California Environmental Protection Agency

AIR RESOURCES BOARD

AIR QUALITY SURVEILLANCE BRANCH

STANDARD OPERATING PROCEDURES

FOR

TISCH ENVIRONMENTAL MODEL TE-6070V SIZE SELECTIVE INLET PM10 SAMPLER with VOLUMETRIC FLOW CONTROLLER

AQSB SOP 408

First Edition

MONITORING AND LABORATORY DIVISION

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California Environmental Protection Agency
AIR RESOURCES BOARD

Approval of Standard Operating Procedures (SOP)

Title: TISCH ENVIRONMENTAL MODEL TE-6070V SIZE SELECTIVE INLET PM10 SAMPLER with VOLUMETRIC FLOW CONTROLLER

SOP: AQSB SOP 408, First Edition

Section: Operation Support Section, Air Monitoring North Section

Branch: Air Quality Surveillance Branch (AQSB)

Division: Monitoring and Laboratory Division (MLD)

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1.0 GENERAL INFORMATION

1.1 Introduction:

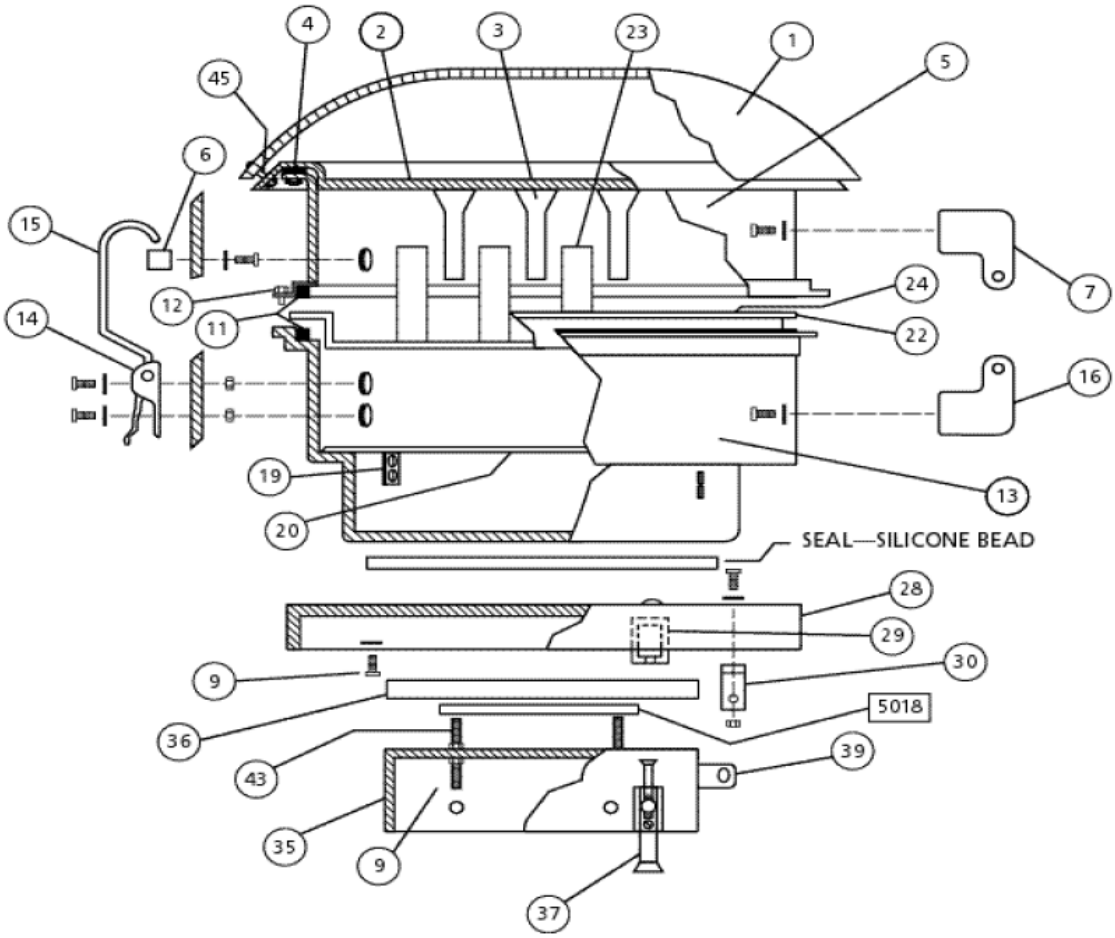
The purpose of this Standard Operating Procedure (SOP) is to document the Tisch Environmental Model TE-6070V Size Selective Inlet PM10 Sampler with Volumetric Flow Controller (PM10 VFC Sampler) procedures used by the Air Quality Surveillance Branch (AQSB) of the California Air Resources Board (ARB). The goal of this SOP is two-fold; to formalize the PM10 VFC Sampler configuration and operation procedures in order to ensure comparability among all PM10 VFC Sampler data, and to describe supplemental information and modifications to the TE-6070V Operation Manual necessary to successfully integrate the PM10 Sampler into AQSB's ambient air monitoring network. The PM10 VFC Sampler Operation Manual contains a significant source of information pertinent to the operation, maintenance, and understanding of this instrument, and therefore the AQSB highly recommends a thorough review of the PM10 VFC Sampler Operation Manual.

1.2 Principle of Operation:

Refer to Figure 1, PM10 VFC Sampler Head, and Figure 2, PM10 VFC Sampler Base, of this document, as the following describes the operation of the Tisch Environmental Model TE-6070V Size Selective Inlet PM10 Sampler with Volumetric Flow Controller.

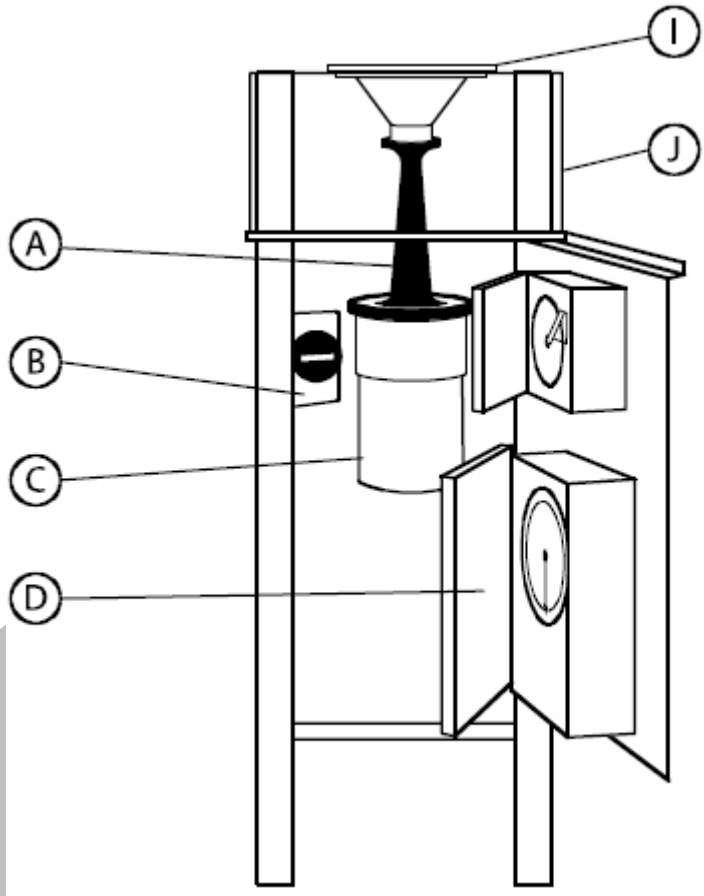
The PM10 VFC Sampler draws air into a specifically shaped inlet at 40 cubic feet per minute (CFM). The standard flow rate is altitude dependent. PM10 particulate matter collects on an 8" x 10" matted quartz fiber surface. The concentration of PM10 particulate matter (in micrograms per cubic meter) is calculated by weighing the collected particulates and dividing by the measured volume of air sampled. The standard sampling frequency is every sixth day for a 24 hour period.

The inlet head is symmetric and therefore insensitive to wind direction, and has been determined to be relatively insensitive to wind speed. Using a motor and volumetric flow controller, the air is drawn through the acceleration nozzles at 40 CFM. Particles larger than 10 microns cannot follow the air stream as they are deflected below the nozzles and fall onto the flat surface of the greased collection shim below the nozzles. The air sample is then drawn through vent tubes, and then through the filter, where the particulate matter less then 10 microns is collected. The height of the vent tube inlets above the acceleration nozzle plate and the use of the greased shim prevents re-entrainment of particles larger than 10 microns.



1. Hood
2. Acceleration Nozzle Plate with 9 nozzles
3. Acceleration Nozzle
20. Bug Screen
23. Vent Tube
24. Greased Collection Shim

Figure 1
PM10 VFC Sampler Head (only pertinent parts noted)



A. Volumetric Flow Controller
B. Elapsed Time Meter
C. Motor Housing
D. Timer
I. Filter Cartridge

Figure 2
PM10 VFC Sampler Base (only pertinent parts noted)

Figure 3
PM10 VFC Sampler

1.3 Safety Precautions:

Only properly trained personnel should perform PM10 VFC Sampler 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.

To avoid electrical shock, prior to cleaning or performing any maintenance on the PM10 VFC Sampler, unplug the 115 volt AC power cord.

1.4 Interferences/Limitations:

1. The matted quartz fiber filter is very delicate and can be easily torn or gouged. Handle carefully by the edges. Damaged filters will be invalidated.

2. Use factory specified replacement parts only. Each PM10 VFC Sampler model is a separate United States Environmental Protection Agency (U.S. EPA) Designated Reference Method.

1.5 Siting:

The PM10 VFC Sampler should be sited in accordance with the U.S. EPA Title 40, Code of Federal Regulations Part 58 (40 C.F.R. 58 Appendix E)

2.0 SAMPLING PROCEDURE

2.1 Sampling Frequency:

The AQSB PM10 VFC samplers are typically operated on a six-day sampling schedule as specified by the U.S. EPA. For special projects, the sampling frequency may vary. Table 1 specifies ARB's standard six-day sampling schedule for 2010. The sampling duration is 24 hours, 0001 to 2359 hours PST. Special sampling (sulfates, etc.) may require varied time schedules and other than the 0001 hour starting time.

2.2 Pre-Run Procedure:

1. Prior to sampling, complete the 24-Hour PM10 Air Sample Report as shown in Appendix A of this document. The Air Sample Report is provided with each pre-weighed filter. Record sample information on the AQSB Monthly Quality Control Check Sheet (AQSB QC Form 408), as shown in Appendix B of this document.

2. Install a clean, unexposed, pre-weighed filter. The PM10 VFC Sampler is equipped to use a portable filter cartridge (FC) to protect the fragile filter during installation under windy conditions. The clean, unexposed filter should be installed in the FC inside a clean monitoring station or a clean office before being transported to the sampling site. Place the numbered side of the filter facing down. When handling quartz PM10 filters during the FC loading and unloading operations, avoid contamination of the filter by wearing latex gloves. The filter should be carefully placed on the stainless steel screen of the FC and secured in place by the hold-down frame. Care should be taken to install the filter evenly on the frame so the exposed area is parallel with the filter sides. Install the windscreen cover on the FC and transport the loaded FC to the sampler and place it over the 8" x 10" mount and attach it to the bottom base plate with four swing bolts and nuts. Figure 4 of this document shows an installed FC.

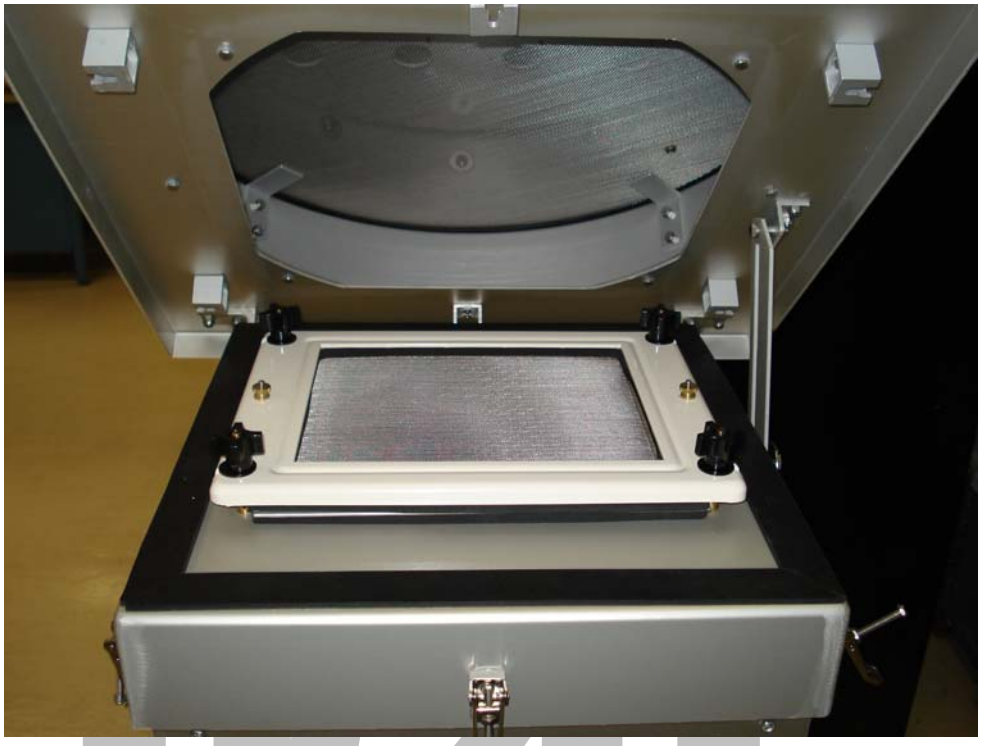


Figure 4
Installed Filter Cartridge

Close the Size Selective Inlet (SSI) hinged top and tighten down the swing nuts to seal the 8" x 10" SSI base gasket to the top of the FC. Do not over tighten or it may result in deformation of the faceplate gasket.

3. Record the filter number, station number, and sample date on the back of the Dickson chart. Carefully insert the new chart into the recorder. Center the tab on the slotted drive (turn the chart if necessary) so that the chart will rotate the full 360 degrees without binding or slipping. If an uneven chart is encountered, it may be required to cut approximately 1/8" off the circumference of the chart to prevent binding. Rotate the chart so that the pen head rests on the predetermined start time (usually 0001 hours) if the chart drive on the recorder does not run continuously, or to the current standard time if the chart drive runs continuously. Turn on the sampler, tap the recorder lightly, and allow it to run for 5 minutes.

   The Dickson chart is used to verify that the sampler operated at a constant flow rate for a 24 hour sample period. Figure 5 of this document shows an installed Dickson chart.

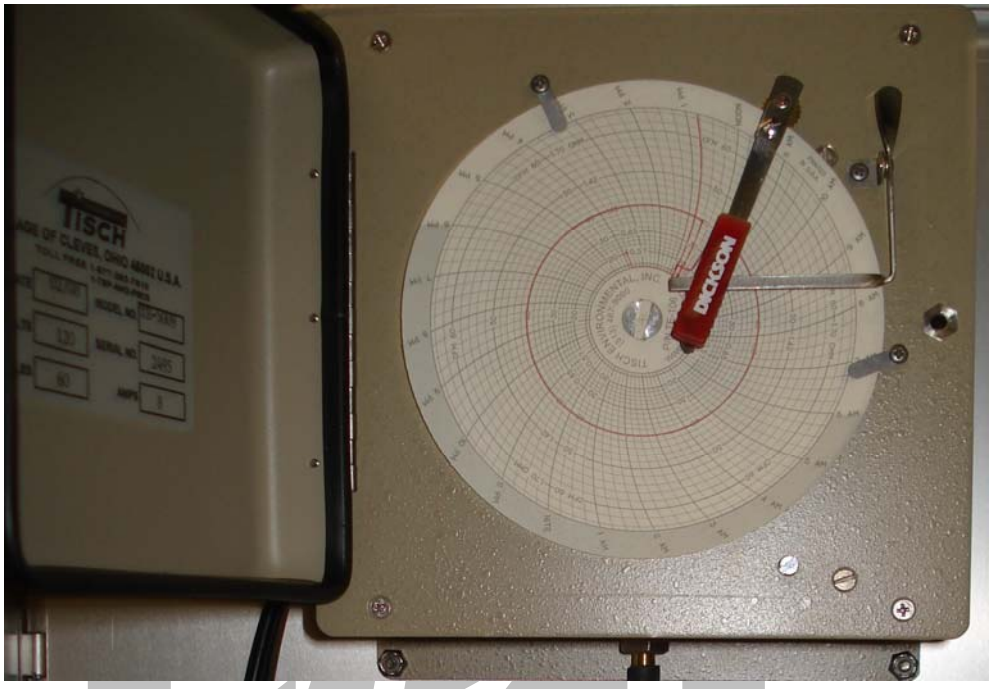


Figure 5
Dickson Chart

4. Determine the initial differential pressure reading, across the filter, from the 0 – 40 inches of water Magnehelic mounted on the sampler. Pre and Post Magnehelic readings are averaged to determine the pressure drop across the filter for the 24 hour sample period. Record the Pre reading on the 24-Hour PM10 Air Sample Report in the "Pd(I)" box and on the Monthly Quality Control Maintenance Check Sheet in the "Initial Filter Pressure Drop" box.

5. Turn off the sampler.

6. Set the sampler's timer to start at the pre-determined start time on the designated date, and to shut off 24 hours later as follows:

   a. Dayton or Paragon Seven Day Timer – There are two separate trippers on the dial rim--they are not interchangeable. Place Tripper A at the desired time the sampler should turn on. Place Tripper B at the desired time the sampler should turn off. Trippers must be tight against the dial rim. Tighten tripper screws with fingers only. Grip dial and rotate CLOCKWISE ONLY until current day and time of day appear at the time pointer (do not turn the time pointer). The tripper must be adjusted to give a sample time of 24 hours $\pm$15 minutes.

b. General Metal Works Timer/Programmer (GMW-800) – Sixth Day Sampling: Place all seven day switches in the DOWN position. Reset the indicator light to the fifth from the left position (Thursday) by sequentially pressing the DAY RESET switch. Place the sixth DAY SAMPLE switch and the sixth from the left day switch (Friday) in the UP position. Set the toggle switch between clocks "A" and "B" to the left hand position. The sampling period is now set from midnight of the current day to midnight the following day, and every six days thereafter.

c. Tisch Environmental 302 Digital Timer – Set the Sample After Days dial to whatever number of days until the next sampling day. Set the Sample Every Days dial to position 6 for six-day sampling. Set the Sample For Hours dial to position 24. Press and release the Reset switch toward "Timer." A small triangle will start blinking on the display indicating that the timer is running.

7. Record the initial elapsed time meter reading on the 24-Hour PM10 Air Sample Report on the line marked "START", and on the Monthly Quality Control Maintenance Check Sheet in the "Initial Time Meter Reading" box.

8. Set the sampler as scheduled.

2.3 Post-Run Procedure:

1. Remove the Dickson chart and verify that the sampler operated as expected.

2. Record the final elapsed time meter reading on the 24-Hour PM10 Air Sample Report on the line marked "FINISH", and on the Monthly Quality Control Maintenance Check Sheet in the "Final Time Meter Reading" box. These elapsed time meter readings are used in calculating the concentration of collected particulates as they are more accurate than the timer or flow chart times.

3. Turn on the sampler and allow it to run for 5 minutes. Read the differential pressure reading, across the filter, from the 0 – 40 inches of water Magnehelic mounted on the sampler. Record the Post reading on the 24-Hour PM10 Air Sample Report in the "Pd(F)" box and on the Monthly Quality Control Maintenance Check Sheet in the "Final Filter Pressure Drop" box.

4. Turn the sampler off.

5. Obtain the most accurate ambient temperature for the site of the 24 hour sampling period. This information can be obtained from the following list in preferential descending order:

   a. The ambient temperature sensor/data logger system on site.

   b. Any ARB/MLD air monitoring station within 25 miles and 500 feet in elevation.

   c. The average temperature for the run period as collected in the area from the National Weather Service.

   d. A seasonal average daily temperature for the sampling site.

   Record this temperature on the 24-Hour PM10 Air Sample Report on the line marked “Ta”, and on the Monthly Quality Control Maintenance Check Sheet in the “Average 24 Hour Ambient Temperature” box.

6. Obtain the most accurate average daily barometric pressure. This information can be obtained from Table 2 of this document. For air monitoring sites with elevations below 50 feet, use the ambient sea level pressure (760 mmHg). For air monitoring sites with elevations greater than 50 feet and less than 149 feet, use the pressure correction factor for 100 feet. For air monitoring sites with elevations greater than 150 feet and less than 249 feet, use the pressure correction factor that corresponds to 200 feet, etc.

   The pressure can also be calculated by multiplying the altitude correction factor by 760 mmHg. The pressure must be reported in mmHg. Enter the pressure value in the box labeled "Ambient Pres mmHg (Pa)" on the VFC Calibration Data Sheet. Also, report the barometric pressure value on the Monthly Quality Control Maintenance Check Sheet in the box labeled "Average 24 Hour Ambient Press".

7. Carefully remove the exposed filter. The removable (FC) should be loaded and unloaded at the station operator's headquarters to avoid contamination and damage to the quartz fiber filter media. Install the metal window screen and remove the FC from the sampler and install a second pre-loaded FC in the sampler. After transporting the FC to an inside room, remove the metal window screen cover. Then remove the filter from the FC after removing the knurled brass nuts and hold-down frame. Grasp the exposed filter without touching the darkened area and fold it in half, width-wise, with the exposed, darkened side in. Slide the folded filter into the provided wax envelope.

When handling quartz PM10 filters during the FC loading and unloading operations, avoid contamination of the filter by wearing latex gloves. A satisfactory filter is one which has a uniform white border. Dark streaks into the border may indicate an air leak which could invalidate the sample. If the dividing line between dark exposed portion and white unexposed portion of the filter is blurred or not straight, or is undefined, the filter hold down gasket may be leaking or warped, and should be replaced. If there are insects on the filter, remove them carefully with tweezers. Note on the Air Sample Report if the filter is torn or ruptured, if pieces of filter are left sticking to the gasket, if the start or finish times are not known, or if the flows are outside the acceptable range.

Send the filter, Dickson chart and 24-Hour PM10 Air Sample Report to the laboratory in a provided manila folder.

Invalidations may be determined by Field and/or Laboratory staff.

8. The quantification of the flow through the VFC PM10 Sampler is a two part process. The first part of the calculation requires the determination of the sampler "volumetric flow". The second part requires the determination of the sampler "standard flow". For the size selective inlet in the PM10 sampler to collect valid samples, the PM10 sampler must operate between 36 and 44 cubic feet per minute (CFM).

   Data reported to the Federal database must be reported at standard conditions in standard cubic feet per minute (SCFM). SCFM is the flow rate referenced to a temperature of 25 degrees centigrade, and a pressure of 760 millimeters of mercury (mmHg).

   Data reported to the State database must be reported at local conditions in actual cubic feet per minute. Actual flow uses the same formula to determine standard flow, but using local temperature and pressure conditions (LTP).

   The calculation to determine volumetric flow for the ARB PM10 VFC samplers is:

   Volumetric CFM = [45.379 x (Po/Pa) - 2.243] + [(Ta - 25) x 0.059]

   Po/Pa = Pressure ratio (1 – Pf/Pa)
   Pf = differential pressure across filter (mmHg)
   Pa = the ambient pressure (mmHg)
   Ta = the temperature in degrees centigrade (deg C)

This equation was developed by the ARB in 1993 by evaluating the pressure ratio (Po/Pa) versus actual flow rate (CFM) for 40 VFC PM10 Samplers where:

Once the volumetric flow has been calculated for the PM10 sample, its value is used to determine the standard flow with the following relationship:

$$SCFM = CFM \times (Pa/760) \times (298/Ta)$$

Pa = the average absolute ambient pressure in mmHg
Ta = the average absolute ambient temperature in degrees Kelvin (K)
(degrees K = degrees C + 273)

The Laboratory Information Management System (LIMS) automatically calculates the volumetric and standard flow rates with the pre and post filter pressure drops, the average ambient temperature, and the average ambient pressure for the samples analyzed at the PM10 balance room in Sacramento.

2.4 Quality Control Criteria:

Quality control invalidation criteria for PM10 quartz filter samples collected on Size Selective Inlet (SSI) samplers are listed below. All samples collected in the field are to be checked using these criteria. If a sample does not meet these criteria, the sample is invalid. If a **SAMPLE IS INVALIDATED** the **FILTER** and the **COMPLETED REPORT FORM** should be sent to the **LABORATORY** and a **MAKE-UP SAMPLE SCHEDULED FOR THE EARLIEST POSSIBLE DATE**.

1. Filter Contamination – Filters which are dropped or become contaminated by any foreign matter (i.e., dirt, finger marks, ink, liquids, etc.) are invalid.

2. Damaged or Torn Filters – Filters with tears or pinholes which occurred before or during sampling are invalid.

   NOTE: Care should be used when removing a spent filter from the sampler holder. If you tear, rip or otherwise damage a filter when removing it, it is considered invalid and a make-up run should be conducted.

3. Sample Flow Rate – If the flow rate through the sampler varies outside the calculated acceptable range for each site for more than one hour during the sampling period, the sample is invalid. This includes irregular flow rate excursions and the sampler warm-up stabilization period.

4. Start/Stop Times – The sampler start and stop time must be 12:00 midnight ± 30 minutes. Please, note that if the Dickson recorder chart indicates the sample began before 2330 hours or after 0030 hours, the sample is invalid unless the operator can determine that the error in start/stop time was the result of an accidental error in the recorder pen alignment. Please note the error and verify the validity of the sample in the comments section of the report form.

5. Sample Run Duration – Sample run duration shall be at least 23 hours and no more than 25 hours. Filter samples collected on samplers which operated for less than 23 hours or more than 25 hours, as documented by the Dickson recorder chart and/or the elapsed time meter, are invalid.

6. Power Failure – If a power failure during a sample run causes the stop time or sample run duration requirements (4 and 5 above) to be violated, the sample is invalid.

7. Dickson Recorder Chart – A complete Dickson recorder chart, documenting the flow rate through the sampler for 24 hours, must be submitted to the laboratory with each filter sample. Filter samples without a complete Dickson recorder chart record are invalid.

   NOTE: In cases of inking problems where the trace is not complete, if the operator validates the sampler operated properly in the comments section of the report form, the sample will be considered valid.

8. Report Form – The filter is considered invalid if a completed 24-Hour PM10 Air Sample Report is not included with the sample.

9. Filter Leakage – If the filter shows signs of air leakage due to a worn or improperly seated gasket, the sample will be invalidated.

2.5 Data Completeness:

Per 40 C.F.R. 50 Appendix K, a minimum of 75 percent of the scheduled PM10 sample runs per quarter are required. If a sample is invalidated or the PM10 VFC Sampler does not run as scheduled, a make-up sample run shall be scheduled for the earliest possible date.

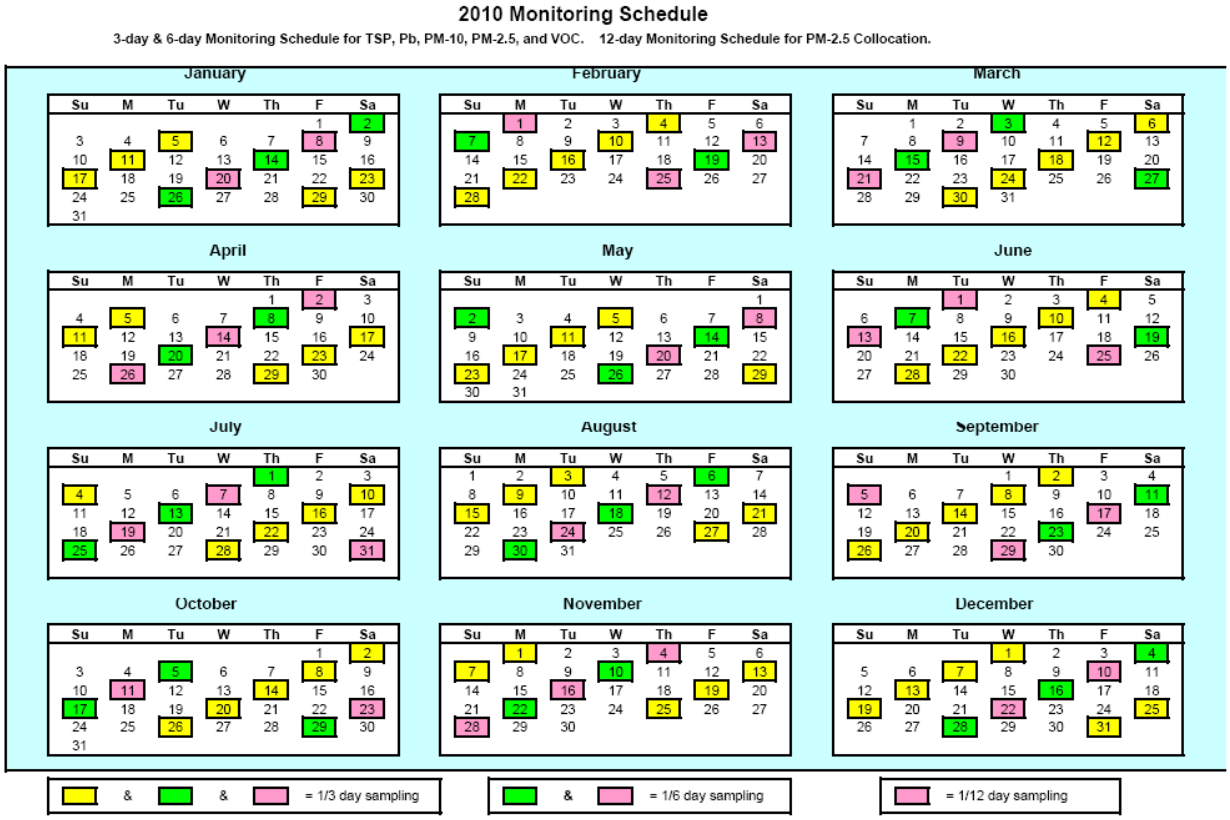


Table 1
Sampling Schedule – 2010

Altitude (feet)	ACF	Pressure mmHg	Altitude (feet)	ACF	Pressure mmHg	Altitude (feet)	ACF	Pressure mmHg
0	1.0010	760	3100	0.8922	678	6200	0.7953	604
100	0.9973	758	3200	0.8889	676	6300	0.7924	602
200	0.9936	755	3300	0.8857	673	6400	0.7894	600
300	0.9899	752	3400	0.8824	671	6500	0.7865	598
400	0.9863	750	3500	0.8791	668	6600	0.7836	596
500	0.9826	747	3600	0.8758	666	6700	0.7807	593
600	0.9790	744	3700	0.8726	663	6800	0.7778	591
700	0.9753	741	3800	0.8694	661	6900	0.7749	589
800	0.9717	739	3900	0.8662	658	7000	0.7721	587
900	0.9681	736	4000	0.8629	656	7100	0.7692	585
1000	0.9645	733	4100	0.8958	653	7200	0.7663	582
1100	0.9610	730	4200	0.8566	651	7300	0.7635	580
1200	0.9574	728	4300	0.8534	649	7400	0.7607	578
1300	0.9539	725	4400	0.8502	646	7500	0.7579	576
1400	0.9503	722	4500	0.8471	644	7600	0.7551	574
1500	0.9468	720	4600	0.8440	641	7800	0.7523	572
1600	0.9433	717	4700	0.8408	639	7900	0.7495	570
1700	0.9398	714	4800	0.8377	637	8000	0.7467	567
1800	0.9363	712	4900	0.8346	634	8100	0.7412	563
1900	0.9329	709	5000	0.8315	632	8200	0.7384	561
2000	0.9294	706	5100	0.8284	630	8300	0.7357	559
2100	0.9260	704	5200	0.8254	627	8400	0.7330	557
2200	0.9225	701	5300	0.8223	625	8500	0.7303	555
2300	0.9191	699	5400	0.8193	623	8600	0.7276	553
2400	0.9157	696	5500	0.8162	620	8700	0.7249	551
2500	0.9123	693	5600	0.8132	618			
2600	0.9090	691	5700	0.8102	616			
2700	0.9056	688	5800	0.8072	613			
2800	0.9022	686	5900	0.8042	611			
2900	0.8889	683	6000	0.8012	609			
3000	0.8956	681	6100	0.7983	607			

Table 2
Altitude vs. Barometric Pressure

3.0 CALIBRATION INFORMATION

3.1 Calibration Introduction:

A calibration is a procedure for aligning, checking, or adjusting the output of an instrument to a known “true” standard. An “AS-IS” verification is performed initially to quantify the instruments accuracy. The “AS-IS” verification verifies the accuracy of recently generated data, usually back to the previous calibration. A “Final” calibration is performed just after an instrument has been adjusted to a “true” standard. To ensure the quality of the data provided by the PM10 VFC Sampler, the sampler must be calibrated after any new installation, every six months, after any major maintenance, or if the initial flow meter reading falls outside the average initial flow meter reading tolerance limits shown on the Monthly Quality Control Check Sheet.

3.2 Calibration Overview:

The PM10 VFC Sampler is calibrated using an orifice transfer standard that has been standardized against a primary standard Roots meter. Two different types of orifice calibrators are available. One type uses multi-hole adapter plates to vary the flow. The second type has an adjustable flow restrictor. In either case, the calibrator is connected to a differential pressure gauge or slack tube manometer. Pressure drops and indicated flow meter readings are recorded and corrected for elevation as necessary. Using the pressure drops, the standard (true) flow rates are calculated using the certification equation for the transfer standard.

The volumetric flow controller (VFC) uses a vacuum cleaner motor that operates at maximum speed. The vacuum motor draws air through a fixed area in the VFC, and a critical flow is established through the PM10 sampling head at 40 CFM. Since the VFC's performance varies with ambient temperature and pressure, each VFC has a set of NIST traceable factory calibration tables for temperature in degrees C and F. For the sake of simplicity and with minimum error (+ 2.5 percent), all of the VFC calibration curves have been averaged to produce an average slope and intercept. The average slope and intercept will be used for the calibration and operation of the volumetric flow controllers used by all AQSB PM10 VFC samplers.

The VFC does not contain moving parts, so there is no mechanism to adjust the flow. The VFC's calibration will not change if the orifice is clean and the motor is able to operate at maximum speed. The following calibration procedure describes a "Single Point Calibration Verification" (SPCV).

3.3 Calibration Apparatus for PM10 VFC Sampler:

1. Certified BGI flow transfer standard (variable orifice)
2. Clean, quartz fiber filter
3. Dwyer digital manometer (0 – 40 inches of H_2O)
4. Certified BGI Delta Cal with temperature sensor
5. Dickson recorder chart
6. Calibration report or worksheet form (Appendix C or D)

4.0 CALIBRATION PROCEDURE

4.1 AS-IS Verification Procedures:

1. Turn on the digital manometer and BGI Delta Cal and allow the instruments to acclimate to ambient conditions for a minimum of 30 minutes.

2. Complete the Volumetric Flow Control PM10 Calibration Form (AQSB Cal Form 408) as much as possible before starting calibration. Record the date, location, site number, sampler make and model, VFC serial number, property number and relevant calibration standards information.

3. Measure and record the ambient temperature (Ta) and ambient pressure (Pa) with the temperature and pressure standard. Correct the temperature and pressure display readings if required.

4. Place a new circular chart on the samplers Dickson Chart Recorder. Install a clean quartz fiber filter in the sampler filter holder. Connect a certified digital manometer to the pressure tap at the top of the PM10 VFC Sampler. Turn on the sampler and allow it to run for 5 minutes to warm up the sampler motor. Measure the direct pressure drop across the filter (Pf) as displayed by the digital manometer in mmHg. Apply correction and conversion factors as necessary and record the Pf in mmHg. Gently tap the side of the Dickson chart recorder and spin the chart about 7 degrees of arc. Read and record the indicated Dickson chart reading on the PM10 VFC calibration form.

5. Turn off the sampler, remove the filter and install a certified BGI variable orifice as shown in Figure 6 of this document. Turn on the sampler and adjust the variable orifice until the pressure drop as measured by the digital manometer matches the Pf reading recorded in Section 4.1.4 above. Read and record the differential pressure on the BGI variable orifice magnehelic and the samplers' magnehelic gauge readings in inches of water.

Figure 6
Installed BGI Variable Orifice

6. Using the certification equation for the BGI variable orifice, calculate the true flow rate (Qt) as measured by the orifice. Record the true flow rate as indicated by the orifice. The following equation is it used to calculate Qt:

$$Qt_{(cfm)} = \left(cert\ slope \sqrt{orifice\ mag \times \left({Ta(^{\circ}K)}/{Pa} \right)} \right) - cert\ intercept$$

Where:

Qt = True flow in CFM
Cert slope = Certification slope for BGI Variable Orifice
Orifice Mag = The pressure drop measured by variable orifice in in H_2O
Ta = Ambient temperature in degrees Kelvin
Pa = Ambient pressure in mmHg
Cert Intercept = Certification intercept for BGI Variable Orifice

7. Next calculate the samplers volumetric flow rate. To do this, the pressure ratio (Po/Pa) must to be determined.

$$\frac{Po}{Pa} = \left(1 - \frac{Pf}{Pa}\right)$$

Where:

Po/Pa = pressure ratio
Pf = filter pressure differential (mmHg)
Pa = ambient pressure (mmHg)

8. Record the value for Po/Pa on the calibration worksheet. Calculate the samplers volumetric flow rate (Qv) using the following equation:

$$Qv_{(cfm)} = \left[\left(45.379 \times \left(Po/Pa\right)\right) - 2.243\right] + \left[\left(Ta - 25\right) \times 0.065\right]$$

Where:

Qv = Volumetric flow in CFM
Po = Absolute Pressure drop across clean filter in mmHg
Pa = Ambient Pressure in mmHg
Ta = Ambient Temperature in degrees Celsius

The slope and intercept of the above equation was developed by the Monitoring and Laboratory Division in April 1993. (Shahinian, 1993) These values were determined by comparing the relationship between the pressure ratio (Po/Pa) and the true flow (Qt) for forty PM10 volumetric flow controllers. Each VFC was received with a NIST traceable factory calibration look-up table specific for each VFC. The look-up table lists actual flow rates in CFM for different pressure ratios ranging from 0.930 to 0.979 at different temperatures. A slope and intercept relationship between the pressure ratio and true flow rate was determined for all 40 PM10 VFC's for ambient temperatures of 42, 76 and 100 degrees Fahrenheit and pressure ratio from .930 to .979. These slopes and intercepts where then averaged to develop the slope and intercept listed in the equation above.

In addition, the flow rate in CFM must be adjusted for temperature. The slope and intercept derived above were calculated at 25 degrees Celsius. The correction factor for temperature is ± 0.059 CFM per deg. C^o. The correction will be negative for temperatures below 25 C^o and positive for temperatures above 25 C^o. The correction factor for temperature in degrees Fahrenheit is ± 0.033 CFM per deg. F^o .

Record the samplers Qv in CFM on the calibration worksheet.

9. Calculate the samplers Percent difference from True using the following equation:

$$\%\ diff\quad from\, true = \left(\frac{Qv - Qt}{Qt}\right) \times 100$$

If the percent difference from true is greater than ± 5 percent perform a system leak check, inspect the sampler for debris or corrosion; inspect the motor brushes and motor or replace the VFC. If problems persist, contact the ARB's Operation Support Section's Instrument Laboratory.

10. Calculate the samplers' Percent Difference from Previous Calibration using the following equation:

$$\%\ diff\quad from\, previous = \left(\frac{Qt - Qtprev}{Qtprev}\right) \times 100$$

11. Read and record the zero point of the sampler magnehelic gauge on the calibration worksheet. If the zero reading is not zero, adjust magnehelic to read zero.

12. Determine the sampler magnehelic percent accuracy by using the equation below.

$$Magnahelic\ Accuracy\ (\%) = \left(\frac{((sam\ mag \times 1.867) - (Pa - aPf))}{(Pa - aPf)} \right) \times 100$$

Where:

Sam mag: = sampler magnehelic reading across clean filter in inches H20
Pa: = Ambient Pressure in mmHg
aPf: = Absolute pressure drop across a clean filter mmHg
aPf = Pa - Pf

The magnehelic accuracy percent must be within $\pm$ 5 percent. If the gauge is outside this limit it must be replaced.

13. Complete the calibration worksheet or AQSB Calibration Form 408 and submit to second level reviewer or supervisor for approval. Approved calibrations reports should be returned to site operator for inclusion in station file.

4.2 Final Calibration Procedures:

A final calibration is required after specified maintenance is performed (i.e., flow recorder change, 0-40 inch Magnehelic adjustment, VFC cleaning, VFC replacement, moving the sampler etc.). A final calibration is not needed for brush changes, unless the fixed orifice test indicates that the flow has changed by more than 2 percent. A final calibration can be performed by repeating the AS-IS verification procedure.

5.0 ROUTINE SERVICE CHECKS

5.1 General Information:

The following routine service checks are to be performed in accordance with the maintenance schedule listed below. Perform the routine service checks at least at the prescribed intervals or more often if necessary. The AQSB Monthly Quality Control Check Sheet (AQSB QC Form 408, as shown in Appendix A) should be completed weekly and submitted monthly to the station operator's supervisor. The station operator must keep a copy of the Monthly Quality Control Check Sheet in the air monitoring station.

5.2 Each Run:

At the end of each run, inspect the faceplate gasket to see if it has lost resilience and become deformed or flattened. The resulting air leakage shows as an irregular edge of particulate deposit on the filter – when the condition is noticed, replace the gasket.

Ensure recorder operation. During the initial flow meter check, observe the flow recorder. If the pen does not move freely, determine the cause. The electric chart drive is permanently lubricated and requires no periodic maintenance. Replace the recorder if it is erratic or inoperative. Recalibrate the sampler after replacing the recorder. If the pen is dry, place a small amount of ink in the hole by the pen tip; if it is a cartridge type, carefully replace the pen. Unless the replacement pen is positioned exactly as the old one, recalibration will be required. After inking or pen replacement, turn on the sampler briefly to verify that the recorder is inking and zeroing properly.

Inspect the tubing for deterioration or cracks. Replace if necessary.

5.3 Monthly Checks:

A fixed orifice check should be conducted every 30 days. Operate the sampler until it is adequately warmed up, approximately 5 minutes. Install a clean filter and place the fixed orifice over the filter and tighten it down. Turn on the sampler and allow the Dickson Chart trace to stabilize for 5 minutes. Convert the manometer pressure drop reading to true flow and record the flow and pressure readings on the Monthly Quality Control Check Sheet. If the fixed orifice reading is more than + 5% from the reading taken after calibration with respect to the Dickson reading, perform a recalibration.

Inspect and clean the size selective inlet. The inlet must be inspected and cleaned at intervals dependent on local average total suspended particulate concentrations. Your supervisor will provide the cleaning frequency required for a 6 day sampling schedule at the specific site.

1. Remove the hood; clean the nine acceleration nozzles with a bottle brush; wipe the surfaces clean with a damp cloth and reassemble.

2. Release the four hook catches on the side of the inlet and raise the upper half of the inlet.

3. Carefully remove the greased shim and clean on a flat surface using a clean cloth or Kimwipe. If necessary, use a small vacuum cleaner to remove dirt. Isopropyl alcohol or acetone may be used to aid in cleaning. After the shim is clean and dry, generously coat the shim evenly with Dow Silicone #316, holding the spray can containing the silicone mixture 8 to 10 inches from the surface of the shim.

4. Remove the vent tube plate and clean the tubes with a bottle brush and wipe the external surfaces with a clean rag or Kimwipe.

5. Remove the bug screen and wipe with a clean rag. Inspect to make sure no lint remains on the screen.

6. Wipe the interior of the inlet with a clean cloth.

7. Inspect the joint seals and screw holes where the acceleration nozzles are attached to the acceleration nozzle plates and where the vent tubes are attached to the impaction plate. If the seals are damaged, replace them.

8. Reassemble inlet, making sure that the greased shim is held down by the two shim clips.

9. If necessary, adjust the four hook catches to slightly and evenly compress the sealing gasket when the inlet is closed.

10. Reassemble the hood onto the housing with screws and spacers.

11. Document the cleaning date on the Monthly Quality Control Check Sheet.

Complete Monthly Quality Control Maintenance Check Sheet (AQSB QC Form 408) and submit to your assigned 2nd level reviewer.

5.4 800 Hour Checks:

The following are to be performed every 800 hours (48,000 minutes) of operation as per the sampler's elapsed time meter.

Change the sampler motor brushes. The electric motor of the sampler uses a pair of carbon brushes which wear during sampler operation and periodically must be replaced. This should be done on a regular basis rather than waiting until brushes wear down and excessive pitting and arcing occurs or the motor stops. Record the date the brushes are changed and the elapsed time meter reading on the Monthly Quality Control Check Sheet. After changing brushes, note the following precaution:

> Calibrating and sampling should only be performed after a break in period of 2 hours to properly seat the brushes against the armature. This period requires running the sampler against a resistance equivalent to a clean filter or a number 18 calibration plate.
>
> NOTE: When replacing brushes, pull at the center motor shaft to check for excessive play. If shaft play exceeds 1/8 inch in any one direction, replace the motor.

When opening the motor housing to change the brushes, inspect the armature. Once the armature becomes worn, the brush life drops considerably, to 300 hours or less. Replace the motor if the armature has excessive wear, such as deep grooving on the commutator or lack of segmentation. Recalibration is then required.

After changing the brushes, allow them to burn-in as described in Section 5.5 of this document.

Inspect motor windings for any abnormalities such as burnt wires. Clean dust from motor. If motor is inoperative or unable to give a flow rate (with two clean filters in place), troubleshoot the system (motor, flow controller, line voltage) and correct as required.

Inspect top and bottom motor gaskets for wear and deterioration and replace if necessary. Twisted power leads indicate that motor gaskets are not holding motor firmly and gaskets need to be replaced.

Verify timer. Check upon installation and every 800 hours against an elapsed time meter. If not within $\pm$15 minutes/24 hours, adjust and repeat test on next scheduled run.

Verify elapsed time meter. Check upon installation and every 800 hours against a standard timepiece of known accuracy, such as a standard electric clock connected during a scheduled run. If not within ±2 minutes/24 hours, adjust or replace.

Conduct a flow rate calibration as detailed in Section 4 of this document.

Check power cords for deterioration and replace if necessary.

After replacement of brushes (except for 800 hour maintenance interval), repair or replacement of motor or the rate measuring device, run a single point fixed orifice check. If the value varies from the previous monthly reading by more than ±10%, recalibrate the sampler.

5.5 Brush Burn-In:

After changing the brushes as part of the 800 hour check, allow them to burn-in.

1. Use a PM10 motor housing as a brush burn-in test stand. Insert the motor in the housing upside down to see the brushes. Elevate the PM10 motor housing, so the air hole is free to draw air from the bottom of the motor housing. Install the new brushes, check the alignment, connect the wires to the Variac, and run the motor up to about 25% of full power. Visually inspect for arcing.

2. If arcing is excessive, reduce the Variac power, and unplug the power cord. Since there is some play in the placement of the brushes, reposition the brushes for a better fit. Run the motor at 25% of full power for about 20 minutes, then at 50% of full power for an additional 40 minutes. At this point, the air gap between the brushes and the commutator will be reduced, and arcing will be minimal.

3. Disconnect the power cord to the motor, and exchange motors before the expected brush life is exceeded. It may be possible to get 700+ hours on the white type brushes issued from the stockroom, with little or no wear on the motor commutator. New brushes are approximately 1 inch long. It is suggested that the brushes not be worn all the way down. At 1/4 inch of brush remaining, it is possible to hit the core of the brush. Having the brush core wear on the commutator will reduce the life of the motor.

4. Inspect VFC pressure tubing for kinks and cracks.

6.0 MAINTENANCE PROCEDURES

6.1 General Information:

The PM10 VFC Sampler is designed to operate unattended for long periods of time and other than routine checks required in Section 5 of this document, the instrument requires little maintenance. However, maintenance requirements vary from instrument to instrument, thus operators should refer to the instrument operating manual to become familiar with maintenance requirements.

Corrective maintenance is any scheduled maintenance activity that becomes necessary due to system malfunctions.

If station operators cannot repair an instrument using procedures stated in the instrument manual, contact the ARB's Operations Support Section's Instrument Laboratory.

6.2 PM10 VFC Sampler Maintenance:

Replacing carbon brushes:

1. Unplug the main power cord from the timer. Unplug the flow meter tubing. Remove motor from PM10 shelter.

2. Remove the nuts on the locking clamp which secures the cylindrical motor housing to the sampler head (or unscrew the adapter mounting plate in some designs).

3. Remove the top rubber gasket. Put it aside.

4. Loosen nut on power cord where cord enters the motor housing.

5. Remove the motor from the housing.

6. Disconnect flat electrical connector from each brush by sliding it out toward the armature using a screwdriver.

7. Remove screws from clamps securing both brush holders. Remove the old brushes and discard.

8. Install the new brushes so that the slot in the base of the brush holder seats on the metal base peg. Tighten screws on brush holder clamps.

9. Slide the flat electrical connector into each brush holder – the reverse of 6.2.6 above.

10. Dust off both gaskets with a clean cloth. Replace if the foam (motor gasket) or rubber is deteriorated.

11. Reassemble the motor into its cylindrical housing and assemble to the mating, sampler head - the reverse of steps 2 and 5 above.

12. Placement of wire in plenum: Keep wire length as short as possible; twist wire and place as near to side of plenum as possible.

13. Install the motor in the PM10 shelter. Connect the power cord and flow meter tubing. Burn in new brushes as detailed in Section 5.5 of this document.

14. Check with a fixed orifice and recalibrate if > 10% change in pressure.

To replace the sampler motor, follow steps 1 to 5 and 10 to 13 above.

APPENDIX A
AQSB 24-HOUR AIR SAMPLE REPORT
TISCH ENVIRONMENTAL MODEL TE-6070V SIZE SELECTIVE INLET PM10 SAMPLER with VOLUMETRIC FLOW CONTROLLER

CALIFORNIA AIR RESOURCES BOARD
Volumetric PM10 24-Hour Sample Report/Sample Tracking

SAMPLE NO. (FILTER PAPER NO.): 4084043

Station Name: ROSEVILLE
Station Address: 151 N. SUNRISE AVE #570
Project Name (*If Applicable*):
Station Operator/Agency: BREITWIESER / CARB Phone No: 784-8065

COUNTY: 31 SITE: 00822 AGENCY: A
INSTRUMENT NO.: 03787

SAMPLING CONDITIONS: *

LOCAL CONDITION CODES (ENTER APPROPRIATE CODE IN THE BOX AT LEFT)

* - NO UNUSUAL CONDITIONS	J - CONSTRUCTION NEARBY	P - ROOFING OPERATIONS
A - HIGH WINDS	K - FARMING NEARBY	Q - PRESCRIBED BURN
E - FOREST FIRE	L - HIGHWAY CONSTRUCTION	X - RAIN Y - SNOW
F - STRUCTURAL FIRE	N - SANDING/SALTING STREETS	Z - OTHER (Explain in Field Comments)

SAMPLE COLLECTION DATA

	DATE YEAR	MONTH	DAY	TIME HOURS	MIN.	ELAPSED TIME METER (MIN.)	FILTER PAPER WEIGHT (GRAMS)
FINISH	08	06	11	24	00	20258.65	
START	08	06	11	00	00	20234.65	4.4075
NET:						24.00	

DATE OF LAST CALIBRATION: YEAR 08 MONTH 02 DAY 07
AVERAGE STD FLOW (SCFM):
AVERAGE IND. FLOW RATE: 40.1

INDICATED FLOW RATE
Pd(I) 20.3 in. Pd(F) 20.0 in. Ta 23.0 °C Pa 753 mmHg D- 4.4071

Type of Sample: [✓] Regular [ ] Collocate [ ] Make up

TO BE COMPLETED BY SAMPLER OPERATORS:

[✓] Inspection of sampler and filter indicates that sample collected is in compliance with quality control standards for sampling. Filter and Dickson recorder chart enclosed.

[ ] Sample does not meet quality control standards for sampling and should be invalidated. Dickson recorder chart and filter enclosed.
Make up sample scheduled for _____
Reasons:
___ Filter Contaminated or Damaged ___ High/Low Flowrate ___ Erratic Flowrate
___ Power Outage ___ Dickson Chart Recorder Problem ___ Timer Problem
___ Other _____

Field Comments: _____

Sample Tracking

Action	Transfer Method (Check One) Carrier	Person	Name & Initials	Date/Time
Released by Field		✓	BREITWIESER	6.12.08 AM
Received by Lab				

====FOR LABORATORY USE ONLY====

LIMS Sample ID: _____
Sample Conditions upon Received: _____
Lab Comments: _____

	PRE-ANA.	POST-ANA.
Initials	MM	
Date	4/11/08	

California Air Resources Board, Monitoring and Laboratory Division, P.O. Box 2815, Sacramento, CA 95812
03/10/04

APPENDIX B
AQSB MONTHLY QUALITY CONTROL MAINTENANCE CHECK SHEET 408
TISCH ENVIRONMENTAL MODEL TE-6070V SIZE SELECTIVE INLET PM10 SAMPLER with VOLUMETRIC FLOW CONTROLLER

CALIFORNIA AIR RESOURCES BOARD
MONTHLY QUALITY MAINTENANCE CHECK SHEET
VOLUMETRIC FLOW CONTROL PM10 SAMPLERS

Location: _____ Month/Year: _____
Station Number: _____ Technician: _____
Property Number: _____ Agency: _____

Sample Date:						
Filter Number:						
Initial Filter Pressure Drop:						
Final Filter Pressure Drop:						
Avg. 24 hr Ambient Temp.:						
Avg. 24 hr Ambient Press.:						
Initial Time Meter Reading:						
Final Time Meter Reading:						

OPERATOR INSTRUCTIONS:

1. Each Run: Check and record the pre and post filter drop readings, inspect faceplate gasket, verify flow recorder operation, record initial and final elapsed time meter readings.

2. Monthly: Fixed Orifice Check Date performed:

   Clean sampler and greased shim. Date last cleaned:

	Slope	Intercept	Cert. Date	Cert. Expires
Orifice Certification:				

	Orifice Indicated flow	Orifice True Flow	Sampler Mag Indicated Flow	Percent diff. from 40 cfm
Flow Verification Readings:				

4. 800 Interval: Replace sampler motor brushes and inspect armature, motor shaft, motor gaskets, motor wiring, and flow meter. Date Performed: _____ Motor Reading: _____

5. Semi-Annual: Calibrate sampler. Date last calibrated: _____

Date	Comments or Maintenance Performed:

Reviewed by: _____ Date: _____.

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APPENDIX C
AQSB CALIBRATION REPORT 408
TISCH ENVIRONMENTAL MODEL TE-6070V SIZE SELECTIVE INLET PM10 SAMPLER with VOLUMETRIC FLOW CONTROLLER

Calibration Summary:

ID Information:

Station Name:	Sacramento-T Street	Make:	Tisch	As Is:	X
Site AIRS #:	1927 13th Street	Model #:	6070DV	Final:	
Station Address:	Sacramento	Property #:	07682	Calib. Date:	8/13/2010
Agency:	ARB	VFC Serial #:	P1880	Report Date:	8/13/2010
		Agency:	ARB	Last Cal. Date:	10/20/2008
				Head Cutpt.:	10 micron.

Calibration Results:

Pollutant:	PM-10
Volumetric (True) Flow Rate, Qt (CFM):	40.2
Sampler Flow Rate, Qv (SPCV) (CFM):	40.9
% Difference from True (Qv vs. Qt):	1.9%
% Change from Previous Calibration:	0.5%
Magnehelic Percent Accuracy:	-2.5%

Meteorology:

Temp. (Deg. C):	27.8
Temp. (Deg. K):	301
Amb. Pres (mmHg):	757.1
Corr. P. (mmHg):	756.63
Elevation (Ft.):	25.0

BGI Var. Orfice TSE:	m :	x :		b :
Air Flow (CFM)=	30.7	*Sqrt (P* Ta/Pa)	+/-	0.759

Transfer Standard Correction Equations:

	m :	x :		b :
True Pressure =	1.0050	*Disp	+/-	-4.26
True Temperature =	0.9997	*Disp	+/-	-0.07
Dig. Man. True Pres =	1.0000	*Disp	+/-	0.00

Transfer Standard ID's:

Make & Model:	BGI Orifice
Prop. #:	20003948
Cert. Exp.:	9/27/2009
Make & Model:	DeltaCal
Prop. #:	20003948
Cert. Exp.:	9/27/2009
Make & Model:	Manometer
Prop. #:	20003948
Cert. Exp.:	9/27/2009

==========

Calibration Data--Single Point Flow Verification:

Sampler Flowrate (Qv):

Digital Manometer Reading (Pf) (mmHg):	39.4
Corrected Digital Manometer Reading (Pf) (mmHg):	39.4
Sampler Magnehelic Reading (" H2O):	20.6
Sampler Magnehelic Reading (mmHg):	38.5
Dickson Chart Reading:	40.0
Calculated Corr. Temp. (Deg. C):	27.8
Calculated Corr. Absolute Temp. (Deg. K):	300.8
Absolute Pressure Drop through Filter (mmHg):	717.2
Po/Pa:	0.9479
Qv (CFM):	40.9

Orifice Standard Flowrate (Qt):

BGI Pres. ("H2O):	4.15
BGI Pres. (mmHg):	7.7
Qt (CFM):	40.2
Qt prev. (CFM):	40.4

Percent Diff. from Prev. Calib.:

Qt (prev.) vs. Qt:	0.52%

Magnehelic:

Percent Accuracy:	-2.5%

Percent Diff. from True:

Qv vs. Qt:	1.85%

Comments:	
Calibrated by:	Checked by:

APPENDIX D
AQSB WORKSHEET REPORT 408
TISCH ENVIRONMENTAL MODEL TE-6070V SIZE SELECTIVE INLET PM10 SAMPLER with VOLUMETRIC FLOW CONTROLLER

CALIFORNIA AIR RESOURCES BOARD
VOLUMETRIC FLOW CONTROL SSI SAMPLER
CALIBRATION DATA SHEET

Date		Address		Tech	
Site Name		Site Number			

CALIBRATION STANDARDS

						slope	intercept
Orifice Std.	Prop No.		Cert Date		Cert Factor (CFM)		
Temp Std.	Prop No.		Cert Date		Cert Factor T:		
Press Std.	Prop No.		Cert Date		Cert Factor P:		

SAMPLER DATA

Make/Model		VFC Serial #	
Property No		Last Calibration	

Measure Ta and Pa using Temperature and Pressure standard

	raw	corrected	
Ambient Temp (Ta)			°C
K=°C+273			°K
Ambient Pressure (Pa)			mmHg
Elevation			feet

Install clean filter and new chart. Connect pressure standard to pressure tap on sampler. Turn on sampler and run for 5 minutes. Then record pressure drop and Dickson chart values.

	raw	corrected	
Pressure drop across filter (Pf)			mmHg
Dickson chart reading			
Sampler Magnahelic with clean filter		"H2O	

Turn off sampler, remove filter, and install orifice. Turn on sampler and adjust orifice until pressure drop (as read on pressure standard) agrees with measurement in previous step (Pf).

Orifice Magnahelic Pressure Reading *at Pf raw value*		"H2O

Turn off sampler.

Calculate True flow *Qt* based on orifice certification values.

1. $Qt_{(cfm)} = \left(cert\ slope \sqrt{orifice\ ma\ g \times \left(Ta(^\circ K) / Pa \right)} \right) - cert\ inter\ cept$	

Calculate sampler's volumetric flow *Qv* using average VFC slope and intercept values for ARB samplers: Slope: 45.379; intercept: -2.243 and Po/Pa = 1 - (Pf/Pa)

2. $Qv_{(cfm)} = \left[\left[45.379 \times \left(Po / Pa \right) \right] - 2.243 \right] + \left[(Ta - 25) \times 0.059 \right]$	
3. $\%\ diff\ \ from\ true = \left(\frac{Qv - Qt}{Qt} \right) \times 100$	
4. $\%\ diff\ \ from\ previouscal = \left(\frac{Qt - Qt\ prev}{Qt\ prev} \right) \times 100$	
5. $Magnahelic\ accuracy\ (\%) = \left(\frac{\left(\left(sample\ mag \times 1.867 \right) - \left(Pa - Pf \right) \right)}{\left(Pa - Pf \right)} \right) \times 100$	

Clean and lube shim with silicon spray (initial :_____)

QC: confirm latches are fitting tightly and tubing is in good condition (initial :_____)

Read and Record Magnahelic gauge zero point (initial :_____) Adjust if necessary to zero

pm10cal_cksht_new.doc (3/2010)