Standard Operation Procedures for Beta Attenuation Mass Monitor

In Use By

Polk County Air Quality
Ambient Air Monitoring Personnel

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POLK COUNTY AIR QUALITY DIVISION

STANDARD OPERATING PROCEDURE MANUAL FOR MET-ONE INSTRUMENTS BETA ATTENUATION MASS MONITOR

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28 STANDARD OPERATING PROCEDURE FOR THE MET-ONE INSTRUMENTS BETA ATTENUATION MASS MONITOR (BAM-1020)

28.1 Purpose

To establish a standard operating procedure (SOP) for the Polk County Air Quality Division personnel concerning the procedures involved with the operation of the Met-One Instruments Beta Attenuation Mass Monitor (BAM-1020).

28.2 Scope

These procedures are to be used by Polk County Air Quality Division personnel. The objective of this SOP is to familiarize the station operator with procedures used in the collection of air monitoring data. The accuracy of data obtained from any instrument depends upon the instrument's performance and the operator's skill. It is important that the station operator become familiar with both this SOP as well as the manufacturer's operation manual in order to achieve a high level of data quality. This SOP is to be used as an outline and is not intended to replace the equipment manufacturer's manual or procedures.

28.3 References

28.3.1 40 Code of Federal Regulations (CFR) Part 58, Appendix A, Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS).

28.3.2 Quality Assurance Guidance Document 2.12, Monitoring PM2.5 in Ambient Air Using Designated Reference or Class I Equivalent Methods, USEPA, Nov. 1998 (http://www.epa.gov/ttn/amtic/pmqainf.html).

28.3.3 40 Code of Federal Regulations (CFR) Part 50, Appendix L, Reference Method for the Determination of Particulate Matter as PM2.5 in the Atmosphere.

28.3.4 BAM 1020 Particulate Monitor Operation Manual, BAM-1020-9800 Rev J. Met One Instruments, Inc., 2008.

28.3.5 BX-302 Zero Filter Calibration Kit Manual, BX-302-9800 Rev C. Met One Instruments, Inc., 2007.

28.3.6 Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, May 2013 edition, Appendix D

28.4 Introduction

This document describes the procedures used to measure relative particulate concentration by Beta Attenuation using the Met-One Instruments Beta Attenuation Mass Monitor, Model 1020. It is intended that this document be used together with the sampler-specific information and instructions provided by the manufacturer.

The BAM-1020 uses beta ray attenuation to calculate collected particle mass concentrations in units of ug/m^3. A ^{14}C element emits a constant source of low-energy electrons, also known as beta particles. The beta rays are attenuated as they collide with particles collected on a filter tape. The decrease in signal detected by the BAM scintillation counter is inversely proportional to the mass loading on the filter tape.

The Met One BAM-1020 collects particles by pulling a measured volume of ambient air through filter paper. In operation, the Beta detector counts the number of Beta particles passing through the filter paper before and after the filter paper collects particulate matter. A known amount of electron scattering and attenuation through a clean filter is compared with that of a dust-sampled filter. To calculate the mass concentration, a ratio of the number of detected beta particles passing through the filter and the sample volume is used.

The radioactive carbon 14 Beta source has been selected to match the energy of the Beta spectrum to the mass to be measured. The carbon 14 Beta source has a long half-life of 5,700 years, which translated to a constant level of energy without other spectral emissions.

28.5 Health and Safety Warning/Precautions

Only properly trained personnel should perform BAM-1020 testing, installation, operation, maintenance and calibration procedures. As with all monitoring equipment, precautions should be taken when working around electricity, power tools and above ground elevations.

The carbon 14 radioactive Beta source (^{14}C) should never be dismantled, removed or tampered with. It will never be necessary for any field personnel to adjust, replace or touch the ^{14}C source. All ^{14}C issues will be handled by the manufacturer. When working with the BAM door open and in the immediate vicinity of the ^{14}C source, the wearing of long sleeves and laboratory gloves may help reduce possible exposure to ^{14}C Beta rays.

28.6 Sampler Set-up

The BAM-1020 monitor has specific physical requirements that should be considered prior to installation. The BAM central unit and pump is neither waterproof nor water-resistant and must be protected from moisture. The BAM as designed to operated in a temperature controlled enclosure (between 0-40°C), and where the relative humidity is not condensing and does not exceed 90 percent. All Polk County BAM monitors will be deployed inside a weather proof and temperature controlled structure. The effort towards maintaining a consistent temperature for the BAM throughout each day is to ensure a baseline quality database by limiting the number of unknown variables that may exist within Polk County's Ambient Monitoring Network.

Specifications for siting a BAM-1020 will mirror the Federal EPA PM2.5 criteria listed in the Code of Federal Regulations (40 CFR 58, Appendix A).

28.6.1 Inspecting New Equipment

Upon receipt of the BAM-1020, visually inspect it to ensure that all components are accounted for. Inspect the instrument for external physical damage due to shipping, such as scratched or dented panel surfaces and broken knobs or connectors.

Open the instrument cover and remove all interior foam packing and save (in case future shipments of the instrumentation are needed). Make note of how the foam packing was installed.

Inspect the interior of the instrument for damage, such as broken components or loose circuit boards. Make sure that all of the circuit boards are completely secured. (Loose boards could short out the motherboard). If no damage is evident, the monitor is ready for installation, calibration and operation. If any damage due to shipping is observed contact the manufacturer for instructions on how to proceed.

Notify Met One Instruments immediately if any equipment is missing or damaged. Repack it in the same way it was delivered.

28.6.2 Set-Up of New Equipment

The Bam-1020 can be rack mounted, placed on a table, shelf or other flat surface. Because the BAM connector fitting for the inlet tube is located on the top on the central unit, installation of the BAM does

not allow for the other instruments to be mounted above it. Wherever the BAM-1020 is installed, space for the vertical position of the inlet tube, inlet hardware and heater must be taken into account.

28.6.2.1 Inlet Installation

The maximum allowable total inlet tube length is 16 feet between the BAM-1020 and the bottom of the inlet head. After locating a suitable place for the BAM-1020 monitor, the holes for the BAM inlet tube can be drilled. Protect the instruments from falling debris. The inlet support hardware includes a rooftop mounting plate for stations with a flat roof. The mounting plate has a circular ridge that protrudes beneath the surface and therefore a 2 ¼" diameter recess must be made on top of the roof in order to accommodate the ridge. Drill a 3/8" hole 6 inches from the first hole for the ambient temperature and pressure sensor cable (BX-596).

Caulk around the 2 ¼" hole and install the roof flange. Secure in place with 4 self-taping screws. Caulk around the screws to prevent leaks. Thread the gray roof fitting into the roof flange. Push the temperature and pressure sensor cable through the 3/8" diameter hole. Caulk around to prevent hole from leaking.

Remove the white cap and rubber fitting. Place the inlet tube through the roof assembly and into the top of the BAM.

Install the Smart Heater on the inlet tube at this time. When secured, the bottom of the heater element should be installed 2" above the BAM. The Smart Heater is installed with the wires facing down.

Press the inlet tube firmly in the BAM until it stops. It is important for the inlet tube to be perpendicular with the top of the BAM. The nozzle will not close properly if there is a bind caused by misalignment. A simple check is to see if the inlet tube spins freely when installed.

Slide the rubber fitting and white cap over the inlet tube. The rubber fitting will slide easier if the inlet tube is lightly dampened with water. Tighten the white cap onto the gray roof fitting.

Slide the temperature support over the inlet tube approximately 6" and tighten the screws. Clamp the BX-596 temperature and pressure sensor assembly to the support.

Place the inlet struts at 90 degrees to one another and secure to the inlet tube with hose clamps. Secure the opposite end of the inlet struts with self-tapping screws into the roof. Caulk around the screws to prevent leaks.

Slide the PM2.5 Sharp Cut Cyclone (SCC), depending on method using, over the inlet tube. Slide the PM10 Head Assembly onto the top of the SCC.

28.6.2.2 Electrical Connections

Connect the Smart Heater Cable to the connector on the back of the BAM, near the top. Connect the pump 2-wire electrical connector to the BAM terminals labeled "Pump Control". Connect the opposite end to the relay terminals on the pump. Polarity does not matter. Connect the vacuum tube to the pump and the hose fitting on the back of the BAM. Plug the pump into the AC Power. Connect the green wire to the BAM Ground. One end is connected to the terminals

marked "Chassis" on the back of the BAM and the other end should be connected to a known good Earth Ground. Connect the cable for the BX-596 Temperature and Pressure Sensor to the back of the BAM. Connect the "Voltage Out" terminals to an external data logger. Connect the BAM power cord to AC power.

28.6.2.3 Loading Filter Tape

Loading the filter tape must be performed before accessing other BAM-1020 functions. Begin by lifting the pinch roller (the pin with the black roller located in the upper front of the BAM) and lock the roller into position with the latch (located immediately to the left of the pinch roller). Remove both clear spool caps by unscrewing the black knobs (bottom left and bottom right spools). Unroll approximately 2 to 3 feet of tape and slide the roll on to the bottom right spool (supply spool) of the BAM. Position the supply spool so that as the tape unwinds on the spool, the roll turns counter clockwise. The tape will 'S' around the two center rollers by feeding around the left supply tension roller located just above and to the left of the supply spool, then around the right side of the right end roller located slightly above and to the right of the tension roller. The tape slides in the slit located between the source and detector, and between the pinch roller and capstan shaft (the thin metal shaft located just below the pinch roller). 'S' the tape around the left side of the of the left end roller (just below the upper left), then tape onto the take-up spool (located bottom left). Wrap the tape approximately 1 ½ times around the take-up spool. The left side tape configuration should mirror the right side. Figure 28-1 displays of diagram of a properly loaded BAM filter tape.

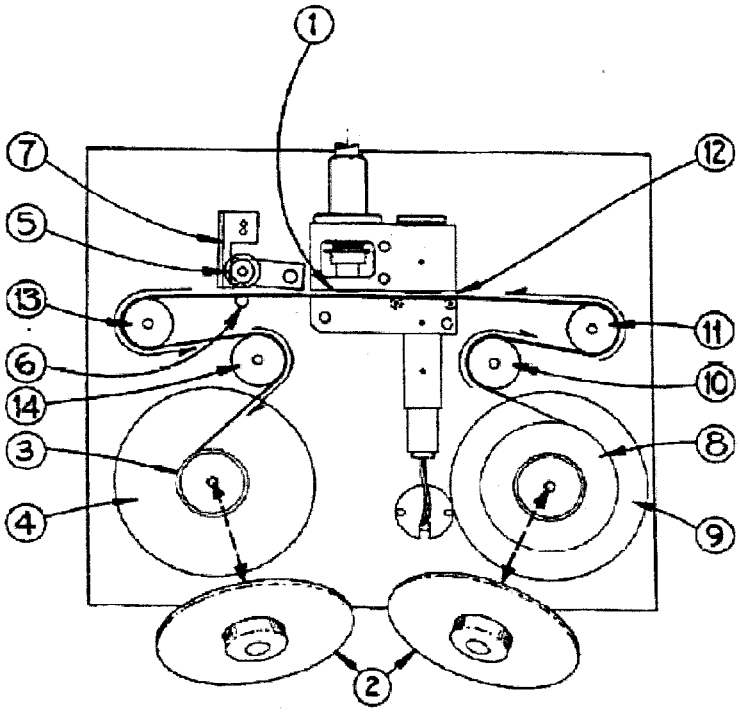
NOTE: The filter tape must be changed once every 60 days under normal operating conditions.

Lift up on the pinch roller (the latch will automatically unlock). Gently lower the pinch roller until it completely touched the filter tape against the capstan roller. Visually check tape for binding, tears or other obvious problems. Wherever the tape comes in contact with the rollers, the entire width of the tape should be on the roller with a little bit of the roller's edge showing. **Note: It is highly recommended to perform a 'Self Test' following the BAM-1020 installation, after routine filter tape change, and following troubleshooting procedures.**

The BAM-1020 'Self Test" is performed using the following procedure:

1. In the BAM main menu, press the TAPE key.
2. Press the SELF TEST key.
3. If all BAM checks pass, the display will read "Status: SELF TEST PASSD". If the display reads "FAILED", repeat procedures for loading the filter tape to remedy the problem. Rerun the SELF TEST.
4. At the completion of the BAM Self Test, press the EXIT key to return to the main menu. The BAM tape is now loaded and adjusted correctly.

Figure 28-1 Diagram of the Proper Filter Tape Loading Procedures



Filter Tape Loading Diagram

28.6.2.4 Agilaire Model 8832 Data Logger Connection

When using the Agilaire Model 8832 data logger, two separate data logger channels are required. One channel is configured as the raw BAM-1020 input and the other is configured for a math averaging function. The Agilaire 8832 contact closure commands are independent of channel configurations. A hard wire connection must be installed for the BAM raw data and the clock contact closure function. No hard wiring is necessary for the math averaging channel.

28.6.2.4.1 Raw Data Channel Connection

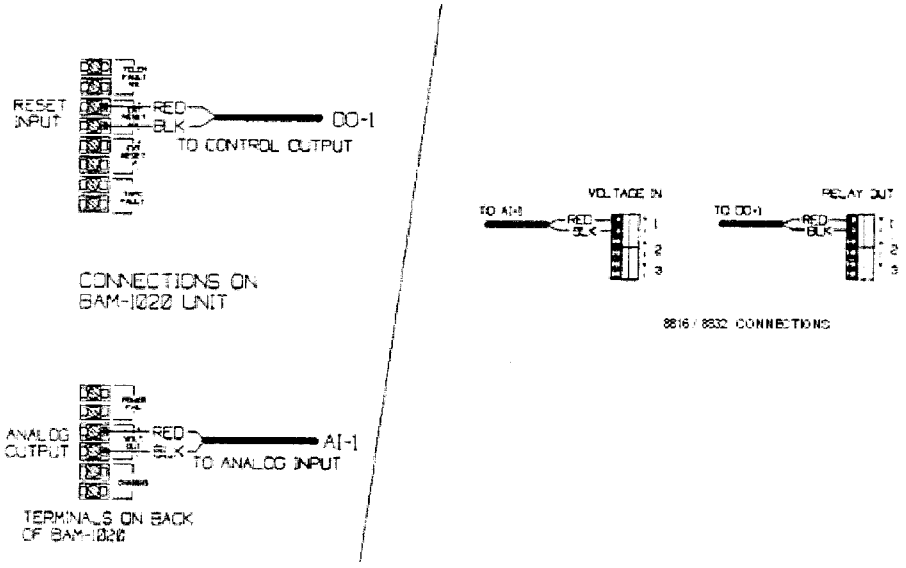
Attach one end of a shielded 2-wire cable (not-supplied) to the (+) and (-) connectors at the rear of the BAM monitor labeled "VOLT OUT". Attach the other end of the (+) and (-) lead to the Agilaire 8832 "Analog In" channel.

28.6.2.4.2 Contact Closure Channel Connection

A contact closure connection is required to sync the BAM monitor clock with the Agilaire 8832 data logger. The importance of syncing the two clocks together is limited to the time frame in which the BAM data is available and the necessity of the data logger collected it before the sampling hour is ended.

Attach one end of a shielded 2-wire cable to the connectors at the rear of the BAM monitor labeled "EXT RESET N.V.". Attach the other end of the 2-wire cable to the "Relay Out" channel on the data logger. Figure 28-2 displays the proper connections between the BAM and the data logger. The input can be set to normally-open or normally-closed in the SETUP > INTERFACE menu. For the Reset Polarity, select NORM for normally-open. The data logger is also set to normally open. The contact closure will close when the clock synchronization signal goes through.

Figure 28-2 Connections from BAM-1020 to Agilaire Model 8832 Data Logger



28.6.2.4.3 Flow Fault Contact Closure

The "flow fault" contact closure (#5) will assign a void flag to data if the flow measured by the BAM deviates excessively from the design flow rate of the size separators (16.7 LPM). The void flag will be assigned to the hour any time the average air flow over the 42 minute sample was outside the low and high limits of 10 and 20 lpm. In addition, the void flag is assigned to the hour any time the flow rate deviates more than 5% from regulation for more than 5 minutes, or is outside +/- 10% for more than one minute.

28.6.2.4.4 Invalid Data Contact Closure

The invalid data contact closure (#6) will be connected to the data logger to invalidate hourly averages whenever a C (beta count too low), P (excessive pressure drop across the

tape), N (nozzle stuck), R (auto-calibration/test membrane can't extend or retract), L (power failure), M (Maintenance), I or U error is generated by the BAM.

28.6.3 Field Set-Up

Each BAM-1020 is calibrated at the factory and therefore has unique calibration settings. The correct settings are located in Appendix B of the Operation Manual.

When configuring or calibrating the BAM, it is important to exit out to the main menu before proceeding to the next parameter. This will ensure that each change has been saved and that the BAM has updated its memory to the new configuration or set point. The BAM is in the main menu when the bottom of the display reads: SETUP, OPERATE, TEST and TAPE.

28.6.3.1 Clock Set

When setting up the BAM-1020, it is crucial that the clock is set to the data logger clock (within 30 seconds). If the clocks are not set to within 30 seconds of each other, then the clock syncing program will not work and the data will be flagged.

To set the clock: Go to SETUP, then to CLOCK and press SELECT. Use the cursor arrows to adjust the date and time, and press SAVE. Press EXIT. Confirm that the correct date and time are displayed in the main menu.

28.6.3.2 Temperature and Pressure Sensor

Check for the proper setup of BX-596 Temperature and Pressure Sensor: Go to SETUP, then to SENSOR. Scroll to Channel 6. Check that MODE is set to AUTO ID. This is changed with the button at the bottom of the screen.

28.6.3.3 Flow Type

Actual flow type is the most accurate flow control mode, and is required for PM2.5 monitoring. The unit always uses actual ambient air temperature and barometric pressure to correct the flow reading, and the flow rate is continuously and automatically adjusted to correct for changes in ambient conditions and filter loading. The flow values will be displayed and stored in actual volumetric conditions. To operate the BAM in actual flow mode, the unit must have a BX-596 ambient temperature and pressure sensor attached to channel 6. Check for proper Flow Type: Go to SETUP, then to CALIBRATE. Check that Flow Type is ACTUAL. Verify that the Concentration Type on the same screen is also ACTUAL, and the flow rate is set to 16.7 LPM.

28.6.3.4 Smart Heater

Check for proper setup of the Smart Heater: Go to SETUP, then to CALIBRATE. Check that the Heater is set to AUTO. Next, go to SETUP, then to HEATER. Check that RH Control is set to YES. For PM2.5 monitoring, set RH set point to 35%. The Smart Heater will be automatically turned on full power whenever the humidity in the sample stream exceeds 35%. When the RH falls back below 35%, the heater turns down to a "low power" heat mode. DATALOG RH and DATALOG DELTA T should both be set to YES so these two parameters will be recorded on channels 4 and 5 on the BAM internal logger. Set DELTA T CONTROL = NO. When the delta T control option is set to no, the value for the delta T set point becomes irrelevant with respect to both heater levels, as well as to when N flags are assigned.

28.6.3.5 Early Cycle Mode

There are two different configurations for the BAM-1020 analog output, "Standard" mode and "Early Cycle" mode. To configure the BAM-1020 so that the data logger will capture data within the correct hour, the BAM-1020 must be configured to the "Early Cycle" mode.

Each measurement cycle begins at the 5 minutes before the top of the hour according to the time on the instrument clock. A cycle contains the following steps. Each cycle begins with an initial count of the clean filter tape. The new spot is positioned between the beta source and the detector, and the BAM begins counting the beta particles through the clean spot for exactly 8 minutes (I_0).

Next, the filter tape is advanced forward, and the sampling begins on the section of tape where I_0 was just measured. The sampling period is defined by the inlet nozzle being lowered down to the surface of the filter paper and the vacuum pump turning on. Air is drawn through the small spot on the filter tape for 42 minutes at 16.7 liters per minutes.

When the sampling period ends, the vacuum pump turns off, the nozzle raises and moves and the filter tape is moved backwards. This puts the spot that was just loaded with particulate back between the beta source and the detector. The BAM begins counting the beta particles through this now dirty spot of tape for exactly 8 minutes (I_3).

Finally, the BAM 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 micrograms per cubic meter of air. The BAM then sits idle and waits a few moments for the remaining time in the hour to expire.

At 5 minutes before the top of the hour, the BAM instantly records the just-calculated concentration value to memory and sets the analog output voltage to represent the previous 42 minute, or current hour's, concentration. The unit advances to a fresh spot of tape and the whole measurement cycle starts over.

To set to EARLY CYCLE: Go to SETUP, then to INTERFACE and press SELECT. Use the cursor arrows to adjust the CYCLE MODE to EARLY. Press SAVE, then press EXIT.

Section 1.6 of the Operators Manual lists the settings that the EPA requires when using the BAM to monitor PM2.5 particulate levels. Verify that the instrument is configured in accordance with this list:

- The COUNT TIME must be set for 8 minutes.
- The SAMPLE TIME must be set for 42 minutes.
- The unit must be equipped with firmware revision 3.2.4 or later.

28.6.3.6 Agilaire Model 8832 Data Logger Configuration

The BAM-1020 can be used with the Agilaire Model 8832 data loggers to collect data at the last 5 minutes of the hour. This allows for the data value from the hour to be in the same hourly average as other data that was collected during that hour. The data logger must be configured to perform this function by using a Standard Average Channel, an Average Math Channel and a Digital Event Program.

Configure the Standard Average Channel (BAM_RAW) with the proper scaling for the tape sample output for volt full scale and engineering units. Configure the Base Averaging Interval for 1 minute. Write the Base Average to Math Constant K1. The value of K1 will update at the end of the Base Averaging Interval with the latest base average value.

Configure the Average Math Channel (BAM_AVG) with the equation K1=. Configure the Average #2 Interval for 1 hour averages and 14 days of storage time (Average #2 Interval, Storage: 1h, 14d 9h). The average math channel only does one averaging calculation at the end of each averaging interval. Since K1 is updated every minute by BAM_RAW.

Configure the Digital Event Program (BAM) to turn on an output relay at 5 minutes before the top of the hour for 5 seconds, and repeat every hour.

The hour averages of BAM_AVG will be the last 1 minute Average from the BAM Sampler.

System Configuration Screen

Logger Date	:	7/1/07
Logger Time	:	12:10:16
Time Zone	:	
Logger ID Code	:	07
Station ID Code	:	
Logger Description	:	Agilaire 8832
Baud Rate – Ext. Modem	:	9600
Baud Rate – Port 1	:	9600
Baud Rate – Port 2	:	N/A
Baud Rate – Port 3	:	N/A
Parallel Port Timeout	:	5s
Automatic Logout Time	:	45m
% For Valid Base Avg	:	100
% For Valid Ext. Avg	:	75
Debounce Digital Inputs?	:	N
Default Dig. Inputs to OR?	:	N
Math Update Rate	:	2
Alarm Deadband (%of limit)	:	0.0
Allow Auto Corr if Config'd?	:	Y

Standard Channel Configuration

Instrument Name	:	BAM_RAW
Analog Input Number	:	01
Report Channel Number	:	01

Volts full scale	:	1
High Input	:	985
Low Input	:	-15
High Output (E.U.s)	:	1
Low Output (E.U.s)	:	0
Units	:	UG/M3
Base Avg. Interval, Storage	:	1m , 1d
Average #1 Interval, Storage	:	15m , 0s
Average #2 Interval Storage	:	1h , 0s
Use 40CFR75 Validation (Y/N)	:	N

Note: To configure the following 'Average Validation Configuration' parameters, move the cursor in the above menu to the line labeled 'Base Avg. Interval, Storage: 1m, 55s, and press 'CTRL V'. This screen must be accessed from the data logger itself. Most of the parameters are set up as defaults in the data logger, and only need to be checked. The Average to Math Constant is what needs to be configured.

Average Validation Configuration

High-High Alarm Limit	(H)	:	1E+10
High Alarm Limit	(h)	:	1E+10
Low Alarm Limit	(I)	:	-1E+10
Low-Low Alarm Limit	(L)	:	-1E+10
High ROC Alarm Limit	(J)	:	1E+10
Low ROC Alarm Limit	(j)	:	1E+10
Floor Limit	(f)	:	-1E+10
Floor Value		:	0
Ceiling Limit	(c)	:	1E+10
Ceiling Value		:	0
Percent for valid Average		:	Default (100)
Average to Math Constant		:	K1

Configuration Channel Options

Name (Not Editable)	:	BAM_RAW
Ch1 Number (Not Editable)	:	01
Decimal Positioner	:	00
Span for Cal Err	:	(not set)
Round Precision	:	(None)

Average Math Channel Configuration

Instrument Name	:	BAM_AVG
Report Channel Number	:	02
Equation	:	K1=
Units	:	UG/M3
Base Avg. Interval, Storage	:	1m , 0s
Average #1 Interval, Storage	:	15m , 0s

Average #2 Interval Storage	:	1h , 14d 9h
Round Constituents: (Y/N)	:	N
Use 40CFR75 OOC (Y/N)	:	N

Configuration Channel Options

Name (Not Editable)	:	BAM_AVG
Ch1 Number (Not Editable)	:	02
Decimal Positioner	:	00
Span for Cal Err	:	(not set)
Round Precision	:	(None)

Configuration Digital Event Program

Dig. Event Program Name	:	BAM
Starting Time	:	07/01/07 11:55:00 (For Early Cycle Mode)
Repeat Interval	:	1h
Output Line(s)	:	1,
Output Duration	:	5s
Disable During Cal(s)	:	(none)

28.7 Standards

28.7.1 Transfer Standards

Transfer standards are used to calibrate the station "field" samplers and to perform verifications. Instruments designated as transfer standards are used so the primary standard can remain at a fixed laboratory location where conditions can be carefully controlled and damage to the instrument minimized. Transfer standards are calibrated against the higher-level, primary standards. All transfer standards must be accompanied by the following:

- The manufacturer's manuals for the instruments
- A logbook including a complete chronological record of all certification and recertification data as well as all sampler calibrations carried out with the transfer standard
- A complete listing and description of all equipment, materials, and supplies necessary or incidental to the use of the transfer standard
- A complete and detailed operational procedure for using the transfer standard, including all operational steps, specifications and quality control checks

28.7.2 Audit Standards

Audit standards are used to challenge the station "field" sampler and to perform accuracy checks on a quarterly basis. Audit standards are calibrated against the higher-level, primary standards. All audit standards must be accompanied by the following:

- The manufacturer's manuals for the instruments
- A logbook including a complete chronological record of all certification and recertification data as well as all sampler calibrations carried out with the audit standard
- A complete listing and description of all equipment, materials, and supplies necessary or incidental to the use of the audit standard

- A complete and detailed operational procedure for using the audit standard, including all operational steps, specifications and quality control checks

28.7.3 Qualification, Certifications and Recertification

Qualification consists of demonstrating that the transfer and audit standards are sufficiently stable (repeatable) to be useful as a transfer standard. Repeatability is necessary over a range of variables such as temperature, line voltage, barometric pressure, elapsed time, operator adjustments, or other conditions, any of which may be encountered during use of the transfer standard. After a transfer and audit standard has been shown to meet the qualification requirements, certification is required before it can be used.

28.8 Quality Control

28.8.1 Analog Output Test

The DAC screen is used to test the function of the analog concentration output voltage and the digital-to-analog-converter (DAC) electronics. On the BAM-1020, go to TEST then to DAC, and press SELECT. With the up and down arrow keys, select 0 to 10 volts in 1 volt increments. Measure the VOLT OUT +/- terminals on the back of the BAM with a highly qualified volt meter and verify that the voltage matches the BAM display within 0.002 volts across the full scale. Then attach the voltmeter to the input of your data logger and repeat the test to verify the correct voltages get to the input. If the analog output does not match the value on the DAC screen, contact the Service Department for instructions.

28.8.2 Field Zero Background Calibration

The Background value is a correction offset for the concentration data collected by the BAM-1020. This value is factory calibrated for each unit under laboratory conditions. The BAM units set up for running PM2.5 need to have this value field verified (and adjusted if necessary) prior to first use and then every 6 months using the BX-302 Zero Filter Calibration Kit. This test corrects the BKGD value to compensate for minor variations caused by local conditions such as grounding and shelter characteristics.

Note: Always perform a leak check before and after changing the Background value. Leaks at the nozzle will appear as a background problem. Also, inspect for debris around the nozzle that could cause the nozzle to rest higher than it should when in the down position.

28.8.2.1 Leak Check Procedure

Remove the PM10 head assembly and the PM2.5 SCC from the inlet tube and install BX-302 leak test valve onto the inlet tube. Turn the valve to the OFF position to prevent any air from entering the inlet tube.

Go to TEST then to TAPE and press SELECT. Advance the tape to a fresh, unused spot.

Go to TEST then to PUMP and press SELECT. Turn on the pump. The flow rate should drop below 1.0 LPM. If the leak value is greater then 1.0 LPM, then the nozzle and vane may need cleaning, or there may be another leak in the system. If the leak check is less then 0.5 LPM, proceed with the Background Value Calibration.

28.8.2.2 Background Zero Calibration

When setting the Background Value, run the BAM-1020 for a minimum of 72 hours with the BX-302 installed.
Remove the PM10 head assembly and the PM2.5 SCC from the inlet tube and install the BX-302 leak test valve onto the inlet tube. All zero air tests are done using filtered outdoor air. Make sure that the valve is fully open so that the unit is pulling sample air through the inline HEPA filter at the top of the tool. To prevent water from getting into the HEPA filter, a rain hood has been built for use with the HEPA Filter.

The Smart Heater should be installed and configured in the same way as it would during normal operation. If the monitor has been shut off, allow it to warm up for 24 hours prior to the start of the 72 hour period. During routine monitoring, and especially during the background zero calibrations, the OFFSET value should be set to less than zero, so a valid zero average can be obtained from measurements that include negative values. If the OFFSET value is -15 ug/m3, the operator should make sure the e1 in the EXTRA1 screen is also set to -15 ug/m3. e1 is a clamp which sets the lowest value stored or displayed regardless of the measured value.

Go to the CALIB screen and change BKGD to 0.000.

After the 72 hours of sampling is finished, ignore the first 4 hours after the BAM starts gathering data. The average concentration for the 68-hour period varies from unit to unit, and typically will be a number between -3 and 1 $\mu g/m^3$. Throw out any values of 985. Outliers should be investigated, but not excluded from the calculations unless it can be shown that they arise from conditions that will not occur during routine sampling. A statistical analysis should be done on the zero test data to determine if it is acceptable. Download hourly averages for the zero test period from the internal memory of the BAM. Calculate average to four decimal places. Compare the new zero value to the factory zero. The values should be within a couple of micrograms. The standard deviation should be calculated to four decimal places. This value varies from unit to unit but should be less than 2.4 micrograms.

If these criteria are not met, the operator will troubleshoot the instrument until a zero test is completed with acceptable results. If these criteria are met, average the 68-hour period, multiply by negative 1, and set the result as the BKGD. Enter the new BKGD number into the CALIB screen, press SAVE and then EXIT.

For further instructions, see Met One Instruments BX-302 Zero Filter Calibration Kit Manual.

Following the Background Zero Calibration, follow section 28.8.2.1 to repeat a leak check.

28.9 Equipment, Maintenance and Trouble Isolation

There are several routine duties that must be performed each time an air monitoring station is inspected. These duties include equipment inspection, performing calibrations, assisting during audits, documentation, and making necessary adjustments or repairs to the instruments.

28.9.1 The Monitoring Station

It is the operator's responsibility to maintain the monitoring station. Routine maintenance includes keeping site clean and being observant of potential problems. Examples of potential problems include:

- Accumulation of dirt and debris
- Infestation by rodents or insects
- Overgrowth of vegetation around the site

28.9.2 Preventative Maintenance

Each instrument must be periodically examined and serviced to anticipate and prevent instrument failure. Scheduled maintenance on the instruments will prevent costly repairs and loss of data. The routine maintenance required on the samplers by the station operator is minimal and is outlined in the manufacturer's manual. By keeping track of the instruments' responses from week to week, trends can be observed which would alert the operator of a potential problem, and to correct the situation before the instrument fails. Some minor but critical maintenance procedures are as follows:

28.9.2.1 Field BKGD Zero Tests

BAM-1020 units set up to monitor PM2.5 need to have the Background value field verified every 6 months using the BX-302 Zero Filter Calibration Kit. This test corrects the BKGD value to compensate for minor variations caused by local conditions. The test involves running the BAM in its normal operating environment with a zero filter on the inlet for at least 72 hours. The new BKGD will then be calculated and entered into the BAM. This test should not be performed during a period of rapidly changing weather. See Section 28.8.2.2 of this SOP for specific instructions.

28.9.2.2 Nozzle Component Replacement

The nozzle components need periodic inspection, cleaning and replacement. The nozzle o-ring will need to be replaced every year to prevent the nozzle from starting to stick. The nozzle itself may need to be replaced if it becomes worn or damaged, and should be removed and thoroughly cleaned annually. A BX-308 service tool kit is required for nozzle re-assembly. See Section 28.13.5 of this SOP for nozzle cleaning instructions.

28.9.2.3 Beta Detector Count Rate Test

The Beta Detector Count Rate Test should be performed once per year or as needed. The TEST > COUNT screen allows the user to check the function of the beta detector and beta source separate from the rest of the mechanical or flow operations. Each count test will take 4 minutes, and will show the number of beta particles counted as they accumulate. The final count value will stay on the display after the counting is finished, and up to 6 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. Typical 4-minute count values are between 600,000 and 1,000,000 counts through clean filter tape. If the count total is less than 500,000, then the beta detector is probably burning out. For further instructions, see Section 7.9 of Met One Instruments, Inc. BAM-1020 Particulate Monitor Operation Manual.

28.9.2.4 Filter Temperature Sensor

The filter temperature sensor needs to be calibrated once every 6 months or as needed. The TEST > Filter-T screen is used to calibrate the filter temperature sensor located in the air stream beneath the filter tape. When the screen is entered, the BAM will automatically raise the nozzle and turn the pump on. This allows ambient room air to equilibrate the filter temperature sensor without the heating effects of the Smart Heater. Allow the pump to run for at least 5 minutes to allow the sensor to equilibrate. Enter the ambient room temperature from your reference

standard into the REFERENCE field and press CALIBRATE. The BAM reading should change to match within +/- 1 °C. The RESET key can be used to revert to default factory calibrations and start over.

28.9.2.5 Filter Humidity Sensor

The filter humidity sensor needs to be calibrated once every 6 months or as needed. **NOTE: The RH sensor must be allowed to fully equilibrate to ambient conditions prior to calibration. Otherwise, a large positive offset will be introduced so that the BAM Filter RH values will always be too high.**

28.9.2.5.1 Equilibrate the RH Sensor

Enter the TEST > FILTER RH screen. The BAM will raise the nozzle and turn the pump on to pull room air past the RH sensor. Unplug the Smart Inlet Heater and allow the BAM to cool completely to ambient conditions. Wait at least an hour before proceeding with calibration procedures.

28.9.2.5.2 Calibrate the RH Sensor

The TEST > FILTER RH screen is used to calibrate the filter relative humidity sensor located in the air stream beneath the filter tape. Remove the case cover from the BAM-1020. Remove the filter RH sensor by unplugging it from its compression fitting. Leave the harness from the sensor plugged into the circuit board so that the sensor continues to function. Place the RH sensor and the RH reference standard in a baggie. Allow the sensor and reference standard to equilibrate for at least five minutes. Enter the ambient room relative humidity from your reference standard into the REFERENCE field and press CALIBRATE. The BAM reading should change to match within +/- 4% RH. The RESET key can be used to revert to default factory calibrations and start over.

NOTE: The RH sensor is sensitive to damage from static discharge and contamination from oils. Never touch the element on the end of the RH Sensor.

28.9.2.6 Pump

It is recommended that pumps be tested every 6 months, and rebuilt or replaced once every 2 years. Pumps may be rebuilt, but should be replaced after several rebuilds.

The pump muffler should be cleaned or replaced once every 6 months.

28.9.3 Trouble Isolation

The instruments in Polk County Air Quality's air monitoring network are very reliable. However, after a period of continuous use problems may occur. Leaks in the system, dirt build up and pump failure are typical. After time, the operator should be able to quickly distinguish the symptoms and causes of equipment failure.

It is suggested that each station operator consult the **Met One Instruments Operator's Manual** and compile personal notes on troubleshooting as they gain experience with the BAM-1020. The operator is encouraged to contact the manufacturer when attempting any repairs.

The manufacturer's manual is the best resource the station operator has for the information on the operation and maintenance of the BAM-1020.

28.10 Quality Assurance (Accuracy-Audits)

Each of the operating BAM-1020 samplers will be audited once during each calendar quarter by the designated Quality Assurance Officer utilizing the procedures and calculations specified in 40 CFR 58, Appendix A, "Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS)."

Perform audits as described by procedures outlined in Section 28.13.3.2, Temperature, Pressure and Flow Verifications, of this SOP. Table 28-1 below outlines the activities to be audited and their acceptable criteria. All steps are to be recorded on the "Audit Field Sheet" Form 1, Appendix A.

Audits should be conducted in the same way as the routine verifications performed once every fourteen days, with the following exceptions:

- Audits must be done using standards that are not used for routine calibrations and checks, and should be done by someone other than the routine operator. For example, a special BIOS Dry-Cal/BGI Tetra Cal are used for flow audits.
- The acceptance criteria for audits are listed in the Operational Evaluations section of the Redbook MQO tables and below in Table 28-1. However data should not be invalidated based on audit results alone. An investigation initiated by audit results that are outside the limits of relevant acceptance criteria, may point to other factors which require data invalidation.
- Flow audit results are uploaded to AQS. The flows that are uploaded to AQS are observed with the BIOS Dry-Cal or BGI Tetra Cal and its adapter in place. The actual flow is obtained from the audit standard. The indicated flow corresponds to the samplers own internal flow measurement device.

Table 28-1 Audit Activities and Acceptance Criteria

Activity	Acceptance Criteria
One Point Flow Rate Audit	± 4% of the Audit Standard
Ambient Temperature Sensor Audit	± 2°C of Standard
Ambient Pressure Sensor Audit	± 10 mm Hg
External Leak Audit	< 1.0 LPM

28.11 Data Quality Assessment

For each calendar quarter and year, Polk County Air Quality will prepare data precision, accuracy and completeness reports for the Iowa Department of Natural Resources (Iowa DNR) and EPA-Region 7 in accordance with the current Letter of Agreement (LOA).

28.11.1 Precision

The precision for the BAM-1020 PM2.5 will be evaluated and reported employing the frequencies, procedures and calculations outlined in the Code of Federal Regulations and current EPA guidance documents.

28.11.2 Accuracy

The accuracy will be evaluated and reported for the BAM-1020 PM2.5 using results from the performance audits and the calculations outlined in the Code of Federal Regulations and current EPA guidance documents.

28.11.3 Data Completeness

The completeness of the data will be determined for each monitoring instrument and expressed as a percentage. Percent valid data will be a gauge of the amount of valid data obtained from the monitoring instrument, compared to the amount expected under ideal conditions, or which were discontinued prior to the end of any reporting period for calculation purposes.

28.12 Calibrations-Temperature, Pressure and Flow

Prior to performing a calibration or any maintenance procedures, "as found" conditions need to be determined and recorded for: leak check, flow, temperature and pressure.

See Section 28.8.2.1 to determine the "as found" leak check rate.

If any maintenance is performed, another leak check must be performed prior to calibration procedures, see Section 28.8.2.1.

To proceed with the calibration, on the BAM-1020, go to TEST then to FLOW and press SELECT. The nozzle will lower automatically when this screen is entered. The "BAM" column is what the BAM measures for each parameter, and the "STD" column is where the correct values from a reference standard will be entered. The <CAL> symbol will appear next to the parameter selected for calibration. The ambient temperature (AT) and barometric pressure (BP) must be calibrated first, as the BAM uses these parameters to calculate the air flow rate in actual mode.

Measure the ambient temperature with the reference standard positioned near the BX-596 ambient temperature and pressure probe. Use the arrow keys to enter the value from the reference standard into the STD field. Press the CAL key to correct the BAM reading. The BAM and STD values should now be the same.
Press the NEXT key to move the <CAL> indicator to the BP field. Measure the barometric pressure with the reference standard positioned near the BX-596 ambient temperature and pressure probe. Use the arrow keys to enter the value from the reference standard into the STD field. Press the CAL key to correct the BAM reading. The BAM and STD values should now be the same.

After the temperature and pressure readings are correct, remove the PM10 head assembly and the PM2.5 SCC, and install the BIOS or BGI reference flow meter onto the inlet. Press the NEXT key to move the <CAL> indicator to the first flow point of 15.0 LPM. The pump will turn on automatically. Allow the unit to regulate the flow until the BAM reading stabilizes at the target flow rate. Use the arrow keys to enter the flow value from the standard into the STD field. Press the CAL key to correct the BAM reading. **NOTE: The BAM reading will not change to match the STD until all 3 calibration points have been entered.**

Press the NEXT key to move the <CAL> indicator to the second flow point of 18.4 LPM and repeat the process. Press the NEXT key to move the <CAL> indicator to the second flow point of 16.7 LPM and repeat the process again. When all of the calibrations are complete, the BAM reading for the 16.7 LPM flow point should match the STD reading at +/- 0.1 LPM. All steps are to be recorded on the "Calibration Field Sheet" Form 2, Appendix A

Note: The DEFAULT key can be pressed to reset the user calibration for the selected parameter and replace it with a factory setting at any time.

Exit the calibration menu. The BAM-1020 is now ready to start sampling.

NOTE: To start sampling, return to the main menu. In most cases the BAM will typically start sampling at the beginning of the next measurement cycle.

28.13 Sampler Operations

This section describes the routine field operations for the Met One Instruments BAM-1020. Routine operations are defined as those performed on a monthly, or more frequent, basis.

28.13.1 Quality Control

28.13.1.1 Leak Check

Perform a leak check at least once every 14 days or as needed. There is a 1.0 LPM leak flow allowance due to the factory test conditions. With the inlet shut off, the vacuum in the system is very high, about 21 inHg. This is 10 times greater than what the BAM will encounter during normal sampling. If the flow reading during this test is 1.0 LPM or less, there will not be a significant leak during normal operation. A leak check value between 0.7 – 1.0 LPM still passes, but indicates the potential of a leak check failure in the near future. If an as-found leak value shows a flow between 1.0 – 1.5 LPM, this may result in the invalidation of data back to the last successful leak check. If an as-found leak value is measured at greater than 1.5 LPM, data will be invalidated back to the last successful leak check.

28.13.1.2 Temperature Check

Perform a temperature verification at least once every 14 days or as needed. Sampler measured (current) temperature must be within $\pm 2°C$ of the temperature measured by an external transfer standard. Failure to meet the $\pm 2°C$ criteria may result in the invalidation of data back to the last successful temperature verification.

28.13.1.3 Pressure Check

Perform an ambient pressure verification at least once every 14 days or as needed. Current ambient pressure must be within ± 10 mmHg of actual ambient pressure. Failure to meet this criteria may result in the invalidation of data back to the last successful pressure verification.

Converting inHg to mmHg: inHg x 25.4 = mmHg

28.13.1.4 Flow Check

Perform flow rate verification at least once every 14 days or as needed. A 1-point flow verification is subjected to the following 3 checks:

- Percent difference from "Current":
  [(Current-Actual)/Actual] x 100 < $\pm 4\%$

- Percent difference from sampler set flow:
  [(Set Flow (16.70) -Actual)/16.7] x 100 < ±5%

- Percent difference between sampler set flow and current flow:
  [(Set Flow (16.70) -Current)/16.7] x 100 < ±2%

Failure to meet any of these criteria will result in the invalidation of data back to the last successful flow verification.

28.13.1.5 Maintenance

See Chapter 7 in the BAM 1020 Particulate Monitor Operation Manual, BAM-1020-9800 Rev J. Met One Instruments, Inc. 2008.

Table 28-2 summarizes the calibration, verification and maintenance frequencies.

Table 28-2 Verification, Calibration and Maintenance Check Intervals

Activity	Frequency	Acceptance Criteria
Temperature verification	14 days from previous check	± 2°C of Standard
Temperature Calibration	As needed or at least 1/month	± 2°C of Standard
Pressure Verification	14 days from previous check	± 10 mm Hg
Pressure Calibration	As needed or at least 1/month	± 10 mm Hg
Leak Check	14 days from previous check	<1.0 LPM
Background Zero Leak Check	As needed or at least 1/6 months	
Cleaning of SCC	1/4 Weeks	
Disassemble, Inspect and Clean PM10 Inlet	1/4 Weeks	
Clean and empty water collection jar	As needed or at least every 14 days	
Clean Nozzle and Vane	1/4 Weeks	
Replace Filter Tape	As needed or at least 1/60 days	

28.13.2 Procedures

New station operators will be provided with on-site training by an experienced operator before they operate a station on their own. The following procedures are intended to assist the operator in performing and documenting monitoring procedures. Monitoring personnel must become familiar with the Met One Instruments BAM-1020 Particulate Monitor Operation Manual.

Included are the steps involved in bi-weekly verifications. The following materials are required:

- BAM-1020 central unit
- Vacuum pump
- Inlet tubing
- PM10 FRM inlet (BX-802)
- PM2.5 Sharp Cut Cyclone (SCC) inlet

- Smart Heater (BX-830)
- Filter tape
- Outside temperature and pressure sensor (BX-596)
- Leak Check filter (BX-302)
- NIST traceable flow meter (flow standard)
- NIST traceable barometer (pressure standard)
- NIST traceable thermometer (temperature standard)
- Agilaire Model 8832 data logger
- Lap top computer with HyperTerminal software installed for data acquisition
- 9 to 9 pin RS-232 cable
- Field sheets
- Station logbook
- Isopropyl Alcohol
- Cotton swabs
- Small flashlight

28.13.3Bi-weekly Verifications
At a minimum, perform verifications and leak checks at the frequency listed in the Quality Control Section 28.13.1 of this SOP.

28.13.3.1 Temperature, Pressure and Flow Verifications
It is important that you do not interrupt the sample flow until after you have performed the as-found flow check. Therefore the flow verification **MUST** precede a leak check.

On the BAM, press the down arrow on the front of the unit. This screen will display the current Flow Statistics. Press the down arrow button until ambient temperature (AT) and barometric pressure (BP) are displayed on the screen.

Measure the ambient temperature with the reference standard positioned near the BX-596 ambient temperature and pressure probe. Compare the BAM-1020 temperature value listed next to the "AT" column to reference standard.

Measure the barometric pressure with the reference standard positioned near the BX-596 ambient temperature and pressure probe. Compare the BAM-1020 pressure value listed next to the "BP" column to reference standard.

After the temperature and pressure readings are obtain, remove the PM10 head assembly and the PM2.5 SCC from the inlet tube and install the BIOS or BGI reference flow meter onto the inlet. Press the up arrow key to until FLOW RATE is displayed on the Flow Statistics screen. Compare the BAM-1020 flow value displayed for FLOW RATE to reference standard. All steps are to be recorded on the "Verification Field Sheet" Form 3, Appendix A

Flow verification results are uploaded to AQS. The flows that are uploaded to AQS are observed with the BIOS Dry-Cal or BGI Tetra Cal and its adapter in place. The actual flow is obtained

from the transfer standard. The indicated flow corresponds to the samplers own internal flow measurement device.

Note: If a problem is recognized while performing any maintenance, diagnostic, external, or internal checks which has or could affect data a corrective action form is to be filled out describing the problem identified and the action taken to correct the problem. All information should be recorded on a "Corrective Action Form" Form 4, Appendix A.

28.13.3.2 Leak Checks

Go to TEST then to TAPE and press SELECT. Advance the tape to a fresh, unused spot.

Go to TEST then to PUMP and press SELECT. Turn on the pump. The flow rate should drop below 1.0 LPM. If the leak check is less then 1.0 LPM, the leak check has passed.

Remove the PM10 head assembly and the PM2.5 SCC from the inlet tube and install BX-302 leak test valve onto the inlet tube. Turn the valve to the OFF position to prevent any air from entering the inlet tube.

If the leak value is greater then 1.0 LPM, then the nozzle and vane may need cleaning, or there may be another leak in the system. If the source of the leak is not obvious, remove the tape and use the rubber nozzle seal (part #7440) to isolate the cause of the leak, see Section 5.4 of the Operator's Manual. The side with the hole can be used to check the airflow pathway between the pump and the leak check valve, while eliminating leakage due to the tape. The solid side will check only the portion below the support vane. Following these procedures, a calibration must be performed, see Section 28.12.

28.13.3.3 Clock Verification

Compare the date and time of the BAM-1020 clock display to the data logger date and time display. If either the date or time of the BAM-1020 does not agree with the data logger, correct the BAM-1020 to match the data logger. If the BAM-1020 clock drifts significantly from the data logger, the data will become flagged with and E for External Reset Failure. The absence of this flag does not necessarily guarantee that the clock synchronization is occurring, since this flag is generated when a clock synchronization pulse arrives at the wrong time. Clock drift indicates a problem may exist with the contact closure relay configuration. If the clocks disagree by more than 30 seconds, troubleshoot the contact closure hardwiring and configuration that controls the clock synchronization signals. Diagnose and correct.

28.13.4 Monthly Maintenance Procedures

28.13.4.1 Maintenance of the Sharp Cut Cyclone (SCC)

Figure 28-3 is a schematic drawing showing the Sharp Cut Cyclone (SCC). The SCC is designed and manufactured by BGI Incorporated. Recommended cleaning materials include mineral free water and lint free lab wipes.

To Disassemble a BGI SCC: remove the SCC from its installed position in the instrument. Pull off the side transfer tube. If it is too tight to remove by hand, pry it off with a rigid plastic

lever. Care should be taken to not damage the two "O" ring seals. Remove the top cap and grit pot by unscrewing. Wet a lint free wipe with water and remove all visible deposits. These are most likely to be found at the bottom of the cone and inside the grit pot. Inspect all "O" rings for shape and integrity. If at all suspect, replace. Lubricate all "O" rings with light grease. It is important to well lubricate the transfer tube to avoid difficult disassembly. Assemble in reverse order and reinstall. Perform a leak check according to manufacturers operating manual specifications.

28.13.4.2 Maintenance of the PM10 Head Assembly

Figure 28.4 is a schematic drawing showing the PM10 head assembly. The inlet is designed to remove particles with aerodynamic diameter greater than 10 μm and to send the remaining smaller particles to the next stage. The design flow rate through the inlet is 16.7 liters per minute.

28.13.4.2.1 Maintenance of the Top Acceleration Assembly

Mark the top plate deflector cone and lower plate with a pencil scribe to facilitate proper orientation for easier reassembly after cleaning and maintenance. Using a Phillips blade screwdriver, remove the four pan head screws from the top of the top plate, and lift the top plate off the four threaded spacer standoffs and set aside. Inspect the insect screen for contamination and clean by lifting the screen off the lower plate rain deflector and brush or rinse with water until clean. Dry and reinstall. Using a general purpose cleaner and paper towel, clean the top plate deflector cone and internal wall surface of the acceleration assembly. Be sure that after cleaning is complete, the acceleration nozzle is clean. If not, use a cotton swab and cleaner to remove contamination. Inspect the large diameter impactor nozzle O-ring for wear. Replace if necessary, or using a light coating of silicone grease, apply a thin film on the O-ring itself; and likewise a small light coating on the aluminum threads of the acceleration assembly. After reinstalling the bug screen, align the top plate markings with the lower plate markings. The four holes in the top plate should align with the four spacer standoffs. Insert and tighten securely the four pan head screws.

Figure 28-3: Schematic Drawing of the Air Flow through a Sharp Cut Cyclone

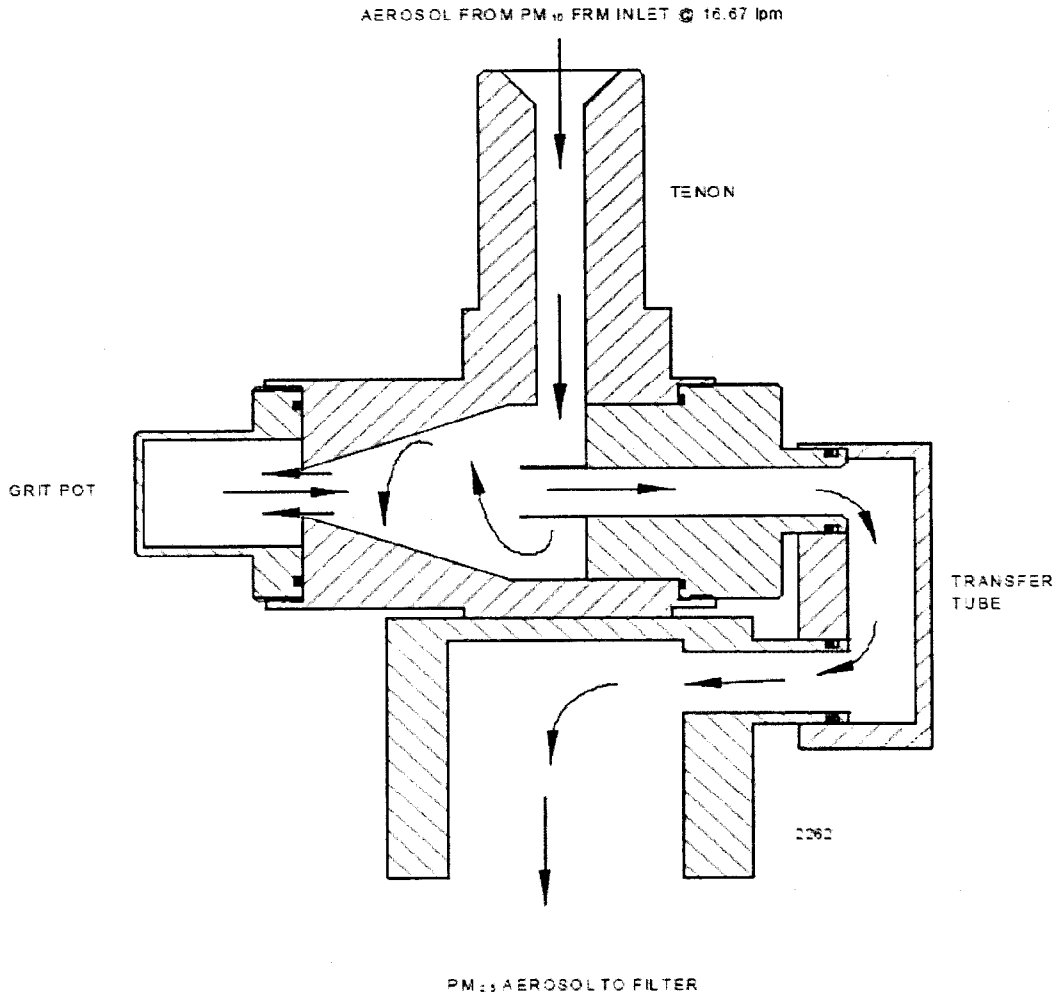
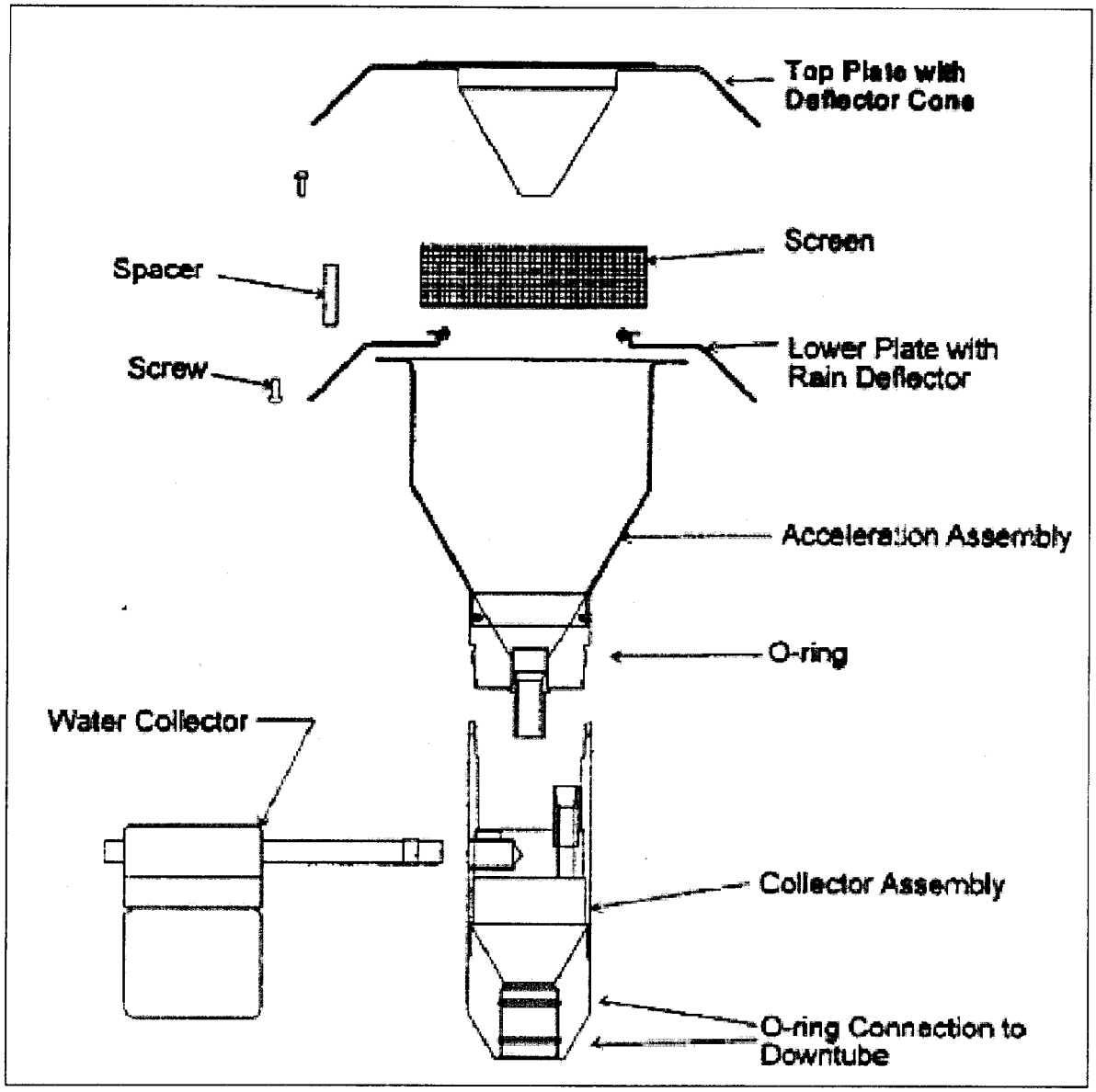


Figure 28-4: Exploded Cross-Sectional View of PM10 Head Assembly



28.13.4.2.2 Maintenance of the Lower Collector Assembly

It is on the collector plate that most of the contamination in the inlet is found. The threads should be cleaned to facilitate a tight seal when the two halves are reassembled. Follow the steps below to clean the lower collector assembly:

Using a general purpose cleaner with a paper towel, clean the collector assembly walls and the three vent tubes. A cotton swab may be necessary to clean these vent tubes. Likewise, clean the bottom side of the collector assembly. Using a cotton swab, also clean the weep hole in the collector plate where the moisture runs out to the moisture

trap. Remove the water collection jar and clean. The water collection jar should be cleaned and emptied out every 14 days. Inspect the brass nipple fitting to ensure tightness and non-blockage. When reinstalling the rain jar, place a light coating of silicone grease on the gasket inside the cap of the rain jar. This will ensure a leak-free fit. Inspect the two inlet-to-inlet tube sealing O-rings for wear. Replace if necessary. Use a light coating of silicone grease on these O-rings to ensure that a seal is made when reinstalled on the 1 ¼" OD sampler tube.

28.13.4.2.3 Reassemble and Reinstallation of Inlet

Reassemble the top and bottom inlet assemblies until the threads tighten. Hand-tighten only. Carefully place the inlet back on top of the 1 ¼" OD sample tube. Take care not to damage the internal O-rings. The performance verification and maintenance is now complete. Replace the PM10 1st stage inlet on top of the SCC on the sample tube by pressing down until it hits a stop.

28.13.5 Maintenance of the Nozzle and Vane

Over time, filter fibers from the tape will accumulate on the nozzle and vane, creating air leaks or even punching small holes in the filter tape. This will cause measurement errors. The nozzle and vane must be cleaned at a minimum of once every 4 weeks as a preventative measure.

On the BAM-1020 go to the TEST menu and select PUMP. Raise the nozzle and remove the filter tape from the nozzle area. It is not necessary to completely remove the tape from the unit. With the nozzle up, use a small flashlight to inspect the cross-hair vane. Clean the vane with a cotton-tipped applicator and isopropyl alcohol. Hardened deposits may have to be carefully scraped off with a dental pick. Then lower the nozzle.

Manually lift the nozzle with your finger and insert another cotton swab with alcohol between the nozzle and the vane. Let the nozzle press down onto the swab with its spring pressure. Use your fingers to rotate the nozzle while keeping the swab in place. A few rotations should clean the nozzle lip. Repeat the nozzle cleaning until the swabs come out clean. Inspect the nozzle lip and vane for any burrs which may cause leaks to tape damage.

Reinsert the filter tape. Run a "Self Test" as described in Section 28.6.2.3 of this SOP to make sure the filter tape was installed correctly.

28.14 Retrieving BAM-1020 Internal Data

A desktop or laptop computer is an important tool when verifying proper data logger acquisition and trouble shooting. Error codes, current BAM-1020 configurations and data can be observed and downloaded using the Microsoft Windows Hyperterminal software program. Nearly all PCs running Microsoft Windows 95 or later operating systems have the HyperTerminal program included. This section describes how to set up this program for communication with the BAM-1020.

Connect the RS-232 port on the back of the BAM-1020 to a computer or laptop using the appropriate cable. Connect to the REPORT serial port on the back of the BAM.

Open HyperTerminal. (Usually located in the Program\Accessories\Communications directory). The program will ask you to type a name for the connection. Type "BAM-1020", then click "OK". The "Connect To"

window will open. Select COM1 (or another port if used) from the drop-down menu in the "Connect using:" field. Click "OK". **Note:** A program to dial BAM through a modem could also be set up in this window.

The "COM1 Properties" window will open. Set the following values in the drop-down menus, then click "Apply" and "OK".

Bits per second:	9600
Data Bits:	8
Parity:	None
Stop Bits:	1
Flow Control:	None

The main HyperTerminal connection window should now be open. Press the ENTER key a couple of times. The window should respond with an asterisk (*) indicating that the program has established communication with the BAM-1020.

Once communication is established, press the "**h**" key. This should cause the BAM-1020 System Menu to appear on the window. The following menu options will appear:

1. **Display Current Data**-This file will include the current day's data only
2. **Display All Data**-This file will download all the data stored in the BAM-1020 memory
3. **Display New Data**-This fill will contain all of the data stored by the BAM-1020 since the last time the data was downloaded.
4. **Display System Configuration**-This file will contain a list of most of the BAM-1020 settings and calibration values.
5. **Display Date/Time**-This file will show the date, time and serial number of the BAM-1020.
6. **CSV Type Report**-This command will give you 3 Comma-Separated-Value options.
7. **Display Last 100 Errors**-This file will contain the date, time and a description of each of the last 100 errors logged by the BAM-1020.
8. **Display>Bam-1020<Utility Commands**-This file contains a list of the ASCII commands that can be sent to the BAM-1020 through the serial port to configure certain parameters or to perform advanced diagnostics.

The HyperTerminal will only display 100 lines of data in the window. To capture larger files (such as all data), first select Transfer > Capture Text from the drop-down menu. Select a location for the file, then click the "Start" button. Retrieve the desired files, and HyperTerminal will automatically store them to the text file.

When exiting HyperTerminal, it will ask if you want to save your connection. Click "Yes" and a file name BAM-1020.ht will be created in the HyperTerminal folder, which will have all of the setting saved. Use this for future communications with the BAM.

28.15 Data Processing and Validation

28.15.1 Qtot Validation Criteria

The PM2.5 concentration is calculated, external to the BAM-1020, as a 24 hour daily average of the hourly concentration measurements made by the BAM-1020. At least 18 of the 24 data points must be valid with no error flags in order to calculate a daily average.

Qtot Validation Criteria: The 'Qtot' value recorded in the BAM-1020 data logger is the average hourly volume measured during each sample. Forty-two minutes of a 16.67 LPM flow equals 0.700 m^3:

$$\frac{(42 \text{ minutes})(16.67 \text{ liters})(\ 1m^3\ )}{(1 \text{ minute})(1000 \text{ liters})} = 0.700 \text{ } m^3$$

Therefore, the ideal hourly 'Qtot' value will be recorded as 0.700 m^3. This Qtot is an indication that the BAM-1020 flow was operating at the 16.7 LPM set point and stable throughout the sampling period. The 'Qtot' value is an important validation criteria data point for each hourly average mass value. **The 'Qtot' validation criterion is ± 0.42% of 0.700 m^3 (or 0.697 – 0.703m^3).**

28.15.2 AIRNow Data Validation

Real-time BAM hourly concentrations will be transferred to EPA's AIRNow website http://www.epa.gov/airnow/.

The digital data capture from AirVision will be used for AIRNow Reporting. AirVision takes the hourly digital data directly out of the BAM, so there is no need to validate this data(except on a monthly basis). Please refer to SOP 18 AirVision for more information on the setup of this data capture.

However the back-up polling system uses the average math channel to upload data to AIRNow reporting.

To ensure the accuracy of AIRNow reports, monthly hourly averages downloaded from the BAM will be compared against the corresponding hourly averages from the average math channel of the data logger. The BAM is configured to the Early Cycle mode, which allows for the data value to be reported in the same hour it was collected on the data logger. However, the BAM-1020 will actually store that value in the next hour. For example, the BAM-1020 hourly average with a time stamp of 3:00 will be compared against the hourly average with a time stamp of 2:00. Differences in and BAM-1020 data logger values should consistently read no more than 1.0 ug/m^3 from each other. If larger differences are observed, perform and analog output test (see Section 28.8.1) to check the digital to analog conversion electronics on the BAM. Adjust voltages on the BAM until the problem is resolved.

If it cannot be demonstrated that the clock synchronization pulse is working, or if the hourly averages from the data logger, do not show the expected level of agreement with those downloaded from the BAM, AIRNow posting should be suspended until the problem is diagnosed and resolved.

28.15.3 AQS Data Validation

BAM continuous hourly data will be uploaded to AQS on a monthly basis within 15 days upon the completion of a calendar month. The concentrations used to create AQS strings will be obtained from the files downloaded from the BAM-1020, rather than from the average math channel of the data logger.

Comma separated files, with hourly concentrations and associated flags, will be downloaded from the internal memory on the BAM-1020 and imported into the AirVision database. For more information on this topic refer to SOP 18 AirVision. AQS strings will be created from the imported data in the database.

APPENDIX A-Critical Forms and Field Sheets

Form 1.....**BAM-1020 PM2.5 Audit Field Sheet**
Form 2.....**BAM-1020 PM2.5 Monthly Calibration Field Sheet**
Form 3.....**BAM-1020 PM2.5 Verification Field Sheet**
Form 4.....**Corrective Action Form**

Form 1: BAM-1020 PM2.5 Audit Field Sheet

BAM-1020 PM2.5 AUDIT SHEET

Site Name: _____ **Date:** _____
Site Location: _____ **Time:** _____
Technician's Name: _____ **Serial #:** _____
Observer's Name: _____ **Sampler Model:** BAM-1020

1). As Found Flow Audit:

Set Point	Sampler	Actual
16.70		
(Sampler - Actual) x 100 / Actual		≤ 4%
(16.70 - Actual) x 100 / 16.70		≤ 5%
(16.70 -Sampler) x 100 / 16.70		≤ 2%
Perform a flow calibration if the % difference is greater than 2%.		

2). As Found Leak Check:

	Pass or Fail ≤ 1.0 LPM	Indicated LPM
Leak Check		
If leak check passes, proceed with verication. If leak cheak fails, clean nozzle and vane and perform calibration.		

3). As Found Temp. (AT) Audit:

	Sampler	Actual	
Amb Temp (°C)			≤ 2°C
Perform a temperature calibration if sampler and actual temperatures are not within limits.			

4). As Found Pressure (AP) Audit:

	Sampler	Actual	
Amb Pressure			≤ 10 mmHg
Perform a pressure calibration if sampler and actual pressures are not within limits.			

	Manufacturer	Model	Serial Number	Recertification Date
Temperature Reference	Cole Palmer	91100-20		
Pressure Reference	CE	Hand Held		
Flow Standard				

Comments: _____

Form 2: BAM-1020 PM2.5 Monthly Calibration Field Sheet

BAM-1020 PM2.5 CALIBRATION SHEET

Site Name: _____ **Date:** _____
Site Location: _____ **Time:** _____
Technician's Name: _____ **Serial #:** _____
Observer's Name: **Sampler Model:** BAM-1020

1). As Found Checks	Sampler	Actual	Difference
Flow Set Point 16.70			≤ 4%
Leak Check			≤ 1 LPM
Ambient Temp (°C)			≤ 2 °C
Ambient Pressure			≤ 10 mmHg

2). General Maintenance	Yes or No
Cleaned Nozzle & Seal (1/month)	
Cleaned VSCC/SCC (1/month)	
Cleaned PM10 Head (1/month)	
Replaced Filter Tape (1/60 days)	

3). As Left leak Check:	Pass or Fail ≤ 1.0 LPM	Indicated LPM
Leak Check		

Almost all leaks occur at the nozzle where it contacts the filter tape. Clean nozzle and vane and repeat leak check. If problem persists, refer to Operator's Manual.

4). Temperature (AT) Calibration:	Sampler	Actual	
Amb Temp (°C)			≤ 2°C

Repeat Calibration if sampler and actual temperatures are not within limits.

4). Pressure (AP) Calibration:	Sampler	Actual	
Amb Pressure			≤ 10 mmHg

Repeat Calibration if sampler and actual pressures are not within limits.

6). Flow Calibration:		
Pre-Calibraton		
Set Point	**Sampler**	**Actual**
15.00		
18.40		
16.70		
Post-Calibration		
Set Point	**Sampler**	**Actual**
15.00		
18.40		
16.70		
Set Point: 15.00		
(Sampler - Actual) x 100 / Actual		≤ 2%
(15.00 - Actual) x 100 / 15.00		≤ 5%
(15.00 - Sampler) x 100 / 15.00		≤ 2%
Set Point: 18.40		
(Sampler - Actual) x 100 / Actual		≤ 2%
(18.40 - Actual) x 100 / 18.40		≤ 5%
(18.40 - Sampler) x 100 / 18.40		≤ 2%
Set Point: 16.70		
(Sampler - Actual) x 100 / Actual		≤ 2%
(16.70 - Actual) x 100 / 16.70		≤ 5%
(16.70 - Sampler) x 100 / 16.70		≤ 2%

Repeat flow calibration if the % difference is greater than the specified range.

	Manufacturer	Model	Serial Number	Recertification Date
Temperature Reference	Cole Palmer	91100-20		
Pressure Reference	CE	Hand Held		
Flow Standard	BGI	Tetra-Cal		

Form 3: BAM-1020 PM2.5 Verification Field Sheet

BAM-1020 PM2.5 VERIFICATION SHEET

Site Name: _____
Site Location: _____
Technician's Name: _____
Observer's Name: _____

Date: _____
Time: _____
Serial #: _____
Sampler Model: BAM-1020

1). As Found Flow Verification:

Set Point	Sampler	Actual
16.70		
$\frac{(\text{Sampler} - \text{Actual}) \times 100}{\text{Actual}}$		≤ 4%
$\frac{(16.70 - \text{Actual}) \times 100}{16.70}$		≤ 5%
$\frac{(16.70 - \text{Sampler}) \times 100}{16.70}$		≤ 2%

Perform a flow calibration if the % difference is greater than 2%.

2). As Found Leak Check:

	Pass or Fail ≤ 1.0 LPM	Indicated LPM
Leak Check		

If leak check passes, proceed with verication. If leak cheak fails, clean nozzle and vane and perform calibration.

3). As Found Temp. (AT) Verification:

	Sampler	Actual	
Amb Temp (°C)			≤ 2°C

Perform a temperature calibration if sampler and actual temperatures are not within limits.

4). As Found Pressure (AP) Verification:

	Sampler	Actual	
Amb Pressure			≤ 10 mmHg

Perform a pressure calibration if sampler and actual pressures are not within limits.

	Manufacturer	Model	Serial Number	Recertification Date
Temperature Reference	Cole Palmer	91100-20		
Pressure Reference	CE	Hand Held		
Flow Standard	BGI	Tetra-Cal		

Comments: _____

Form 4: Corrective Action Form

Polk County Air Quality - Corrective Action Form

To: _____ Polk County Air Quality _____
(position)

From: _____

Copies of completed form to: AQ Supervisor, File

Urgency: ☐ Emergency (immediate action needed) ☐ Urgent (24 Hr.)
☐ Routine (7 days) ☐ Next scheduled visit ☐ Information only

Problem Identification:

Site: _____
System: _____
Date: _____

Description of Problem: _____

Recommended Action: _____

Signature of Initiator: _____ Date: _____

Problem Resolution:

Date of Corrective Action: _____

Summary of Corrective Action: _____

Result of Corrective Action: _____

Signature of resolver: _____ Date: _____

Signature of QA Officer: _____ Date: _____