

E-BAM PARTICULATE MONITOR OPERATION MANUAL

E-BAM-9805 REV E



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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, which all E-BAM owners and operators should read and understand. Toward the back are sections that provide in-depth information on subjects such as theory, diagnostics, accessories, and alternate settings. These sections provide valuable information which should be consulted as needed. Electronic versions of this manual are also available.

1.2 Technical Service

This manual is structured by customer feedback to provide the required information for setup, operation, testing, maintaining, and troubleshooting of the E-BAM unit. Should support still be required after consulting the printed documentation, contact one of the expert Met One Instruments, Inc. technical service representatives during normal business hours of 7:00 a.m. to 4:00 p.m. Pacific Standard Time, Monday through Friday. In addition, technical information and service bulletins are often posted on the Met One Instruments, Inc. website. Please contact the service department and obtain a Return Authorization (RA) number before sending any equipment back to the factory. This allows for tracking and scheduling service work and to expedite customer service. Please have the instrument serial number available when contacting the manufacturer.

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1.3 E-BAM: *Environmental Beta Attenuation Monitor*

The Met One Instruments, Inc. model E-BAM automatically measures and records airborne PM₁₀ or PM_{2.5} particulate concentration levels using the principle of beta ray attenuation. This method provides a simple determination of concentration in units of milligrams of particulate per cubic meter of air. A small ¹⁴C (Carbon 14) element emits a constant source of high-energy electrons known as beta rays. Beta rays are detected and counted by a sensitive scintillation detector. A vacuum pump pulls a measured amount of dust-laden air through the filter tape, which is positioned between the source and the detector thereby causing an attenuation of the beta ray signal. The degree of attenuation of the beta ray signal is used to determine the mass concentration of particulate matter on the filter tape and the volumetric concentration of particulate matter in ambient air.

The E-BAM is designed as a simple, compact, and self-contained beta gauge, for portable applications where rapid deployment and short interval real-time measurements are required. In addition to the main housing, the monitor includes an internal pump, a multi-parameter ambient sensor, and a mounting tripod. See section 2.2 for a listing of standard and optional accessories.

1.4 Beta Radiation Safety Statement

The Met One Instruments E-BAM contains a small ^{14}C (Carbon 14) beta radiation-emitting source. The nominal activity of the source is 60 microcuries, which is below the “Exempt Concentration Limit” as defined in 10 CFR Section 30.71 – Schedule B. The owner of an E-BAM is not required to obtain any license in the United States to own or operate the unit. The owner of an E-BAM may elect to return the entire unit to Met One Instruments for recycling of the ^{14}C source when the unit has reached the end of its service life, although the owner is under no obligation to do so. Under no circumstances should anyone but factory technicians attempt to remove or access the beta source. The beta source has a half-life of about 5730 years and should never need to be replaced unless it becomes damaged or corroded. Neither the ^{14}C source nor the beta particle detector are serviceable in the field. Should these components require repair or replacement, the E-BAM must be returned to the factory for service and recalibration. The E-BAM is manufactured in compliance with the U.S. NRC safety criteria in 10 CFR 32.27.

1.5 E-BAM Specifications

PARAMETER	SPECIFICATION*
Measurement Principle	Particulate Concentration by Beta Attenuation
U.S. EPA Designations	None
Measurement Range	-15 µg/m ³ – 10,000 µg/m ³
Measurement Resolution	1.0 µg/m ³
Sensitivity Standard Deviation	(σ) (1 hour) Less than 3.0 µg/m ³
Lower Detection Limit†	(2σ) (1 hour) Less than 6 µg/m ³ (2σ) (24 hour) Less than 1.2 µg/m ³
Measurement Sample Time	1 Hour
Flow Rate	16.7 L/min inlet flow rate; actual volumetric flow
Filter Tape	Continuous glass fiber filter; 30 mm x 21 m roll; > 60 days/roll
Span Check	Manual, 800ug (typical), span foil included.
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 organic plastic scintillator
Operating Temperature Range	-25° to +50°C.
Operating Humidity Range	0 – 90% RH, noncondensing
Inlet Humidity Control	Actively controlled inlet heater module
User Interface	4.3" graphical touch screen
Ambient Sensor	Model BX-597A combination AT, RH, and BP serial sensor AT: -50° to +70°C; RH: 0 to 98%; BP: 375 to 825 mmHg
7500 Digital Serial Interface	2 channels, half duplex RS-485
Serial Interface	1 channel; full duplex RS-232, USB (Shared common serial output) 1 channel; half duplex RS-485 Baud rates: 2400, 4800, 9600, 19200, 38400, 57600, 115200
Internal Data Storage	15 Days 1-minute average, 2.6 years 60-minute average
External Data Storage	1 USB Flash drive device
Compatible Software	Air Plus 5, Comet™, HyperTerminal®
Power Supply	Universal 100-230 VAC input, 12 VDC output power supply included. Compatible with solar power kits or external batteries using included External Battery Cable.
Power Consumption	2.65 amps @12VDC (32 Watts) - Normal sampling with inlet heater off. 3.65 amps (44 Watts) - Normal sampling with maximum inlet heat. 5.5 amps (66 Watts) - Maximum pump speed with maximum inlet heat.
Weight	31 lbs. (14.1 kg)
Dimensions (Without Tripod)	Height: 18 in (46 cm) Width: 16 in (41 cm) Depth: 9 in (23 cm)

* Specifications may be subject to change without notice.

† The hourly detection limit is defined as twice the standard deviation of the hourly zero noise of the instrument. The 24-hour detection limit is defined as the hourly detection limit divided by the square root of 24 (approximately 4.9).

2 E-BAM INSTALLATION AND COMMISSIONING

This section describes assembly, start-up, and filter tape installation for the E-BAM unit.

2.1 Unpacking

Any damage incurred to the equipment during shipping are the responsibility of the carrier. If any damage to the shipment is noticed before unpacking, **a claim must be filed with the commercial carrier immediately**. Follow any special unpacking instructions provided by the carrier as all items are then carefully removed from the containers. Inspect each component thoroughly. It is recommended to document and photograph all damaged packages and items before, during, and after unpacking them. Contact Met One Instruments, Inc. (see section 1.2 of this manual) to arrange for any replacement items needed.

Unpack the mass monitor and accessories and compare them to the packing list to make sure all items are present.

The E-BAM is shipped with the nozzle shipping device installed under the nozzle which prevents the vane assembly from being damaged in transit. The device must be replaced anytime the mass monitor is being transported in order to avoid damaging the nozzle and vane assembly. Do not ship or transport the E-BAM with filter tape installed.

Please keep all special shipping items (box, foam packing material, etc.) used to ship the E-BAM. They should be re-used if the monitor is transported (changing site locations, returning to the factory, etc.). Met One Instruments, Inc. is not responsible for damage to the mass monitor if shipped in non-original packaging or without the shipping shim in place. Contact Met One Instruments, Inc. (see section 1.2 of this manual) for replacement packing materials, if necessary.

2.2 Accessories

Every E-BAM requires the use of ancillary components. The items supplied with a standard E-BAM PM₁₀ monitoring system are shown in Table 2-1.

Standard Components	Part No.
Mounting Tripod	EX-905
PM ₁₀ Size Selective Inlet	BX-802
Inlet Tube (8.5 inches)	9187
Ambient Combination Sensor (AT, BP, RH)	BX-597A w/ 82959-8 Cable Assembly
Filter Tape	460180
Accessory Kit*	83293

*See section 7 for a complete listing of all items contained in the Accessory Kit

Table 2-1 Standard E-BAM Accessories

Application and installation dependent accessories for the E-BAM are also available from Met One Instruments, Inc. Common optional items are shown in Table 2-2.

Common Optional Component	Part No.
Wind Speed and Direction Sensor	EX2-034 or EX2-AIO
PM2.5 Sharp Cut Cyclone	BX-807
Volumetric Flow Calibration Kit	BX-307
Zero Filter Kit	BX-302

Table 2-2 Optional E-BAM Accessories

2.3 Assembling the E-BAM

The E-BAM is designed to be field deployable by an average person in less than 15 minutes under normal conditions. Refer to the photos and diagrams below while performing the following steps to assemble the unit:

1. **Deploy the tripod:** Remove the three stainless steel detent pins from the tripod base by pulling the rings. Unfold the three tripod legs and reinsert the three pins so that each pin secures a leg in the open position. Make sure the erected tripod is rigid and stable. Fasten or bolt down the tripod legs to prevent tip over (see section 4.2 **Error! Reference source not found.**)

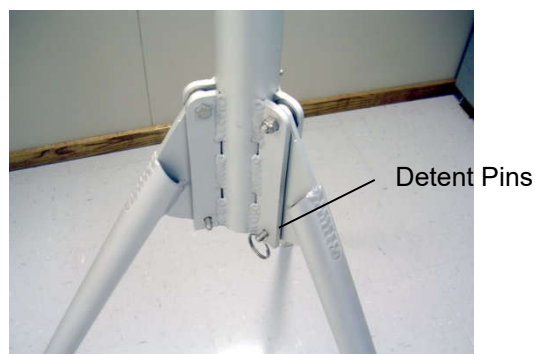


Figure 2-1 Tripod Deployment

2. **Install the E-BAM onto the tripod:** Lift the E-BAM assembly and slide the slot on the back of the E-BAM over the tab on the top of the tripod. Insert the supplied $\frac{1}{4}$ - 20 bolt through the tab on the bottom of the E-BAM and through the hole in the body of the tripod (see Figure 2-2). Secure it with the supplied washers and nut. This prevents the E-BAM from shifting on the tripod.
3. **Install the inlet components:** Loosen the weatherproof fitting on top of the E-BAM and insert the short inlet tube into the top of the unit. The tube must go through the fitting and through two O-rings in the top of the E-BAM. *Make sure the tube is fully seated* by rotating it back and forth. Tighten the weatherproof fitting to secure the inlet tube. For PM₁₀ monitoring, install the BX-802 PM₁₀ inlet directly onto the top of the short inlet tube. *If a BX- 807 cyclone is to be used for PM_{2.5} monitoring, it must be installed under the PM₁₀ head as shown in Figure 2-2.* Lubricate the O-rings as necessary.

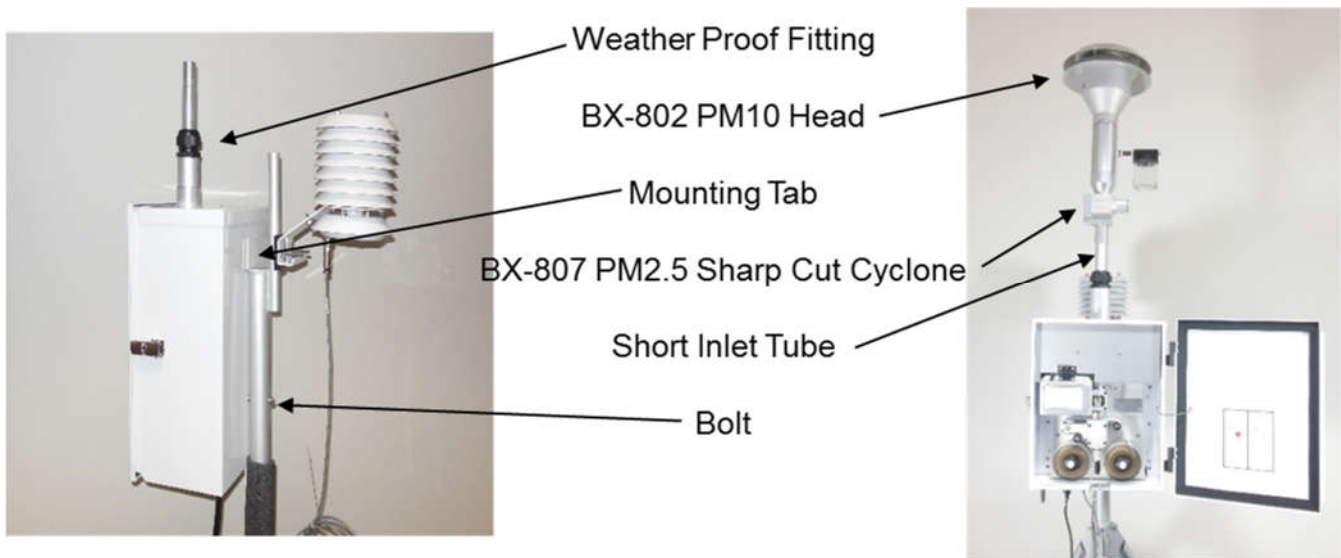


Figure 2-2 Tripod Mounting of the E-BAM

4. **Install BX-597A Sensor:** Connect the BX-597A sensor to the post on the back of the tripod with the supplied mounting hardware (user supplied 7/16" wrench required). The BX-597A sensor should face away from the E-BAM as shown in Figure 2-3. Verify configuration after power-up as detailed in section 2.7.1.

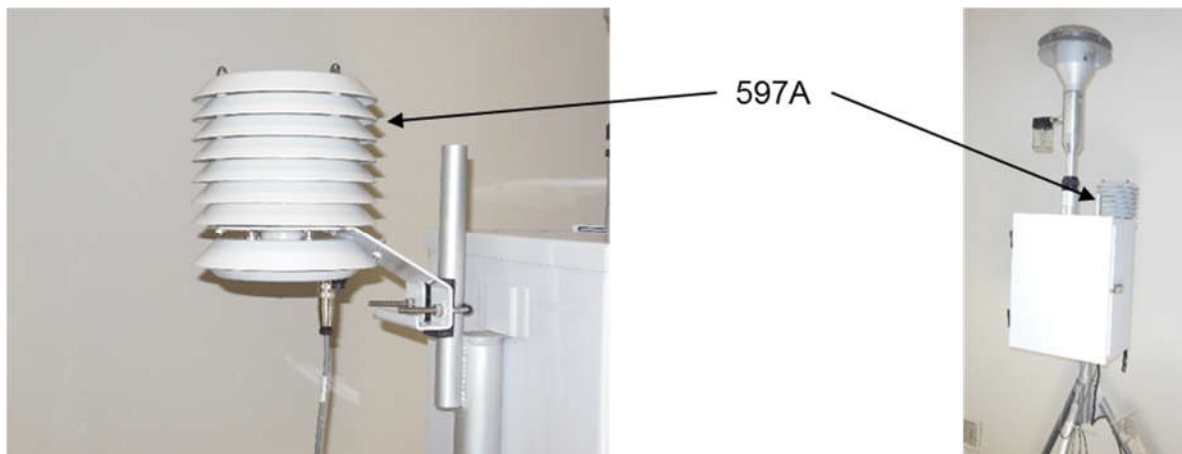


Figure 2-3 Mounting the BX-597A Sensor

5. **Optional Wind Sensor:** If an optional wind speed/direction sensor (such as the EX2-034 or EX2-AIO) is purchased a cross-arm tube to use for mounting the wind sensor will be included. Connect the cross-arm to the post on the back of the tripod with the supplied $\frac{3}{4}$ " x $\frac{3}{4}$ " fitting and set screws and then install the sensor at end of the arm as suggested in Figure 2-4. The wind sensor should be as far from the E-BAM unit as possible, and the wind vane must be able to rotate fully without obstruction. Plug the wind sensor into the corresponding connector on the bottom of the E-BAM. Depending on the type of wind sensor, it may need to be oriented to the south. Consult the separate manual that comes with the wind sensor for details. Verify configuration after power-up as detailed in section 2.7.2.

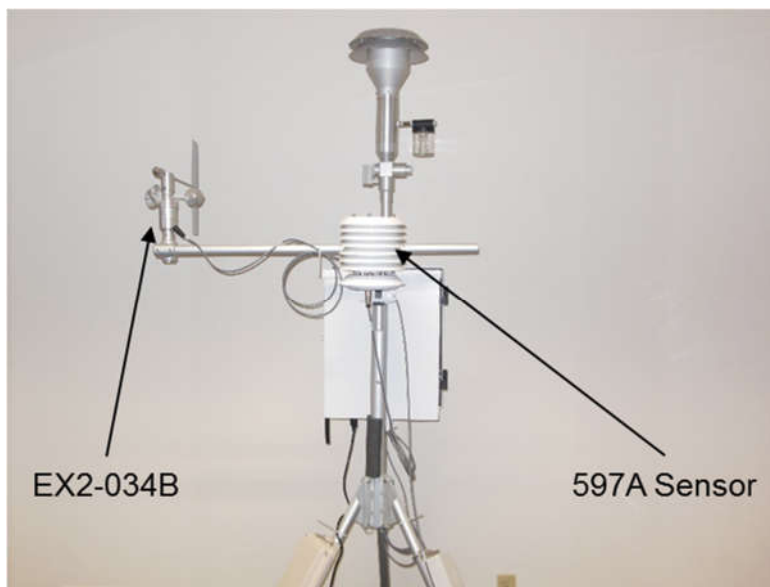


Figure 2-4 Sensor Mounting with an Optional Wind Sensor

2.4 Electrical Connections

The E-BAM has a set of weatherproof connectors on the bottom of the unit. These connectors provide the connections for the power supply, external sensors, and communications.

The E-BAM chassis ground lug should be connected to an earth ground whenever possible, to reduce electrical noise in the unit. A 20-foot ground cable is included in the Accessory Kit.

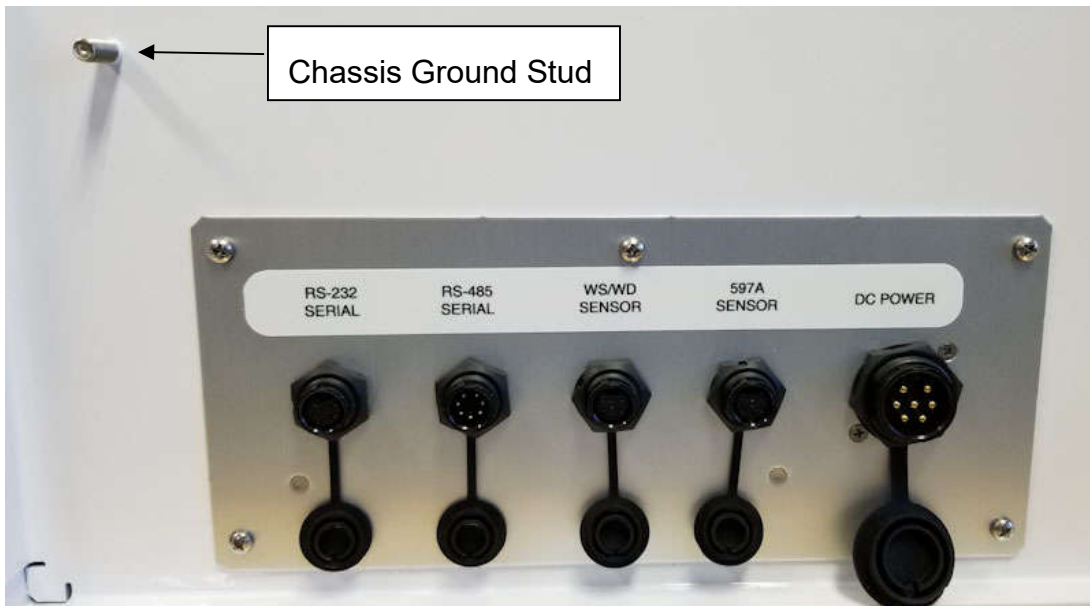


Figure 2-5 E-BAM Connectors

2.5 Power-up and Automatic Operation

The E-BAM is designed to turn on automatically when power is applied. It will provide options to start immediately or enter the setup menus. If START NOW is selected, ensure shipping device is removed. Choosing setup will present several setup menus for verification. These are described in section 2.6.

Note: If no user activity is detected for several minutes after power-up, the E-BAM will automatically begin sampling based on the existing setup options and settings, if filter tape is installed, and no hardware or voltage failures are detected. This makes it possible to fully configure and calibrate the unit in the lab, then simply deploy it to the field and power it up with no further actions required.

Always remove the shipping device before allowing the monitor to self-start.

2.6 Power-up Settings Verification and Automatic Self-Test

The E-BAM will present several setup parameters for verification whenever it is powered on. These setup screens can also be viewed or edited in the SETUP menu under the main E-BAM menu system. See section 3.6 for detailed descriptions of the SETUP parameters.

When power is applied to the E-BAM, the unit will show the startup splash screen for the touchscreen display for a moment, then display the welcome screen as shown in Figure 2-6.

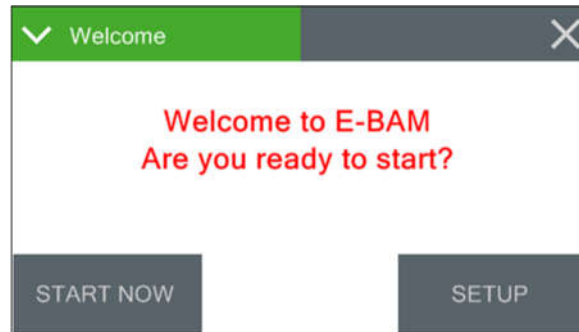


Figure 2-6 Welcome Screen

Press the SETUP button and the clock screen is displayed (see Figure 2-7). If the time and date are correct, press the YES button again. If the date or time need to be changed, press the EDIT button. See section 3.6.1 for details on changing the date and time.

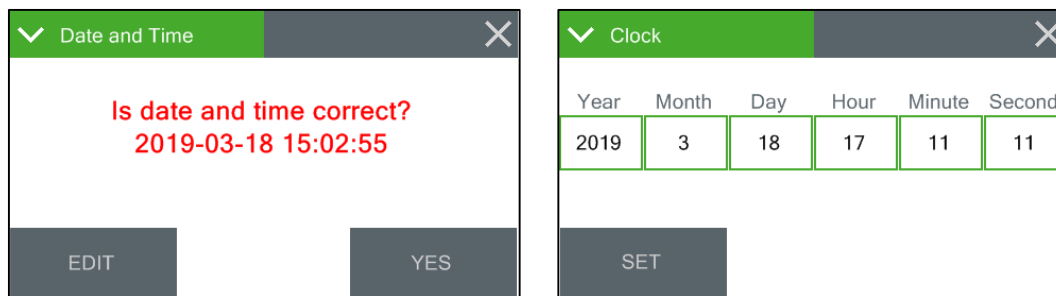


Figure 2-7 Verifying the Clock

After the time is verified, the unit will display the Settings screen shown in Figure 2-8 below. If the settings need to be changed, press the green bordered value box to be updated and the associated edit screen will be displayed.

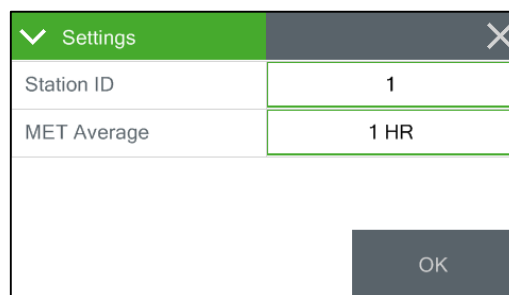


Figure 2-8 Verifying the Initial Settings

After confirming or setting the Station ID (Section 3.6.9) and MET Average (Section 3.6.10) settings, press OK.

The E-BAM will then check whether a roll of filter tape is installed. If no tape is detected, the unit will prompt for installation of filter tape:

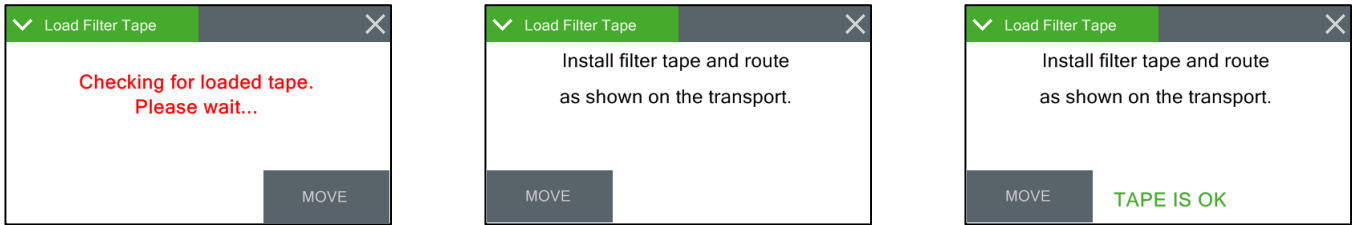


Figure 2-9 Verifying Filter Tape is loaded

Install a roll of filter tape as described in section 2.8. When the filter tape is installed, press MOVE. The unit will again try to detect the tape.

If tape is detected, the unit will proceed to the self-test screen. Press START to begin a self-test. After a successful self-test, press the X to proceed to operations.

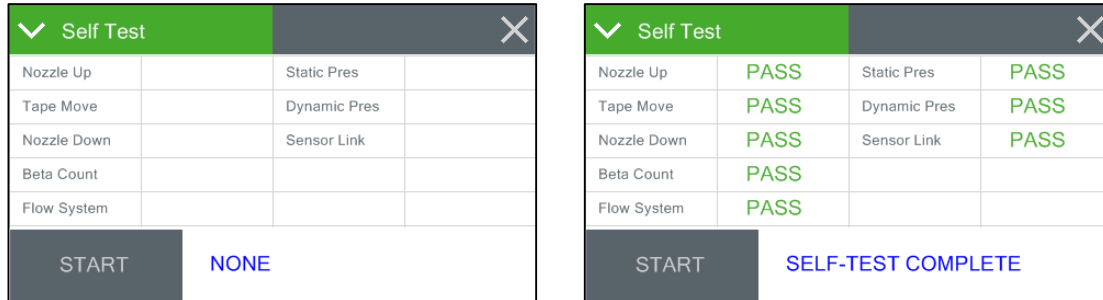


Figure 2-10 Self-Test Screen

2.7 Configuring External Sensors

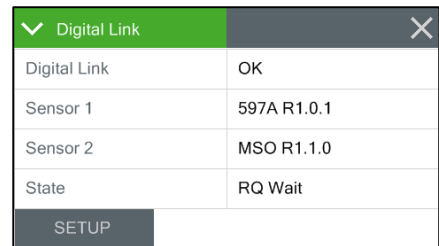
The E-BAM must have a BX-597A sensor connected and properly configured for operation. If the BX-597A is not present, the E-BAM will not begin sampling. See section 8.1 for more details about available wind sensors.

2.7.1 Configuring the BX-597A Sensor

The E-BAM requires a BX-597A sensor at address 1 of its serial network to begin sampling. Once the physical connections are made the sensor is programmed using the Digital Link screen located in the Test menu (see section 3.5.11).

Upon entering the Digital Link screen, any digital sensor connected to the E-BAM with address 1 or 2 programmed in it will appear in either the Sensor 1 or Sensor 2 fields, as appropriate. In addition to the sensor type, the address fields on this screen also display the firmware currently installed in the sensor.

Figure 2-11 shows a typical configuration.



Digital Link	
Digital Link	OK
Sensor 1	597A R1.0.1
Sensor 2	MSO R1.1.0
State	RQ Wait
SETUP	

Figure 2-11 The Digital Link Screen

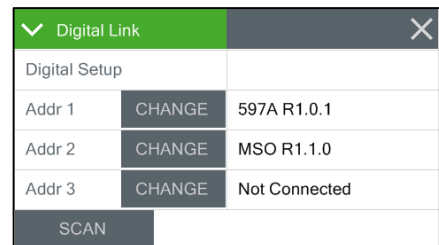
The State field indicates that the E-BAM is either starting up digital communications or waiting for a response from the sensor. If either the sensor type or firmware revision is missing or incorrect, communications are not properly established with the sensor. The grey SETUP button in the lower left corner provides access to the Digital Setup screen for configuring the addresses of the digital sensors. See section 2.7.2 for details.

2.7.2 Changing Sensor Addresses

The default address for most Met One Instruments, Inc. digital sensors is 1.

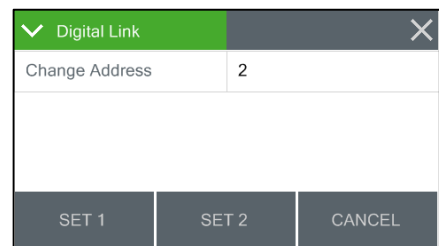
If a connected sensor has an address other than 1 or 2, it can be located in the Digital Setup screen by pressing the grey SCAN button in the bottom left corner (see Figure 2-12). The E-BAM will scan through all potential network address nodes to locate any connected devices. Progress of this scan can be seen in the third address field label (which displays Addr 3, by default) and the word “Scanning” will appear in the field itself.

If a device is located at some other address, it can be changed by pressing the grey CHANGE button next to the third address field. In the example shown in Figure 2-13, the BX-597A has been configured for address 2. Pressing the grey SET 1 button will update the address in the sensor to address number 1 and exit back to the main Digital Link screen. The Sensor 1 field will now display the BX-597A details like Figure 2-11.



Digital Link	
Digital Setup	
Addr 1	CHANGE 597A R1.0.1
Addr 2	CHANGE MSO R1.1.0
Addr 3	CHANGE Not Connected
SCAN	

Figure 2-12 Scanning for Sensors



Digital Link	
Change Address	2
SET 1 SET 2 CANCEL	

Figure 2-13 Change the Address

If two sensors share the same address, disconnect one of them and then use the CHANGE button to set the other one to a different address. Remember that the BX-597A must be configured for address number 1 and if an optional wind sensor is connected, it will need to be set to number 2.

2.8 Filter Tape Loading

Filter tape must be loaded into the E-BAM for sampling. One roll of tape will last anywhere from a few weeks to more than a year, depending on the Tape Advance setting (see section 3.6.4) and ambient particulate levels. It is important to have spare rolls of tape available to avoid data interruptions. Used filter tape should never be “flipped over” or re-used. This will result in inaccurate measurements! When loading a roll of filter tape, use the following steps:

1. If the nozzle is in the down position, it will need to be raised. Enter the Load Filter Tape screen in the Operate menu. The unit will raise the nozzle and provide a prompt to load the filter tape.
2. If replacing a used roll of tape, remove the old roll and then thoroughly clean the nozzle and vane as described in section 5.5.
3. An empty core tube must be installed on the left (take-up) reel hub. This provides a surface for the used tape to spool-up on. Met One supplies a plastic core tube to use with the first roll of tape. After that, use the empty cardboard core tube left over from the last roll to spool-up the new roll. *Never fasten the filter tape directly to the aluminum hub!*
4. Load the new roll of filter tape onto the right (supply) reel and route the tape through the nozzle area as shown in Figure 2-14. Attach the loose end of the filter tape to the empty core tube with tape.
5. Rotate the tape roll to remove excess slack, then install the plastic spool covers tightly. The spool covers clamp the tape rolls to the hubs to prevent them from slipping.
6. Press the grey MOVE button to verify tape is properly loaded.
7. Press the X button to return to the Operate menu.

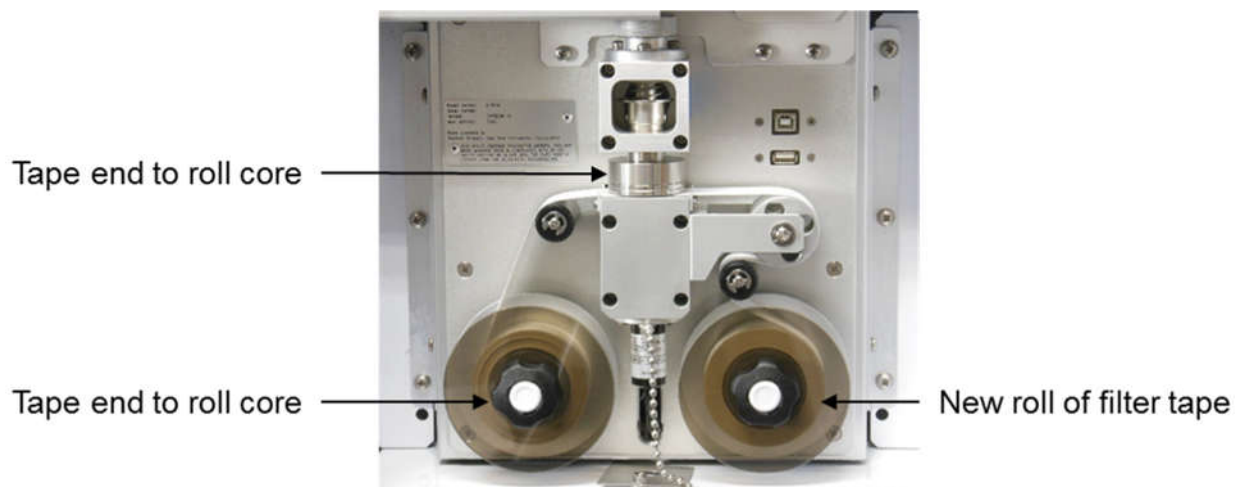


Figure 2-14 Proper Loading of the Filter Tape

2.9 Warm-up Period

The E-BAM must warm up for at least one hour before optimum accuracy of the concentration data can be obtained. This is because the beta detector contains a vacuum tube which must stabilize. This applies any time the unit is powered up after being off for more than a moment. Setups, tests, and flow calibrations can be performed during this warm up time. The first hour of data should often be discarded or ignored.

3 E-BAM USER INTERFACE and MENU SYSTEM

This section describes the E-BAM user interface system. It also explains the functions of the main and sub menu options, navigation of the menus, and how to view data and errors.

3.1 The User Interface - Touchscreen Display Functions

The E-BAM user interface is a touchscreen display used to control almost all the features and functionality of the E-BAM. It is mounted inside the enclosure on a hinged stainless-steel plate located on the right-hand center of the monitor.

3.2 Main Operating Screen

In addition to the last hourly concentration reading, this screen shows the current real-time values being measured and the operational state of the E-BAM.

E-BAM 2020-12-30 14:07:24	
Conc HR	22.1 ug/m3
Status	SAMPLING
ConcS	21.7 ug/m3
Conc RT	20.6 ug/m3
Flow	16.73 LPM
▼	

E-BAM 2020-12-30 14:09:49	
Conc HR	22.1 ug/m3
AT	9.1 C
RH	83 %
BP	729.6 mmHg
▼	

E-BAM 2020-12-30 14:10:22	
Conc HR	22.1 ug/m3
FT	14.6 C
FRH	47 %
WS	0.0 m/s
WD	0 Deg
▼	

Figure 3-1 The E-BAM Main Operating Screens

Note that the display has a limited amount of space and cannot show all the real time data on one screen. Tap down arrow key in the lower left corner of the display to navigate between the three screens shown in Figure 3-1.

Note: A concentration value of 99.999 mg/m3 or 99999 ug/m3 is an invalid concentration measurement and is due to an appropriate alarm condition. It will also be displayed when initially starting the instrument until completion of the monitor's first successful measurement sample.

Table 3-1 describes the parameters visible in the main sampling display as shown in Figure 3-1. In addition to the hourly, standard, and real-time average concentrations, the logged parameters in the E-BAM are:

Parameter	Description
Conc HR	The concentration at Actual conditions of the last hourly sample
Status	The current operational status or alarm condition of the monitor
ConcS	The concentration (at Standard conditions) of the last hourly sample
Conc RT	The average real-time period concentration (see Section 3.6.2)
FLOW	Primary air flow rate in actual LPM
AT	BX-597A Ambient Temperature
RH	BX-597A ambient Relative Humidity
BP	BX-597A ambient Barometric Pressure
FT	Internal Filter Temperature after the filter tape in degrees C
FRH	Internal Filter RH after the filter tape
WS	Wind speed in meters per second (if equipped)
WD	Wind direction in degrees (if equipped)

Table 3-1 Main Display Parameter Descriptions

3.3 Menu Hierarchy and Navigation

The E-BAM menu structure is outlined in the following table.

Main Menu	Sub Menu Options	Overview
Operate See section 3.4	Start Sample Load Filter Tape Transfer Data About Parameters Prepare Shipping Conc Chart	Begin or resume monitoring. Load and properly tension the filter tape Download stored data to a USB memory stick Details the current E-BAM firmware type and version number Review current settings Prepares for shipping unit A real-time chart of conc
Test See section 3.5	Leak Test Ambient Temperature Ambient Pressure Flow Calibration Run Self-Test Filter Sensors Span Mass Audit Tape Test Inlet Heater Nozzle/Count Test Digital Link	Perform the leak test Calibrate ambient temperature or restore default settings Calibrate ambient pressure or restore default settings Calibrate flow rate or restore default settings Run the E-BAM Self-Test Calibrate filter temp, pressure, and RH or restore default settings Run the zero and span foil tests Verify tape travels expected distance Manually turn the inlet heater on and off Beta-Count Test Test and configure communications with digital sensors
Setup See section 3.6	Clock Sample Calibration Inlet Heater Tape Advance Restart BV Clear memory Password Reports Station ID MET Average Serial Port Modbus Sound Volume Touch Calibrate Language	Set the date and time Set the conc. units and the averaging interval for collecting real time data Change the concentration offset & span membrane Set the RH threshold for the inlet heater to activate Set the differential pressure threshold for advancing the filter tape Set the battery voltage threshold for resumption of sampling operations following a Low Battery alarm Clear all stored data Change the master password Set the type of time stamp to use for the hourly report Set the location number used to identify the E-BAM Set the averaging interval for collecting other than hourly data Set the baud rate and connection type for serial communications Set the Modbus port and address Adjust the volume of the touchscreen sounds Calibrate the touch screen Set the language
Alarms See section 3.7	No sub menu	View alarms

Table 3-2 Menu Hierarchy

Menu selections and instructions are detailed in the following sections of this operating manual as detailed in the Main Menu column Table 3-2 above.

To access the various main menus, press the three horizontal lines in the top left corner. A drop-down menu will appear (Figure 3-2) to allow selection of any of the four main menus. This option is available on all main menu screens (such as the Setup Menu shown in Figure 3-3) and on the main operating screen

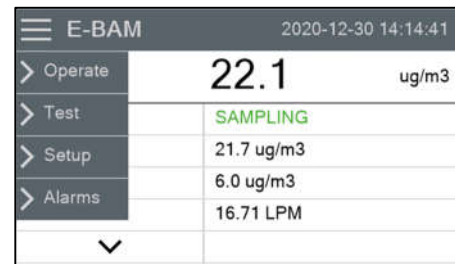


Figure 3-2 Main Menu Drop Down Selections



Figure 3-3 Setup Menu

To return to the main operating screen (see section 3.2), press the Home icon located in the upper right corner of all main menu screens. This icon can clearly be seen in the Setup Menu image shown here in Figure 3-3

To cancel and action and return to the previous menu screen, press the X icon located in the upper right corner of all sub menu screens. This icon can clearly be seen in the Set Clock screen image in Figure 3-4.

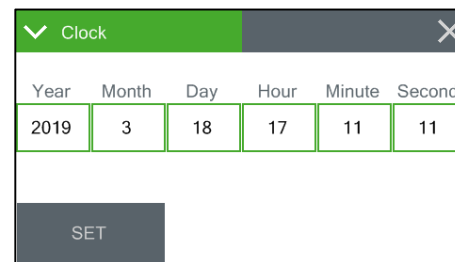


Figure 3-4 Set Clock Screen

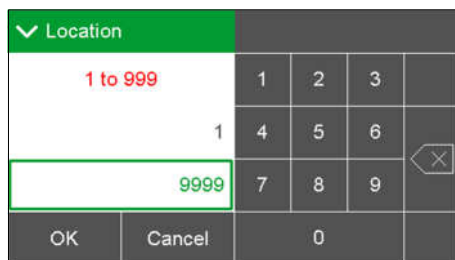


Figure 3-5 Keypad for Numeric Entry

Some parameters, such as the Date and Time settings (Figure 3-4) or a Location value, require numeric entry. When pressing the button to edit such a field, a visual keypad (Figure 3-5) will open and allow operators to input the value. Press the OK key to accept the changes or the Cancel key to return to the previous screen. The X key on the far right performs a backspace operation

3.4 Operate Menu

The Operate Menu is the doorway to the most commonly used areas for normal operation of the E-BAM.

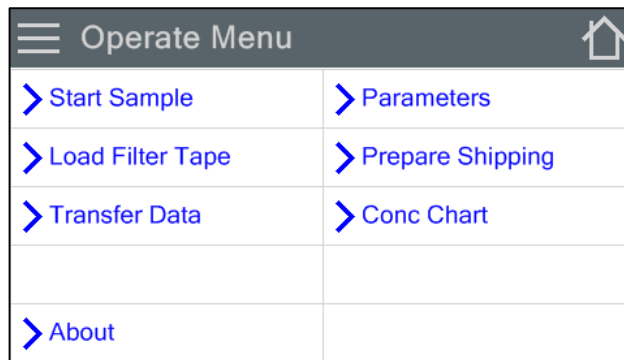


Figure 3-6 The Operate Menu

3.4.1 Start Sample

This screen allows users to both start and stop the E-BAM sampling process. Upon entering this screen, a warning will be displayed asking users if they would like to start or stop a sample, depending on the current state of the monitor. If there is no sample currently being taken, the grey button in the lower left corner will be labeled START. If there is a sample in progress, it will read STOP.

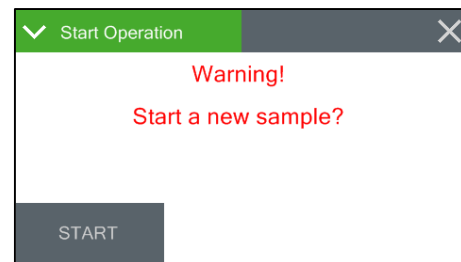


Figure 3-7 The Start Sample Screen

3.4.2 Load Filter Tape

This menu option is used for filter tape installation. Load the tape and press the MOVE key to go back to the main menu. See section 2.8 for details.

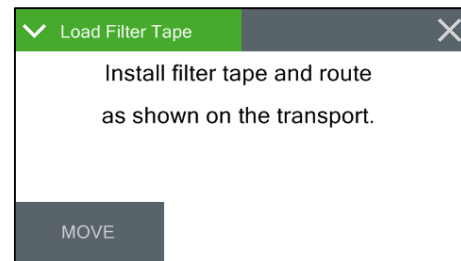


Figure 3-8 The Load Filter Tape Screen

3.4.3 Transfer Data

Copying data to a USB memory stick is performed from this screen. See section 6.2 for detailed instructions.

3.4.4 About

This screen shows the monitor’s serial number and installed firmware type and version number. It also provides firmware type and version number for the touchscreen display.

✓ About	✕
Website	www.metone.com
Serial Number	X25505
Firmware Version	83231, R2.0.0
Display Version	82451, R1.1

Figure 3-9 The About Screen

3.4.5 Parameters

These screens are not password protected. They provide the ability to view the real time value of a wide variety of parameters. Results are updated once per second. No changes can be made in these screens. They are for viewing purposes only.

✓ Parameters	✕
Flow	16.70 LPM
AT	22.6 C
RH	34 %
BP	727.8 mmHg
↓	↑

✓ Parameters	✕
Upper	728.6 mmHg
Lower	614.5 mmHg
FT	25.5 C
FRH	20 %
↓	↑

✓ Parameters	✕
WS	0.3 m/s
WD	189 Deg
↓	↑

✓ Parameters	✕
Box	25.0 C
Beta	2137 Hz
Heat	7.3 %
BV	11.54 V
↓	↑

Figure 3-10 Parameters

Note that the display has a limited amount of space and cannot show all the real time data on one screen. Tap the down arrow key in the lower left corner of the display to scroll through the four screens shown in Figure 3-10. Tapping the arrow on the last screen will return to the first one

3.4.6 Prepare Shipping

This screen provides a means of inserting the shipping shim and securing it in place for transporting the instrument. To use it, simply press the Prepare Shipping field on the main Operate Menu. The nozzle will raise and instruct users to insert the shipping device (see Figure 3-11). Once inserted, the nozzle will automatically lower and lock the shipping device in place. At this point, the display will change to indicate that the E-BAM may be shut down. Remove power from the monitor and it is now ready to be disassembled and relocated.

✓ Shipping Device	✕
Please insert nozzle shipping device.	

✓ Shipping Device	✕
OK to shut down the E-BAM	

Figure 3-11 Prepare Shipping

3.4.7 Conc Chart

This screen provides a chart of the last 24 hourly (Conc HR) concentration measurements.

3.5 Test Menu

The Test Menu provides a means of testing and calibrating individual sensor inputs and calculations. Because these settings directly impact flow and concentration values, most of these tests are password protected.

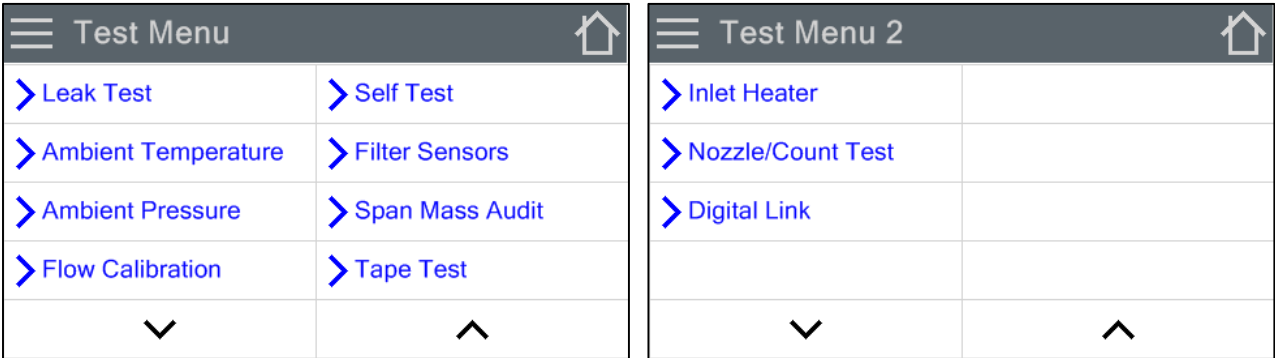


Figure 3-12 Test Menus

3.5.1 Leak Test

This screen provides the options and indications needed to perform a leak test of the sampling system. The grey pump control button in the lower left corner will read PUMP ON which indicates that pressing it will turn on the pump. Similarly, when the pump is running, this button will display PUMP OFF.

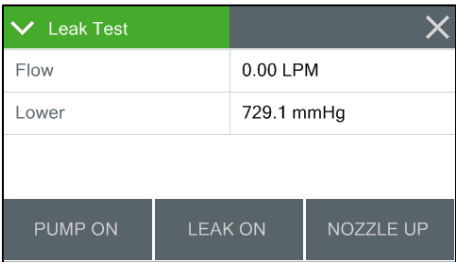


Figure 3-13 The Leak Test Screen

The grey NOZZLE control button in the lower right corner will always be labeled as NOZZLE when this test screen is first entered. Pressing it will cause the button label to change NOZZLE UP or NOZZLE DOWN. The button will now display what will happen if it is pressed again, just like the pump control button. This means that it will read NOZZLE UP if the nozzle is in the down position or NOZZLE DOWN if it is in the up position.

The flow and lower pressure sensor indications are provided for reference when performing the leak test. See section 5.2 for detailed instructions on performing a leak test.

3.5.2 Ambient Temperature

This screen provides the options and indications needed to default, verify, and calibrate the external ambient temperature sensor as part of the flow audit and calibration. See section 5.6 for detailed instructions.

▼ Ambient Temp		✕
E-BAM	22.6 C	
Reference	+22.6	
DEFAULT		CALIBRATE

Figure 3-14 The Ambient Temperature Screen

3.5.3 Ambient Pressure

This screen provides the options and indications needed to default, verify, and calibrate the external ambient pressure sensor as part of the flow audit and calibration. See section 5.7 for detailed instructions.

▼ Ambient Pressure		✕
E-BAM	727.8 mmHg	
Reference	+728	
DEFAULT		CALIBRATE

Figure 3-15 The Ambient Pressure Screen

3.5.4 Flow Calibration

These four screens provide the options and indications needed to default, verify, and calibrate the internal flow sensor as part of the flow audit and calibration procedures. See section 5.8 for detailed instructions.

▼ Zero Flow		✕
Flow	-0.00 LPM	
DEFAULT	ZERO	CONTINUE

Figure 3-16 Flow Calibration Screen (1 of 4)

3.5.5 Self-Test

This screen runs the self-test sequence. Press X to exit once it is complete

▼ Self Test		✕	
Nozzle Up		Static Pres	
Tape Move		Dynamic Pres	
Nozzle Down		Sensor Link	
Beta Count			
Flow System			
START		NONE	

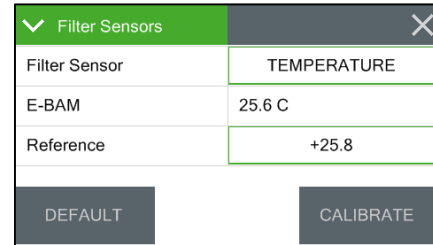
▼ Self Test		✕	
Nozzle Up	PASS	Static Pres	PASS
Tape Move	PASS	Dynamic Pres	PASS
Nozzle Down	PASS	Sensor Link	PASS
Beta Count	PASS		
Flow System	PASS		
START		SELF-TEST COMPLETE	

Figure 3-17 The Self Test Screen

3.5.6 Filter Sensors

This screen provides the options and indications needed to default, verify, and calibrate the filter temperature, humidity, and upper and lower pressure sensors. See section 5.10 for detailed instructions.

The Filter Sensor field indicates which sensor is currently being audited. To select a different sensor, press the green bordered value box and a list of the sensors will be displayed. Use the arrow buttons at the bottom of the screen to see more choices. Tap the option to be used, and it will be selected. Press the OK button to exit the screen and audit the sensor.



Filter Sensors	
Filter Sensor	TEMPERATURE
E-BAM	25.6 C
Reference	+25.8

DEFAULT CALIBRATE

Figure 3-18 The Filter Sensors Screen

The E-BAM field displays the current value of the chosen Filter Sensor.

The Standard field is the field where the value shown on the traceable reference standard is entered if the E-BAM value needs to be adjusted. To make a change, press the green bordered value box and the numerical entry keypad (Figure 3-5) will be displayed. Enter the value currently shown on the standard and press the OK key to set it. Press the CALIBRATE key to set any changes. The E-BAM and Standard fields should now match.

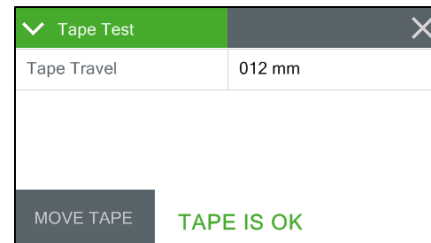
The DEFAULT key can replace the current calibration factors with the factory default settings on any of the four sensors. If difficulty is encountered during the audit process, press the DEFAULT key to set that specific sensor back to factory values and then try the calibration again.

3.5.7 Span Mass Audit

This screen runs the Span Mass Audit. The sequence begins as soon the menu is entered. See section 5.9 for detailed instructions.

3.5.8 Tape Test

This screen provides a means to verify proper installation and operation of the filter tape and motors. Press the grey TEST TAPE button to advance the tape. The pass criteria is ≥ 12 mm. The status of the tape, such as OK or if there is a Tape Break error, will be displayed to the right of the TEST TAPE button.



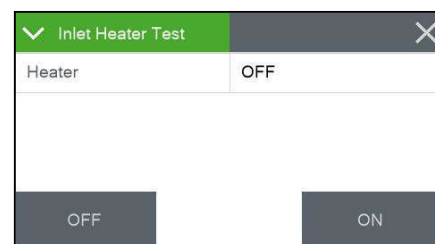
Tape Test	
Tape Travel	012 mm

MOVE TAPE TAPE IS OK

Figure 3-19 The Tape Test Screen

3.5.9 Inlet Heater

This screen allows manual operation of the inlet heater assembly. Press ON to turn the heater on and verify the element heats up as expected. Press OFF to turn the heater off; verify it shuts off and then cools down. Exiting this test screen will also turn off the heater if it is left in the ON state.



Inlet Heater Test	
Heater	OFF

OFF ON

Figure 3-20 The Inlet Heater Test Screen

3.5.10 Nozzle/Count Test

The Nozzle/Count Test screen provides the ability to manually raise and lower the nozzle. Pressing the grey NOZZLE button will cause the nozzle to change state. When the nozzle is in the down position, the E-BAM beta count results can also be verified as shown in Figure 3-21. The frequency for beta counts is typically greater than 1500 Hz.

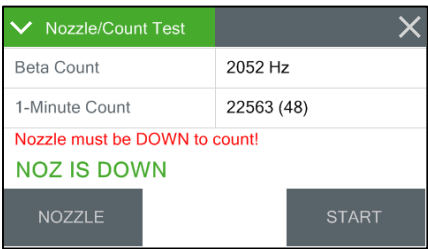


Figure 3-21 The Nozzle/Count Test Screen

Counting should only occur when the nozzle is in the down position. Figure 3-21 shows a typical count value for the Beta Count field.

The 1-Minute Count test is for troubleshooting purposes with factory support technicians and will not commonly be used when deployed. Pressing the grey START button will begin the 1-Minute Count test. The counts displayed in the 1-Minute Count Field will start from zero and begin counting up. A 60 second countdown timer will be shown in parenthesis next to the count value.

3.5.11 Digital Link

Test digital communications with the BX-597A by entering this screen. The BX-597A firmware version should be displayed when the proper link is established. See section 2.7 for details on how to configure the BX-597A sensor, as well as any optional wind sensors.

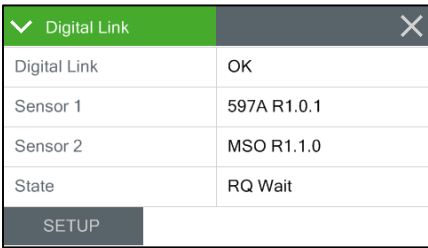


Figure 3-22 The Digital Link Screen

3.6 Setup Menu

The Setup Menu grants access to the configuration of most of the operating parameters for the E-BAM. It allows for changing the offsets, clearing the memory, setting the date and time, and much more. Because of the changes able to be made, the Setup Menu is password protected.

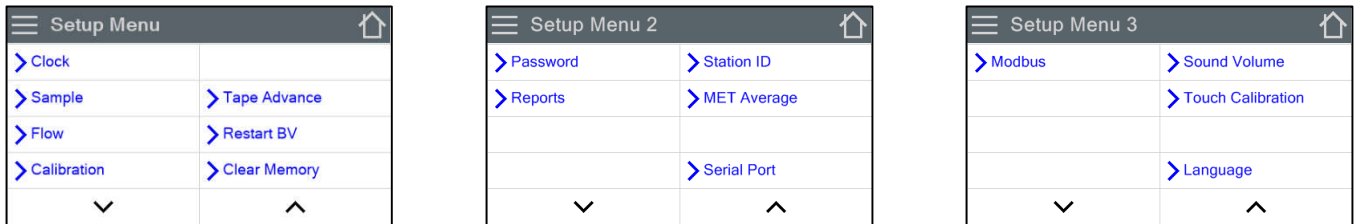


Figure 3-23 Setup Menus

Note that the display has a limited amount of space and cannot show all options on one screen. Tap the down or up keys in the lower right corner of the display to navigate between the three screens shown in Figure 3-23.

3.6.1 Set Clock

This is where the date and time are set. Press the green box of the field that needs to be modified. The numerical entry keypad (Figure 3-5) will be displayed and allow entry of the value for that parameter. Once all fields have been entered, press the grey Set button in the lower left corner to set them.

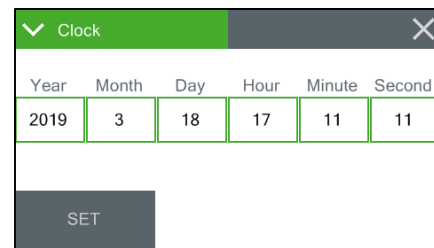


Figure 3-24 The Set Clock Screen

3.6.2 Sample

The concentration (Conc) Units of the E-BAM can be set to either mg/m^3 or $\mu\text{g}/\text{m}^3$. To change this setting, press the green bordered value box and a list of the settings available will be displayed. Select the desired units and the press the grey OK button.

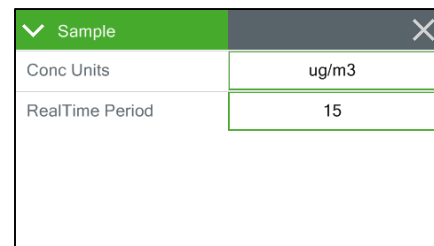


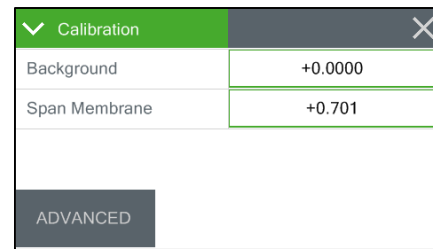
Figure 3-25 The Sample Screen

The Real Time Period sets the time interval for the real-time concentration (Conc RT) algorithm. The Conc RT will use the last X number of minutes where X is Real Time Period value set in the Sample menu screen.

For example, if 15 minutes is chosen, nothing will be displayed for minutes 1-14. After minute 15, the first Conc RT will be displayed. Each minute after that will update the Conc RT based on the previous 15 minutes. This means that minute 16 will display the data from minute 2-16, and so on. The Real Time Period may be set anywhere from 8 to 60 minutes, in one-minute increments.

3.6.3 Calibration

The background value is the zero correction (offset) for the E-BAM concentrations. It is applied to all data collected to compensate for measured mass in the absence of any particulate matter. This screen allows for editing the background zero correction factor after performing a zero test with the BX-302 Zero Filter. See section 5.4.



Calibration	
Background	+0.0000
Span Membrane	+0.701
ADVANCED	

Figure 3-26 The Calibration Screen

Press the green bordered value box and the numerical entry keypad (Figure 3-5) will be displayed. Enter the new calculated correction factor. Regardless of the concentration units setting the background is always entered in units of mg/m³.

Met One supplies the E-BAM with a factory-set background value. Use the BX-302 zero filter kit to audit the background value and set it for local conditions. See the BX-302-9800 manual for the zero-test procedure or contact the Met One Instruments service department (see section 1.2) for more information.

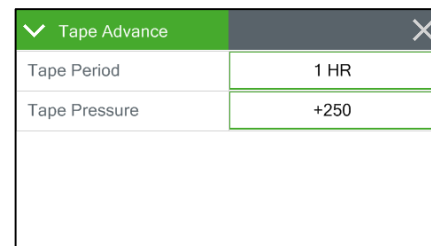
WARNING: This calibration value may significantly affect the accuracy of the unit.

The grey ADVANCED button in the lower left corner provides access to the K factor setting for the E-BAM. This should **NOT** be adjusted unless directed by factory personnel. It is set at the factory and altering it will void the unit's calibration.

3.6.4 Tape Advance

The filter tape in the E-BAM will be automatically advanced at a specified time interval or whenever too much particulate has been deposited on it.

The tape advance time is adjustable and can be set to Auto, 1, 2, 3, 4, 6, 8, 12, or 24 hours. It is recommended to use the greatest duration possible while avoiding an automatic advance due to a pressure drop error. This will allow for maximum tape usage over time. The shorter the advancement period is set, the faster the filter tape will be consumed. The "Auto" setting will result in a tape advance only when tape pressure has been exceeded.



Tape Advance	
Tape Period	1 HR
Tape Pressure	+250

Figure 3-27 The Tape Advance Screen

Heavy particulate buildup will result in an excessive pressure drop across the tape. If the pressure drop gets too large, the E-BAM will advance the filter tape to a clean spot and then continue sampling. This is to prevent straining the pump when sampling in air with higher contamination levels. The pressure threshold for this action can be set from 50 to 350 mmHg in one mmHg increments.

To change the Tape Period, press the green bordered value box and a list of the settings available will be displayed. Tap the required option and it will be applied.

To change the Tape Pressure, press the green bordered value box and the numerical entry keypad (Figure 3-5) will be displayed. Enter the new pressure threshold value and press the OK key to set it. Decimal values will be rounded up or down to the nearest whole number.

3.6.5 Restart BV

The Battery Voltage level (BV) displayed in the Parameters screen (Figure 3-10) represents the DC input voltage as measured by the device. The reported BV level is always less than the supplied input voltage due to a voltage drop caused by internal circuit protection components. For example, connecting a typical fully charged battery with a voltage of approximately 12.7V will result in an E-BAM BV level of approximately 12.2V. The Restart BV setting is an important parameter to understand if the unit is to be run on batteries or solar power. If the BV level drops to a 1-minute average of 11.0 volts, the E-BAM will generate a Low Battery alarm and stop sampling, entering standby mode. The Restart BV setting is *the lowest BV level at which the E-BAM will resume sampling*, such as after the battery has been recharged. This allows the batteries enough time to adequately recharge before the E-BAM turns back on, particularly when used with a solar panel array, and prevents the unit from rapidly cycling on and off when the batteries are low. The default setting of 12.5V is suitable for most solar panel array configurations. Consult your battery documentation for the optimal recharge profile. The Restart BV threshold can be set from 11.0 to 15.0V. Press the green bordered value box and the numerical entry keypad (Figure 3-5) will be displayed. Enter the new Restart BV level and press the OK button to set it.



Figure 3-28 The Restart BV Screen

3.6.6 Clear Memory

The alarm and data logs may be cleared from this screen by pressing either the CLEAR DATA or CLEAR ALARM button. A warning screen will appear and request confirmation that all data will be cleared. Press the CLEAR to erase the data (or alarm) log or press the white X in the upper right corner of the screen to cancel the operation without erasing the log.

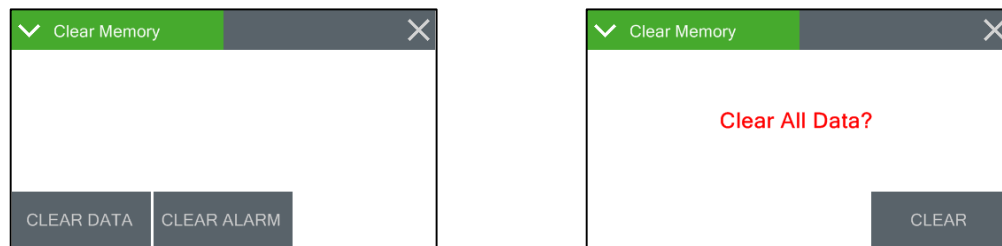
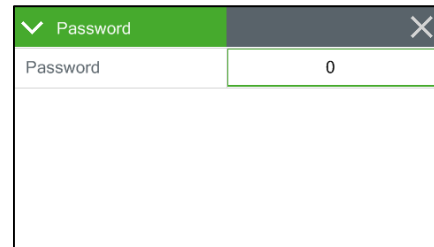


Figure 3-29 The Clear Memory Screen

3.6.7 Password

Certain menus and options of the E-BAM are password protected. A valid password consists of any four digits, and this is the screen that provides access to change it. Press the green bordered value box and the numerical entry keypad (Figure 3-5) will be displayed. Enter the new password.

Setting the Password to 0 removes password protection on all user accessible menus and options.

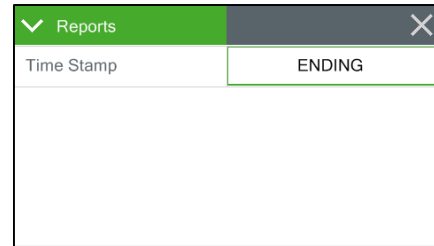


✓ Password		✕
Password	0	

Figure 3-30 The Password Screen

3.6.8 Report

The report time stamp can be set to mark the data with the time from either the beginning or ending of the hour. For example, if set to BEGINNING, data collected during the hour from 8:00 to 9:00 would be marked as 8:00. Similarly, if that data were collected with ENDING as the choice, the data time stamp would be 9:00 instead.

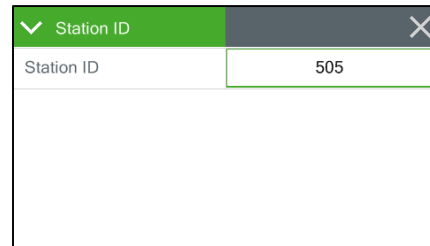


✓ Reports		✕
Time Stamp	ENDING	

Figure 3-31 The Report Screen

3.6.9 Station ID

This screen provides the option to enter a three-digit location ID for the E-BAM. Press the green bordered value box and the numerical entry keypad (Figure 3-5) will be displayed. Enter the new location ID value.

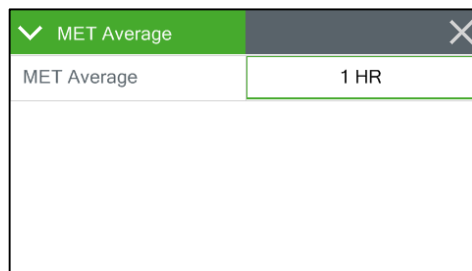


✓ Station ID		✕
Station ID	505	

Figure 3-32 The Station ID Screen

3.6.10 MET Average

The default averaging period for the E-BAM is 60 minutes. If an alternate averaging period is needed, it may be selected from this screen. Press the green bordered value box and the selection screen shown on the right of Figure 3-33 will be displayed. Not all choices are able to be presented at the same time. Use the up and down arrow keys under the displayed options to show additional selections. Tap the required period length and then press the OK button to set it. The available MET average periods are 1, 5, 10, 15, 30, and 60 minutes.



✓ MET Average		✕
MET Average	1 HR	

Figure 3-33 The MET Average Screens

3.6.10.1 Data Average Capacity

The E-BAM internal data logger can store 22,528 records. With a fixed number of records, the time until the internal logger is full will vary depending on the averaging period selected. The shorter the time interval, the faster the logger will fill up. Table 3-3 shows the approximate length of time in days, months, and years before the logger reaches full capacity. Once the circular memory is full, the E-BAM will begin overwriting the oldest data with the most recently collected data points.

Time Period in Minutes	Approximate Capacity in Days	Approximate Capacity in Months	Approximate Capacity in Years
1	15.6	0.5	0.0
5	78.2	2.6	0.2
10	156.4	5.2	0.4
15	234.7	7.8	0.6
30	469.3	15.6	1.3
60	938.7	31.3	2.6

Table 3-3 Approximate Data File Capacity in Time

3.6.11 Serial Port

This is where the serial communication settings are configured. The baud rate options are 2400, 4800, 9600, 19200, 38400, 57600, and 115,200.

Press the green bordered value box and a list of the settings available will be displayed. The default baud rate is 115,200 baud.

The RS-232 port will typically be used for direct connection to a PC or other RS-232 compatible device.

The RS-485 port will typically be used with the Met One CCS Modem option.

In some cases, remote access over Ethernet or modems may require flow control to compensate for slow or noisy connections. In these situations, the RS-232 serial connection can be configured to use XON/XOFF flow control. Flow control is set to NONE by default but can be changed using the Flow Control-232 selection box.

See Section 6 for more details about serial communications.

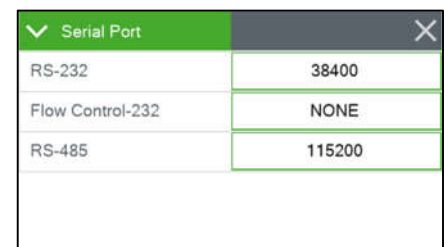


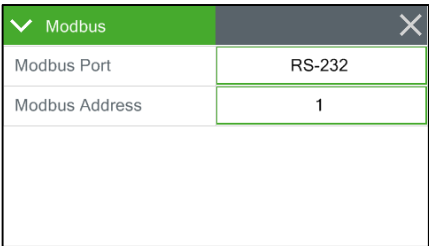
Figure 3-34 The Serial Port Screen

3.6.12 Modbus

This menu is used to select the active slave Modbus Port: RS-232 or RS-485.

The port is accessed from the bottom panel (Figure 6-1).

Select the slave Modbus address. Each slave must have a unique address from 1 to 247.



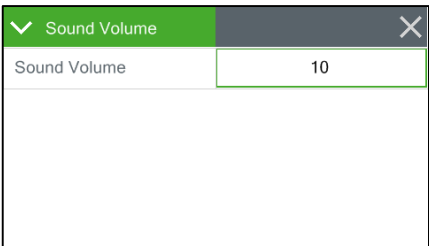
Modbus	
Modbus Port	RS-232
Modbus Address	1

Figure 3-35 The Modbus Screen

3.6.13 Sound Volume

The touchscreen will beep every time a selection is made. The volume of that beep may be adjusted in this screen. Press the green bordered value box and the numerical entry keypad (Figure 3-5) will be displayed.

The volume range is 0 – 100 with 100 being very loud and 0 being no beep at all.



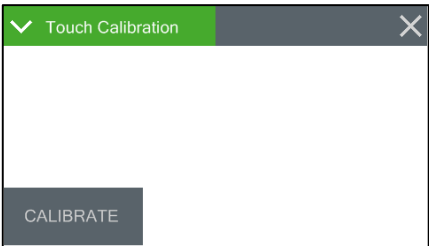
Sound Volume	
Sound Volume	10

Figure 3-36 The Sound Volume Screen

3.6.14 Touch Calibrate

This screen allows for calibration of the touchscreen. Press the grey Calibrate button to begin and then simply follow the instructions on the screen to calibrate it.

If each step is not completed within five seconds, the test will cancel itself and return to page two of the Setup menu.



Touch Calibration	
CALIBRATE	

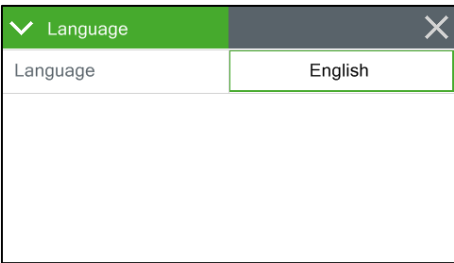
Figure 3-37 The Touch Calibrate Screen

There is a countdown clock for this feature displayed on each step of the calibration process.

3.6.15 Language

The E-BAM display may be configured to read out in either English or Chinese characters. This screen is used to select which language is to be displayed.

Press the green bordered value box and a selection menu will be displayed. Tap the language that is preferred and then press the grey OK button to set it.



Language	
Language	English

Figure 3-38 The Language Screen

3.7 Alarms

This screen is used to view time-stamped alarm events with the most recent alarm will be displayed first. Use the up and down arrow keys located at the bottom of the screen to scroll through the alarm log.

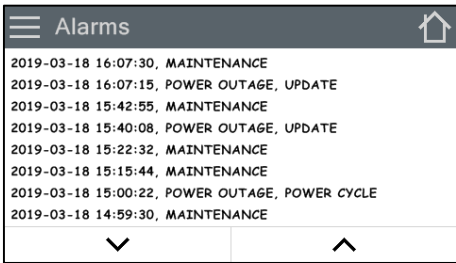


Figure 3-39 The Alarms Screen

4 SAMPLE SITE SELECTION

Use the following criteria when deciding on a sampling location for the E-BAM. Always consider the safety and security of the unit as well as the suitability of the sampling environment.

4.1 Site Selection Requirements

Selection of a proper site for the E-BAM is critical for accurate measurements. In many cases, these items must be correctly addressed for the collected data to be acceptable for regulatory requirements, such as FEM, ARM or SPM methods. The following is a general list of site considerations:

1. Inlet height
2. Spacing and clearance
3. Proximity to particulate sources, both mobile and stationary
4. Additional siting criteria or other considerations

These details should all be understood and considered when selecting a site. Consult any local regulations and guidance documentation that may exist. In any case, the Code of Federal Regulations takes precedence where applicable. The US EPA provides a variety of guidance documents where site selection issues are addressed. Refer to the EPA website at <http://www.epa.gov/www.epa.gov>.

4.2 Fall Hazard and Security Cautions

If the E-BAM is to be installed more than three meters above ground level, then the tripod legs must be fastened or bolted down to prevent the unit from falling to the ground. An accidental fall of more than three meters may compromise the containment of the radioactive source and the unit will need to be returned to the factory for testing. In addition, dropping the E-BAM from any height will cause a potential safety hazard for those below, and may damage the unit beyond repair.

The E-BAM tripod should be secured to the mounting surface in windy conditions to prevent the unit from falling over, even at ground level. This is especially important in winds over 30 mph. If bolt-down is not possible, then the tripod legs may be weighted down with sandbags to secure the unit. Wind or fall damage is not covered under warranty.

The E-BAM should be secured from theft or vandalism to the extent possible. A limited-access rooftop or a fenced lot are often good places to deploy the unit. Solar panels and batteries are also highly susceptible to theft and should be secured.

4.3 Confined Sampling Locations

Because of the portable nature of the unit, the E-BAM is sometimes deployed in confined or non-ambient locations to monitor highly localized particulate sources, such as tunnels, mines, quarries, shopping malls, train stations, etc. Each of these applications are unique and present various challenges. It is recommended that a Met One Instruments, Inc. representative be contacted to help determine the suitability of the instrument if a custom deployment like this is being planned.

4.4 Smoke and Ash Monitoring

A primary design use for the standard E-BAM is for tracking smoke and ash plumes from wildfires, prescribed burns, agricultural burns, and even volcanic activity. In these cases, the unit is often sited at the outskirts of a populated area in the expected path of the smoke plume. The unit is usually equipped with an optional wind speed and direction sensor for these applications, in order to correlate changing wind patterns with particulate events. The wind sensor needs to be set up in the digital link interface (see section 3.5.11) and requires a cross-arm for the tripod mount. See step 5 in section 2.3 for mounting details.

In smoke tracking applications, the filter tape may be consumed at a much faster rate than normal. This is because the E-BAM may automatically advance the filter tape to a new spot if the particulate loading becomes excessive, regardless of the user-defined tape advance setting.

This is based on the measured pressure drop across the filter tape. This feature protects the pump, preserves accurate flow control, and prevents damage to the filter tape.

4.5 Remote Monitoring with Solar or Battery Power

The E-BAM is designed to be deployable in remote areas where AC power is not available. These applications may require periodically exchanged deep-cycle batteries or batteries charged in place by a solar panel array. The E-BAM is rated for a worst-case continuous power draw of 66 Watts (approximately 5.5 amps at 12 volts DC).

4.5.1 External Battery Operation

The E-BAM can run for extended periods on external batteries. The most common type for this application is 12 volt, 110 amp-hour, gel-cell or AGM, deep cycle batteries. The setup will require the included External Battery Cable (83246) which plugs into the main power connector on the bottom of the unit. The other end connects to the battery terminals. The batteries should usually be enclosed in a plastic box on the ground near the E-BAM. **Note:** The E-BAM AC power supply cannot be connected to the E-BAM while batteries or solar kits are connected, since these use the same power input connector. Batteries can be manually removed and recharged elsewhere or charged in place by a solar array.

Assuming an E-BAM (with maximum inlet heat) current draw of 3.65 amps, a single fully-charged 110Ah battery would have the theoretical capacity to run the unit for 30 hours. However, the general rule is that a lead-acid battery should not be discharged by more than 2/3 of its capacity to prevent battery damage, especially in temperatures below 40 degrees F. Runtime calculations are as follows:

- $((110\text{Ah} / 2.65\text{A}) * .67) = \text{about } \mathbf{28 \text{ hours}}$ of run time per battery (no heat)
- $((110\text{Ah} / 3.65\text{A}) * .67) = \text{about } \mathbf{20 \text{ hours}}$ of run time per battery (maximum heat)
- $((110\text{Ah} / 5.5\text{A}) * .67) = \text{about } \mathbf{13 \text{ hours}}$ of run time per battery (maximum heat and pump)

Increased run time can be achieved by connecting additional batteries **in parallel** to the first battery. Additional batteries **must** be of the same type!

Met One supplies an EX-12 External Battery Kit providing battery power for temporary instrument deployments in remote areas where AC power is not available and where solar power is not feasible. Due to the high cost of shipping batteries, some users may find it preferable to configure their own battery power kit based on locally available parts. In this case, the EX-12-9800 document available at <https://metone.com/support-documents>, can be used as a general guide.

4.5.2 Solar Operation

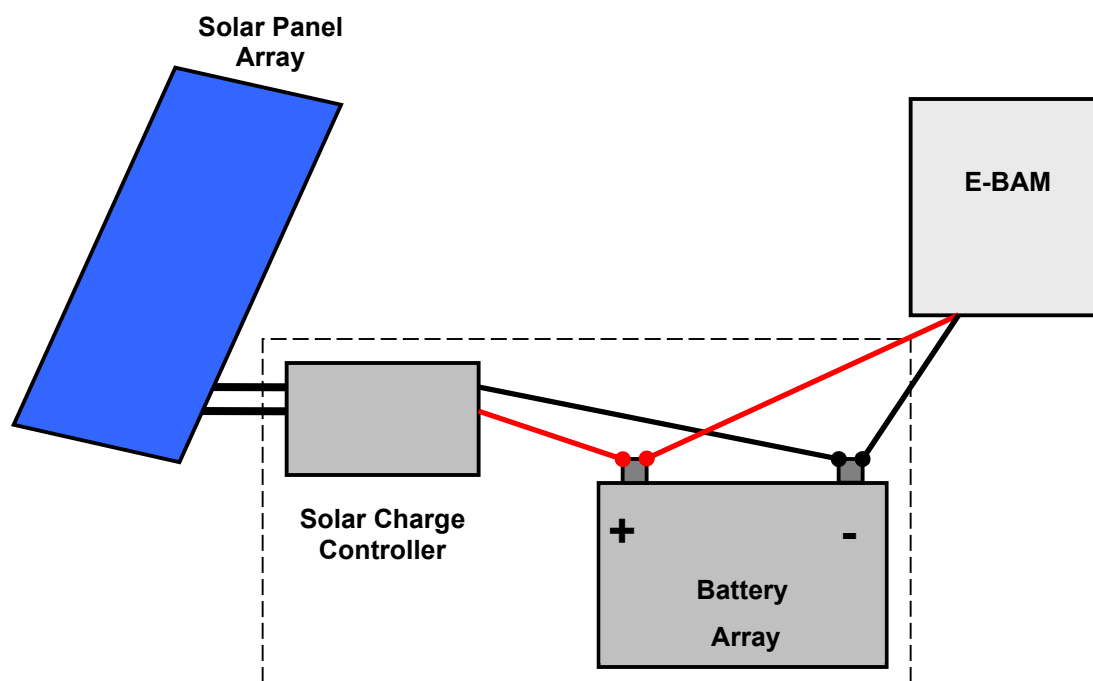
Some remote applications may require operating the E-BAM using a solar array to charge one or more 12V batteries. Care must be taken to ensure that the solar array is designed correctly and is specified to meet the power requirements of the unit. Many people greatly underestimate the amount of solar wattage required to run a particular load continuously year-round. If the solar array is not sufficient, the batteries will eventually become depleted, and the E-BAM will shut down.

Met One supplies a line of standardized portable solar power kits for use with the E-BAM. Data sheets are available. These are usually drop shipped directly from the manufacturer, and work in most (but not all) areas and applications. However, it is often preferable to contact your local solar shop and have your own array built locally based on your exact needs.



Warning! Never connect a solar panel directly to the E-BAM power input! Never connect the E-BAM to a solar power kit without first connecting the batteries to the solar kit! Immediate over-voltage damage to the E-BAM can result!

Solar panels output a high DC voltage during sunlight hours, beyond their nominal voltage. Even a solar charge controller may output higher voltages if not connected to a battery. A bank of external batteries is always required when using a solar array, to ensure proper function during the night and cloudy weather. The solar panels must be wired to charge these batteries through an appropriate charge controller. The E-BAM must be powered by the solar system battery array only. The E-BAM particulate monitor will only tolerate a 11 to 15 VDC input.



Simplified E-BAM Solar System Diagram

5 MAINTENANCE, ALARMS and TROUBLESHOOTING

This section describes the audit and calibration process for the E-BAM flow system, ambient temperature sensor, barometric pressure sensors, filter sensors, analog output, and span membrane. **The most important maintenance parameters are the leak checks, nozzle/vane cleaning, and flow checks!**

5.1 Met One Suggested Periodic Maintenance

Table 5-1 shows the Met One recommended periodicity for routine maintenance items. Some of these items will need to be performed more or less often depending on the deployment site characteristics. The program administrator should review these items and establish SOPs appropriate for the sampling location.

Maintenance Item	Interval	Reference
Replace the filter tape (for alternative tape advance settings)	As needed	Sec. 2.8
Basic leak check	8 Weeks	Sec. 5.2
Nozzle and vane cleaning	8 Weeks	Sec. 5.5.1
Flow audit (verify and/or calibrate flow system)	8 Weeks	Sec. 5.8
Clean PM ₁₀ inlet particle trap	3 Months or Less	BX-802 Manual
Clean PM _{2.5} cyclone particle trap	3 Months or Less	BX-807 Manual
Verify or set the clock	8 Weeks	Sec. 3.6.1
Mass Audit	6 Months	Sec. 5.9
Background determination	As needed	Sec 5.4
Internal Nozzle Cleaning	6 Months	Sec. 5.5.2

Table 5-1 Suggested Periodic Maintenance

5.2 Basic Leak Check

The E-BAM flow system must be checked for leaks periodically (see Table 5-1), after every filter tape change, and before any flow calibrations are performed. Enter the Leak Test screen (see section 3.5.1).

✓ Leak Test		✕
Flow	0.00 LPM	
Lower	729.1 mmHg	
PUMP ON	LEAK ON	NOZZLE UP

✓ Leak Test		✕
Flow	16.65 LPM	
Lower	615.5 mmHg	
PUMP OFF	LEAK ON	NOZZLE UP

Figure 5-1 Leak Test

Under test conditions, vacuum in the flow system is several times greater than during normal sampling. This state exaggerates any leaks. If a leak found during this test is less than or equal to 1.5 lpm, there should not be a significant leak during normal operation. A leak of greater than 1.5 Lpm must be corrected immediately.

As-found leak checks (before cleaning the nozzle and vane) may be performed for data validation purposes. The recommended threshold for invalidating as-found leak values (before cleaning nozzle and vane) is 1.5 lpm or higher.

Routine cleaning of the Nozzle/Vane interface is recommended to prevent leaks from developing. See section 5.5.1 for cleaning instructions.



Important Notes About Leak Checks:

Leaks may be caused by degraded O-rings or an improper inlet tube to receiver connection, but almost all air leaks in the E-BAM occur where the nozzle contacts the filter tape. Because the airflow sensor is located downstream of the filter tape the E-BAM has no way of automatically detecting a leak at this interface.

There will normally be a small amount of leakage at the tape, but an excessive leak lets an unknown amount of air enter the system through the leak instead of the inlet. This will cause the air volume calculation and the concentration measurement to be incorrect. **Allowing a leak to persist may cause data to be invalidated back to the last known good leak check.**

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

Use the following steps to conduct the basic leak check:

1. Remove the PM₁₀ head from the inlet tube. Install a BX-305 leak test valve, BX-302 zero filter, or equivalent valve for leak checking FRM samplers onto the inlet tube (see Figure 5-2). If a PM_{2.5} inlet cyclone is used, it is usually best to install the leak valve above the cyclone in order to test it for leaks as well. The BX-305 valve should be open.
2. Navigate to the TEST>TAPE TEST menu. Move tape and exit.
3. Navigate to the TEST>LEAK TEST screen.
4. Verify the nozzle is in the down position. If it is not, press the NOZZLE control button to lower it. The E-BAM is ready to begin the leak test.
5. Confirm the BX-305 valve is open, and then press grey PUMP ON control button to turn on

the pump.

6. Monitor the flow rate on the E-BAM display. When stabilized at 16.7 press LEAK ON to disable flow regulation and lock the flow controller in its current position.
7. Close the leak check valve (see Figure 5-2) to prevent any air from entering the inlet tube.



Figure 5-2 BX-305 Installed on Inlet Tube

8. Verify flow is equal to or less than 1.5 lpm
9. **SLOWLY** open leak check valve and then press the PUMP OFF button.
10. If results are equal to or less than 1.5 lpm then proceed to step 11. If greater than 1.5 lpm, the Advanced Leak Checks must be performed to locate the leak. See section 5.3.
11. Remove the leak check valve and replace the size selective inlet(s).
12. Return to the Operate Menu and select START SAMPLE to resume normal operations.

5.3 Advanced Leak Checks

If the basic leak check detailed in section 5.2 persistently fails, and the location of the leak cannot be identified, the following procedures will help isolate the problem.

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

5.3.1 Lower System Leak Test

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

1. Navigate to the TEST>LEAK TEST menu and press NOZZLE to raise the nozzle if needed.
2. Remove filter tape from nozzle area.
3. Insert the Nozzle Seal Tool without the hole between the nozzle and vane. Note the proper alignment in the photo below.



Figure 5-3 Nozzle Sealing Tool Lower System Test Configuration

4. Press NOZZLE to lower nozzle onto the sealing tool.
5. Verify the leak check valve is open and then press the PUMP ON button to turn on the pump. Monitor the flow rate on the E-BAM display until it stabilizes.
6. If the flow rate falls below 1.5 lpm, the leak is not in the lower system. Turn off the pump and proceed to section 5.3.2.
7. If the flow rate does not fall below 1.5 lpm, there is a leak located in the tubing or fittings between the vane and flow sensor. Contact the Met One service team for resolution.
8. Repeat the above steps until the leak has been identified and corrected.
9. Remove the rubber sealing tool, remove the leak check valve, install the tape and replace the size selective inlet(s).
10. Return to the Operate Menu and select START SAMPLE to resume normal operations.

5.3.2 Upper System Leak Test

Use this procedure to identify leaks above the filter tape. The lower system leak test in section 5.3.1 should be performed first.

1. Navigate to the TEST>LEAK TEST menu and raise the nozzle if needed.
2. Insert the Nozzle Seal Tool with the hole between the nozzle and vane. Note the proper alignment in Figure 5-4.



Figure 5-4 Nozzle Sealing Tool Upper System Test Configuration

3. Press NOZZLE to lower the nozzle down onto the sealing tool.
4. Verify the leak check valve is open and then press the PUMP ON button to turn on the pump. Monitor the flow rate on the E-BAM display until it stabilizes at 16.7 lpm.
5. Press the LEAK ON button to lock the flow controller in its current position.
6. Close the leak check valve and monitor the flow rate.
 - a. If the flow rate falls below 1.5 lpm, the upper system leak check is successful. Turn off the pump and proceed to the Filter Tape Leak Test (section 5.3.3).
 - b. If the flow rate does not fall below 1.5 lpm (and the lower system leak test in section 5.3.1 was successful), then there is a leak located above the nozzle. The issue is likely due to faulty or failed O-rings within the receiver or in the PM2.5 size selector (if installed). It can also be caused by an improper inlet tube connection. Contact the Met One Instruments, Inc. service department if additional assistance is needed. See section 1.2.
7. Once the failure is resolved and a successful leak check is achieved, remove the rubber sealing tool, remove the leak check valve, install the tape and replace the size selective inlet(s).
8. Return to the Operate Menu and select START SAMPLE to resume normal operations.

5.3.3 Filter Tape Leak Test

Use this procedure to identify a leak at the filter tape interface. The lower and upper system leak tests in sections 5.3.1 and 5.3.2 above should be performed first.

1. Navigate to the TEST>LEAK TEST menu and raise the nozzle, if needed.
2. Remove all tape from the nozzle area. Remove the size selective inlet(s) or leak test valve from the sample tube and install a calibration transfer standard (CTS), such as the BX-307 volumetric flow calibrator.
3. Insert the Nozzle Seal Tool with Hole between the nozzle and vane. Note the proper alignment shown in Figure 5-4. The rubber will guarantee a positive seal at the nozzle/vane interface, regardless of any debris or imperfections.
4. Press the nozzle control button to lower the nozzle down to the sealing tool.
5. Press pump control button to turn on the pump. Monitor the flow rate on the E-BAM display. Remember the flow will temporarily rise before it drops.
6. When the flow rate stabilizes, write down the CTS flow rate value. This is the “Without Tape” value.
7. Turn off the pump and raise the nozzle.
8. Remove the Nozzle Seal Tool.
9. Place a 3-inch-long piece of filter tape directly below the nozzle and lower the nozzle again.
10. Press pump control button to turn on the pump. Monitor the flow rate on the E-BAM display.
11. When the flow rate stabilizes, write down the CTS flow rate value. This is the “With Tape” value.
12. Turn off 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:

$$\text{WithoutTape} - \text{WithTape} = \text{LeakRate}$$

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 (liters per minute) a leak exists at the nozzle / tape interface. Thoroughly clean the nozzle and vane area as directed in section 5.5 and then repeat steps 3 through 14 until the leak is corrected. If this test still fails after a few tries, contact the Met One Instruments, Inc. service department (see section 1.2) for assistance.
15. Once the leak has been resolved, remove the CTS and replace the size selective inlets on the sample tube. Reinstall the tape and resume normal sampling operations.

5.4 Background Determination (Mass Offset)

It is recommended that the E-BAM undergo a background test annually and after any major repairs have been performed.

Required Tools: Zero Filter (Met One Instruments Part No. BX-302)

Use the following steps to conduct a zero-filter background test and set the mass offset.

1. Ensure that the E-BAM has been calibrated and that leaks are not present.
2. Go to the Operate menu and select Stop Sample to stop the current sample.



Figure 5-5 BX-302 Zero Filter Assembly

3. Remove the size selective inlet(s) from the sample tube and install the zero filter.
4. Verify that the zero-filter leak valve is in the open position.
5. Go to the Setup menu and select Background.
6. Set the Background value to zero (see section 3.6.3 for details).
7. Exit the Background menu, go to the Operate menu, select Start Sample, and begin sampling.
8. After no less than 48 hours, retrieve the E-BAM hourly concentration data. Confirm that the monitor ran without disruption. If errors, power outages or maintenance occurred, the test will have to be restarted.
9. Calculate the average of the most recent 48 hourly PM concentrations. This allows the first few hours of the test to be used for warming up the system and allowing it to stabilize before collecting data for the 48 -hour average. Record this value.
10. Calculate the new Background value by determining the negative of the 48-hour average calculated in Step 9. For example, if the 48 hour mean = $1.07 \mu\text{g} / \text{m}^3$, the new Background would be $-1.07 \mu\text{g} / \text{m}^3$. Since all Background values are entered in units of mg / m^3 , round to the fourth decimal place and use $-0.0011 \text{ mg} / \text{m}^3$.
11. Return to the Setup menu and select Background.
12. Enter the new Background value.

13. Go to the Operate menu and select Stop Sample to stop the current sample, if the monitor is still sampling.
14. Remove the zero filter from the inlet tube and install the size selective inlet(s)
15. Resume normal sampling.

NOTES:

For best results, the zero-filter background test should be performed during a period of fairly stable weather.

The zero-filter cartridge should be replaced if there are any obvious signs of discoloration due to aging or the aspiration of water. See section 7.1 for ordering details.

To determine the hourly zero noise and hourly lower detection limit, calculate the standard deviation of the most recent 48 hourly PM concentrations (the values used in step 9 above). The standard deviation (σ) should be less than 5 μg . The hourly detection limit is defined as two times the standard deviation (2σ).

If the standard deviation is greater than 5 μg , the cause should be investigated. Contact the Met One Instruments service department (see section 1.2) for assistance.

5.5 Nozzle/Vane Cleaning

The inside of the E-BAM sample nozzle should be periodically cleaned to remove any particulate which may have settled on the inside surfaces. This cleaning prevents any buildup of particulate which could result in artifacts falling out of the nozzle and onto the tape, causing undesired positive concentration spikes.

The nozzle and vane (located under the tape) must be cleaned regularly to prevent leaks and measurement errors. The cleaning must be done at least each time the filter tape is changed, though monthly cleaning is highly recommended. Some sites will require more frequent cleaning as determined by the site administrator. The worst environment for nozzle contamination is hot, humid environments. This is because damp filter tape fibers more easily stick to the nozzle and vane. The fibers can quickly build up, creating air leaks or punching small holes in the filter tape which will cause measurement errors.

5.5.1 Nozzle/Vane Cleaning

Use the following steps to clean the nozzle/vane interface:

1. It is advisable to perform an as-found leak check (section 5.2) before cleaning the nozzle, in order to validate past data as being leak-free.
2. If the nozzle is down, raise it by pressing the NOZZLE button in the Leak Test screen.
3. Remove the filter tape (if installed) from the nozzle area to allow access to the vane.

4. Thoroughly clean the nozzle sealing surface and the vane crosshairs with a cotton-tipped applicator and isopropyl alcohol (see Figure 5-6). Any hardened deposits may have to be carefully scraped off with the wooden end of the applicator.

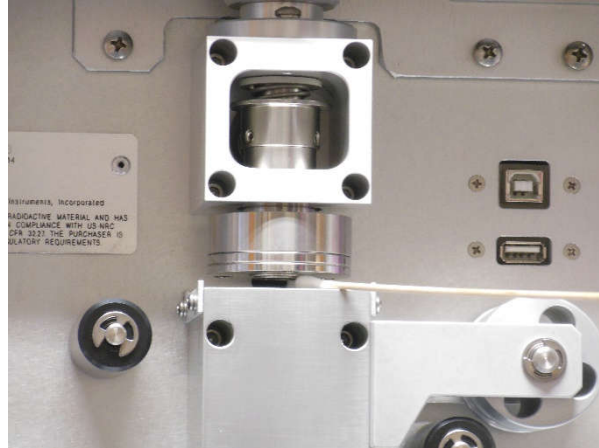


Figure 5-6 Cleaning the E-BAM Nozzle and Vane with a Cotton-Tipped Applicator

5. Inspect the nozzle lip and vane for any burrs which may cause leaks or tape damage.
6. After the cleaning process, it is recommended to use canned dusting air to blow down through the vane crosshairs. This removes any filter debris from the face of the beta detector, which is located directly under the vane. Be careful not to damage the beta detector window!
7. Reinstall the filter tape and perform a final leak check.

Figure 5-7 shows the difference between good and bad filter tape spots. The tape on the right is from an E-BAM with a clean nozzle and vane. The particulate spots have crisp edges, are perfectly round, and are evenly distributed. The tape on the left is from a unit with a dirty vane. A spot of debris has built up and is punching a pin-hole at the edge of each spot. The spots also show a “halo” effect from an air leak because the debris has built up to the extent that the nozzle no longer seals correctly. These faults are easily prevented by keeping the nozzle and vane clean.

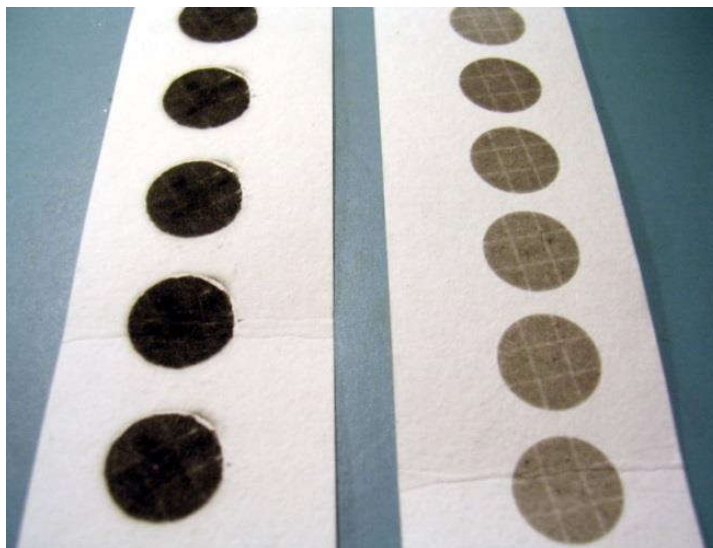


Figure 5-7 E-BAM Filter Tape Examples

5.5.2 Nozzle Interior Cleaning

Every six months, the inside of the nozzle assembly should be cleaned. This process simply involves blowing low pressure compressed air through the assembly.

CAUTION: Never attempt to remove or disassemble the nozzle assembly! The beta source is housed inside the nozzle.

1. Advance the filter tape to a fresh spot.
2. Remove the PM10 head (and the PM2.5 sharp cut cyclone, if installed) and the short inlet tube from the top of the E-BAM.
3. Turn on the sample pump and, while the pump is running, use a can of dusting air with a long plastic nozzle to blow through the inlet on top of the monitor. Three to four blasts at different angles should be sufficient. This will dislodge any particulate from the inside of the nozzle and sample tube walls and deposit it onto the tape.
4. Repeat the process until the tape spot no longer shows signs of particulate. The tape may need to be advanced to an unused spot to determine this.
5. Replace the inlet tube and cyclones when finished.

5.6 Ambient Temperature Sensor Audit

The ambient temperature must be audited or calibrated before any flow calibrations are performed. Enter the Ambient Temperature calibration screen (see section 3.5.2) and perform a single point verification of ambient temperature. This is acceptable for all field calibrations.

The E-BAM parameter is the instantaneous output from the BX-597A sensor. This is the parameter being audited. The Standard parameter is the field where the correct temperature as shown on the traceable reference standard temperature audit device is entered.

Position the reference standard as closely as possible to the AT sensor of the BX-597A and allow them to equilibrate. Compare the E-BAM value to the standard. If an adjustment is necessary, enter the correct temperature in the Standard field and then press the CALIBRATE key to correct the E-BAM sensor reading. The E-BAM and Standard parameters should now match. Press the X key to exit the screen when finished.

If difficulty is encountered during the process, the DEFAULT key can be pressed to erase all field calibration factors from the temperature sensor and to start over with factory default calibration factors. Then try the calibration again.

5.7 Ambient Barometric Pressure Sensor Audit

The ambient barometric pressure must be audited or calibrated before any flow calibrations are performed. Enter the Ambient Temperature calibration screen (see section 3.5.3) and perform a single point verification of ambient barometric pressure. This is acceptable for all field calibrations.

The E-BAM parameter is the instantaneous output from the BX-597A sensor. This is the parameter being audited. The Standard parameter is the field where the correct pressure as shown on the traceable reference standard pressure audit device is entered.

Position the reference standard as closely as possible to the BP sensor of the BX-597A and allow them to equilibrate. Compare the E-BAM value to the standard. If an adjustment is necessary, enter the correct pressure in the Standard field and then press the CALIBRATE key to correct the E-BAM sensor reading. The E-BAM and Standard parameters should now match. Press the X key to exit the screen when finished.

If difficulty is encountered during the process, the DEFAULT key can be pressed to erase all field calibration factors from the barometric pressure sensor and to start over with factory default calibration factors. Then try the calibration again.

5.8 Flow Audits and Calibrations

The flow calibration is performed after the ambient temperature and pressure sensors are audited (see sections 5.6 and 5.7), because the E-BAM uses these parameters to calculate flow. In addition, *the nozzle and vane must be clean, and a leak check must be performed (see section 5.2) before the flow calibration.* The PM₁₀ inlet head must be removed and a traceable reference standard flow audit device (BGI deltaCal® or equivalent) must be installed in its place onto the top of the E-BAM inlet tube to measure the flow.

The accuracy of the E-BAM flow control system should be periodically verified. If the flow, temperature or pressure sensors are not operating within desired specification, they should be calibrated.

Minimum Suggested Interval: Complete calibration upon commissioning. Verification required after replacing filter tape (8 weeks).

Required Tools: Certified Calibration Transfer Standard (CTS); (e.g. Flow Calibration Kit, Met One Instruments Part No. BX-307)

All calibration transfer standards should be certified to the following criteria, and have a valid certificate of traceability to NIST standards:

Transfer Standard	Acceptance Criteria
Flow Rate	± 2% of NIST Traceable Standard
Ambient Temperature	± 0.1° C Resolution ± 0.5° C Accuracy
Barometric Pressure	± 1 mmHg Resolution ± 5 mmHg Accuracy

Table 5-2 Minimum Calibration Transfer Standard Specifications

If a flow audit is desired (and not a full calibration) the same procedure detailed in this section is followed, but no changes are made; the results are observed and recorded only. A flow audit confirms operation of the flow system without making any alterations. This may be necessary to validate data collected during verification of the E-BAM flow control system, the following acceptance criteria should be maintained.

Parameter	Acceptance Criteria
Flow Rate	± 4% of transfer standard
Ambient Temperature	± 2° C of transfer standard
Barometric Pressure	± 10 mmHg of transfer standard

Table 5-3 E-BAM Flow Calibration Specifications

Use the following steps to verify and calibrate sensors associated with the E-BAM sample flow control system.

1. Make certain that the E-BAM has warmed up for at least 60 minutes prior to performing calibrations. Also, allow the calibration transfer standard (CTS) to equilibrate to ambient conditions for no less than 30 minutes.
2. Go to the Operate menu and select Stop Sample to stop the current sample.
3. Remove the size selective inlet(s) from the sample tube and install the calibration transfer standard (CTS).



Figure 5-8 E-BAM with CTS Installed

4. Enter the Test > Ambient Temperature screen.
5. Compare the E-BAM temperature measurement and CTS temperature reading.
6. If the E-BAM temperature sensor exceeds the criteria listed in Table 5-3, press the grey DEFAULT button to remove any previous offsets. If the temperature now passes, skip the next step.
7. If the temperature still needs to be adjusted, press the green bordered value box and the numerical entry keypad will be displayed. Enter the CTS value in the Standard field and press OK to return to the Ambient Temperature screen. Press the grey CALIBRATE button to enter the new calibration offset.
8. Return to the TEST menu and go to the Ambient Pressure screen.
9. Compare the E-BAM pressure measurement and CTS pressure reading.
10. If the E-BAM pressure sensor exceeds the criteria listed in Table 5-3, press the grey DEFAULT button to remove any previous offsets. If the pressure now passes, skip the next step.
11. If the pressure still needs to be adjusted, press the green bordered value box and the numerical entry keypad will be displayed. Enter the CTS value in the Standard field and press OK to return to the Ambient Pressure screen. Press the grey CALIBRATE button to enter the new calibration offset.
12. Return to the TEST menu and go to the Flow Calibration screen shown in Figure 5-9.
13. If the Flow field does not display 0.00, press the grey ZERO button to set the zero flow value.

Zero Flow	
Flow	-0.00 LPM
<div> <div>DEFAULT</div> <div>ZERO</div> <div>CONTINUE</div> </div>	

Flow Calibration	
Set Point	16.7
E-BAM	16.67 LPM
Reference	+16.70
<div> <div>DEFAULT</div> <div>CALIBRATE</div> </div>	

Set Point	
	16.7
16.7	17.5
16.7	14.0
OK	CANCEL
	<div> <div>▼</div> <div>▲</div> </div>

Figure 5-9 Flow Calibration Screens

14. Press the grey CONTINUE button to advance to the flow calibration menu. The pump will start automatically and adjust flow to the 16.7 lpm test point.
15. Press the green bordered value box the flow rate test set point selection will appear.
16. Select the 14.0 lpm set point and then press the OK button. The display will return to the Flow Calibrate screen and adjust the flow to the new test point.
17. Allow the E-BAM and CTS reading to stabilize (at least one minute) and then compare the E-BAM flow measurement and CTS flow reading.
18. If the E-BAM flow rate exceeds the criteria listed in Table 5-3, press the grey DEFAULT button to remove any previous offsets for all three flow settings. If the flow rate now passes, skip the next step.
19. If the flow rate still needs to be adjusted, press the green bordered value box and the numerical entry keypad will be displayed. Enter the CTS value in the Standard field and press OK to return to the Flow Calibrate screen. Press the grey CALIBRATE button to enter the new calibration offset.
20. Press SET to apply the change. Note: When setting the 16.7 lpm flow rate, the SET option will change to read CALIBRATE.
21. Repeat steps 15 through 18 above for the 17.5 lpm flow rate.
22. Repeat steps 15 through 18 above for the 16.7 lpm flow rate.
23. Return to the Main Operating Screen and remove the CTS from the inlet tube and replace the size selective inlet(s).
24. Resume normal sampling operations.

5.9 Span Mass Audit

The Mass Audit screen, located in the Test menu, is used to verify the performance of the E-BAM beta attenuation system. A zero and span foil (included in the E-BAM accessory kit) will be required to complete this procedure. When this screen is accessed, the nozzle will be raised, and the display will provide instructions to enter the zero-calibration foil.

The filter tape **must be loaded** for this test! Insert the zero foil **above the filter tape** between the nozzle and vane, as shown in Figure 5-10. Note that the membrane is keyed and can only be inserted one way. Take care to minimize tape movement. When the zero foil is detected, the nozzle will automatically lower to the foil and the four-minute measurement will commence.



Figure 5-10 Starting the Zero Test

After four minutes, the nozzle will raise, and the screen will prompt to remove the zero foil. Remove the zero foil, taking care to avoid tape movement.

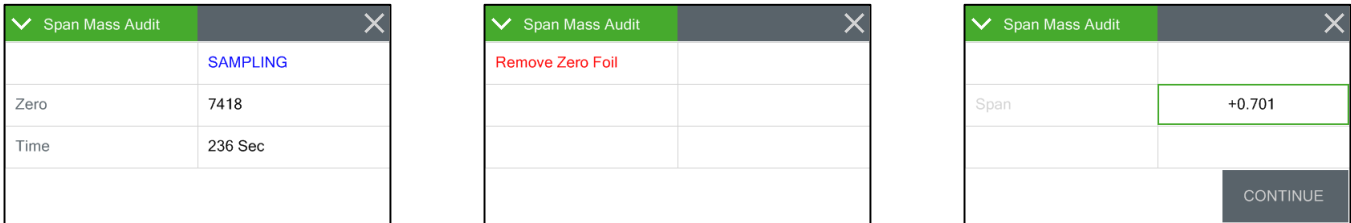


Figure 5-11 Completing the Zero Test

Upon removal of the zero foil, the display will change to list the current span foil setting as shown in Figure 5-11. Compare this value to the value of the span membrane tool. If the values do not match, tap the green bordered span value field and enter the value listed on the span tool. Press the grey CONTINUE button to continue to the next step.

The display will next provide instructions to insert the span foil. Insert the span foil **above the filter tape**, as shown in Figure 5-12. Note that this membrane is also keyed and can only be inserted one way. Take care to minimize tape movement. When the span foil is detected, the nozzle will automatically lower to the foil and the four-minute measurement will commence.



Figure 5-12 Starting the Span Test

After four minutes the display will change to list the results of the audit. The measured mass will be listed on the top, the programmed span value will be in the middle, and the error between the two will be listed on the bottom. See Figure 5-13 for an example. If the error is greater than +/- 5%, the audit has failed. See section 5.5 for cleaning instructions. If the audit continues to fail, contact the Met One Service team (see section 1.2) for assistance.

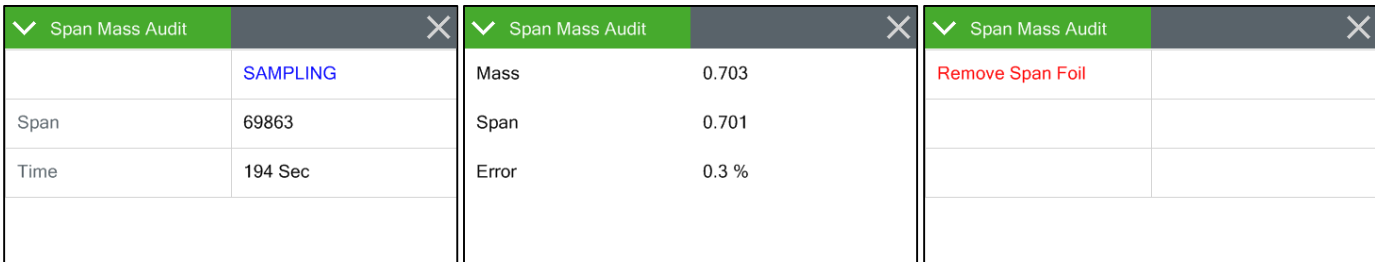


Figure 5-13 Completing the Span Test

Press the X button in the upper right corner to exit the audit. The nozzle will raise, and the screen will display a message to remove the span foil. Remove the foil and the display will automatically return to the Test menu.

5.10 Filter Sensors Audit

There are four sensors located near the filter tape sample location. They are temperature, relative humidity, upper pressure (pressure before the tape) and lower pressure (pressure after the tape). These should be audited using the Filter Sensors test menu (see section 3.5.6) as recommended in section 5.1.

5.10.1 Filter Temperature Sensor Audit

The filter temperature sensor is used to measure the temperature of the sample air and to monitor the function of the inlet heater. Set the Filter Sensor field to the TEMPERATURE option. The nozzle will raise and turn on the pump drawing ambient air in. Depending on difference will determine how long equilibration will take.

The E-BAM parameter is the instantaneous output from the unit's filter temperature sensor. This is the parameter being audited. The Standard parameter is the field where the correct temperature as shown on the traceable reference standard temperature audit device is entered.

Position the reference standard as closely as possible to the filter sensor and allow them to equilibrate. Compare the E-BAM value to the standard. If an adjustment is necessary, enter the correct temperature in the Standard field and then press the CALIBRATE key to correct the E-BAM sensor reading. The E-BAM and Standard parameters should now match. Press the X key to exit the screen when finished.

If difficulty is encountered during the process, the DEFAULT key can be pressed to erase all field calibration factors from the temperature sensor and to start over with factory default calibration factors. Then try the calibration again.

Important Note: It is often difficult to calibrate the sensor if the E-BAM is warm. The heating of the unit will increase the sample temperature (as it should) making it difficult to compare the E-BAM filter temperature reading to an ambient temperature traceable standard reading. If the sensor is to be calibrated, it is best to do it when the E-BAM is cold (equilibrated to ambient). It is recommended to leave the sensor at the factory default calibration.

The E-BAM filter temperature sensor very rarely fails.

5.10.2 Relative Humidity Sensor Audit

The filter relative humidity sensor is used to measure the humidity of the sample air and to control the inlet heater to prevent moisture from being sampled as particulate mass. Set the Filter Sensor field to the HUMIDITY option. The nozzle will raise and turn on the pump drawing ambient air in. Depending on difference will determine how long equilibration will take.

The E-BAM parameter is the instantaneous output from the unit's internal filter relative humidity (RH) sensor. This is the parameter being audited. The Standard parameter is the field where the correct RH as shown on the traceable reference standard RH audit device is entered.

Position the reference standard as closely as possible to the filter sensor and allow them to equilibrate. Compare the E-BAM value to the standard. If an adjustment is necessary, enter the correct RH in the Standard field and then press the CALIBRATE key to correct the E-BAM sensor reading. The E-BAM and Standard parameters should now match. Press the X key to exit the screen when finished.

If difficulty is encountered during the process, the DEFAULT key can be pressed to erase all field calibration factors from the RH sensor and to start over with factory default calibration factors. Then try the calibration again.

Important Note: It is often difficult to calibrate the sensor if the E-BAM is warm, as the heating of the unit will reduce the sample RH (as it should) making it difficult to compare the E-BAM filter RH reading to an ambient RH traceable standard reading. If the sensor is to be calibrated, it is best to do it when the E-BAM is cold (equilibrated to ambient) and the nozzle is raised. It is recommended to just leave the sensor at the factory default calibration. The E-BAM filter RH sensor is only a $\pm 4\%$ device when functioning properly and will typically read a completely unreasonable value if it fails, such as 135% or -25%.

5.10.3 Upper and Lower Pressure Sensors Audit

The upper and lower pressure sensors are used to detect excessive tape loading due to heavy particulate sampling. If the user defined threshold is exceeded, the sample will be suspended and the tape advanced to prevent damage to the pump and the tape itself. See section 3.5.6 for details. To audit these sensors set the Filter Sensor field to the UPPER PRES or LOWER PRES option.

The E-BAM parameter is the instantaneous output from the unit's upper or lower pressure sensor, as selected. This is the parameter being audited. The Standard parameter is the field where the correct pressure as shown on the traceable reference standard pressure audit device is entered.

Position the reference standard near the E-BAM and verify both the standard and the E-BAM values are stable. Compare the E-BAM value to the standard. If an adjustment is necessary, enter the correct pressure in the Standard field and then press the CALIBRATE key to correct the E-BAM sensor reading. The E-BAM and Standard parameters should now match. Press the X key to exit the screen when finished.

If difficulty is encountered during the process, the DEFAULT key can be pressed to erase all field calibration factors from the selected pressure sensor and to start over with factory default calibration factors. Then try the calibration again.

Important Note: The pressure sensors must be audited individually and with the pump off. Selecting either pressure sensor for auditing should cause the pump to stop. If it does not, contact the Met One Instruments service department for assistance (see section 1.2).

5.11 E-BAM Error Displays, Error Logs, and Error Codes

This section provides information about routine maintenance of the E-BAM, and for performing more detailed diagnostic tests if a problem is encountered. The E-BAM often generates error messages on the display or in the data log if a failure or other problem is detected. Many times, there is a simple solution, but persistent errors often signify a failure which will require investigation. The E-BAM error codes are described in this section.

In the event a measured parameter or sequence is not within design specifications, the E-BAM will generate an alarm. These alarms can be monitored via the alarm log, output files or the alarm relay. A list of alarms is detailed in Table 5-4.

Code	Description	Cause
1	Tape Break	No tape movement was detected during the tape move process.
2	Beta Detector	The event occurs when the Beta detector count rate is less than 500 Hz during the sampling cycle.
4	Sensor Range	The event occurs when an analog sensor reading (AT, RH, BP, UPPER, LOWER, FT, FRH) is outside the designated limits.
8	Tape Advance	The event occurs when the pressure drops across the tape exceeded the Tape Advance Pressure setting.
16	Flow Failure	The event occurs when the sample flow is less than 1.0 LPM for greater than 1 minute. The event occurs when the sample flow is +/-10% out of regulation for 1 minute. The event occurs when the sample flow is +/-5% out of regulation for 5 minutes.
32	Nozzle Failure	The event occurs when the nozzle failed to move and stop at the up or down position. The event will also occur when the foil device is still inserted at start of operation.
64	Digital Link Failure	The event occurs when communication with the BX-597A sensor has ceased for greater than 10-seconds.
128	Power Failure	The event occurs for a power cycle or a micro-processor reset.
256	Short Sample	The event occurs when the first sample cycle is less than 1-hour.
512	Maintenance	The event occurs when the user stops normal operation.
1024	Low Battery	The event occurs when battery voltage (BV) 1-minute average is below 11.0 volts.

Table 5-4 The E-BAM Alarm Conditions

An alarm is indicated and logged at the time it occurs. The resolution time is not recorded. See section 3.7 for an explanation of viewing alarms through the E-BAM panel display.

Note: A concentration value of 99.999 mg/m³ or 99999 ug/m³ is an invalid concentration measurement and is due to an appropriate alarm condition.

Note: If multiple errors or alarms occur in the same data period, then the logged alarm code will be the sum of the two individual code numbers. This is a rare occurrence.

5.12 E-BAM Hardware Failure Screen

This screen is presented to the user when a hardware failure occurs with the type of alarm (Tape Break, Sensor Range, Flow Failure, etc.) indicated in red text. Pressing the grey ALARMS button will present the View Alarms screen. See section 3.7 for information about viewing alarms.

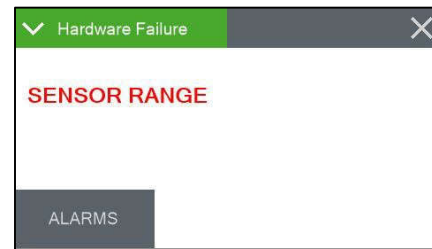


Figure 5-14 Sample Alarm Screen

5.12.1 Sensor Out of Range Event

The sensor outside range alarm event occurs when one of the E-BAM sensors is reading outside of its designated limit. Each sensor, along with its upper and lower range limits, is shown in Table 5-5. The Stop column indicates if the error will cause the E-BAM to stop sampling.

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

Table 5-5 Sensor Ranges

5.13 Basic Problem and Cause/Solution Table

The following table contains information on some of the more common problems that may be encountered, and some steps to identify and remedy the problems. Met One Instruments, Inc. 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 the Met One Instruments, Inc. service technicians for help in resolving the problem. See section 1.2.

Problem:	The mass monitor will not start a measurement cycle.
Cause/Solution:	<ul style="list-style-type: none">• The mass monitor will not start a measurement cycle if it detects a hardware failure, such as low beta count signal, pressure sensor failure, or pump failure.• The mass monitor will not start a cycle if either the zero foil (shipping shim) or the span foil is inserted.• The mass monitor will not start a cycle if the BX-597A sensor is not connected.• The mass monitor will not start a cycle if the filter tape is not installed correctly.• The mass monitor will usually display an error message on the display if it cannot start a cycle.• If the mass monitor is left in a SETUP or FIELD CALIBRATION screen, it should still try to start a cycle after several minutes of inactivity, unless a failure is detected.• The mass monitor will not manually restart if the existing BV level is below 11.0V (BV low limit).• The mass monitor will not automatically restart if a Low Battery alarm has occurred, and the existing BV level is below the Restart BV threshold setting.

Problem:	The mass monitor records frequent “Pressure Drop Excessive” errors.
Cause/Solution:	<ul style="list-style-type: none">• This usually indicates that the filter tape is automatically advancing in response to being clogged due to heavy particulate loading.• If frequent pressure-drop errors are encountered, try setting the TAPE ADVANCE setting to a shorter interval. See section 3.6.4. When hourly PM readings are high, more frequent tape advance intervals may be required.

Problem:	The concentration indicates negative values.
Cause/Solution:	<ul style="list-style-type: none">• It is possible for the mass monitor to occasionally record negative hourly values if the actual particulate concentration is extremely low. This is because the mass monitor has an hourly random noise band of several micrograms.• The real-time averages of the mass monitor (especially the 1- and 5-minute averages) are considerably noisier than the hourly measurements. These noise spikes may indicate negative concentrations unless the true concentrations are high.• The noise performance of the mass monitor may be audited. Met One Instruments supplies the BX-302 zero filter kit for auditing the zero readings of the mass monitor.

Problem:	The airflow will not regulate at the correct rate of 16.7 lpm.
Cause/Solution:	<ul style="list-style-type: none"> • This usually indicates that the air pump is losing vacuum capacity due to wear. • Check for leaks at the nozzle. This will often cause the inlet flow to be low even though the flow sensor is measuring the correct flow rate. This is because the flow sensor is downstream of the filter tape and nozzle. Clean the nozzle and vane. • Perform a flow calibration. If the flow regulates at the lower calibration point, but not the higher point, the pump is probably worn out or there is a leak. • Check the inlet and PM heads for obstructions.

Problem:	The mass monitor has flow leaks, even after cleaning the nozzle and vane.
Cause/Solution:	<ul style="list-style-type: none"> • The nozzle may be sticking. Verify that the nozzle up/down motion is smooth and complete. If the movement is sticky or gritty, the nozzle will not seal properly. • Check the O-rings on the sharp-cut cyclone (if used). These frequently leak. • Check for bad O-rings on the inlet receiver. • Check all of the push-in air fittings throughout the air flow system.

Problem:	The mass monitor will not pass the span membrane test.
Cause/Solution:	<ul style="list-style-type: none"> • This often just indicates the membrane foil surface is dirty or damaged. It can be cleaned with distilled water. Damaged membranes must be replaced. • If the membrane is in good condition, but the mass monitor fails span tests, then the most common problem is debris on the beta detector window. Carefully blow through the vane with canned dusting air to blow debris off of the detector cap and try again. • If the detector is clean and the membrane is in good condition, then failed span tests can indicate that the detector is wearing out. Contact the Service Department.

Problem:	The clock settings are lost when the mass monitor is powered down.
Cause/Solution:	<ul style="list-style-type: none"> • There is a lithium coin cell battery inside the mass monitor that maintains the clock when the mass monitor is powered off. The battery may need to be replaced if the clock resets when the mass monitor is powered off.

6 DATA RETRIEVAL and COMMUNICATIONS

The E-BAM is capable of relaying information to and from external devices using digital inputs and outputs, RS-232 serial, RS-485 communications, USB serial, and USB flash drive.

6.1 Serial Input/output

Cable connections on the bottom panel of the E-BAM are available for communicating with data acquisitions system by means of digital inputs and outputs.



Figure 6-1 E-BAM Serial Cable Wiring

The 12 VDC power supply connects to the DC Power port.

The BX-597A Digital Sensor connects to the 597A SENSOR port.

The optional wind sensor (see section 8.2) connects to the WS/WD SENSOR port.

All other serial outputs use the RS-232 or RS-485 SERIAL port.

6.2 Transfer Data to USB Flash Drive

The E-BAM can copy data files directly to a user-supplied USB flash drive. This drive must be installed in the USB port located on the right-hand side of the tape transport plate inside the monitor. This USB port is not used for any other purpose.

✓ Copy to USB Drive	
Days	ALL DAYS
Files	USER
COPY	

✓ Copy to USB Drive	
Status	COPY COMPLETE
Progress	100 %
Error	

Figure 6-2 Data Transfer Interface Screens

Use the following steps to download data to a USB flash drive:

1. Enter the Operate > Transfer Data menu.
2. Set the Days field to the number of days to download. To change this value, press the green bordered value box and the numerical entry keypad will be displayed. Enter the number of days between 001 and 999. The setting for ALL DAYS is 0.
3. Select which files to download. The FILES field determines whether all of the stored record types or only the user selected records will be copied. The USER files are those used for all routine data collection purposes. The ALL option includes additional factory diagnostics files which are only used if data is being sent to Met One Instruments, Inc. for factory support. The default setting is USER. To change this field, press the green bordered value box and a list of the available options will be displayed. Tap the required type and it will be applied.
4. Locate the USB slot above the tape supply spool and insert a USB memory stick into it.
5. Press the grey COPY button to copy the selected data to the USB memory stick.
6. When the COPY COMPLETE message is displayed, remove the USB memory stick and close the front door of the E-BAM.

6.3 Comet™ Data Retrieval Software

The E-BAM is compatible with the Comet™ program, which is a simple Windows-based communications terminal program developed by Met One Instruments. This is the recommended method for all E-BAM data retrieval, since Comet allows the user to easily download the data logs, error logs, and settings files from the E-BAM without the user having to know any of the underlying communications protocols. A comprehensive pdf user's manual for the program is also available from the Met One Instruments website. Install the program onto the computer that will be used for data retrieval and review the manual for complete data examples.

Note: If the Comet software is being used for data retrieval, none of the terminal mode commands shown in the following sections of this manual will be needed.

Comet is a communications terminal program which can retrieve data from the E-BAM using either a direct local connection or a remote connection via various modem types or even an IP address.

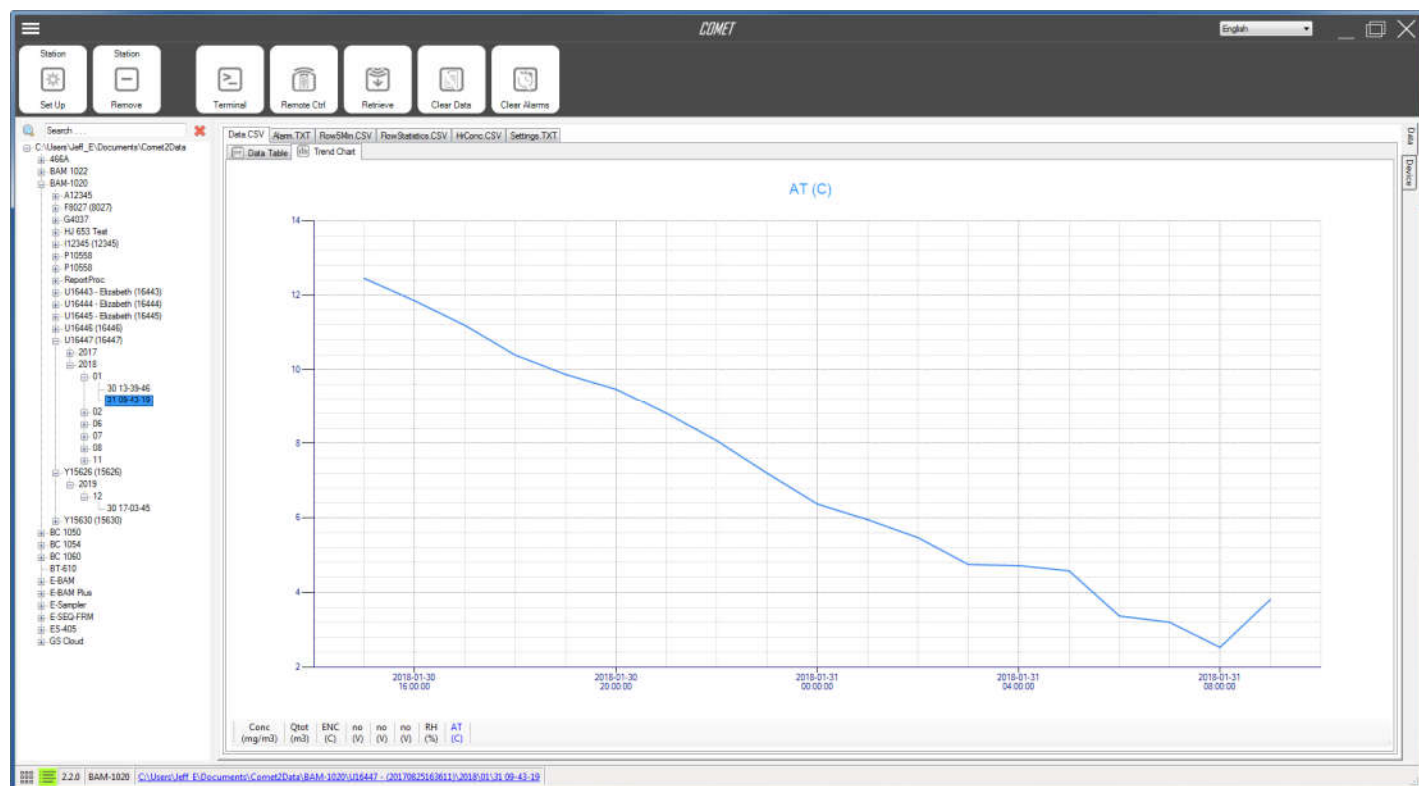


Figure 6-3 Comet Program Interface

Warning: A Silicon Labs CP210x Driver for the USB connection must be installed before connecting to the USB Type B port.

Driver download weblink: <https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers>

Note: Before using the USB Type B port, ensure an existing RS-232 connection is disconnected.

The Comet program is available from the Met One Instruments website:

<https://metone.com/products/comet/>

Install the program on the computer, then run it from the Programs directory. Create a new station for the E-BAM and then use it to retrieve the data from the E-BAM monitor.

The Comet program has a "Terminal" button which provides access to the E-BAM just as when using any other terminal program.

6.4 Downloading Data Using HyperTerminal or other Terminal Programs

The E-BAM communicates via serial commands using RS-232, RS-485, or a USB Serial. The monitor only allows one of these connections at a time. These connections allow users to both download data and operate the instrument.

The default RS-232 settings are as follows:

Baud Rate: 115200
Data Bits: 8
Parity: None
Stop Bits: 1
Flow Control: None

6.4.1 User Communication

In the User Communication (or Terminal) mode, commands are issued by entering a letter or number command and then pressing the Enter, <cr>, key. The <Esc> key is not used when sending commands in this mode.

Press the Enter key three times to enter User Communication mode. An asterisk character appears confirming the mode has been entered and that the instrument is ready for a new command.

Commands will be echoed back from the instrument and an asterisk will appear after a command has completed.

COMMAND	DESCRIPTION
1	Request settings report
2	Request All data report
3	Request New data report
4	Request Last data report
7	Request alarm event report
C	Clear data log file – \$
D	Get/Set date part of the real time clock – \$
H	Help menu
Q	Quit and exit terminal mode
T	Get/Set time part of the real time clock
CA	Clear alarm log file – \$
DT	Get/Set the date and time of the real time clock
ID	Get/Set location ID or address
QH	Report current readings header
RQ	Report current readings without header
RV	Report Model/Part/Revision
SS	Get Met One serial number

Table 6-1 Common Serial Command Set

To issue one of the commands listed in Table 6-1, type the command listed and press the Enter key. The command will run and display the requested information or current setting, as appropriate. For example, to view the current date setting type the letter D followed by the Enter key. The current date will be reported. The sequence would appear like this:

```
D<cr>
D 2013-01-18<cr><lf>
```

To change a setting, the typical sequence is to type the command, press the space bar one time, enter the new value in the same format that is displayed when checking the setting, and then pressing the Enter key.

Continuing the example above, to change the date setting type the letter D, space, and then the current date in YYYY-MM-DD format followed by the Enter key. A confirmation of the new date will be reported. The sequence would appear like this:

```
D 2016-02-28<cr>
D 2016-02-28<cr><lf>
```

Pressing <Esc> or Q<cr> will exit terminal mode.

6.4.2 Computer Communication

In the Computer Communication mode, character echo is suppressed. This means when issuing commands in this mode using a keyboard, the characters being typed will not be displayed on the screen. The command format includes a checksum to verify data integrity.

The mode is entered whenever an <Esc> character is sent to the instrument. Commands are issued using the following format:

```
<Esc>Cmd p1 p2*cs<cr>
```

Computer commands are prefaced with an <Esc> character followed directly by a command (Cmd)... After the command there can be zero or more parameter field (p1 and p2) where each field is separated by a space. The end of the message is signaled by the Checksum Delimiter character (*) followed by the checksum itself (cs). Finally, the command is terminated with a carriage return (<cr>).

A computer command example requesting the Model/Part/Revision numbers would look like this:

```
<Esc>RV0168*<cr>
```

All command responses are terminated with a checksum. The above command response would have this format:

```
E-BAM, 83231, R2.1.0*01054<cr><lf>
Display, 82451, R1.0*01363<cr><lf>
```




For a listing of all commands and their formats along with additional in-depth Computer Communication details, consult the latest E-BAM User 7500 document available from the Met One Instruments website: <https://metone.com/support-documents/>

7 ACCESSORIES and PARTS



7.1 Consumables, Replacement Parts, and Accessories

The following parts are available from Met One for maintenance, replacement, service, and upgrades. If unsure about a part that is needed, please contact the service department (see section 1.2). Some of these parts require technical skills or special considerations before use or installation.

Consumables

Description	Part Number	Graphic
Filter Tape Roll, Glass Fiber, 30 mm x 21 m	460180	
Filter Tape Core Tube, Grey Plastic	8150	
Cotton-Tipped Applicators, nozzle cleaning, 100 pack Solon #362	995217	
O-Ring, Nozzle, 1 required	720066	
O-Ring Kit, for BX-807 Cyclone, set of 6	720097	
O-Ring Kit, for BX-802 PM ₁₀ Head, set of 3	8965	






Tools

Zero Filter Calibration Kit, with valve 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 audit meter	BX-307	




Flow System Components

Description	Part Number	Graphic
E-BAM Pump & Mounting Bracket	8967-1	
Pressure Sensor	80940-1	
Flow Sensor	82982	
Filter RH Sensor, Replacement Only	80212-1	
Filter Temperature Sensor, Replacement Only	9279-3	

Inlet Components

PM ₁₀ Inlet Head, EPA Specified	BX-802	
TSP Sampling Inlet Cap, Harsh Environment with insect screen and rain cap	BX-803	
PM _{2.5} Sharp Cut Cyclone	BX-807	
PM _{2.5} WINS Impactor	BX-804	
Inlet Tube, E-BAM, Aluminum, 8.5 inches	9187	

Meteorological Sensors

Description	Part Number	Graphic
Combination Sensor for Ambient Temperature, Relative Humidity, and Barometric Pressure	BX-597A	
Combination Sensor for Wind Speed and Wind Direction	EX2-034	
Combination Sensor for Sonic Wind Speed and Wind Direction	EX2-AIO	

Miscellaneous Accessories




Weatherproof DC Power Supply, 12 VDC, 8.5 A	EX2-100-240	
Tripod Assembly, E-BAM/E-SAMPLER	EX-905	
Cross-arm Clamp, $\frac{3}{4}$ " x $\frac{3}{4}$ ", Aluminum, Mounts cross-arms to the E-BAM tripod	1552	
Cross-arm, 18 inches	1539-4	
Tape Spool Cover, Replacement, 2 per unit	82148	
RS-232 Communication Cable, E-BAM	83245	
External Battery Kit (Batteries, Charger, and Cables)	EX-12	



Figure 7-1 Standard Shipping Accessory Kit (PN: 83293)

Description	Part Number	Qty
SENSOR, RH / TEMP / BARO	BX-597A	1
GROUND CABLE ASSEMBLY	9035	1
INLET TUBE (UPPER SECTION)	9187	1
PM-10 SAMPLING INLET	BX-802	1
TRIPOD FOR E-BAM/E-SAMPLER	EX-905	1
CABLE ASSEMBLY, EXTERNAL BATTERY, E-BAM	83246	1
CABLE ASSY, BX-597A SENSOR TO E-BAM	82959-8	1
RS-232 COMM CABLE, E-BAM	83245	1
MOUNTING CHANNEL	10660	1
ASSY, REFERENCE MEMBRANE	9325	1
FILTER TAPE, GLASS FIBER, 25M LONG, 30MM WIDE	460180	1
CABLE TIE, 7 5/16 LONG, BLACK	500532	6
JIFFY TUFFGUARD 4X6 WHITE CUSHIONED MAILER	550547	1
ALLEN WRENCH, 5/32, SHORT ARM	993005	1
USB CABLE, A-B MALE, 4.9 FT.	500784	1

8 SPECIAL E-BAM CONFIGURATIONS

The E-BAM can be supplied in custom configurations or with non-standard accessories in order to meet specific monitoring needs.

8.1 *Comet Cloud Service Data Modem*

The E-BAM is compatible with the Comet Cloud Service (CCS). The CCS Modem 2 is available for International customers (GSM connectivity). The CCS Modem-LTE is available for US customers. Averaged data is reported to a secure cloud site every 15 minutes domestically and 1 hour internationally. The modem location is automatically available from the internal GPS and the first year of data service is included with the CCS modem.

8.2 *Wind Sensor Options*

The E-BAM can be equipped with an optional combination wind speed and direction sensor. There are both analog and sonic type sensors available.

8.2.1 EX2-034

The EX2-034 is a mechanical cup and vane sensor that provides wind speed and direction measurements. It is mounted to the E-BAM tripod using the provided cross arm. See Figure 2-4.

It connects to the E-BAM WS/WD SENSOR connector using the included signal cables and analog to digital signal converter. This converter measures the wind sensor's analog signals and provides an RS-485 digital output to the E-BAM with wind speed and direction values.

This type of sensor requires manual orientation when deployed. Consult the separate manual that comes with the wind sensor for details.

8.2.2 EX2-AIO

The EX2-AIO sensor provides sonic wind measurements. It is mounted using the same cross-arm assembly as shown for the EX2-034 in Figure 2-4. However, it has a different adapter to mate it to the cross-arm itself.

It connects to the E-BAM through the WS/WD SENSOR connector on the bottom of the monitor. This connection both provides power to the sensor and collects its digital output string to provide wind speed and direction information.

This type of sensor includes an internal compass for wind direction correction and does not require manual orientation when deployed. Consult the separate manual that comes with the wind sensor for details.