BAM 1020
PARTICULATE MONITOR
OPERATION MANUAL
BAM 1020-9800 REV Y

Met One Instruments, Inc

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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.

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.

This manual is periodically revised for maximum accuracy, and to incorporate new features or updates. Below is a brief description of the BAM 1020 manual revision history:

Rev	Released	Manual Description
A-E	1998-2006	Obsolete revisions of the manual. These are only suitable for older BAM 1020 units with firmware Rev 2.58 or earlier. Users of these units should acquire a newer manual revision.
F	March 2007	Complete re-write of the entire manual to accompany the EPA PM2.5 FEM candidate modifications for the BAM 1020. Extensively corrected, reorganized, and updated all sections. Applies to all BAM 1020 units of all vintages. All BAM 1020 units using revision 3.0 or later firmware must have a Rev F or later manual.
G	May 2008	Minor revisions for the official sales release of the EPA designated PM2.5 FEM version of the BAM 1020. Added final PM2.5 designation requirements and installation drawings. Other minor revisions throughout the manual. Applies to all BAM 1020 units. All BAM 1020 units using revision 3.2.5 or later firmware should have a Rev G or later manual.
H	June 2010	Revisions to incorporate information about the PM-Coarse designated version, and to add information about new firmware features up to firmware rev 3.6. Additional maintenance procedures added.
J	Sep 2011	Minor revisions to zero filter test instructions.
K	Oct 2012	Added electrical safety requirements and smart heater configurations in section 2. Added report processor and firmware compatibility details. Firmware features up to version 3.7.
L	Dec 2015	Designation update, minor changes to reflect functionality changes
M	June 2016	General Rewrite. Correction of errors, removal of unnecessary information.
N	July 2016	Correction of several formatting errors..
P	Oct 2016	Minor changes to reflect functionality updates.
Q	Feb 2017	Clarification of Zero Background Test instructions..
R	Aug 2017	Correction of minor errors..
T	Oct 2017	Updated replacement parts table..
U	Nov 2017	Minor changes to reflect functionality updates.
W	Sep 2018	Changes to support Firmware V3.13.0 and V3.14.0.
X	Feb 2020	Updated 500 Series Sensor wiring colors.
Y	Aug 2021	Remove Delta-T references (pages 90-91, 98) Section 2.5: Added BX-824 Inlet Slip Coupler information Section 6.7: Removed DELTAP setting. Section 7.2: Alarm Code F, Flow Failure, Added Qtot conditional (Change to support firmware 3236-5 V3.14.4). Section 10.1: Added BX-824 Inlet Slip Coupler Assembler, BX-811 (PM1).

1.2 Technical Service

Should you require support, please consult your printed documentation or our website www.metone.com to resolve your problem. If you are still experiencing difficulty, you may contact a Technical Service representative during normal business hours. 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 to expedite customer service.

Monday – Friday 7:00 a.m. to 4:00 p.m. Pacific Time.

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All BAM 1020 monitors have a serial number on the label on the back panel, embossed on the two metal NRC tags, and printed on the calibration certificate. This number is needed if you contact the technical service department to request information about repairs or updates for your BAM 1020. The serial number begins with a letter which represents the year of manufacture, followed by a unique four or five digit number. Example: F8029 was built in 2006.

Letter	Year	Letter	Year	Letter	Year
W	1998	H	2008	X	2018
X	1999	J	2009	Y	2019
Y	2000	K	2010	A	2020
A	2001	M	2011	B	2021
B	2002	N	2012	C	2022
C	2003	P	2013	D	2023
D	2004	R	2014	E	2024
E	2005	T	2015	F	2025
F	2006	U	2016	G	2026
G	2007	W	2017	H	2027

1.3 BAM: Beta Attenuation Monitor

The Met One Instruments BAM 1020 beta attenuation mass monitor automatically measures and records ambient particulate mass concentration levels using the principle of beta ray attenuation. This method provides a simple determination of the ambient concentration of particulate matter in mg/m^3 or $\mu g/m^3$. A small ^{14}C (carbon 14) element inside of the BAM 1020 provides a constant source of beta rays. The beta rays traverse a path through which glass fiber filter tape is passed before being detected with a scintillation detector. At the beginning of the measurement cycle the beta ray count (I_0) across clean filter tape is recorded. Then, an external pump pulls a known volume of PM-laden air through the filter tape thereby trapping the PM on the filter tape. At the end of the measurement cycle the beta ray count (I_3) is re-measured across PM-laden filter tape. The ratio of I_0 to I_3 is used to

determine the mass density of collected PM on the filter tape. A complete description of the measurement cycle is included in Section 4. In addition, a scientific explanation of the theory of operation and the related equations is included at 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 ±15 μCi (microcurries), which is below the "Exempt Concentration Limit" of 100 µCi as determined by the United States Nuclear Regulatory Commission (US-NRC). The owner or operator of the BAM 1020 is not required to have a license to possess or operate the equipment under US-NRC regulations. The owner may however elect to return the monitor to Met One Instruments for recycling of the ^{14}C source when the monitor has reached the end of its service life, although is under no obligation to do so. Under no circumstances should anyone but factory technicians attempt to remove or access the ^{14}C source. ^{14}C has a half-life of about 5730 years, and should never need to be replaced. Neither the ^{14}C source nor the 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 BAM 1020 US-EPA Configurations

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

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

US-EPA designated methods using the BAM 1020 are modified from time to time in order to reflect hardware or software improvements. These modifications do not impact previously designated configurations of the BAM 1020 but may provide the end user with a product upgrade path that will allow the monitor to continue to be operated as a US-EPA designated method. For further details, please contact our service department. Details concerning US-EPA designated configurations of the BAM 1020 may be found on the US-EPA website:

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

1.6 BAM 1020 Other Configurations

The BAM 1020 is used worldwide. Although many international jurisdictions use the US-EPA configurations, others do not. Please consult with your local monitoring authority for details on how the BAM 1020 should be configured and operated locally.

1.7 BAM 1020 Specifications

PARAMETER	SPECIFICATION
Measurement Principle:	Particulate Concentration by Beta Attenuation.
U.S. EPA Designations:	PM_{10}: EQPM-0798-122 $PM_{2.5}$ EQPM-0308-170 $PM_{2.5}$ EQPM-0715-266 $PM_{10-2.5}$ FEM: EQPM-0709-185
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.
Lower Detection Limit: (2σ) (1 hour)	< 4.8 μg/m^3 (< 4.0 μg/m^3 typical) (8-minute count time)
Lower Detection Limit: (2σ) (24 hour)	< 1.0 μg/m^3
Measurement Cycle Time:	1 hour
Flow Rate:	16.70 liters/minute
Filter Tape:	Glass fiber filter
Span Check:	Nominally 800 μg/cm^2
Beta Source:	C-14 (carbon-14), 60 μCi ±15 μCi (< 2.22 X 10^6 Beq), Half-Life 5730 years.
Beta Detector Type:	Photomultiplier tube with scintillator.
Operating Temp. Range:	0° to +50°C
Ambient Temp. Range:	-40° to +55°C standard. Optional -50 °C temperature sensors available.
Ambient Humidity Range:	0 to 90% RH, non-condensing.
Humidity Control:	Actively controlled inlet heater module, 10% - 99% RH set point.
Approvals:	U.S. EPA, MCERTS, CE, NRC, TUV, CARB, ISO-9001.
Standard User Interface:	Menu-driven interface with 8x40 character LCD display and dynamic keypad.
Optional User Interface:	Graphic color touch screen display module, Model BX-970.
Analog Output:	Isolated 0-1 VDC output standard. 0-10V, 4-20mA, 0-16mA switch-selectable.
Serial Interface:	RS-232 2-way serial ports 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:	Air Plus™, Comet™, MicroMet Plus®, HyperTerminal®, ProComm Plus®.
Error Reporting:	User-configurable. Available through serial port, display, and relay outputs.
Memory:	4369 records (182 days @ 1 record/hr). Extended memory Report Processor option
Power Supply:	100 - 230 VAC, 50/60 Hz. 0.4 kW, 3.4A max @110V. Not including shelter.
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, Inspection, and Evaluation Testing

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.

Unpack the BAM 1020 and accessories and compare them to the packing list to make sure you have all of the required items for the type of installation you plan to perform. A separate quick setup guide with color photos of most of the common accessories will be included with the this manual. You can use the quick setup guide to fully configure and operate the BAM 1020 on a test bench if desired.

The BAM 1020 is shipped with one or two white foam rings and a white plastic shim inside the front of the BAM 1020, which prevent the moving parts of the tape control assembly from being damaged during transit. The rings and shim should be replaced when the BAM 1020 is being transported in order to avoid damaging the tape control mechanism. Do not ship or transport the BAM 1020 with filter tape installed. We recommend that you keep the special shipping box and foam packing material which the BAM 1020 came in as they could be re-used if you must return the BAM 1020 to the factory for any reason.

2.2 Enclosure Selection and Temperature Control

The BAM 1020 monitor is not weatherproof. It is designed to be mounted in a weatherproof, level, low vibration, dust free, and temperature-stable environment where the operating temperature is between 0º C and +50º 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 BAM 1020. Please contact Met One Instruments for advice if you plan to have a non-standard mounting or enclosure configuration.

1. **A walk-in shelter or building:** These are usually semi-portable pre-fabricated shelters or portable trailers with a flat roof, or a room in a permanent building or structure. The BAM 1020 may be placed on a workbench or mounted in an equipment rack. The inlet tube of the BAM must extend up through a hole in the roof of the structure with appropriate sealing hardware. AC power must be available. Instructions for this type of installation are included in this section of this manual.

2. **BX-902/903/906 mini weatherproof 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). A dual-unit air conditioned mini shelter is also available (BX-906). These enclosures are all specified by Met One to accept the BAM 1020, and are supplied with a supplemental installation manual.

Shelter Temperature Control Notes: The air temperature inside a BAM shelter or enclosure is not required to be regulated to any specific narrow range or set point (such as 25 °C), subject to the following caveats:

1. The shelter temperature must stay between 0 and 50 °C inside at all times or alarms and failures may result. Remember that the vacuum pump and inlet heater can contribute significantly to shelter heating.

2. The exact shelter temperature within the 0-50 °C range is not critical. However temperature changes during the measurement cycle can lead to measurement artifacts. These artifacts, when present tend to present only during hourly measurements and are generally insignificant when daily averages are calculated.

3. Met One Instruments recommends logging the temperature inside non-air conditioned mini enclosures such as the model BX-902. Met One Instruments offers a BX-592-1 room temperature sensor which can be logged directly by the BAM 1020 for this purpose

4. BAM 1020 users in hot climates where the ambient temperature exceeds 40 °C should consider using the model BX-903 air conditioned mini shelter or an air conditioned walk-in shelter to avoid over-heating the BAM 1020.

5. The portion of the inlet tube inside of the shelter or building should always be adequately insulated. This is especially important when the equipment is operated under conditions of high ambient dew point. Otherwise condensation could occur inside the sampling tube and/or measurement artifacts could result. If this proves to be an issue, the user may consider increasing the temperature inside the shelter to a point closer to ambient temperature. The BAM 1020 should not be placed directly in the path on an air conditioning vent.

2.3 Site Selection and Inlet Positioning Criteria

We recommend that you check for local regulations and guidance documentation that may exist before selecting the site in which to install the BAM 1020. For example, US-EPA provides a variety guidance documents where site selection issues are addressed. Such guidance and regulation may provide information concerning:

1. Inlet height

2. Spacing and clearance

3. Proximity to particulate sources, both mobile and stationary

4. Additional siting criteria or considerations

These details should be understood before selecting a site.

2.4 Mounting Options in a Walk-In Shelter

When the BAM 1020 is to be located in a walk-in shelter, it may be installed in either an equipment rack or on a bench top. Take the following into account when planning the mounting:

- **Rear Access:** It is important that you leave plenty of access to the rear of the BAM 1020 for wiring connections and maintenance. At least five inches is required. Full access to the back is recommended whenever possible. There must be adequate access to the power switch located on the back of the instrument.

- **Top Access:** It is necessary to have a minimum of eight inches clearance between the top of the BAM 1020 inlet receiver and the bottom of the shelter ceiling to accommodate the smart inlet heater.

- **Mobile Shelters:** If the BAM 1020 is being installed into an equipment rack in a mobile trailer or van, then additional care should be taken to ensure that the mounting can

handle the 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 usually necessary to modify the top plate of the equipment rack by cutting a 2 inch diameter (75mm) hole to allow the inlet tube to extend through to the ceiling. The BAM 1020 dimensional drawings below show the location of the inlet. *Note:* The inlet heater installs onto the inlet tube two inches above the top of the inlet receiver of the BAM 1020. If the BAM 1020 is to be mounted in a rack, it will be necessary to leave extra room above the BAM 1020 in the rack for the heater, or to make the hole in the top of the rack larger in order to clear the heater diameter. The heater is supplied with a foam insulation sleeve which may be modified as needed. Make sure these parts are going to fit before installing the BAM 1020.

2.5 BAM 1020 Installation Instructions

When installing the BAM 1020 into a shelter or structure the following issues should be taken into consideration.

1. **Roof Modifications:** Determine the exact location where the BAM inlet tube will pass through the roof of the shelter, and drill a 2 ¼" or 2 ½" (60mm) diameter hole through the roof at that location. Make sure the hole is directly above where the inlet receiver is to be located, so the inlet tube will be perfectly vertical. A plumb weight is useful for determining where to locate the hole. Note that the inlet receiver on the BAM 1020 is slightly off-center! BX-902/903 mini shelters do not require any roof drilling.

2. **Waterproof Roof Flange:** Apply all-weather silicone caulking around the top of the hole, and install the BX-801 roof flange onto the hole. The threaded barrel of the flange is usually installed downward. 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 tightly. BX-902/903 mini shelters come with a roof flange installed, and only need the watertight fitting. **Note:** Some users prefer to fabricate their own roof flange instead of using the one supplied by Met One Instruments, due to factors such as high snow loading or a sloped roof. Equipment damage from a leaking roof is not covered under warranty.

3. **Inlet Tube Installation and Alignment:** Remove the white threaded cap and rubber seal from the watertight inlet tube seal assembly. This makes it easier to install the inlet tube since the rubber seal is a tight fit. Lower the inlet tube through the flange assembly and into the inlet receiver on the BAM 1020, making sure that the inlet tube is fully seated. It is very important for the inlet tube to be perpendicular to the top of the BAM 1020. The nozzle may bind if the inlet is misaligned. A simple check is to rotate the inlet tube back and forth by hand before tightening the roof flange seal or the BAM 1020 inlet set screws. If the inlet tube is straight, then the tube should rotate fairly easily while inserted into the BAM 1020. If it does not rotate, check the inlet tube for vertical alignment or move the BAM 1020 slightly.

   It is always recommended that the exposed portion of the inlet tube inside the shelter be insulated.

4. **Smart Inlet Heater Installation:** Before tightening the inlet tube in place, the BX-827 or BX-830 smart inlet heater (used on most BAM 1020 monitors) must be installed onto the tube. Lift the inlet tube out of the top of the BAM 1020, 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 smart 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 white 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. The insulation sleeve provides more consistent heating, and also prevents items from coming into contact with the hot heater body.

5. **Smart Heater Electrical Connections:** All generations of the BX-827/830 Smart Heater have the same green metal power connector. However, there are two different configurations for the way the heater plugs into the BAM 1020 depending on the heater control relay location. Make sure that you recognize which of the two following configurations you have.

Most units built between 2008 and 2012 were supplied with an external gray relay module which plugs into a mating **black plastic connector on the back of the BAM 1020**. The Smart Heater connector plugs into the green connector on the top of this relay module, as shown in the left photo below. These external relay modules have their own AC power cord to supply power to the heater, and have a 3A fuse inside.

In the other possible configuration of the kit, the green metal Smart Heater connector simply plugs directly into the mating **green metal connector on the back of the BAM 1020**. The heater relay is located inside the BAM 1020, and the heater power comes from the BAM AC power supply at line voltage and frequency, and is fused by the main 3.1A fuses in the power input module.

⚠️ *Warning! It is possible to incorrectly force the green metal heater connector into the black plastic connector on a BAM 1020 which is configured to use the external relay, even though both connectors have male pins. If this is done the BAM 1020 will not be damaged, but the heater will not function and no sample RH control will occur!*

⚠️ *Warning! The heater relay controls live AC line voltage to the green socket in either version. Treat the green socket like a live power outlet whenever power is applied. Do not open or service the relay module or heater module when power is applied.*

⚠️ *Warning! The Smart Heater has triple redundant safety features to prevent overheating, but the heater surface temperature can exceed 70 degrees C during high humidity conditions. Use the white insulation sleeve to prevent contact with the heater during operation.*

Smart Heater

Version A: Green metal heater connector plugs into green metal connector on the relay module. Relay module plugs into black plastic connector on the BAM.

Version B: Green metal heater connector plugs into green metal connector on the BAM, with no relay module.

Heater
Power Cord

Two Different Smart Heater Power Configurations

6. **Tightening the Inlet:**   After the inlet tube is aligned and the heater installed, 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 first. Tighten the white plastic cap. Tighten the two set screws in the top of the BAM 1020 inlet receiver.

7. **Inlet Support Struts:**   The BX-801 inlet kit 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). Some installations may require different methods or hardware for supporting the inlet tube. Support the tube in the best manner available. The BX-902/903 mini shelters do not require inlet tube supports.

8. **Temperature Sensor Installation:**   BAM 1020 units are supplied with a BX-592 (temperature only), BX-596 (AT/BP), or BX-597 (AT/BP/RH) sensor, which attaches to the inlet tube above the roof. The sensor cable must route into the shelter to be attached to the BAM. Use a waterproof cable entry point or weatherhead if your shelter has one. The BX-902/903 mini shelters have a cable entry on the side. Route the cable into the shelter in the best manner available. In some cases you may need to simply drill a 3/8" hole through the roof a few inches away from the inlet tube, route the cable through the hole and caulk it to prevent leaks. The BX-596 and BX-597 sensors attach 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.

Connect the cable to the terminals on the back of the BAM 1020 as follows. Additional optional Met One auto ID sensors may be connected to channels 1 through 5 to log other meteorological parameters. Details on these optional sensor connections are given in Section 10.2 of this manual.

BX-597 Temp/Baro/RH Combo Sensor	
Wire Color	Terminal Name
Blue (AT)	Channel 6 SIG
Black/Shield, Orange	Channel 6 COM
Red	Channel 6 POWER
Green	Channel 6 ID
White (BP)	Channel 7 SIG
Brown (RH)	Channel 1-3 SIG*

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

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

9. **Inlet Separator Heads:**   For PM$_{10}$ monitoring, the BX-802 Size-Selective Inlet is installed directly onto the inlet tube with no cyclone. To configure the BAM 1020 for PM$_{2.5}$ monitoring, install the PM$_{2.5}$ size fractionator the PM$_{10}$ head as shown below. Use O-ring lubricant as needed. Met One Instruments offers a variety of PM$_{2.5}$ fractionators for use with the BAM 1020.

10. **Inlet Tube Grounding:**   The two ¼"-20 set screws located in the inlet receiver of the BAM should create a ground connection for the inlet tube to prevent static electricity from building up on the inlet tube under certain atmospheric conditions. This is also 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 1020. It should measure only 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.

11. **Pump Location and Installation:**   The best location for the vacuum pump is often on the floor under the rack or bench, but it may be located up to 25 feet away if desired. It may be preferable to locate the pump so that noise is minimized if the BAM 1020 is in an area where personnel are present. If the pump is to be enclosed, ensure that it will not overheat. The Gast pumps have a thermal shutdown inside which may trip if overheating occurs. Route the clear 10 mm air tubing from the pump to the back of the BAM 1020, and insert it firmly into the compression fittings on both ends. The tubing should be cut to the proper length and the excess tubing saved.

The pump is supplied with a 2-conductor signal cable which the BAM 1020 uses to turn the pump on and off. Connect this cable to the terminals on the back of the BAM 1020 marked "PUMP CONTROL" The end of the cable with the black ferrite filter goes toward the BAM. The cable has no polarity, so 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.

There are two pump types available for the BAM 1020. The Gast rotary vane pumps are louder and draw considerably more power than the Medo linear piston pumps, but have better vacuum capacity, especially at higher altitude or in 50 Hz applications. The Medo pumps are smaller, quieter, and more efficient, but aren't recommended for 50 Hz use.

12. **Optional External Data Logger Connections:**   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. The logger input must be correctly scaled in order to log the voltage accurately! Information on configuring this analog output is provided in Section 8 of this manual. A current loop output is also available.

Newer data loggers often interface to the BAM 1020 using the digital serial ports for better accuracy. Information about this is also found in Section 8. Met One can also supply additional technical bulletins on the subject.

The BAM 1020 has a variety of other telemetry I/O relays, error relays, and serial data connections located on the back of the BAM 1020 as shown below. These items are described in Section 8 and Section 9 of this manual.

BX-802
PM$_{10}$ Head

BX-806, BX-807, BX-808 or BX-809 PM$_{2.5}$ Cyclone

BX-596 AT/BP Sensor (or BX-592)

8112 Inlet Tube 8' standard

Inlet Support Struts

BX-801 Roof Flange

Enclosure Roof

BX-827 or 830 Smart Heater with insulation

BAM 1020
With Medo vacuum pump or equivalent

Mounting
Bench or Rack

adds 14.0"

adds 19.0"

2 Meters
6.5 feet

5' typical

Pipe Insulation (recommended)

8" min. clearance
3 to 4 feet typical

2"

BAM 1020

1/20/2007   BAM 9830   56:88:29
LAST CONCENTRATION: 0.038 mg/m3
CURRENT FLOW: 16.7 LPM
STATUS: ON
FIRMWARE: 3238-02 3.2.4
SETUP   OPERATE   TEST   TAPE

MET ONE INSTRUMENTS

Typical BAM 1020 Installation in a walk-in shelter

BX-802
PM₁₀ Head

BX-806, BX-807, BX-808 or BX-809 PM₂.₅ Cyclone

BX-596 AT/BP Sensor (or BX-592)

27" Inlet Tube

8119 Inlet Seal

BX-827 or 830 Smart Heater with insulation

Mounting Rack

BX-902 or 903 Environmental Enclosure

BX-126 Vacuum Pump or equivalent

adds 14.0"

adds 19.0"

27" typical Inlet tube

15.5"

2"

BAM 1020

MET ONE INSTRUMENTS

-Total Height-
6.6 ft (2.0 meters) without cyclone

7.0 ft (2.1 meters) with cyclone

Typical BAM 1020 Installation in a BX-902 mini enclosure

5" min. rear clearance

C$_L$

TOP

16"

Lifting Notes:

The main unit weighs slightly over 50 lbs, with the center of mass near the front of the BAM 1020. Lift by the rack rails or by the bottom corner bracket. Observe proper lifting and carrying techniques.

74mm (2 $^{15/16}$ ")
from front face of BAM

71mm (2 $^{13/16}$ ")
from front of rack

14mm (9/16")
from center

14.25"

12.25"

9.25"

3.5"

BAM 1020

MET ONE INSTRUMENTS

FRONT

120 VOLTS

BACK

17"

19"
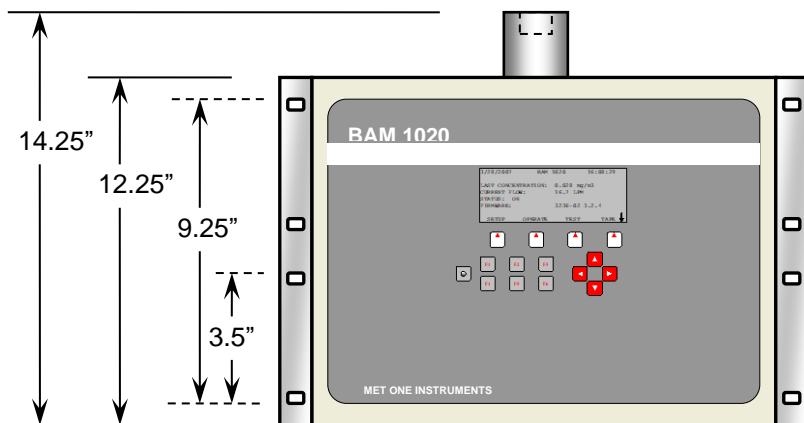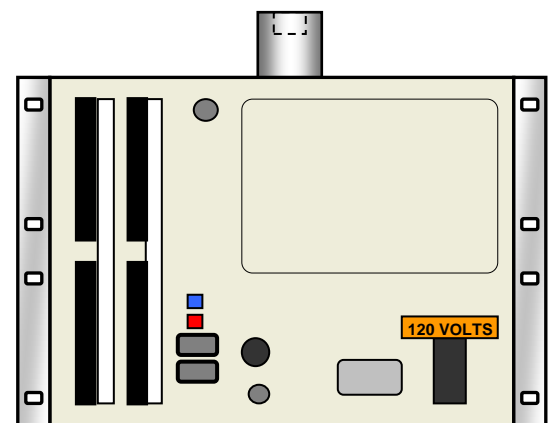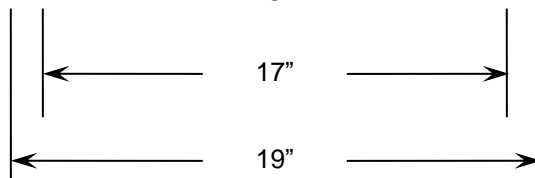
BAM 1020 mounting dimensions

SIGNAL
COMMON
POWER
ID
CHAN 1

SIGNAL
COMMON
POWER
ID
CHAN 2

SIGNAL
COMMON
POWER
ID
CHAN 3

SIGNAL
COMMON
CHAN 4

TELEMETRY
FAULT
NO VOLTAGE

EXTERNAL
RESET
NO VOLTAGE

+
EXTERNAL
RESET VOLTAGE
-

TAPE
FAULT

FLOW
FAULT

INVALID
DATA

MAINTENANCE

SMART
HEATER

Notes About Expanded Digital Ports:
There are several generations of the BAM 1020 digital port configurations. Older units do not have the **REPORT, COM 3, USB, or Ethernet** ports. The optional BX-965 *Report Processor* back panel adds and enabled these data ports. Starting in 2012, all units have these physical back panel connections, but they are **not enabled unless the optional BX-965 daughter board is installed inside the BAM**. Contact technical service for further details.

POWER
ID
CHAN 5

SIGNAL
COMMON
POWER
ID
CHAN 6

SIGNAL
COMMON
POWER
ID
CHAN 7

SIGNAL
COMMON
POWER
ID

RELAY 1 NC
COMMON
COMMON
RELAY 1 NO
PUMP
CONTROL
POWER
FAIL
+
VOLTAGE
OUTPUT
-
CHASSIS
GROUNDS
+
CURRENT
OUTPUT
-

OPTION SWITCH
1 2 3 4
SW1 OFF= 0-1V
SW1 ON= 0-10V
SW2 OFF= 0-16mA
SW2 ON= 4-20mA

RS232
POLARITY
C1 NORMAL
C2 REVERSE

RS-232

PRINTER

REPORT
POLARITY
C1 NORMAL
C2 REVERSE

REPORT

COM 3

ETHERNET

BAM 1020 Rear Panel Connections

2.6 BAM 1020 Power and Electrical Service

The BAM 1020 uses internal 120V AC motors for the tape control system. The power supply is factory-wired to run on **either 110-120V or 220-240V, and either 50Hz or 60Hz**. The external vacuum pump and inlet heater are also AC powered and voltage-specific, and should match the voltage setting of the BAM 1020. Note: The pump power cord is hardwired, and may need to be replaced or adapted to match local outlet types outside of North America.

⚠️ *Warning: Your shelter and/or electrical service must be wired for the correct voltage and frequency in accordance with local electrical codes. Running the BAM 1020, vacuum pump, or inlet heater on incorrect line voltage or frequency will cause improper operation.*

The current draw of the system varies considerably depending on optional accessories and environmental conditions. A dedicated 15 Amp electrical circuit is generally adequate to run a single complete BAM 1020 system, unless a large air conditioner is on the same circuit. Consult a qualified electrician if unsure. A summary of some worst-case loads is given below:

Model	Description	Amps	Wattage
BAM 1020	BAM 1020 only, 120V, worst case with tape transport motors running.	0.17A	20W
BX-126	Medo Linear Piston Pump, 120V, 60Hz, at 16.70 L/min through clean tape.	1.25A	150W
BX-121	Gast Rotary Vane Pump, 120V, 60Hz, at 16.70 L/min through clean tape.	4.44A	530W
BX-122	Gast Rotary Vane Pump, 230V, 50Hz, at 16.70 L/min through clean tape.	2.30A	530W
BX-827	Smart Inlet Heater, 120V, 60Hz, running at 100% high RH duty cycle.	0.85A	100W
BX-830	Smart Inlet Heater, 230V, 50Hz, running at 100% high RH duty cycle.	0.76A	175W
BX-902B	Shelter One Mini Shelter, 120V, worst case with shelter heater ON	4.2A	500W
BX-903	Ekto Mini Shelter, 120V, 2000 BTU air conditioner.	7.4A	586W
BX-904/906	Ekto Mini Shelter, 120V, 4000 BTU air conditioner.	13.5A	1172W

Notes:

- The BAM transport motors only run for a few seconds each per hour. Quiescent BAM current is 0.1A.

- The vacuum pump runs for either 42 or 50 minutes per hour. Startup inrush current is higher.

- Smart Heater wattage drops to idle at 20% (120V) or 6% (230V) when filter RH is below 35%.

- The BX-902B shelter heater is usually off whenever shelter temp is over 40 degrees F, and can be disabled.

- Values are based on measurements or best available information. Additional information is available from Service.

Fuses: There are two 5x20mm, 3.15A, 250V fuses located inside the BAM 1020 power switch module on the back of the BAM 1020. They can be accessed by prying open the top of the small cover surrounding the switch. The power cord <u>must be removed</u> in order to open this cover.

Power Outages and Battery Backup: Any momentary AC power outages will reset the BAM 1020 CPU and prevent data collection for the sample hour. The BAM 1020 may be plugged into a PC-style uninterruptible power supply (UPS) battery back-up unit to prevent this. A UPS of at least 300 Watts is usually sufficient. The vacuum pump does not need to be connected to the UPS, because the BAM 1020 can compensate for short pump flow outages of less than 1 minute duration. If the pump is to be backed up, then a much larger UPS wattage is required.

Chassis Ground: Connect one of the terminals marked "CHASSIS" on the back of the BAM 1020 to an earth ground point using the green/yellow ground wire supplied with the BAM

1020. A copper earth-ground rod is recommended. The chassis ground is primarily for added RFI/EMI noise immunity. The power cord also uses the standard electrical safety ground.

3   INITIAL SETUP OF THE 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 BAM 1020 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 BAM 1020 is already installed and sited as described in Section 2. In some cases it is useful to first set up the BAM 1020 on a test bench before deployment or installation in order to explore the functions and perform setups. The following steps for starting up your BAM 1020 are described in this section:

1. **Power on and warm up.**

2. **Become familiar 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 Up

The power switch is located on the back of the BAM 1020 above the power cord. Verify that the BAM 1020 is plugged in to the correct AC voltage, and that any electrical accessories are correctly wired before powering it up. (Section 2.6) When power is switched on, the main menu screen should appear after a few seconds as shown below. The screen may 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.

3.2 Warm-up Period

The BAM 1020 must warm up for at least one hour before valid concentration data can be obtained. This is because the beta detector contains a vacuum tube which must stabilize. This also allows the electronics to stabilize for optimal operation. This applies any time the BAM 1020 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. You may consider discarding the first few hours of data after the equipment is powered up.

3.3 The Main Menu and Using the Keypad and Display

When the BAM 1020 is powered up it will display the main menu (top level menu) on the LCD display. This menu is the starting point for all functions of the BAM 1020 user interface. Note: The main menu will have a slightly different layout on BAM 1020 units configured in the dual-unit PM-coarse configuration.

```
8/30/2018 BAM 1020 PM2.5 FEM 16:08:29

LAST CONCENTRATION:   0.028 mg/m3
CURRENT FLOW:         16.7 LPM
STATUS:  ON
FIRMWARE: 3236-05 3.14.0

   SETUP        OPERATE       TEST    TAPE ↓
```
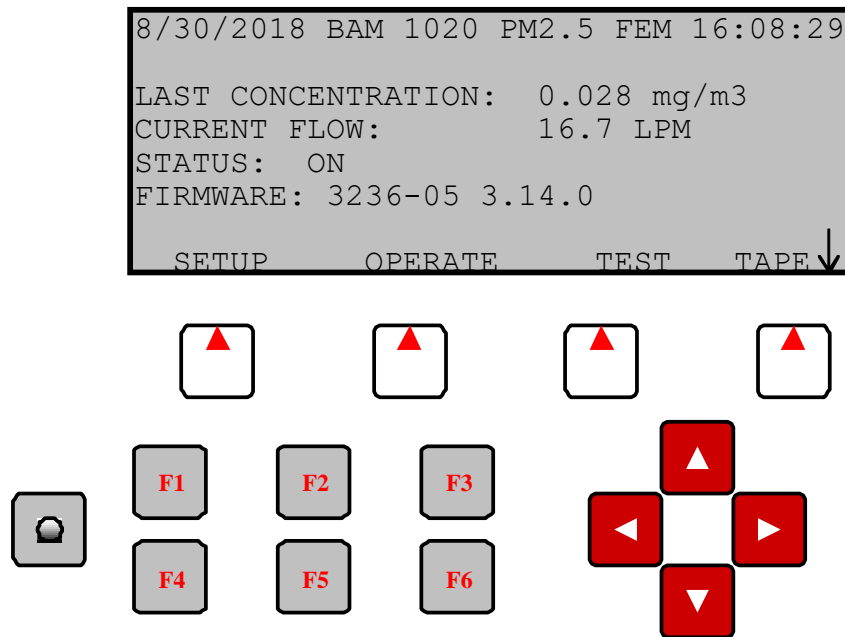
The BAM 1020 Standard User Interface and Keypad

Soft Keys:

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

Arrow (Cursor) Keys:

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

Contrast Key:

The key with a circular symbol on it is for adjusting the light/dark contrast on the LCD display. Press and hold the key until the desired contrast is achieved. It is possible to over-adjust the contrast and make the entire display completely blank or completely dark, so be careful to set it to a visible level.

Function Keys F1 to F6:

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

> **F1 "Current":** This key is a shortcut to the OPERATE > INST screen, used to display instantaneous data values being measured by the BAM 1020. See section 3.12.
>
> **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 3.12.
>
> **F3 "Error Recall":** This key allows the user to view the errors logged by the BAM 1020. The errors are sorted by date. The last 12 days which contain error records are available, and the last 100 errors can be viewed.
>
> **F4 "Data Recall":** This key allows the user to view the data stored in the BAM 1020, including concentrations, flow, and all six external channels. The data is sorted by date, and the user can scroll through the data hour-by-hour using the soft-keys. Only the last 12 days which contain data records are available for viewing in this menu.
>
> **F5 "Transfer Module":** This key is used to copy the memory contents to an optional data transfer module. The transfer module option is obsolete and no longer used.
>
> **F6:** This key is not assigned a data function.

3.4 Filter Tape Loading

A roll of Met One glass fiber filter tape must be loaded into the BAM 1020 for sampling. A roll of tape will last more than 60 days under normal operation. It is important to have spare rolls available to avoid data interruptions. Some agencies save and archive the used filter tape, although the used sample spots are not protected from contamination, and are not marked to indicate the sample hour or site. Chemical analysis may be affected by the binder agent in the tape. Used filter tape should never be "flipped over" or re-used! This <u>will</u> result in measurement problems. Loading a roll of filter tape into the BAM 1020 is a simple matter using the following steps:

1. Turn on the BAM 1020. The BAM 1020 should automatically raise the sample nozzle.

2. Lift the rubber pinch roller assembly and latch it in the UP position.

3. Unscrew and remove the two clear plastic reel covers.

4. An empty core tube **MUST** be installed on the left (take-up) reel hub. This provides a surface for the used tape to spool upon. Met One supplies a plastic core tube to use with the first roll of tape. After that, you can use the empty core tube left over from the previous roll. Never fasten the filter tape to the aluminum hub.

5. Load the new roll of filter tape onto the right (supply) reel, and route the tape through the transport assembly as shown in the drawing. Attach the loose end of the filter tape to the empty core tube with adhesive cellophane tape or equivalent.

6. Rotate the tape roll by hand to remove excess slack, then install the clear plastic reel covers. The covers must be tight in order to properly clamp the tape in place and prevent slipping.

7. Align the filter tape so that it is centered on all of the rollers. Newer units have score marks on the rollers to aide in visually centering the tape.

8. **Unlatch and lower the pinch roller assembly onto the tape. The BAM 1020 cannot automatically lower the rollers, and the BAM 1020 will not operate if the pinch rollers are left latched in the up position!**

9. 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.
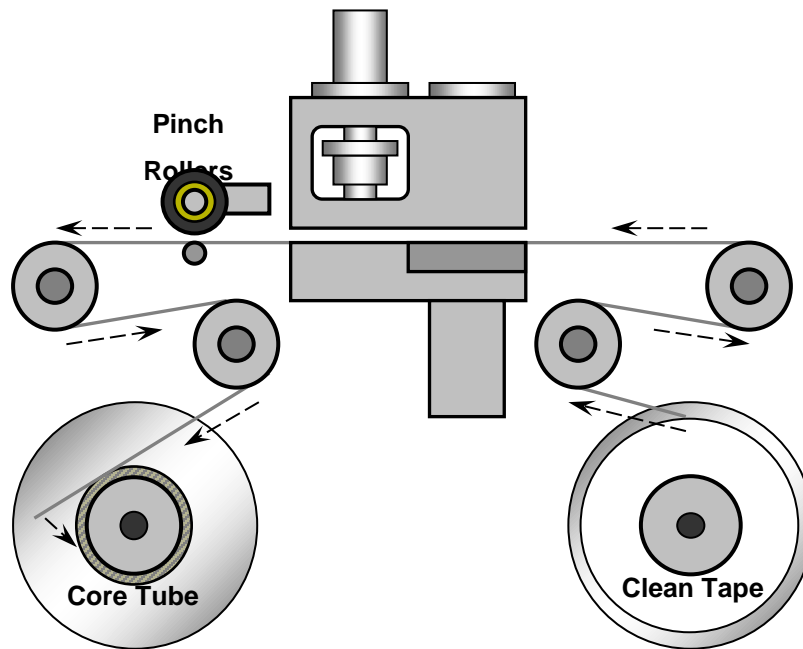
BAM 1020 Filter Tape Loading Diagram

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 BAM 1020. 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 BAM 1020. More detailed diagnostic test menus are also available in the BAM, and those are described in the troubleshooting Section 7.

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.

```
02/08/1999            15:29:30
LATCH: OFF            TAPE BREAK: OK
CAPSTAN: OK           TAPE TENSION: OK
NOZZLE DN: OK         SHUTTLE: OK
NOZZLE UP: OK         REF EXTEND: OK
FLOW: OK              REF WITHDRAW: OK
Status:    SELF TEST PASSED
TENSION    SELF TEST            EXIT
```

Self-Test Status Screen

LATCH: This will show OFF if the photo interrupter senses that the pinch rollers are unlatched (down) as in normal operation. It will show ON if the roller assembly is latched in the up position. The tape cannot advance if the rollers are up!

CAPSTAN: The BAM 1020 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 BAM 1020 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 nozzle O-ring maintenance is necessary.

NOZZLE UP: The BAM 1020 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 BAM 1020 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 BAM 1020 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 BAM 1020 will tension the filter tape, and then check the condition of the tensioner photo interrupters.

SHUTTLE: The BAM 1020 will attempt to move the shuttle beam left and right, and will check the motion with a photo interrupter.

REF EXTEND: The BAM 1020 will attempt to extend the reference membrane, and will check the motion with a photo interrupter.

REF WITHDRAW: The BAM 1020 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. Most of these setup values will not be changed, since the default values are correct for most applications. 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 two 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

The BAM 1020 comes with factory-set flow calibration parameters which will allow the BAM 1020 to accurately control the 16.70 L/min sample flow system right out of the box. However, due to minor variations between different types of flow transfer standards, it is best to calibrate the BAM flow system with your own traceable flow audit standard. Perform leak checks and flow checks/calibrations as described in Section 5. Become comfortable with these processes, as they will be performed on a routine basis.

3.8 Starting a Measurement Cycle

When the preceding setup 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 BAM 1020 will start at the top (beginning) of the next hour, and will continuously operate until commanded to stop.

The BAM 1020 will stop if the operator 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 Accessing the Flow Statistics Screen

While the BAM 1020 is displaying the main menu screen, the ▼ button can be pressed and the BAM will display a FLOW STATISTICS screen as shown below. This screen displays the flow, temperature and pressure statistics for the current measurement cycle. Pressing the ▼ key again will further scroll down to the remaining parameters below the viewable area of the display. This screen will not interrupt the sample cycle. This function is only available with revision 3.2 firmware or later.

```
03/28/2007   FLOW STATISTICS      16:26:30
 SAMPLE START: 2007/03/28 16:08:30
      ELAPSED: 00:18:00
    FLOW RATE: 16.7 LPM
 AVERAGE FLOW: 16.7 LPM
      FLOW CV: 0.2%
       VOLUME: 0.834m3
                                      EXIT
      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 Menus

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 simply stop the measurement cycle, but will not power-down the BAM 1020. **NOTE: Even if the operator sets the Operation Mode to OFF, or the BAM 1020 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 BAM 1020 from automatically starting an hourly cycle are to power off the BAM 1020, leave the BAM 1020 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 BAM 1020 is operating: NORMAL, INST, and AVERAGE.

3.11 The NORMAL Operation 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 BAM 1020 is operating, instead of the Main menu.

```
11/15/2009          Normal Mode          11:27:54

                                     Flow: 16.7 LPM
                                    AMB P: 764 mmHg
LAST C: 0.061 mg/m3                 TAPE P: 584 mmHg
LAST m: 0.806 mg/cm2                   RH: 27 %
                                   Heater: OFF
                                   Delta-T: 4.2 C
STATUS: SAMPLING                             EXIT
```

The NORMAL Operation 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 span value (**ABS**). The other values are instantaneous measurements.

3.12 The INSTANTANEOUS and AVERAGE Operation Screens

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.

```
11/15/2009                               11:27:54
        Eng Units                     Eng Units
1 Conc     0.010  mg    2 Qtot       .834  m3
3 WS       0.000        4 WD         0.000
5 BP       0.000        6 RH         0.000
7 SR       0.000        8 AT         0.000

                        VOLT/ENG      EXIT
```

The Instantaneous Menu

The VOLT / ENG soft-key toggles the displayed values between units and voltages, useful for diagnostic checks on external sensors.

The AVERAGE screen is the same as the INST screen shown above, except that the concentration and flow are presented as the previous hour's average values, and the six external data logger 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. An understanding of the measurement is helpful for the effective operation and maintenance of the BAM 1020. For advanced information on the underlying theory and mathematics of the measurement see Theory of Operation, Section 11.
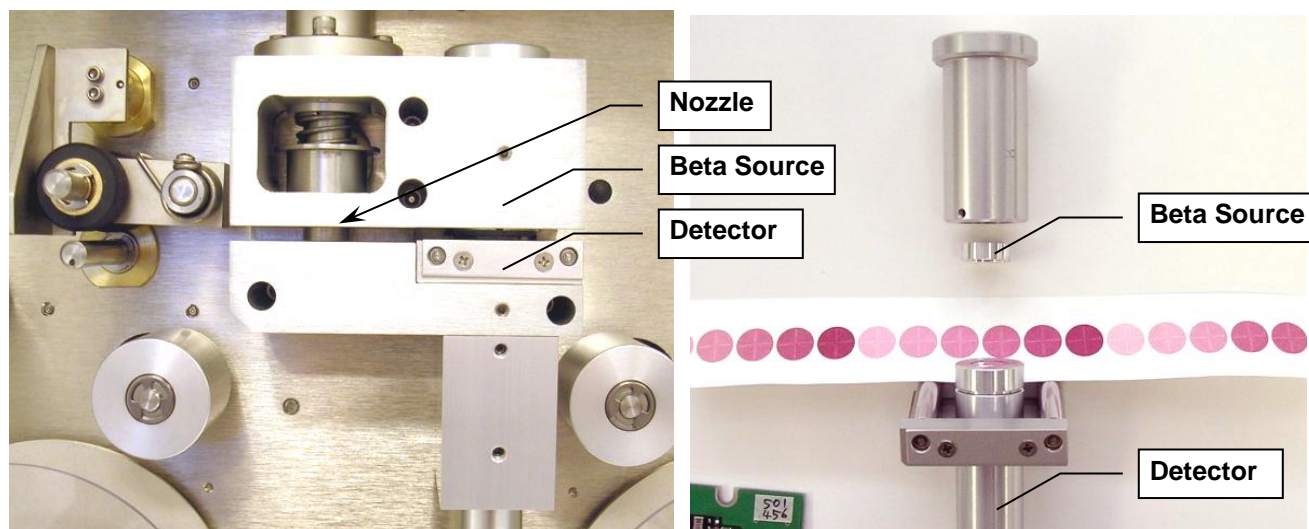
BAM 1020 Sample and Measurement Stations

4.1   The One-Hour Cycle Timeline

The BAM 1020 is almost always configured to operate on 1-hour cycles. The BAM 1020 has a real-time clock which controls the cycle timing. The COUNT TIME on the BAM 1020 is user selectable, but is generally set to 4 minutes for PM_{10} measurement or to 8 minutes for $PM_{2.5}$ measurement. In the example timeline below the BAM 1020 makes an 8-minute beta measurement at the beginning and the end of each hour, with a 42 minute air sample period in between, for a total of 58 minutes. The other two minutes of the hour are used for tape and nozzle movements during the cycle. This timeline applies if the BAM 1020 is set for a COUNT TIME of 8 minutes, which is required for all EPA and EU designated $PM_{2.5}$ configurations.

BAM 1020 monitors operating with firmware 3236-5 version 3.7.1 or later may be configured for PM_{10} or $PM_{2.5}$ operation. When configured as a US-EPA designated equivalent method for $PM_{2.5}$, COUNT TIME must be set to 8 minutes. If you desire to operate the BAM 1020 as a non-designated method for $PM_{2.5}$ monitoring you may set the COUNT TIME to 4, 6, or 10 minutes. When running the BAM 1020 as a US-EPA designed equivalent method for PM_{10} COUNT TIME may be set to 4, 6, 8, or 10 minutes. The total measurement cycle is 1 hour. The pump sampling time may be calculated by subtracting twice the COUNT TIME from 60 minutes and then subtracting an additional 2 minutes to allow for tape movement. Therefore a COUNT TIME of 8 minutes would provide a pump sampling time of 42 minutes (60-8-8-2). **Note:** This cycle will be slightly altered if the BAM 1020 is operated in the special Early Cycle mode with an external data logger. See Section 8.

The example below provides an example of the timing of a measurement cycle with a COUNT TIME of 8 minutes.

1. **Minute 00:**   The beginning of an hour. The BAM 1020 advances the filter tape forward one "window" to 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 BAM 1020 then lowers the nozzle onto the filter tape and turns the vacuum pump on, pulling particulate-laden air through the filter tape on which I_0 was just measured, for 42 minutes at 16.70 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 the 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 BAM 1020 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 until the top of the next hour.

5. **Minute 60:**   The beginning of the next hour. The BAM 1020 records the just-calculated concentration value to memory and sets the analog output voltage to represent the previous hour's concentration. The BAM 1020 advances a new fresh spot of tape to the beta measurement area and the measurement cycle starts again.

4.2 Automatic Span Checks During The Cycle

While the vacuum pump is on and pulling air through the filter tape as described above the BAM 1020 performs a span check. The user may set up the BAM 1020 to perform the span check hourly, once per day, or not at all. The BAM 1020 also performs a stability test:

1. **Minute 08:**   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. The BAM 1020 begins counting the beta particles through this spot for exactly eight minutes. The measured value is recorded as I_1.

2. **Minute 16:**   The BAM 1020 stops counting beta particles 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 is of known mass density (mg/cm^2). The BAM starts counting beta particles for eight minutes again, this time through the membrane *and* the filter tape spot at the same time. This value is recorded as I_2.

3. **Minute 24:**   The BAM 1020 stops counting beta particles through the membrane withdraws the membrane assembly, and calculates the mass density of the membrane.

4. **Minute 42:**   (Eight minutes before the pump stops) The BAM 1020 counts the beta particles through the same spot again (without the membrane) for another eight minutes. This value is recorded as I_1' .

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 1020 in which it was installed. Each measurement of *m* must match the **ABS** value within ±5%. If not, the BAM 1020 records a "D" alarm for that hour's data. Typically, the value of *m* is within a few mg/cm^2 of the expected value. The **ABS** value is unique to each BAM 1020, and can be found on the calibration sheet. Most membrane alarms are caused by a dirty membrane foil.

The stability measurements I_1 and I_1' may be compared to determine if the beta counts have changed appreciably during the measurement cycle. Rapid changes in temperature, relative humidity or other factors may lead to this.

4.3 Filter Tape Use

The BAM 1020 positions the filter spots very close to one another so as not to waste filter tape. Once each day at midnight, the BAM 1020 will skip a spot (there will not be a spot where one is expected to be). This is done to make it easier for the user to match the spot on the take up spool with the hour and the day the spot was generated if this is necessary to be done. Met One Instruments currently offers filter tape using part number 460180.

5 FLOW SYSTEM and FLOW CALIBRATIONS

5.1 Flow System Diagram

The BAM 1020 is designed to operate with an air flow rate of 16.70 liters per minute (L/min or LPM). The flow rate must be maintained at this value in order for the commonly used the EPA PM_{10} inlet head (BX-802) and $PM_{2.5}$ cyclones (BX-806, BX-807, BX-808 or BX-809) to work effectively. Periodic airflow audits must be performed to ensure that the BAM 1020 maintains the 16.70 LPM flow rate.

Filter Barometric Pressure Sensor

Filter Temp and RH sensors

Inlet Receiver

Beta Block

Debris Filter

Mass Flow Meter

Automatic Flow Controller

(Rotary Cam Valve)

Standard on all units

Outlet to Vacuum Pump

Manual Needle Valve

- early units only -
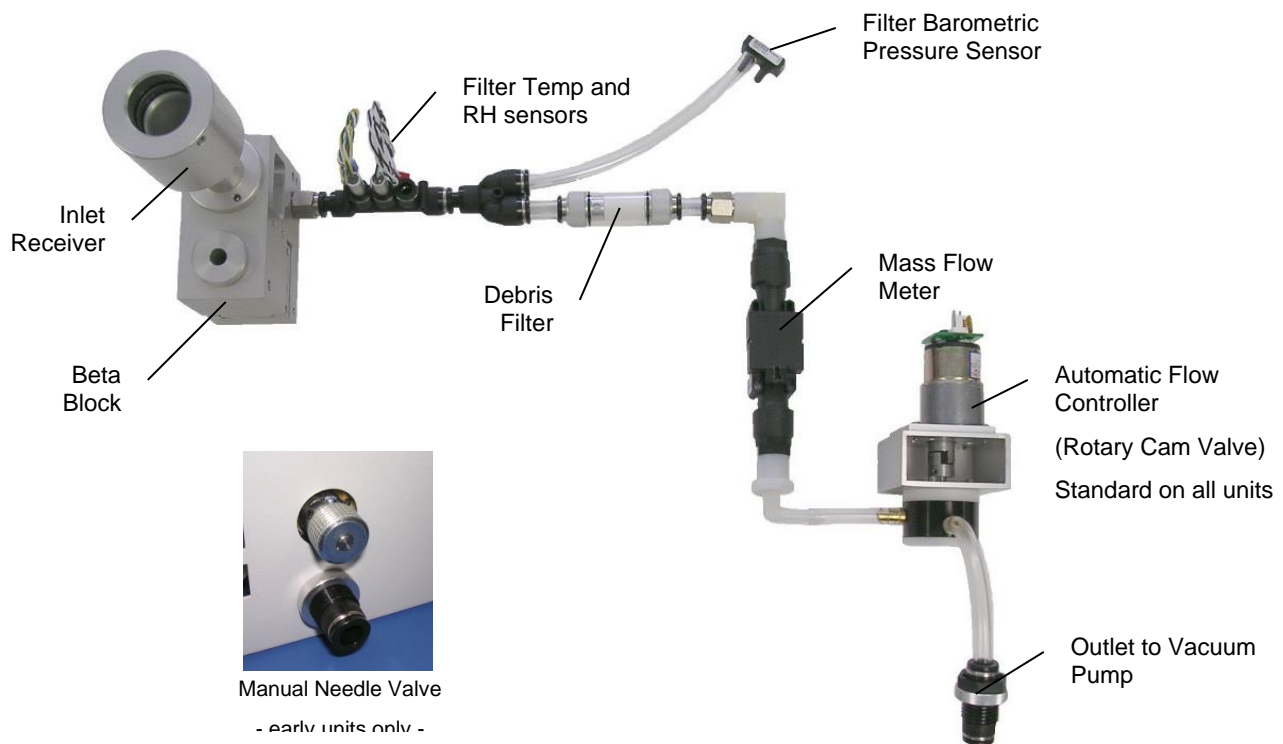
Complete BAM 1020 Flow Control System

All BAM 1020 monitors have a mass flow sensor and a barometric pressure sensor. The BAM 1020 is also equipped with an ambient temperature sensor model BX-592 or BX-596. Temperature and barometric pressure measurements are needed to convert mass flow into volume flow rate (LPM).

5.2 Flow Control and Flow Reporting Types – Standard or Actual Flow

BAM 1020 monitors with firmware revision 3.0 or later (after 2006) have both a FLOW TYPE and a CONC TYPE setting. Both can be set to either STD or ACTUAL (see Section 6.3). The BAM 1020 is capable of controlling the flow using either standard or actual temperature/pressure conditions, and can independently report the particulate concentrations based on either a standard or actual volume of sampled air. BAM 1020 monitors with firmware revision 2.58 and earlier (pre 2007) had a single FLOW TYPE setting which set both the flow control and the concentration reporting conditions.

5.2.1 ACTUAL Flow Control:

FLOW TYPE should always be set to ACTUAL for firmware version 3.0 or greater. Under actual flow control, ambient temperature and barometric pressure measurements are used to convert the measured mass flow into volumetric flow (LPM). As the measured temperature and barometric pressure change, the mass flow controller will adjust its output to maintain constant volumetric flow. CONC TYPE may be set to ACTUAL in which case sampled volume is reported in (actual) LPM sampled. CONC TYPE may also be set to STD, in which case sampled volumes are adjusted and reported under standard conditions (25°C, 1 atm.).

5.2.2 STANDARD Flow Control:

This mode of operation is not recommended as the cut points for the PM_{10} inlets and the $PM_{2.5}$ size fractionators require a nominal flow of 16.70 actual liters per minute. All BAM 1020 monitors built since 2008 include a mass flow controller as standard equipment. External temperature sensors (either BX-592 or BX-596) are required for mass flow control.

ACTUAL Flow Reporting

To report mass concentrations under actual conditions set **CONC TYPE** to **ACTUAL**. This configuration is almost always used for $PM_{2.5}$ concentration reporting. It is also used when reporting PM_{10} concentrations when paired BAM 1020 monitors are used for $PM_{10\text{-}2.5}$ monitoring.

STD Flow Reporting

To report mass concentrations under standard conditions set **CONC TYPE** to **STD**. The BAM 1020 will then convert the actual volume sampled during the measurement cycle into the corresponding standard volume and report the mass concentration under standard conditions.

5.3 Total Flow (Q_{TOT}) and Flow Rate (LPM) Conversions

The Q_{TOT} measurement can be converted to LPM by multiplying the Q_{TOT} value by 1000, then dividing by the BAM Sample Time. For example, to determine what the flow rate was of a 42 minute sample with a Q_{TOT} value 0.700, perform the following calculation:

(Q_{TOT} * 1000) / Sample Time = (0.700 * 1000)/42 = 16.67 LPM

5.4 About Leak Checks, Nozzle Cleaning, and Flow Checks

Met One Instruments recommends that users perform leak checks, nozzle and vane cleaning (if needed) and a flow check or calibration (if needed) at least once a month. Complete flow system maintenance typically requires less than 10 minutes to perform.

The best order for the monthly flow system checks is:

1. **As-found leak check.**
2. **Nozzle and vane cleaning.**
3. **As-left leak check.** (If a leak was corrected)
4. **Three-point flow check/audit and calibration if required.**

If an air leak is found, it could be caused by degraded O-rings, or an improper inlet tube to receiver connection. However, it *almost always* occurs at the interface between the nozzle and the filter tape due to debris buildup. There is normally an insignificant amount of leakage

at the tape interface, but an excessive leak lets an unknown portion of the 16.70 L/min sample flow to enter the system at the leak point instead of the inlet. This could cause the total volume of air sampled through the inlet to be incorrect, and the resulting concentration data could be unpredictably biased. **The BAM 1020 cannot automatically detect a leak at the tape/nozzle interface because the airflow sensor is located downstream of the filter tape. Allowing a significant leak to persist may result in concentration data being invalidated!**

Routine leak checks and nozzle cleaning prevent any significant leaks from forming. Performing an as-found leak check before cleaning the nozzle or performing any service is needed for validating data collected since the last successful leak and flow check.

Even if the leak check value is found to be within acceptable bounds, the nozzle and vane should still be cleaned if any buildup or debris is noticed.

5.5 Leak Check Procedure

The basic leak check should always be performed first. If it passes, then there is no need to perform the advanced steps. However, if the basic check fails, the advanced leak check steps must be taken to locate the problem.

NOTE: *Only Met One Instruments, Inc. factory authorized tape should be used with the BAM-1020 monitor. Tape supplied by other vendors has not been tested or approved for use and any data collected using third party filter tape will not be considered valid.*

Required Tools: Leak Check Valve (Part No. BX-305 or included as part of the BX-302)

Minimum Suggested Interval: Monthly and whenever the filter tape is changed.

5.5.1 Basic Leak Check

Use the following steps to perform the basic leak check:

1. Go to the TEST>PUMP menu. This will stop the current sample, if one is in progress.

2. Remove the PM10 size selective inlet from the sample tube and install the BX-305 leak check valve (or BX-302 zero filter). If a PM2.5 cyclone is being used, it should be left in place and included in the leak check. Verify that the leak valve is in the open position,

3. Press the PUMP button. The BAM-1020 will automatically lower the nozzle (if needed) and start the pump.

4. Allow sufficient time for the flow to stabilize at 16.7 LPM on the BAM-1020 display and then press the LEAK button. Verify the status changes to indicate LEAK ON.

5. Turn the BX-305 leak valve on the inlet to the closed position as shown in Figure 5-1.

Figure 5-1 BX-305 Leak Check Valve Installed on Inlet Tube

6. The pump flow rate should drop below 1.5 LPM.

    a. If the flow rate is 1.5 LPM or less, the leak check is satisfactory. Proceed to step 7.

    b. If the flow rate is greater than 1.5 LPM, the leak check fails. Proceed to step 7 and then repeat the leak test after completing step 11. If it fails a second time, go to section 5.5.2.

7. <u>Slowly</u> open the BX-305 valve to restore normal flow through the BAM-1020.

8. Press the PUMP button to turn off the pump and then go to the TEST > TAPE menu.

9. Advance the tape forward seven windows by pressing the UP arrow to set the WINDOWS field to 7 and then pressing the FWD button. The nozzle should raise automatically and then advance the tape. If the last sample spot is not clearly visible, advance the tape one window at a time until it is.

10. Inspect the last sample spot on the tape roll. Examine it closely for any abnormal deformation or holes. The presence of abnormalities indicates debris build up at that location of the nozzle / vane interface. These indicate areas of the interface that may require additional cleaning. Note that in low concentrations the sample spot may not be easily located.

11. Remove the tape and thoroughly clean the nozzle / vane interface as instructed in the MAINTENANCE, DIAGNOSTICS and TROUBLESHOOTING section of the BAM-1020 Operation Manual. Pay particular attention to areas shown to have build-up in step 10 above.

12. Reinstall the filter tape as directed in the Filter Tape Loading section of the BAM-1020 Operation Manual. If step 6 failed, repeat the above leak check procedure now. If step 6 passed, continue on to step 13.

13. Exit to the Main Menu

14. Remove the BX-305 and replace the PM_{10} size selective inlet.

15. Resume normal sampling operations.

5.5.2 Advanced Leak Checks

If the basic leak check detailed in section 5.5.1 fails, the following procedures will isolate the problem.

Required Tools: Leak Check Valve (Met One Instruments Part No. BX-305 or BX-302)

Nozzle Seal Tool (Part No. 7440)

Figure 5-2 7440 Leak Isolation Shim

5.5.2.1 Total System Leak Test

This procedure will create a positive seal at the nozzle / vane interface. With this seal in place, the rest of the flow system can be tested for leaks.

The following procedure assumes steps 1 through 6 in section 5.5.1 have just been completed and a flow rate of greater than 1.5 LPM was found.

1. If running, press the PUMP button to turn off the pump. Slowly open the BX-305 valve and then press the NOZZLE button to raise the nozzle.

2. Remove the filter tape from beneath the nozzle and insert the Nozzle Seal Tool with the hole positioned beneath the nozzle. See Figure 5-3.

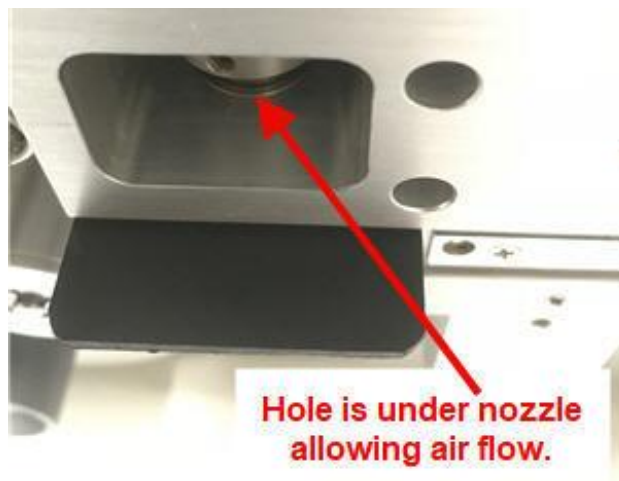Hole is under nozzle allowing air flow.

Figure 5-3 Nozzle Seal Tool with Hole Under the Nozzle

3. Verify the BX-305 valve is still mounted on the inlet and is in the open position.

4. In the TEST>PUMP menu. Press the PUMP button. The BAM-1020 will automatically lower the nozzle and start the pump.

5. Allow sufficient time for the flow to stabilize at 16.7 LPM on the BAM-1020 display and then press the LEAK button. Verify the status changes to indicate LEAK ON.

6. Turn the BX-305 leak valve on the inlet to the closed position as shown in Figure 5-1.

7. The pump flow rate should drop below 0.3 LPM.

   a. If the flow rate is 0.3 LPM or less, the leak check is satisfactory. The high flow rate observed during the basic leak test is located at the nozzle / tape interface. Proceed to section 5.5.2.3.

   b. If the flow rate is greater than 0.3 LPM, then there is a leak somewhere in the system. Go to section 5.5.2.2 to locate the leak.

5.5.2.2 Lower Leak Test

This procedure will split the flow system at the nozzle / vane interface. With this seal in place, only the portion of the flow system downstream of this location will be placed under vacuum and tested for leaks.

The following procedure assumes the steps listed in section 5.5.2.1 were performed and a leak of greater than 0.3 LPM was found.

1. If running, press the PUMP button to turn off the pump. Then, press the NOZZLE button to raise the nozzle.

2. Rotate the Nozzle Seal Tool so that the solid portion of the tool is positioned beneath the nozzle. See Figure 5-4.
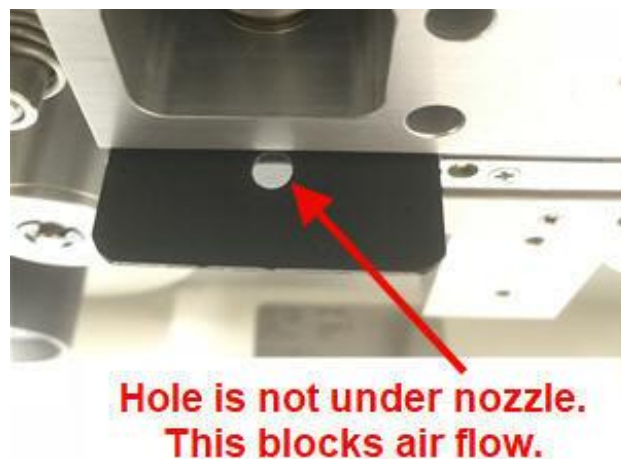
Figure 5-4 Nozzle Seal Tool with Solid Side Under the Nozzle

3. Verify the LEAK status still indicates LEAK ON. If not, press the LEAK button to turn it on and then press the PUMP button. The BAM-1020 should automatically lower the nozzle and start the pump.

4. The pump flow rate should drop below 0.3 LPM.

   a. If the flow rate is 0.3 LPM or less, the leak check is satisfactory. This confirms that the leak is above the nozzle. Investigate all mating connections and O-

rings in the flow path before the nozzle / vane interface to locate and correct the leak.

b. If the flow rate is greater than 0.3 LPM, then there is a leak downstream of the nozzle. Investigate all mating connections and O-rings in the flow path after the nozzle / vane interface to locate and correct the leak.

c. Once resolved, repeat the steps listed in section 5.5.1 to verify the flow system integrity.

5.5.2.3 Filter Tape Leak Test

Use this procedure to assess the actual leak rate at the nozzle / tape interface. It is assumed that the Basic Leak Check and the Total System Leak Test have both already been performed and a high flow rate (greater than 1.5 LPM) at the nozzle / tape interface was found. It is also assumed that the filter tape is still <u>not</u> installed.

Required Tools: Certified Calibration Transfer Standard (CTS) such as the BX-307

Nozzle Seal Tool (Part No. 7440)

Filter Tape (Part No. 460180)

1. Remove the BX-305 from the sample tube and install the calibration transfer standard (CTS).

2. Navigate to the TEST>PUMP menu.

3. The Nozzle Seal tool may already be installed with the hole positioned beneath the nozzle (see Figure 5-3). If this is not the case, press the NOZZLE button to raise the nozzle (if needed), position the sealing tool in this configuration, and then lower the nozzle.

4. If the LEAK status is set to LEAK ON, press the LEAK button to set the status to LEAK OFF.

5. Press the PUMP button to start the pump.

6. Allow at least 2-3 minutes for the flow to fully stabilize. When the flow rate stabilizes, write down the CTS flow rate value. This is the "Without Tape" value.
NOTE: *If after 5 minutes, the flow still has minor fluctuations, estimate the average flow rate and use that for the "Without Tape" value.*

7. Stop the pump and raise the nozzle.

8. Remove the Nozzle Seal Tool.

9. Place a three-inch-long piece of filter tape directly below the nozzle.

10. Press the PUMP button. The BAM-1020 should automatically lower the nozzle onto the strip of tape and start the pump.

11. When the flow rate stabilizes, write down the CTS flow rate value. This is the "With Tape" value.

12. Stop the pump and raise the nozzle.

13. Remove the strip of filter tape.

14. Subtract the "With Tape" value from the "Without Tape" value using the following equation:

WithoutTape – WithTape = LeakRate

The result should be a positive value of 0.3 LPM or less. A typical example might look like this: 16.71 LPM – 16.58 LPM = 0.13 LPM

a. If the difference is 0.3 LPM, or less, the leak test passes. Record the results (as needed), remove all test equipment, and resume normal sampling operations.

b. If the difference is greater than 0.3 LPM, an out of tolerance leak exists at the nozzle / tape interface. Thoroughly clean the nozzle and vane area and then perform this test again. Repeat this test. If after a couple of attempts this test still fails, contact the Met One Instruments, Inc. service department (see section1.2) for assistance.

Troubleshooting Section 7.5 contains additional tips for resolving leaks in the flow system.

5.6 Nozzle and Vane Cleaning Procedure

The nozzle and tape support vane (located under the nozzle) must be inspected regularly and cleaned as needed in order to prevent leaks at the interface between these parts and the filter tape. We recommended that the nozzle and vane be inspected monthly for tape build up. Some sites may require a more frequent inspection and cleaning interval. BAM 1020 monitors operated in hot, humid environments may require more frequent nozzle and vane cleaning. When the nozzle and vanes are not regularly cleaned filter tape debris may build up. This can lead to pin holes being punched through the filter tape which can in turn cause flow leaks and erroneous beta ray measurement. Use the following steps to clean the nozzle and vane parts:

1. Latch up the tape pinch rollers, and raise the nozzle in the TEST > PUMP menu. Slide the filter tape out of the slot in the beta block nozzle area. It is not necessary to completely remove the filter tape from the BAM 1020.

2. With the nozzle up, use a small flashlight to inspect the vane. Any debris will usually be visible. Clean the vane surface with a cotton-tipped applicator and deionized water or isopropyl alcohol. Hardened deposits may have to be carefully scraped off with the wooden end of the applicator. Take care not to damage the vane!

3. Lower the nozzle in the TEST > PUMP menu. Lift the nozzle with your finger and insert another wet cotton applicator between the nozzle and the vane. Let the nozzle press down onto the swab with its spring pressure. Use your thumb to rotate the nozzle while keeping the swab in place. A few rotations should clean the nozzle lip.

4. Repeat the nozzle cleaning until the swabs come out clean, then inspect the nozzle lip and vane again, looking for any burrs which may cause tape damage.
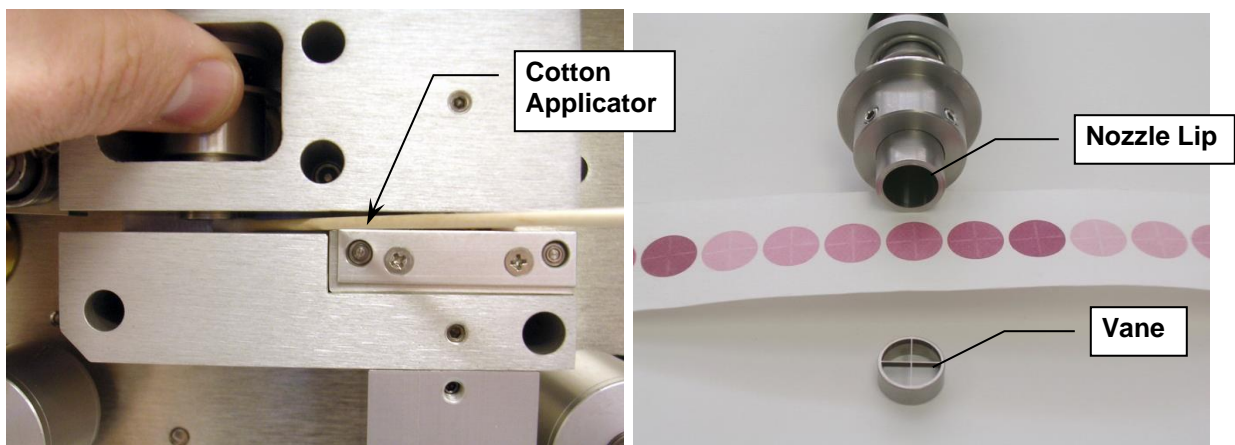
Nozzle and Vane Cleaning, and Disassembled View

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. The dust spots have crisp edges, are perfectly round, and are evenly distributed.

The tape on the right is from a unit which has a leak. 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 unattenuated which can lead to erroneous concentration measurements. The spots also show a "halo" effect due to air leaking in around the edge because the nozzle is not sealing correctly. These faults are easily corrected and prevented by keeping the nozzle and vane clean.
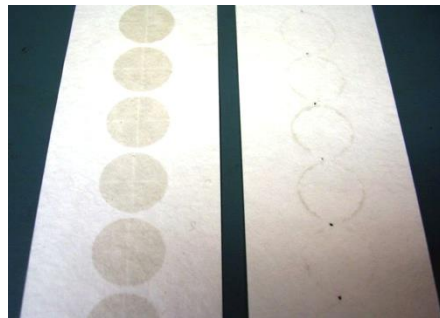
BAM 1020 hourly filter tape spots

5.7 Field Calibration of the Flow System – Actual Flow Mode

Flow calibrations, checks, or audits on any BAM 1020 set for actual flow control are very fast and easy. An ambient temperature sensor must be connected to input channel 6. The FLOW TYPE setting must be set to ACTUAL in the SETUP > CALIBRATE menu, or the flow calibration screen will not even appear as an option in the TEST menu. Perform a leak check and nozzle cleaning before doing any flow calibrations.

The TEST > FLOW calibration screen is shown below. The "BAM" column displays what the BAM 1020 measures for each parameter. The "STD" column is where you can enter the correct values from your traceable reference standard device. The <CAL> symbol appears to the left of row of the active selected parameter. The selected parameter can be changed by pressing the NEXT key. No calibration changes are made to the selected parameter unless the CAL or DEFAULT key is pressed. The ambient temperature and pressure are always calibrated before the flow, because the BAM 1020 uses these parameters to calculate the air flow rate in actual mode.

```
MULTIPOINT FLOW CALIBRATION

                 TARGET     BAM      STD
          AT:               23.8    23.8 C
          BP:                760     760 mmHg
<CAL>  FLOW 1:    15.0     15.03   15.00 LPM
       FLOW 2:    18.4     18.41   18.40 LPM
       FLOW 3:    16.7     16.67   16.70 LPM
   CAL          NEXT     DEFAULT       EXIT
```

Actual Flow Calibration Screen

1. Enter the TEST > FLOW menu as shown above. The nozzle will lower automatically when this screen is entered.

2. (Optional Audit Only) To perform a simple flow "check" or "audit" in which no calibrations are to be changed, simply use the NEXT soft key to select the AT (temperature), BP (pressure), and FLOW 3 (16.7) parameters one at a time. Compare the BAM column reading to your standard device for each parameter, and record the results. No calibrations are altered if the CAL or DEFAULT keys are not pressed. If calibration is required, go on to step 3.

3. Select the AT parameter if not already selected. Measure the ambient temperature with your reference standard device positioned near the BAM 1020 ambient temperature probe. Enter the value from your reference standard into the STD field using the arrow keys. Press the CAL soft key to calibrate the BAM reading. The BAM and STD temperature values should now be the same.

4. Press the NEXT key to select the BP field. Enter the barometric pressure value from your reference standard into the STD field, and press the CAL soft key to calibrate the BAM reading. The BAM and STD pressure values should now be the same.

5. After the temperature and pressure readings are both correct, remove the PM$_{10}$ head from the inlet tube and install your reference flow meter onto the inlet tube. Press the NEXT key to select the first flow point of 15.0 L/min. The pump will turn on

automatically. *Allow the BAM 1020 to regulate the flow until the BAM reading stabilizes at the target flow rate.* Enter the flow value from your standard device into the STD field using the arrow keys, then press the CAL soft key. Note: *The BAM flow reading will not change to match the STD until after you have entered all three flow calibration points, since it is done on a slope.*

6. Press the NEXT key to select the second flow point of 18.4 L/min. Allow the flow to stabilize again, then enter the value from your standard device and press the CAL key. Note: If the BAM 1020 is unable to achieve flow regulation at the 18.4 L/min point, this could be an indication that the vacuum pump needs to be serviced.

7. Press the NEXT key to select the third flow point of 16.70 L/min. Allow the flow to stabilize again, then enter the value from your standard device and press the CAL key.

8. After this third flow point is calibrated, the BAM flow reading will change to show the corrected flow, then the BAM 1020 will quickly re-regulate the flow to 16.70 L/min based on the new calibration. The BAM 1020 flow reading should now match your flow standard device at 16.70 ± 0.1 L/min. Exit the calibration menu.

Resetting Flow Calibrations:

If the BAM 1020 flow, temperature, or pressure readings do not correctly change to match your standard device during the above calibration process, or if multiple calibrations are required in order to get a good match, then the BAM flow calibrations may need to be reset. This case has sometimes been observed during the first flow calibration after a BAM 1020 firmware update.

Select a parameter and press the DEFAULT soft key to clear out all previous calibration factors from that parameter and replace them with the original factory calibration factor. Default all of the AT, BP, and flow parameters, then try again to calibrate them to your standards. You may also need to reset the filter RH and filter temperature sensor calibrations. The default factory calibration factors should be very close to the correct values.

Actual flow calibrations in units with older firmware:

BAM 1020 units with firmware revisions 2.58 and earlier had a different TEST > FLOW screen, as shown below. These units are calibrated as described above, except that the flow calibration is performed at only a single point of 16.70 L/min. The NEXT key selects the AT or BP parameter to be calibrated, and the PUMP ON key selects the flow point for calibration. The ADJUST/SAVE key calibrates the selected parameter to the reference value.

```
        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
```

Old Format of the Actual Flow Calibration Screen

5.8 Field Calibration of the Flow System – Standard Flow Mode

All BAM 1020 monitors configured for PM$_{2.5}$ and almost all units configured for PM$_{10}$ with firmware 3.0 and later, are set with a FLOW TYPE of ACTUAL, and must be calibrated as described above in Section 5.6. If the BAM 1020 must be operated in standard flow mode, see below.

STANDARD Flow BAMs with a Temperature Sensor:

If the BAM 1020 is an older PM$_{10}$ unit <u>without</u> a separate CONC TYPE setting, or if the operational FLOW TYPE must be set to STANDARD for some special reason, then *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 a normal actual flow audit or calibration as described above*. If this method is used, be sure to set the BAM 1020 back to STD flow type when finished. This works as long as the BAM 1020 is equipped with an ambient temperature sensor on input channel six.

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 BAM 1020. Most of these settings are set at factory default values. Some settings may be altered by the operator. This section describes the SETUP menu in detail, and should be reviewed when the instrument is first put into service. Once set, most of the values in the SETUP menus will not need to be changed. The SETUP values will not be lost if the BAM 1020 is unplugged or powered down.

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

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

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.

```
                        SETUP MODE SELECT

CLOCK      SAMPLE     CALIBRATE EXTRA
ERRORS     PASSWORD   INTERFACE SENSOR
HEATER     QUERY      REPORTS   HJ 653


 SELECT                          EXIT
```

The SETUP Menu

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

Menu	Settings
CLOCK	BAM 1020 real-time clock date and time settings.
SAMPLE	Range, Offset, Sample Time, Count Time, Conc Units, Avg Period, Unit ID, and RS-232 settings.
CALIBRATE	Factory Calibration Values, (C_v, Q_0, ABS, μsw, K, BKGD) Flow rate, Flow type, Conc Type.
EXTRA1	Low concentration clamp, e1 – e4, Rarely used.
ERRORS	Analog error selections, Flow limits, Pressure drop limit.
PASSWORD	Password change screen.
INTERFACE	Cycle Mode early/standard, alarm relay polarity.
SENSOR	Meteorological sensor scaling and configuration screens, Channels 1 – 6.
HEATER	RH set-point for Smart Heater.
QUERY	Configuration for the custom Query data output file, and the European Bayern-Hessen protocol.
REPORTS	Daily data report hours, BP and Reference Membrane logging options
HJ 653	Data format compliance with Chinese HJ 653-2013 standard

6.1 CLOCK Setup 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 lithium battery backup keeps the clock running during power-down. Met One Instruments recommends a monthly check of the clock.

6.2 SAMPLE Setup Screen – Range, Sample, and Timing Settings

The SETUP > SAMPLE screen is used to set the BAM 1020 sampling and averaging periods, and some other important settings. 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   050 MIN
INLET TYPE PM10
STATION # 001       MET SAMPLE   60  MIN
RANGE    1.000 mg   OFFSET   -0.015 mg
CONC UNITS mg/m3    COUNT TIME    4  MIN
   SAVE                         EXIT
```

The SETUP > 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. The default setting is 9600 baud. The BAM 1020 must be set to 9600 baud during flash firmware upgrades, but may be set faster for data collection. The handshaking settings "8N1" means 8 data bits, no parity, 1 stop bit. These cannot be edited.

BAM SAMPLE: This value sets the number of minutes per sample hour that the pump is ON. See Section 4.1 for a description of the hourly cycle. The BAM SAMPLE time must be set in response to the COUNT TIME value, since current versions of the BAM 1020 allow the option of setting the count time to 4 or 8 minutes. *If the BAM 1020 is used for PM$_{2.5}$ FEM or EU PM$_{2.5}$ monitoring, the BAM SAMPLE must be set to 42 minutes with 8-minute count time.* PM$_{10}$ monitors are usually set for 50 minute sample time with 4 minute count time, but may be set for 42/8 if the installed firmware allows it.

Count Time	BAM Sample	Used for
4 min	**50 min**	PM$_{10}$ monitoring, units without a count time setting
8 min	**42 min**	All PM$_{2.5}$ FEM, PM-coarse, EU PM$_{2.5}$ monitoring, PM$_{10}$ monitoring

The BAM SAMPLE setting has a range of 0-200 minutes for custom applications. If set for shorter period, such as 15 minutes, the pump will only sample for 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 pump cycle per hour is allowed, regardless of duration. Setting the BAM SAMPLE value too long may cause the total measurement cycle to overlap into the next hour, so that the BAM 1020 only collects the concentration every second hour.

INLET TYPE This setting helps users identify whether the BAM 1020 is collecting TSP, PM_{10}, or $PM_{2.5}$ data. Whichever option is selected sets the corresponding label to be displayed at the top of the main menu screen. This setting is for providing indication on the display only and does not impact any of the actual data collection or reports.

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

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

Warning: This setting will affect how long the memory will last before getting full!
There are **4369 records** available in the memory. The default MET SAMPLE period of 60 minutes (1 record per hour) will result in 182 days of memory capacity, but a 1 minute average period would fill up these memory records in only 3 days. When the memory gets full the BAM 1020 overwrites the oldest data. It is recommended that the MET SAMPLE period set at the default value of 60 minutes unless a faster average is required for a particular met sensor application.

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

RANGE: The RANGE setting sets the full-scale range of the concentration measurement system of the analog voltage output. The BAM 1020 internal digital data logger range will vary depending on the DYNAMIC RANGE setting (see section 6.11.2). The RANGE value is usually kept at the default setting of 1.000 mg, with a default OFFSET (lower limit of the range) of -0.015 mg. This means that the BAM measures a maximum full-scale range of -0.015 mg + 1.000 mg = 0.985 mg by default. The table below shows some examples of how the RANGE and OFFSET setting interact to produce the concentration data outputs.

OFFSET Setting	RANGE Setting	Dynamic Range Setting	Resulting Digital Data Range	Resulting Analog Output Range
-0.015 mg	1.000 mg	STANDARD	-0.015 to 0.985 mg	0-1V = -0.015 to 0.985 mg
-0.005 mg	1.000 mg	EXTENDED	-0.005 to 9.995 mg	0-1V = -0.005 to 0.995 mg
-0.015 mg	0.200 mg	EXTENDED	-0.015 to 9.985 mg	0-1V = -0.015 to 0.185 mg
0.000 mg	1.000 mg	STANDARD	0.000 to 1.000 mg	0-1V = 0.000 to 1.000 mg
-0.015 mg	2.000 mg	STANDARD	-0.015 to 1.985 mg	0-1V = -0.015 to 1.985 mg

The RANGE value may be set to 0.100, 0.200, 0.250, 0.500, 2.000, 5.000, or 10.000 mg. *It is important to understand this setting if an external data logger is used to log the BAM 1020 analog output, since the data logger must be set to scale the analog voltage correctly. See Section 8.*

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 require 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 concentration range for both the analog output and internal digital ranges. The factory default value for OFFSET is -0.015 mg, which is the recommended setting. When set this way the BAM 1020 can report from -.015 mg (0.0 V) to .985 mg (1.0 V).

Note: Changing the offset setting will affect past data already stored to memory. Always download any old data before changing settings, then clear the memory. Firmware version 3.2.4 or later will require 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 µg/m^3 (micrograms) or mg/m^3 (milligrams) per cubic meter. Older revisions of firmware were fixed at mg/m^3 only, and this is still the default setting. **Note:** 1.000 mg = 1000 µg.

COUNT TIME: This is the time the BAM 1020 takes to perform the I_0 and I_3 counts at the beginning and the end of the sample hour. *When used for PM$_{2.5}$ FEM, EU PM$_{2.5}$, or PM$_{10-2.5}$ (coarse) monitoring, the COUNT TIME must be set to 8 minutes.* For PM10 measurement COUNT TIME may be set to 4, 6 or 8 minutes.

See the BAM SAMPLE setting description above, and Section 4.1. The BAM 1020 will prompt you to change the BAM SAMPLE time setting if you change the COUNT TIME to an incompatible value.

6.3   CALIBRATE Setup Screen –Flow and Calibration Settings

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 BAM 1020. 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.

```
CALIBRATE SETUP
SPAN CHECK: 24HR     FLOW RATE:   16.7
 CONC TYPE: ACTUAL   FLOW TYPE: ACTUAL
        Cv: 1.047          Qo:   0.000
       ABS: 0.822         µsw:   0.306
         K: 1.005        BKGD:  -0.0030
  STD TEMP: 25C
   SAVE                          EXIT
```
The SETUP > CALIBRATE Screen

SPAN CHECK: This setting determines how often the BAM 1020 performs the automatic span membrane check. If the value is set to 1 HR, the BAM measures and displays the span each hour. If this value is set to 24 HR, then the BAM will only perform the span check once per day during the sample hour beginning at midnight and during any sample hour following a power failure. The resulting value will be displayed throughout the rest of the day. If this value is set to OFF, the span check will be disabled entirely. **Note:** This setting does not appear in any firmware before V3.7.0, where the setting is invisible and fixed at hourly.

FLOW RATE: This sets the air flow rate for the BAM 1020, and the BAM 1020 will continuously regulate the flow to this value during sampling. The FLOW RATE is always set for **16.70 liters per minute**, as this is required for all $PM_{2.5}$ and PM_{10} monitoring. The only time this might be changed temporarily is if a site operator was testing the ability of the pump and flow controller to regulate the flow at different levels for troubleshooting purposes. The range of the setting is 10 to 20 L/min.

CONC TYPE: This sets the way that the concentration values are reported. *The CONC TYPE must be set to ACTUAL for all $PM_{2.5}$ monitoring, and is almost always set to STD for PM_{10} monitoring.* If set to ACTUAL, then the concentration is calculated and reported based on the volume of the air at local ambient conditions. An ambient temperature sensor is required. If set to STD, the concentration is calculated and reported based on the standard values for temperature and pressure (760 mmHg and usually 25C), even if a temperature sensor is available. See Section 5.2. Note: units with firmware prior to rev 3.0 do not have this setting available, and the concentration reporting is determined by the FLOW TYPE setting.

FLOW TYPE: This setting selects the flow control scheme used by the BAM 1020. The options are ACTUAL or STD. **Section 5.2 contains a detailed description of each of these flow types**, and should be studied to ensure proper operation of the BAM 1020.

The FLOW TYPE should be set to ACTUAL on all BAM 1020 monitors equipped with an external temperature sensor (BX-592, BX-596 or BX-597). FLOW TYPE should be set to STD only if an external temperature sensor is unavailable.

Cv: This value is a factory-set scaling slope for the internal mass flow sensor. The value of Cv is never altered except when performing a flow calibration on old units without an automatic flow controller. All newer units with flow controllers and ambient temperature sensors never need to have this value altered, because the flow calibrations are done in the TEST > FLOW screen.

Qo: This value is the factory-set zero correction offset for the internal mass flow sensor, and is almost always zero. Qo is usually never changed by the user except when troubleshooting a leak check failure if the BAM flow display does not drop to 0.0 L/min when the pump tubing is disconnected from the BAM 1020.

ABS: The ABS value is the factory-set expected mass of the reference membrane foil used during the automatic hourly span check. This expected value is compared to the measured value each hour (see section 4.2). Each unit's ABS value is different, but is typically near 0.800 mg/cm^2. **The ABS value is never changed by the operator unless the span membrane foil is replaced due to damage.**

µsw: This is called the mu-switch value, and is the factory-set mass absorption coefficient used by the BAM 1020 in the concentration calculations. The value is typically around 0.3

and may vary slightly from one BAM 1020 to the next. Older units built before 2007 had a µsw value near 0.285.

K: K is the factory-set, instrument specific calibration factor for the BAM 1020 concentrations. K is determined by running the BAM 1020 against a calibration standard while both are sampling from a smoke chamber over a wide variety of concentrations. K ranges typically from 0.9 to 1.1.

BKGD: BKGD is used to compensate for measured mass concentration output in the absence of PM. It is determined by operating a BAM 1020 for several days (48-72 hours) in the absence of PM (achieved by equipping the BAM 1020 inlet with a hepa-filter). The average mass concentration of the 48 or 72 1-hour readings multiplied by -1 will be the calculated BGKD. With a properly set BKGD a BAM 1020 making multiple readings of air with zero PM should read on average 0 µg/m^3.

STD TEMP: This is the value of standard air temperature, used only for standard flow control or standard concentration calculations. STD TEMP is generally set to 25C. Depending on local regulations it may have different values however.

6.4 EXTRA1 Setup Screen

The settings in the EXTRA1 screen are special settings for specific unusual applications and must not be changed under normal sampling conditions. Below is a brief explanation of these settings and the factory set values. These settings should never be modified without first consulting Met One Instruments for guidance.

e1   Low Concentration Limit: This is the lowest concentration value the BAM 1020 is allowed to store or display and must always be set to match the OFFSET value in the SETUP > SAMPLE menu. The default value is -0.015 mg.

e2   Not used: The default value is 0.500.

e3   Membrane OFF Delay: The default value is 0.000.

e4   Membrane Time Out: The time the BAM 1020 allows for the membrane assembly to move before generating an error. The default value is 15.00 seconds.

6.5 ERRORS Setup Screen for the Analog Output

The SETUP > ERRORS screen allows the option of encoding BAM 1020 errors onto the analog output signal when used with an external analog data logger. Using this method, the BAM 1020 sets the analog output voltage to full scale (1.000 volts) whenever any of the enabled error types occurs. When there are no alarming conditions present, the voltage represents the last valid concentration level. See Section 8 for external data logger setup information.

The operator can select which errors will cause this full-scale response by enabling (1) or disabling (0) each of the 12 error types as shown in the screen below.

```
                                   SETUP ERRORS
EUMILRNFPDCT        AP
000000000000        150
1 = ON, 0 = OFF


CONCENTRATION ERROR: "ERROR" TEXT


   SAVE                            EXIT
```

The ERRORS Screen

Note: Some minor alarms such as E, U, R, P, or D can occur when there may be nothing wrong with the hourly concentration value, yet these alarms are still typically enabled to set the analog output to full-scale in order to alert the data system of their presence. In this case, the concentration value can still be downloaded from the BAM digitally. Regardless which error types are enabled for the analog output, *all alarms and errors are always stored in the BAM 1020 digital alarm log and data log*, and may be viewed by downloading the data.

The following table briefly describes which type of alarm each letter represents. Complete error and alarm descriptions are found in Section 7.2.

Code	Error/Alarm Type	Basic Description
E	External Reset	Failed BAM clock reset.
U	Telemetry Fault	External data logger fault.
M	Maintenance Alarm	Entering the SETUP or TEST menus or setting Maintenance on
I	Internal CPU Error	Internal processor error, or failed data link between coarse units.
L	Power Failure	Power failure prevented sample completion.
R	Reference Membrane	Reference span membrane not extending or retracting properly.
N	Nozzle Error	Nozzle motor malfunction.
F	Flow Error	Flow system failure, or temperature/pressure sensor failure.
P	Pressure Drop Alarm	Tape blocked by excessive dust loading.
D	Deviant Span Density	Span check did not match the expected ABS value.
C	Count Error	Beta particle detector error.
T	Tape System Error	Broken filter tape, or an error in the tape control system.

The following settings related to the alarms are located in the SETUP > ERRORS screen:

AP Pressure-drop limit. This is the maximum amount of increase in pressure drop which is allowed to occur across the filter tape due to heavy dust loading, before the "P" alarm will be generated. Setting the AP higher will allow more dust to accumulate before the sample is terminated, but may cause flow regulation problems. See the pressure-drop alarm description in Section 7.2. The default setting of **150** mm Hg is correct for most applications using the standard Medo or Gast pumps. Larger pumps can

accommodate a higher AP setting and higher dust loads while still being able to regulate the sample flow. The setting range is 0-500 mm Hg.

The **CONCENTRATION ERROR** field determines what is logged, displayed, and reported whenever one of the major alarm types that affects the concentration calculation is present. Minor alarms such as E, U, R, P, or D do not trigger this behavior and will still record the actual concentration value. There are three choices: FULL SCALE VALUE, MIN SCALE VALUE, and "ERROR" TEXT.

FULL SCALE VALUE The full scale concentration value (typically 0.985 mg) will be displayed on the BAM 1020 front panel screen, stored in the data file, included on all data reports, and output on the analog output terminals.

MIN SCALE VALUE The minimum scale concentration value (typically -0.015 mg) will be displayed on the BAM 1020 front panel screen, stored in the data file, and included on all data reports. The full scale value will still be output on the analog output terminals.
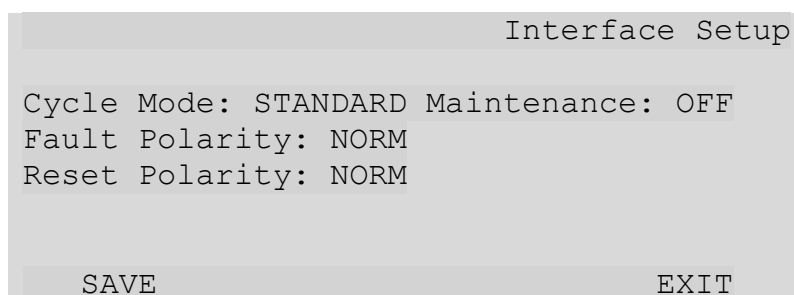
"**ERROR" TEXT** The full scale concentration value (typically 0.985 mg) will be output on the analog output terminals. The word ERROR will be displayed in place of the concentration value on the Main Menu, Normal, Instantaneous, and Average screens. See section 3 for more information about these screens. The word ERROR will also be stored in the data file and printed in place of the concentration value in the Daily and CSV reports.

6.6 PASSWORD Setup Screen

The SETUP > PASSWORD screen allows one to change the password required to enter many of the TEST or SETUP menus. The password prevents users without the password from changing critical settings or calibrations on the BAM 1020. The password can be any 4-key combination of the six function keys, F1 to F6. The default password is **F1, F2, F3, F4**. Met One Instruments does not recommend changing the default password unless necessary. Contact the Met One Instruments service department for instructions if the password is lost or forgotten.

6.7   INTERFACE Setup 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.

```
                            Interface Setup


Cycle Mode: STANDARD Maintenance: OFF
Fault Polarity: NORM
Reset Polarity: NORM




    SAVE                               EXIT
```

The INTERFACE screen

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.

Maintenance: This can be used to manually toggle the "M" digital maintenance flag and the maintenance relay on the back of the BAM 1020 ON or OFF. This can be useful to flag data when performing the zero filter test or testing that will affect the data integrity. It will also display the words MAINTENANCE MODE on the Main Menu screen. The Maintenance flag can be toggled on and off remotely using the <ESC>MN serial command.

Fault Polarity: This sets the polarity of the Telemetry Fault Relay input. NORM is normally open, INV is normally closed. Almost never 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 1020 clock to an external data logger. NORM is normally open, INV is normally closed. Almost all data loggers use normal open polarity for the signal.

6.8 SENSOR Setup Screen for External Met Sensors

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 BX-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. The six channels can also be manually configured for other sensors. Almost any meteorological sensor with a voltage output range of 1.0 or 2.5 volts can be scaled and logged by the BAM 1020.

```
                    SETUP CHAN PARAMS

 CH    TYPE  UNITS  PREC  MULT   OFFSET
 06    AT    C       1   0100.0  -050.0
          SENSOR FS VOLT:  1.000
 INV SLOPE:N VECT/SCALAR:S MODE:AUTO ID

   SAVE               ID MODE     EXIT
```

The SENSOR Menu

CH: Selects the channel to be viewed. The up/down arrow keys select the channel.

TYPE: This is the parameter name. You can enter a name here by using the arrow keys to scroll through the alphabet and other ASCII 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 really the measurement range or the span of the sensor. If a baro sensor has a range of 525 to 825 mmHg, then the MULT would be 300 (mmHg). If a RH sensor has a range of 0 to 100%, then the MULT would simply be 100 (%).

OFFSET: This is the range offset value, or the measurement value that the sensor represents at 0.000V output. In the screen shown above, the AT sensor has a 0-1V output representing -50 to +50°C. So the MULT range is 100 (C) and the offset is -50, because 0.000V from the sensor represents -50°C.

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 BAM 1020 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 all BAM 1020 monitors equipped with an ambient temperature sensor.**

6.9 HEATER Setup Screen – RH Control Settings

The SETUP > HEATER screen is only visible if the HEATER CONTROL mode 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 1020 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. If the measured relative humidity of the sampled air stream is higher than about 50% then PM measurements might be skewed higher those produced from a collocated reference sampler. The Smart Heater can reduce this effect by actively heating the inlet tube by warming the sampled air stream whenever the RH value measured downstream of the filter tape exceeds a user selectable value.

It should be noted that the relative humidity downstream of the filter tape is not necessarily the same as the ambient relative humidity. Relative humidity is a measure of how much moisture the air is holding compared to how much moisture the air can hold (dew point) and is strongly temperature dependent. For example, if the ambient relative humidity is 50% and the ambient temperature is 3°C, the relative humidity downstream of the filter tape would be about 22 % were the filter temperature 15°C, which means that the Smart Heater would not have to apply additional heat were the BAM 1020 to be operated inside of a temperature-controlled enclosure set maintain an instrument temperature of about 20 °C in order to maintain the filter temperature RH value of 35%.

```
HEATER SETUP
      HEATER MODE: AUTO
      FRH CONTROL: YES
      FRH SETPOINT: 35 %
        LOW POWER: 20 %    ( 06)
   LOG FILTER-RH: YES (CHAN 4)
    LOG FILTER-T: YES (CHAN 5)
  SAVE                      EXIT
```

The SETUP > HEATER Screen

Heater Mode: This setting selects which operation mode the Smart Inlet Heater uses to control RH. This value must be set to AUTO for all PM$_{2.5}$, PM$_{10,}$ and PM$_{10-2.5}$ monitoring. When set to AUTO, the Smart Heater uses the filter RH sensors to control the inlet tube heating. For most sampling conditions, HEATER MODE should not be set to MANUAL.

FRH 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 Set point. When the RH falls back below the set point, the heater turns down to a low power heat mode which applies only slight heating. If this is set to NO, The Smart Heater will stay in low power mode and no additional RH control will be performed.

FRH Set point: This is the relative humidity level that the filter will be regulated at or below by the inlet heater. This value must be set to 35% for the version of the BAM 1020 employing the smart heater when operated as a PM2.5 US-EPA designated federal equivalent method. The RH set point is set to 45% for European (EU) PM$_{2.5}$ units, and may be either 35% or 45% for PM$_{10}$ units. The RH set point is otherwise adjustable from 10% to 99%.

Low Power: This is the power level of the smart heater when the Filter RH value is below the FRH setpoint.

Log Filter-RH: Turns logging of the Filter RH value on and off. When set to ON, the Filter-RH value will be logged on analog input channel 4.

F Log Filter-T: Turns logging of the Filter Temperature value on and off. When set to ON, the Filter-T value will be logged on analog input channel 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.
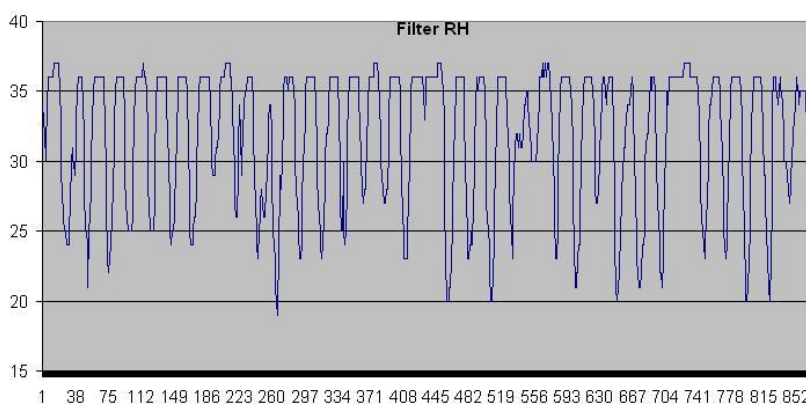
Properly Regulated Channel 4 Hourly Filter RH Graph

6.10   QUERY Setup Screen – Custom Data Array Setup

The SETUP > QUERY screen allows the user to configure a custom digital data array for the new Query Output, or for the European BH Bayern-Hessen protocol. The user can select exactly which data parameters appear in the array, and in what exact order they appear. The custom array can be as simple as a single concentration value, or it can be very comprehensive including some parameters that are not even available in any of the standard data files, such as the hourly span membrane check value. The setup of this custom array does not affect any of the standard BAM 1020 data arrays. The query output is available in firmware revisions 3.6.3 and later and requires the Report Processor. The BH protocol is available in revision 5 series European firmware. A separate technical document for the Bayern-Hessen protocol functions is also available. See Section 9.9 for instructions about how to retrieve the Query output files.

```
N:08                      DATA QUERY FIELDS
 01 TIME      02 CONC_A     03 FLOW
 04 AT        05 BP         06 RH
 07 REF       08 ERRORS     09
 10           11            12
 13           14            15
 16           17
   SAVE                         EXIT
```

The SETUP > QUERY Screen

The **N:** field sets how many values to include in the array. Up to 17 parameters can be included. Increment the N value with the up/down arrow keys. For each increment of the N value, another position in the array will be activated, starting with position 01.

Each position in the array can be changed to any desired parameter using the left/right keys to select the position, and the up/down keys to scroll through the whole list of parameters. In the example above, eight parameters are included and the shown parameters were selected for each of the eight positions in the array. The available parameters are listed in the table below:

Parameter	Description
CONC_A	Concentration value for the last sample period.
Q_STD	Sample flow volume in cubic meters at standard conditions.
Q_ACT	Sample flow volume in cubic meters at actual AT/BP conditions.
STAB	Stability measurement. Diagnostics use only. EU firmware only.
REF	Reference span membrane mass measurement in mg/cm2.
FLOW	Real time flow or average flow for the last sample.
CV	Flow coefficient of variability for the last sample period. (Standard deviation divided by the mean)
AT	Average ambient temperature for the sample period.
BP	Average barometric pressure for the sample period.
ANALOG 1	Average of analog met sensor channel 1 (user defined channel).
ANALOG 2	Average of analog met sensor channel 2 (user defined channel).
ANALOG 3	Average of analog met sensor channel 3 (user defined channel).
ANALOG 4	Average of analog met sensor channel 4 (usually filter FRH).
ANALOG 5	Average of analog met sensor channel 5 (usually FT).
ANALOG 6	Average of analog met sensor channel 6 (almost always AT).
CONC_S	PM10 concentration using standard conditions. Used in PM-coarse systems where the coarse PM10 value is in actual conditions, but the standard PM10 value is also needed for regular PM10 reporting requirements. This parameter is only available in the PM10 master unit of a coarse set
PM2.5	PM2.5 concentration from the slave unit in a PM-coarse. This parameter is only available in the master unit of a coarse set.
PMc	PM-coarse (PM10 - PM2.5) concentration value. This parameter is only available in the master unit of a coarse set.
TIME	Date and Time stamp for the sample period. Ignored for BH protocol.
ERRORS	Decimal error codes of the 12 major error categories.

6.11 REPORTS Setup Screen – Daily Data and Dynamic Ranges

The SETUP > Reports screen provides options for setting the hours of the daily data average period and the type of dynamic range being used.

```
Report Setup


   DAILY RANGE: 01  :00 – 24:00
 DYNAMIC RANGE: EXTENDED
        LOG BP: CHAN 1
 LOG MEMBRANE: CHAN 2


 SAVE                        EXIT
```

The SETUP > HEATER Screen

6.11.1   Daily Data Range

The DAILY RANGE field is used to select which hours are included in the daily BAM 1020 data file reports. The two possible choices are:

00:00 to 23:00 (old default setting) or **01:00 to 24:00** (correct newer setting)

The BAM 1020 time stamp is the <u>end</u> of the sample hour, not the beginning, so the 01:00 data point is for air sampled between midnight and 1:00 am. Always select 01:00 to 24:00 unless the monitor is being used in a special application requiring 00:00 to 23:00.

6.11.2   Dynamic Range

The DYNAMIC RANGE field is used to choose the range of the concentration value being stored in the data logger. The two possible choices are **STANDARD** or **EXTENDED.**

Both settings will utilize the same OFFSET value configured in the SETUP > SAMPLE screen. See section 6.2 for details on setting the OFFSET value.

The STANDARD range sets the logger scaling to match the analog output range as determined using the RANGE setting in the SETUP > SAMPLE screen. See section 6.2 for details on setting the RANGE value.

Choosing the EXTENDED range forces the logger scaling to be 10 mg, regardless of the analog output RANGE setting. The EXTENDED range is automatically selected when setting the HJ 653 option (see section 6.12) to YES.

Most locations will use the STANDARD range. However, areas with heavy concentrations (or where local regulations may require it) should use the EXTENDED option.

Note: Changing this setting will clear all data stored in memory. Be certain to download and save any collected data prior to changing the range.

6.11.3   Log BP

The ambient barometric pressure measurement on analog input channel 7 can be logged on channel 1, 2, or 3. This setting can also be set to NONE if it is not desired to log ambient barometric pressure.

6.11.4   Log Membrane

The results of the reference membrane measurement can be logged on channel 1, 2, or 3. This setting can also be set to NONE if it is not desired to log these test results.

6.12   HJ 653 Setup Screen – Chinese Data Formatting

The SETUP > HJ 653 screen is used to set data formatting to match the Chinese National Standards on Environmental Protection document HJ 653-2013. When set to YES, the concentration display resolution on all screens will show micrograms to the tenths position. It will be shown in the format of "x.x ug/m3".

The data report will be in one of two formats, depending on the concentration type selected (see section 6.3). Flow must be set to ACTUAL in both circumstances.

If the concentration is also set to ACTUAL, it will be formatted in this manner:

```
Time,ConcA(ug/m3),QtotA(m3),XXXXX(XXX),XXXXX(XXX),XXXXX(XXX),RH(%),XXXXX(XXX),AT(C
),ConcS(ug/m3),QtotS(m3),BP(kPa),Flow(LPM),E,U,M,I,L,R,N,F,P,D,C,T
2017-10-15 16:40,  123.4, 0.700,     0,     0,     0,    39,     0,  24.3, 139.1,
0.621, 100.2, 16.69, 0,0,0,0,0,0,0,0,0,0,0,0
```

If the concentration is set to STANDARD, it will be formatted in this manner:

```
Time,ConcS(ug/m3),QtotA(m3),XXXXX(XXX),XXXXX(XXX),XXXXX(XXX),RH(%),XXXXX(XXX),AT(C
),ConcA(ug/m3),QtotS(m3),BP(kPa),Flow(LPM),E,U,M,I,L,R,N,F,P,D,C,T
2017-10-15 16:40,  139.1, 0.700,     0,     0,     0,    39,     0,  24.3, 123.4,
0.621, 100.2, 16.69, 0,0,0,0,0,0,0,0,0,0,0,0
```

Also, selecting YES will force the DYNAMIC RANGE setting (see section 6.11.2) to EXTENDED.

If the HJ 653 option is set to OFF, the data report will be as shown in section 9.4.

7 MAINTENANCE, DIAGNOSTICS and TROUBLESHOOTING

This section provides information about routine maintenance, identifying errors and alarms, and performing diagnostic tests on the BAM 1020. The TEST menu functions are also described in this section.

Met One Instruments also publishes a comprehensive array of technical bulletins that covers additional information about subsystem troubleshooting, upgrades, and repairs. These are available in the "BAM Users" section of our website, or by e-mail request from the Technical Service department.

7.1 Met One Recommended Periodic Maintenance Table

The following table shows the recommended interval for the regular BAM 1020 maintenance, field check, and service tasks. Special tools are not required for any of the routine BAM service tasks on less than yearly intervals. Met One recommends the BX-308 and BX-344 kits for non-routine service and repairs such as nozzle removal and detector tests. Complete instructions are included.

Maintenance Item	Period
Nozzle and vane cleaning.	**Monthly**
Leak check.	**Monthly**
Flow system check/audit.	**Monthly**
Clean capstan shaft and pinch roller tires.	**Monthly**
Clean PM10 inlet particle trap and PM2.5 cyclone particle trap.	**Monthly**
Download and save digital data log and error log.	**Monthly**
Compare BAM 1020 digital data to external analog data logger data, if used.	**Monthly**
Check or set BAM real-time clock.	**Monthly**
Replace filter tape roll.	**2 Months**
Run the SELF-TEST function in the TAPE menu.	**2 Months**
Download and verify BAM 1020 settings file.	**Quarterly**
Complete flow system calibration.	**Quarterly**
Completely disassemble and clean PM10 inlet and PM2.5 cyclone.	**Quarterly**
Replace or clean pump muffler.	**6 months**
Test filter RH and filter temperature sensors.	**6 months**
Test smart heater function.	**6 months**
Clean internal debris filter.	**12 Months**
Remove and check membrane span foil.	**12 Months**
Beta detector count rate and dark count test.	**12 Months**
Clean vertical inlet tube (BX-344 cleaning kit).	**12 months**
Test analog DAC output, if used.	**12 Months**
Replace lithium battery if necessary.	**12 Months**
Rebuild vacuum pump.	**24 months**
Replace nozzle O-ring.	**24 months**
Replace pump tubing, if necessary.	**24 Months**
Factory recalibration is not required except for units sent for major repairs.	**---**

7.2 BAM 1020 Error and Alarm Descriptions

The following table describes the BAM 1020 error and alarm codes. Errors are grouped into twelve categories. If an error or alarm occurs, it will appear at the end of the hourly digital data array as a simple "1" bit in one of the twelve error bit positions. This allows data collection systems to easily identify errors. See Section 9 for data examples. Errors and alarms are also stored in the separate BAM digital error log file, which contains more detail about the specific sub-category cause of the alarm.

Note: *In general, any error which prevents the BAM 1020 from making a valid, hourly concentration measurement will also cause the digital concentration value to be stored as a full-scale value (usually 0.985 mg) in order to indicate invalid data.* In most cases, critical errors will also force the analog output to full-scale (1.00V). The rules for which errors cause invalid data and full-scale values have varied slightly with past revisions of firmware. The following descriptions explain these conditions in as much detail as possible. If an error occurs in your unit which does not seem to agree with this description, please note your firmware revision and contact Technical Service.

Code	Error/Alarm Type	Error/Alarm Description
E	**External Reset** or **Interface Reset**	This alarm indicates that an external data logger sent a clock synchronization signal to the BAM on the EXT RESET input, but the BAM was unable to reset its clock, because it occurred outside of the allowable time window. Hourly clock reset signals will be ignored by the BAM from minutes 5-54 (standard cycle) or minutes 0-49 (early mode). See Section8.2.The alarm will also be generated if the synch signal occurs within the acceptable window near the end of the hour, but before the BAM has finished the previous concentration calculation. The digital error log will indicate which of these two has conditions occurred. If an external clock reset event is successful, then no alarm is logged. These alarms do not prevent the BAM from storing a valid data record for the sample hour. Manually set the BAM 1020 clock to match the data logger clock initially. This should cause subsequent clock synch events to succeed. Make sure the BAM lithium battery is functional.
U	**Telemetry Fault** or **Interface Fault**	This alarm indicates that an external data logger has sent an error signal to the BAM 1020 on the TELEM FAULT input, indicating that the logger unit has encountered a problem. This feature is almost never used. These alarms do not prevent the BAM from storing a valid data record for the sample hour.
M	**Maintenance Alarm**	This alarm almost always indicates that the sample cycle was stopped because someone entered a SETUP or TEST menu for calibration or testing purposes. Maintenance flags always cause the digital concentration value to go full-scale for that hour, because the sample cycle was not finished.
I	**Internal Error** or **Coarse Link Down**	The "I" error is rare, and indicates that an error occurred in the BAM concentration, mass, span, or stability calculation which prevented the generation of a valid concentration value. The digital error log will indicate which of these calculations has failed. The concentration value is set to full-scale due to invalid data. This may indicate a problem in the digital circuitry. In BAM 1020 units configured as the PM_{10} master unit in a PM-coarse pair, the "I" alarm indicates that the digital link between the two units is down, and the master unit could not obtain the $PM_{2.5}$ value from the slave unit and thus could not calculate a coarse value. The coarse and $PM_{2.5}$ values will be full-scale.

L	**Power Failure** or **Processor Reset**	This error occurs if AC input power is lost even momentarily, or if the power switch is turned off. Frequent "L" errors usually indicate poor quality AC power. If frequent power errors occur even when the BAM 1020 is connected to a UPS backup system, contact Met One Instruments for instructions on possible power supply upgrades. Anything that causes the microprocessor to reset will also result in an "L" error, such as low voltage on the 5.25V Vcc bus, bad connections on the internal DC power harness, or in rare cases electrical interference. All power failure errors cause the digital concentration value to go full-scale.
R	**Reference Error** or **Membrane Timeout**	This error indicates that the span reference membrane assembly may not be mechanically extending or withdrawing properly. The error is generated if photo sensors S2 and S3 never change state after 15 seconds despite drive commands to the membrane motor. The digital error log will indicate which photosensor timed out. It may be a simple sensor/flag alignment problem that can be identified and corrected using the TEST > ALIGN menu. However, if the span foil assembly is stalled in a partially extended position, it could block the beta signal and prevent valid data collection.
N	**Nozzle Error**	This error indicates that the nozzle motor is not operating correctly. The error is triggered if photo sensors S4 and S5 never change state within 12 seconds, despite drive commands to nozzle motor. The concentration value is set to full-scale if the nozzle motor or sensors have failed. The digital error log will indicate which photosensor timed out. **Important Note:** The nozzle sensors watch the motor cam rotation, not the actual action of the nozzle itself, so it is technically possible for the nozzle to become stuck in the UP position even if the motor and sensors indicate no error. This could result in a massive flow leak and useless data with no errors or alarms being generated! Proper maintenance of the nozzle O-ring and proper inlet alignment prevent this.
F	**Flow Error**	Flow errors can occur due to a fault with the flow controller, the flow sensor, or the vacuum pump. See section 7.5 for troubleshooting suggestions. The digital error log contains the exact subcategory which generated the alarm. The following minor flow alarms occur when a parameter was out of bounds, but the sample was not stopped. Concentration data is still stored normally **5% out-of-regulation** - Flow > 5% out of regulation for more than 5 minutes. **AT Failure** – One minute average of the AT sensor was within 1 degree of the sensor min or max range. May occur in extreme cold or hot environments. **Internal or External BP Failure** – One minute average of the barometric pressure sensor exceeded the min or max range of the BP sensor. **Self-Test** – Self test flow rate less than 10 L/min. The following critical flow errors result in the sample being terminated and the concentration data being set to full-scale or as configured in the SETUP > ERRORS menu (see section 6.5). **AT Disconnected** - Missing or incorrectly connected AT sensor. **Pump Off Failure** - Flow sensor indicates >5 L/min with the pump turned off. This critical flow error results in the sample being terminated prematurely and the concentration being calculated with a smaller sample volume of air. **Flow Failure** - Flow > 10% out of regulation for more than 1 minute. If Qtot is less than 0.1 m3 abort the concentration measurement. Otherwise make the concentration calculation based on the partial volume (Qtot), then wait for the next hour.

P	**Pressure Drop Alarm** **or** **Delta-Pressure Alarm**	This error indicates that the pressure drop across the filter tape has exceeded the limit set by the "AP" value and is often due to heavy particulate loading. Current firmware will stop the sample early when this occurs, and make the concentration calculation based on the partial volume, then wait for the next hour. This feature is designed to stop the sample early if the vacuum capacity of the pump is about to be exceeded, before flow errors occur. Firmware before Rev 3.6.3 would not stop the sample for the "P" alarm, and subsequent flow errors could occur due very high concentration dust loading. The pump cycle must run for at least 5 minutes before a pressure drop alarm event can occur. See Section 6.5.
D	**Deviant Membrane Density Alarm** **or** **BAM CAL alarm**	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%. These alarms are often caused by a dirty or damaged membrane foil. If the foil is clean and undamaged, the alarm could indicate that the beta detector tube itself is noisy or beginning to wear out, or that the membrane holder is not extending and withdrawing fully. These alarms do not prevent the BAM from storing a valid concentration for the sample hour because the dust mass is a completely separate measurement, but the alarm should be investigated and resolved in order to ensure proper beta detector operation.
C	**Count Error** **or** **Data 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 counts during any of the mass, membrane, or stability measurements. The 4-minute beta count rate through clean filter tape is usually more than 800,000 counts. This rare error occurs if the beta detector, high voltage, or digital counter has failed or if the beta signal is physically obstructed. This alarm sets the concentration value to full-scale. The sub-category "count, failed" occurs if the beta counter is still counting 10 seconds after the scheduled end of any count period, indicating a digital fault.
T	**Tape System Error** **or** **Filter Tape Error**	The tape error usually indicates that the filter tape is has run out or broken. It occurs if the right spring-loaded tensioner (tape roller nearest to the detector) is at the far left limit of its travel. In this case, tape break photosensor S6 is ON continuously, despite drive commands to the tape reel motors and the capstan motor. The tape error is also generated if the pinch rollers are latched in the up position when a new sample hour starts, preventing the cycle. **Note:** *Firmware revision 3.6 and later will cause the concentration value to go to full-scale due to a tape error, because the cycle cannot be performed with broken tape. All previous firmware revisions did not set the concentration to full-scale, but instead repeated the last valid concentration value until the tape was replaced.* In rarer cases, a tape error may also be generated due to a failure in the tape control electromechanical system. In current firmware there are several possible sub-categories for this error which will appear in the digital error log: • Tape, Latch – Pinch rollers latched up at cycle start. • Tape, Shuttle – Shuttle photosensor not responding to shuttle move. • Tape, Forward/Backward – Tape supply motor or take-up motor not responding. • Tape, Tension/Un-tension – Tensioner photosensor not responding. • Tape, Capstan – Capstan motor or capstan photosensors not responding. • Tape, Self-Test – Shuttle beam did not respond during self-test. • Tape, Break – Broken or empty tape. Tape errors caused by failures other than broken tape or latched pinch rollers can usually be identified using the TEST > ALIGN menu to manually operate the motors and photosensors. See Section 7.16. Tape errors can be caused by grit in the shuttle beam ball slide. Contact tech service if the left/right shuttle slide action is not smooth.

7.3　Comparison of BAM 1020 Data to Integrated Filter Sampler Data

Each new BAM 1020 has been calibrated against a reference beta gauge whose calibration is traceable to a gravimetric standard. This calibration information is provided in the calibration certificate that accompanies each BAM 1020 as K and as μ_{sw}. As the BAM 1020 span response is virtually insensitive to the chemical composition of the sampled PM one should expect excellent agreement between mass density determined by a manual filter-based sampler and the mass density determined by a collocated BAM 1020.

Most PM reference methods are based on manual, integrated sampling techniques in which PM is sampled onto pre-weighed filters. Sampled filters are then equilibrated and then re-weighed. The net weight gain is used along with the volume of air sampled to determine the mass density of PM in the sampled volume. PM reference methods may differ from one jurisdiction to another. Furthermore, the BAM 1020 may be operated differently from one jurisdiction to another. For example, the BAM 1020 may be configured to operate as a US-EPA designated $PM_{2.5}$ Federal Equivalent Method. Or it may be configured to operate in accordance with EU guidelines for $PM_{2.5}$.

Users may collocate a PM_{10} or a $PM_{2.5}$ reference sampler with a newly deployed BAM 1020 and collect data on both devices for a period of time in order to demonstrate reasonable correlation and acceptable levels of multiplicative (slope) and additive (intercept) bias between the two methods. Performing such a field test is beneficial as it could reveal an undetected performance or data reporting issue. Common issues could include improper data logger scaling, incorrect background (BKGD) values, or improper flow calibration due to a mis-calibrated flow standard. A scatter plot between the reference standard results (plotted along the x-axis) and the BAM 1020 results (plotted along the x-axis) can reveal these problems.

In order for such an analysis to be useful however it is necessary to have a suitable number of data points, an acceptable level of dispersion (range) in the measured values and acceptable level of correlation (r^2) in a regression between the reference results and the BAM 1020 measurements.

Below are several additional considerations:

- Nozzle leaks can lead to poor correlation between the BAM 1020 and the reference standard.

- Improper inlet tube insulation or placing the BAM 1020 directly in the path of an air conditioner vent during operation under hot, humid conditions can lead to poor correlation with the reference standard and unpredictable levels of multiplicative and additive bias.

- The collocated inlets should be at approximately the same height and within several meters of one another during the comparison test.

- The start time and the stop time of the filter-based method should correspond to the hourly BAM 1020 measurement cycles.

7.4 Power Up Problems and Electrical Safety Considerations

The BAM 1020 must be at a state where it can be powered on before any other testing or diagnosis can be performed:

- Make sure that the BAM 1020 is plugged into the correct AC voltage. The BAM 1020 is internally wired for either 110/120V or 220/240V. The digital, analog, and user interface systems are powered from a universal-input power supply, so these should work even if the line voltage is not correct. The filter tape, nozzle, and span check control motors all run on AC voltage and will not operate correctly if the line voltage is incorrect.

- Check 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. See Section 2.6.

- It is possible for the display contrast to be set so lightly that it looks like the display is OFF when it is really ON. Try pressing and holding the contrast key on the front door for a few seconds while the BAM 1020 scrolls through the contrast settings. In rare cases the display may fail completely. If the BAM 1020 "beeps" when you press the keys, it is ON.

- If the above checks do not resolve the power-up problem, then there could be a failed power supply or other significant problem inside the BAM 1020. Contact Met One for further instructions. Do not attempt to open or repair the power supply assembly unless qualified.

⚠ *Warning! The BAM 1020 uses hazardous live voltages which can cause electrocution if electrical safety precautions are not strictly followed during service or repair of the machine. The BAM 1020 is designed to provide protection from hazardous voltages during normal operation. If the equipment is modified or used in a manner not specified by the manufacturer, protection provided by the equipment may be impaired.*

Hazardous voltages are present in the following areas:

- **Power Supply AC:** The main power supply is located inside the BAM 1020, inside the power supply sub-enclosure labeled "DANGER HIGH VOLTAGE". The power supply enclosure contains the main AC-to-DC converter and the motor driver board for the transport motors, all of which contain live AC line voltage when the BAM 1020 is powered up. Do not open the power supply sub-enclosure lid without unplugging the BAM 1020 power cord.

- **Detector Negative High Voltage DC:** The 3150 circuit board is inside the BAM 1020, mounted vertically on the outside of the power supply sub-enclosure, and covered with a clear plastic safety shield. This circuit board generates a dangerous negative DC bias voltage for the beta detector of between -800 and-1200 volts. Do not remove the clear cover or touch the board without unplugging the BAM 1020. Do not touch the large green capacitor or the detector preamp board with the BAM 1020 turned on.

- **Pump AC:** The vacuum pump is powered by AC line voltage, and has its own power cord. Do not open the electrical junction box on the side of the pump, or touch the enclosed solid-state relay without first unplugging the pump power cord.

- **Inlet Heater AC:** The inlet heater is powered by AC line voltage. The heater either plugs into an external gray plastic relay enclosure on the back of the BAM (with its own power cord), or it plugs directly into the back of the BAM and takes power from the main power supply, with the relay located under a clear plastic cover on the inside floor of the BAM enclosure. See Section 2.5. Do not open the relay cover or touch the relay while the BAM and/or the relay box is plugged in. Do not remove the cylindrical metal shell from the smart heater module, or touch any of the internal parts while the heater is plugged in. The heater module does not contain any serviceable parts inside the metal shell.

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 BAM 1020 is programmed not to start a sample cycle until the beginning of an hour. Make sure the clock is set correctly. - The BAM 1020 will wait until the beginning of a new hour before it starts, even if the operation mode is set to ON. - Don't expect the pump to turn on until the clean tape count is finished, about 8 minutes after the start of the hour. - The BAM 1020 cannot start if the pinch rollers are latched UP! The BAM 1020 cannot lower them. - Make sure the filter tape is installed correctly. - The BAM 1020 will never start a cycle if the display is left in a TEST or SETUP menu! The main screen or OPERATE menu must be displayed. - The BAM 1020 will usually display an error if it cannot start a new sample cycle.

Problem:	The analog output voltage and/or digital concentration reading are full-scale.
Cause/Solution:	The BAM 1020 will force the analog and digital concentration values to full-scale (usually 0.985mg) to indicate that an error has prevented the collection of a valid hourly data point, or that the hourly cycle was interrupted. Download the digital error log to identify the cause. The current hourly record after power-up will also be full-scale.

Problem:	The BAM hourly concentration is reading negative values.
Cause/Solution:	- It is possible for the BAM 1020 to occasionally read negative numbers if the actual ambient particulate concentration is below the detection limit of the BAM 1020, such as below 3 micrograms. This is because the BAM has a noise band of several micrograms. This should not happen often. - If the BAM 1020 is reading negative numbers hour after hour, it may be punching holes in the filter tape. These holes can be very small. This is almost always caused by debris on the nozzle or vane. Clean the parts. - The BKGD zero correction offset value may have been incorrectly entered, or may need to be audited. Met One supplies the BX-302 zero filter kit for auditing the zero average and noise floor of the BAM 1020. Set the BKGD value to 0.000 during the test. - Look for sources of electrical noise, such as bad grounding. Any source of noise will show up in the zero filter test. - Verify that the inlet tube is grounded to the chassis of the BAM 1020.

Problem:	The airflow rate is too low and won't adjust up to 16.70 L/min.
Cause/Solution:	• The gray plastic pump mufflers on the Medo pumps may clog up after several months. Replace it or drill a hole in the end of it for a temporary fix. The brass mufflers on Gast pumps 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 vacuum 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 16.70 lpm when it needs to be rebuilt. • Checking the 18.4 L/min point during the regular 3-point flow audits verifies the pump capacity. • 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. • Perform the 3-point flow audit in the TEST > FLOW screen. The BAM should try to regulate to these flow values. If the flow does not change, the flow controller may not be working. • Unplug the pump power while performing a 3-point flow check. With the pump off, you should be able to clearly hear the flow controller pulse at 1-second intervals as it rotates and attempts to regulate the flow. If not, the flow controller is not working or the circuit board output is not working. • If the flow regulates lower, but not higher than 16.70 lpm, the pump is probably worn out, or there is a leak.

| Problem:	The nozzle gets stuck in the UP position, or won't press down onto the tape fully.
Cause/Solution:	• With the nozzle in the down position, lift the nozzle up and down with your thumb and determine if it feels sticky or gritty. • The nozzle O-ring eventually breaks down and needs to be replaced. See Section 7.6 for instructions. • The brass nozzle bushings may have grit in them. See Section 7.6. Remove the nozzle and clean the parts. A shim kit is required for nozzle reassembly. • A stuck nozzle is sometimes caused by a misaligned inlet tube. Make sure it is straight up and perpendicular to the top of the BAM 1020.

Problem:	The BAM 1020 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. • 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 BAM 1020. Verify that the flow reading on the BAM reads less than 0.2 L/min. If not, the flow sensor Q_0 zero offset setting may need to be adjusted in the SETUP > CALIBRATE menu. The Q_0 setting is usually very close to zero. • Check for bad O-rings on the BAM inlet tube 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 BAM 1020 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 on the harness pins which can cause the BAM 1020 to reset frequently. Upgrade parts may be available for certain units. Current power supplies have the output harness wires soldered to the supply. 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. This only occurs on firmware before R3.6. • If the RANGE setting on the BAM is set higher than 2.000mg, 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. • Verify that the ABS expected membrane mass matches the calibration certificate.

Problem:	The clock settings are lost when the BAM 1020 is powered down.
Cause/Solution:	• It is normal for the clock to drift as much as 1 minute per month. • The BR2032 lithium battery on the 3230 circuit board may need to be replaced every 1-2 years.

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 BAM 1020 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. • BAM 1020 units with firmware part 3236-2 (PM10 only) cannot identify the BX-596.

7.6   Nozzle Component Service and O-ring Replacement

The BAM 1020 sample nozzle system needs periodic inspection and service in order to prevent flow leaks. The primary indicator is if the nozzle up/down motion feels sticky or gritty when performing the normal monthly nozzle cleaning, or if the nozzle fails to fully seal against the tape when lowered, causing leakage. The nozzle O-ring may need to be replaced approximately every two years during continuous operation. This is a simple matter and no special tools are required. Instructions for O-ring replacement are below.

The sample nozzle may also be easily removed from the BAM 1020 for further cleaning or rebuild. This requires a set of brass adjustment shims to set the spring tension during reassembly. The standard BX-308 BAM tool kit contains all of the required tools and instructions. The BX-310 kit includes the two shims only.
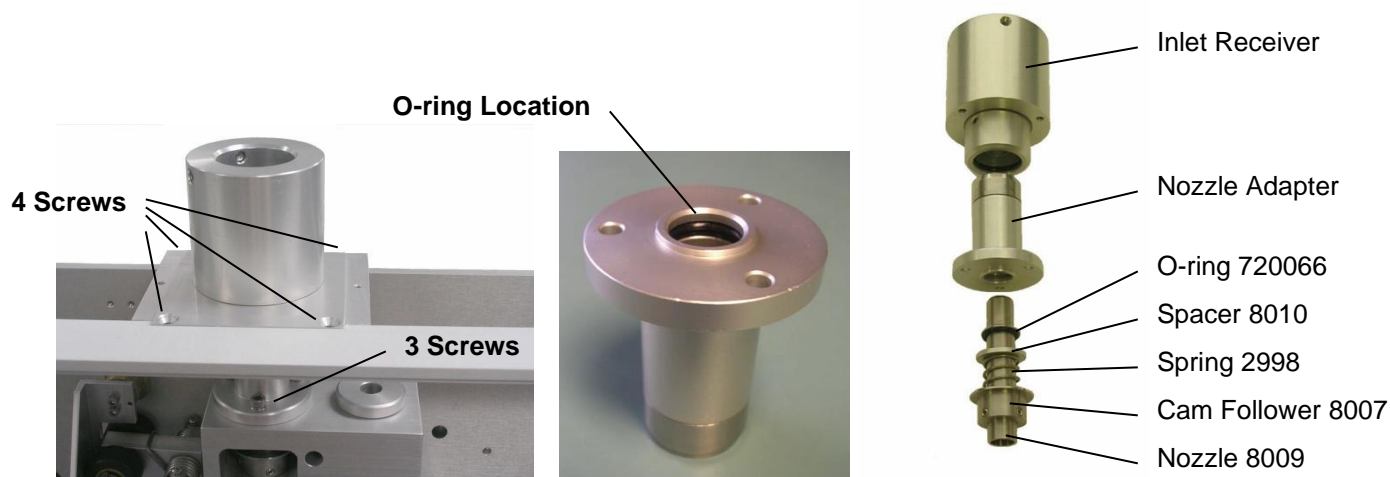
1. Remove the filter tape and the main BAM 1020 case cover. The sample nozzle <u>must be in the down position</u>. Lower it using the TEST > PUMP menu if needed. Lift the nozzle up and down against its spring with your thumb and note the action feel.

2. Remove the four screws (two flat head Philips, two 9/64" hex) that fasten the square inlet receiver bracket to the BAM chassis. Lift the assembly off of the BAM. It is not necessary to remove the bracket from the inlet receiver cylinder.

3. Remove the three 9/64" hex screws that fasten the nozzle adapter to the top of the beta block. A T-handle hex wrench is easiest. The nozzle adapter can now be lifted off of the top of the nozzle, revealing the O-ring location. Clean the top of the nozzle.

4. Remove the O-ring from the groove. Thoroughly clean the O-ring groove and the inside if the nozzle adapter using alcohol and cotton-tipped applicators, then install the new O-ring and lubricate it with silicone grease.

5. Check the nozzle up/down action again before reassembly. If the nozzle action feels smooth, then reinstall the nozzle adapter and inlet receiver assemblies. Check the nozzle action after each step of reassembly to identify any binding or sticking. Perform a normal leak check when finished.

6. **Optional further disassembly (shim set required):** If the nozzle action feels feel sticky or gritty with the nozzle adapter removed, then the nozzle needs to be removed and the nozzle and bushings cleaned. Loosen the two (or three) set screws in the cam

follower with a 5/64" hex wrench. The nozzle can now be lifted out of the bushings. The cam follower, spring, and spacer can be removed from the front of the block.

7. Clean the nozzle inside and out, and inspect the nozzle face for any burrs or defects. Clean the two brass bushing bores with a cotton-tipped applicator. This is also a good time to clean and inspect the tape support vane since the nozzle is out of the way. The bushings do not need to be lubricated. Reinstall the cam follower, spring, and spacer, and align them with the bushing bores.

8. Lower the nozzle down through the bore. The two brass shims must be positioned as shown before the set screws are tightened to retain the nozzle. The square shim must be under the nozzle face. The slotted shim goes under the cam follower. Tighten the set screws evenly, only a little at a time to avoid distorting or binding the nozzle.

9. Remove the shims and check the up/down action of the nozzle before reassembling the nozzle adapter and inlet receiver. It must feel smooth and even after each step of reassembly. If the nozzle still binds or sticks, then contact technical service.
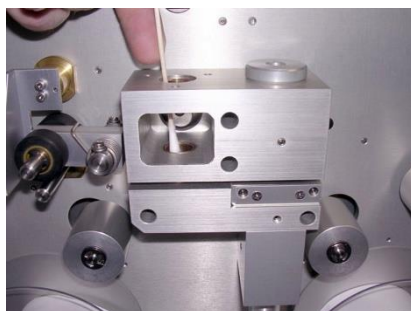
Nozzle Removal   Cleaning the Bushings   Using Shims for Reassembly

7.7   Performing the 72-Hour Zero Filter Background Test

All BAM 1020 monitors should have a zero-filter test performed before the equipment is first deployed so that an initial BKGD adjustment may be made, if necessary. This test should be repeated periodically as part of a QA/QC program, the frequency of which is up to the user.

When the BAM 1020 is set up for the first time, a minimum of 48-72 valid 1-hour zero-test data points should be collected in order to accurately determine the BKGD value. Subsequent, periodic zero tests may be performed with fewer 1-hour values, but this will result in a less accurate BKGD calculation.

The initial zero-test is used to determine the instrument noise (σ) and to confirm that the lower limit of detection (LLD), which is 2σ, is within specifications. For an 8-minute count cycle the LLD is <4.8 µg/m^3 for a 1-hour measurement cycle and for a 4-minute count cycle the LLD is <7 µg/m^3. The initial zero test and all subsequent zero tests should be performed using an 8-minute count cycle if the BAM 1020 will be operated with an 8-minute count cycle. The zero tests should be performed with a 4-minute count cycle if the BAM 1020 will be operated with a 4-minute count cycle.

The initial zero-filter test should be performed after the BAM 1020 is installed at the monitoring site. If this is not feasible, then performing the test with the monitor sitting on a nearby laboratory bench before deployment is acceptable.

If the BAM 1020 is to be operated with a "smart heater" (BX-826 or BX-827), the zero-filter test should be performed with the smart-heater engaged, but running in "low power mode" for

the duration of the test. Low power mode is activated by setting the FRH CONTROL parameter to NO (see section 6.9).

Weather (rain, mist, very high humidity, high dew point, etc.) can sometimes make it difficult to perform the zero-filter test with the filter mounted outdoors at the monitoring site. In these situations, the BX-302 zero filter assembly should be mounted inside the shelter. Replace the standard inlet tube , with the short 1.5 foot long inlet tube (this tube is included with each BAM 1020 to sample room air). Mount the smart-heater and the BX-302 zero filter assembly on this shorter tube inside the shelter.

The ambient temperature sensors (BX-592, BX-596, or BX-597) should always be placed in the same environment from which the air is sampled. If the BX-302 is mounted inside the shelter, the ambient temperature sensor should also be placed inside the shelter.

It is recommended that the BAM 1020 be operated for at least 24-hours before commencing the zero-filter test. A leak check and flow check should be performed before proceeding on to the following steps for the zero-test. Although it is not necessary to reset the existing BKGD value to 0 for the purpose of conducting the zero-test, doing this will minimize the chance of a miscalculation.

1. Enter the SETUP > CALIBRATE menu.

    a. Record the existing BKGD value, then change it to 0.0000 (optional).

    b. Note the Conc type and set it to Actual if it is not.

    c. Note the Flow type and set it to Actual if it is not.

    d. Save and exit back to the main menu.

2. Install the BX-302 zero filter assembly onto the top of the inlet tube.

    Note: When it is necessary, the BX-302 zero filter assembly may be inside the shelter to avoid aspiration of water through the zero filter.

3. Allow the BAM 1020 to sample for 48-72 consecutive hours, not counting the warm-up period for the initial zero-test. For the zero-test to be valid, no errors should be logged either during the warm-up period or during the 48-72-hour sampling period. For subsequent zero tests the user may decide to use fewer valid data points (such as 24 for example).

4. Calculate the average of the hourly BAM 1020 concentrations to the nearest 0.1 $\mu g/m^3$. **The new BKGD value is the negative of this average**. For example, if the average of the data sample is 0.0021 mg (2.1 μg), the correct BKGD value is -0.0021. Record the new BKGD value.

    Note: If the BAM 1020 is being deployed for the first time, replace the factory-set BKGD with the new BKGD value. As Met One Instruments runs the initial factory zero-test without the smart heater engaged, the initial zero-test performed by the end user may differ from this value if the end user used a smart heater during the test.

5. Calculate the standard deviation of the sample (STDEV on MS Excel) to the closest 0.1 $\mu g/m^3$. Confirm that the LLD of the BAM 1020 meets the factory specified value.

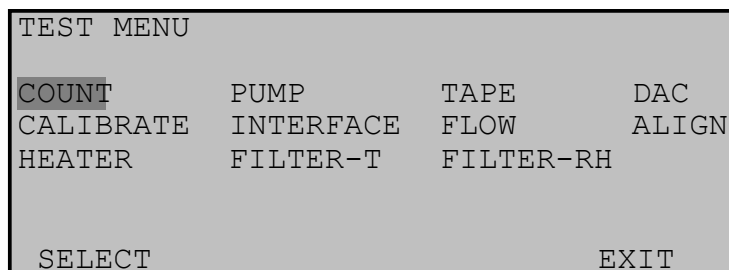   **Note:** Older non-FEM compatible units may not meet these noise specifications.

6. If the results of the zero test indicate that the instrument LLD is higher than the factory specified value or that the BKGD value has changed by more than 2 $\mu g/m^3$ since the

most recent field (not factory) zero-filter test, repeat the zero-filter test. If the problem persists contact the factory.

7. Enter the new BKGD value into the SETUP > CALIBRATE menu on the BAM 1020. Restore the CONC and FLOW type settings to their pre-test configuration, if applicable. Save and exit back to the main menu.

8. Set the FRH Control back to YES to exit low power mode. Save and exit back to the main menu.

9. Resume normal operations or continue with additional testing, as needed.

7.8 The TEST Menu System – Overview

The following sub-sections provide information for performing diagnostic checks on the BAM 1020 sub-systems using the TEST menus. Most of these tests are used for troubleshooting purposes only, and are not necessary on properly functioning units. The TEST menu system is accessed by the TEST 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.

```
TEST MENU

COUNT       PUMP        TAPE        DAC
CALIBRATE   INTERFACE   FLOW        ALIGN
HEATER      FILTER-T    FILTER-RH


 SELECT                             EXIT
```

The TEST Menu

7.9 COUNT Test Menu – Beta Detector Count Tests

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 total 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 GO soft key is pressed to start a new four-minute static count test. The COUNT value on the screen will immediately begin to count rapidly if the detector is operational and unobstructed. Typical four-minute count totals through clean filter tape are between 600,000 and 1,100,000 counts. The count total will be lower if the membrane is extended. After four minutes the counting will stop and wait for the operator to initiate another count or EXIT.

The M value on the screen indicates if the membrane was extended (Y) or withdrawn (N) during the count period. The MEMBRN and NO MEMBRN soft keys can be used to manually extend or withdraw the span membrane foil before a count test if desired.

Dark Count Tests: A steel shim such as Met One 7438 can be placed between the beta source and detector to perform a dark count test. The shim blocks all beta particles, and only counts created by noise or cosmic rays will appear. The total four-minute dark count value should be less than 10 counts. If the total is more than 50 counts, contact technical service.

7.10 PUMP Test Menu – Manual Pump and Nozzle Tests

The TEST > PUMP screen is used to perform leak checks. It can also be used to manually force the pump on and off, or to manually move the nozzle. **Note:** *The BAM will regulate the flow to the 16.70 L/min set point, but the flow rate shown on this screen is uncorrected and always in standard conditions, even if the BAM operates in actual flow mode.* For this reason, no flow audits or checks should be performed using this screen! Obsolete BAM 1020 units with a manual flow valve were calibrated using this screen.

```
            NOZZLE/PUMP EST MODE

NOZZLE:

FLOW:      16.67 SLPM   PUMP:   ON



MOVE NOZZLE   PUMP ON   PUMP OFF    EXIT
```

The PUMP Test screen

The NOZZLE status value will indicate if the nozzle is currently UP (▲) or DOWN (▼). The PUMP status indicates if the pump is turned ON or OFF. The FLOW value is the current flow rate, displayed in standard liters per minute (25C) only.

The MOVE NOZZLE soft key can be used to force the nozzle up or down for testing purposes. Elapsed time is about 5 seconds. If the pump is ON this operation is disabled.

The PUMP ON and PUMP OFF soft keys can be used to turn the vacuum pump on or off. The nozzle will be lowered automatically if PUMP ON is pressed.

7.11 TAPE Test Menu – Manual Filter Forward/Backward Tests

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 for spooling up the first few turns of a fresh roll of tape, to test the tape transport mechanism, or to change spots of tape for 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.

The "X:" value is the number of windows moved in the last motion. This number will be negative if the last move was backwards.

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

The FWD and BKWD soft key move the tape forward or backward by the current 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 output voltage and the DAC (digital/analog converter) electronics. Use the up/down arrow keys to force the voltage to any value between 0.000 and 1.000 volts (0.100V increments). The corresponding voltage on the VOLT OUT +/- terminals on the back of the BAM 1020 should always match within ±0.001 volts. Use a high-quality voltmeter for these tests. If the actual voltage does not match the value on the TEST > DAC screen, contact the service department.

Note: This function is critical for all users of external analog data loggers. Measure the voltage all of the way to the input of your data logger. *Every millivolt of error is a microgram of error!* Make sure the logger is scaling the voltage correctly. In most cases 0.000V should scale as -0.015mg, and 1.000V should scale as 0.985mg. See Section 6.2.

7.13 CALIBRATE Test Menu – Span Membrane Mass Tests

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%, and will typically match within just a few micrograms. If not, the most common cause is a dirty membrane foil, which can be carefully cleaned with canned air or clean water rinse. Alcohol is not used because it leaves a film. CD cleaner works well for badly soiled membranes.

Caution: The span membrane foil is a thin sheet of polyester and is fragile. It must be replaced if damaged. Contact the Service department for replacement instructions.

```
              CALIBRATION MODE

REF MBRN: <
COUNT  (Io):        634000
COUNT  (I):         556234
CAL MASS M:         0.801 mg/cm2

START     STOP                    EXIT
```

The CALIBRATE Test Screen

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

The COUNT (I_0) value is the total 4-minute beta count through the filter tape only.

The COUNT (I) value is the total 4-minute beta count through both the filter and the membrane, and is always less the I_0 count.

The CAL MASS M value is the measured mass of the foil derived from the two count values.

The START 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 – Relay I/O Channel Tests

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 this screen changes in response.

The relay outputs TAPE FAULT, FLOW FAULT, INVALID DATA, MAINTENANCE, RELAY 1, and RELAY 2 are tested by turning them ON or OFF using the arrow keys, then verifying that

the contact closure outputs on the back panel terminals respond accordingly with an Ohm-meter. The old RANGE relay output is no longer supported.

7.15 FLOW Test Menu

The TEST > FLOW screen is where the important flow audits, checks, and calibrations are performed on the BAM 1020. See sections 5.4 and 5.5. This screen is also useful for checking the ambient temperature and barometric pressure sensors, and for pump capacity and flow controller tests.

7.16 ALIGN Test Menu – Tape Transport Motor and Photosensor Tests

The TEST > ALIGN menu system is used primarily to test the nine photosensors which monitor all of the mechanical movement in the BAM 1020 tape transport assembly. This is useful if the BAM 1020 has failed some of the Self-Test parameters. The function of the six ALIGN sub-menus are described in this section. **Note:** The filter tape should be removed during these tests, because many of these functions will break the tape.

```
TEST MENU


NOZZLE      SHUTTLE     IDLER       CAPSTAN
LATCH       REF



SELECT                              EXIT
```
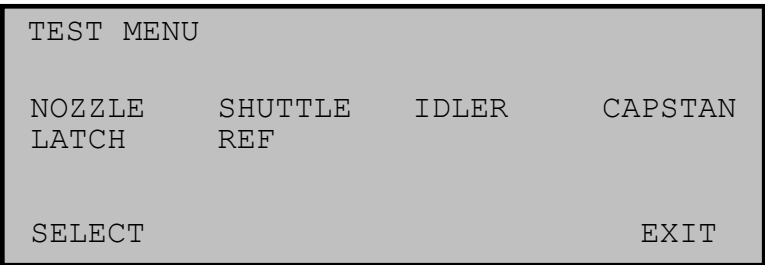
The TEST > ALIGN Menu

NOZZLE: This screen tests the two nozzle photosensors and the nozzle motor. 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 photosensor which monitors the position of the shuttle beam (the two outer tape rollers that move together). The status of photo sensor S7 should <u>only change to ON when the beam is moved all the way to the right side</u>. The shuttle must be moved by hand for this test. It rides on a ball slide and is not motor-driven.

IDLER: This screen tests the photosensors which monitors the position of the right-side spring-loaded tape tensioner. The tensioner must be moved by hand. When the tensioner is in the leftmost position under its spring pressure, 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. These are the sensors which monitor tape breakage and tape tensioning. The left side tensioner assembly has no photosensors.

CAPSTAN: This screen tests the photosensor which watch the rotation of the Capstan shaft motor. 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 turn 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.
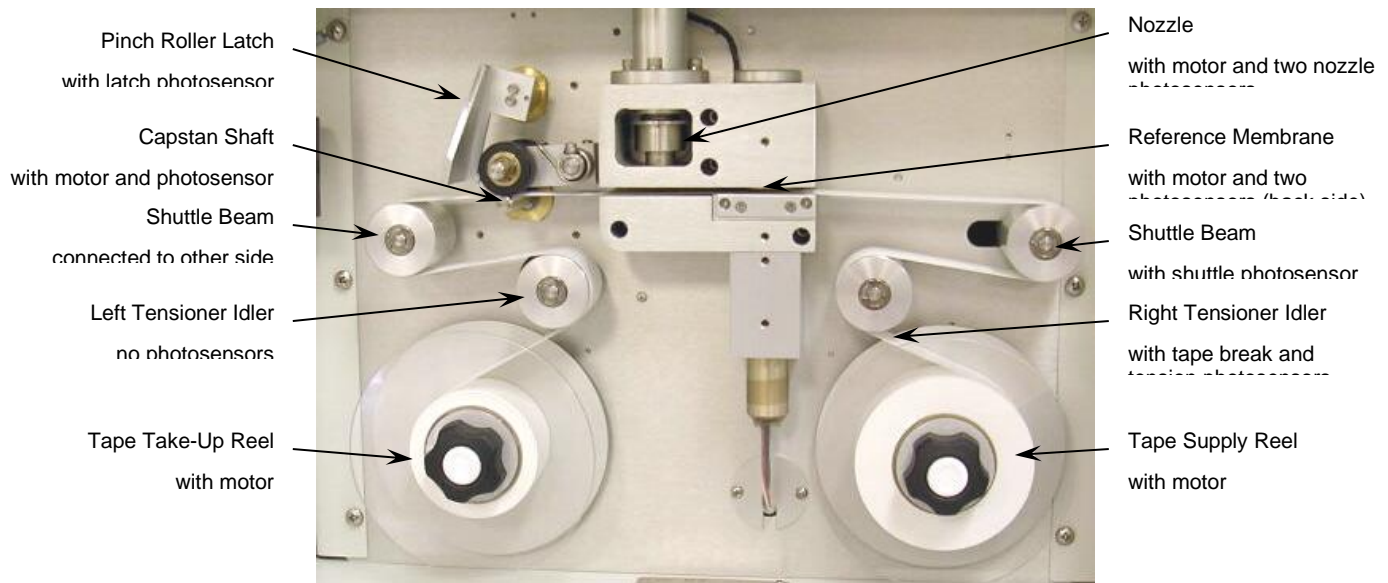
Tape Transport Assembly

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.
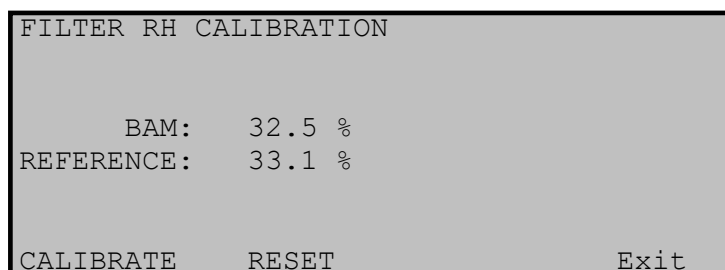
7.18 FILTER-T Test Menu – Filter Temperature Sensor Tests

The TEST > FILTER-T screen is used to check or 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. Allow the pump to run for at least 5 minutes to allow the sensor to equilibrate. When fully equilibrated, the filter temperature should match ambient within **+/- 1 deg C**. To calibrate it, enter the ambient room temperature from your reference standard into the REFERENCE field and press the CALIBRATE soft key. The RESET soft key can be used to revert to default calibrations and start over if difficulty is encountered.

Note: Never calibrate this sensor if the BAM inlet heater has been operating recently. The heater causes this sensor to measures higher than ambient. See the notes about equilibrating or removing the filter RH sensor for calibrations below.

7.19 FILTER-RH Test Menu – Filter Humidity Sensor Test and Calibration

The TEST > FILTER-RH screen is used to check or calibrate the filter relative humidity sensor located in the air stream beneath the filter tape. The sensor measures the RH of the sample air to control the Smart Inlet Heater system, which turns up or down as needed to maintain the sample near or below the RH set point value. See Section 6.9. The filter RH sensor (part 9278) should match ambient RH within +/- 4% when properly equilibrated. If the sensor fails, it usually reads something impossible like -25% or 135% RH.

```
FILTER RH CALIBRATION


      BAM:     32.5 %
REFERENCE:     33.1 %



CALIBRATE     RESET              Exit
```

The FILTER RH Test Screen

Important Equilibration Notes: It is difficult to effectively correlate an ambient RH measurement to the filter RH reading, because the BAM has some self-heating from the Smart Heater which causes the filter sensor to measure significantly lower than ambient RH. For this reason it is usually best to leave the factory default calibration alone, unless you have clear evidence that it needs to be calibrated. *If the filter RH sensor is calibrated without first being fully equilibrated to ambient, it will introduce a large artificial offset.*

For example: The ambient RH is 50%, but the filter RH sensor reads 20% due to inlet heat. If the filter sensor calibration is adjusted to that it matches 50%, this adds a +30% offset to all RH readings. Now the filter RH data values are all 30% too high and it looks like the inlet heater is not functioning and not regulating the sample RH when it actually is. In addition, the inlet heater may run at full power trying to achieve regulation to the set point.

To equilibrate the sensor without removing it from the sample stream: Enter the TEST > FILTER RH screen. The BAM will raise the nozzle and turn the pump on to pull room air past the RH sensor. Unplug the inlet heater and allow the BAM to cool completely to room conditions. This might take an hour or more. Position your RH audit device as close as possible to the BAM sample nozzle during calibration.

To remove the sensor from the flow system for calibration: Unplug the inlet heater and remove the BAM case cover. Remove the black 3-port compression manifold from the flow path. It is located under the nozzle motor and holds the two filter sensors. This is easiest with tool 9627 from the BX-308 tool kit. Leave the sensors plugged into the circuit board. Do not touch the RH sensor element because it is ESD sensitive. Move the sensor manifold away from the BAM so that an accurate ambient RH value can be obtained. Enter the TEST > FILTER-RH menu and allow the sensor to equilibrate for at least five minutes, then compare the BAM RH reading on the display to your reference RH device. To calibrate the sensor, enter the reference value into the BAM display and press CAL to change the BAM value to match.

The RESET key can be used to remove all previous field calibrations from the sensor and restore the default factory calibration. Do not press the CAL key after RESET, or whatever value happens to be in the REFERENCE field will be calibrated.

8 EXTERNAL DATA LOGGER INTERFACE SYSTEM

This section describes the configuration of the BAM 1020 to work with a separate, external data logger. The BAM 1020 provides an analog concentration output voltage along with a clock synchronization input feature which allows unit to function with many analog data loggers. The BAM 1020 digital data outputs can also be collected with digital data loggers or automatic digital data acquisition systems. In any case, the BAM 1020 internal digital data logging system still stores the complete data array, which can be collected periodically.

This section describes the BAM 1020 configurations required for external data loggers. Consult your data logger documentation for the specific setup requirements for your model. Met One Instruments can also supply technical bulletins describing sample setup programming for several of the more popular types of data logger.

8.1 Analog Concentration Output Signal

The BAM 1020 analog output type is selectable between voltage output (0-1 or 0-10 volt DC) or isolated current output (4-20 or 0-16 mA). The rear panel dipswitches are used to select the desired output as shown in the table below. The 1-volt voltage output is almost exclusively used for analog data logging applications.

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

Important Note: The scale of the output voltage of the BAM 1020 is determined by the RANGE and OFFSET setting. See Section 6.2. In most applications where the OFFSET is set to -0.015, and the RANGE is set to 1.000 mg, the BAM 1020 analog output will be scaled as **0.000v to 1.000v equals -0.015 mg to 0.985 mg.** It is critical that your analog data logger input is programmed to scale this voltage correctly, or a significant data offset mistake will occur! The BAM digital data should be periodically compared to the analog logger data to ensure correct logger scaling. In addition, the BAM output voltage DAC should be tested as described in Section 7.12 to ensure that the actual voltage output of the BAM matches the expected voltage.

Analog Error Encoding: The analog output is the only voltage channel available between the BAM 1020 and the data logger, so any errors generated by the BAM are reported using the same voltage signal. The BAM 1020 will set the analog output to its full-scale reading whenever a critical error prevents a valid concentration from being measured. It can optionally set the voltage to full-scale in response to other non-critical alarms as described in section 6.5. The external data logger should be programmed to recognize a full-scale reading as an error, and not a valid concentration. This method is used because it is rare for an actual concentration reading to exceed the range of the BAM 1020, and if it does, it should be reported as an invalid data point anyway. The digital data values stored in the BAM are always unaffected and available, if the alarm was non-critical and did not prevent the hourly concentration measurement from occurring.

8.2 Early Cycle Mode Option For Analog Data Collection

During a standard BAM 1020 measurement cycle, the BAM 1020 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 data loggers 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 BAM 1020 to start and finish the measurement a few minutes early in order to output the concentration voltage for the last five minutes of the hour which was just sampled. The data logger must be programmed to read this value during the window. Because of the critical timing involved, the BAM 1020 clock will have to be synchronized to the data logger clock using the EXT RESET inputs described below. The following describes the timing of the STANDARD and EARLY modes.
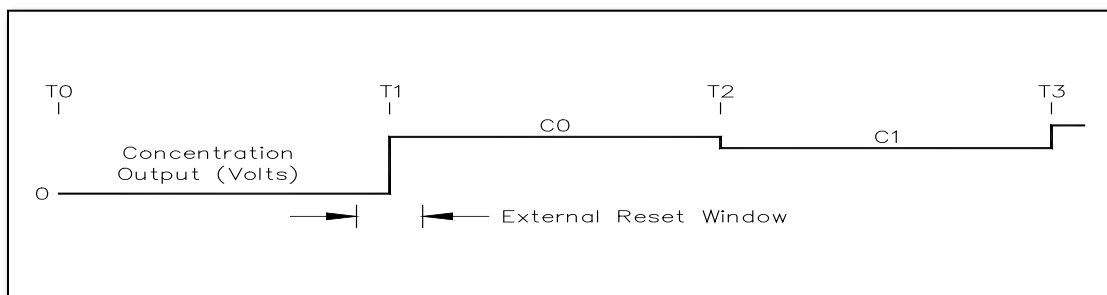
STANDARD Cycle Example
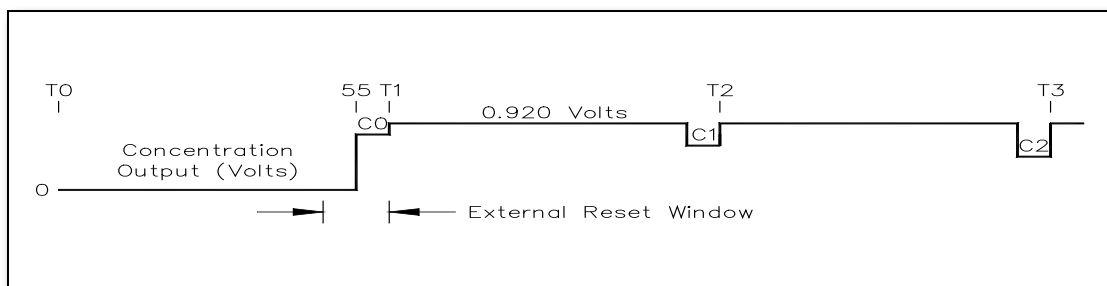
EARLY Cycle Example

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 fixed at 0.920 volts.

External Reset Windows

An external reset signal may be used to synchronize the BAM 1020 clock to the data logger. 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 BAM clock will not reset if the previous cycle has not finished the I_3 count, and an "E" alarm will be logged. See Section 7.2.

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 "E" alarm 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 "E" alarm 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 voltage, several input and output relay connections are provided on rear panel of the BAM 1020. These can be connected to an external data logger as a second method of indicating alarms between the BAM and the logger, but in practice most of these relay telemetry connections are rarely used. The function of each input and output is described below.

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 data logger. The data logger should not apply any voltage to the terminals. **Contact-closure outputs** from the BAM 1020 are provided by the BAM 1020 shorting the two terminals together with an internal relay, without applying any voltage or current to them. The external data logger must then sense the closure. The contacts are rated at 100VDC, 0.5A max. **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.

SIGNAL
COMMON
POWER — CHAN 1
ID

SIGNAL
COMMON
POWER — CHAN 2
ID

SIGNAL
COMMON
POWER — CHAN 3
ID

SIGNAL
COMMON — CHAN 4

TELEMETRY
FAULT
NO VOLTAGE

EXTERNAL
RESET
NO VOLTAGE

+
EXTERNAL
RESET VOLTAGE
-

TAPE
FAULT

FLOW
FAULT

INVALID
DATA

MAINTENANCE

POWER
ID
SIGNAL
COMMON — CHAN 5
POWER
ID
SIGNAL
COMMON — CHAN 6
POWER
ID
SIGNAL
COMMON — CHAN 7
POWER
ID

RELAY 1 NC
COMMON

COMMON
RELAY 1 NO

PUMP
CONTROL

POWER
FAIL

+
VOLTAGE
OUTPUT
-

CHASSIS
GROUNDS

+
CURRENT
OUTPUT
-

Analog Output Switch

OPTION SWITCH
1 2 3 4

SW1 OFF= 0-1V
SW1 ON= 0-10V
SW2 OFF= 0-16mA
SW2 ON= 4-20mA

RS232 POLARITY
C1 NORMAL
C2 REVERSE

RS-232

PRINTER

REPORT POLARITY
C1 NORMAL
C2 REVERSE

REPORT

COM 3

ETHERNET

BAM 1020 Back Panel and Relay Connections (Extra Report Processor Digital Outputs Shown)

1. **TELEMETRY FAULT NO VOLTAGE**   This input can be used to signal the BAM 1020 that the external telemetry system (data logger) is not operational. This contact-closure input 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 7.2), and will also activate the INVALID DATA relay output. This input can be set to normally-open or normally-closed in the SETUP > INTERFACE menu. Rarely used.

2. **EXTERNAL RESET NO VOLTAGE**   This input can be used to synchronize the BAM 1020 clock to the external data logger at the top of the hour, and is often used in EARLY cycle mode. 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. **EXTERNAL RESET VOLTAGE**   This input is the same as above except the input is activated by a TTL logic voltage 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" tape error is generated by the BAM (see section 7.2). Polarity is normally-open.

5. **FLOW FAULT**   This is a contact-closure output which will be activated whenever an "F" flow error is generated by the BAM (see section 7.2). 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 7.2). Polarity is normally-open.

7. **MAINTENANCE**   This is a contact-closure output which will be activated whenever a maintenance "M" flag is generated by the BAM (see section 7.2). Polarity is normally-open.

8. **RELAY 1 NC/NO**   This relay output is used in dual-unit coarse configurations only. The master BAM outputs a clock synch signal to the external reset input of the slave unit using this output.

9. **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.

10. **POWER FAIL**   This is a contact-closure output which will be activated (closed) whenever a power failure or an "L" error occurs in the BAM (see section 7.2).

11. **VOLTAGE OUTPUT**   This is the BAM analog concentration output voltage connection. See section 8.1. Polarity must be observed on this output.

12. **CHASSIS GROUNDS**   These are the earth-ground terminals. These should be attached to a ground rod for best operation of the BAM 1020.

13. **CURRENT 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 data logger. Output is selectable between 4-20mA or 0-16mA.

8.4   Interfacing a Digital Data logger with the BAM 1020

Many BAM 1020 users configure an external digital data logger to retrieve data from the BAM 1020. This typically requires some programming experience with the particular type of digital logger to be used. Several environmental data logger manufacturers supply pre-made BAM 1020 drivers for basic data collection applications. All digital files from the BAM 1020 must be obtained through the RS-232 port or the newer REPORT serial port, or in some cases from the PRINTER port. The BAM 1020 digital files are described in Section 9.

The most common method is to program the digital logger to request the last hourly comma-separated data record array from the BAM 1020, once per hour, using the RS-232 or REPORT port. In this case, the logger must establish connection with the BAM by sending three carriage returns (ENTER key), then send the **6 (csv report), 4 (last data)** command string just like you might when downloading the data with a computer and a terminal program as described in Section 9.4. The logger must ignore the BAM menu responses, then receive the hourly data array response and parse out the desired data parameters and store them appropriately. The last concentration value, Qtot flow volume, ambient temperature, pressure, filter RH, and alarm bits are often collected in this manner.

CPU Interruptions: Care is required when collecting data from the classic BAM 1020 RS-232 port. The BAM main CPU cannot multitask, so if the BAM 1020 is moving any of the filter tape or span membrane motors (especially near the top of each hour) it will ignore any RS-232 serial port commands and interrupt any serial data downloads until the mechanical motion is complete. See Section 4. The best solution when using the classic RS-232 port is to program the digital logger to make a single hourly data request to the BAM near the middle of each hour, such as between minute 25 and minute 50. However, small files such as the last hourly record can be downloaded very quickly, and may be accomplished at almost any time during the hour as long as the timing is carefully controlled. If your data logger is programmed to digitally request data from the BAM 1020 RS-232 port continuously throughout the hour (such as every minute), then some number of the data requests will certainly be ignored by the BAM due to mechanical interrupts.

The BX-965 Report Processor back panel option was designed to allow easier digital data connectivity with the BAM 1020. The REPORT serial port works exactly like the classic RS-232 port and accesses the same files, except that it has its own CPU and memory and cannot be interrupted or ignored. The REPORT port also has much more data memory capacity. The classic RS-232 port and it's legacy functionality is also still supported on Report Processor back panels as a backup.

Clock Timing With Digital Loggers: Timing must also be considered when collection BAM data with a digital system. If the BAM is operating in standard cycle mode, then the digital concentration data values are updated exactly at the top of the hour. If the digital logger is set to collect the BAM concentration value as soon as it is available, then the clocks should be synchronized to prevent collecting the wrong hourly record.

If the logger must have the BAM concentration before the top of the hour, then the BAM can be set for early cycle mode, and the BAM clock will have to be synchronized to the logger. Some BAM 1020 users leave the BAM in standard cycle mode and set their digital logger to synchronize the BAM clock at minute 59 of the hour. This causes the BAM to be one minute ahead of the logger so that the concentration is available at the top of the logger hour. This method is similar to running in early cycle mode, except the timing schedule is much easier to understand.

9   DIGITAL COMMUNICATIONS AND 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 BAM 1020 has one or more two-way RS-232 serial ports which may be used with a computer, laptop, modem, or digital data logger. The data can be accessed through the serial ports with a terminal program and a simple menu driven interface, or by using the free Comet software that comes with the BAM.
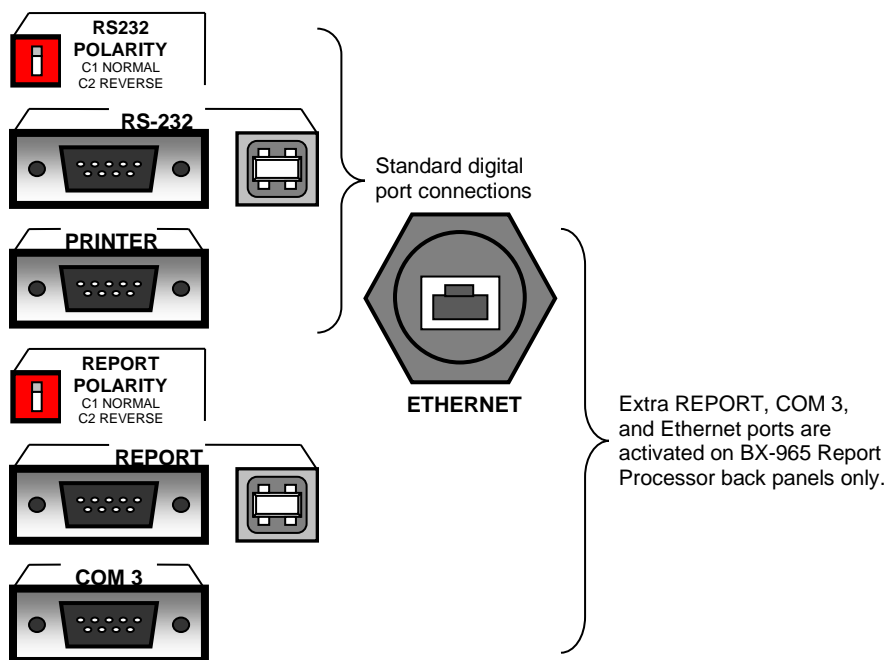
BAM 1020 Back Panel Digital Connections

9.1   Direct Serial Port Connections and Settings

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

RS-232 Connections:

Most older desktop and laptop computers have a standard 9-Pin serial port available for communications. In these circumstances, the BAM 1020 RS-232 or REPORT port can be directly connected to the serial port. Connect the port on the back of the BAM 1020 to the COM port connector on the computer with the supplied BAM serial cable (part 400658, female-to-female 9-pin null). **CAUTION:** Do not confuse the parallel printer port or video adapter port on your computer with a serial port.

USB Connections:

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

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

Communication Settings:

The BAM 1020 communicates at 9600 Baud, 8 data bit, no parity, one stop bit, and no flow control. The default 9600 baud rate may be changed to a faster setting for downloading large BAM data files, but in any case, the terminal program baud rate must match the BAM baud setting. If unable to establish communications, try changing the RS-232 Polarity switch (or the Report Polarity switch, if using the REPORT connection) on the back of the BAM 1020. This swaps the polarity of the TX and RX lines (pins 2&3) and functions as a null modem.

NOTE: The BAM 1020 user interface must be in the main top-level menu or OPERATE menu before any communication can be established through the RS-232 port. The LCD display and keypad on the BAM 1020 are disabled whenever RS-232 communication with the CPU is in progress. The optional REPORT port does not have these limitations.

9.2 Using Met One Comet Communications Software

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

The Comet program is very simple and easy to use and can be mastered quickly without having to navigate any of the BAM terminal menus described in sections 9.3 and 9.4.
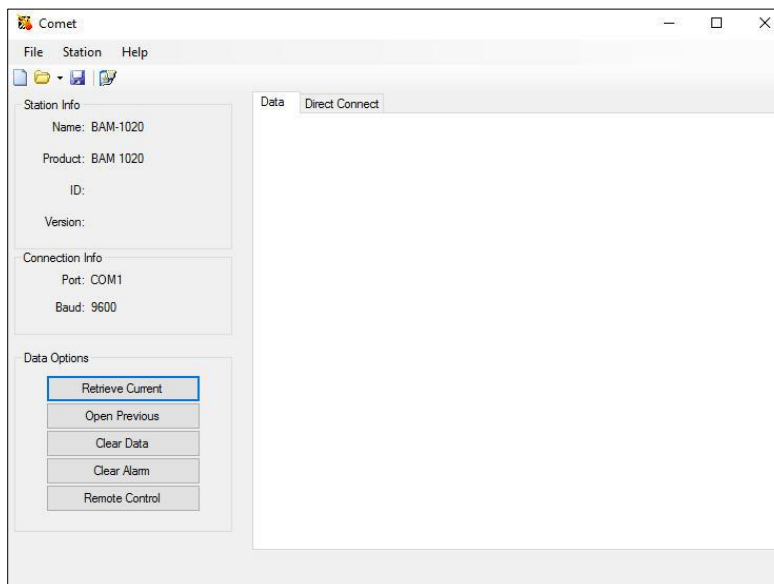
Install the program on your computer, then run it from the programs directory. You will have the option to select a previously saved station, or to create a new one.

Once you have your station open and ready for use, click the "Retrieve Current" button. A window will appear to select which files you want to retrieve. Press Retrieve to collect and save the selected files.

The Comet program has a "Direct Connect" tab which allows you to access the ASCII menu system and data files from the BAM exactly as you would when using any other terminal program as described in section 9.4.

9.3 Downloading Data Using Simple Terminal Programs

The BAM 1020 data can be easily downloaded through the serial ports using HyperTerminal® or other simple terminal programs. Nearly all PCs have the HyperTerminal program already included. The following describes how to set up the program with the BAM 1020:

1. Connect the RS-232 or REPORT 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 can 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 ASCII characters in the menu to retrieve the desired files. The menu options are described in the following section.

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. Anything that comes through the terminal window will be saved to the file. Click the "Stop" button to stop capturing the text.

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.
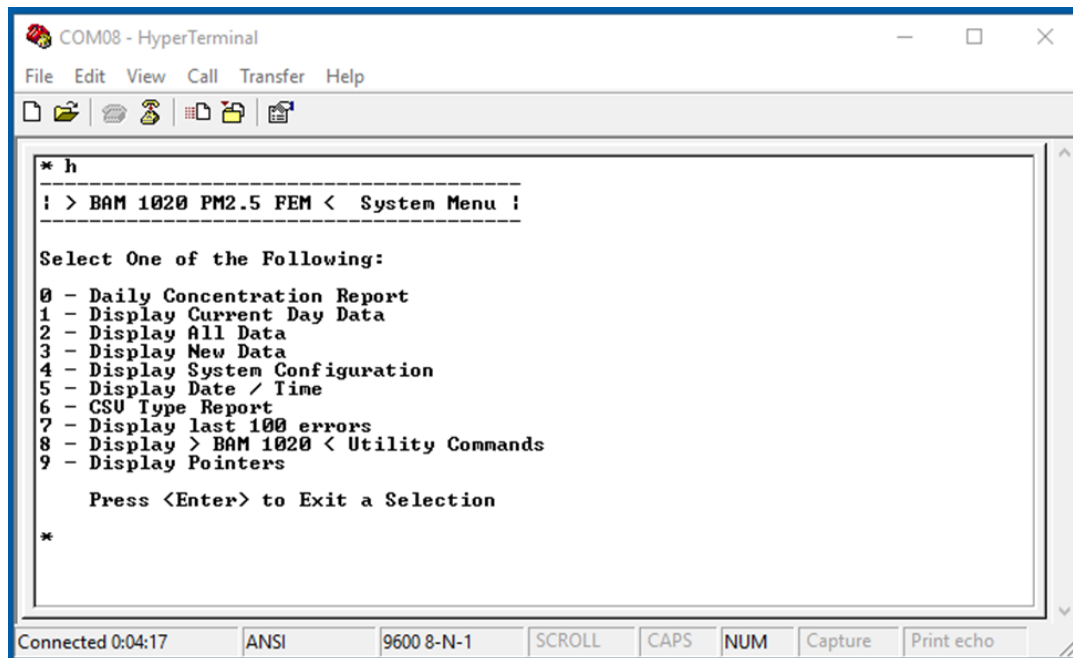
Terminal Window showing BAM 1020 menu

9.4   System Menu and File Descriptions Using a Terminal Program

Once a serial connection between a terminal program 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 BAM 1020. 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 press ENTER three times to reestablish the asterisk command prompt, then send another **"h"** to refresh the menu. If you already know the number of the file you want, you can skip the H menu altogether.

File 0:   Daily Concentration Report:

This file reports the daily concentration values. It provides the date, the daily concentration value, and the data percentage captured that day. Entering this menu option will display options for either all of the stored daily concentration data or just the new daily data captured since the last download. A data pointer is set in the BAM indicating where the last download stopped. See Section 9.8. A typical daily concentration report looks like this:

```
Daily Conc Report
2018-05-31 12:16:55, 1
Date,Conc(mg/m3),Capture(%)
2018-05-25, 0.0001, 33
2018-05-26, 0.0012,100
2018-05-27, 0.0007,100
2018-05-28, 0.0007,100
```

Files 1, 2, and 3:   Current Day Data, All Data, New Data:

These files are simple text views, and are for easy visual checks of the data only, because it is difficult to import these into a spreadsheet for analysis. An example of the data format is shown below. File 1 Current Data is data from the current day only. File 2 All Data is all of the data in the BAM separated into daily blocks. File 3 New Data is all data since the last download, also in daily blocks. A data pointer is set in the BAM indicating where the last download stopped. See Section 9.8.

The first data column is the time, followed by a series of dashes which represent error or alarm bits. 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. The Qtot column is total flow volume for the hour. With a flow rate of 16.70 L/min and a sample time of 50 minutes, this value will be about .834 m^3 per hour. With a sample time of 42 minutes this value will be about 0.701 m^3 per hour. The remaining six columns are the six data logger 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 the unused channels 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 Current Day data text file example

File 4:   Display System Configuration (BAM Settings File):

This file contains a list of the BAM 1020 settings and calibration values. This is useful for verifying the setup parameters and will most likely be requested by the factory if service is required. Following is an example of the File 4 settings report. Older revisions of BAM firmware may display a slightly different report format than the one shown on the next page.

```
BAM 1020 Settings Report
08/21/2018  09:00:12

      Station ID, 1
   Serial Number, P10558

        Firmware, 3236-05 V3.14.2
   80350 Firmware, 80353-03 R2.8.0

              K, 01.000
           BKGD, 0.0000
            usw, 00.285
            ABS, 00.890
          Range, 1.000
         Offset, -0.005
          Clamp, -0.005
     Conc Units, mg/m3
      Conc Type, ACTUAL
     Count Time, 4
     Conc Error, FULL SCALE VALUE
     Inlet Type, PM10

             Cv, 01.000
             Qo, 00.000
      Flow Type, ACTUAL
     Flow Setpt, 0016.7
      Std Temp, 25

      Heat Mode, AUTO
       FRH Ctrl, YES
      FRH SetPt, 35
      Low Power, 20
        FRH Log, YES
         FT Log, NO

     BAM Sample, 50
     MET Sample, 1
     Cycle Mode, STANDARD
  Fault Polarity, NORM
  Reset Polarity, NORM
    Maintenance, OFF

        HJ 653, NO

   EUMILRNFPDCT
   111111111111

             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,     41,
     Channel ID,    255,    255,    255,    255,    255,    254,
           Name,   BP  ,  XXXXX,   Memb ,  FRH  ,  XXXXX,   AT ,
          Units,    mHg,    XXX,    mg ,    %  ,    XXX,   C  ,
           Prec,      1,      0,      3,      0,      0,      1,
       FS Volts,  2.500,  1.000,  2.500,  0.500,  1.000,  2.500,
           Mult,  300.0,      1,  4.095,     32,      1,  100.0,
         Offset,  525.0,      0,  0.000,    -26,      0,  -50.0,
    Vect/Scalar,      S,      S,      S,      S,      S,      S,
      Inv Slope,      N,      N,      N,      N,      N,      N,

    Calibration,  Offset,   Slope,
           Flow,   0.000,   1.000,
             AT,  80.000,
             BP,   0.000,
            FRH,  50.000,
             FT,   0.000,

          QUERY,         1,   CONC_A,
    Daily Range, 01:00 - 24:00
  Dynamic Range, EXTENDED
     Span Check, 1 HR
         Log BP, CHAN 1
   Log Membrane, CHAN 3
```

File 4 System Configuration (Settings) File Example

File 5:   Display Date / Time:

This file command will show the date and time of the BAM 1020 real-time clock.

File 6:   CSV Type Report:

The CSV data menu is commonly used for BAM data retrieval through terminal programs. The 6 command will respond with the sub-commands shown below. The data values in each file are separated by commas. This allows the text file to be opened directly by 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 data logger. Following is a list of the sub-files available in CSV format. Sub files 5, 6, 7, and 8 are flow diagnostics files and are rarely used.

> **2 – Display All Data**   **(All data records in the BAM)**
> **3 – Display New Data**   **(Data records since last download)**
> **4 – Display Last Data**   **(Previous hour's data only)**
> 5 – Display All Flow Stats   (All flow stats files)
> 6 – Display New Flow Stats   (Flow 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)
> **9 – Display Error Log**   **(Error/alarm log showing sub-categories)**

Example of a CSV report of the "LAST DATA" record (File 6 sub-file 4):

The following example shows a typical CSV download of the file 6,4 last data record from the BAM 1020, such as might be retrieved by an external digital data logger on an hourly basis. 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. The BAM responds with a single asterisk (*) indicating that communication is established.

2. An ASCII character "6" is sent to the BAM requesting the file 6 CSV menu. The BAM responds with the CSV menu options as shown below, ending with ">".

3. An ASCII character "4" is sent to the BAM, requesting file 4 "Display Last Data". The BAM responds with the Station ID number, 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.

```
* 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),FRH(%),FT(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 (File 6 sub-file 3):

The following example shows a typical CSV download of the file 6,3 new data records form the BAM 1020, such as might be done for routine data collection using a local computer or modem. The file contains all of the data record since the last download, and resets the data pointers. See Section 9.8.

1. A series of three carriage returns is sent to the BAM through the serial port. The BAM responds with a single asterisk (*) indicating that communication is established.

2. An ASCII character "6" is sent to the BAM requesting the file 6 CSV menu. The BAM responds with the CSV menu options as shown below, ending with ">".

3. An ASCII character "3" is sent to the BAM, requesting file 3 "Display New Data". The BAM responds with the Station ID number, then the header info, then the data records.

The data starts at the first record since last time it was retrieved. In this example, the MET SAMPLE was set to log the array every 15 minutes.

```
* 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

9 - Display Error Log

>3 - Display CSV Data
Station,  5
Time,Conc(mg/m3),Qtot(m3),WS(MPS),WD(DEG),BP(mm), FRH(%),FT(C),AT(C),E,U,M,I,L,R,N,F,P,D,C,T
10/02/07 17:45,  0.001, 0.700, 0.110,0,0,36,28.3,23.0,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 18:00,  0.001, 0.700, 0.127,0,0,38,28.4,23.2,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 18:15,  0.001, 0.700, 0.130,0,0,38,28.2,23.6,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 18:30,  0.001, 0.700, 0.110,0,0,36,28.1,23.5,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 18:45,  0.001, 0.700, 0.110,0,0,37,28.2,24.0,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 19:00,  0.003, 0.700, 0.127,0,0,38,28.1,24.6,0,0,0,0,0,1,0,0,0,0,0,0,
10/02/07 19:15,  0.003, 0.700, 0.129,0,0,38,28.1,24.8,0,0,0,0,0,0,0,0,0,0,0,0,
10/02/07 19:30,  0.003, 0.700, 0.109,0,0,37,28.9,24.0,0,0,0,0,0,0,0,0,0,0,0,0,
```
Example of CSV new data report

If the HJ 653 option is set to ON (see section 6.12), the file will be formatted as shown in section 6.12 instead of in the manner shown above.

Note: *The user can delete the menu characters from the beginning of the text file, leaving only the data header row and the data records, then save the text file. The file extension can then be changed from .txt to .csv to change the file format into one that can be directly opened by a spreadsheet. Each data parameter should then appear in its own column of the spreadsheet.*

CSV Reports of Flow Statistics and 5-Min Flow Files:

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. The flow statistics files are typically used for diagnostics only.

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.
BP Min	Minimum ambient pressure for the BAM sample period.
BP 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	5 Minute average flow rate for the BAM sample period.
AT	5 Minute average ambient temperature for the BAM sample period.
BP	5 Minute average ambient pressure for the BAM sample period.
FP	5 Minute average filter pressure for the BAM sample period.

File 7:   Display Last 100 Errors (Error Log):

This file contains the date, time, and a description of each of the last 100 errors logged by the BAM 1020, in text format. This file reports the 12 main alarm categories only, but not the sub-categories showing the more specific alarm cause. For this reason, the csv error log file should be used instead (file 6 sub-file 9). This file should be downloaded to identify the exact sub-category of any errors or alarms which are not immediately evident.

File 8:   Display BAM 1020 Utility Commands:

This file contains a list of 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 functions are shown in the table below.

Command	Command Function
a	**Printer Port Output Configuration.** This sets what is output on the printer 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 serial command erases all stored data from memory! Password required.
d	**Set Date.** This sets the date on the BAM 1020. 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	**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 BAM 1020. Password required.
b	**XMODEM Data Download**. This command allows binary data transfer of the BAM 1020 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. Available in firmware 3.2 or later only.

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 Functions

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 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. If a different modem is used, it must be set in "dumb terminal" mode or equivalent because the BAM does not support handshaking with the modem. 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, Air Plus 5, or Comet 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. After connection, the data collection is the same as it would be with a direct serial connection to the BAM.

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 at least three times 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 ASCII menu driven interface as used for the direct PC connection.

9.7 BAM 1020 Firmware Upgrades

The BAM 1020 has a system of one or more firmware (embedded software) programs located in one or more EEPROM chips that control the operation of the BAM 1020. There are also several different possible versions of these firmware programs depending on the intended configuration of the BAM 1020.

The BAM 1020 CPU board in all units runs at least the main instrument control firmware program (part number 3236-X), which can be updated through the RS-232 port. The optional BX-965 Report Processor back panel board has its own firmware (part number 80353-X), which can be updated through the REPORT port. The optional BX-970 touch screen display has its own software based on Windows CE (part number 80596), which can be updated by installing an update flash drive in a USB port inside the front door on these touch screen units. The following is a basic table of the different firmware programs:

Part Number	Ver/Rev Series	Description
3236-02	V 3.X.X (and earlier)	PM10-only firmware for main CPU. Units without touch screen.
3236-02	V 3.4.X	PM10 and PM2.5 FEM (USA type) firmware for main CPU. Units without touch screen.
3236-05	V 3.X.X	PM2.5 FEM (USA type) firmware for main CPU. Units without touch screen.
3236-06	V 3.X.X	PM-Coarse FEM firmware for main CPU. Units without touch screen.
3236-07	V 5.X.X	PM10 & PM2.5 EU (Euro type) firmware for main CPU. Units without touch screen.
3236-55	V 4.X.X	PM2.5, PM10, & Coarse FEM (USA type) firmware for main CPU, units with touch screen only.
3236-77	V 5.X.X	PM2.5 & PM10 EU (Euro type) firmware for main CPU, units with touch screen only.
80353-1	V 1.X.X	BX-965 Report Processor firmware, older units with HC11 processor only
80353-3	R 2.X.X	BX-965 Report Processor firmware, units with HC12 processor, all units except touch screen.
80353-4	R 2.X.X	BX-965 Report Processor firmware, for all units with BX-970 touch screen.
80596	V 2.X.X	BX-970 Touch Screen panel PC software.

Warning! The compatibility and interactivity of these various firmware programs is complex. Some firmware versions and/or revisions are incompatible with others, and upgrading one program may require upgrading other programs in order to maintain compatibility. Please contact Met One technical service in order to ensure that you have the correct files before attempting to upgrade any firmware.

The BAM 1020 has the capability for flash firmware upgrades through the serial ports. Flash updates allow the field operator to easily reprogram the main EEPROM firmware to the latest revision through the serial port using the Flash Update Utility. Units which currently run firmware revision 3.0 or later already have a flash compatible EEPROM. If the BAM 1020 has old revision 2.58 or earlier firmware, then you will need to physically replace the EEPROM chip with a flash compatible chip available from Met One.

You will need a computer or laptop with an RS-232 (9-pin) serial COM port and the standard BAM serial cable that came with the BAM 1020. Laptops without a 9-pin COM port will need a reliable USB-to-RS-232 converter, or a USB cable can be used if your BAM has the USB converter port on the back. Do not update the firmware over a modem.

Note: The main BAM 1020 operating system firmware is always updated through the standard RS-232 port only. The Report Processor back panel option has its own EEPROM, its own processor, and its own memory. The Report Processor firmware can be flash updated through the REPORT port, in a similar manner to the main BAM firmware.

Warning! Take great effort to ensure that the power source to the BAM 1020 will not be interrupted during the flash firmware update process! A power interruption may cause the firmware to become inoperative, and the BAM 1020 will have to be returned to the factory!

Before the flash firmware update:

- Download and save all BAM 1020 data and error logs. These files will be erased from memory during the upgrade process!

- Download the BAM 1020 settings file, or at least record your current settings in the SETUP > SAMPLE and SETUP > CALIBRATE screens. Note: If the BAM already has revision 3.2 or later firmware, then none of the settings or calibrations should be affected by the update process.

- Set the BAM baud rate to 9600 for the flash update process.

Flash Update Process:

1. A Met One technician will probably e-mail you a link to the FTP file server site where the current Firmware Update Utility program is located. It will look something like the following:

   http://metoneftp.com/service/Firmware_Upgrades/BAM 1020%20Firmware/BAM%201020%20Firmware %20Installer%20PM2.5%203236-05%20V3.4.3.exe

2. Click on the link or paste it into your internet browser address bar. After a moment the following download window should appear:

   You can run the executable installer program if this is the same computer you plan to use to update the BAM unit, otherwise click "Save" and save the installer to the hard drive or to a removable drive that you can use to transfer the file to the computer you plan to use for the update.

3. Transfer the executable installer file to the appropriate computer if needed, then run the .exe program to extract and install the Firmware Update Utility. The installer will guide you through the installation steps.

4. Connect the COM port of the computer (usually COM 1) to the **RS-232** port on the BAM 1020 with the standard BAM serial cable. The BAM 1020 should be set to 9600 baud in the SETUP menu. The BAM must be powered on and displaying the main menu screen.

5. From the Windows Start menu, go to *Programs/Met One/BAM 1020/BAM 1020 Firmware Installer* to run the Firmware Update Utility program as shown below. Press Y and the Enter key to proceed. The program will then prompt you for the COM port number. Enter the number (usually 1) and press the Enter key to begin the update process.
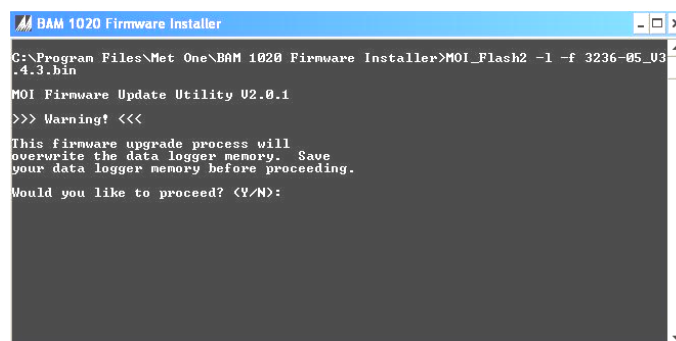
6. Execution time is approximately 12 minutes. Do not disconnect the serial cable or power during this time. The BAM display will show a warning screen during the update. If the main menu is still displayed, then the update is not occurring. Check the

BAM baud rate, serial cable connections, and polarity switch. A "Done!" message will be displayed in the computer window at the end of the update process.

After the flash firmware update:

- Check or set the BAM baud rate back to the desired rate for regular data collection.

- Reset the calibration of the filter temperature and filter RH sensors. Default and then recalibrate the ambient temperature, pressure and flow in the TEST > FLOW screen. **Note:** *Sometimes false field calibration values can end up in these parameters as a result of firmware updates, and they must be cleared out for proper BAM operation.*

- Check and verify the settings in the SETUP > SAMPLE and SETUP > CALIBRATE screens to ensure that they are still correct. It is always good practice to review all settings after any firmware update.

9.8   Resetting the Data Pointer for New Data Collection

The BAM 1020 sets a data pointer when data files are retrieved. The pointer indicates the last data record collected, so that next time "new data" is retrieved, only data back to that pointer is sent. This prevents collecting redundant data and needlessly large files. It is sometimes helpful to be able to manually reset this pointer back to a specific record if it becomes incorrectly set, such as if a modem hangs up in the middle of a download. BAM firmware rev 3.2.6 and later allows the data pointer to be manually reset by sending an escape command through the serial port. Note: The REPORT port on the optional Report Processor back panel uses different pointer reset commands. See the BX-965 manual.

The reset command is **<esc>FH<cr>** where **<esc>** is the esc key. F is the desired file number of **3** (data log file), **6** (flow stats file), or **8** (5-min flow file). H is the number of hours back from current to set the pointer (1 to 9999). **<cr>** is the enter key.

For example, sending **<esc>3 24<cr>** through the RS-232 port would set the data pointer of the main BAM data memory back to 24 hours ago.

The daily concentration values pointer may also be reset in a similar manner using the command **<esc>0 D<cr>** where **<esc>** is the esc key. **0** is the daily concentration log file, and **D** is the number of days back from the current set point. The time is always set as 00:00:00, the start of the day.

9.9   Data Collection Using the Query Output or Bayern-Hessen Protocol

BAM 1020 units equipped with revision 3.6.3 or later firmware are capable of outputting the custom Query digital data array. European units with revision 5 series firmware are compatible with the Bayern-Hessen data protocol. The format of the Query or BH data array outputs is determined by the user-selected parameters in the SETUP > QUERY menu as described in Section 6.10. **Note:** The Query output can only be accessed through the REPORT serial port on the optional BX-965 Report Processor back panel.

Bayern-Hessen "BH" Protocol:

The Bayern-Hessen protocol is used to support certain European data networks. The complete protocol is not described in this manual, but is available a separate technical document. The primary difference between the Query and the BH data configurations is that the BH protocol does not support the time/date field used in the Query array, but the BH protocol does support a diagnostic stability field which is not accessible with the Query array.

In addition, the BH protocol can only accommodate eight alarm types (0-7) instead of the standard twelve, so some of the alarm states are grouped together. The BH protocol also supports eight real-time status bits to indicate which part of the sample cycle is in progress.

Custom Query Output:

The Query output is provided to allow easier configuration of digital data logger and more flexibility in the BAM 1020 digital output array. The Query output array is set to include only the desired parameters in the desired order, and is accessed with a simple escape command sequence. This eliminates much of the work associated with programming a digital data logger to establish a command prompt, navigate the classic digital menu system, and parse out multiple unused data parameters.

No command prompt must be established with the BAM 1020 as with the classic digital menu access commands. Only the <Esc> escape character (hex 1B) or the <STX> character (hex 02) followed by the desired Query file and a carriage return (enter). The resulting Query output from the BAM will consist of the last data record in the BAM memory, in comma-separated format. The available Query commands are listed below:

Escape Command	Description
<Esc> QC <enter>	Custom Query output. Data is formatted exactly as specified in the SETUP > QUERY screen. All values are in comma separated format, with a fixed width of 7 characters per field excluding commas.
<Esc> QCH <enter>	Data header for the custom Query output.
<Esc> Q <enter>	Standard Query output. Data array configured exactly like the standard csv last data output (menu 6,4) regardless of the Query setup screen. All values are in comma separated format, with a fixed width of 6 characters per field excluding commas.
<Esc> QH <enter>	Data header for the standard Query output.

An example of one possible QCH (custom array header) and QC (custom Query array) command are shown below. Each escape command is followed by the response from the BAM 1020:

```
<Esc>QCH
TIME,CONC(mg/m3),FLOW(lpm),AT(C),BP(mmHg),RH(%),REF(mg),ERRORS,*4348
<Esc>QC
07/06/10 13:22, 0.0230,   16.7,   23.6,   761,   26, 0.8160,   0,*3129
```

An example of the QH and Q commands is shown below. This mirrors the familiar csv last data output of the BAM 1020, and ignores the user set format of the custom Query array:

```
<Esc>QH
Time,Conc(mg/m3),Qtot(m3),WS(KPH),WS(MPS),WS(MPS),FRH(%),FT(C),AT(C),E,U,M,I,L,R,N,F,P,D,C,T,*6451
<Esc>Q
07/06/10 15:00, 0.023, 0.701,   0.8,   0.8,   0.8,   26, 28.6,  23.6,0,0,0,0,0,0,0,0,0,0,0,0,*4224
```

If the error status is included in the custom Query array (QC), it will appear as a decimal error code as shown below. Each decimal code value corresponds to one of the twelve regular BAM 1020 error or alarm types as described in Section 7.2.

Decimal Code	Error Flag	Description
0	none	No error
1	T	Tape System Errors
2	C	Beta Count Error
4	D	Deviant Membrane Density Alarm
8	P	Pressure Drop Alarm
16	F	Flow Errors
32	N	Nozzle Error
64	R	Reference Error, Membrane Timeout
128	L	Power Failure
256	I	Internal Error, Coarse Link Down
512	M	Maintenance Flag
1024	U	Telemetry Fault
2048	E	External Reset Error
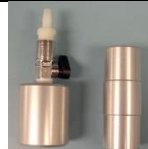
A data integrity checksum is included at the end of each Query array, after the delimiter asterisk character '*'. The checksum is the 16-bit arithmetic sum of all characters in the line up to but not including the asterisk.

Note: Digital data loggers may be programmed to use the <STX> (hex 02) character instead of the <ESC>, to prevent the echoing of the command back to the logger.

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 and provide the serial number of your BAM 1020. Some of these parts require technical skills or special considerations before use or installation.

Consumables		
Description	**Part Number**	**Graphic**
Filter Tape Roll, Glass Fiber, 70+ days per roll 30mm x 25m	**460180**	
Cotton-Tipped Applicators, nozzle cleaning, 100 pack Solon #362	**995217**	
Silicone O-Ring Grease, mini packets	**995712**	

Calibration & Service Tools		
Description	**Part Number**	**Graphic**
BAM 1020 Basic Service Tool Kit: Includes nozzle shims, reel spacer, filter sensor removal tool, dark test shim, rubber leak check tool, hex wrenches.	**BX-308**	
BAM 1020 Distributor Service Tool Kit: Includes all of the above plus two spring scales.	**BX-308-1**	
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**	
Nozzle Adjustment Shim Kit. 8235/8236 Shims Only.	**BX-310**	
Rubber Leak Test Nozzle Seal Tool	**7440**	
Span Membrane Assembly, Standard Replacement Approx 0.800 mg/cm2	**8069**	
Span Membrane Assembly, Mid-Range Approx 0.500 mg/cm2	**BX-301**	
Flow Inlet Adapter Kit (Leak Test Valve) Includes short inlet tube adapter.	**BX-305**	

Description	Part Number	Graphic
Zero Filter Calibration Kit, with leak check valve. Required for PM2.5 FEM monitoring. Same as BX-305 but with 0.2 micron filter.	**BX-302**	
Volumetric Flow Calibration Kit (BGI deltaCal™) Flow, Temp, and Pressure Reference Standards Met One recommended flow meter	**BX-307**	

Vacuum Pumps & Pump Parts

Description	Part Number	Graphic
Pump, Medo, 115 VAC, 50/60 Hz, Low Noise	**BX-126**	
Pump, Gast, Rotary Vane, 100/115 VAC, 50/60 Hz	**BX-121**	
Pump, Gast, Rotary Vane, 220/240 VAC, 50/60 Hz	**BX-122**	
Muffler, Medo/Gast Pump, Replacement	580293	
Gast Pump Rebuild Kit. Vanes, filters.	680828	
Medo Pump Rebuild Kit, Piston, filters	680839	
Pump Service Kit, Filter Replacement, Medo	8588	
Pump Controller (Relay Module Only) Medo	**BX-139**	
Pump Controller (Relay Module Only) Gast	**BX-139-1**	

Flow System Components

Description	Part Number	Graphic
Flow Sensor, Mass, 0-20 LPM, Internal Assembly	80324	
Automatic Flow Controller	**BX-961**	
Filter Assembly, Pisco In-line	580291	
Filter Element Only, Pisco In-line	580292	
Filter RH Sensor Replacement Only	9278	
Filter Temperature Sensor Replacement Only	9279	

O-Ring, Nozzle	720066	
Nozzle Rebuild Kit, with parts and tools	80355	
O-Ring, Inlet Tube Receiver, 2 required.	720069	
O-Ring Kit, Inlet Tube Receiver and Nozzle.	9122	
Pump Tubing, Clear, 10mm O.D., 6.5mm I.D. Polyurethane, 25 foot roll standard	960025	

Electrical & Electronic Parts

Description	Part Number	Graphic
Board Stack Assembly	9304	**Contact Technical Service for Circuit Board Replacement Information.**
Power Supply Module with Wire Harness	80315	
Circuit Board, AC Motor Driver	3110-2	
Circuit Board, High Voltage	3150-1	
Front Door Assembly, BAM 1020 Standard Version	9628	
Rear Panel Assembly	80679	
Fuse, 3.15A, 250V, 5x20mm, 2 Required	590811	
Motor, with gear box, 4 RPM. 4 per unit.	8105-2	
Motor, with gear box, 10 RPM, Capstan Drive Only.	8106-1	

Inlet Components

Description	Part Number	Graphic
PM10 Size-Selective Inlet Head, EPA Specified	**BX-802**	
TSP Sampling Inlet, with insect screen	**BX-803**	
PM1 Sharp Cut Cyclone, BGI Inc.	**BX-811**	
PM2.5 WINS Impactor	**BX-804**	
PM2.5 Sharp Cut Cyclone	**BX-807**	
PM2.5 Very Sharp Cut Cyclone, BGI Inc. VSCC™ Valid for PM2.5 FEM monitoring	**BX-808**	
PM2.5 Cyclone – URG Valid for PM2.5 FEM monitoring	**BX-809**	
Inlet Roof Mounting Kit – includes roof top flange, sealing gland, braces, and standard 8 foot inlet tube.	**BX-801**	
Waterproof Inlet Tube Sealing Gland Only	**8119**	
Roof Top Flange Weldment Only	**8120**	

Description	Part Number	Graphic
Inlet Tube Coupler Assembly, with O-rings. Connects two inlet tubes together Inlet tube sold separately	**BX-821**	
Inlet Slip Coupler Assembly, with O-rings. Quick disconnect inlet accessory which allows the BAM-1020 to be removed from its installation without loosening the roof flange seal.	**BX-824**	
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 Element with Cable, 115 VAC	**81120**	
Smart Heater Element with Cable, 230 VAC	**81121**	
Smart Heater Insulating Sleeve, White	**9123-1**	
External Heater Relay with Enclosure	**80316**	
O-Rings, BX-807 SCC Cyclone, set of 6	**720097**	
O-Rings, BX-808 VSCC™ Cyclone, set of 8	**720105**	
O-Rings, BX-809 URG Cyclone, set of 6	**720228**	
O-Rings, PM10 Head, set of 3	**8965**	

Meteorological Sensors

Description	Part Number	Graphic
590 Wind Direction Sensor, Auto ID	**BX-590**	
591 Wind Speed Sensor, Auto ID	**BX-591**	
592 Ambient Temperature Sensor, Auto ID	**BX-592**	
592 Room/Shelter Temperature Sensor, Auto ID	**BX-592-1**	
593 Ambient Relative Humidity Sensor, Auto ID	**BX-593**	
594 Ambient Barometric Pressure Sensor, Auto ID	**BX-594**	

Description	Part Number	Graphic
595 Solar Radiation Sensor, Auto ID	**BX-595**	
596 AT/BP Combo Sensor, -40 +55C. 597A AT/BP/RH Combo Sensor, -50 +70C.	**BX-596** **BX-597**	
Cable assembly for BX-596 sensor	**10076**	
Cable assembly for BX-597 sensor	**10609**	
Real-Time Module (RTM) Instantaneous particulate mass trending option	**BX-895**	

Communications Options & Accessories

Description	Part Number	Graphic
Touch Screen Display Option. Complete Front Door Assembly for BAM 1020.	**BX-970**	
Report Processor kit. Complete back panel assembly or plug-in board. **Call Met One for upgrade details**. Required for PM-Coarse Configuration.	**BX-965**	
Modem Kit for BAM 1020	**BX-996**	
Cellular/IP Modem Kit for BAM 1020	**BX-911**	
BAM 1020 Serial Cable, DB-9 Female Ends, Null.	**400658**	
Belkin F5U109 USB-to-RS-232 Adapter	**550067**	
Serial Printer Kit	**BX-601**	
Converter for Parallel Printers	**BX-602**	

Weatherproof Mini Shelters/Enclosures

| Description	Part Number	Graphic
Mini Enclosure, Heated and Vented. Mfg by Shelter One	**BX-902B**	
Mini Enclosure, Heated and Air Conditioned. Mfg by Ekto. 2000 BTU A/C.	**BX-903**	
Mini Enclosure, Heated and Air Conditioned. Mfg by Ekto. 4000 BTU A/C.	**BX-904**	
Enclosure, Dual Unit, Heated and Air Conditioned. Mfg by Ekto. 4000 BTU A/C.	**BX-906**	

10.2 BX-500 Series Meteorological Sensor Configurations

The BAM 1020 has six channels of inputs available on the back of the BAM 1020 for data logging external sensors. The BX-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 type of sensor. When one of these sensors is attached to the BAM, the BAM 1020 senses this ID voltage and automatically configures the channel with all the correct scaling parameters. **The ID MODE for the desired channel must be set to AUTO in the SETUP > SENSORS menu in order for the BAM 1020 to identify the sensor**. See Section 6.8 for details about setting up the channels in the BAM 1020. The scaling and setup values of the series BX-500 sensors are shown in the chart below.

Temperature Input for Flow Control: The ambient temperature signal used for BAM 1020 flow control must always be connected to channel six. BAM 1020 units are equipped with at least a BX-592 ambient temperature sensor. If the BAM is configured as a PM$_{2.5}$ FEM monitor, then the BX-596 sensor is required. This is a combination ambient temperature and barometric pressure sensor which attaches to channels six (AT) and seven (BP) for actual flow control and flow statistics. *The channel 7 pressure signal is not logged in the standard BAM data arrays*. In order to log the barometric pressure from the BX-596, you must jumper the channel 7 signal terminal over to another unused channel input with a short wire. Then you must manually scale the second channel with the multiplier, offset, and full scale voltage of the BX-596 as shown below. BX-596-1 is an special extended range version for very low temperature or high altitude locations. BX-597 has an additional ambient RH signal and extended ranges on the other parameters.

Model	Type	Units	Range	Mult	Offset	FS Volts	S/V	Inv Slope	ID Voltage
500 Series Sensor Setup Parameters									
BX-590	**WD**	Deg	0 to 360	360	0	1.0	**V**	N	1.10v
BX-591	**WS**	mph m/s	0 to 100 0 to 44.704	100 44.70	0 0	1.0 1.0	S S	N	0.20v
BX-592	**AT**	^{0}F ^{0}C	-22 to +122 -30 to +50	144 80	-22 -30	1.0 1.0	S S	N	1.80v
BX-593	**RH**	%	0 to 100	100	0	1.0	S	N	2.10v
BX-594	**BP**	inHg mmHg mbar	20 to 32 508.0 to 812.8 677.1 to 1083.6	6 152.40 203.19	26 660.40 880.46	1.0 1.0 1.0	S S S	N N	2.60v
BX-595	**SR**	Ly/ min W/M2	0 to 2 0 to 2000	2 2000	0 0	1.0 1.0	S S	N	3.70v
BX-596	**AT** **BP**	^{0}C mmHg	-40 to +55 525 to 825	95 300	-40 525	2.5 2.5	S S	N	3.50v
BX-596-1	**AT** **BP**	^{0}C mmHg	-50 to +50 400 to 825	100 425	-50 400	2.5 2.5	S S	N	4.10v
BX-597	**AT** **BP** **RH***	^{0}C mmHg %	-50 to +70 375 to 825 0 to 100	120 450 100	-50 375 0	2.5 2.5 2.5	S S S	N	4.20v

* The RH signal from the BX-597 sensor may optionally be connected to an unused met channel. These setup parameters must be manually entered by the user in the SETUP > SENSOR screen for the selected channel.
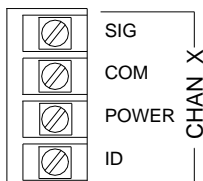
BAM 1020 Back Panel Met Sensor Input Terminal

BX-500 Series Met Sensor Wiring Connections for BAM 1020

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

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

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

BX-593 Relative Humidity Sensor	
Terminal Block	**Cable Wire Color**
SIG	Orange or 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	Green

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

BX-596 Temperature/Baro Combo Sensor	
Terminal Block	**Cable Wire Color**
Channel 6 SIG	Orange or Yellow (AT)
Channel 6 COM	Black/Shield
Channel 6 POWER	Red
Channel 6 ID	Green
Channel 7 SIG	White (BP)

BX-597 Temp/Baro/RH Combo Sensor	
Terminal Block	**Cable Wire Color**
Channel 6 SIG	Blue (AT)
Channel 6 COM	Black/Shield, Orange
Channel 6 POWER	Red
Channel 6 ID	Green
Channel 7 SIG	White (BP)
Channel 1-3 SIG*	Brown (RH)

* The BX-597 RH signal can be connected to any unused met channel, typically 1, 2, or 3. It must be manually scaled.
The BX-596 BP signal must be connected to unlogged channel 7, but may be jumped to another unused channel for logging.

Sensor Physical Mounting:

The BX-500 series sensors typically mount near the top of the BAM 1020 inlet tube with a supplied short cross-arm and/or related hardware. The sensors can also be mounted to a separate nearby tripod, such as Met One model 905. Wind sensors must be mounted to avoid any possible wind obstructions caused by the BAM inlet components.

11 THEORY OF OPERATION

^{14}C (carbon-14) is a naturally occurring isotope of carbon that forms in the atmosphere by the interaction of cosmic rays with nitrogen. Of the three naturally occurring isotopes of carbon,

^{14}C is the only to occur in trace amounts. The half-life of ^{14}C is 5,730 years. It undergoes beta-decay and is converted into ^{14}N (nitrogen-14). During the beta decay process high energy electrons are emitted. Beta radiation through the decay of ^{14}C is distributed around an average energy of approximately 49 keV. In air these electrons travel a maximum distance of around 22 cm before being fully absorbed.

Beta-ray absorption is the principle by which the BAM 1020 makes its measurement. ^{14}C is convenient source to use in beta absorption measurements. Its long half life means that the source will outlast the service life of the instrument. When used in modest amounts (less than 100 microcuries), generally no license is required to possess the equipment.

This beta ray absorption process by matter may be described by the following relationship:

$$I = I_0 exp\left(-\frac{\mu M}{S}\right)$$

In the above equation I_0 is the measured beta ray flux (counts) across clean filter tape, I is the measured flux (counts) across aerosol-laden filter tape, M is the aerosol mass deposited on the filter tape (mg), S is the spot area (cm^2). μ is the beta ray absorption cross section (cm^2/mg). The absorption cross section μ to a very good approximation depends only on the mass of the absorbing species and not on its chemical composition. In other words the absorption cross sections for commonly found species in ambient particulate matter such as soot, iron oxide, silica, or salt are all approximately the same. It is for this reason that one does not need to know ahead of time the chemical composition of the aerosol being sampled in order to perform an accurate mass measurement using the BAM 1020.

During the factory calibration process, the BAM 1020 being calibrated is first challenged with a membrane whose mass density $\left(\frac{M}{S}\right)$ is known. Repeated measurements of I_0 and I for the beta gauge under calibration allows us to calculate the absorption cross section μ as is shown below:

$$\mu = \frac{S}{M} ln\left(\frac{I_0}{I}\right)$$

Tiny variations in the measured absorption cross section μ will be found from one BAM 1020 to the next. These differences are due to small differences between the activities of the beta sources and due to small differences in the geometries (i.e., manufacturing tolerances) that exist between one instrument and the next. This membrane calibration process allows us to standardize the span response of all BAM 1020 monitors.

The same membrane whose known mass density $\left(\frac{M}{S}\right)$ is used to determine μ is built into the instrument and subsequently used to challenge the same BAM 1020 on an hourly basis to ensure that the original span calibration is being held.

A final calibration is then performed on this BAM 1020. It is collocated with a reference BAM 1020 monitor. The collocated monitors then sample and measure the same aerosol (smoke) for 48 or 72 hours. A linear regression of the hourly output of the BAM 1020 under test against the transfer standard BAM 1020 will provide a slope "k" is used to set the final calibration. This is shown in the equation below.

$$C = k\frac{m}{V} + BKGD$$

In this equation C is the aerosol mass concentration in mg/m^3, m is the sampled mass in mg, V is the sampled volume in m^3, and $BKGD$ is the instrument response in the absence of any particulate matter as determined by the zero-filter test in mg/m^3.

The span membrane response is in mg/m^3 and depends only on μ, the beta ray absorption cross section, whereas C, the measured aerosol concentration in mg/m^3 depends on both μ, k, and $BKGD$. Since sampled volume is also used in this calculation the accurate determination of C also depends on the ability of the equipment to accurately measure volume.

11.1 Converting Data Between EPA Standard and Actual Conditions

The BAM 1020 is always sampling under actual flow conditions. The BAM 1020 may however be set to report concentrations under either actual flow conditions or standard flow conditions. The difference between these two values corresponds to the change in volume between a BAM 1020 sample taken under actual conditions and that same sample taken under standard conditions.

$$C_{std} = C_{amb} \frac{P_{std}}{P_{amb}} \frac{T_{amb}}{T_{std}}$$

This equation 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. Please note that temperatures must be reported in degrees Kelvin and that standard temperature may vary somewhat from one jurisdiction to another. It is usually either 273 °K or 298 °K.

$$C_{amb} = C_{std} \frac{P_{amb}}{P_{std}} \frac{T_{std}}{T_{amb}}$$

This equation 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.

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

$$C_{amb} = 27 * (720/760) * (298/303)$$

$$C_{amb} = 27 * 0.9474 * 0.9835$$

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:	slpm	slpm	as left:	slpm	slpm	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 Set point	**BAM Flow**
15.0 LPM	
16.70 LPM	
18.4 LPM	

Setup and Calibration Values

Parameter	Expected	Found	Parameter	Expected	Found	Parameter	Expected	Found
Clock Time/Date			FLOW TYPE			AP		
RS232 baud			Cv			Password		
STATION #			Qo			Cycle Mode		
RANGE			ABS			Filter-RH Control		
BAM SAMPLE			µsw			Filter-RH Setpoint		
MET SAMPLE			K Factor			Datalog Filter-RH		
OFFSET			BKGD			Log Filter-T		
CONC UNITS			STD TEMP			Log BP		
COUNT TIME			HEATER			Log Membrane		
FLOW RATE			e1					
CONC TYPE			Errors					

Last 6 Errors in BAM 1020 Error Log

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

Audit Notes:

Manual Notes: