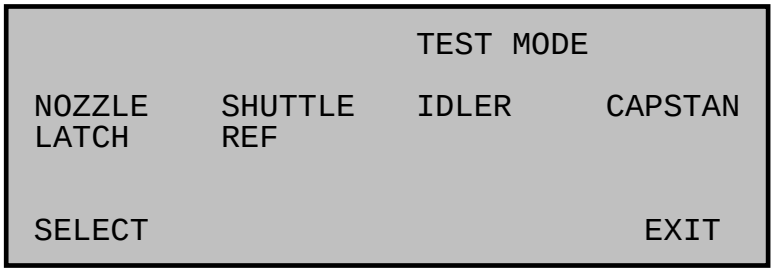
The TEST > INTERFACE screen is used to test the relay inputs and outputs on the back of the BAM-1020. The two inputs (TELEM FAULT and EXT RESET) are tested by applying the appropriate signal to the terminals on the BAM, then verifying that the value on the screen changes in response. The five relay outputs (TAPE BREAK, FLOW ERROR, DATA ERROR, MAINTENANCE and RANGE) are tested by turning them ON or OFF using the arrow keys, then verifying that the outputs on the terminals respond accordingly. Note: RANGE not used.

7.15 FLOW Test Menu

The TEST > FLOW screen is where the very important flow calibrations are performed on most BAM-1020 units. See section 5.6. This screen is also useful to check the ambient temperature and barometric pressure sensors, and for pump and flow controller tests.

7.16 ALIGN Test Menu – Photo Sensor Tests

The TEST > ALIGN menu system is used primarily to factory-test the photo sensors which monitor all of the mechanical movement in the BAM-1020. This is useful if the unit has failed some of the Self-Test parameters. The function of the six ALIGN sub-menus are described in this section. **Note:** Remove the filter tape for these tests, or it will break.



The ALIGN Menu

NOZZLE: This screen tests the two nozzle photo sensors. Use the UP and DOWN soft-keys to move the nozzle, and monitor the status of the **S4** and **S5** photo sensors on the screen.

SHUTTLE: This screen tests the photo sensor which monitors the position of the shuttle beam (the two tape rollers that move together). The status of photo sensor **S7** should only change to ON when the beam is moved all the way to the right side. The shuttle must be moved by hand for this test.

IDLER: This screen tests the photo sensor which monitors the position of the right-side tape tensioner (the spring-loaded tape roller on the right). When the tensioner is in its left position under its spring tension, both photo sensors **S6** and **S1** should be OFF. If the tensioner is moved to the middle of its travel, photo sensor S1 should be ON and S6 OFF. When the tensioner is at the rightmost position, S1 and S6 should both be ON. The tensioner must be moved by hand. The left side tensioner assembly has no sensors to check.

CAPSTAN: This screen tests the two photo sensors which watch the rotation of the Capstan shaft. This is the shaft under the rubber pinch rollers which drives the filter tape forwards and backwards. Press the ADVANCE soft-key to rotate the Capstan counter-clockwise, and the BACKUP soft-key to rotate clockwise. The shaft should rotate one-half of a rotation each time. Photo sensor **S8** should turn ON to stop the shaft at each half-turn, and will be OFF while the shaft is turning. It is helpful to put an ink mark on the end of the shaft to view the rotation.

LATCH: This screen shows the status of the pinch roller latch. If the rollers are latched in the UP position, then **S9** should be ON. S9 should turn OFF if the latch is unhooked.

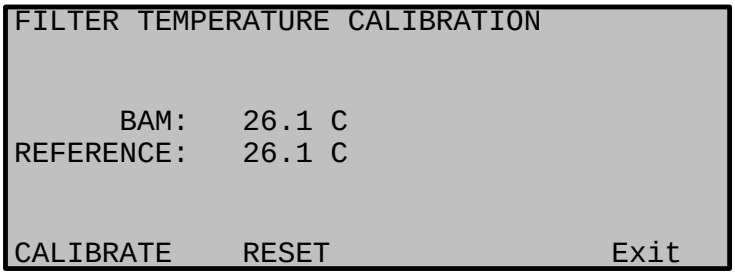
REF: This screen tests the two photo sensors which monitor the position of the reference membrane assembly. When the EXTEND soft-key is pressed the membrane should extend and the **S2** photo sensor should be ON, and **S3** OFF. When the WITHDRAW soft-key is pressed the membrane should withdraw and the S2 photo sensor should be OFF and S3 ON. It takes a few seconds for the membrane to move.

7.17 HEATER Test Menu

The TEST > HEATER screen is used to force the Smart Heater ON or OFF for testing purposes. The heater takes several minutes to heat up or cool down noticeably. The heater automatically turns back off upon exit from the screen.

7.18 FILTER-T Test Menu – Filter Temperature Sensor

The TEST > FILTER-T screen is used to calibrate the filter temperature sensor located in the air stream beneath the filter tape. When this screen is entered, the BAM will automatically raise the nozzle and turn the pump on. This allows ambient room air to equilibrate the filter temperature sensor without the heating effects of the Smart Heater. Allow the pump to run for at least 5 minutes to allow the sensor to equilibrate. Press the RESET hot key to clear out any past calibration values, then enter the ambient room temperature from your reference standard into the REFERENCE field and press the CALIBRATE hot key. The BAM reading should change to match within **+/- 1 deg C**. The RESET hot key can be used to revert to default calibrations and start over if difficulty is encountered. Older revisions of BAM firmware contain a different test screen for this sensor.



The FILTER-T Test Screen

7.19 RH Test Menu – Filter Humidity Sensor

The TEST > RH screen is used to calibrate the filter relative humidity sensor located in the air stream beneath the filter tape. This screen works just like the FILTER-T screen described above. Allow the pump to run for at least 5 minutes to allow the sensor to equilibrate. Press the RESET hot key to clear out any past calibration values, then enter the ambient room relative humidity from your reference standard into the REFERENCE field and press the CALIBRATE hot key. The BAM reading should change to match within **+/- 4% RH**. The RESET hot key can be used to revert to default calibrations and start over if difficulty is encountered. Older revisions of BAM firmware contain a different test screen for this sensor.

8 EXTERNAL DATALOGGER INTERFACE SYSTEM

This section describes the configuration of the BAM-1020 to work with a separate, external datalogger. The BAM-1020 provides an analog concentration output voltage, as well as an array of relay inputs and outputs. These allow the BAM-1020 to function as a sensor in a larger array of data collection instruments. There are a variety of dataloggers available which are compatible with the BAM-1020 outputs, so consult the manual for your datalogger for the specific setup requirements. Met One can supply a document showing a sample of the setup programming required for several types of datalogger manufactured by under the ESC brand name. Contact the Service department.

8.1 Analog Concentration Output Signal

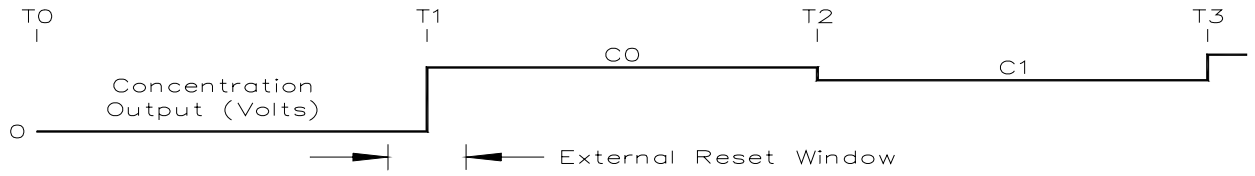
The primary link between the BAM-1020 and an external datalogger is the analog concentration output signal. The analog output type is selectable between isolated voltage (0-1 or 0-10 volt DC) and isolated current (4-20 or 0-16 mA). The rear panel dipswitches are used to select the output as shown in the table below. The one-volt range is by far the most common. The full-scale value of the output voltage corresponds to the full-scale measurement of the BAM-1020, determined by the RANGE and OFFSET setting. See Section 6.2. In the majority of applications, the analog output is set for **0-1 volt = 0 to 1.000mg or 0-1 volt = -.005 to .995mg**. If the OFFSET is set to -0.015 for $PM_{2.5}$, then the analog output is **0-1 volt = -.015 to .985mg.** The analog output should be tested as described in Section 7.12.

SWITCH	ON	OFF
SW1	0-10 vdc	0-1 vdc
SW2	4-20mA	0-16mA
SW3	Not used	Not used
SW4	Not used	Not used

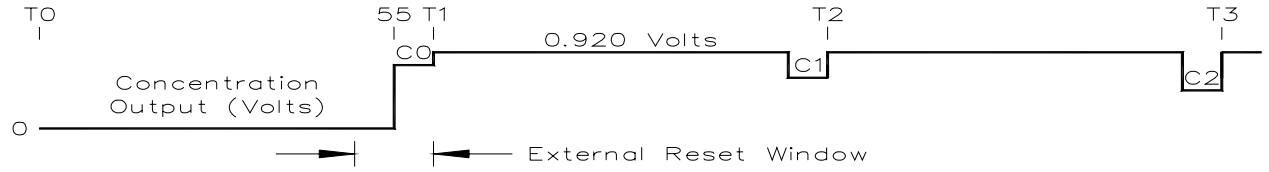
In most cases the analog output is the only channel available between the BAM-1020 and the datalogger, and any errors generated by the BAM must be reported using the same voltage signal. The BAM-1020 will set the analog output to its full-scale reading when any of the selected errors occur. The errors which cause this are selectable, and are described in section 6.5. The external datalogger should be programmed to recognize a full-scale reading as an error, not a valid concentration. This method is used because it is very rare for a concentration reading to exceed the range of the BAM-1020. The digital data values stored in the BAM are unaffected and may be viewed with the display or by downloading.

8.2 Early Cycle Mode Description

During a standard BAM-1020 measurement cycle, the unit waits for the beginning of the new hour before it sets the analog output to represent the just-finished hour's concentration. However, some types of dataloggers (such as ESC) must have the concentration value available **before** the new hour starts, or the data will be stored in the wrong hour. The BAM-1020 has a special EARLY cycle mode (in the SETUP > INTERFACE menu) which causes the unit to start and finish the measurement a few minutes early in order to output the concentration voltage for the last 5-minutes of the hour which was just sampled. The datalogger must be programmed to read this value during the window. The BAM-1020 clock and the datalogger clock will usually need to be synchronized because of the critical timing involved. The following describes the timing of the STANDARD and EARLY modes.



STANDARD Cycle Example



EARLY Cycle Example

Analog Output Levels

C_0 represents the concentration output level measured from time **T_0** to **T_1**, where the T labels represent the top (beginning) of an hour (such as 12:00:00). As you can see, the concentration voltage **C_0** for the standard cycle is present for the whole next hour following the measurement. In early mode the **C_0** voltage for the current hour is present for only the last 5 minutes of the hour just-sampled (minute 55 to 60), and all other times the concentration output voltage is 0.920 volts.

External Reset Windows

An external reset signal may be used to synchronize the BAM-1020 clock to the datalogger. In standard mode the external reset window is plus or minus 5 minutes around the beginning of the hour, but in early mode the external reset window is between minute 50 and 60 only. The clock will not reset if the cycle has not reached the I_3 count. The error log will contain the

date and time of the reset attempt. If the I_3 count is in progress, or the cycle is past the I_3 count, then the measurement cycle is canceled. The error log will contain the date and time of the reset. A canceled cycle will also force the analog output to the full-scale values (1.000 volts in standard mode, or 0.920 volts in early mode).

Standard Mode Clock Resets:

Minute 0 to 5: An external reset signal will change the BAM clock back to the 00:00 of the current hour. If a cycle has already started, it will continue. No error occurs since there is adequate time to complete the cycle.

Minute 5 to 55: An external reset signal has no effect. The error log will contain the date and time of the reset attempt.

Minute 55 to 60: If an external reset occurs after a completed cycle (idle condition), then no error occurs. The clock will be set forward to 00:00 of the next hour and a new measurement cycle will start.

EARLY Mode Clock Resets:

Minute 55 to 60: The external reset signal changes the clock back to minute 55:00 of the current hour. A new measurement cycle will start at that moment. If a cycle has already started, it will continue. No error occurs since there is adequate time to complete the cycle.

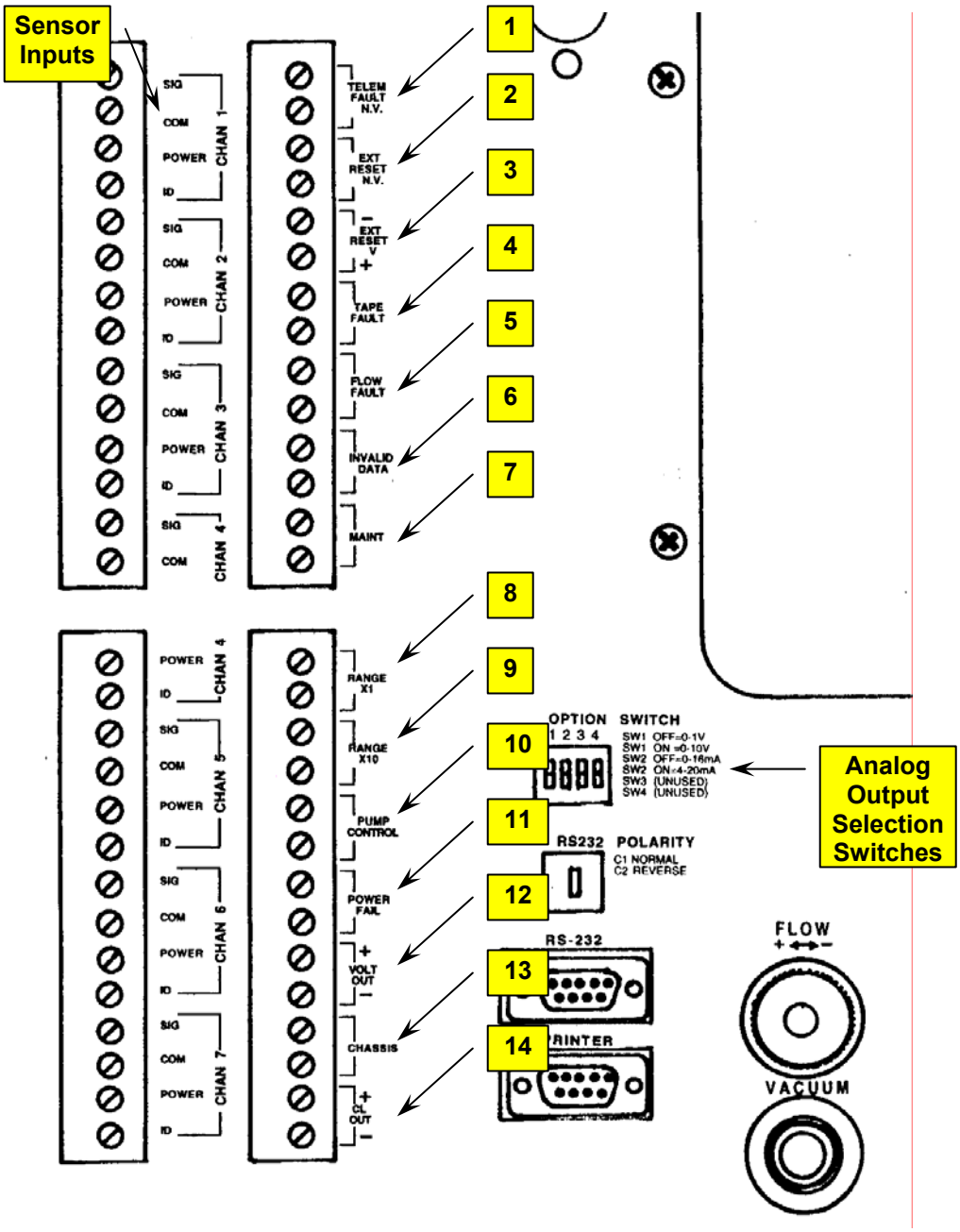
Minute 0 to 50: The external reset signal has no effect. The error log will contain the date and time of the reset attempt.

Minute 50 to 55: If an external reset occurs after a completed cycle (idle condition), then no error occurs. The clock will be set forward to minute 55:00 of the current hour and a new measurement cycle will start.

8.3 Telemetry and Error Relays

In addition to the analog output, input and output relay connections are provided on rear panel of the BAM-1020 to allow the unit to be used with an external data logger in a synchronous mode of operation. The function of each input and output is described below. Many of the relay outputs described below are related to BAM-1020 error conditions described in section 6.5.

Note: A **contact-closure input** to the BAM-1020 is achieved by shorting the two terminals on that particular input together, usually with a relay on the external datalogger. The datalogger should not apply any voltage or current to the terminals. **Contact-closure outputs** from the BAM-1020 are provided by the unit shorting the two terminals together with an internal relay, without applying any voltage or current to them. The external datalogger must then sense the closure. **Normally-Open** means that the relay contacts are not shorted together unless a certain condition occurs, while **Normally-Closed** means that the relay contacts are shorted until the condition occurs, then they open.



BAM-1020 Back Panel Relay Connections

1. **TELEM FAULT N.V.** Telemetry Fault Non-Voltage. This input can be used to signal the BAM-1020 that the external telemetry system (datalogger) is not operational. This is a contact-closure input which must be activated for a minimum of 2-seconds. If activated, the BAM will continue to function and will log a “U” error (see section 6.5) and activate the DATA ERROR relay output. This input can be set to normally-open or normally-closed in the SETUP > INTERFACE menu.
2. **EXT RESET N.V.** External Reset Non-Voltage. This input is can be used to synchronize the BAM-1020 clock to the external datalogger, and is often used in EARLY cycle mode (see section 8.2). This is a contact-closure input which must be activated for a minimum of 2-seconds. The input can be set to normally-open or normally-closed in the SETUP > INTERFACE menu.

3. **EXT RESET V** External Reset Voltage. This input is the same as above except the input is activated by a voltage logic level instead of a contact-closure. Max 15mA @ 15V or 5mA @ 5V DC. Five volt logic is typically used for this input.
4. **TAPE FAULT** This is a contact-closure output which will be activated whenever a “T” or tape error is generated (see section 6.5). Polarity is normally-open.
5. **FLOW FAULT** This is a contact-closure output which will be activated whenever an “F” or flow error is generated (see section 6.5). Polarity is normally-open.
6. **INVALID DATA** This is a contact-closure output which will be activated whenever a C, P, N, R, L, I, M, or U error is generated by the BAM (see section 6.5). Polarity is normally-open.
7. **MAINT** This is a contact-closure output which will be activated whenever a maintenance “M” flag is generated (see section 6.5). Polarity is normally-open.
8. **RANGE X1** This contact-closure output is no longer supported. The relay for this channel is now used by the Smart Heater.
9. **RANGE X10** This contact-closure output is no longer supported. The relay for this channel is now used by the Smart Heater.
10. **PUMP CONTROL** This is the low-voltage output which signals the vacuum pump to turn on or off. There is no polarity on this output because the pump controller has a diode bridge input. Connect the two-wire control cable from the pump to these output terminals.
11. **POWER FAIL** This is a contact-closure output which will be activated (closed) whenever a power failure of the 5 volt DC system or an “L” error occurs (see section 6.5).
12. **VOLT OUT** This is the analog concentration output voltage terminal. Typically 0-1 VDC. See section 8.1. Polarity must be observed on this output.
13. **CHASSIS** These are the earth-ground terminals. These must be attached to a solid ground point for best operation of the unit.
14. **CL OUT** Current Loop Output. This is used when the analog output is needed in current loop form instead of voltage. Typically only used if there is a long distance between the BAM and the datalogger. Output is selectable between 4-20mA or 0-16mA.

8.4 Digital Datalogger Interfacing with the BAM-1020

Applications involving digital data transfer between the BAM-1020 and other manufacturer’s digital dataloggers, such as DR DAS™ and Campbell CR-1000™ models among others, have become more common. This typically requires a considerable amount of programming experience with the particular type of logger to be used. Any digital files from the BAM-1020 must be obtained from either the RS-232 two-way serial port, or the RS-232 output-only printer port. There are several possible pitfalls which can be encountered when collecting BAM-1020 data with a digital datalogger.

The most straight-forward way to accomplish digital datalogger interface with the BAM is to configure the printer output port as a fixed width data output as described in Sections 9.5 and 9.4. This causes the BAM-1020 to output a single fixed-width string of data at the end of each sample hour without having to be prompted. The digital logger must be programmed to wait for the data string, then process it appropriately.

The alternative is to program the digital datalogger to send the BAM-1020 the appropriate commands to retrieve data, just like you would when downloading the data with a computer as described in Section 9.4. Typically, the BAM would be sent the appropriate commands to respond with CSV files 6,3 (new data since last download) or 6,4 (last hourly data record only). The digital logger must receive and sort the files appropriately.

The most important consideration when collecting the data in this manner is to remember that the BAM-1020 only measures concentration data once per hour, and during other parts of the hour (especially near the beginning and end of each hour) the BAM is often moving tape transport parts and making mechanical adjustments which **prevent the unit from responding to digital data requests** due to a busy processor. See Section 4. The best solution is to program the digital logger to make a single data request to the BAM at some time during the sample period near the middle of each hour, such as between minute 25 and minute 50. This is especially important if large amounts of data are to be downloaded at once, since it can take more than 10 minutes to download the entire data log. If the download overlaps a mechanical motion by the BAM, then the data can be delayed by several seconds in the middle, or even interrupted entirely. Small digital files (such as the last hourly record only) can be downloaded very quickly, and may be accomplished at almost any time during the hour as long as the timing is carefully controlled. It is highly recommended that the BAM clock be regularly synchronized by the external datalogger to prevent timing problems due to clock drift.

If a datalogger is programmed to digitally request data from the BAM-1020 continuously throughout the hour (such as every minute), then there will almost certainly be a number of requests each hour which will be ignored by the BAM due to mechanical interrupts.

Met One is often able to provide more technical information and support to help our customers develop effective programs for operating certain types of digital dataloggers with the BAM-1020. In addition, we are always eager to hear about new ways that users have found to implement this type of interface. Contact Met One Technical Service.

9 RS-232 SERIAL COMMUNICATIONS – DATA RETRIEVAL

This section describes the methods used to retrieve digital data files through the RS-232 serial communications system on the BAM-1020. The unit has a two-way serial port which may be used with a computer, laptop, modem, digital datalogger, or data transfer module. There is also a configurable output-only serial printer port. Access to the data through the serial port is a simple menu driven interface.

9.1 Serial Port Connections and Settings

The RS-232 serial port on the back of the BAM-1020 handles data transfer and may also be used for instrument setup and operation status checks. The serial port may also be used with an optional modem for remote communications through a phone line (See Section 9.6).

Desktop Computer Connections: The BAM-1020 can be connected to almost any standard PC that has an RS-232 serial port available (COM1 to COM4). Connect the RS-232 port on the back of the BAM-1020 to the COM port connector on the computer with a female-to-female 9-pin null RS-232 cable. (Belkin F3B207-06 is recommended and available from Met One). **CAUTION:** Do not confuse the parallel printer port or video adapter port on your computer with a serial port. Connecting the BAM-1020 to these may cause damage to your computer and the BAM. If in doubt, consult the computer manual before connecting.

Laptop Computer Connections: The BAM-1020 can be connected to most laptop computers. Most older laptops have a regular 9-pin RS-232 serial port, just like a desktop computer. Modern laptops do not usually have RS-232 ports, so a converter will have to be obtained. The easiest and cheapest type is a USB-to-RS232 serial adapter. Met One recommends the Belkin F5U109, available from Met One or a local electronics store. You will still need the Female-to-Female 9-pin RS-232 cable. Certain laptops occasionally have difficulty communicating through this type of adapter. Met One does not recommend converters sold under the Radio Shack brand name. Another option is an RS-232 serial PCMCIA card, such as the Quatech SSP-100 which installs in an expansion card slot in the laptop and provides a serial port for the BAM. This type of adapter is very reliable, but more expensive and takes longer to install and configure. See www.quatech.com for more information.

Communication Settings: The BAM-1020 communicates at 9600 Baud, 8 data bit, no parity, one stop bit. 9600 baud is the default setting which may be changed. The BAM-1020 settings must match these in the SETUP > SAMPLE menu. If unable to communicate, try changing the RS-232 Polarity switch on the back of the BAM-1020. This swaps the polarity of the TX and RX lines (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 serial port communication can be established.** The serial port is disabled in all other menus. Also, the LCD display and keypad on the BAM-1020 are disabled whenever RS-232 communication is in progress.

9.2 Met One Communications Software

The BAM-1020 is compatible with several communications software programs available from Met One Instruments:

MicroMet® Plus: A powerful and comprehensive data logging program for meteorological applications which is configurable to collect and manage all data from the BAM-1020.
Comet™: A simple and easy to use communications terminal program which can retrieve data from Met One data loggers, including the BAM-1020. This program replaces the old TUS (Terminal Utility Software) program.

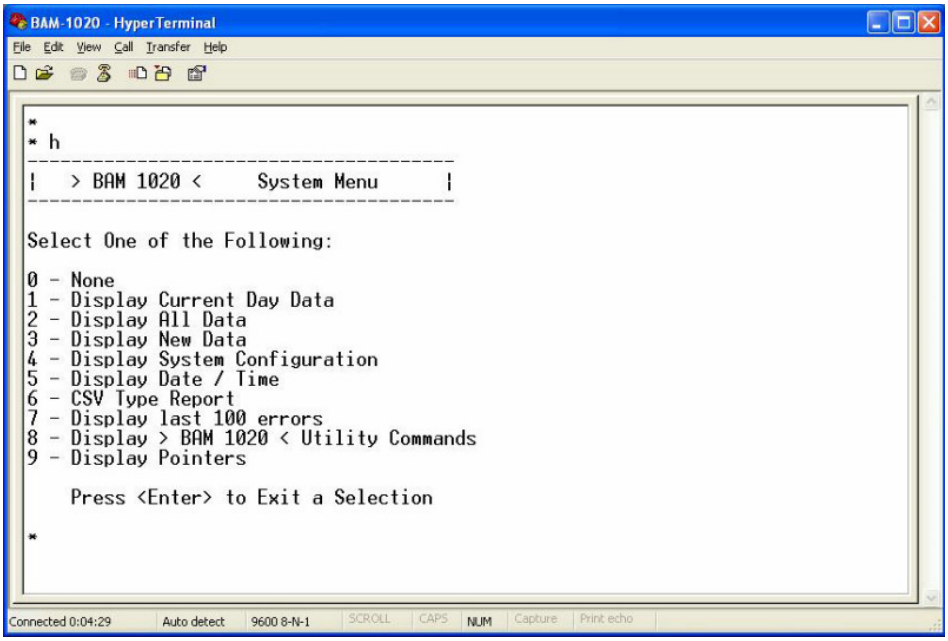
9.3 Downloading Data Using HyperTerminal

The BAM-1020 data can be easily downloaded through the serial port using HyperTerminal® or other simple terminal programs. Nearly all PCs running Microsoft Windows 95® or later operating systems have the HyperTerminal program included. This section describes how to set up this program for communication with the BAM-1020. **Note:** The BAM-1020 display must be on the Main Menu in order to establish communications.

1. Connect the RS-232 port on the back of the BAM to your computer or laptop using the appropriate cable. Connect to the Com1 serial port if available.
2. Open HyperTerminal. (Usually located in the Programs\Accessories\Communications directory). The program will ask you to type a name for the connection. Type “BAM-1020” or a name of your choice, then click “OK”.
3. The “Connect To” window will open. Select COM1 (or another port if used) from the drop-down menu in the “Connect using:” field. Click “OK”. Note: You could also set up the program to dial the BAM through a modem in this window.
4. The “COM1 Properties” window will open. Set the following values in the drop-down menus, then click “Apply” and “OK”.

Bits per second:	**9600**
Data bits:	**8**
Parity:	**None**
Stop bits:	**1**
Flow control:	**None**

5. The main HyperTerminal connection window should now be open. Press the ENTER key three times. The window should respond with an asterisk (*) indicating that the program has established communication with the BAM-1020.
6. Once communication is established, press the **h** key. This should cause the BAM-1020 System Menu to appear on the window as shown below. You can now send any of the characters in the menu to retrieve the desired files. The menu options are described in the following sections.
7. HyperTerminal will only display 100 lines of data in the window. To capture larger files (such as All Data), first select Transfer > Capture Text from the drop-down menu. Select a location for the file, then click the “Start” button. Retrieve the desired files, and HyperTerminal will automatically store them to the text file.
8. When you exit HyperTerminal, it will ask if you want to save your connection. Click “Yes” and a file named BAM-1020.ht will be created in the HyperTerminal folder, which will have all of the settings saved. Use this for future communications with the BAM.



Terminal Window showing BAM-1020 menu

Windows 95® and HyperTerminal® are registered trademarks of their respective corporations.

9.4 System Menu File Descriptions

Once a serial connection between the computer and the BAM-1020 has been established as shown above, you will have access to the main BAM-1020 System Menu. Each number 0-9 represents a different data file you can download from the unit. Each file is described below. To get the desired file, simply press the appropriate number on your keyboard. **Note:** After a few minutes, the BAM will stop waiting for a command and you will have to send another **"h"** to reestablish the connection.

File 1: Display Current Day Data

This file will include a text view of the current day's data only. An example of the data format is shown below. The first column is the time, followed by a series of dashes. Each dash represents a possible error. If an error occurred, a letter representing the error will appear in this field. For this example, at 7:00 am an **"L"** error (power failure) occurred. Then at 8:00 an **"M"** error was logged, indicating that the operator was performing maintenance that hour.

The next column is the concentration. Notice that the values went full-scale during the two hours that errors were logged. This indicates invalid data. The Qtot column is total flow volume for the hour. With a flow rate of 16.67 LPM, and a sample time of 50 minutes, this value will be about .834 m^3 per hour. (16.7 * 50 / 1000 = .8335). The remaining six columns are the six datalogger inputs on the BAM. In this example RH was logged on channel 4, and Ambient Temperature was logged on channel 6. The other four channels had nothing attached, but will appear in the array anyway. (The data shown on those channels in this example is only noise.)

Report for 04/22/2005 - Day 112 > BAM 1020 < Station ID: 1

Channel			01	02	03	04	05	06
Sensor	Conc	Qtot	WS	no	WS	RH	WS	AT
Units	mg/m3	m3	KPH	V	MPS	%	KPH	C
01:00	----------	0.010	0.834	019.6	0.012	000.3	00017	132.2	008.7
02:00	----------	0.009	0.834	019.9	0.012	000.3	00018	132.1	007.4
03:00	----------	0.011	0.834	019.8	0.012	000.3	00018	132.1	006.5
04:00	----------	0.011	0.833	020.0	0.012	000.3	00018	132.1	006.1
05:00	----------	0.012	0.833	019.8	0.012	000.3	00018	132.1	005.3
06:00	----------	0.011	0.834	020.1	0.012	000.3	00018	132.0	005.6
07:00	----L------	0.995	0.000	020.3	0.012	000.3	00018	132.0	007.4
08:00	---M------	0.995	0.000	019.8	0.012	000.3	00017	132.1	009.4
09:00	----------	0.008	0.833	019.9	0.012	000.3	00015	132.2	012.5
10:00	----------	0.003	0.834	019.5	0.012	000.3	00014	132.2	016.2
11:00	----------	0.007	0.833	019.5	0.012	000.3	00013	132.2	019.7
12:00	----------	0.011	0.833	019.5	0.012	000.3	00012	132.0	020.7
13:00	----------	0.008	0.833	019.1	0.011	000.3	00010	132.0	021.9
14:00	----------	0.010	0.833	019.2	0.011	000.3	00010	131.9	022.3
15:00	----------	0.020	0.833	019.1	0.011	000.3	00011	132.0	020.9
16:00	----------	0.011	0.834	019.3	0.011	000.3	00012	132.1	018.7
17:00	----------	0.010	0.833	019.5	0.012	000.3	00012	132.2	017.9
18:00	----------	0.010	0.833	019.4	0.012	000.3	00012	132.1	017.1
19:00	----------	0.010	0.834	019.4	0.012	000.3	00014	132.2	015.3
20:00	----------	0.007	0.833	019.6	0.012	000.3	00015	132.1	014.4
21:00	----------	0.006	0.834	019.5	0.012	000.3	00017	132.1	013.3
22:00	----------	0.006	0.834	019.7	0.012	000.3	00021	132.0	011.2
23:00	----------	0.005	0.833	019.6	0.012	000.3	00023	132.0	010.0
00:00	----------	0.011	0.834	019.9	0.012	000.3	00017	132.2	009.5
Savg		0.009	0.833	019.7	0.012	000.3	00015	132.1	013.2
Vavg		0.000	0.000	000.0	0.000	000.0	00000	000.0	000.0

Data Recovery 100.0 %

File 1 data text file example

File 2: Display All Data

This file will download a text file of all of the data stored in the BAM-1020 memory, in the same format as the above example. Be sure to capture text (section 9.3) if downloading this file using HyperTerminal, as it can be fairly large.

File 3: Display New data

This file will contain text of all of the data stored by the BAM-1020, since the last time the data was downloaded. Useful to avoid duplicate data in your database. A flag is set in the BAM indicating where the last download stopped.

File 4: Display System Configuration

This file will contain a list of most of the BAM-1020 settings and calibration values as shown below. This is useful for verifying the setup on a remote BAM, and to send to the factory if service is required. The setting report has been updated and reformatted. Following is an example of the new settings report. Older firmware will show a slightly different report.

```
BAM 1020 Settings Report
06/07/2007  14:19:45
     Station ID, 1
       Firmware, 3236-02 3.2.5
              K, 01.000
           BKGD, 00.000
            usw, 00.301
            ABS, 00.805
          Range, 1.000
         Offset, -0.015
          Clamp, -0.015
     Conc Units, mg/m3
      Conc Type, ACTUAL
             Cv, 01.000
             Qo, 00.000
      Flow Type, ACTUAL
     Flow Setpt, 0016.7
       Std Temp, 25
      Temp Mult, 1.0000
      Pres Mult, 1.0000
      Flow Mult, 1.0000
High Flow Alarm, 20
 Low Flow Alarm, 10
      Heat Mode, AUTO
       Heat OFF, 20
        RH Ctrl, YES
       RH SetPt, 35
         RH Log, YES
        DT Ctrl, NO
       DT SetPt, 99
         DT Log, NO
     BAM Sample, 42
     MET Sample, 60
     Cycle Mode, STANDARD
 Fault Polarity, NORM
 Reset Polarity, NORM
    Maintenance, OFF
   EUMILRNFPDCT
   000000000000
             AP, 000150
      Baud Rate, 9600
 Printer Report, 2
             e3, 00.000
             e4, 15.000

       Channel,       1,       2,       3,       4,       5,       6,
     Sensor ID,     255,     255,     255,     255,     255,     255,
    Channel ID,     255,     255,     255,     255,     255,     255,
          Name,   XXXXX,   XXXXX,   XXXXX,   XXXXX,   XXXXX,   XXXXX,
         Units,     XXX,     XXX,     XXX,     XXX,     XXX,     XXX,
          Prec,       0,       0,       0,       0,       0,       0,
      FS Volts,   1.000,   1.000,   1.000,   1.000,   1.000,   1.000,
          Mult,   1.000,   1.000,   1.000,   1.000,   1.000,   1.000,
        Offset,   0.000,   0.000,   0.000,   0.000,   0.000,   0.000,
   Vect/Scalar,       S,       S,       S,       S,       S,       S,
     Inv Slope,       N,       N,       N,       N,       N,       N,
```

File 4 system configuration file example

File 5: Display Date / Time
This file will show the date, time and serial number of the BAM-1020.

File 6: CSV Type Report
This command will give you three Comma-Separated-Value options which you can select by sending the appropriate number below. Each of the data files are the same as above, except the values in each column are separated by commas (,). This allows the text file to be opened directly by Microsoft Excel® or other spreadsheets. This is the recommended data retrieval method. Be sure to capture text when downloading large files if using HyperTerminal. The CSV reports are also often used when BAM data is downloaded by an external digital datalogger. Following is a list of the files available in CSV format:

2 – Display All Data	(All data)
3 – Display New Data	(Data since last download)
4 – Display Last Data	(Previous hour's data only)
5 – Display All Flow Stats	(All flow stats)
6 – Display New Flow Stats	(Stats since last download)
7 – Display All 5 Min Flow	(5 minute averages of all flow stats)
8 – Display New 5-Min Flow	(5 min averages of flow stats since last download)

Example of a CSV Report of the "LAST DATA" record:
The following example shows a CSV download of the last data record from the BAM-1020. This file download does not reset the data pointer.

1. A series of three carriage returns is sent to the BAM through the serial port.
2. After the third carriage return, the BAM responds with a single asterisk (*) indicating that communication is established. If the BAM is moving the tape, it will respond with "BUSY". If the BAM is not in one of the OPERATION menus, it will not respond at all.
3. A single character "6" is sent to the BAM requesting the file 6 menu (CSV).
4. The BAM responds with the CSV menu options as shown below, ending with ">". The system requesting the files can ignore the menu response.
5. A single character "4" is sent to the BAM, requesting file 4 "Display Last Data".
6. The BAM responds with the Station ID number (in this case 5), then the header info, then the data record.

The data includes date/time stamp, concentration for the last hour (CONC), Flow volume for last hour (Qtot), then all six individual met sensor channels. The labels for these channels will vary, but will always appear in the data array regardless if used or not. In this example the six channels start with "WS" and end with "AT". At the end of the array are twelve error bits, each representing a different possible error. "0" indicates no error of that type, and "1" indicates an error. In this example, the "M" and "T" bits are high, indicating that the unit is taken out of operation, and that the tape has run out.

```
* 6
CSV Type Reports

2 - Display All Data
3 - Display New Data
4 - Display Last Data

5 - Display All Flow Stats
6 - Display New Flow Stats

7 - Display All 5-Min Flow
8 - Display New 5-Min Flow

>4 - Display CSV Data
Station,  5
Time,Conc(mg/m3),Qtot(m3),WS(MPS),WD(DEG),BP(mm),RH(%),Delta(C),AT(C),E,U,M,I,L,R,N,F,P,D,C,T
01/30/08 16:00,  0.084, 0.834, 0.0,0,0,30,57.0,27.1,0,0,1,0,0,0,0,0,0,0,0,1,
```

Example of CSV last data report

Example of a CSV Report of the "NEW DATA" records:

This file contains all of the data record since the last download, and resets the pointers. In the following example, the data is retrieved exactly the same way as described above, except that file 3 "new data" is requested. The data starts at the first record since last time it was retrieved (oct 2, 2007 at 17:45). In this example, the MET SAMPLE was set to log the array every 15 minutes, but the particulate concentration value just repeats until the next hour.

```
* 6
CSV Type Reports

2 - Display All Data
3 - Display New Data
4 - Display Last Data

5 - Display All Flow Stats
6 - Display New Flow Stats

7 - Display All 5-Min Flow
8 - Display New 5-Min Flow

>3 - Display CSV Data
Station,  5
Time,Conc(mg/m3),Qtot(m3),WS(MPS),WD(DEG),BP(mm),RH(%),Delta(C),AT(C),E,U,M,I,L,R,N,F,P,D,C,T
10/02/07 17:45,  0.001, 0.700, 0.110,0,0,36,1.3,23.0,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 18:00,  0.001, 0.700, 0.127,0,0,38,1.4,23.2,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 18:15,  0.001, 0.700, 0.130,0,0,38,1.2,23.6,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 18:30,  0.001, 0.700, 0.110,0,0,36,1.1,23.5,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 18:45,  0.001, 0.700, 0.110,0,0,37,1.2,24.0,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 19:00,  0.003, 0.700, 0.127,0,0,38,1.1,24.6,0,0,0,0,0,0,0,1,0,0,0,0,
10/02/07 19:15,  0.003, 0.700, 0.129,0,0,38,1.1,24.8,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 19:30,  0.003, 0.700, 0.109,0,0,37,0.9,24.0,0,0,0,0,0,0,0,0,0,0,0,0,
```

Example of CSV new data report

The flow statistics fields available in the CSV menu are described below. These files are not available except on BAM units configured as FEM $PM_{2.5}$ units. A BX-596 sensor is required.

Field	Description
Start	Start time of BAM sample period.
Elapsed	Elapsed BAM sample time.
Flow	Average flow rate for the BAM sample period.
CV	Flow rate coefficient of variance for the BAM sample period.
Volume	Sample volume for the BAM sample period.
Flag	Flow regulation out of range warning flag.
AT	Average ambient temperature for the BAM sample period.
AT Min	Minimum ambient temperature for the BAM sample period.
AT Max	Maximum ambient temperature for the BAM sample period.
BP	Average ambient pressure for the BAM sample period.
AT Min	Minimum ambient pressure for the BAM sample period.
AT Max	Maximum ambient pressure for the BAM sample period.

The 5 minute flow statistics averages are described below. These files are not available except on BAM units configured as FEM $PM_{2.5}$ units. A BX-596 sensor is required.

Field	Description
Time	Event time stamp in seconds since January 1, 1970 00:00:00
Flow	Minute average flow rate for the BAM sample period.
AT	Minute average ambient temperature for the BAM sample period.
BP	Minute average ambient pressure for the BAM sample period.

File 7: Display Last 100 Errors

This file will contain the date, time, and a description of each of the last 100 errors logged by the BAM-1020. This is a useful file for troubleshooting, and it will often be requested by Met One technicians if service is required.

File 8: Display > BAM-1020 < Utility Commands

This file contains a list of the ASCII commands can be sent to the BAM-1020 through the serial port to configure certain parameters or to perform advanced diagnostics. Most of these commands will not be used by the typical operator unless instructed by a factory technician. Some of these commands require a password to access. The password is the same as the F-key sequence used to enter SETUP screens (default password is **1 2 3 4**). The appropriate command character is sent to the BAM to apply the functions shown in the table below.

Command	Command Function
a	**Printer Port Output Configuration.** This sets what is output on the 2nd serial port. Sending this command will prompt the following sub-menu: 1 – Printer Port (default) 2 – Standard Diagnostic Port 3 – Factory Diagnostic Port 4 – Comma Separated Data Output Port
c	**Clear Data Memory.** This command erases all stored data from memory! Password required.
d	**Set Date.** This sets the date on the unit. Password required.
e	**Display Hex EEPROM Setup Values.** This displays the special memory locations where the setup values are stored. Diagnostic only.
f	**Factory Calibration Test.** This is used for factory calibration only!
h or ?	**Display System Menu.** This is the command used to access the data downloading menu options. Become familiar with this command.
i	**Display ID Values.** This command displays the ID codes of the met sensors for diagnostic purposes.
m	**Display Hex Data Memory Values.** This command displays the data memory locations for diagnostic purposes.
p	**Modify Modem Pointer.** Factory use only.
q	**Display Station ID.** This command displays the preset station ID number.
t	**Set Time.** This command sets the time on the unit. Password required.
b	**XMODEM Data Download**. This command allows binary data transfer of the unit memory. Download only. Requires software handshaking. For use with special software only, not terminal programs. Advanced use only.
r	**XMODEM Real-Time Value Download.** This command is only used by special software to scan instantaneous values of sensors, alarms and settings. Requires software handshaking. Advanced use only.
x	**XMODEM EEPROM Value Download.** This command allows quick scanning of non-volatile memory for diagnostic purposed. Advanced use only.
z	**Enable concentration report to PRINTER output.** This command configures the printer port to output a fixed-width concentration report at the end of the sample period. For external loggers.

File 9: Display Pointers
This file is a display of the current status of the data storage memory. The current pointer position and number of full memory locations is shown. Rarely used.

9.5 Printer Output Port

The Printer port on the back of the BAM-1020 is an output-only RS-232 serial interface which may be used with a serial printer or as a diagnostic output to a computer. The printer port output can be configured by using the "**a"** utility command through the main RS-232 port. (See section 9.4) The output may be set for data printouts, fixed-width data output, or one of two diagnostic modes. Diagnostic modes are not used except by a factory technician.

A new configuration has been added for the printer port which enables it to output a fixed-width concentration report at the end of the sample period, which can be used to interface to a serial data logger. This output is enabled by using the **"z"** utility command through the serial port. The output format is date, time, concentration, and flow volume as shown below.

Format in mg/m3 is: **mm/dd/yy hh:mm:ss,+99.999,+9.999**
Format in μg/m3 is: **mm/dd/yy hh:mm:ss,+999999,+9.999**

If the BAM is set to STANDARD cycle mode, the output will occur at the top of the next hour. For example, if a measurement is made over hour 2, then the format would be:

03/28/07 03:00:00, +00.027,+0.834

If the BAM is set to EARLY cycle mode, the output will occur at minute 55:00 for the current hour. For example, if a measurement is made over hour 2, then the format would be:

03/28/07 02:55:00, +00.027,+0.834

9.6 Modem Option

The Met One Instrument BX-996 modem is recommended for use with the BAM-1020, as it is designed to reliably communicate when other modems may not. Note: the RS-232 Polarity switch on the back of the BAM-1020 may need to be set to REVERSE polarity for communication using the modem. If you are using one of the Met One Instruments data acquisition programs such as MicroMet Plus or MicroMet AQ, you need only enter the telephone number of the site in the system setup menu of the program. Multiple telephone numbers can be entered for connection to multiple remote sites.

If you are communicating with a terminal program such as HyperTerminal® or ProComm Plus® you will need to define the serial port configuration in the setup of the program. Set the baud rate to 9600, with 8 data bits, no parity, and 1 stop bit. Use the terminal program's internal dialing command sequence to dial up the BAM-1020. Verify the connection to the BAM-1020 by pressing the <Enter> key until the command prompt asterisk (*) appears. If not, verify the cabling and communications settings. Once connected, the access to the BAM-1020 is the same menu driven interface as used for the direct PC connection.

9.7 Flash Firmware Upgrades

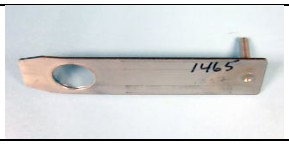
The BAM-1020 now has the capability for flash firmware upgrades. This allows the field operator to reprogram the flash EEPROM through the serial port using the Flash Update Utility. Units with a firmware revision of 3.0 or higher can be flash upgraded. If the unit currently has a revision lower than 3.0, the EEPROM will have to be replaced with a flash compatible chip. The following tasks must be performed whenever firmware is upgraded or the EEPROM is replaced:

1. Download and save all data and error logs before proceeding. These will be cleared during the upgrade process!
2. Record the OFFSET value from the SETUP > SAMPLE screen, and the BKGD value from the SETUP > CALIBRATE screen. A download of the settings file is advised.
3. Update the firmware.
4. The baud rate will default to 38400. Reset as appropriate.
5. Recalibrate the filter temperature and filter RH sensors.
6. Set the values of OFFSET, CONC UNITS, and COUNT TIME in the SETUP > SAMPLE screen.
7. Set the values of CONC TYPE, FLOW TYPE, and BKGD in the SETUP > CALIBRATE screen. Review all other BAM-1020 settings to make sure they are all correct.

10 ACCESSORIES and PARTS

10.1 Consumables, Replacement Parts, and Accessories

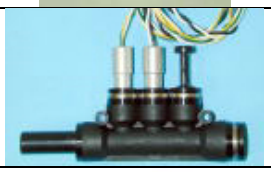
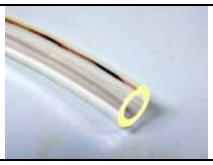
The following parts are available from Met One for maintenance, replacement, service, and upgrades. If unsure about a part you need, please contact the Service department. Some of these parts require technical skills or special considerations before use or installation.

Description	Part Number	Graphic
Consumables		
Filter Tape Roll, Glass Fiber, 60+ days per roll 30mm x 21m	**460130**	
Cotton-Tipped Applicators, nozzle cleaning, 100 pack Solon #362	**995217**	
Tools		
BAM-1020 Service Tool Kit: Includes nozzle shims, spring scales, reel spacer, filter sensor removal tool	**BX-308**	
Leak Test Rubber Nozzle Seal	**7440**	
Membrane Assembly, Replacement, 0.800 mg/cm2	**8069**	
Membrane Assembly, Mid-Range, 0.500 mg/cm2	**BX-301**	
Mass Flow Calibration Kit, 0-20 SLPM	**BX-303**	
Flow Inlet Adapter Kit (Leak Test Valve) Includes short inlet tube	**BX-305**	
Zero Filter Calibration Kit, with valve Required for PM2.5 FEM monitoring Same as BX-305 but with 0.2 micron filter	**BX-302**	
Volumetric Flow Calibration Kit (BGI Delta Cal™) Flow, Temp, and Pressure Reference Standards Met One recommended flow meter	**BX-307**	

Pumps and Pump Parts

Pump, Medo, 115 VAC, 50/60 Hz, Low Noise	**BX-126**	
Pump, Medo, 230 VAC, 50/60 Hz, Low Noise	**BX-127**	
Pump, Gast, Rotary Vane, 100 VAC, 60 Hz	**BX-123**	
Pump, Gast, Rotary Vane, 115 VAC, 50/60 Hz	**BX-121**	
Pump, Gast, Rotary Vane, 230 VAC, 50 Hz	**BX-122**	
Pump, Gast, Rotary Vane, 230 VAC, 60 Hz	**BX-124**	
Muffler, Medo/Gast Pump, Replacement	**580293**	
Pump Rebuild Kit, Gast	**680828**	
Pump Rebuild Kit, Medo	**680839**	
Pump Service Kit, Filter Replacement, Medo	**8588**	
Pump Controller (Relay Module) Medo/Gast	**BX-839**	

Flow Components

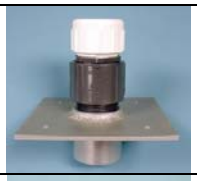
Flow Sensor, Mass, 0-20 LPM, Internal Assembly	**80324**	
Flow Controller Assembly, Replacement Only	**8776**	
Automatic Flow Controller Upgrade Kit	**BX-961**	
Filter Assembly, Pisco In-line	**580291**	
Filter Element Only, Pisco In-line	**580292**	
Filter Temperature and RH Sensor Kit	**BX-962**	
Filter RH Sensor Replacement Only	**9278**	
Filter Temperature Sensor Replacement Only	**9279**	
Nozzle, Stainless Steel, Replacement Part	**8009**	
Nozzle Spring, Replacement	**2998**	
O-Ring, Nozzle	**720066**	
O-Ring, Inlet Receiver, 2 required	**720069**	
O-Ring Kit, BAM	**9122**	
Pump Tubing, Clear, 10mm O.D., 6.5mm I.D. Polyurethane, 25 foot roll standard	**960025**	

Electrical and Electronic Parts

Display, LCD, Front Panel	**2823**	
Circuit Board, CPU	**3230-8**	
Circuit Board, Interface	**3250-1**	

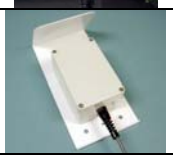
Circuit Board, Rear Panel Interconnect	**3260-1**	
Fuse, BAM-1020, 3.15A, 250V, 5x20mm, 2 Req'd	**590811**	
Motor, with gear box, 4 RPM	**8105-1**	
Motor, with gear box, 10 RPM	**8106-1**	
Power Supply, 115 VAC, 60 Hz	**BX-115**	
Power Supply, 115 VAC, 50 Hz	**BX-116**	
Power Supply, 230 VAC, 60 Hz	**BX-230**	
Power Supply, 230 VAC, 50 Hz	**BX-231**	
Power Supply, 100 VAC, 60 Hz	**BX-100**	
Power Supply, 100 VAC, 50 Hz	**BX-101**	

Inlet Components

PM10 Inlet Head, EPA Specified	**BX-802**	
TSP Sampling Inlet Cap, with bug screen	**BX-803**	
PM2.5 Sharp Cut Cyclone	**BX-807**	
PM2.5 Very Sharp Cut Cyclone, BGI Inc. VSCC™ Required for PM2.5 FEM monitoring	**BX-808**	
PM2.5 WINS Impactor	**BX-804**	
Inlet Roof Mounting Kit, with waterproof roof flange, inlet tube and braces. Specify tube length, 8 feet std	**BX-801**	
Inlet Tube Coupler Assembly, with o-rings Connects two inlet tubes together Inlet tube sold separately	**BX-821**	
Inlet Tube Extension Kit, 4 foot, with coupler and tube	**BX-822**	
Inlet Tube Extension Kit, 8 foot, with coupler and tube	**BX-823**	
Inlet Tube, Aluminum, 8 foot length standard	**8112**	
Inlet Tube, Custom Length Dash number is length in feet, 8' max per tube	**8112-X**	

Smart Heater Option, 115 VAC	**BX-827**	
Smart Heater Option, 230 VAC	**BX-830**	
Smart Heater Upgrade Kit, 115VAC	**9307**	
Smart Heater Upgrade Kit, 220VAC	**9308**	
BAM Inlet Cleaning Kit Includes pull-rope, tube brush, microfiber rags, cleaning brushes, o-ring grease, cotton applicators. For cleaning inlet tube and PM10, PM2.5 inlets.	**BX-344**	
O-Rings, Cyclone, set of 6	**720097**	
O-Rings, PM10 Head, set of 3	**8965**	

Meteorological Sensors

590 Wind Direction Sensor, Auto ID	**BX-590**	
591 Wind Speed Sensor, Auto ID	**BX-591**	
592 Ambient Temperature Sensor	**BX-592**	
593 Ambient Relative Humidity Sensor	**BX-593**	
594 Ambient Barometric Pressure Sensor, Auto ID	**BX-594**	
595 Solar Radiation Sensor, Auto ID	**BX-595**	
596 AT/BP Combo Sensor Required for PM2.5 FEM monitoring	**BX-596**	
Real-Time Module (RTM), BAM Inlet Particle Sensor	**BX-894**	

Communications Components and Misc. Accessories

Serial Printer Kit	**BX-601**	
Converter for Parallel Printers	**BX-602**	
Modem Kit	**BX-996**	
Serial Cable, 6', DB-9 female/female, null, BAM to PC	**400658**	
Belkin F5U109 USB-to-RS-232 Adapter	**550067**	
Enclosure, Outdoor, Heated, Mfg by Shelter One	**BX-902**	
Enclosure, Outdoor, Heated and Air Conditioned Mfg by Ekto. Available with 2000 or 4000 BTU A/C.	**BX-903** **BX-904**	

10.2 Series 500 Sensor Configurations

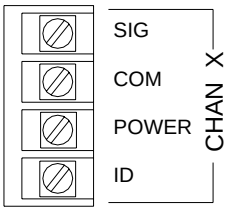
The BAM-1020 has six channels of inputs available on the back of the unit for data logging external sensors. The 500 Series sensors are a set of meteorological sensors designed for direct compatibility with these channels. The sensors each have an auto-identification (ID) signal wire with a voltage unique to that particular type of sensor. When one of these sensors is attached to the BAM, the unit senses this ID voltage and automatically configures the channel to read the sensor with all the correct scaling parameters.

Most BAM-1020 units are equipped with at least the ambient temperature sensor BX-592 because ambient temperature is required on channel six for actual flow control. If the BAM is used for $PM_{2.5}$ monitoring, then the BX-596 sensor is required instead. This is a combination ambient temperature and barometric pressure sensor which attaches to channels six and seven, and provides the EPA required AT/BP measurements for actual flow control and flow statistics.

The scaling and setups values of the series 500 Sensors are provided in the chart below. The unit should automatically set these values in the SETUP > SENSORS menu. The ID MODE must be set to AUTO to identify the sensors, or set to MANUAL to change the parameters.

500 Series Sensor Setup Parameters

Model	Type	Units	Range	Mult	Offset	FS VOLT	S/V	Inv Slope
BX-590	WD	Deg	0 to 360	360	0	1.0	V	N
BX-591	WS	mph	0 to 100	100	0	1.0	S	N
		m/s	0 to 44.704	44.70	0	1.0	S	N
BX-592	AT	^{0}F	-22 to +122	144	-22	1.0	S	N
		^{0}C	-30 to +50	80	-30	1.0	S	N
BX-593	RH	%	0 to 100	100	0	1.0	S	N
BX-594	BP	inHg	20 to 32	6	26	1.0	S	N
		mmHg	508.0 to 812.8	152.40	660.40	1.0	S	N
		mbar	677.1 to 1083.6	203.19	880.46	1.0	S	N
BX-595	SR	Ly/ min	0 to 2	2	0	1.0	S	N
		W/M2	0 to 2000	2000	0	1.0	S	N
BX-596	AT/BP	^{0}C	-40 to +55	95	-40	2.5	S	N
		mmHg	525 to 825	300	525	2.5	S	N



BAM-1020 Back Panel Sensor Input Terminal

500 Series Sensor Wiring Connections for BAM-1020

BX-590 Wind Direction Sensor	
Terminal Block	**Cable Wire Color**
SIG	Yellow
COM	Black/Shield
POWER	Red
ID	Green

BX-591 Wind Speed Sensor	
Terminal Block	**Cable Wire Color**
SIG	Yellow
COM	Black/Shield
POWER	Red
ID	Green

BX-592 Ambient Temp Sensor	
Terminal Block	**Cable Wire Color**
SIG	Yellow
COM	Black/Shield
POWER	Red
ID	Green

BX-593 Relative Humidity Sensor	
Terminal Block	**Cable Wire Color**
SIG	Yellow
COM	Green/Shield
POWER	White
ID	Red

BX-594 Barometric Pressure Sensor	
Terminal Block	**Cable Wire Color**
SIG	White
COM	Black/Shield
POWER	Red
ID	Yellow

BX-595 Solar Radiation Sensor	
Terminal Block	**Cable Wire Color**
SIG	Yellow
COM	Black/Shield
POWER	Red
ID	Green

BX-596 Temperature/Pressure Combo Sensor	
Terminal Block	**Cable Wire Color**
Channel 6 SIG	Yellow
Channel 6 COM	Black/Shield
Channel 6 POWER	Red
Channel 6 ID	Green
Channel 7 SIG	White

Notes:

- BX-592 is always connected to channel 6 when used for flow control with a BAM-1020.
- BX-592 or BX-596 is required for actual flow control.
- BX-596 is required for $PM_{2.5}$ monitoring, effective March 2007.

Mounting:

The 500 series sensors typically mount near the top of the BAM-1020 inlet tube with a short cross-arm and related hardware. The sensors may also be mounted to a nearby tripod, such as Met One model 905.

11 THEORY OF OPERATION and MATHEMATICAL ANALYSIS

When the high-energy electrons emanating from the radioactive decay of ^{14}C (carbon-14) interact with nearby matter they loose their energy and, in some cases, are absorbed by the matter. These high-energy electrons emitted through radioactive decay are known as beta rays and the process is known as beta-ray attenuation. When matter is placed between the radioactive ^{14}C source and a device designed to detect beta rays, the beta rays are absorbed and/or their energy diminished. This results in a reduction in the number of beta particles detected. The magnitude of the reduction in detected beta particles is a function of the mass of the absorbing matter between the ^{14}C beta source and the detector.

The number of beta particles passing through absorbing matter, such as dust deposited on a filter tape, decrease nearly exponentially with the mass through which they much pass. Equation 1 shows this relationship.

Equation 1

$$I = I_0 e^{-\mu x}$$

In Equation 1, I is the measured beta ray intensity (counts per unit time), of the attenuated beta ray (dust laden filter tape), I_0 is the measured beta ray intensity of the un-attenuated beta ray (clean filter tape), μ is the absorption cross section of the material absorbing the beta rays (cm^2/g), and x is the mass density of the absorbing matter (g/cm^2).

Equation 1 very closely resembles the Lambert-Beers Law, which is used in spectrometric analysis. Just as the Lambert-Beers Law is an idealization of what is actually observed, Equation 1 is also an idealized simplification of the true processes occurring meant to simplify the corresponding mathematics. However, experimental measurement shows that in properly designed monitors, such as the BAM-1020, the use of this equation introduces no substantial error.

Equation 1 may be rearranged to solve for x, the mass density of the absorbing matter. This is shown in Equation 2.

Equation 2

$$-\frac{1}{\mu}\ln\left[\frac{I}{I_0}\right] = \frac{1}{\mu}\ln\left[\frac{I_0}{I}\right] = x$$

In practice, the absorption cross section is experimentally determined during the calibration process. Once I and I_0 are experimentally measured, it is a simple matter to calculate x, the predicted mass density.

In practice, ambient air is sampled at a constant flow rate (Q) for a specified time Δt. This sampled air is passed through a filter of surface area A. Once x, the mass density of collected particles, has been determined, it is possible to calculate the ambient concentration of particulate matter ($\mu g/m^3$) with Equation 3.

Equation 3

$$c\left(\frac{\mu g}{m^3}\right) = \frac{10^6 A(cm^2)}{Q\left(\frac{liter}{min}\right)\Delta t(min)\mu\left(\frac{cm^2}{g}\right)}$$

In Equation 3, c is the ambient particulate concentration ($\mu g/m^3$), A is the cross sectional area on the tape over which dust is being deposited (cm^2), Q is the rate at which particulate matter is being collected on the filter tape (liters/minute), and Δt is the sampling time (minutes). Combining these equations yields to the final expression for the ambient particulate concentration in terms of measured quantities. This is shown in Equation 4.

Equation 4

$$c\left(\frac{\mu g}{m^3}\right) = \frac{10^6 A(cm^2)}{Q\left(\frac{liter}{min}\right)\Delta t(min)\mu\left(\frac{cm^2}{g}\right)} \ln\left(\frac{I_0}{I}\right)$$

The key to the success of the beta attenuation monitor is due in part to the fact that μ, the absorption cross-section, is almost insensitive to the nature of the matter being measured. This makes the BAM-1020 very insensitive to the chemical composition of the material being collected.

It is instructive to perform a conventional propagation of errors analysis on Equation 4. Doing so, one can develop an equation for the relative measurement error (σ_c/c) as a function of the uncertainty in each of the parameters comprising Equation 4. This leads to Equation 5.

Equation 5

$$\frac{\sigma_c}{c} = \sqrt{\frac{\sigma_A^2}{A^2} + \frac{\sigma_Q^2}{Q^2} + \frac{\sigma_t^2}{t^2} + \frac{\sigma_\mu^2}{\mu^2} + \frac{\sigma_I^2}{I^2 \ln\left[I/I_0\right]^2} - \frac{\sigma_{I_0}^2}{I_0^2 \ln\left[I/I_0\right]^2}}$$

Inspection of Equation 5 reveals several things. The relative uncertainty of the measurement (σ_c/c) is decreased (improved) by increasing the cross sectional area of the filter tape (A), the flow rate (Q), the sampling time (t), the absorption cross-section (μ), I and I_0.

In practice, the uncertainty associated with the filter area (σ_A/A), may be minimized by ensuring that the tape is in exactly the same position during the I_0 measurement as in the I measurement phase. Careful design of the shuttle and tape control mechanisms inside of the BAM-1020 results in minimal error here.

The uncertainty in the flow rate (σ_Q/Q) may be minimized by properly controlling the flow of the instrument. For BAM-1020 units with a manual flow valve, this value is on the order of $\pm$ 3%. For BAM-1020 units equipped with the mass flow controller device, (σ_Q/Q) decreases to $\pm$ 1%.

The relative error due to the uncertainly in the absorption cross section (σ_μ/μ), is due to its slight variation as a function of the chemical composition of the matter being monitored. Generally, this relative error is on the order of $\pm$ 2-3%, with judicious selection of the calibrated value of μ.

The uncertainty associated with the measurement of I and I_0 has to do with the physical nature of the process leading to the emission of beta particles from the decay of ^{14}C. This process follows Poisson statistics. Poisson statistics show the uncertainty in the measurement of I (σ_I/I) and I_0 (σ_{I0}/I_0) are minimized by increasing the sampling time. Mathematical analysis shows that doubling the sampling time and hence the measured intensity of I or I_0 will reduce the uncertainty of the measurement by a factor of 1.41 (square root of 2).

11.1 Converting Data Between EPA Standard and Actual Conditions

As described in this manual, the BAM-1020 can obtain concentration data using either actual or standard values for ambient temperature and pressure. In some cases, it is necessary to convert past concentration data collected in standard conditions to actual conditions, or the other way around. Note: temperature is in degrees Kelvin (C+273) and pressure is in mmHg.

Equation 6

$$C_{std} = C_{amb} * (P_{std} / P_{amb}) * (T_{amb} / T_{std})$$

Equation 6 can be used to calculate the standard concentration (C_{std}) from the ambient concentration (C_{amb}) data using ambient barometric pressure and temperature data (P_{amb} and T_{amb}) from the same time period in which the ambient concentration was recorded. P_{std} and T_{std} are the values of standard barometric pressure and standard ambient temperature. These values are usually the EPA mandated 760 mmHg and 298 degrees Kelvin (25 C). **Note:** Some other countries use different values for standard temperature and pressure.

Equation 7

$$C_{amb} = C_{std} * (P_{amb} / P_{std}) * (T_{std} / T_{amb})$$

Equation 7 can be used to calculate the ambient concentration (C_{amb}) from the standard concentration (C_{std}) data using the ambient temperature and pressure. It is necessary to have access to valid data for the ambient temperature and pressure for the desired sample hour in order to be able to make the calculations.

Example: You have a data value of 27μg from a BAM which was configured to report data in EPA Standard conditions (298K and 760 mmHg), but you need to know what the concentration would have been in actual conditions. The actual average temperature for the hour in question was 303K and the average pressure was 720mmHg.

$$C_{amb} = C_{std} * (P_{amb} / P_{std}) * (T_{std} / T_{amb})$$
$$C_{amb} = 27 * (720/760) * (298/303)$$
$$C_{amb} = 27 * 0.9474 * 0.9835$$
$$\mathbf{C_{amb} = 25.1\ \mu g}$$

BAM-1020 Audit Sheet

Model: BAM-1020 **Serial Number:**

Audit Date: **Audited By:**

Flow Audits			
Flow Reference Standard Used:	Model:	Serial No:	Calibration Date:
Temperature Standard Used:	Model:	Serial No:	Calibration Date:
Barometric Pressure Standard Used:	Model:	Serial No:	Calibration Date:

Leak Check Value: as found: lpm as left: lpm

		BAM	Ref. Std.		BAM	Ref. Std.	
Ambient Temperature:	as found:	C	C	as left:	C	C	N/A
Barometric Pressure:	as found:	mmHg	mmHg	as left:	mmHg	mmHg	
Flow Rate (Actual Volumetric):	as found:	lpm	lpm	as left:	lpm	lpm	N/A
Flow Rate (EPA Standard):	as found:	lpm	lpm	as left:	lpm	lpm	N/A

Mechanical Audits

Pump muffler unclogged:	as found	as left		PM10 particle trap clean:	as found	as left	N/A	
Sample nozzle clean:	as found	as left		PM10 drip jar empty:	as found	as left	N/A	
Tape support vane clean:	as found	as left		PM10 bug screen clear:	as found	as left	N/A	
Capstan shaft clean:	as found	as left		PM2.5 particle trap clean:	as found	as left	N/A	
Rubber pinch rollers clean:	as found	as left		Inlet tube water-tight seal OK:	as found	as left		
Chassis ground wire installed:	as found	as left		Inlet tube perpendicular to BAM:	as found	as left		

Analog Voltage Output Audit N/A

DAC Test Screen	BAM Voltage Output	Logger Voltage Input
0.000 Volts	Volts	Volts
0.500 Volts	Volts	Volts
1.000 Volts	Volts	Volts

Membrane Audit	
LAST m (mg):	
ABS (mg):	
Difference (mg):	
% Difference:	

Flow Control Range	
Flow Setpoint	**BAM Flow**
15.0 LPM	
16.7 LPM	
18.3 LPM	

Setup and Calibration Values

Parameter	Expected	Found	Parameter	Expected	Found	Parameter	Expected	Found
Clock Time/Date			FLOW TYPE			AP		
RS232			Cv			FRl		
STATION #			Qo			FRh		
RANGE			ABS			Password		
BAM SAMPLE			µ sw			Cycle Mode		
MET SAMPLE			K Factor			RH Control		
OFFSET			BKGD			RH Setpoint		
CONC UNITS			STD TEMP			Datalog RH		
COUNT TIME			HEATER			Delta-T Control		
FLOW RATE			e1			Delta-T Setpoint		
CONC TYPE			Errors			Datalog Delta-T		

Last 6 Errors in BAM-1020 Error Log

Error	Date	Time	Error	Date	Time
1			4		
2			5		
3			6		

Audit Notes:

OPERATOR NOTES: