PM 10 Sampler Standard Operating Procedure (SOP)

Reference: 40 CFR Part 50, Appendix J

Safety

Repair of instrumentation should only be attempted by trained personnel and should only be conducted in accordance with system documentation. Do not tamper with the hardware. High voltages may be present in all instrument enclosures. Use established safety precautions when working with instrumentation. Instrument is supplied with a ground fault circuit interrupter (GFCI) and is designed for outdoor use. When operating the instrument outdoors, be sure that it is plugged into a properly rated exterior (outdoor) outlet. The instrument stand must be anchored when installed outdoors to prevent tipping of the sampler and/or stand in high winds. Be careful to avoid pinching your fingers between the assembly parts.

I. Routine Operations

As with any procedure relative to air quality monitors if you have any questions do not hesitate to contact Office of Air Quality Monitoring (OAQM).

A. Presampling Filter Preparation

Loading the PM10 filter paper cartridge/cassettes in the office or in protected areas will minimize damage; however, if extreme care is exercised, they can be loaded at the site when ambient conditions permit.

PM10 Filter Paper Cartridge/Cassette Parts


Snap-on protective cover and 2 wing nuts


Upper cassette plate (faceplate)


Filter

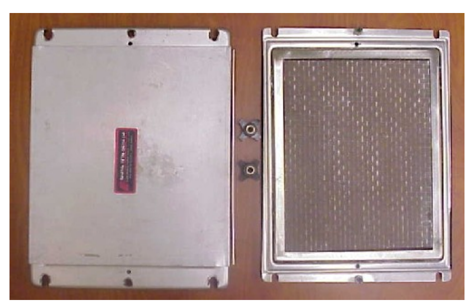

Lower cassette plate with filter support screen

1. **Keep filters in protective folders or boxes before use.** Do not bend or fold unexposed filters.

2. **Remove the 2 wing nuts on the cassette and remove upper cassette plate (faceplate).**

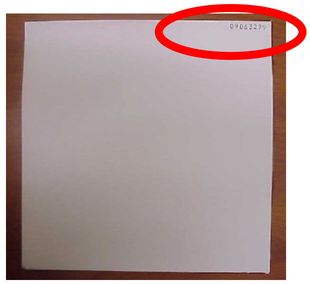

Cassette with wing nuts attached

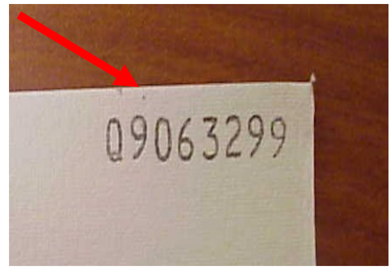

Cassette with wing nuts removed


Faceplate with cover attached; wing nuts; and lower cassette plate

3. **Select a clean, unexposed filter from the ones OAQM has provided.** Make sure it is not a TSP filter. The filter can not have been bent, folded, or torn in corners. Make sure it does not have any dust or particles on it.

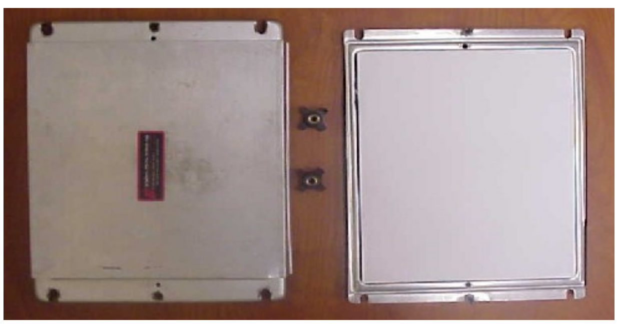
Protective box for filters

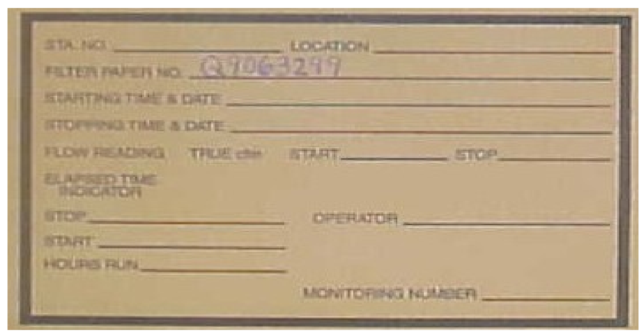

Clean, unexposed filter, not bent or folded



Filter number from top right corner of filter

4. **Place the filter <u>number side down</u> on the wire screen.**
<u>Record the filter number on a blank filter envelope</u>. Center it on the wire screen so it will form an airtight seal on the outer edge of the filter when the faceplate is in place. Take care when placing the filter. Poorly aligned filters will show an uneven white border after exposure.


Faceplate with cover attached; wing nuts; and filter centered on wire screen of lower cassette plate



Filter number recorded on filter envelope

5. **Place the faceplate on the filter.**
Align the wing nut slots when placing the faceplate.

6. **Set the wing nuts in place and tighten them on the cassette.**
Do not overtighten. Overtightening may cause the filter to stick or may cause permanent damage to the gasket.

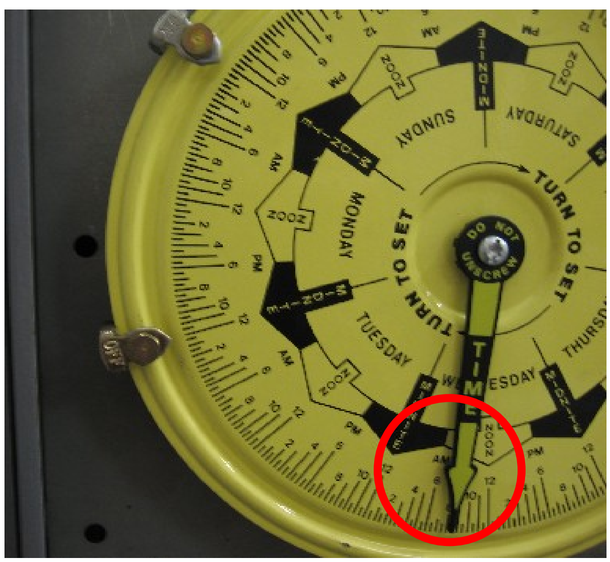

Protective cover; faceplate placed on filter, wing nuts tight

7. **Bring the cassette, the filter envelope with the filter number recorded, and a pen to the PM10 sampler location**.
   Each operator will need a system to make sure the filter envelope correctly matches the filter number with the monitor in which it was loaded.

B. **Removing a Filter from the PM10 Sampler**

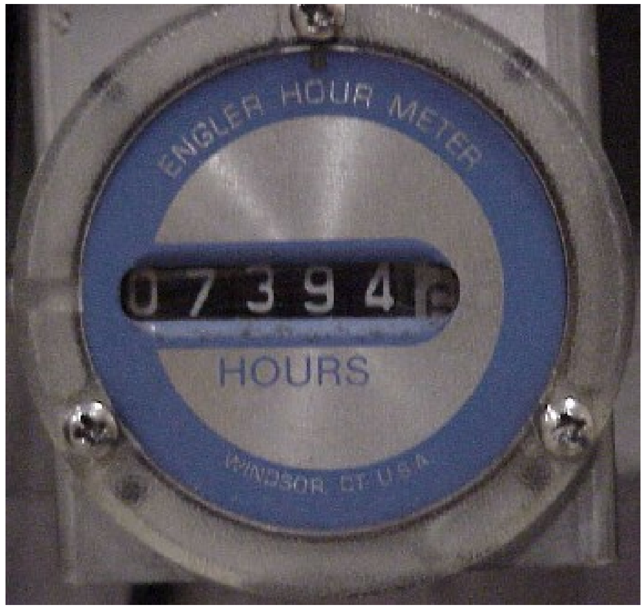
For purposes of quality assurance as soon as possible after sampling, retrieve the exposed filter. Particle loss or filter damage can result if the filter is left in the sampler for extended periods.

1. **Verify the clock timer is on the correct day and time.**
   SAFETY - There is a protective plastic sheet visible once you open the timer door. Leave the plastic sheet in place to protect you from electric shock.
   Upon arrival at the monitoring site, open the door to the sampler base and verify the clock timer is on the correct day and time. (Note: all times are in Eastern Standard Time.)



This shows the current day and time as Wednesday about 8:15. Sample run on Monday

2. **Verify that the sample ran for the 24-hour sampling period by checking the elapsed time indicator.** The elapsed time indicator is used to determine the number of hours that a sample has run. The elapsed time indicator looks like a car odometer with rolling digits.



An elapsed 24 hours on this time would be 7418.6 (7418.6-7394.6 = 24.0)

To obtain the total hours run time for the sample:

a. **Locate the elapsed time indicator.** It is just below the timer compartment.
b. **Record the stop value on the filter envelope.** Look at the indicator and record the digits on the filter envelope exactly as displayed on the meter. Record the value next to the word stop at the lower left of the envelope. The start time should already be recorded on the envelope.
c. **Calculate the total hours run.** Some of the elapsed time indicators record hours, some record minutes.
    1. If the elapsed time indicator is in hours, subtract the start time from the stop time. Record the result on the envelope as the hours run. (See picture above.)
    2. If the elapsed time indicator is in minutes, subtract the start time from the stop time; then divide by 60 to convert to hours. Record this result on the envelope as the hours run.
d. If the sample ran for less than 23 hours or more than 25 hours the sample is not valid. OAQM must be notified, and an invalid data sheet must be turned in. Troubleshoot to determine if a power failure occurred, motor failure, elapsed time indicator broken or operator set points are incorrect.

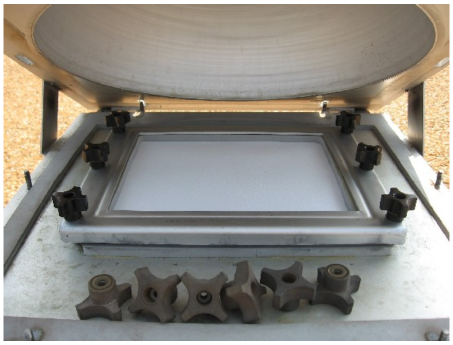
3. **Remove the 6 plastic wing nuts securing the inlet to the PM10 sampler base.** (Graphic illustrations are in C below - page 8.) Retain the wing nuts in an easily accessible location for retightening.

4. **Tilt the inlet back until it comes to a stop.**
   Tilting the inlet back allows access to the cassette assembly.

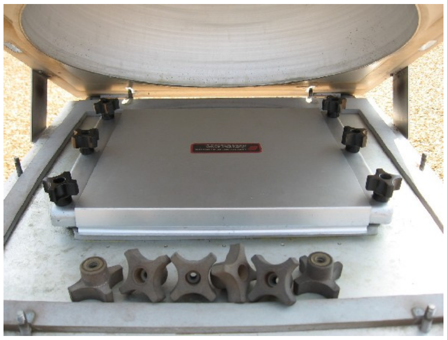
Inlet tilted on base side view

Inlet tilted on base front view

5. **Place the snap-on protective cover on the cassette.**
   The cover protects the filter during transport.

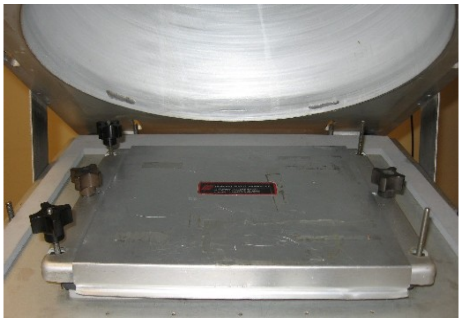


Exposed filter, wing nuts tight

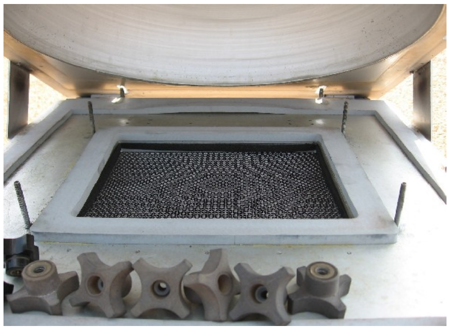


Snap on cover installed

6. **Loosen 4 wing nuts on the filter cassette and remove the filter cassette.**
   Remove 2 wing nuts and remove the entire cassette assembly.



Wing nuts loosened and 2 removed



Filter cassette removed

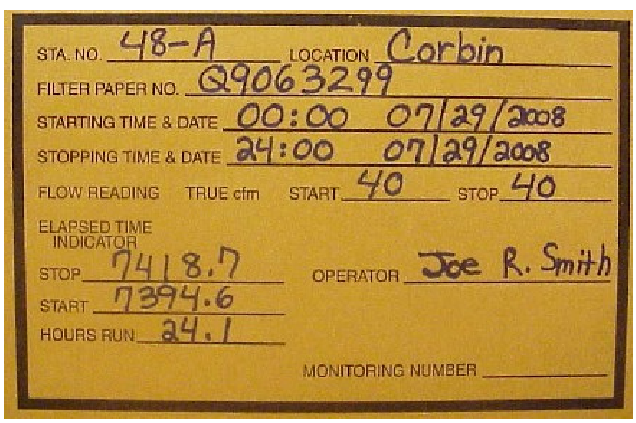
7. **Turn the sampler on briefly to verify that the motor is still operational.** (See C9 below, page 11.)

8. **If you are not going to be loading a filter, secure the 4 wing nuts on the threaded posts, close the inlet and secure it to the base with the 6 wing nuts. Make sure all sampler doors are closed.**

9. **Record information on the filter envelope.**
   If the motor is still operational as determined in step 7 immediately above, record the following:
   Stopping Time & Date – 24:00 and Run date
   Flow Reading stop value as **40** (This is the fixed design flow.)

   If the motor is not operational troubleshoot to determine if a power failure occurred, motor failure, elapsed time indicator broken before contacting OAQM.

10. **Review the recorded information on filter envelope.**
    All the information should already be filled in on the envelope. See prior instructions for how to fill out the envelope if needed. Note: if the person who removed the filter is different from the person who installed the filter be sure to include both of their names as the operator.



STA. NO. 48-A LOCATION Corbin
FILTER PAPER NO. Q9063299
STARTING TIME & DATE 00:00 07/29/2008
STOPPING TIME & DATE 24:00 07/29/2008
FLOW READING TRUE cfm START 40 STOP 40
ELAPSED TIME INDICATOR
STOP 7418.7 OPERATOR Joe R. Smith
START 7394.6
HOURS RUN 24.1
MONITORING NUMBER

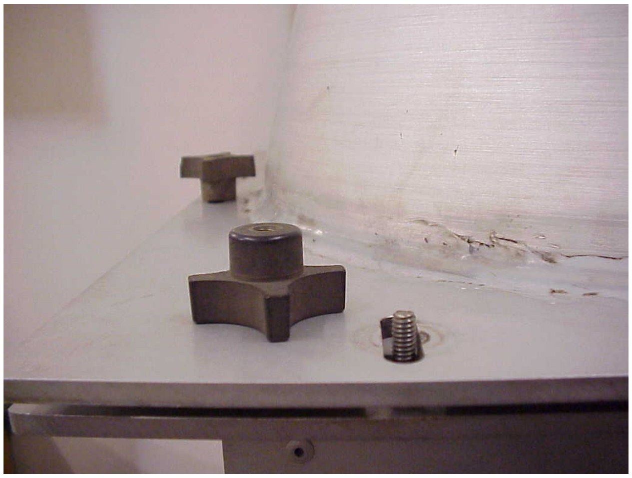
PM10 filter envelope filled out

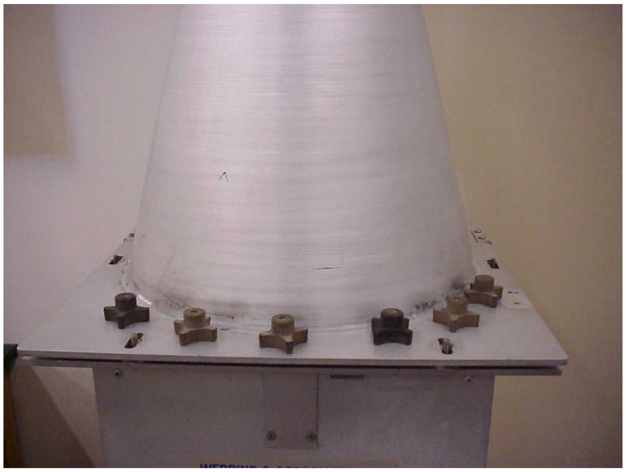
11. **Place the filter in the envelope.**
    Upon return to the office or to a protected area, remove the filter from the cassette. Fold the filter so that the exposed side (dirty side) is on the inside and the filter number is visible. Place a protective paper around the filter and insert it into the envelope. Filter and folded paper should both have the opening pointed up in the same direction. **Note:** The side of the paper that makes contact with the filter should be clean, free of debris, and have no markings on it.

12. **Transmit the filter to OAQM.**
    The filter must be sent to OAQM within 5 days of sample day.

C. **Loading a Filter onto the PM10 Sampler**
The procedures below discuss loading a cassette on to a PM10 filter base that is not previously loaded with a filter cassette from a previous run. To read the procedures for removing a sampled cassette see B. above page 4.

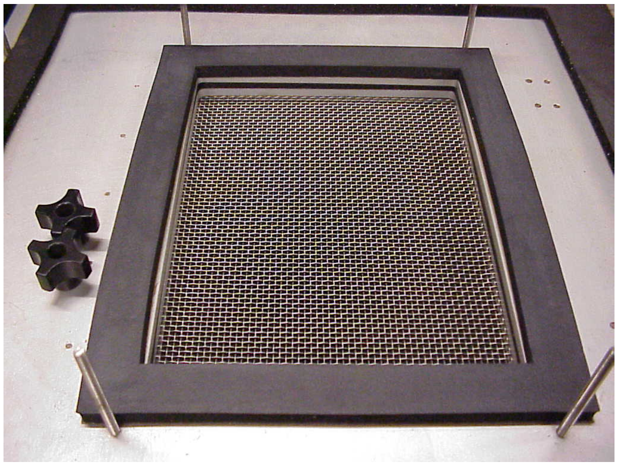
1. **Remove the 6 plastic wing nuts securing the inlet to the PM10 sampler base.**
   Retain the wing nuts in an easily accessible location for retightening.


Example wing nut


All 6 wingnuts removed

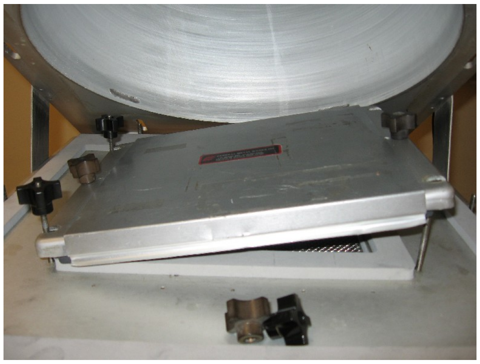
2. **Tilt the inlet back until it comes to a stop.**
   Tilting the inlet back allows access to the sampler support screen. (See photos of tilted inlet on page 6.

3. **Examine the sampler support screen.**
   If the screen appears dirty, wipe it clean. Use a Kimwipe® to assure that the support screen is free of debris.

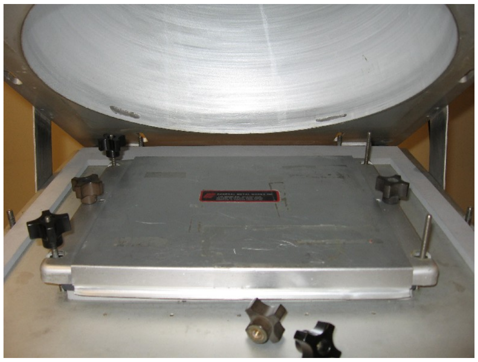


Clean sampler support screen

4. **Place the loaded cassette in position on the sampler support screen.**
   Set the 4 wing nut slots on the filter assembly in line with the threaded wing nut posts.

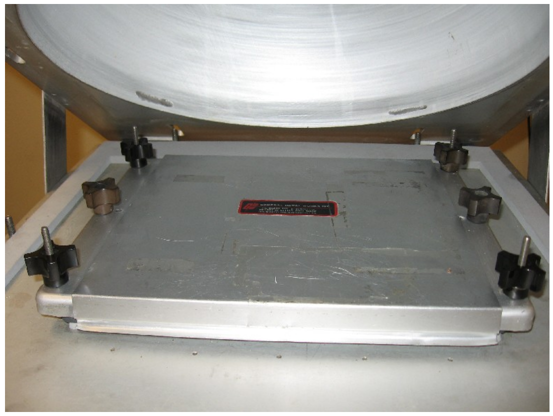


Loaded cassette in place



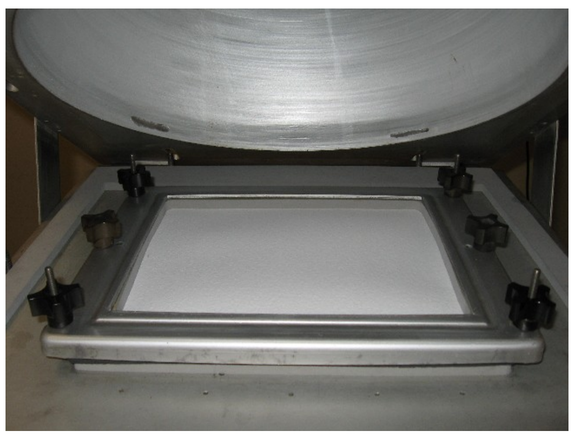
Aligned wing nut posts

5. **Tighten the wing nuts completely to secure the filter.**
   The wing nuts should be hand tightened. The wing nuts only need to be tightened sufficiently to hold the filter cassette securely and to prevent leaks by sealing the gasket between the lower cassette plate and the Sampler Support Screen. Too much compression can damage the sealing gasket, warp the cassette, and lead to leakage. The nuts on alternate corners should be tightened until contact is made with the filter cassette. Tighten securely after each wing nut makes contact with the cassette. Tighten alternate corners in sequence.



Secured filter with wing nuts tightened

6. **Remove the protective cover from the cassette assembly.**
   Be careful not to make contact with the filter media. If there is difficulty removing the cover, slightly loosen wing nuts, remove cover, and retighten wing nuts.



Protective cover removed

7. **Set the sampler inlet onto the sampler base.**

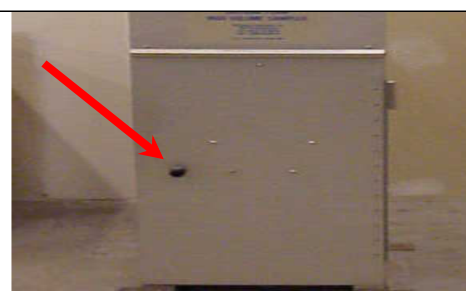
Inlet set on sampler base

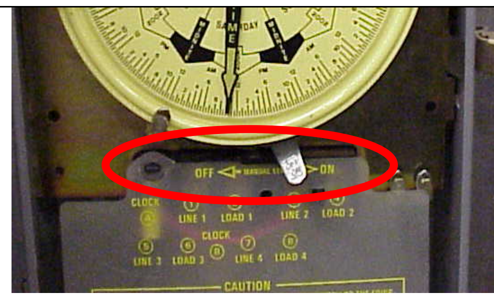
8. **Secure the inlet to the sampler base with the six plastic wing nuts.** The wing nuts should be handtightened. Do not overtighten.

Inlet secured to sampler base

Tightening the wing nuts is intended to prevent leaks by sealing the gasket between the PM10 inlet and base. Do not overtighten so that the wing nuts can be removed the next time. Too much compression can damage the sealing gasket and lead to leakage.

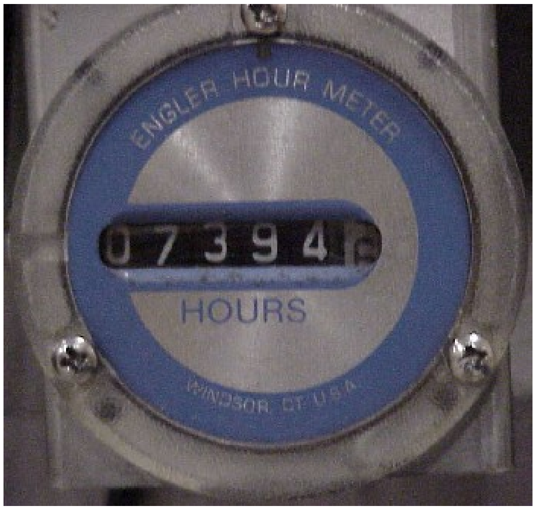
9. **Turn the sampler on briefly to verify that the motor is still operational.** To turn the sampler on -

a. Open the sampler door by turning the knob on the exterior of the PM10 sampler counter-clockwise and pulling it toward you.	
b. Open the timer door. The timer door is attached to the interior of the sampler door.	

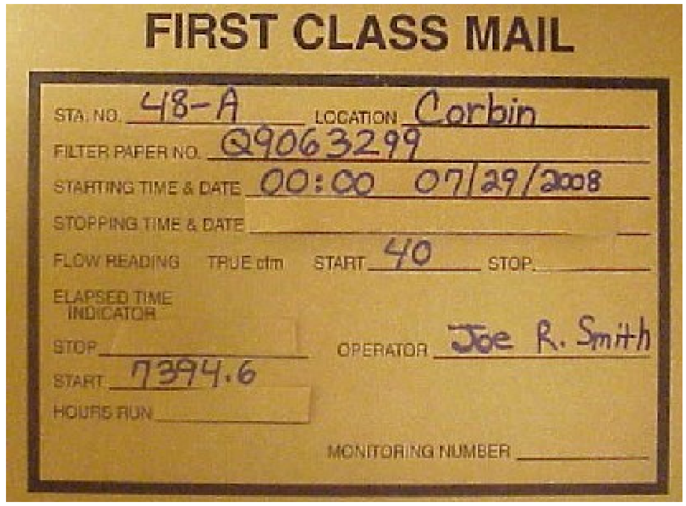
c. Once the timer door is open, locate the manual lever. Looking from top to bottom, the manual lever is just below the yellow circular timer. **SAFETY - There is a protective plastic sheet visible once you open the timer door. Leave the plastic sheet in place to protect you from electric shock.**	
d. Move the manual lever to ON (the manual lever moves left to right and right to left. Move it to the right to turn it ON.) Run the motor for at least 20 seconds. Listen to the motor to make sure it is operating properly. Listen for a smooth motor sound, not rattling. See page 18 C. PM10 motor assembly for motor replacement instructions if needed.	
e. Move the manual lever to OFF by moving it to the left. The manual lever should be in the OFF position unless you are testing the motor.	

10. **Record the flow reading start value on the filter envelope.**
If the motor is still operational as determined in step 9 immediately above, record the flow reading start value as **40** (This is the fixed design flow). If the motor is not operational, check GFCI test/reset button, verify power before contacting OAQM.

11. **Record the elapsed time indicator start time on the filter envelope.**
The elapsed time indicator is used to determine the number of hours that a sample has run. The elapsed time indicator looks like a car odometer with rolling digits. Record the digits on the filter envelope exactly as displayed on the elapsed time indicator.



Elapsed time indicator reading



Parameters filled out on envelope

12. **Record the following parameters on the filter envelope in ink.**
    Station No. - the number of the site
    Site location - the name of the site
    Starting Time & Date – 00:00 and run date
    Operator - the name of the person who loaded the filter.

13. **Set the timer for the next run day.**
    The timer is used to turn the motor on and off for the sampling period. See D below (page 14) for instructions on how to set the timer.

14. **Secure all doors on the sampler.**
    Close the timer door. Close the sampler door and secure it by turning the knob clockwise to latch it. Pull the door to make sure it is latched firmly.

Sampler door open,
Timer exposed

Sampler door closed

15. **The sampler is now ready to collect a particulate sample**.

D. **Setting the Timer**

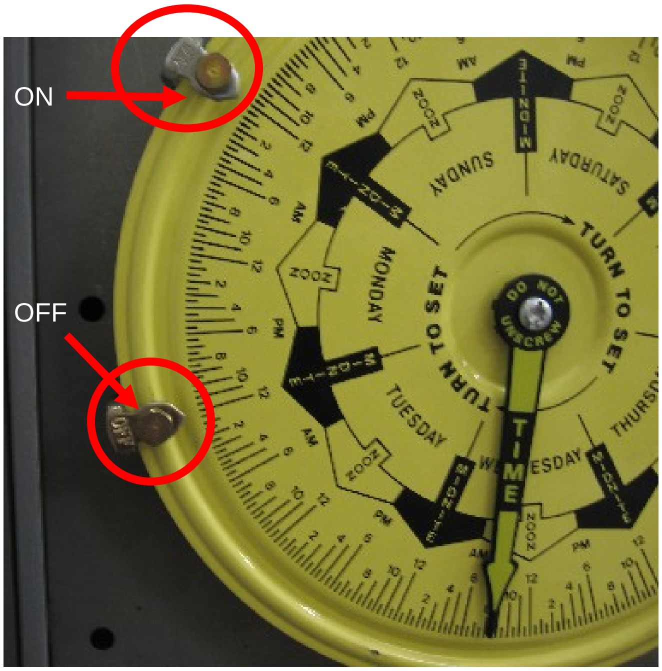
The timer is used to turn the motor on and off for the sampling period. The timer is a yellow circular disk that has days of the week and times printed on it, it has a large arrow pointing down that marks the current day and time, and it has ON and OFF set screws that are placed on the yellow disk at the corresponding days/times for when the sample should start and stop sampling.

When using a 7-day timer, to run a sample for 24 hours from midnight to midnight, perform the following steps.

1. **Check the current reading on the timer.**
   Make sure the timer displays the current time and day. The big arrow that is labeled TIME should be pointing at the time and day corresponding to the current time and day. **Note:** Each operator will need to make sure that they independently verify that the timer displays the correct Eastern Standard Time (EST).

2. **Set the starting time.**
   Place the set screw labeled with the word ON at the 12 midnight mark between the day before the sample run day and the sample run day.

3. **Set the stopping time.**
   Place the set screw labeled with the word OFF at the 12 midnight mark between the sample run day and the day following the sample run day.



Clock timer with sample run on Monday, current day is Wednesday

II. **General Maintenance**

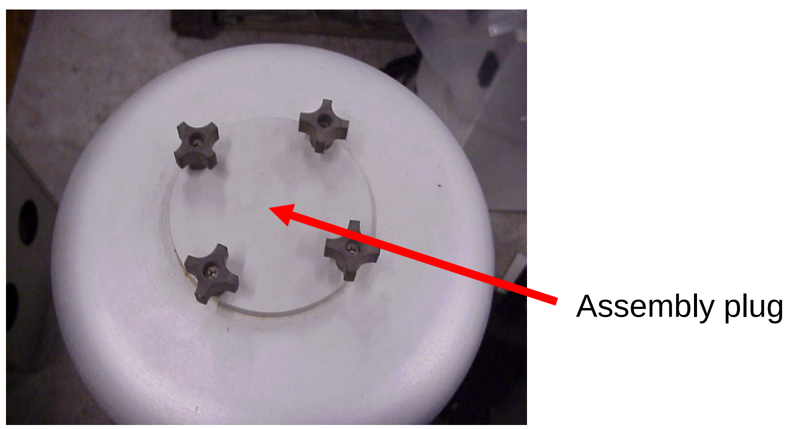
A. **Cleaning Inlet Sampling Head**

The Wedding sampling inlet is constructed such that the fractionating element is readily accessible for cleaning through the maintenance access port. The sampling inlet should be cleaned once per quarter. **Note:** The criteria for cleaning the sampling inlet is when a cumulative amount of 1000 micrograms per cubic meter of transmitted PM-10 mass has been collected on the filters.

Always keep the inlet in an upright position during maintenance or transport. Rotating the inlet to a horizontal position during maintenance or transport will result in the residual leakage of oil from the middle tube onto the inside surface of the outer tube. If this occurs, the inside surface of the outer tube must be thoroughly cleaned to prevent particulate deposition and contamination of the filter substrate.

1. **Move the maintenance access port.**
   To reach the maintenance access port located at the top of the inlet tilt the unit back as far as the safety catch brackets will allow.

Inlet tilted back



Maintenance access port (view from top of inlet)

2. **Remove the knobs holding the assembly plug.**
   Use a step stool to reach the top of the inlet. Remove the four wing nuts holding the assembly plug in place. Remove the assembly plug.

Access port with knobs removed

3. **Inspect the assembly plug gasket.**

Assembly plug gasket exposed

4. **Inspect the inner deposition tube.**
   Set the assembly plug and knobs aside. The inner tube which is the site of the primary deposition in the cyclone fractionating assembly is now exposed for cleaning.

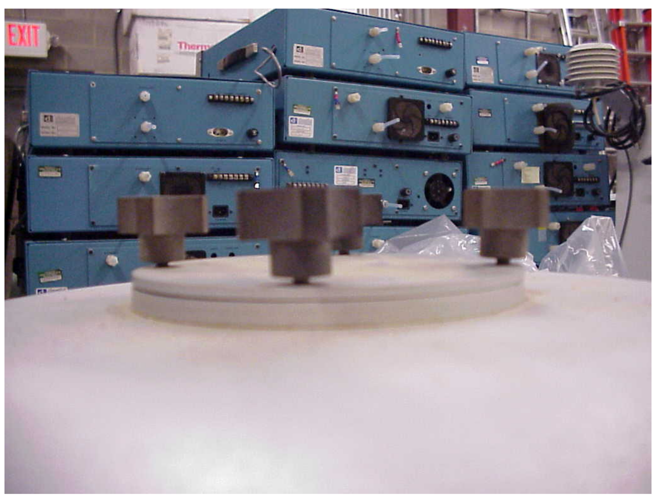
5. **Clean the flow pathway in the deposition tube.**
   NOTE: Before cleaning the flow pathway, be sure the support screen is covered with a covered filter cassette to prevent debris from falling into the CFD (critical flow device).

   After looping the brush string around your wrist, pass the cleaning brush down the inner tube, rotating it as it is pushed up and down. Make 3 round trips through the tube. Remove any residual particle material remaining on the surface by blowing or wiping the particles away. No re-oiling of the surface is required by the operator. The oiled deposition surface is regenerated by the internal oil reservoir.

Example process of cleaning the inner tube. Rotate 3 times around the tube.

6. **Replace the assembly plug.**
   When maintenance is completed, replace the cleaning assembly plug.



Retaining knobs should be fastened evenly around the plug

7. **Replace the assembly plug wing nuts.**
   Make sure that the four wing nuts are snugly in place.

B. **Routine Maintenance Practices**
   Routine maintenance will be conducted at a minimum of once every three months or more frequently as specified below.

1. **Inspect all gaskets** for wear, tears, or excessive compression. Replace as needed.

2. **Inspect elapsed time indicator.**
If meter is malfunctioning, contact the Office of Air Quality Monitoring for replacement.

3. **Inspect the clock timer.**
The current time should accurately be displayed as referenced by Eastern Standard Time (EST). If the time needs to be adjusted, grab the yellow disk and turn it clockwise. Replace it immediately if it is malfunctioning. Contact OAQM.

4. **Inspect the sampling equipment.**
Corrosion, dirty conditions, and damage to the sampler should be corrected. Equipment that cannot be repaired should be replaced.

5. **Test the ground fault circuit interrupter (GFCI).**
All wiring must be on a ground fault circuit interrupter. This circuit must be tested monthly to ensure that the breaker is still operational. All other wiring should be inspected for cracking, fraying, or general deterioration and replaced if necessary.

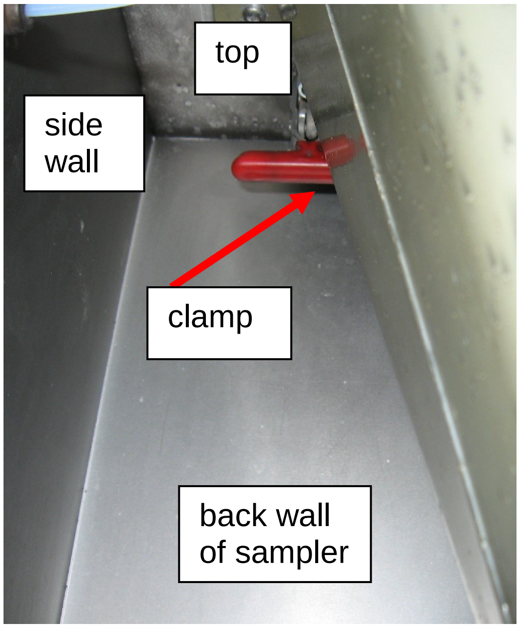
To test the GFCI, turn the PM10 motor on, then press the "TEST" button on the GFCI. The motor should turn off and the GFCI's "RESET" button should pop out. If both of these things do not happen the GFCI is not working correctly. Notify OAQM. To complete the test and restore power to the outlet, press the "RESET" button and turn off the PM10 motor.

6. **Transmit a copy of the completed maintenance check sheet.**
All maintenance procedures are conducted every three months at a minimum. Forward a completed copy of the maintenance check sheet to the OAQM, Manager of Criteria Pollutants Group within 5 working days of completing the procedures.

C. **PM 10 Motor Assembly Removal from Sampler**
Replace the brushes on the motor assembly every 3 months at a minimum. To replace the motor brushes, the motor assembly must be removed from the Critical Flow Device (CFD) as follows:

1. **Unplug motor assembly.**

2. **Unlatch the CFD hold-down clamps.**
The two holding clamps are located inside the sampler at the back. The clamps are bolted onto the lower adapter plate on both sides of the Critical Flow Device flange. Push the clamps away from you toward the back of sampler. Keep fingers out of the way so they don't get pinched.



View of hold-down clamp when CFD is in normal operating position

Fingers out of way while pushing clamp

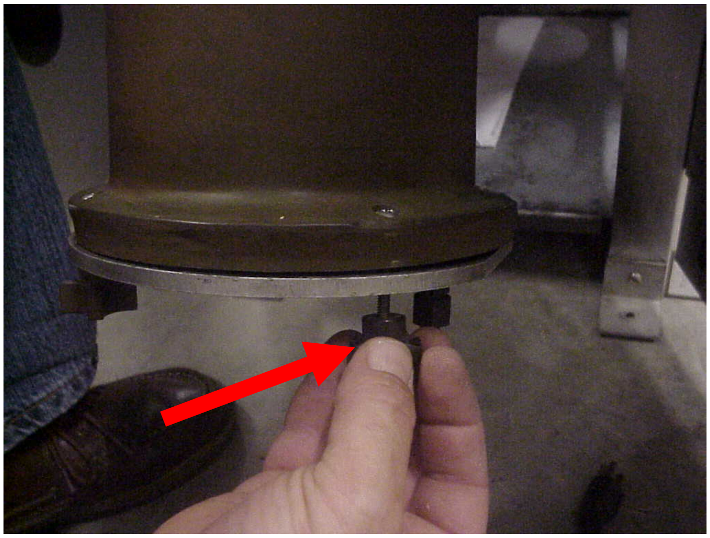
3. **Swing out the critical flow device (CFD).**
   The CFD is balanced so the swing out should occur automatically. The motor assembly needs to be clear of the sampler.

Critical Flow Device clear of assembly (front view)

Critical Flow Device clear of assembly
(side view)

4. **Remove the motor mount flange plate wing nuts.**
   There are four plastic wing nuts located on the orifice plate. Remove wing nuts evenly to allow the motor to slide out slowly.

Safety
The motor will be unsupported when all wing nuts are removed. Be careful to support the motor with your free hand as you remove the last knob.



Motor Mount Flange plate wing nuts

5. **Slide the motor assembly out of the CFD.**

Motor assembly removal

6. **Transport the motor assembly back to the office.**
   When transporting the motor assembly, lay it on its side; do not set it down on the gasket.

D. **Putting the Motor Assembly Back into the Sampler.**

1. **Make sure the sampler door is open and the critical flow device (CFD) is clear of the assembly.**

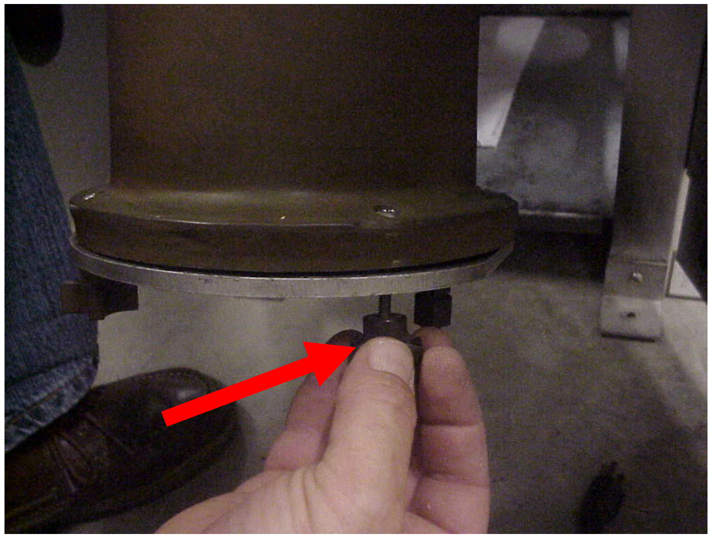
Critical Flow Device clear of assembly (front view)

Critical Flow Device clear of assembly (side view)

2. **Slide the motor assembly into the (CFD).**
   Support the motor with your hand since it will be unsupported until the wing nuts are installed.

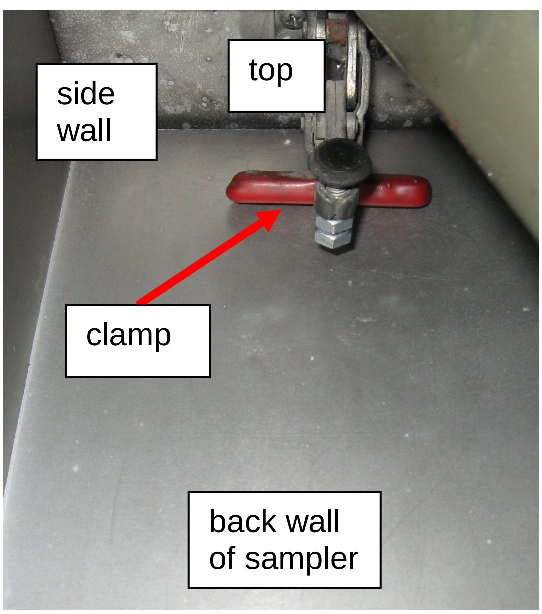
Motor assembly being put into the CFD

3. **Install the four wing nuts on the motor mount flange plate.**



Motor Mount Flange plate wing nuts being installed

4. **Swing in the CFD and latch the hold-down clamps.**
   While holding the CFD in position with one hand, latch both clamps with the other hand by pulling the clamp toward you so it can pivot up toward the top of the instrument. There will be an audible click that signifies the clamp is properly positioned.



View of hold-down clamp when CFD is swung out

View of hold-down clamp when CFD is in normal operating condition

5. **Plug the motor cord into the receptacle.**
   Tape the connection with electrical tape to prevent water from getting into the plug.

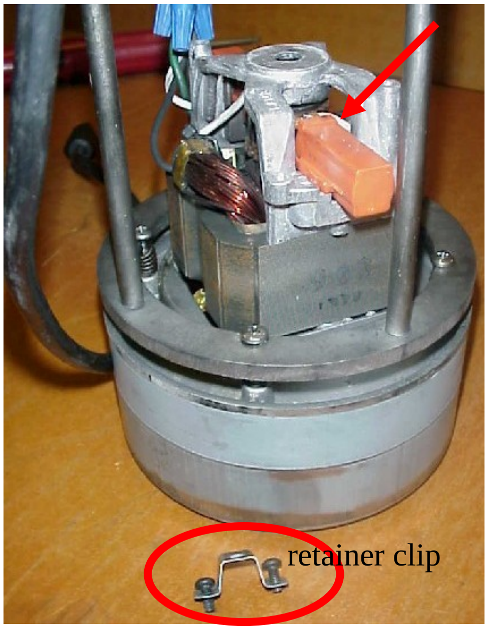
Sealed and taped electrical plug.

E. **Graphite Brush Replacement on Motor**

Wedding and Associates motor assemblies use two high performance graphite brushes. Brushes for the PM10 motors and brushes for the TSP sampler are not interchangeable and must be kept separate.

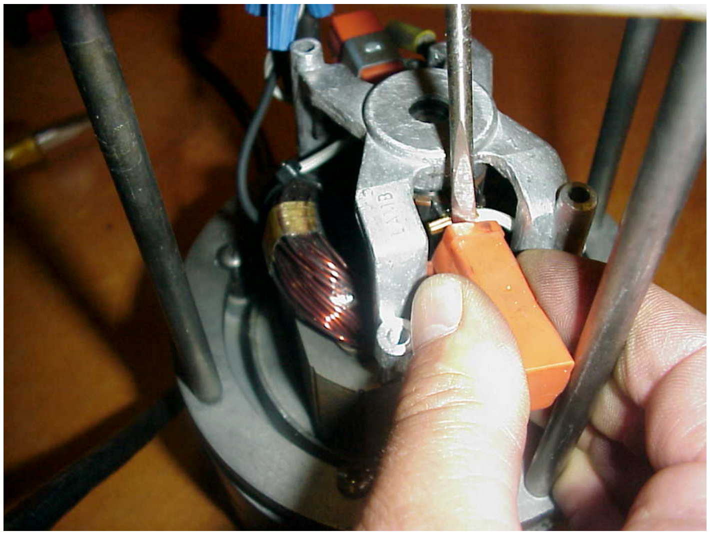
The brushes can be changed with the motor in the cage, or with the motor removed from the cage (see F below page 26.) Whichever way is chosen, it is easier if the work is done in the office at a work bench or desk. <u>Setting the motor on its base can compress the gasket, therefore this should be kept to a minimum. If the motor must be set on its base, it must be on a clean, flat surface.</u>

1. **Remove the retainer clips from the brushes.**
   Loosen and remove the two matching screws and retainer clip from each brush using a screwdriver.



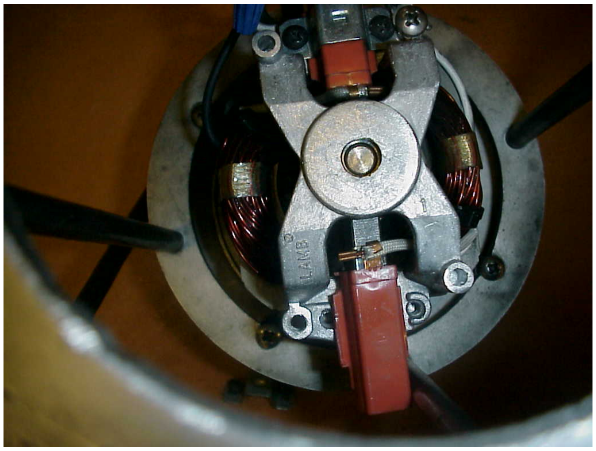
Retainer clip separated from brush

2. **Separate the contact clips from the brushes.**
   Use the blade of a flathead screwdriver to pry and slide the contact clips away from the brushes. To remove the contact clips, gently back the contact clip out of the brush. Hold brush securely while prying clip away.

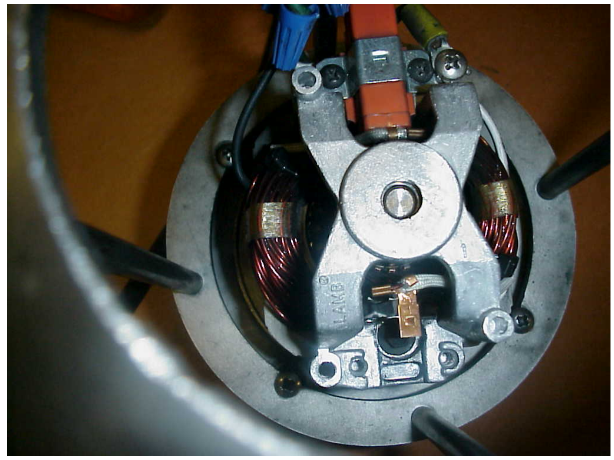


Removing contact clip from brush

3. **Remove the contact clips from the brushes.**
   Remove the contact clips and discard old brushes.

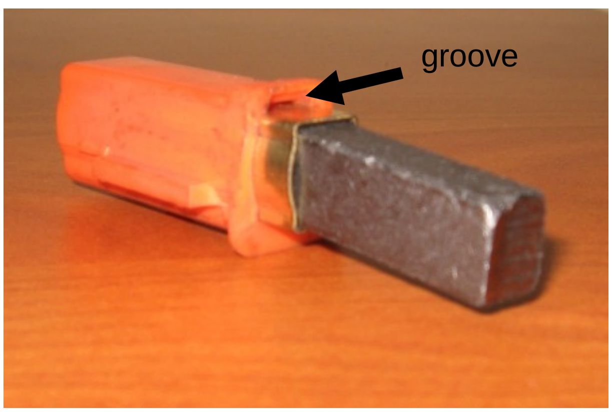


Partially removed contact clip

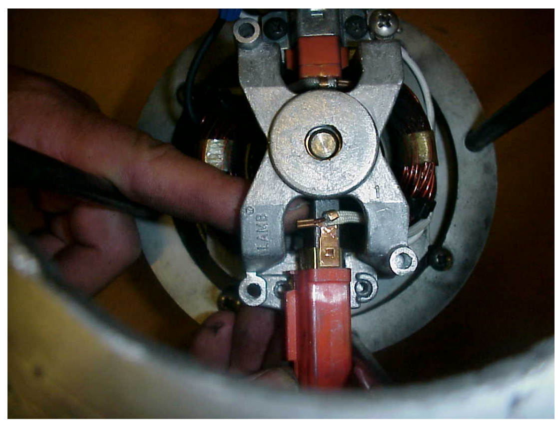


Contact clip with brush removed

4. **Connect the contact clips with the new brushes.**
   Insert the contact clips in the new brushes. The brush has a groove that must be lined up with the contact clip.

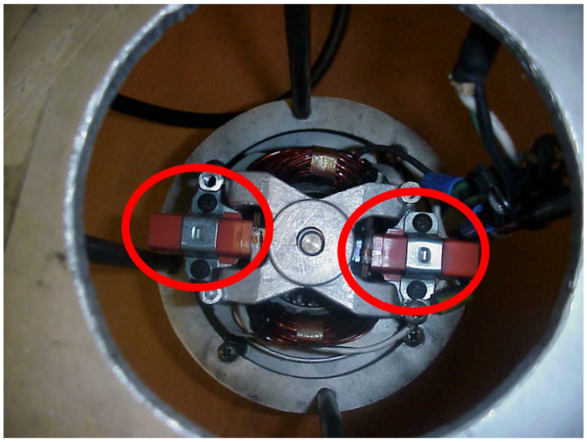


Groove on brush that contact clip goes into



Slide new brush into place

5. **Secure the brushes in place.**
   Secure each brush in place using two matching machine screws and one retainer clip. Make sure that each contact clip is fully inserted into each brush.



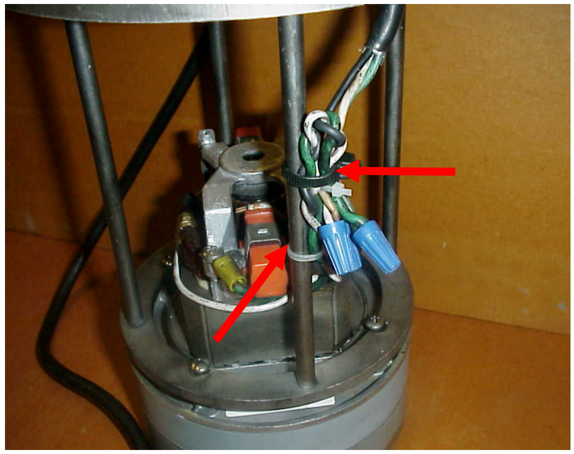
Note retaining clips highlighted above.

6. **Seat the new brushes.**
   The new brushes need to be seated, or burned in, against the commutator before use. Plug the motor into a variable voltage regulator. Run at a low speed for approximately 20 minutes. Look for excessive sparking at variable speeds. Disconnect the motor and check the brushes for correct alignment if you detect excessive sparking. Contact OAQM if you need assistance with this procedure.

Variable voltage regulator

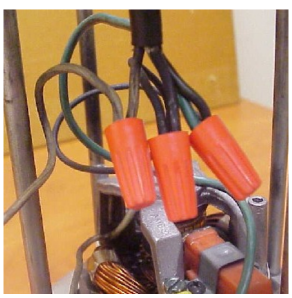
F. **Motor Removal from the Metal Cage**
   Note that brushes can be changed without removing the motor from the metal cage. But when replacing the motor, it needs to be removed from the metal cage. This is normally performed by OAQM. The operators will receive the motors in the cages from OAQM.

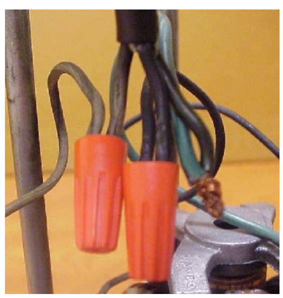
1. **Separate the wire bundle from the support arm of the cage.**
   Cut the nylon ties that secure the bundle to the motor cage.



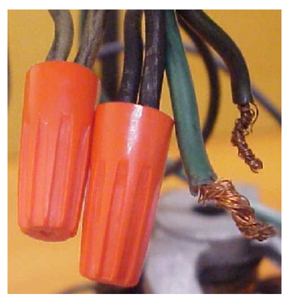
Motor inside cage; nylon ties secure wire bundle

2. **Disconnect motor wires from lead wires.**
   If wire nuts are not in use on the wire bundle, cut and strip the leads, and use wire nuts to connect the motor wires with the lead wires.





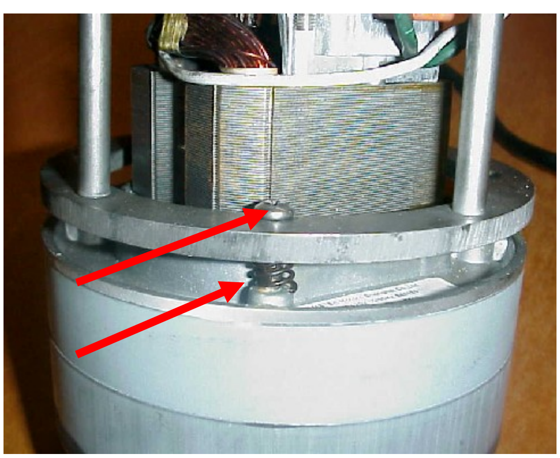
1 nut removed



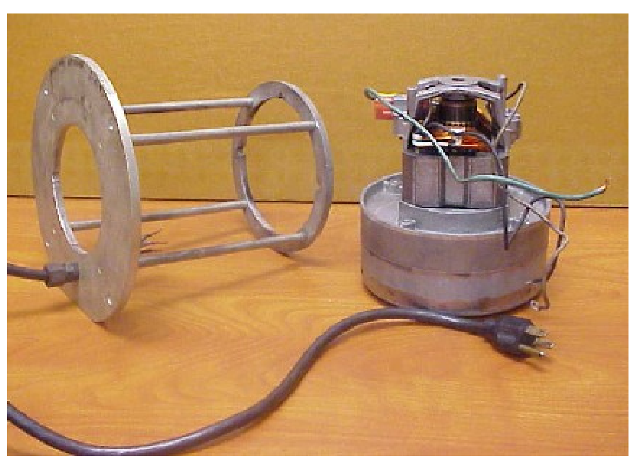
Untwist wires

All 3 sets disconnected

3. **Remove the motor from the cage.**
   Using a screwdriver, remove the four long machine screws and springs that hold the motor to the cage. Lift the cage off the motor.



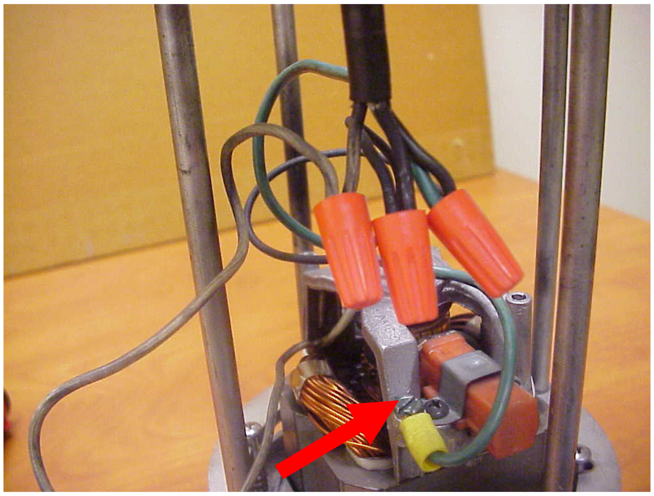
Note spring is under tension



Cage separated from motor

G. **Motor reinstallation (putting it into the cage)**
Motor replacement is generally done in the office for ease of completion.

1. **Inspect the new motor for a ground wire.**
If the new motor does not have a ground wire attached, use the one from the old motor.

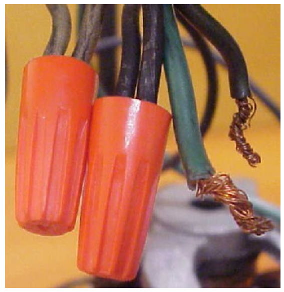

Note ground wire indicated above

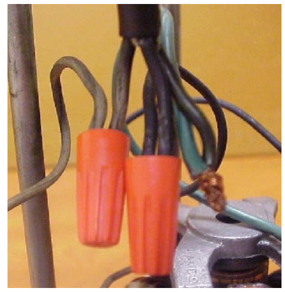
2. **Place the new motor inside the motor mount cage.**
Reinsert the four machine screws and springs. Tighten the screws so that the springs are compressed about 1/8 of an inch.

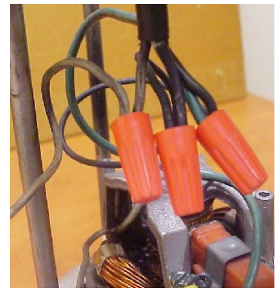

Note cage fits over motor

3. **Reconnect the motor wires.**
   Connect motor wires to the lead wires with wire nuts.

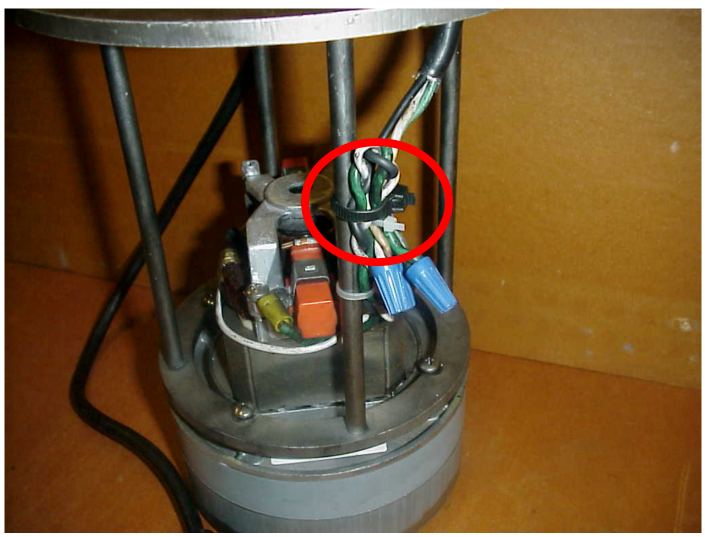

Disconnected wire set


Separated wires

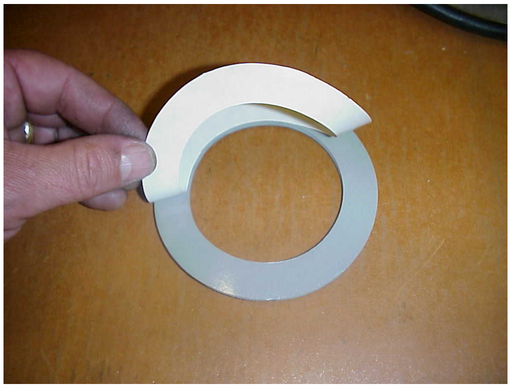

Twist wires


All 3 sets connected

4. **Secure the wire bundle to the inside of the support arm of the cage.**
   Use a nylon tie to secure the wire bundle. Clip off excess nylon tie so it does not interfere with the motor operation.


Note wire bundle secured with nylon tie.

5. **<u>Optional Step</u>: Attach the motor gasket to the motor base.**
   Inspect the motor gasket to determine if it needs to be replaced. Remove the protective backing from a gasket and secure it in place on the motor base.


Removing backing from gasket

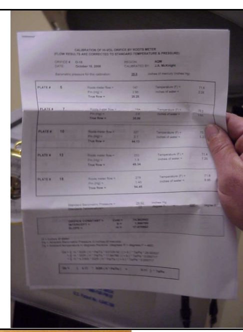

Completed gasket installation

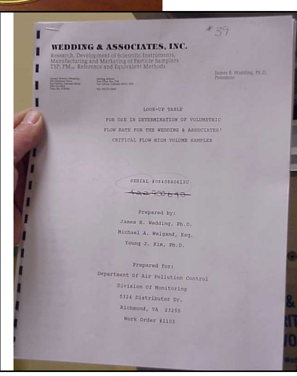
H. **Single Point Verification for the Wedding Volumetric Flow Controlled PM10 Sampler**

The PM10 single point verification is to be done every three months. The quarterly flow check is not a substitute for the single point verification, and conversely, the single point verification is not a substitute for the quarterly flow check. Both are part of the quality assurance procedures for this sampler. Failure to perform a timely single point verification will result in the voiding of all data produced by the sampler during the month in which the verification was to have taken place, and all data collected thereafter, until a proper verification is performed.

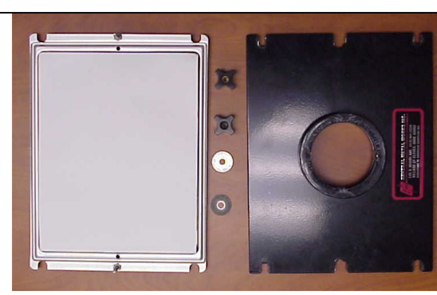
1. **Assemble the single point verification equipment**

   The following equipment is required to perform a single point verification:

a. A flow rate transfer standard (Hi Vol calibration orifice) with current calibration equation.		
b. Tubing and a manometer(s) capable of measuring 0 to 20 inches of water, and 0 to 8 inches of mercury.		

c. A filter lower cassette plate, a clean microquartz filter, a top loading adapter and washers and wing nuts to secure the items together. In the photo they are shown stacked one on top of the other.		
d. A thermometer capable of measuring the ambient temperature to the nearest +/- 1 degree Fahrenheit.		
e. A barometer capable of measuring the ambient barometric pressure to the nearest hundredth of an inch of mercury.		
f. Single point verification data sheet and manufacturer's Look-Up table specific for the sampler being verified. Instead of the look-up table you can use the PM10 multipoint calibration equation (if it is available).	[data sheet with look-up table]	WEDDING & ASSOCIATES, INC. Research, Development of Scientific Instruments, Manufacturing and Marketing of Particle Samplers TSP; PM10; Reference and Equivalent Methods James B. Wedding, Ph.D. President LOOK-UP TABLE FOR USE IN DETERMINATION OF VOLUMETRIC FLOW RATE FOR THE WEDDING & ASSOCIATES' CRITICAL FLOW HIGH VOLUME SAMPLER Prepared by: James B. Wedding, Ph.D. Michael A. Weigand, Esq. Young J. Kim, Ph.D. Prepared for: Department Of Air Pollution Control Division Of Monitoring 5324 Distributor Dr. Richmond, VA 23255 Work Order #1103

2.   Single Point Verification Procedure Utilizing Factory Look-Up Table

a. Remove upper portion of the filter cassette, set a clean quartz filter in place on the lower cassette plate, and install top loading adapter.	 filter centered on wire screen of lower cassette plate; washers & wing nuts; top loading adapter

b. Attach calibration orifice to the top loading adapter. NOTE: Do not use any flow restriction plates with the calibration orifice during this procedure	
c. Turn the sampler on and allow it to warm-up to operating temperature (usually 3 minutes).	refer to picture of on off switch

d. Read and record the following parameters on the single point verification data sheet:

- Station #, location, and date
- Sampler base #, inlet #, state ID #
- Ambient station barometric pressure
- Ambient temperature
- Orifice #, orifice calibration date
- Orifice calibration equation parameters (slope and intercept)

data sheet using lookup table

STATION # ______ LOCATION ____________________ DATE ________

SAMPLER BASE # ________ INLET # _______ STATE ID #__________

P_o = Ambient Barometric Pressure = _______ inches of Mercury

T_o = _________ Temp. $^oF + 460^o$ = _________ ^oR

Orifice s/n __________ Orifice Calibration Date ____________

Orifice Cal. Equation:

$$Q_a = [(\_\_\_\_\_\_\_\_ * \sqrt{H_2O * P_o/T_o}) \pm \_\_\_\_\_\_\_\_] * T_o/P_o$$

e. Connect the manometer (reading in inches of water) to the calibration orifice on the top loading adapter. Ensure that one side of the manometer is open to the atmosphere.

f. On the data sheet record the pressure drop reading from the water manometer.

H_2O Orifice, in. water	P_{stg}, in. Hg	$P_1 = P_o - P_{stg}$
4.98		

g. Connect the manometer (reading in inches of mercury) to the sampler stagnation pressure port located on the side of the sampler base. Ensure that one side of the manometer is open to the atmosphere.

h. On the data sheet record the stagnation pressure (Pstg) reading from the mercury manometer.

H_2O Orifice, in. water	P_{stg}, in. Hg	$P_1 = P_o - P_{stg}$
4.98	1.81	

i. Calculate P1. P1 = Po – Pstg.

H_2O Orifice, in. water	P_{stg}, in. Hg	$P_1 = P_o - P_{stg}$
4.98	1.81	27.93

j. Determine the ratio of P_1/P_0. This will be a number less than 1.000. The ratio should be recorded to the third decimal point.

P_{stg}, in. Hg	$P_1 = P_o - P_{stg}$	P_1/P_o
1.81	27.93	0.939

k. Using the manufacturer's Look-up table, determine the flow rate for the ratio of P_1/P_0 and the ambient temperature. Record this sampler flow rate on the single point verification sheet.

Note: Use of the look-up table is part of initial training for sampler operation.
Contact OAQM with questions.

$P_1 = P_o - P_{stg}$	P_1/P_o	Q_a, Sampler Look-Up Table
27.93	0.939	39.51 cfm

l. Determine Qa, orifice flow, by using the orifice calibration equation and record on the single point verification data sheet in the box labeled Qa, orifice equation.

P_1/P_o	Q_a, Sampler Look-Up Table	Q_a, Orifice Equation
0.939	39.51 cfm	41.50 cfm

m. Determine the "Difference cfm" and record.

$$\text{Difference cfm} = Q_a\ (\text{PM10 sampler}) - Q_a\ (\text{Orifice flow})$$

n. Determine the "difference %" and record.

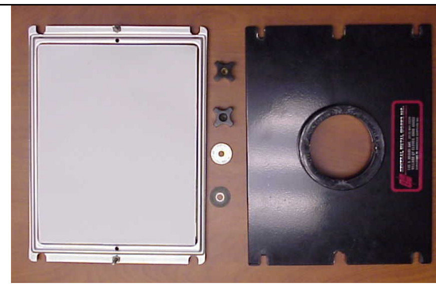
$$\text{Difference \%} = \frac{Q_a\ (\text{PM10 sampler}) - Q_a\ (\text{Orifice flow})}{Q_a\ (\text{Orifice flow})} * 100$$

o. If the result of the single point verification is within the acceptable range of +/- 7%, shut off the sampler and remove the verification equipment. If the result is outside the desired limits, check for leaks, errors in calculation, etc. If the problem cannot be resolved on-site, notify the PM10 coordinator, Office of Air Quality Monitoring immediately.

Difference	
CFM	%
-1.99 cfm	-4.80 %

p. Photocopy and keep a copy of the calibration for regional records. Forward the original to the PM10 coordinator at OAQM within five working days after the calibration.

3. **Single Point Verification Procedure Utilizing Flow Rate Equation**

a. Remove upper portion of the filter cassette, set a clean quartz filter in place on the lower cassette plate, and install top loading adapter.	 filter centered on wire screen of lower cassette plate; washers & wing nuts; top loading adapter
b. Attach calibration orifice to the top loading adapter. NOTE: Do not use any flow restriction plates with the calibration orifice during this procedure	
c. Turn the sampler on and allow it to warm-up to operating temperature (usually 3 minutes).	refer to picture of on off switch

d. Read and record the following parameters on the single point verification data sheet:

- Station #, location, and date
- Sampler base #, inlet #, state ID #
- Ambient station barometric pressure
- Ambient temperature
- Orifice #, orifice calibration date
- Orifice calibration equation parameters (slope and intercept)

data sheet using calibration flow rate equation

STATION # ______ LOCATION ____________________ DATE ________

SAMPLER BASE # ________ INLET # _______ STATE ID #__________

P_o = Ambient Barometric Pressure = _______ inches of Mercury

T_o = _________ Temp. $^oF + 460^o$ = _________ ^oR $\sqrt{T_o}$=__________

Orifice s/n __________ Orifice Calibration Date ____________

<u>Orifice Cal. Equation:</u>

$$Q_a = [(\_\_\_\_\_\_\_\_ * \sqrt{H_2O * P_o/T_o}) \pm \_\_\_\_\_\_\_\_] * T_o/P_o$$

e. Connect the manometer (reading in inches of water) to the calibration orifice on the top loading adapter. Ensure that one side of the manometer is open to the atmosphere.

f. On the data sheet record the pressure drop reading from the water manometer.

H_2O Orifice, in. water	P_{stg}, in. Hg	$P_1 = P_o\text{-}P_{stg}$
4.98		

g. Connect the manometer (reading in inches of mercury) to the sampler stagnation pressure port located on the side of the sampler base. Ensure that one side of the manometer is open to the atmosphere.

h. On the data sheet record the stagnation pressure (Pstg) reading from the mercury manometer.

H_2O Orifice, in. water	P_{stg}, in. Hg	$P_1 = P_o\text{-}P_{stg}$
4.98	1.81	

i. Calculate P_1. $P_1 = P_0 - \text{Pstg}$.

H_2O Orifice, in. water	P_{stg}, in. Hg	$P_1 = P_o\text{-}P_{stg}$
4.98	1.81	27.93

j. Determine the ratio of P_1/P_0. This will be a number less than 1.000. The ratio should be recorded to the third decimal point.

P_{stg}, in. Hg	$P_1 = P_o - P_{stg}$	P_1/P_o
1.81	27.93	0.939

k. Using the PM10 multi point calibration flow rate equation, determine the flow rate. Record the flow on the single point verification sheet in the box labeled Qa, PM10 cal. equation.

Slope (m) and intercept (b) will be provided by OAQM.

$P_1 = P_o - P_{stg}$	P_1/P_o	Q_a, PM10 cal. equation
27.93	0.939	39.51 cfm

PM10 FLOW RATE EQUATION: Date of current multi-point cal. ______

From multi-point calibration: m = ________ b = _________

$$Q_a = \frac{(P_1/P_o - b) * \sqrt{T_o}}{m}$$

l. Determine Qa, orifice flow, by using the orifice calibration equation and record on the single point verification data sheet in the box labeled Qa, orifice equation.

P_1/P_o	Q_a, Sampler Look-Up Table	Q_a, Orifice Equation
0.939	39.51 cfm	41.50 cfm

m. Determine the "Difference cfm" and record.

$$\text{Difference cfm} = Q_a\ (\text{PM10 sampler}) - Q_a\ (\text{Orifice flow})$$

n. Determine the "difference %" and record.

$$\text{Difference \%} = \frac{Q_a\ (\text{PM10 sampler}) - Q_a\ (\text{Orifice flow})}{Q_a\ (\text{Orifice flow})} * 100$$

o. If the result of the single point verification is within the acceptable range of +/- 7%, shut off the sampler and remove the verification equipment. If the result is outside the desired limits, check for leaks, errors in calculation, etc. If the problem cannot be resolved on-site, notify the PM10 coordinator, air monitoring section immediately.

Difference	
CFM	%
-1.99 cfm	-4.80 %

p. Photocopy and keep a copy of the calibration for regional records. Forward the original to the PM10 coordinator at the Office of Air Quality Monitoring within five working days after the calibration.

I. Quarterly Flow Check for the Wedding Volumetric Flow Controlled Sampler

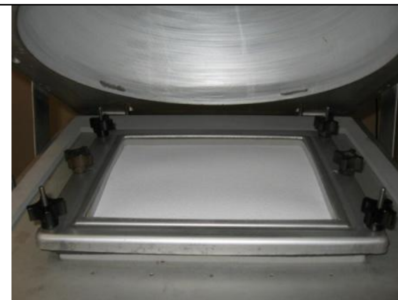
A flow check is to be performed on the Wedding and Associates PM10 sampler once every three months. This procedure is for verification that the sampler is operating at its design condition flow rate of 40 actual cubic feet per minute (CFM). The single point verification is not a substitute for the quarterly flow check, and conversely, the quarterly flow check is not a substitute for the single point verification. Both are part of the quality assurance procedures for this sampler. Failure to perform a timely quarterly flow check will result in the voiding of all data produced by that monitor during the quarter in which the flow check was to have taken place.

1. Assemble the quarterly flow check equipment

The following equipment is required to perform a quarterly flow check:

a. A filter cassette and a clean filter.	
b. A thermometer capable of accurately measuring ambient temperatures to the nearest +/- 1 degree Fahrenheit.	
c. A barometer capable of accurately measuring ambient station barometric pressure to the nearest hundredth of an inch of mercury.	
d. Tubing and a mercury manometer for measurement of the stagnation pressure in the sampler.	
e. Quarterly flow check data sheet and manufacturer's look-up table specific for the sampler. Instead of the look-up table you can use the PM10 multipoint calibration equation (if it is available). Quarterly flow check data sheet	

2. **Quarterly flow check procedure utilizing factory look-up table or PM10 flow rate equation**

a. Place a clean PM10 quartz filter in a filter cassette, and install in the sampler.	
b. Close the inlet.	
c. Connect the mercury manometer to the stagnation pressure port mounted on the sampler. Make sure that one side of the manometer is open to the atmosphere	
d. Turn the sampler on and allow it to warm-up to operating temperature (usually 3 minutes).	refer to picture of on off switch

e. Read and record the following parameters on the monthly flow check form:

- Station#, location, and date
- Sampler base #, inlet #, state ID #
- Ambient station barometric pressure
- Ambient temperature
- PM10 flow rate equation parameters (if available)

data sheet for quarterly flow check

STATION # ______ LOCATION ____________________ DATE ________

SAMPLER BASE # ________ INLET # _______ STATE ID #__________

P_o = Ambient Barometric Pressure = _______ inches of Mercury

T_o = _________ Temp. $^oF + 460^o$ = _________ ^oR $\sqrt{T_o}$=__________

f. Measure the stagnation pressure drop (Pstg) at the port on the left side of the monitor in inches of mercury. Make sure that the same units are used for both the barometric pressure and the stagnation pressure drop.

g. On the data sheet record the stagnation pressure (Pstg) reading from the mercury manometer.

Design Flow	P_{stg}, in. Hg	$P_1 = P_o - P_{stg}$
40 cfm	1.58	

g. Subtract the stagnation pressure drop from the barometric pressure ($P_1 = P_0$ – Pstg) and record on the form.

Design Flow	P_{stg}, in. Hg	$P_1 = P_o - P_{stg}$
40 cfm	1.58	28.16

h. Calculate P_1/P_0 and record on the form.

P_{stg}, in. Hg	$P_1 = P_o - P_{stg}$	P_1/P_o
1.58	28.16	0.947

h. <u>If using the manufacturer's look-up table</u>, use the P_1/P_0 ratio and ambient temperature to find the flow rate. Record this value on the form as Qa, the calculated flow rate. Proceed to instruction j.

$P_1 = P_o - P_{stg}$	P_1/P_o	Q_a, Flow Rate
28.16	0.947	40.31 cfm

i. <u>If using the [PM10 flow rate equation]</u>, use the P1/Po ratio, ambient temperature, and equation parameters to solve for Qa.

$P_1 = P_o - P_{stg}$	P_1/P_o	Q_a, Flow Rate
28.16	0.947	40.31 cfm

j. Determine the "Difference cfm" and record.

$$\text{Difference cfm} = Q_a\ (\text{PM10 sampler}) - Q_a\ (\text{Orifice flow})$$

k. Determine the "difference %" and record.

$$\text{Difference \%} = \frac{Q_a\ (\text{PM10 sampler}) - Q_a\ (\text{Orifice flow})}{Q_a\ (\text{Orifice flow})} * 100$$

l. Compare the calculated flow rate with the design flow rate, i.e., “difference cfm” and “difference %”. The flow rate difference should be +/- 7%. If not, check for leaks, errors in calculation, etc. If the problem cannot be resolved, contact PM10 coordinator, Office of Air Quality Monitoring immediately.

Difference	
CFM	**%**
-1.99 cfm	**-4.80 %**

m. Forward the results of the flow check to PM10 coordinator, OAQM, within five (5) working days.

Attachment A

Note: The multipoint calibration is not a routine QA/QC procedure. The procedures are provided as information purposes only, and to provide a thorough coverage of PM10 standard operating procedures. This is OAQM's responsibility.

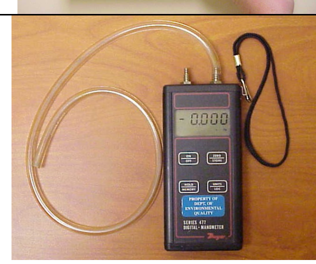
J. **Multipoint Flow Rate Calibration Procedure for Wedding Volumetric-Flow Controlled PM-10 Sampler**

Calibration of the Wedding VFC sampler requires the determination of the ratio of the sampler stagnation pressure (P_1) to the ambient pressure (P_0) and the ambient temperature (T_0).

The calibration relationship, which relates the sampler's average actual flow rate (Qa to P_1/P_0 and T_o) is incorporated by the manufacturer into a LOOK-UP table for use in the field. Since the calculations to determine these flow rates manually are extensive (requiring certain constants, average annual temperature at monitoring site, and the diameter of the sampler's critical flow orifice), accuracy of the manufacturer's table is verified by performing a multipoint calibration and design condition test.

The sampler's flow control system (a critical orifice) is precisely designed for a given annual temperature and pressure, and no means is provided for the user to adjust the operational flow rate.

1. **Assemble the multipoint flow rate calibration equipment**

a. Flow rate standard (variable orifice type) with current calibration traceable to NBS, and top loading adapter.	
b. Tubing and a water manometer with 0 to 20 inch range and a mercury manometer with 0 to 8 inch range, both with a minimum scale division of one-tenth. (W & A calibrator may be used in place of mercury manometer).	

c. A thermometer capable of accurately measuring ambient temperature to the nearest +/- 1 degree Fahrenheit.	
d. Barometer, capable of accurately measuring ambient barometric station pressure to the nearest hundredth of an inch of mercury.	
e. Multipoint calibration worksheet. – Contact OAQM.	
f. Calculator.	

2. **Multipoint Flow Rate Calibration Procedure**

a. Remove the filter cassette and replace with top loading adapter. Figure 1 illustrates the calibration configuration of the Wedding VFC sampler. Install variable orifice open to maximum flow and turn the sampler on. Allow the sampler to warm-up to operating temperature (3 to 5 minutes).
b. Read and record the following parameters on the Sampler Data Sheet:

- Ambient Temperature (T_0)
- Ambient barometric pressure (P_0)
- Sampler model #, S/N
- Orifice serial # & parameters
- Date, location, operator

c. Connect the water manometer to the variable orifice and the mercury manometer (or W & A calibrator) to the sampler stagnation pressure port located on the side of the sampler base. Ensure that one side of each manometer is open to atmospheric pressure.
d. Record the water manometer reading on the calibration sheet. Record the stagnation pressure drop (Pstg) as indicated by the mercury manometer. If using the W & A calibrator, record the digital readout in the P_1 column and leave the Pstg column blank.
e. Repeat step d for the rest of the variable orifice settings
f. Turn the sampler off, disconnect the manometer tubes and remove the calibration orifice with top loading adapter. Replace the filter cassette
g. Perform the calibration calculations. The data generated will be used to establish the correct calibration formula to be used for single point verifications and monthly flow checks.

3. **Multipoint Flow Rate Calibration Calculations**

All calibration data should be collected, including the orifice calibration information and the sampler calibration data sheet.

a) If a mercury manometer was used, calculate the P_1 column by subtracting the Pstg reading from the barometric pressure value.
b) Calculate the Ratio (Y) reading by dividing the value in the P_1 column by the barometric pressure value.
c) Calculate the Qa values by using the H2O readings and the orifice calibration equation.
d) Calculate the X values by dividing the readings in the Qa column by the square root of T_o (ambient temperature in Rankine).
e) On a piece of graph paper, plot the values of the Ratio (Y) column versus the corresponding values in the X column. Using linear regression, determine the best fit line through the points. If any values fall substantially off the line, then that point should be repeated. If this is done, replot the point and recalculate the linear regression.
f) Determine and record the slope (m), intercept (b), and the correlation (r) in the blanks and in the calibration formula section on the lower portion of the multipoint calibration sheet.
g) Conduct a single point verification and quarterly flow check utilizing the new PM10 calibration formula. Staple all three checks with a photocopy of the graph of X vs. Y, and deliver to the PM10 coordinator within two working days of the calibration.

Sampler Calibration Frequency – To ensure accurate measurement of the PM10 concentration, a multipoint calibration is to be performed on the unit:

1. before installation,
2. after any repairs that may affect sampler calibration, or
3. if the results of a field flow check exceed +/- 10% from the sampler's indicated flow rate.