ADMS BAM 1000 /1100
PARTICULATE MONITOR
OPERATION MANUAL

Anodyne Water Engineering Co. Pvt. Ltd.
Email: info@anodyne.in ; support@anodyne.in
Telephone: +91-8950431340
www.anodyne.in

TABLE OF CONTENTS

1 INTRODUCTION

1.1 About This Manual

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

Toward the back are sections that provide in-depth information on subjects such as theory, diagnostics, accessories, and alternate settings. These sections provide valuable information which should be consulted as needed.

1.2 Technical Service

Technical Service representatives are available during normal business hours of 10:00 a.m. to 6:00 p.m. Pacific Standard Time, Monday through Saturday. In addition, technical information and service bulletins are available from our website . Please contact us at the phone number or email address below to obtain a Return Authorization (RA) number before sending any equipment back to the factory.

Phone: +91-7496969760

E-Mail: Address: support@anodyne.in ; it@anodyne.in

Web: www.anodyne.in

Address :Plot No 340, HSIIDC Industrial Estate ,Rai ,District Sonipat ,Haryana – 131029

Corporate: Unit No 1301, Aggarwal Corporate Heights, Pitampura, Delhi - 110034

ADMS ADMS BAM 1000/1100 monitors have a serial number on the label, and printed on the calibration certificate . We request to share this number to the technical service department for repairs or updates for your ADMS ADMS BAM 1000/1100 1000/1100.

1.3 ADMS BAM 1000/1100: Beta Attenuation Monitor

The ADMS ADMS BAM 1000/1100 beta attenuation mass monitor automatically measures and records ambient particulate mass concentration levels using the principle of beta ray attenuation. This method provides a simple determination of the ambient concentration of particulate matter in mg/m3or µg/m3. A small C(carbon 14) element inside of the ADMS BAM 1000 /1100 provides a constant source of beta rays. The beta rays traverse a path through which glass fibre filter tape is passed before being detected with a scintillation detector . At the beginning of the measurement cycle the beta ray count (I0) across clean filter tape is recorded . Then, an external pump pulls a known volume of PM-laden air through the filter tape thereby trapping the PM on the filter tape. At the end of the measurement cycle the beta ray count (I3) is re-measured across PM -laden filter tape . The ratio of I0 to I3 is used to determine the mass density of collected PM on the filter tape . A complete description of the measurement cycle is included in further sections . In addition , a scientific explanation of the theory of operation and the related equations is included at the back of the manual.

1.4 Beta Radiation Safety Statement

ADMS BAM 1000/1100 contains a small 14C (carbon 14) beta radiation-emitting source. The activity of the source is 60 μCi ±15 μCi (microcurries), which is below the "Exempt Concentration Limit" of 100 μCi as determined by the United States Nuclear Regulatory Commission (US-NRC). The owner or operator of the ADMS BAM 1000/1100 is not required to have a license to possess or operate the equipment under US-NRC regulations . The owner may however elect to return the monitor to Anodyne for recycling of the 14C source when the monitor has reached the end of its service life, although is under no obligation to do so. Under no circumstances should anyone but factory technicians attempt to 14 C source. It has a life of 5730 years and should never be replaced. Should these components require repair or replacement, the ADMS BAM 1000/1100 must be returned to the factory for service and recalibration.

1.5 ADMS BAM 1000/1100 Configurations

The ADMS BAM 1000/1100 is used worldwide. Although many international jurisdictions use the US-EPA configurations, others do not. Please consult with your local monitoring authority for details on how the ADMS BAM 1000/1100 should be configured and operated locally.

1.7 ADMS BAM Specifications

Principle	Beta ray Attenuation	
	Particle Size Cut Off	0-10 Microns
Performance Specification	Measurement Range	0 – 5000 $\mu g/m^3$ User Selectable
	Measurement Cycle	Primary: Automatic hourly PM measurement
		Secondary: User selectable short term average – 30 minutes
	Resolution	1$\mu g/m^3$
	Lower Detectable Limit	< 4.8$\mu g/m^3$
	Reproducibility	< 7 %
	Range	1 mg / m^3 to 10 mg/m^3 Selectable
	Sample cycle	One hour or one minute with RTPM option/user selectable
	Sample Flow Rate	16.7 l/min / 0-30 lpm(adjustable)
	Flow Accuracy	± 1% F.S.
	Flow Stability	± 2 % F.S.
	Beta Source	14C (Carbon – 14), 60 µCi ± 15 µCi; Half Life – 5730 years
	Beta Detector Type	Scintillation Photomultiplier tube with Organic plastic scintillator / GM Counter
	Filter Tape	Continuous Glass filter Tape; 40 mm x 30 m roll, 90 days of operation
	Sampling Head	Dynamic heated sampling head for measurement of PM10 with adjustable temperature 20-70^{O} C
	Calibration	Reference membrane facility should be provided for calibration of analyzer
Environmental	Operating Temperature	- 30 ° C to +50 °C
	Ambient Humidity	0 – 98 % RH, Non – condensing
	Ambient Pressure	86 – 116 kPa
Physical and Electrical	Display	Digital Display(LCD/LED)
	Power supply	230 ± 10 % VAC, 50 ± 1 Hz; optional 24 VDC
	Power consumption	350 W with pump and heater
	Dimensions	310 mm (H) x 430 mm (W) x 400 mm (D) (manufacturer dimensions varies as per design)
	Weight	40 lbs: 25 kg
Communication	Communication Port	RS 232/485
	Digital I /O	2 – input digit, 4 – digit input
	Analog I/O	Two (4 – 20 mA), 0 – 1V , 0 – 10V output

2 SITE SELECTION AND INSTALLATION

2.1 Unpacking, Inspection, and Evaluation Testing

If any damage to the shipment is noticed before unpacking, a claim must be filed with the commercial carrier immediately. Notify Anodyne Water Engineering Co Pvt Ltd after notification of the commercial carrier.

Unpack the ADMS BAM 1000/1100 and accessories and compare them to the packing list to make sure you have all of the required items for the type of installation you plan to perform.

The ADMS BAM 1000/1100 is shipped with one or two white foam rings and a white plastic shim inside the front it, which prevent the moving parts of the tape control assembly from being damaged during transit. The rings and shim should be replaced when the ADMS BAM 1000/1100 is being transported in order to avoid damaging the tape control mechanism. Do not ship or transport the ADMS BAM 1000/1100 with filter tape installed. We recommend that you keep the special shipping box and foam packing material which the ADMS BAM 1000/1100 came in as they could be re- used if you must return the ADMS BAM 1000/1100 to the factory for any reason.

2.2 Enclosure Selection and Temperature Control

The ADMS BAM 1000/1100 monitor is not weatherproof. It is designed to be mounted in a weatherproof, level, low vibration, dust free, and temperature-stable environment where the operating temperature is between 0 to +50degrees, and where the relative humidity is non-condensing and does not exceed 90%. There are two standard configurations described below for providing a weatherproof location in which to install the ADMS BAM 1000/1100. Please contact us for advice if you plan to have a non-standard mounting or enclo sure configuration.

1. A walk-in shelter or building: These are usually semi-portable pre-fabricated shelters or portable trailers with a flat roof, or a room in a permanent building or structure. The ADMS BAM 1000/1100 may be placed on a workbench or mounted in an equipment rack. The inlet tube of the ADMS BAM 1000/1100 must extend up through a hole in the roof of the structure with appropriate sealing hardware. AC power must be available. Instructions for this type of installation are included in this section of this manual.

2. Mini weather proof enclosures: These small pre-fabricated enclosure are just big enough for the ADMS BAM 1000/1100 and related accessories, and are installed on the ground or on the roof of a larger building. They are available with a heater or with a heater and air conditioner. A dual-unit air conditioned mini shelter is also available BAM 1000/1100, and are supplied with a supplemental installation manual.

Shelter Temperature Control Notes: The air temperature inside a ADMS BAM 1000/1100 shelter or enclosure is not required to be regulated to any specific narrow range or set point (such as 25 °C), subject to the following caveats:

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

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

3. We recommend logging the temperature inside non-airconditioned mini enclosures.

4. ADMS BAM 1000/1100 users in hot climates where the ambient temperature exceeds 40°C should consider air conditioned mini shelter or an air conditioned walk-in shelter to avoid over-heating the ADMS BAM.

5. The portion of the inlet tube inside of the shelter or building should always be adequately insulated. This is especially important when the equipment is operated under conditions of high ambient dew point. Otherwise condensation could occur inside the sampling tube and/or measurement artifacts could result. If this proves to be an issue, the user may consider increasing the temperature inside the shelter to a point closer to ambient temperature. The ADMS BAM 1000/1100 should not be placed directly in the path on an air conditioning vent.

2.3 Site Selection and Inlet Positioning Criteria

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

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

These details should be understood before selecting a site.

2.4 Mounting Options in a Walk-In Shelter

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

- **Rear Access:** It is important that you leave plenty of access to the rear of the ADMS BAM for wiring connections and maintenance. At least five inches is required. Full access to the back is recommended whenever possible. There must be adequate access to the power switch located on the back of the instrument.
- **Top Access:** It is necessary to have a minimum of eight inches clearance between the top of the inlet receiver and the bottom of the shelter ceiling to accommodate the smart inlet heater.
- **Mobile Shelters:** If theADMS BAM is being installed into an equipment rack in a mobile trailer or van, then additional care should be taken to ensure that the mounting can

handle the additional strain. The foam shipping rings must also be inserted any time a mobile shelter is moved with the ADMS BAM inside.

- Rack Modifications: It is usually necessary to modify the top plate of the equipment rack by cutting a 2 inch diameter (75mm) hole to allow the inlet tube to extend through to the ceiling. The ADMS BAM 1000/11000 dimensional drawings below show the location of the inlet. Note: The inlet heater installs onto the inlet tube two inches above the top of the inlet receiver of the ADMS BAM. If the ADMS BAM is to be mounted in a rack, it will be necessary to leave extra room above it in the rack for the heater, or to make the hole in the top of the rack larger in order to clear the heater diameter. The heater is supplied with a foam insulation sleeve which may be modified as needed. Make sure these parts are going to fit before installing it.

2.5 Installation Instructions

When installing the ADMS BAM 1000/1100 into a shelter or structure the following issues should be taken into consideration.

1. **Roof Modifications:** Determine the exact location where the ADMS BAM inlet tube will pass through the roof of the shelter, and drill a 2 ¼" or 2 ½" (60mm) diameter hole through the roof at that location. Make sure the hole is directly above where the inlet receiver is to be located, so the inlet tube will be perfectly vertical. A plumb weight is useful for determining where to locate the hole.

2. **Waterproof Roof Flange:** Apply all-weather silicone caulking around the top of the hole, and install roof flange onto the hole. The threaded barrel of the flange is usually installed downward . Secure the flange in place with four lag bolts or self-tapping screws (not supplied). Caulk around the screws to prevent leaks. Apply Teflon tape to the threads of the gray plastic watertight fitting, and screw it into the roof flange tightly. Mini shelters come with a roof flange installed, and only need the watertight fitting. Note: Some users prefer to fabricate their own roof flange instead of using the one supplied by Anodyne, due to factors such as high snow loading or a sloped roof. Equipment damage from a leaking roof is not covered under warranty.

3. **Inlet Tube Installation and Alignment:** Remove the white threaded cap and rubber seal from the watertight inlet tube seal assembly. This makes it easier to install the inlet tube since the rubber seal is a tight fit. Lower the inlet tube through the flange assembly and into the inlet receiver on the ADMS BAM 1000/1100, making sure that the inlet tube is fully seated. It is very important for the inlet tube to be perpendicular to the top of the ADMS BAM. The nozzle may bind if the inlet is misaligned. A simple check is to rotate the inlet tube back and forth by hand before tightening the roof flange seal or the BAM inlet set screws. If the inlet tube is straight, then the tube should rotate fairly easily while inserted into the ADMS BAM. If it does not rotate, check the inlet tube for vertical alignment or move the ADMS BAM 1000/1100 slightly.

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

4. **Smart Inlet Heater Installation:** Before tightening the inlet tube in place, smart inlet heater (used on ADMS BAM monitors) must be installed onto the tube. Lift the inlet tube out of the top of the ADMS BAM 1000/1100, and pass the tube

through the hole in the heater body (the cable end is the bottom). Then re-insert the inlet tube into the ADMS BAM. Position the bottom of the smart heater unit two inches above the top of the inlet receiver on the ADMS BAM, and securely tighten the two set screws in the heater to fasten it to the tube.

Included with the smart heater is a 12" tube of white insulation. The tube is split down its length for easy application. Wrap the insulation around the heater body and peel back the adhesive cover strip to secure in place. The insulation may be cut to fit if needed. The insulation sleeve provides more consistent heating, and also prevents items from coming into contact with the hot heater body.

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

Most units are supplied with an external gray relay module which plugs into a mating black plastic connector on the back of the ADMS BAM 1000/1100. The Smart Heater connector plugs into the green connector on the top of this relay module, as shown in the left photo below. These external relay modules have their own AC power cord to supply power to the heater, and have a 3A fuse inside.

In the other possible configuration of the kit, the green metal Smart Heater connector simply plugs directly into the mating green metal connector on the back of the ADMS BAM 1000/1100. The heater relay is located inside the ADMS BAM 1000/1100 and the heater power comes from the BAM AC power supply at line voltage and frequency, and is fused by the main 3.1A fuses in the power input module.

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

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

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

Two Different Smart Heater Power Configurations

6. Tightening the Inlet: After the inlet tube is aligned and the heater installed, slide the black rubber seal and white cap down over the top of the inlet tube and into the roof flange. It is easier if you wet the rubber seal with water first. Tighten the white plastic cap. Tighten the two set screws in the top of the ADMS BAM inlet receiver.

7. Inlet Support Struts: The inlet kit comes with two angled aluminum struts to support the inlet tube above the roof and prevent the inlet from moving in the wind. These struts are typically fastened (about 90 degrees apart) to the inlet tube with a supplied hose clamp. The bottom ends of the struts should be fastened to the roof with lag bolts (not supplied). Some installations may require different methods or hardware for supporting the inlet tube. Support the tube in the best manner available. The mini shelters do not require inlet tube supports.

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

   Connect the cable to the terminals on the back of the ADMS BAM 1000/1100 as follows.

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

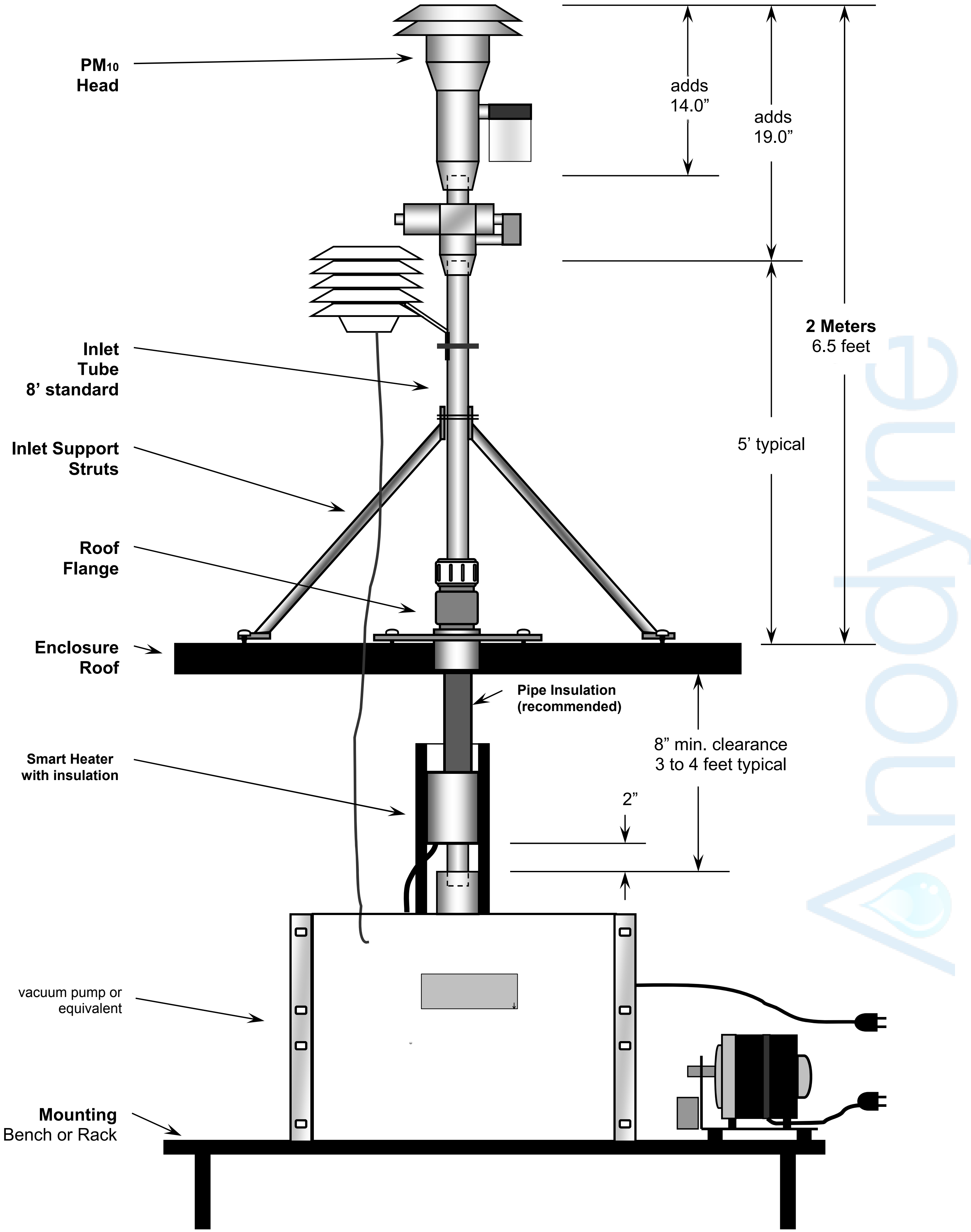
10. **Inlet Tube Grounding:** The two ¼”-20 set screws located in the inlet receiver of the BAM should create a ground connection for the inlet tube to prevent static electricity from building up on the inlet tube under certain atmospheric conditions. This is also important in areas near electromagnetic fields , high voltage power lines , or RF antennas. Check the connection by scraping away a small spot of the clear anodizing near the bottom of the inlet tube, and use a multimeter to measure the resistance between this spot and the “CHASSIS ” ground connection on the back of the ADMS BAM 1000 /1100 . It should measure only a couple of Ohms or less if a good connection is made with the set screws . If not, remove the set screws and run a ¼- 20 tap through the holes . Then reinstall the screws and check the electrical resistance again. Note: Anodized aluminum surfaces are non-conductive.

11. **Pump Location and Installation :** The best location for the vacuum pump is often on the floor under the rack or bench, but it may be located up to 25 feet away if desired. It may be preferable to locate the pump so that noise is minimized if the ADMS BAM is in an area where personnel are present . If the pump is to be enclosed , ensure that it will not overheat. The Gast pumps have a thermal shutdown inside which may trip if overheating occurs. Route the clear 10 mm air tubing from the pump to the back of the ADMS BAM 1000/1100, and insert it firmly into the compression fittings on both ends. The tubing should be cut to the proper length and the excess tubing saved.

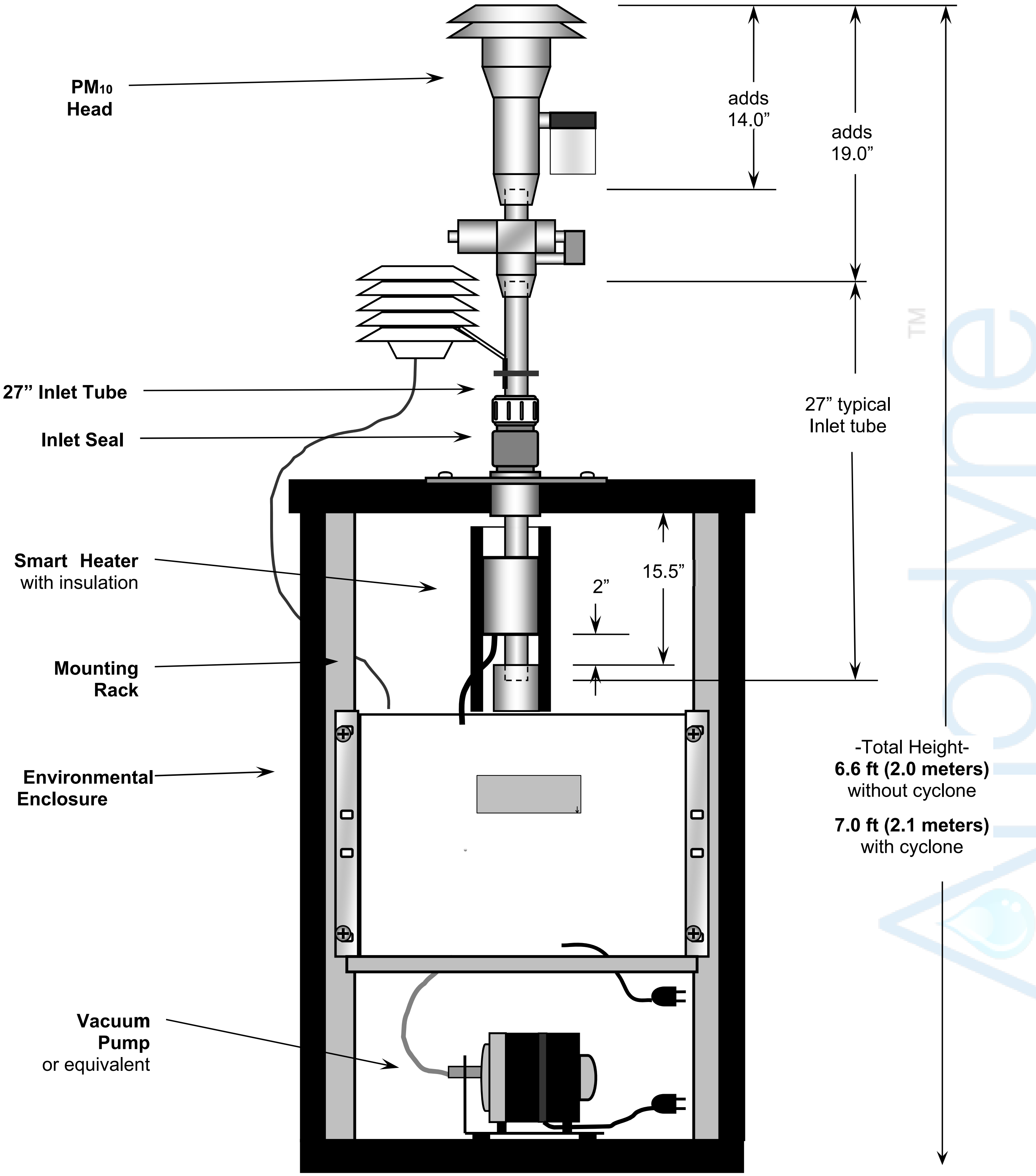
    The pump is supplied with a 2-conductor signal cable which the ADMS BAM uses to turn the pump on and off. Connect this cable to the terminals on the back of the ADMS BAM 1000/1100 marked “PUMP CONTROL ” The end of the cable with the black ferrite filter goes toward the ADMS BAM. The cable has no polarity, so either the red or black wire can go to either terminal. Connect the other end of the cable to the two terminals on the pump.

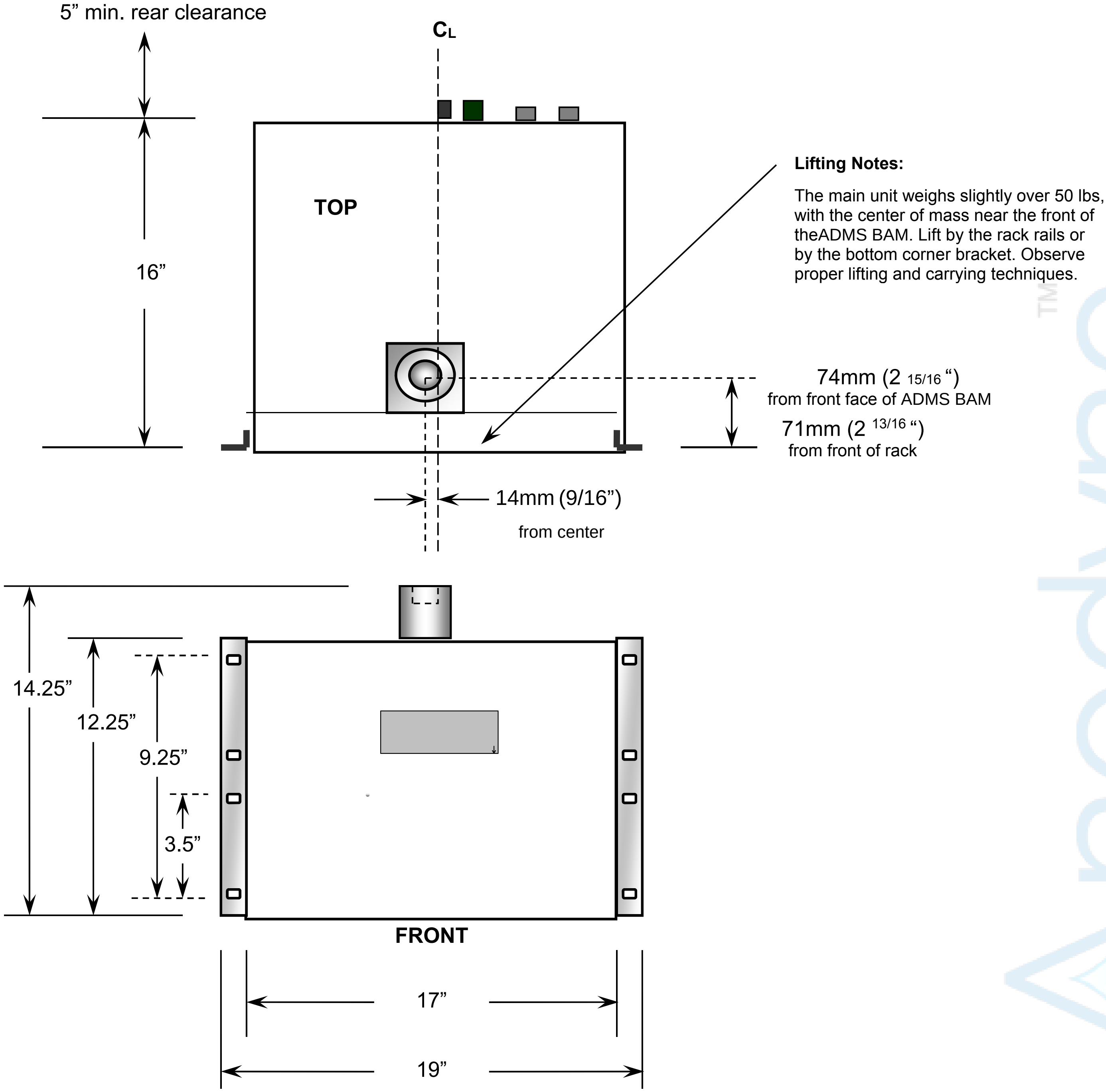
12. **Optional External Data Logger Connections :** The ADMS BAM models have an analog output which may be recorded by a separate data logger if required. Connect the terminals on the back of the BAM marked ”VOLT OUT +, -“ to the data logger with 2-conductor shielded cable (not supplied). Polarity must be observed. The logger input must be correctly scaled in order to log the voltage accurately ! Information on configuring this analog output is provided in this manual. A current loop output is also available.

    Newer data loggers often interface to the ADMS BAM 1000/1100 using the digital serial ports for better accuracy. Information about this is also found in Section 8. Andoyne can also supply additional technical bulletins on the subject.



Typical Installation in a walk-in shelter


PM10 Head
27" Inlet Tube
Inlet Seal
Smart Heater with insulation
Mounting Rack
Environmental Enclosure
Vacuum Pump or equivalent
adds 14.0"
adds 19.0"
27" typical Inlet tube
15.5"
2"
-Total Height-
6.6 ft (2.0 meters) without cyclone
7.0 ft (2.1 meters) with cyclone



ADMS BAM mounting dimensions

3 SETTING UP THE ADMS BAM 1000/1100

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

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

3.1 Power Up

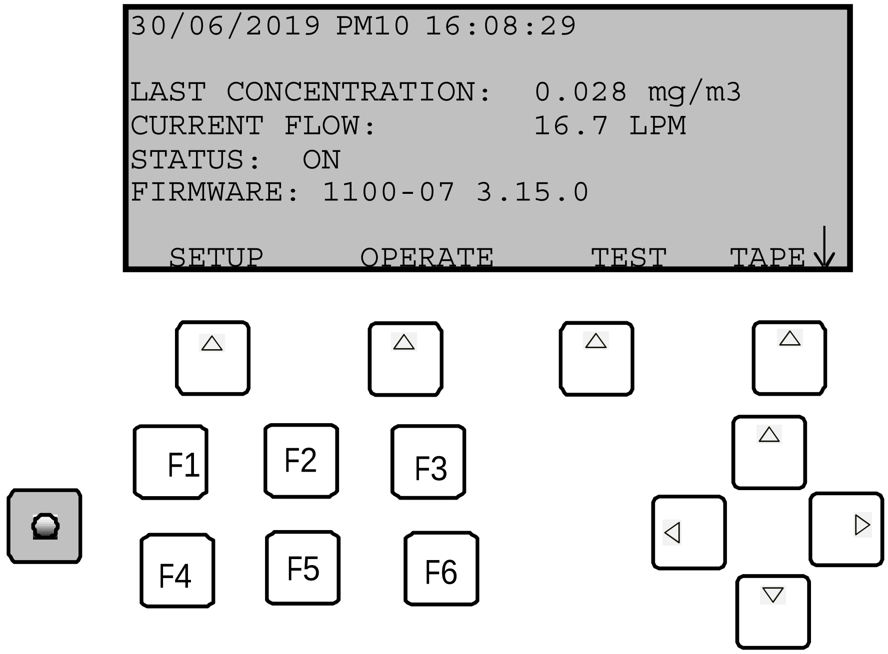
The power switch is located on the back of the instrument, above the power cord. Verify that the instrument is plugged in to the correct AC voltage, and that any electrical accessories are correctly wired before powering it up. When power is switched on, the main menu screen should appear after a few seconds as shown below. The screen may flash an error indicating that there is no filter tape installed or earlier firmware will display a slightly different main menu screen.

3.2 Warm-up Period

The ADMS BAM 1000/1100 must warm up for at least one hour before valid concentration data can be obtained. This is because the beta detector contains a vacuum tube which must stabilize. This also allows the electronics to stabilize for optimal operation. This applies any time the instrument is powered up after being off for more than a moment. Instrument setups and filter tape installation can be performed during this warm up time. You may consider discarding the first few hours of data after the equipment is powered up.

3.3 The Main Menu and Using the Keypad and Display

When the instrument is powered up it will display the main menu (top level menu) on the LCD display. This menu is the starting point for all functions of the ADMS BAM 1000/1100 user interface. Note: The main menu will have a slightly different layout on ADMS BAM units configured in the dual- unit PM-coarse configuration.



The Standard User Interface and Keypad

Soft Keys:

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

Arrow (Cursor) Keys:

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

Contrast Key:

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

Function Keys F1 to F6:

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

F1 "Current": This key is a shortcut to the OPERATE > INST screen, used to display instantaneous data values being measured by the ADMS BAM 1000/1100.

F2 "Average": This key is a shortcut to the OPERATE > AVERAGE screen, used to display the latest average of the data recorded by the ADMS BAM 1000/1100.

F3 "Error Recall": This key allows the user to view the errors logged by the ADMS BAM 1000/1100. The errors are sorted by date. The last 12 days which contain error records are available, and the last 100 errors can be viewed.

F4 "Data Recall": This key allows the user to view the data stored in the ADMS BAM 1000/1100, including concentrations, flow, and all six external channels. The data is sorted by date, and the user can scroll through the data hour-by-hour using the soft-keys. Only the last 12 days which contain data records are available for viewing in this menu.

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

F6: This key is not assigned a data function.

3.4 Filter Tape Loading

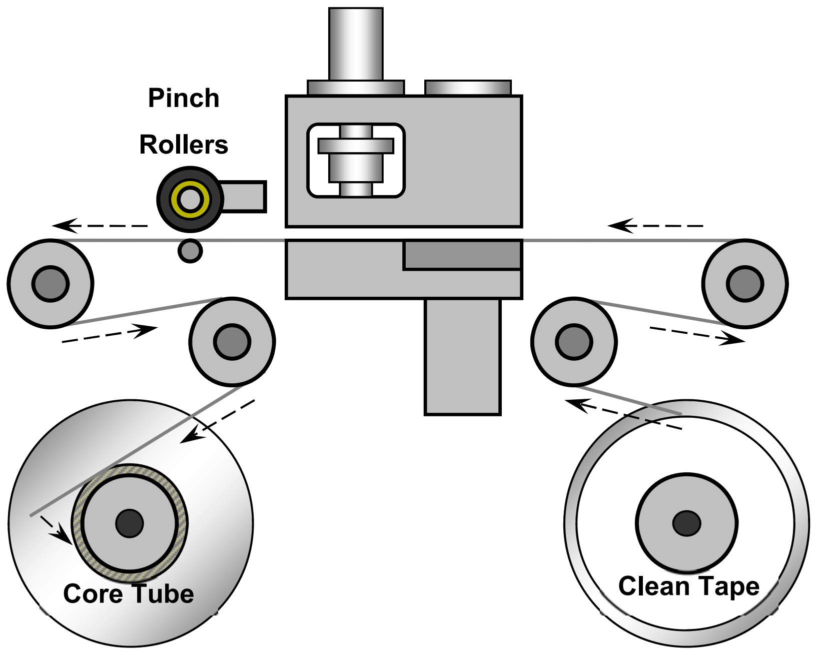
A roll of glass fiber filter tape must be loaded into the ADMS BAM 1000/1100 for sampling. A roll of tape will last more than 90 days under normal operation. It is important to have spare rolls available to avoid data interruptions. Some agencies save and archive the used filter tape, although the used sample spots are not protected from contamination, and are not marked to indicate the sample hour or site. Chemical analysis may be affected by the binder agent in the tape. Used filter tape should never be "flipped over" or re-used! This will result in measurement problems. Loading a roll of filter tape into the ADMS BAM 1000/1100 is a simple matter using the following steps:

1. Turn on the ADMS BAM. The instrument automatically raises the sample nozzle.
2. Lift the rubber pinch roller assembly and latch it in the UP position.
3. Unscrew and remove the two clear plastic reel covers.
4. An empty core tube MUST be installed on the left (take-up) reel hub. This provides a surface for the used tape to spool upon. **Anodyne** supplies a plastic core tube to use with the first roll of tape. After that, you can use the empty core tube left over from the previous roll. Never fasten the filter tape to the aluminum hub.
5. Load the new roll of filter tape onto the right (supply) reel, and route the tape through the transport assembly as shown in the drawing. Attach the loose end of the filter tape to the empty core tube with adhesive cellophane tape or equivalent.
6. Rotate the tape roll by hand to remove excess slack, then install the clear plastic reel covers. The covers must be tight in order to properly clamp the tape in place and prevent slipping.

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

8. Unlatch and lower the pinch roller assembly onto the tape. The ADMS BAM 1000/1100 cannot automatically lower the rollers, and the instrument will not operate if the pinch rollers are left latched in the up position!

9. Press the TENSION soft-key in the TAPE menu.
   The ADMS BAM will set the tape to the correct tension and alert you if there was an error with the process. Exit the menu.



ADMS BAM 1000/1100Filter Tape Loading Diagram

3.5 Self-Test

The ADMS BAM 1000/1100 have a built-in self-test function which automatically tests most of the tape control and flow systems of the ADMS BAM 1000/1100. The self-test should be run right after each time the filter tape is changed, and it can also be used if the operator suspects a problem with the instrument . More detailed diagnostic test menus are also available in the BAM, and those are described in the troubleshooting Section.

The self-test feature is located in the TAPE menu. Press the SELF TEST soft-key to start the test. The tests will take a couple of minutes, and the ADMS BAM 1000/1100 will display the results of each tested item with an OK or a FAIL tag. If all of the test items are OK, the status will show SELF TEST PASSED as shown in the drawing below. If any item fails, the status will show ERROR OCCURRED.

```
02/08/2019               13:00:00
LATCH: OFF               TAPE BREAK: OK
CAPSTAN: OK              TAPE TENSION: OK
NOZZLE DN: OK            SHUTTLE: OK
NOZZLE UP: OK            REF EXTEND: OK
FLOW: OK                 REF WITHDRAW: OK
Status:   SELF TEST PASSED
TENSION   SELF TEST                 EXIT
```

Self-Test Status Screen

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

CAPSTAN: The ADMS BAM 1000/1100 will rotate the capstan shaft forward and backwards and will check if the photo interrupter sees the shaft rotating. The Capstan shaft is what moves the filter tape back and forth.

NOZZLE DN: The ADMS BAM 1000/1100 will attempt to lower the nozzle, and will check if the nozzle motor has moved to the down position with a photo interrupter. It is possible for the nozzle to become stuck in the UP position, even if the nozzle motor has successfully moved to the DOWN position. For this reason, proper inlet alignment and nozzle O-ring maintenance is necessary.

NOZZLE UP: The ADMS BAM 1000/1100 will attempt to raise the nozzle, and will check if the nozzle motor has moved to the up position with a photo interrupte.

FLOW: The ADMS BAM 1000/1100 will attempt to turn the pump on, and will then look for output on the flow sensor. This test takes about a minute and will fail if the pump is not connected.

TAPE BREAK: The ADMS BAM 1000/1100will move the supply and take-up motors to create slack in the filter tape, and look for proper operation of the tensioner photo interrupters.

TAPE TENSION: The ADMS BAM 1000/1100 will tension the filter tape, and then check the condition of the tensioner photo interrupters.

SHUTTLE: The ADMS BAM 1000/1100 will attempt to move the shuttle beam left and right, and will check the motion with a photo interrupter.

REF EXTEND: The ADMS BAM 1000/1100 will attempt to extend the reference membrane, and will check the motion with a photo interrupter.

REF WITHDRAW : The ADMS BAM 1000/1100 will attempt to withdraw the reference membrane, and will check the motion with a photo interrupter.

3.6 Initial SETUP Settings Considerations

The ADMS BAM 1000/1100 come pre-programmed with a wide array of default values for the settings which govern the measurement and calibration. Most of these setup values will not be changed, since the default values are correct for most applications. At the very least, review the following parameters:

1. Set the system clock in the SETUP > CLOCK menu. The ADMS BAM 1000/1100, clock may drift as much as two minutes per month. It is important to check the clock at least once per month to ensure the samples are performed at the correct times.
2. Review the SAMPLE, COUNT TIME, MET SAMPLE, RANGE, and OFFSET values in the SETUP > SAMPLE menu.
3. Review the FLOW RATE, FLOW TYPE, CONC TYPE, and HEATER CONTROL settings in the SETUP > CALIBRATE menu.
4. Review the scaling of any external sensors in the SETUP > SENSORS menu.
5. Review the Smart Heater control settings in the SETUP > HEATER menu.

3.7 Initial Leak Check and Flow Check

The ADMS BAM 1000/1100 comes with factory-set flow calibration parameters which will allow the instrument to accurately control the 16.70 L/min or 30 lph sample flow system right out of the box. However, due to minor variations between different types of flow transfer standards, it is best to calibrate the ADMS BAM 1000/1100 flow system with your own traceable flow audit standard. Become comfortable with these processes, as they will be performed on a routine basis.

3.8 Starting a Measurement Cycle

When the preceding setup steps of Section 3 have been completed, exit out to the main top level menu. The “Status” line should display “ON” (no errors). If so, the ADMS BAM 1000/1100 will start at the top (beginning) of the next hour, and will continuously operate until commanded to stop.

The ADMS BAM 1000/1100 will stop if the operator enters any of the SETUP or TEST menus. The ADMS BAM 1000/1100 will also stop itself if a non-correctable error is encountered, such as broken filter tape or failed air flow.

3.9 Accessing the Flow Statistics Screen

While the ADMS BAM 1000/1100, will display the main menu screen, the ▼ button can be pressed and the instrument will display a FLOW STATISTICS screen as shown below. This screen displays the flow, temperature and pressure statistics for the current measurement cycle. Pressing the ▼ key again will further scroll down to the remaining parameters below the viewable area of the display. This screen will not interrupt the sample cycle.

```
30/06/2019   FLOW STATISTICS    16:26:30
SAMPLE START: 2007/03/28 16:08:30
ELAPSED: 00:18:00
    FLOW RATE: 16.7 LPM
 AVERAGE FLOW: 16.7 LPM
      FLOW CV: 0.2%
       VOLUME: 0.834m3
                                EXIT
    FLOW FLAG: OFF
           AT: 23.0
       MAX AT: 23.5
   AVERAGE AT: 23.0
       MIN AT: 22.5
           BP: 760
       MAX BP: 765
   AVERAGE BP: 760
       MIN BP: 755
```

The FLOW STATISTICS Screen

3.10 The OPERATE Menus

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

```
30/08/2019  OPERATE MODE       14:13:07

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

  NORMAL     INST    AVERAGE     EXIT
```

The OPERATE Menu

The DOWN arrow can be used to set the Operation Mode from ON to OFF. This will simply stop the measurement cycle, but will not power-down the ADMS BAM 1000/1100.

The OPERATE menu has three soft-key options for viewing the operating status and sensor measurements while the ADMS BAM 1000 /1100 is operating : NORMAL , INST , and AVERAGE.

3.11 The NORMAL Operation Screen

Normal Mode is the primary operation screen which displays most of the important parameters of the sample progress in one place, as shown below. Many operators leave their instrument in the NORMAL screen whenever the ADMS BAM 1000 /1100 is operating , instead of the Main menu.

```
30/08/2019          Normal Mode        11:27:54
                                    Flow: 16.7 LPM
                                  AMB P: 764 mmHg
LAST  C:  0.062  mg/m3           TAPE P: 584 mmHg
                                      RH: 27 %
LAST  m: 0.806 mg/cm2            Heater: OFF
                                Delta-T: 4.2 C
STATUS: SAMPLING                           EXIT
```

The NORMAL Operation Menu

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

3.12 The INSTANTANEOUS and AVERAGE Operation Screens

The INST (Instantaneous) screen displays the instantaneous data values that are being measured by the ADMS BAM 1000/1100 This screen is useful for monitoring the current reading of any optional sensors that may be connected to the ADMS BAM 1000/1100. All values except Conc (concentration) and Qtot (total flow volume) are current . The Conc represents the concentration of the last period. Qtot represents total flow volume during the last period.

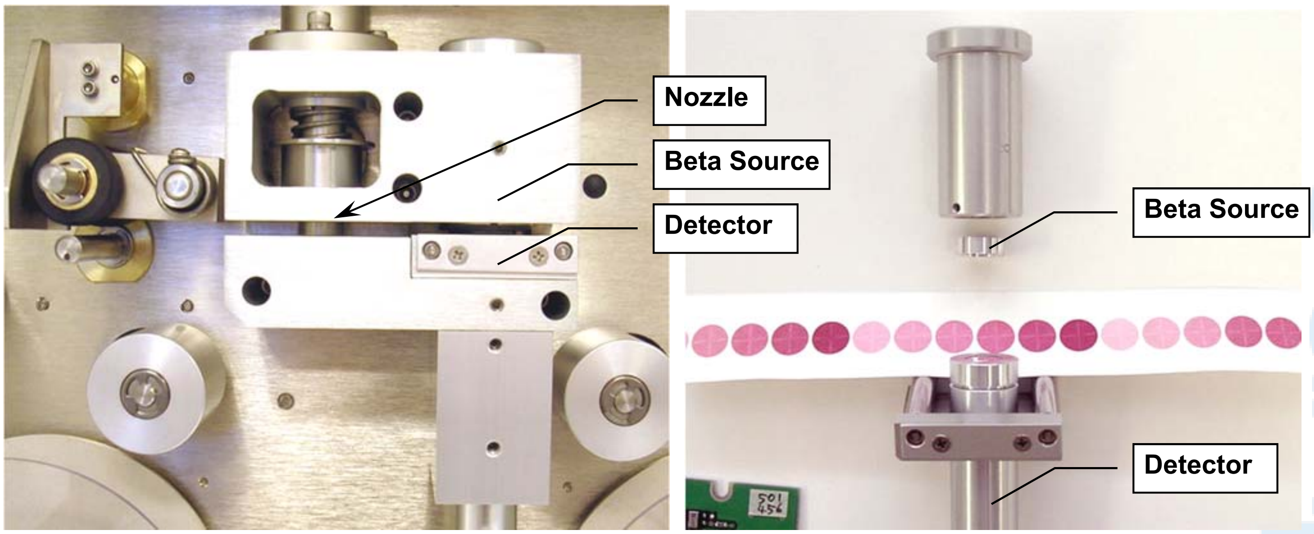
```
30/08/2019                              11:27:54
           Eng Units                  Eng Units
1 Conc     0.010 mg     2 Qtot        .834 m3
3 WS       0.000        4 WD          0.000
5 BP       0.000        6 RH          0.000
7 SR       0.000        8 AT          0.000

                          VOLT/ENG      EXIT
```

The Instantaneous Menu

4 THE MEASUREMENT CYCLE

This section describes the measurement and timing cycle of the ADMS BAM 1000/1100. An understanding of the measurement is helpful for the effective operation and maintenance of the ADMS BAM 1000/1100.



ADMS BAM 1000/1100 Sample and Measurement Stations

4.1 The One-Hour Cycle Timeline

The ADMS BAM 1000/1100 is almost always configured to operate on 1-hour cycles. The ADMS BAM 1000/1100 has a real-time clock which controls the cycle timing. The COUNT TIME on the instrument is user selectable, but is generally set to 4 minutes for PM_{10} measurement or to 8 minutes for $PM_{2.5}$ measurement. In the example timeline below the ADMS BAM 1000/1100 makes an 8-minute beta measurement at the beginning and the end of each hour, with a 42 minute air sample period in between, for a total of 58 minutes. The other two minutes of the hour are used for tape and nozzle movements during the cycle.

When configured for $PM_{2.5}$, COUNT TIME must be set to 8 minutes. ADMS BAM 1000/1100 for $PM_{2.5}$ monitoring you may set the COUNT TIME to 4, 6, or 10 minutes. When running for PM_{10} COUNT TIME may be set to 4, 6, 8, or 10 minutes. The total measurement cycle is 1 hour. The pump sampling time may be calculated by subtracting twice the COUNT TIME from 60 minutes and then subtracting an additional 2 minutes to allow for tape movement. Therefore a COUNT TIME of 8 minutes would provide a pump sampling time of 42 minutes (60-8-8-2).

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

1. **Minute 00:** The beginning of an hour. The ADMS BAM 1000/1100 advances the filter tape forward one "window" to the next fresh, unused spot on the tape. This takes a few seconds. The new spot is positioned between the beta source and the detector, and the BAM begins counting beta particles through this clean spot for exactly eight minutes. (I_0)
2. **~Minute 08:** The ADMS BAM 1000/1100 stops counting beta particles through the clean spot (I_0), and moves the tape exactly four windows forward, positioning that same spot directly under the nozzle. This takes a few seconds. The instrument then lowers the nozzle onto the filter tape and turns the vacuum pump on, pulling particulate -laden air through the filter tape on which I_0 was just measured , for 42 minutes at 16.70 liters per minute.
3. **~Minute 50:** The ADMS BAM 1000/1100 turns the vacuum pump off, raises the nozzle, and moves the filter tape backwards exactly four windows. This takes a few seconds, and puts the spot that was just loaded with particulate back between the beta source and the detector. The BAM begins counting beta particles through the now dirty spot of tape for exactly eight minutes (I_3).
4. **~Minute 58:** The ADMS BAM 1000/1100 stops counting beta particles through the dirty spot (I_3). The ADMS BAM 1000/1100 uses the I_0 and I_3 counts to calculate the mass of the deposited particulate on the spot, and uses the total volume of air sampled to calculate the concentration of the particulate in milligrams or micrograms per cubic meter of air. The BAM then sits idle until the top of the next hour.
5. **Minute 60:** The beginning of the next hour. The ADMS BAM 1000/1100 records the just- calculated concentration value to memory and sets the analog output voltage to represent the previous hour's concentration. It advances a new fresh spot of tape to the beta measurement area and the measurement cycle starts again.

4.2 Automatic Span Checks During The Cycle

While the vacuum pump is on and pulling air through the filter tape as described above, it performs a span check. The user may set up the ADMS BAM 1000/1100 to perform the span check hourly, once per day, or not at all.

1. **Minute 08:** The ADMS BAM 1000/1100 has just finished moving the clean spot to the nozzle and turned the pump on. There is another clean spot of filter tape upstream four windows, between the beta source and the detector. This same spot will stay there for the entire time the pump is on. The ADMS BAM 1000/1100 begins counting the beta particles through this spot for exactly eight minutes. The measured value is recorded as I_1.
2. **Minute 16 :** The ADMS BAM stops counting beta particles and extends the reference membrane between the beta source and the detector, directly above the spot of filter tape that was just measured . The reference membrane is an extremely thin film of clear Mylar held in a metal tongue . The membrane is of known mass density (mg/cm^2). It starts counting beta particles for eight minutes again, this time through the membrane and the filter tape spot at the same time. This value is recorded as I_2.
3. **Minute 24:** The ADMS BAM 1000/1100 stops counting beta particles through the membrane withdraws the membrane assembly, and calculates the mass density of the membrane.

4. **Minute 42:** (Eight minutes before the pump stops) The ADMS BAM 1000/1100 counts the beta particles through the same spot again (without the membrane) for another eight minutes. This value is recorded as I_1' .

The mass density "m" (mg/cm2) of the reference membrane calculated during this automatic process is compared to the known mass of the membrane; the "ABS" value. During factory calibration, the actual mass of each individual span foil is determined and saved as the ABS value of the ADMS BAM 1000/1100 in which it was installed. Each measurement of m must match the ABS value within ±5%. If not, the ADMS BAM 1000/1100 records a "D" alarm for that hour's data. Typically, the value of m is within a few mg/cm2 of the expected value. The ABS value is unique to each BAM , and can be found on the calibration sheet . Most membrane alarms are caused by a dirty membrane foil.

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

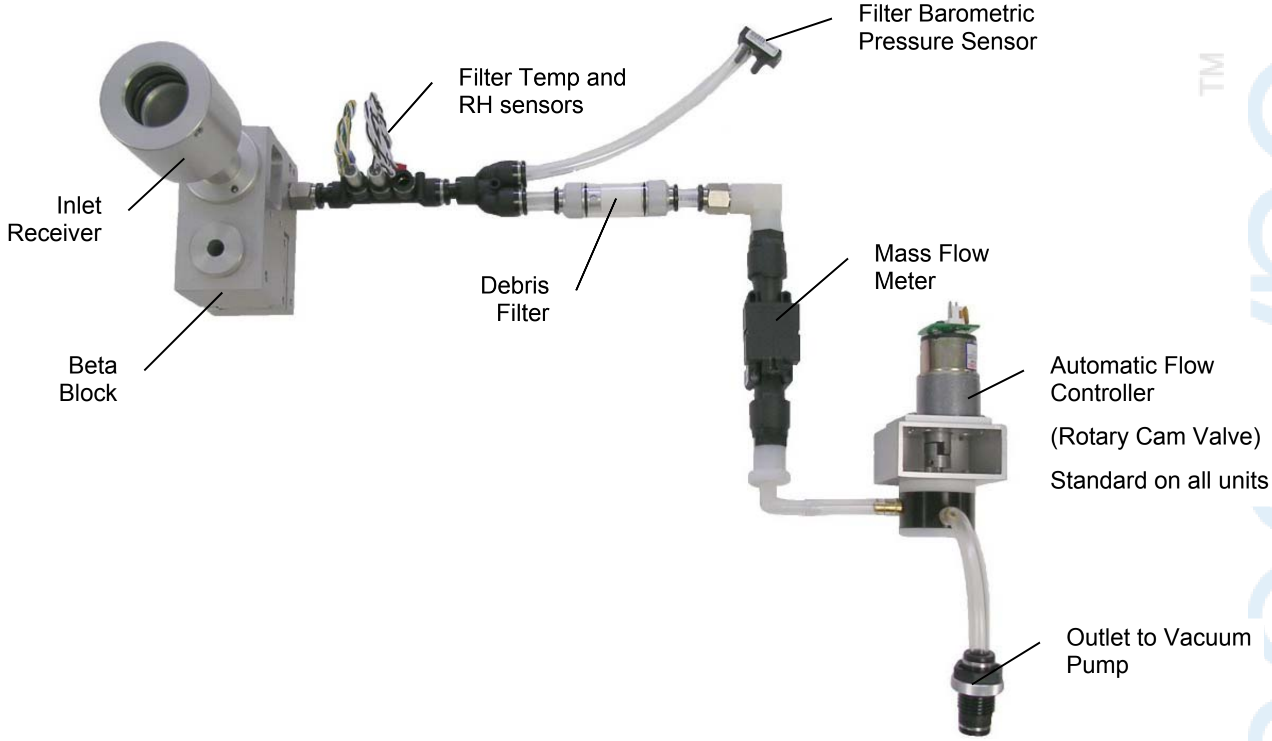
4.3 Filter Tape Use

The ADMS BAM 1000/1100 positions the filter spots very close to one another so as not to waste filter tape. Once each day at midnight, the ADMS BAM 1000/1100 will skip a spot (there will not be a spot where one is expected to be). This is done to make it easier for the user to match the spot on the take up spool with the hour and the day the spot was generated if this is necessary to be done.

5 FLOW SYSTEM and FLOW CALIBRATIONS

5.1 Flow System Diagram

The ADMS BAM 1000/1100 is designed to operate with an adjustable air flow rate but normallyused flow rate of 16.70 liters per minute (L/min or LPM). The flow rate must be maintained at this value in order for the commonly used the PM_{10} and $PM_{2.5}$ cyclones to work effectively. Periodic airflow audits must be performed to ensure that the ADMS BAM 1000/1100 maintains the 16.70 LPM flow rate.



Complete ADMS BAM 1000/1100 Flow Control System

All ADMS BAM 1000/1100 monitors have a mass flow sensor and a barometric pressure sensor. The ADMS BAM 1000/1100 is also equipped with an ambient temperature sensor. Temperature and barometric pressure measurements are needed to convert mass flow into volume flow rate (LPM).

5.2 Flow Control and Flow Reporting Types

The ADMS BAM 1000/1100 is capable of controlling the flow using either standard or actual temperature /pressure conditions , and can independently report the particulate concentrations based on either a standard or actual volume of sampled air. ADMS BAM 1000/1100 monitors.

5.2.1 ACTUAL Flow Control:

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

5.2.2 STANDARD Flow Control:

This mode of operation is not recommended as the cut points for the PM10 inlets and the PM2.5 size fractionators require a nominal flow of 16.70 actual liters per minute . All instruments, include a mass flow controller as standard equipment.

ACTUAL Flow Reporting

To report mass concentrations under actual conditions set CONC TYPE to ACTUAL. This configuration is almost always used for PM2.5 concentration reporting . It is also used when reporting PM10 concentrations when paired ADMS BAM is used for PM10-2.5 monitoring.

STD Flow Reporting

To report mass concentrations under standard conditions set CONC TYPE to STD. The ADMS BAM 1000/1100 will then convert the actual volume sampled during the measurement cycle into the corresponding standard volume and report the mass concentration under standard conditions.

5.3 Total Flow (QTOT) and Flow Rate (LPM) Conversions

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

(QTOT * 1000) / Sample Time = (0.700 * 1000)/42 = 16.67 LPM

5.4 About Leak Checks, Nozzle Cleaning, and Flow Checks

Anodyne recommends its users to perform leak checks, nozzle and vane cleaning (if needed) and a flow check or calibration (if needed) at least once in 2 month. With diagnostics these features can be checked on Real Time Software also.

The best order for the flow system checks is:

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

If an air leak is found, it could be caused by degraded O-rings, or an improper inlet tube to receiver connection. However, it almost always occurs at the interface between the nozzle and the filter tape due to debris buildup. There is normally an insignificant amount of leakage at the tape interface, but an excessive leak lets an unknown portion of the 16.70 L/min sample flow to enter the system at the leak point instead of the inlet. This could cause the total volume of air sampled through the inlet to be incorrect, and the resulting concentration data could be unpredictably biased. The ADMS BAM's cannot automatically detect a leak at the tape/nozzle interface because the airflow sensor is located downstream of the filter tape. Allowing a significant leak to persist may result in concentration data being invalidated!

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

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

5.5 Leak Check

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

NOTE: Only Anodyne, factory authorized tape should be used with the PM monitor. Tape supplied by other vendors has not been tested or approved for use and any data collected using third party filter tape will not be considered valid.

Required Tools: Leak Check Valve

(Minimum Suggested Interval: Whenever the filter tape is changed)

5.5.1 Basic Leak Check

Use the following steps to perform the basic leak check:

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

5. Turn the leak valve on the inlet to the closed position

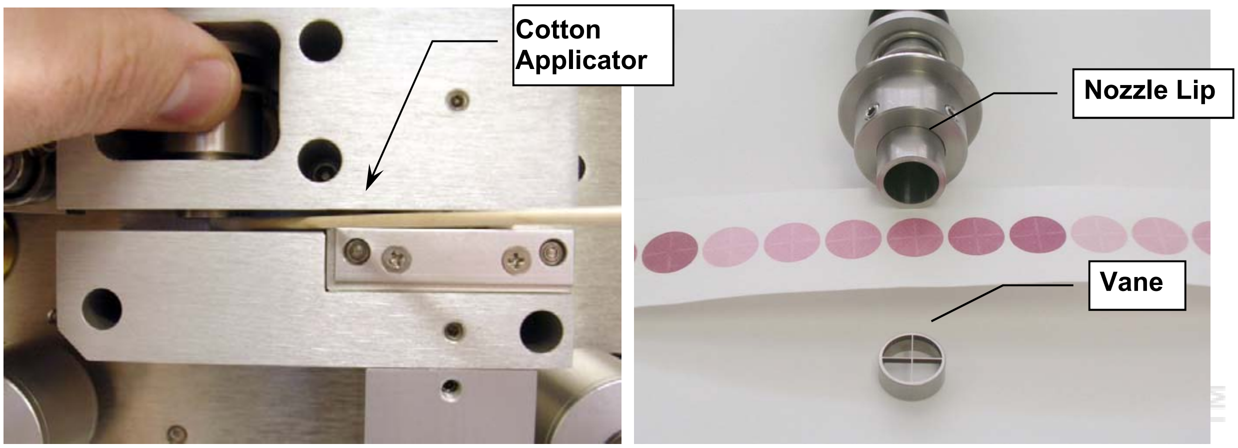
6. The pump flow rate should drop below 1.5 LPM.
    a. If the flow rate is 1.5 LPM or less, the leak check is satisfactory. Proceed to step 7.
    b. If the flow rate is greater than 1.5 LPM, the leak check fails. Proceed to step 7 and then repeat the leak test after completing step 11. If it fails a second time, go to the next section.
7. Slowly open the valve to restore normal flow.
8. Press the PUMP button to turn off the pump and then go to the TEST > TAPE menu.
9. Advance the tape forward seven windows by pressing the UP arrow to set the WINDOWS field to 7 and then pressing the FWD button. The nozzle should raise automatically and then advance the tape. If the last sample spot is not clearly visible, advance the tape one window at a time until it is.
10. Inspect the last sample spot on the tape roll. Examine it closely for any abnormal deformation or holes. The presence of abnormalities indicates debris build up at that location of the nozzle / vane interface. These indicate areas of the interface that may require additional cleaning. Note that in low concentrations the sample spot may not be easily located.
11. Remove the tape and thoroughly clean the nozzle / vane interface as instructed in the MAINTENANCE , DIAGNOSTICS and TROUBLESHOOTING section Operation Manual. Pay particular attention to areas shown to have build-up in step 10 above.
12. Reinstall the filter tape as directed in the Filter Tape Loading section. If step 6 failed, repeat the above leak check procedure now. If step 6 passed, continue on to step 13.
13. Exit to the Main Menu
14. Remove the valve and replace the PM10 size selective inlet.
15. Resume normal sampling operations.

5.6 Nozzle and Vane Cleaning Procedure

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

1. Latch up the tape pinch rollers, and raise the nozzle in the TEST > PUMP menu. Slide the filter tape out of the slot in the beta block nozzle area. It is not necessary to completely remove the filter tape.
2. With the nozzle up, use a small flashlight to inspect the vane. Any debris will usually be visible. Clean the vane surface with a cotton tipped applicator and deionized water or isopropyl alcohol. Hardened deposits may have to be carefully scraped off with the wooden end of the applicator. Take care not to damage the vane!
3. Lower the nozzle in the TEST > PUMP menu. Lift the nozzle with your finger and insert another wet cotton applicator between the nozzle and the vane. Let the nozzle press down onto the swab with its spring pressure. Use your thumb to rotate the nozzle while keeping the swab in place. A few rotations should clean the nozzle lip.
4. Repeat the nozzle cleaning until the swabs come out clean, then inspect the nozzle lip and vane again, looking for any burrs which may cause tape damage.

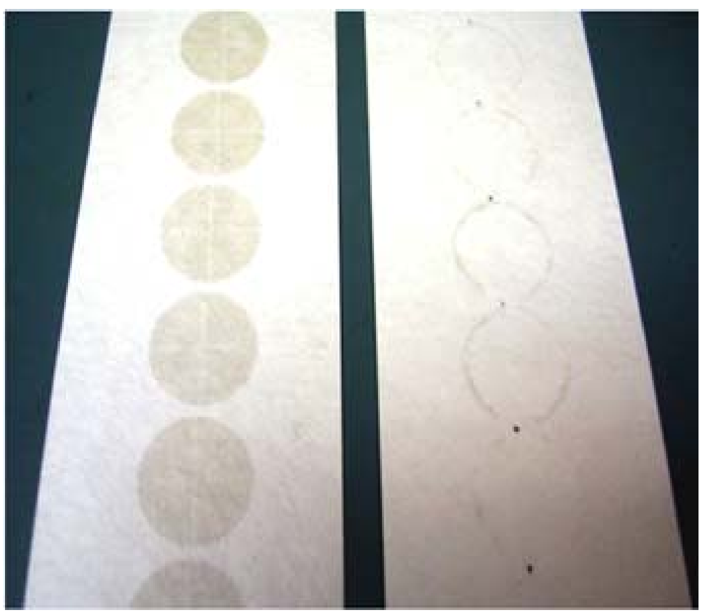
cotton-tipped applicator and deionized water or isopropyl alcohol



Nozzle and Vane Cleaning, and Disassembled View

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

The tape on the right is from a unit which has a leak. A spot of debris has built up on the vane, and is punching a pin-hole at the edge of each spot. These holes can allow beta particles to get through unattenuated which can lead to erroneous concentration measurements. The spots also show a “halo” effect due to air leaking in around the edge because the nozzle is not sealing correctly. These faults are easily corrected and prevented by keeping the nozzle and vane clean.



Hourly filter tape spots

5.7 Field Calibration of the Flow System – Actual Flow Mode

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

The TEST > FLOW calibration screen is shown below. The “BAM” column displays what the ADMS BAM 1000/1100 measures for each parameter. The “STD” column is where you can enter the correct values from your traceable reference standard device. The <CAL> symbol appears to the left of row of the active selected parameter. The selected parameter can be changed by pressing the NEXT key. No calibration changes are made to the selected parameter unless the CAL or DEFAULT key is pressed. The ambient temperature and pressure are always calibrated before the flow, because the ADMS BAM 1000/1100 use these parameters to calculate the air flow rate in actual mode.

```
MULTIPOINT FLOW CALIBRATION

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

Actual Flow Calibration Screen

1. Enter the TEST > FLOW menu as shown above. The nozzle will lower automatically when this screen is entered.
2. To perform a simple flow “check” or “audit” in which no calibrations are to be changed, simply use the NEXT soft key to select the AT (temperature), BP (pressure), and FLOW 3 (16.7) parameters one at a time. Compare the BAM column reading to your standard device for each parameter, and record the results. No calibrations are altered if the CAL or DEFAULT keys are not pressed. If calibration is required, go on to step 3.
3. Select the AT parameter if not already selected. Measure the ambient temperature with your reference standard device positioned near the ADMS BAM 1000/1100 ambient temperature probe. Enter the value from your reference standard into the STD field using the arrow keys. Press the CAL soft key to calibrate the BAM reading. The BAM and STD temperature values should now be the same.
4. Press the NEXT key to select the BP field. Enter the barometric pressure value from your reference standard into the STD field, and press the CAL soft key to calibrate the BAM reading. The BAM and STD pressure values should now be the same.
5. After the temperature and pressure readings are both correct, remove the PM10 head from the inlet tube and install your reference flow meter onto the inlet tube. Press the NEXT key to select the first flow point of 15.0 L/min. The pump will turn on

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

6. Press the NEXT key to select the second flow point of 18.4 L/min. Allow the flow to stabilize again, then enter the value from your standard device and press the CAL key. Note: If the ADMS BAM 1000/1100 is unable to achieve flow regulation at the 18.4 L/min point, this could be an indication that the vacuum pump needs to be serviced.
7. Press the NEXT key to select the third flow point of 16.70 L/min. Allow the flow to stabilize again, then enter the value from your standard device and press the CAL key.
8. After this third flow point is calibrated, the BAM flow reading will change to show the corrected flow, then the ADMS BAM will quickly re-regulate the flow to 16.70 L/min based on the new calibration. The ADMS BAM flow reading should now match your flow standard device at 16.70 ± 0.1 L/min. Exit the calibration menu.

5.8 Field Calibration of the Flow System – Standard Flow Mode

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

STANDARD Flow BAMs with a Temperature Sensor:

If the operational FLOW TYPE must be set to STANDARD for some special reason, then the easiest way to calibrate the flow is to temporarily change the FLOW TYPE from STD to ACTUAL in the SETUP > CALIBRATE menu, then perform a normal actual flow audit or calibration as described above. If this method is used, be sure to set the BAM back to STD flow type when finished. This works as long as the ADMS BAM 1000/1100 is equipped with an ambient temperature sensor on input channel six.

6 SETUP MENU DESCRIPTIONS

ADMS BAM uses a comprehensive system of setup menus which contain all of the settings and parameters needed to perform the measurement and operation. Most of these settings are set at factory default values. Some settings may be altered by the operator. This section describes the SETUP menu in detail, and should be reviewed when the instrument is first put into service. Once set, most of the values in the SETUP menus will not need to be changed. The SETUP values will not be lost if the BAM is unplugged or powered down.

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

WARNING: Entering the SETUP menu system requires stopping the sample cycle.

Press the SETUP soft-key to enter the menu as shown below. The Setup Menu provides a choice of operations. Use the arrow keys to navigate to the desired field, then press the SELECT soft-key to enter.

```
                       SETUP MODE SELECT

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



 SELECT                          EXIT
```

The SETUP Menu

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

Menu	Settings
CLOCK	Real-time clock date and time settings.
SAMPLE	Range, Offset, Sample Time, Count Time, Conc Units, Avg Period, Unit ID, and RS-232 settings.
CALIBRATE	Factory Calibration Values, (C_v, Q_0, ABS, μsw, K, BKGD) Flow rate, Flow type, Conc Type.
ERRORS	Analog error selections, Flow limits, Pressure drop limit.
PASSWORD	Password change screen.
INTERFACE	Cycle Mode early/standard, alarm relay polarity.
HEATER	RH set-point for Smart Heater.
REPORTS	Daily data report hours, BP and Reference Membrane logging options

7 MAINTENANCE, DIAGNOSTICS and TROUBLESHOOTING

This section provides information about routine maintenance, identifying errors and alarms, and performing diagnostic tests on the ADMS BAM 1000/1100. The TEST menu functions are also described in this section. Met One Instruments also publishes a comprehensive array of technical bulletins that covers additional information about subsystem troubleshooting, upgrades, and repairs. These are available in the "BAM Users" section of our website, or by e-mail request from the Technical Service department.

7.1 Recommended Periodic Maintenance Table

The following table shows the recommended interval for the regular ADMS BAM 1000/1100 maintenance, field check, and service tasks. Special tools are not required for any of the routine service tasks on less than yearly intervals. Anodyne recommends for service and repairs such as nozzle removal and detector tests. Complete instructions are included.

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

7.2 Error and Alarms

The following table describes the ADMS BAM 1000/1100 error and alarm codes. Errors are grouped into twelve categories . If an error or alarm occurs, it will appear at the end of the hourly digital data array as a simple “1” bit in one of the twelve error bit positions . This allows data collection systems to easily identify errors. See Section 9 for data examples . Errors and alarms are also stored in the separate digital error log file, which contains more detail about the specific sub-category cause of the alarm.

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

Code	Error/Alarm Type	Error/Alarm Description
E	External Reset or Interface Reset	This alarm indicates that an external data logger sent a clock synchronization signal on the EXT RESET input, but the ADMS BAM was unable to reset its clock, because it occurred outside of the allowable time window. Hourly clock reset signals will be ignored by the BAM from minutes 5-54 (standard cycle) or minutes 0-49 (early mode). The alarm will also be generated if the synch signal occurs within the acceptable window near the end of the hour , but before it has finished the previous concentration calculation. The digital error log will indicate which of these two has conditions occurred. If an external clock reset event is successful, then no alarm is logged. These alarms do not prevent the ADMS BAM from storing a valid data record for the sample hour.
U	Telemetry Fault or Interface Fault	This alarm indicates that an external data logger has sent an error signal to the ADMS BAM on the TELEM FAULT input , indicating that the logger unit has encountered a problem. This feature is almost never used. These alarms do not prevent the BAM from storing a valid data record for the sample hour.
M	Maintenance Alarm	This alarm almost always indicates that the sample cycle was stopped because someone entered a SETUP or TEST menu for calibration or testing purposes . Maintenance flags always cause the digital concentration value to go full-scale for that hour, because the sample cycle was not finished.
I	Internal Error or Coarse Link Down	The “I” error is rare, and indicates that an error occurred in the concentration, mass, span, or stability calculation which prevented the generation of a valid concentration value. The digital error log will indicate which of these calculations has failed. The concentration value is set to full-scale due to invalid data. This may indicate a problem in the digital circuitry. In units configured as the PM10 master unit in a PM-coarse pair, the “I” alarm indicates that the digital link between the two units is down, and the master unit could not obtain the PM2.5 value from the slave unit and thus could not calculate a coarse value. The coarse and PM2.5 values will be full-scale.

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

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

7.3 Comparison of ADMS BAM Data to Integrated Filter Sampler Data

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

Most PM reference methods are based on manual, integrated sampling techniques in which PM is sampled onto pre-weighed filters. Sampled filters are then equilibrated and then re-weighed. The net weight gain is used along with the volume of air sampled to determine the mass density of PM in the sampled volume. PM reference methods may differ from one jurisdiction to another. Furthermore, it may be operated differently from one jurisdiction to another.

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

In order for such an analysis to be useful however it is necessary to have a suitable number of data points , an acceptable level of dispersion (range) in the measured values and acceptable level of correlation (r_2) in a regression between the reference results and the measurements.

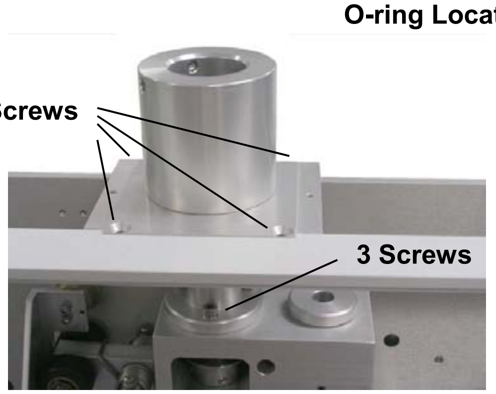
Below are several additional considerations:

- Nozzle leaks can lead to poor correlation between the measurements and the reference standard.
- Improper inlet tube insulation or placing the instrument directly in the path of an air conditioner vent during operation under hot, humid conditions can lead to poor correlation with the reference standard and unpredictable levels of multiplicative and additive bias.
- The collocated inlets should be at approximately the same height and within several meters of one another during the comparison test.
- The start time and the stop time of the filter-based method should correspond to the hourly measurement cycles.

7.4 Nozzle Component Service and O-ring Replacement

The sample nozzle system needs periodic inspection and service in order to prevent flow leaks. The primary indicator is if the nozzle up/down motion feels difficult when performing the normal monthly nozzle cleaning, or if the nozzle fails to fully seal against the tape when lowered, causing leakage. The nozzle O-ring may need to be replaced approximately every two years during continuous operation.

The sample nozzle may also be easily removed, for further cleaning or rebuild. This requires a set of brass adjustment shims to set the spring tension during reassembly. The standard tool kit contains all of the required tools and instructions.



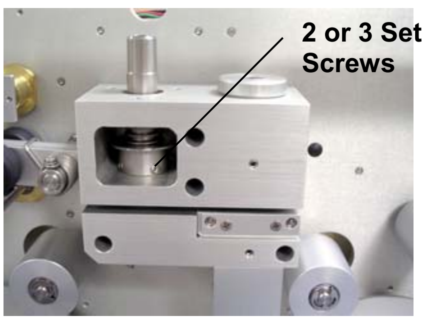
1. Remove the filter tape and the main case cover. The sample nozzle must be in the down position. Lower it using the TEST > PUMP menu if needed. Lift the nozzle up and down against its spring with your thumb and note the action feel.
2. Remove the four screws (two flat head Philips, two 9/64" hex) that fasten the square inlet receiver bracket to the chassis. Lift the assembly. It is not necessary to remove the bracket from the inlet receiver cylinder.
3. Remove the three 9/64" hex screws that fasten the nozzle adapter to the top of the beta block. A T-handle hex wrench is easiest. The nozzle adapter can now be lifted off of the top of the nozzle, revealing the O-ring location. Clean the top of the nozzle.
4. Remove the O-ring from the groove. Thoroughly clean the O-ring groove and the inside if the nozzle adapter using alcohol and cotton-tipped applicators, then install the new O-ring and lubricate it with silicone grease.
5. Check the nozzle up/down action again before reassembly. If the nozzle action feels smooth, then reinstall the nozzle adapter and inlet receiver assemblies. Check the nozzle action after each step of reassembly to identify any binding or sticking. Perform a normal leak check when finished.
6. Optional further disassembly (shim set required): If the nozzle action feels feel sticky or gritty with the nozzle adapter removed, then the nozzle needs to be removed and the nozzle and bushings cleaned. Loosen the two (or three) set screws in the cam

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

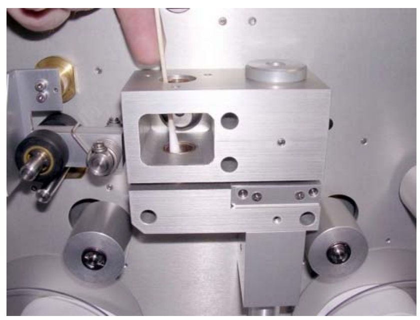
7. Clean the nozzle inside and out, and inspect the nozzle face for any burrs or defects. Clean the two brass bushing bores with a cotton-tipped applicator. This is also a good time to clean and inspect the tape support vane since the nozzle is out of the way. The bushings do not need to be lubricated.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

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

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



Nozzle Removal



Cleaning the Bushings

Using Shims for Reassembly

7.5 Performing the 72-Hour Zero Filter Background Test

All monitors should have a zero-filter test performed before the equipment is first deployed. This test should be repeated periodically as part of a QA/QC program , the frequency of which is up to the user.

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

The initial zero-test is used to determine the instrument noise (σ) and to confirm that the lower limit of detection (LLD), which is 2σ, is within specifications. For an 8-minute count cycle the LLD is <4.8 µg/m3 for a 1-hour measurement cycle and for a 4-minute count cycle the LLD is <7 µg/m3. The initial zero test and all subsequent zero tests should be performed using an 8-minute count cycle if the ADMS BAM will be operated with an 8-minute count cycle. The zero tests should be performed with a 4-minute count cycle when operated with a 4-minute count cycle.
The initial zero-filter test should be performed after installation at the monitoring site. If this is not feasible, then performing the test with the monitor sitting on a nearby laboratory bench before deployment is acceptable.

In case of operation with a smart heater), the zero-filter test should be performed with the smart-heater engaged, but running in “low power mode” for the duration of the test.

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

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

1. Enter the SETUP > CALIBRATE menu.
    a. Record the existing BKGD value, then change it to 0.0000 (optional).
    b. Note the Conc type and set it to Actual if it is not.
    c. Note the Flow type and set it to Actual if it is not.
    d. Save and exit back to the main menu.
2. Install the zero filter assembly onto the top of the inlet tube.

   Note: When it is necessary, the zero filter assembly may be inside the shelter to avoid aspiration of water through the zero filter.
3. Allow the to sample for 48-72 consecutive hours, not counting the warm-up period for the initial zero-test. For the zero-test to be valid, no errors should be logged either during the warm-up period or during the 48-72-hour sampling period. For subsequent zero tests the user may decide to use fewer valid data points.
4. Calculate the average of the hourly concentrations to the nearest 0.1 µg/m3. The new BKGD value is the negative of this average. For example, if the average of the data sample is 0.0021 mg (2.1 µg), the correct BKGD value is -0.0021. Record the new BKGD value.

   Note: If the monitor is being deployed for the first time, replace the factory-set BKGD with the new BKGD value. As Anodyne runs the initial factory zero-test without the smart heater engaged, the initial zero-test performed by the end user may differ from this value if the end user used a smart heater during the test.
5. Calculate the standard deviation of the sample (STDEV on MS Excel) to the closest 0.1 µg/m3. Confirm that the LLD meets the factory specified value.

6. If the results of the zero test indicate that the instrument LLD is higher than the factory specified value or that the BKGD value has changed by more than 2 µg/m3 since the most recent field (not factory) zero-filter test, repeat the zero-filter test. If the problem persists contact the factory.

7. Enter the new BKGD value into the SETUP > CALIBRATE menu. Restore the CONC and FLOW type settings to their pre-test configuration, if applicable. Save and exit back to the main menu.
8. Set the FRH Control back to YES to exit low power mode. Save and exit back to the main menu.
9. Resume normal operations or continue with additional testing, as needed.

7.6 The TEST Menu System – Overview

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

```
TEST MENU

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


 SELECT                          EXIT
```

The TEST Menu

7.7 COUNT Test Menu – Beta Detector Count Tests

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

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

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

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

7.8 PUMP Test Menu – Manual Pump and Nozzle Tests

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

```
          NOZZLE/PUMP EST MODE

NOZZLE:

FLOW:      16.67 SLPM   PUMP:  ON


MOVE NOZZLE   PUMP ON   PUMP OFF   EXIT
```

The PUMP Test screen

The NOZZLE status value will indicate if the nozzle is currently UP (5) or DOWN (6). The PUMP status indicates if the pump is turned ON or OFF. The FLOW value is the current flow rate, displayed in standard liters per minute (25C) only.

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

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

7.9 TAPE Test Menu – Manual Filter Forward/Backward Tests

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

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

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

The FWD and BKWD soft key move the tape forward or backward by the current amount of the FEED value.

7.10 DAC Test Menu – Analog Output Test

The TEST > DAC screen is used to test the function of the analog output voltage and the DAC (digital/analog converter) electronics. Use the up/down arrow keys to force the voltage to any value between 0.000 and 1.000 volts (0.100V increments). The corresponding voltage on the VOLT OUT +/- terminals on the back should always match within ±0. 001 volts. Use a high -quality voltmeter for these tests. If the actual voltage does not match the value on the TEST > DAC screen, contact the service department.

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

7.11 CALIBRATE Test Menu – Span Membrane Mass Tests

The TEST > CALIBRATE screen is used to perform tests of the reference membrane span check which occurs automatically every sample cycle. This test can be run if there has been logging of D errors. Each monitor has an individually weighed membrane, and this mass (m) is measured and displayed during this test. Compare the value from this test with the ABS value on the calibration sheet for your unit. The values must match within 5%, and will typically match within just a few micrograms. If not, the most common cause is a dirty membrane foil, which can be carefully cleaned with canned air or clean water rinse. Alcohol is not used because it leaves a film. CD cleaner works well for badly soiled membranes.

```
          CALIBRATION MODE

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

START    STOP                    EXIT
```

The CALIBRATE Test Screen

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

The COUNT (I0) value is the total 4-minute beta count through the filter tape only.

The COUNT (I) value is the total 4-minute beta count through both the filter and the membrane, and is always less the I0 count.

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

The START soft key starts the test cycle. Counting will immediately begin. After 4-minutes the I0 count will stop, the membrane will extend, and the I count will begin. At the completion of the test, the counting will stop and the mass of the membrane will be calculated. The total elapsed time is about 8.1 minutes per test.

7.12 INTERFACE Test Menu – Relay I/O Channel Tests

The TEST > INTERFACE screen is used to test the relay inputs and outputs on the back. The two inputs TELEM FAULT and EXT RESET are tested by applying the appropriate signal to the terminals on the BAM, then verifying that the value on this screen changes in response. The relay outputs TAPE FAULT, FLOW FAULT, INVALID DATA, MAINTENANCE, RELAY 1, and RELAY 2 are tested by turning them ON or OFF using the arrow keys, then verifying that the contact closure outputs on the back panel terminals respond accordingly with an Ohm-meter. The old RANGE relay output is no longer supported.

7.13 FLOW Test Menu

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

7.14 ALIGN Test Menu – Tape Transport Motor and Photosensor Tests

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

```
TEST MENU

NOZZLE     SHUTTLE    IDLER      CAPSTAN
LATCH      REF


SELECT                             EXIT
```

The TEST > ALIGN Menu

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

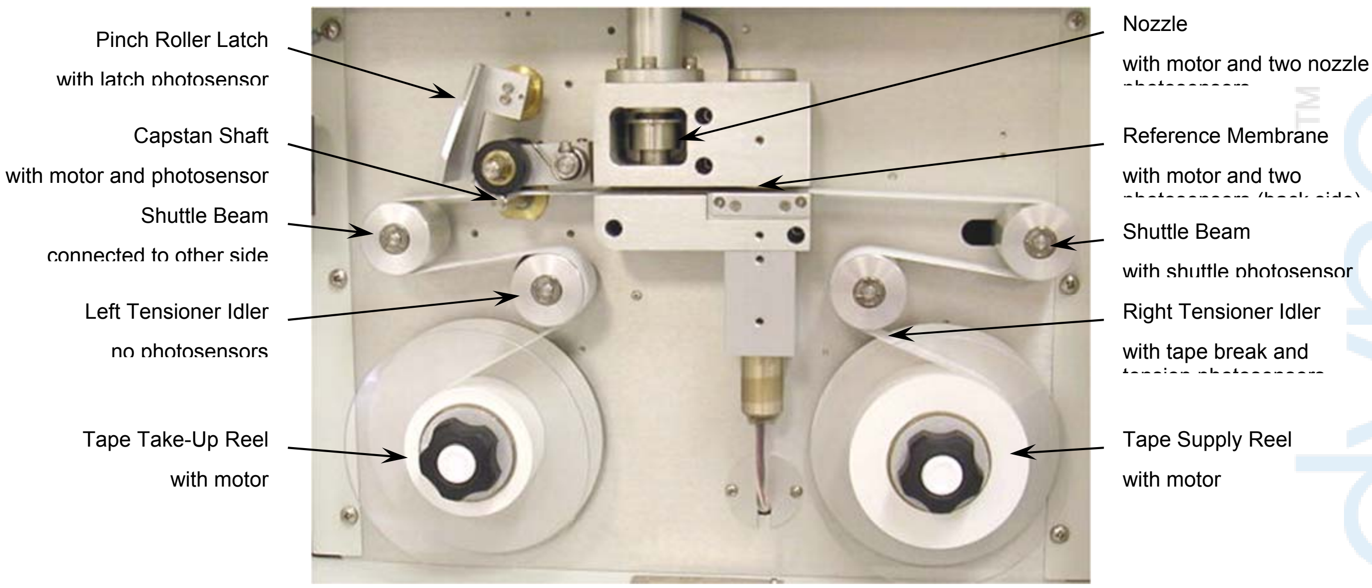
SHUTTLE : This screen tests the photosensor which monitors the position of the shuttle beam (the two outer tape rollers that move together). The status of photo sensor S7 should only change to ON when the beam is moved all the way to the right side. The shuttle must be moved by hand for this test. It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

IDLER: This screen tests the photosensors which monitors the position of the right-side spring-loaded tape tensioner. The tensioner must be moved by hand. When the tensioner is in the leftmost position under its spring pressure, both photo sensors S6 and S1 should be OFF. If the tensioner is moved to the middle of its travel, photo sensor S1 should be ON and S6 OFF. When the tensioner is at the rightmost position, S1 and S6 should both be ON. These are the sensors which monitor tape breakage and tape tensioning. The left side tensioner assembly has no photosensors.

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

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

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



Tape Transport Assembly

7.15 HEATER Test Menu

7.16 FILTER-T Test Menu – Filter Temperature Sensor Tests

8 EXTERNAL DATA LOGGER INTERFACE SYSTEM

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

8.1 Analog Concentration Output Signal

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

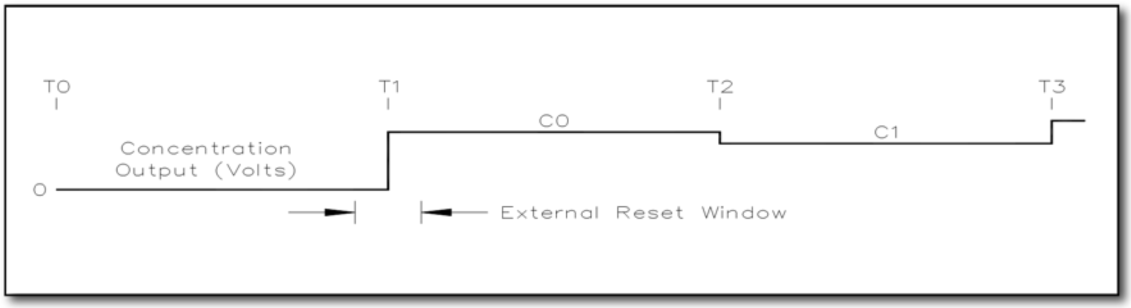
SWITCH	ON	OFF
1	0-10 vdc	0-1 vdc
2	4-20mA	0-16mA

Important Note: In most applications where the OFFSET is set to -0.015, and the RANGE is set to 1.000 mg, the analog output will be scaled as 0.000v to 1.000v equals -0. 015 mg to 0.985 mg. It is critical that your analog data logger input is programmed to scale this voltage correctly, or a significant data offset mistake will occur! The digital data should be periodically compared to the analog logger data to ensure correct logger scaling.

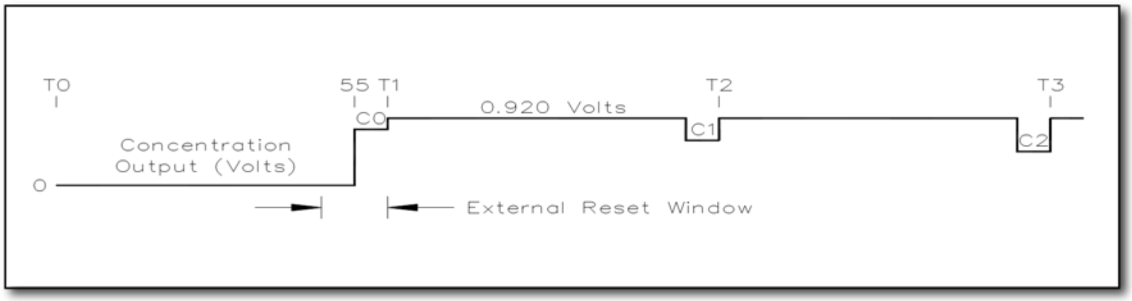
Analog Error Encoding: The analog output is the only voltage channel available between the ADMS BAM 1000/1100 and the data logger, so any errors generated are reported using the same voltage signal. The analog output is set to its full-scale reading whenever a critical error prevents a valid concentration from being measured. It can optionally set the voltage to full-scale in response to other non-critical alarms as described in section 6.5. The external data logger is programmed to recognize a full-scale reading as an error, and not a valid concentration. This method is used because it is rare for an actual concentration reading to exceed the range and if it does, it should be reported as an invalid data point anyway. The digital data values stored are always unaffected and available, if the alarm was non-critical and did not prevent the hourly concentration measurement from occurring.

8.2 Early Cycle Mode Option For Analog Data Collection

During a standard measurement cycle the PM monitor waits for the beginning of the new hour before it sets the analog output to represent the just-finished hour's concentration. However, some types of data loggers must have the concentration value available before the new hour starts, or the data will be stored in the wrong hour. A special EARLY cycle mode (in the SETUP > INTERFACE menu) which leads to start and finish of the measurement allows output the concentration voltage for the last five minutes of the hour which was just sampled. The data logger must be programmed to read this value during the window. Because of the critical timing involved, the clock will have to be synchronized to the data logger clock using the EXT RESET inputs described below. The following describes the timing of the STANDARD and EARLY modes.



STANDARD Cycle Example



EARLY Cycle Example

Analog Output Levels

C0 represents the concentration output level measured from time T0 to T1, where the T labels represent the top (beginning) of an hour (such as 12:00:00). As you can see, the concentration voltage C0 for the standard cycle is present for the whole next hour following the measurement. In early mode, the C0 voltage for the current hour is present for only the last 5 minutes of the hour just-sampled (minute 55 to 60), and all other times the concentration output voltage is fixed at 0.920 volts.

External Reset Windows

An external reset signal may be used to synchronize the clock to the data logger. In standard mode the external reset window is plus or minus 5 minutes around the beginning of the hour, but in early mode the external reset window is between minute 50 and 60 only. The clock will not reset if the previous cycle has not finished the I3 count, and an "E" alarm will be logged.

Standard Mode Clock Resets:

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

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

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

EARLY Mode Clock Resets:

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

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

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

8.3 Telemetry and Error Relays

In addition to the analog output voltage, several input and output relay connections are provided on rear panel. These can be connected to an external data logger as a second method of indicating alarms, but in practice most of these relay telemetry connections are rarely used.

8.4 Interfacing a Digital Data logger

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

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

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

The REPORT serial port works exactly like the RS- 232 port and accesses the same files, except that it has its own CPU and memory and cannot be interrupted or ignored . The REPORT port also has much more data memory capacity. The RS-232 port and it's legacy functionality is also still supported on Report Processor back panels as a backup.

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

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

9 DIGITAL COMMUNICATIONS AND DATA RETRIEVAL

This section describes the methods used to retrieve digital data files through the RS-232 serial communications system. The RS-232 serial ports may be used with a computer, laptop, modem, or digital data logger. The data can be accessed through the serial ports with a terminal program and a simple menu driven interface, or by using a simple computer too.

9.1 Direct Serial Port Connections and Settings

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

RS-232 Connections:

Most older desktop and laptop computers have a standard 9-Pin serial port available for communications, so the RS -232/485 port can be directly connected to the serial port. Connect the port on the back to the COM port connector on the computer with the supplied serial cable (female-to-female 9-pin null). CAUTION: Do not confuse the parallel printer port or video adapter port on your computer with a serial port.

USB Connections:

Most newer computers no longer have the 9-Pin serial communications port In these situations, monitors may still be connected to the computers by using a USB to serial converter. The converters commonly available in local electronics and office supply stores.

Communication Settings:

The PM monitor communicates at 9600 Baud, 8 data bit, no parity, one stop bit, and no flow control. The default 9600 baud rate may be changed to a faster setting for downloading large data files, but in any case, the terminal program baud rate must match the BAM baud setting.

10 THEORY OF OPERATION

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

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

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

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

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

In the above equation I_0 is the measured beta ray flux (counts) across clean filter tape, I is the measured flux (counts) across aerosol-laden filter tape, M is the aerosol mass deposited on the filter tape (mg), S is the spot area (cm^2). μ is the beta ray absorption cross section (cm^2/mg). The absorption cross section μ to a very good approximation depends only on the mass of the absorbing species and not on its chemical composition . In other words the absorption cross sections for commonly found species in ambient particulate matter such as soot, iron oxide, silica, or salt are all approximately the same.

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

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

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

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

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

Comments: