DEPARTMENT OF ECOLOGY
State of Washington

$PM_{2.5}$ & PM_{10} 2025 Sequential Sampler Standard Operating Procedure

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$PM_{2.5}$ & PM_{10} 2025 Sequential Sampler Standard Operating Procedure

February 2020

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1. Introduction

This document describes the Washington State Department of Ecology's procedures for sampling ambient air for particulate matter with aerodynamic diameter of 2.5 µm or less ($PM_{2.5}$) and aerodynamic diameter of 10 µm or less (PM_{10}) using a Thermo (formerly Rupprecht & Patashnik) Partisol®-Plus 2025 Sequential Air Sampler (Sequential Sampler). It covers the configuration, operation and maintenance of the Sequential Sampler and is intended to be used with the model-specific information and instructions provided by the manufacturer.

The filter-based Sequential Sampler provides 24-hour accumulative $PM_{2.5}$ and/or PM_{10} mass concentration measurements in ambient conditions. It was originally designated as a Federal Reference Method (FRM) for measuring $PM_{2.5}$ by the U.S. Environmental Protection Agency (EPA) in 1998 (RFPS-0498-118). In 2016, EPA requested states discontinue the use of the WINS Impactor and switch to the BGI Very Sharp Cut Cyclone (VSCC™) for making the cut from PM_{10} to $PM_{2.5}$. This change has been designated a new Class I, Federal Equivalent Method (FEM, EQPM-0202-145) and amended in the Code of Federal Regulations (40 C.F.R. Part 50, Appendix L). The Sequential Sampler is designated FRM (RFPS-1298-127) for PM_{10} monitoring.

To meet the Class I federal requirements for FEM $PM_{2.5}$ measurement, the sampler must:

- be configured with an approved PM_{10} inlet, followed by a BGI VSCC™ particle size separator;
- use either R&P-specified machined or molded filter cassettes;
- be equipped with software version 1.003 through 1.5 and Partisol® 2025i with firmware version 2.0 or greater;
- be operated with modified filter shuttle mechanism; and
- be operated in accordance with the Partisol®-Plus 2025 or Partisol® 2025i operation manual, as appropriate, with the BGI VSCC™ supplemental manual, and with the requirements specified in 40 CFR Part 50, Appendix L.

For FRM PM_{10} monitoring, the sampler is configured the same as above with the exclusion of the VSCC™ from the sample train and in accordance with the requirements in 40 CFR Part 50, Appendix J. In addition, if the purpose of the PM_{10} Sequential Sampler is to determine compliance with the National Ambient Air Quality Standards, the instrument's reported mass concentration and all flow rate verifications and semi-annual performance audit results must be reported in standard conditions (i.e., EPA's standard temperature of 25°C and pressure of 760 mmHg).

A photo of the Sequential Sampler is shown in Figure 1 below.

Figure 1: Partisol® Plus 2025 Sequential Sampler (Thermo 2018).

2. Principle of Operation

The principle of operation for the Sequential Sampler is PM filter gravimetric analysis. This technique involves drawing ambient air at a flow rate of 16.67 liters per minute (lpm) through a PM_{10} size-selective inlet and ($PM_{2.5}$ monitoring only) a BGI VSCC™ particle size separator to collect PM_{10} or $PM_{2.5}$ on a standard 46.2 mm polytetrafluoroethylene (PTFE) filter. The sampler operates for a continuous 24-hour sampling period with a temperature control system in the filter compartment.

Each sample filter is weighed by the Manchester Environmental Laboratory (MEL) before and after sampling to determine the net weight (mass) gain of the collected sample. The mass concentration is calculated based on the mass gain of the sample and total volume derived from average flow rate over the sampling period and the exact sampling duration. The final mass concentration is reported in micrograms per cubic meter (µg/m3) of air at ambient temperature and pressure conditions.

The Sequential Sampler uses a pair of filter cassette magazines that simplify filter exchange and transport, and minimizes the risk of filter contamination. The supply magazine contains pre-weighed filters for sample collection and the storage magazine receives the exposed filters. After a sample is taken, the sampler automatically advances the next filter into the sample chamber for the next scheduled run.

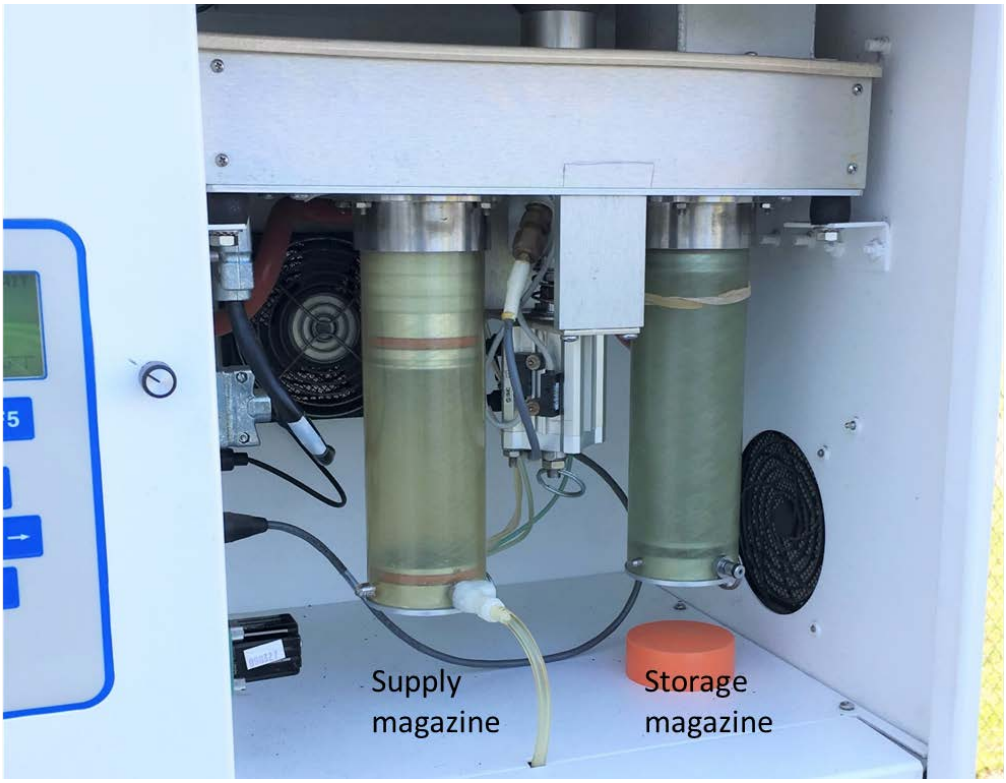

Figure 2: Supply and storage magazines

3. Equipment and Supplies

The equipment, tools, and supplies necessary to operate and maintain a 2025 Sequential Sampler are summarized in Table 1.

Table 1: Equipment and supplies for Sequential Sampler

Category	Equipment	Purchase Schedule
Tools and Equipment	2025 Sequential Sampler	Once
	BGI VSCC™ (model VSCCA) ($PM_{2.5}$ only)	Once
	Filter cassettes (for sampling)	Once, replace as needed
	Filter cassette (for QC)	Once, replace as needed
	Leak check disk (for internal leak check)	Once, replace as needed
	Inlet O-rings and V seals	Once, replace as needed
	Bulb pump hose	Once, replace as needed
	Filter magazines	Once (by MEL)
	Filter magazine transportation cooler equipped with thermometer and white ice packs	Once (by MEL)
	Certified, NIST-traceable flow standard	Once
	Leak check adapter	Once
	Tygon® tubing	Once
	NIST-traceable thermometer	Once
	NIST-traceable handheld barometer	Once
	Digital multi-meter	Once
	Various hand tools (screwdriver, hexagonal wrench, etc.)	Once
Consumables	46.2 mm diameter, 2 μm pore-size PTFE filters	As needed (by MEL)
	Lint-free lab wipes (e.g. Kimwipes)	As needed
	Cotton-tip applicators	As needed
	Rubbing alcohol	As needed

4. Installation Procedure

4.1. Siting

4.1.1. Siting criteria

Proper siting is essential to ensure that data collected are representative at the appropriate scale for the monitoring project. The majority of $PM_{2.5}$ and PM_{10} monitoring in the Washington State Ambient Air Monitoring Network (Washington Network) is conducted at the neighborhood scale. Siting criteria for neighborhood-scale PM monitoring sites are described extensively in 40 CFR Part 58, Appendices D and E; the primary considerations are summarized in Table 2 below. Operators of sites at other monitoring scales should consult Appendices D and E for siting requirements.

Table 2: Summary of $PM_{2.5}$/PM_{10} siting criteria.

Parameter	Category	Siting Requirement
Inlet height	General	2-15 m above ground for neighborhood scale or larger ($PM_{2.5}$ and PM_{10}); 2-7 m above ground for middle scale and microscale (PM_{10})
	On rooftop	2 m above roof
	Collocated samplers	Within 1 vertical m of each other
	Inlet tube length	≤ 4.9 m (16 ft.)
Inlet radius clearance	General	≥ 1 m horizontal and vertical clearance; ≥2 m horizontal clearance for rooftop site placement
	Collocated samplers	1-4 m between inlets (for flow rate ≤ 200 lpm)
	Near small obstructions (fences, walls, etc.)	≥ 2 m
	Near large obstructions (buildings, sound walls, billboards, etc.)	Distance ≥ 2x height of obstruction
	Near overhanging trees	≥ 10 m from dripline; ≥ 20 m from dripline is recommended
	Arc of air flow	Unrestricted 270° arc that includes prevailing direction of high concentrations
Nearby air sources	General	As far away as possible from minor sources such as vents and incineration flues
Distance from roadways	< 3,000 vehicles per day	≥ 5 m from nearest traffic lane
	Elevated roadway (> 25 m high)	≥ 25 m away
	Unpaved roads	As far away as possible

Operators should refer to Ecology's Air Monitoring Site Selection and Installation Procedure for further information on site selection.

4.1.2. Site security

The sampler must be installed in a secure location that can be safely accessed by monitoring staff even during inclement weather. Ground-level sites with fences are common and advised. Rooftop sites may provide a secure alternative given that they meet the Air Quality Program's safety requirements (see the Air Quality Program Safety Plan). Additionally, the site must be equipped with adequate and stable power to support routine operation.

4.2. Installation

The Calibration & Repair Lab will provide a Sequential Sampler that has been fully pre-calibrated.

1. Upon receipt of the Sequential Sampler, visually inspect it to ensure that all components are accounted for. Notify the Calibration & Repair Lab immediately of any missing or damaged equipment and if there are questions about the assembly.
2. Carefully transport the sampler to the field site. Level and secure the sampler and stand in its location. Install any parts separated for shipping as described in the manufacturer's manual.
   Note: When attaching the ambient temperature probe, to prevent water from entering the enclosure, place the washers between the ambient temperature bracket and sampler enclosure, not under the bracket screw head.
3. Install the PM_{10} head on the downtube of the base unit and check all tubing and power cords for crimps, cracks or breaks.
4. Once the sampler has been completely assembled and secured, turn on the sampler and allow it to equilibrate at ambient conditions for about 15 minutes.
5. From the Main screen, press <F5: Setup> to access the Sample Setup screen. This page allows user to set sampling parameters like sample duration and sample frequency.
6. Press <F2: Set EPA> and <F1: Yes> to set up the default sample conditions in the Basic sampling program for EPA standard protocol for a 24-hour sampling period starting at midnight with a sample flow rate of 16.7 lpm, as shown in Figure 3.
7. Using the soft keypad, move to the Default Sample Repeat Time and enter the appropriate time for the run schedule for the sampler (1/1 = 24:00, 1/3 = 72:00, 1/6 = 144:00, 1/12 =288:00) and press <Enter> to save.
8. Verify that all other fields (sample start time, sample duration, filter type, flow rate, error mode, and separators) are exactly the same as shown in Figure 3.

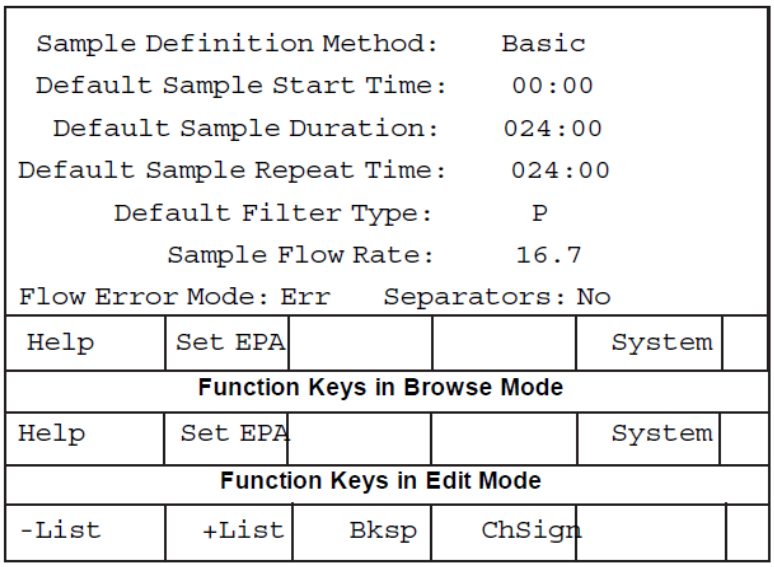

Figure 3: Sample setup screen (Thermo 2006)

9. While in the Sample Setup screen, press <F5: System> to enter the System Setup screen. This page allows the user to set operating parameters like current date/time. The sampler must be in Stop Mode to edit the variables in the System Setup screen.

10. Use the soft arrow keys to move among variables to be edited. As shown in Figure 4, set average/standard temp values to default “99” and average/standard pressure values to default “999”. These defaults allow the sampler to use ambient temperature and pressure readings to maintain proper sample flow rate. Set average time to 30 minutes so input data values are averaged over 30 minutes and stored every 30 minutes. Ensure the filter fan is set to “Auto” and auto run set to “On”.

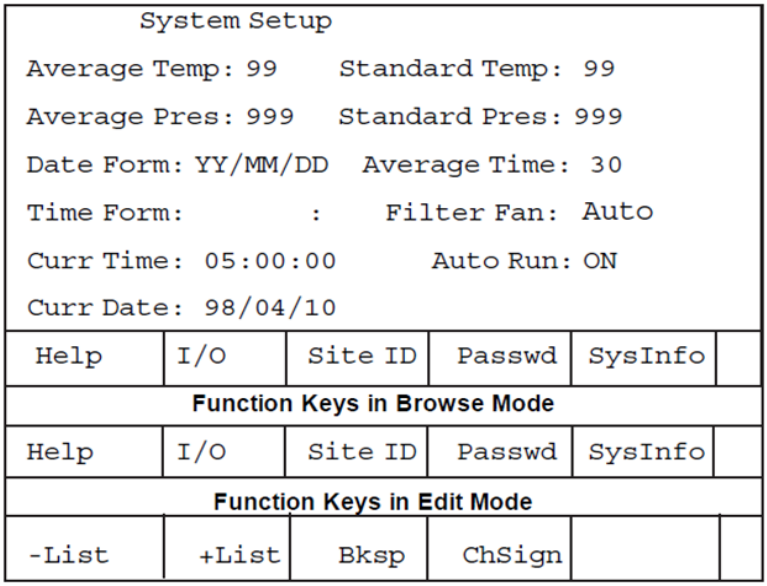

Figure 4: System setup screen (Thermo 2006)

11. Program the current date and time (in PST) using either <-List> and <+List> or direct keypad entry.

12. Program the site ID. In System Setup, press <F3: Site ID> and edit the IDs using the soft keypad for number and <A←> and <A→> for letter, as shown in Figure 5. Enter the AQS ID for the site in ID1 and the site name in ID2. Press <Enter> to save and <Esc> to return to the Main screen. For example, ID1 is 5303300801 and ID2 is SEABEACN for the Beacon Hill site.

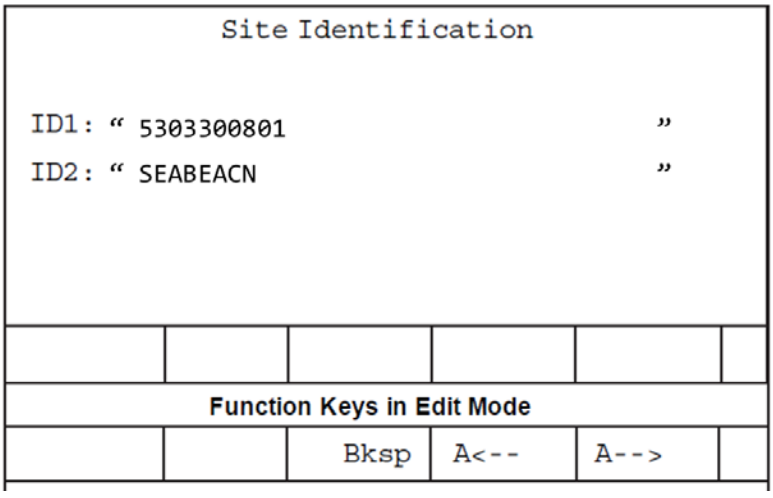

Figure 5: Site identification screen

13. Perform a full initial quality control (QC) check as described in Section 6.1 to verify that the sampler is functioning properly. Submit the QC check results to the QA unit when complete.

14. If the sampler fails any of the QC acceptance limits defined in Table 3, recalibrate the failing parameter(s) according to the calibration procedure in Section 6.2. After making adjustments to any calibrations, perform another full QC to ensure the sampler is fully calibrated prior to sampling. For additional assistance, contact the Calibration & Repair Lab.

5. Field Operations

The Manchester Environmental Laboratory (MEL) technician supplies field operators (via FedEx or other courier service) with pre-weighed sample filters and corresponding Sequential Sampler Run Data Sheets (Run Data Sheet) and a Chain of Custody form (COC) in advance of sampling. Examples of the Run Data Sheet and COC form are shown in Appendix A and B.

The Run Data Sheets comes from MEL in the sequence in which the filters are stored in the magazine. Operators must make sure the filter ID numbers listed on the Run Data Sheets are in a logical numerical orders to ensure the correct Run Data Sheet matches the filter sampled on a specific run day. If there are any questions regarding the order of filters, operators should contact the MEL technician and resolve any discrepancies before loading the filter cassettes into the sampler.

Most of the equipment necessary to ensure proper transport of the samples, such as a sealable plastic bag, cooler, and leak-proof ice substitutes, will be supplied by MEL along with the pre-weighed samples and must be used in the post-sampling procedure.

A Chain of Custody Form (COC) must be filled out and travel with each cooler in which the exposed samples are shipped back to MEL for gravimetric analysis. Operators must record all information on the form, including: project/station name, number of magazines shipped, AQS ID, and individual filter IDs and the corresponding sample dates in the cooler. Operators must also document the cooler conditions such as the instantaneous temperature in the cooler and date/time of recording before placing a lock tag security seal. The MEL technician examines the cooler conditions again upon receipt and records the information on the COC.

Attention: For sites sampling less frequently than every day, install new filters and collect exposed filters on a **non-run day** whenever possible to minimize the risk of an invalid sampling period.

For sites sampling every day, it is acceptable to perform the following pre- and post-sampling procedures while the sampler is in Run Mode.

Attention: Site operators should avoid touching any cassette by hand. To the extent possible, magazines should be retrieved only after all of the scheduled cassettes within a given supply magazine have been sampled in order to minimize the risk of contamination or causing a mismatch of cassettes and corresponding sample IDs as programmed in the Sequential Sampler. If a cassette must be retrieved or handled prior to all of the cassettes in the supply magazine being sampled, the procedures below must be followed:

- Use anti-static, powder-free gloves,
- Carefully transfer any remaining unexposed filters (maintained in sequence) from the supply magazine in the sampler to the top of the new supply magazine, and
- Ensure the filter and cassette IDs in the Filter List Setup are programed correctly in the sampler to include all the filters in the new supply magazine in the correct sequence.

5.1. Pre-sampling

1. Upon receipt of the pre-weighed filter samples in the magazines in the cooler:

    - Inspect the magazine to ensure filter cassettes are still pressed securely to the top of the magazine. If the gasket on the magazine's metal bottom plate is worn, the plate can loosen and allow filters to flip upside down in the magazine and cause cassette transfer errors.

    - Batches of filter samples that will last for approximately 3 weeks are sent by the MEL technician prior to the sampling month. Make sure to use the filter magazine labeled for the specific run week to ensure all filters are sampled by their last viable sample date and meet the holding time requirement for pre-weighed samples.

    - Occasionally, the last filter in a cylinder is past the valid holding time of 30 days. Record the filter ID and document the reason the filter is voided on the Run Data Sheet. Replace it with a new filter when a new batch of filters is delivered. Follow the procedures described preceding Sec. 5.1 when handling individual cassettes.

    - Place the MEL-approved ice substitutes in a 0 ºF/-18 ºC freezer, optimally for 24 hours, to ensure they are frozen solid before return shipment of the exposed filters to the MEL.

2. Prior to sampling, affix the site information stickers containing the AQS ID, site location and site name at the top left portion of the Run Data Sheets.

3. Verify that the filter ID and cassette ID numbers listed on the Run Data Sheets are in the correct sequence. The filters are prepared by the MEL technician such that they are placed in the magazine in sequence. Should the operator need to handle the samples individually, follow the procedures described preceding Sec. 5.1 of this document.

4. Fill out the sample date, your (operator) name, start date/time, stop date/time, total sample time, sample volume and flow rate CV in the Run Data Sheet. Although the time fields are pre-programed in the sampler, the operator must check again when retrieving the samples in case the sampling was terminated outside the scheduled hours.

5. Open the sampler door and install the filter magazine containing pre-weighed filters in the supply side (left side) of the sampler. Ensure the cassettes are compressed to the top of the magazine using the bulb pump hose.

6. Install a clean, empty magazine on the storage side (right side) of the sampler. Ensure the metal bottom plate of the storage magazine is at the top. This prevents the filter cassette from turning upside down as it drops through a large gap in the magazine.

7. In the Main screen, press <F3: FiltSet> to enter the Filter Setup screen, and then press <F4: FiltLst> to display the filter list, as shown in Figure 6.

8. In row #1, press <→> arrow to move the cursor, press <Edit> and enter the filter and cassette ID numbers from the first Run Data Sheet. To enter the remaining filter and cassette IDs numbers, use either Manual or Auto-Fill:

   Manual: Move on to the next row and repeat for the subsequent Run Data Sheets. Press <Enter> to save.

   Auto-Fill: Press <F3: Copy>, <F3: Both> and then <Yes> to copy both filter and cassette IDs you just entered and apply to the remaining sample list with one increment. Press <Enter> to save.

9. Make sure that filter and cassette ID numbers are entered in the same order as they are listed on the Run Data Sheets.

10. To identify field blanks, press <→> arrow to move the cursor to the Blank field; press <F1: -List> or <F2: +List> and select "Yes". Press <Enter> to save.

11. Press <Esc> to go back to Main Menu.

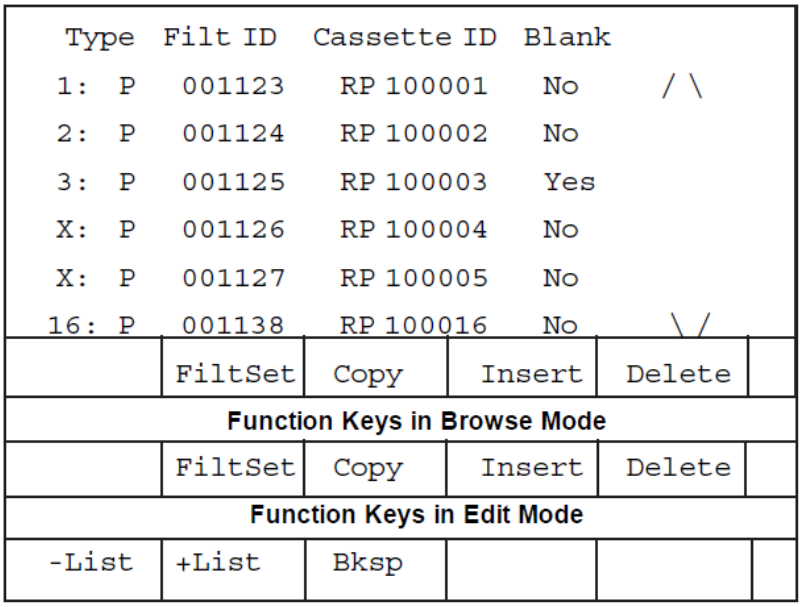

Figure 6: Filter list screen (Thermo 2006).

5.2. Post-sampling

1. Sampled filters must be retrieved within 177 hours from the end of the sample collection period. Carefully remove the sampled filter magazine from the sampler. Place a clean orange cap on the storage magazine to prevent sample contamination.

2. Ensure the exposed filter cassettes are not loosely stored in the magazine by pumping up the piston with a bulb pump hose while keeping fingers on the cap so the cassettes do not blow out due to over-pressure.

3. Place the sampled filter magazine in a polyethylene bag (e.g. plastic Ziploc bag) such that the cap does not come off. Place the magazine in a well-insulated, plastic cooler and cover the magazine with frozen ice packs. Proper equipment must be used to maintain a sample temperature below 25 °C. The sample should be cooled to 4 °C by placing MEL-approved ice substitutes in the cooler during the transport between retrieval from the sampler and a stationary refrigerator. A thermometer must be place in the middle or lower portion of cooler to ensure the temperature is accurately monitored.

4. Check the sampling run status on the Main screen and note if the status is other than OK. Press <F4: Data> to view the filter data from the run. Fill out the rest of the fields in the Run Data Sheet.

   If the status doesn't show OK, verify the validity of the run by pressing <F3: More Data>, until the Data Status Code screen appears.

5. On the **Run Data Sheet**, record any out-of-spec parameters (e.g. the flow rate, filter temperature, elapsed sample time, etc.), flags triggered by the sampler, or any unusual environmental conditions such as construction activities, fires or dust storms in the Operator Comments section.

6. If the validity of any sampled filter is questionable, note the validity concerns in the Operator Comments section on the corresponding Run Data Sheet. Handle the filter magazine as if all filters contained in it were valid samples.

7. Install the new loaded supply magazine and the empty storage magazine following procedures in Section 5.1 for the next sampling run.

8. If samples (including blanks) are not shipped out immediately, store the filter magazine in a refrigerator to keep samples from exposures to temperatures over 4°C. Never freeze the filters as this could rupture filter surfaces. See Table 6 for data validity and post-sampling filter holding time based on filter temperatures.

9. Carefully place the sample magazines, pack the cooler with frozen ice packs, and place them in the cooler.

10. Fill out the COC (for each cooler) except for the very bottom line of the form which is to be filled out by the MEL technician. Measure and record the cooler temperature (in °C) on the COC before sealing the cooler with a lock tag.

11. Put the Run Data Sheets for each sample and COC in the plastic Ziploc bag along with the sample magazines, place a lock tag security seal on the cooler and ship it to MEL via FedEx Priority Overnight using the shipping label supplied by MEL. To ensure filter viability, do not ship coolers on Fridays unless arrangements have been made with MEL.

6. Quality Control & Calibration

This section describes the quality control (QC) and calibration procedures for verifying and ensuring the proper operation of the Sequential Sampler. Because $PM_{2.5}$ concentration standards are not available for establishing calibration relationships, individual components of the sampling method, such as the sample flow rate, ambient temperature, and pressure must be periodically checked and calibrated as needed to ensure integrity of the reported data. It is also critical that the sampler's clock be accurate to ensure that daily samples are comparable across the state and national $PM_{2.5}$ and PM_{10} networks.

Only NIST-traceable devices with current certification can be used to verify and calibrate the sampler's flow, temperature, and pressure. These devices are referred to as *transfer standards* and must be recertified annually. The Calibration & Repair Lab will recertify these field standards for operators on an annual basis. Operators should coordinate with the Calibration & Repair Laboratory and build in sufficient lead-time to ensure that their transfer standards' certifications do not expire.

Operators are required to use the current electronic $PM_{2.5}$ and PM_{10} Quality Control (QC) Check Forms. Examples of these forms are shown in Appendix C. The most current electronic QC check forms can be obtained from Ecology's Quality Assurance unit.

Section 6.1 describes the QC check procedure without any adjustment made to the sampler. Section 6.2 and Chapter 7 describe the calibration and maintenance work involving adjustments to ensure adequate performance of the sampler.

6.1. Field quality control procedure

In order to ensure proper operation of the Sequential Sampler and meet the requirements of 40 C.F.R. Part 58, Appendix A, at a minimum, a full QC check must be conducted every 30 days and following any instrument calibration.

An **as-found** QC must be conducted prior to any instrument adjustments or calibration and an **as-left** QC must be conducted following any calibration, repair, or major maintenance. As-found and as-left QCs must be documented on two separate forms.

Table 3 summarizes the QC check acceptance criteria. Criteria that trigger invalidation of data outside of acceptance limits are marked with a ✓. The validity of data outside of the remaining limits is evaluated by Quality Assurance personnel using a weight-of-evidence approach. Operator should make adjustments or investigate the cause of potential leak when the QC results exceed the action limits to avoid data loss. In addition to calibrating when a parameter falls outside the acceptance limits, the sampler must be calibrated after any repairs and after the sampler is transported.

Table 3: Sequential sampler quality control acceptance criteria

Procedure	Acceptance Limits	Action Limits	Invalid	Section
Clock verification	± 1 min. of data logger	N/A	Weight-of-evidence	6.1.1
Temperature verification	< ± 2.1 °C	1.5 °C	Weight-of-evidence	6.1.2 & 6.1.9
Pressure verification	< ± 10.1 mmHg	7 mmHg	Weight-of-evidence	6.1.3
External Leak check	< 80.1 mL/min (≤ 25 mmHg/min)	20 mmHg/min	✓	6.1.4
Internal Leak Check	< 80.1 mL/min (≤ 140 mmHg/min)	N/A	✓	6.1.5
Flow check (1-pt)	< ± 4.1 % actual flow; < ± 5.1 % design flow	3 % actual flow	✓	6.1.6

6.1.1. Beginning the quality control check

It is important to perform the procedures in the order in which they are described below. Verification or audit of any parameters must be performed when the sampler is in the **Sampling** (SAMP) mode or **Wait** (WAIT) Mode before starting the QC check.

Verify clock and enter Audit mode on the sampler

1. Record the time shown on the sampler and data logger. The difference must be within ± 1 minute.
2. Press the following in order: <Run/Stop>, <F1: Audit>, then press <Menu> twice.
3. Press <Enter> to enter Audit Mode. Verify this by looking at the upper right corner of the display screen before proceeding with the audit or QC check.

Install the QC magazine

1. Remove the spent magazine from the right side. Place an orange plastic cap on top of the magazine to prevent sample contamination and move the magazine to the back of the inside of the sampler compartment so it's out of the way.
2. Disconnect the pneumatic hose from the supply magazine on the left side.
3. Remove the supply magazine (containing pre-weighed filters) from the left side and install it in the storage position on the right.
4. Install a QC magazine in the supply position on the left side. This magazine should contain a blank cassette (i.e., a cassette with a supporting metal screen plate and a clean

47mm filter that is not intended for actual sampling). The beveled edge on the inside of the blank cassette must be facing up.

5. Connect the pneumatic hose on the QC magazine on the left.
6. Press <F4: FiltAdv>. This will advance the blank cassette into the sample position and move the current sample filter to the top of the magazine on the right.
7. Once the filter advance is complete, remove the magazine containing the supply filters from the right side and place it in the supply side on the left. Place the empty QC magazine in the spent position on the right. Make sure the pneumatic hose is connected on the left side after the swap.
8. Follow the steps below, recording the actual and indicated readings on the electronic QC form.

6.1.2. Ambient temperature verification

1. Insert the probe of the thermometer standard into the sampler's ambient temperature radiation shield on the upper left side of the sampler. Wait for the temperature on the standard to stabilize and record the current temperature in degrees Celsius. This is the actual ambient temperature.
2. Record the sampler's "Amb Temp". This is the indicated ambient temperature.

6.1.3. Ambient pressure verification

1. Record the ambient pressure in millimeters of mercury (mmHg) as taken from the barometer standard. This is the actual ambient pressure.
2. Record the sampler's "Amb Pres." This is the indicated ambient pressure.

6.1.4. External leak check

An external check must be conducted both **before** and **after** the V seal is disrupted.

1. Remove the PM_{10} inlet from the down tube.
2. Install the leak check adapter on the down tube and switch the valve to off position.
3. From the Audit Screen, press the following in order: <F5: LeakChk>, <F2: Start>, then <F1: Extern1>.
4. Ensure that the leak check adapter is closed and press <F1: Yes>.
5. Press any key to generate a vacuum and begin test (the test will take 1 minute after which the results will be on the screen). A pressure drop of 25 mmHg/min or less is the sampler's external leak check pass criteria and satisfies the EPA acceptance criteria of < 80.1 mL/min.
6. If you get an initial failure, repeat the external leak check test at least 3 more times.

7. Record whether it passed or failed on the form and record the amount of loss of vacuum in mmHg in the comments section on the form.

8. Slowly turn the leak check adaptor to the open position to release the vacuum.

6.1.5. Internal leak check

An internal leak check is required only in the event of an external leak check failure that cannot be resolved. A specialized impermeable leak check disk is required for an internal leak check. Contact the Calibration & Repair Lab to acquire the leak check disk if you do not have one. A leak check adapter is not needed for an internal leak check.

1. Insert a leak check cassette that has a leak check disk in place of the usual filter. Advance the leak check cassette to the sampling chamber.

2. From the Audit Screen, press the following in order <F5: LeakChk>, <F2: Start>, then <F2: Internl>.

3. Press any key to generate a vacuum and begin test (the test will take 1 minute after which the results will be on the screen). A pressure drop of 140 mmHg/min or less is the sampler's internal leak check pass criteria and satisfies the EPA acceptance criteria of < 80.1 mL/min. Record internal leak result in comments of the QC check form.

4. If a failure message has displayed, clean the cassette and leak check disk carefully. Examine the cassette and disk for any external nicks or scratches. Discard any damaged cassette or disks, and re-run the test with a clean, undamaged cassette and leak check disk.

5. Record whether it passed or failed on the form and record the amount of loss of vacuum in mmHg in the comments section on the form.

6.1.6. Flow rate verification

Use a Gilibrator, Alicat or other certified, NIST-traceable flow standard to perform the flow rate verification as follows.

1. With the leak check adapter installed on the down tube, use nylon tubing to connect it to your flow transfer standard.

2. Turn on the pump by pressing <F1: Pump>, and open the valve by pressing <F2: Valve>.

3. Wait 5 minutes for the sampler’s “Cur Flow” to stabilize (it should be about 16.7 L/min).

4. Record the flow in L/min (at ambient temperature and pressure) as taken from the transfer standard. This is the actual flow.

5. Record the sampler’s “Cur Flow” in L/min. This is the indicated flow.

6. Turn off the pump by pressing <F1: Pump>, and close the valve by pressing <F2: Valve>.

6.1.7. PM_{10} head inspection

1. Pull up on the PM_{10} inlet to remove it from the down tube.
2. Unscrew the bottom portion of the inlet from the cap and inspect it for cleanliness.
3. Inspect the O-ring that seals the top and bottom of the inlet head. Note if it's broken.
4. Note whether the impact plate is clean on the QC check form.
5. Carefully put the PM_{10} head back together and set it on the ground such that it's out of the way and possible contaminants (rain, dust and insects) do not enter the collector assembly.

6.1.8. VSCC™ inspection ($PM_{2.5}$ only)

Remove the VSCC™ from the upper part of the sampler enclosure and inspect the transfer tube and emptying cup as shown in Figure 11. Inspect the O-rings for tear and/or damage.

6.1.9. Filter temperature verification

*Important: An external check must be conducted before and after disrupting the VSCC™ and V seals as an "as-found" and "as-left" condition, respectively.

1. Open the top compartment of the sampler and remove the VSCC™ ($PM_{2.5}$) or the downtube adapter (PM_{10}).
2. Insert the thermometer standard probe into the tube from which the VSCC™ or downtube adapter was removed. This is where the sampler's filter temperature probe is located.
3. Allow 3 minutes for your standard's temperature to stabilize.
4. Record the filter temperature in degrees Celsius as taken from the thermometer standard. This is the **actual** filter temperature.
5. Record the sampler's "Filt Temp". This is the indicated filter temperature.
6. Reinstall the VSCC™ ($PM_{2.5}$) or downtube adapter (PM_{10}) and completely close and seal the top compartment of the sampler.

6.1.10. Finishing the quality control check

1. Perform a final "as-left" external leak check and document the results on the QC check form. If the external leak check fails, refer to the instructions in Section 6.1.4.
2. Remove the leak check adapter from the down tube.
3. Reinstall the PM_{10} head on the down tube.
4. Press <F4: FiltAdv> to advance the current sample filter back into sampling position and move the blank cassette back into the QC magazine on the right side of the sampler.
5. Remove the QC magazine from the storage side (right side) and cap it.

6. Uncap the spent magazine and reinstall it on the storage side.

7. Visually verify that you've put the sampler back together correctly and that the magazines are back in place as you found them at the beginning of the QC check.

8. Press <Run/Stop> to put the sampler back into the mode in which you found it (i.e., WAIT or SAMP). Verify this by looking at the upper right part of the screen.

9. Record the QC check stop time on the electronic QC form.

10. Calculations (the electronic Excel QC sheet will perform these for you). Perform all calculations before leaving the site. The electronic QC form will calculate these values automatically.

$$\text{Flow Percent Difference} = \frac{\text{Indicated} - \text{Actual}}{\text{Actual}} \times 100\ \%$$

$$\text{Design Value Percent Difference} = \frac{\text{Indicated} - 16.67}{16.67} \times 100\ \%$$

11. Make an electronic logbook entry and record your quality control activities and findings.

6.2. Calibration procedure

- It is strongly recommended that calibration activities be performed on a day when sampling is not scheduled, unless interrupting sampling is unavoidable (e.g., daily sampling).
- To calibrate any parameter, the sampler must first be in Stop Mode. From the Stop Mode, you can then access the sampler's Service Mode where adjustments can be made.
- It is important that the procedures described in this section be performed in the order in which they are described.

6.2.1. Beginning the calibration

1. Verify that the sampler is in Stop Mode. If not, press <Run/Stop> to place the sampler in Stop mode.

2. Press <Menu> to display the Master Menu. Scroll to the **Service Menu** option, press <Enter>, as shown in Figure 7.

3. Press <F1: Audit> to enter Audit Mode. Verify this by looking at the upper right corner of the display screen before proceeding.

4. Insert a filter cassette containing a new 47 mm filter in the top-most position in the supply magazine (left side).

5. Press <F4: FiltAdv> to move the filter into the sampling position.

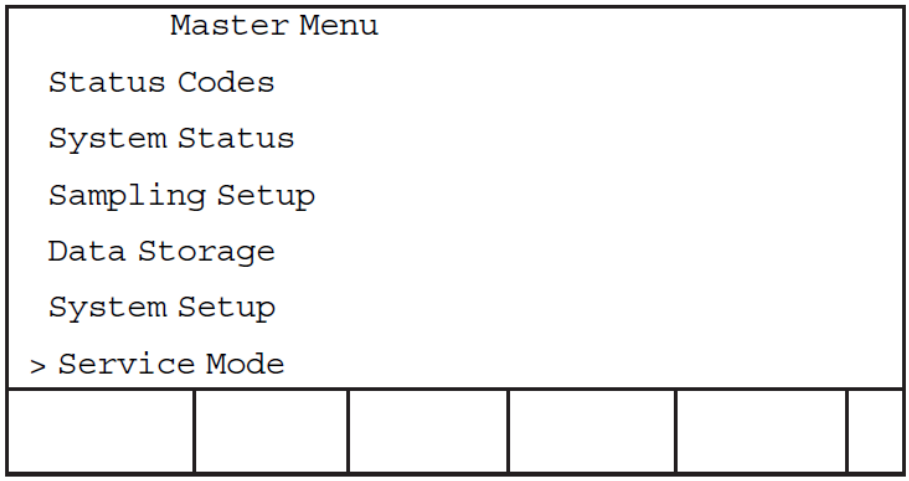

Figure 7: Master menu (Thermo 2006).

To exit Service Mode at any time, select the **Exit Service Mode** option in Service Menu as shown in Figure 8.

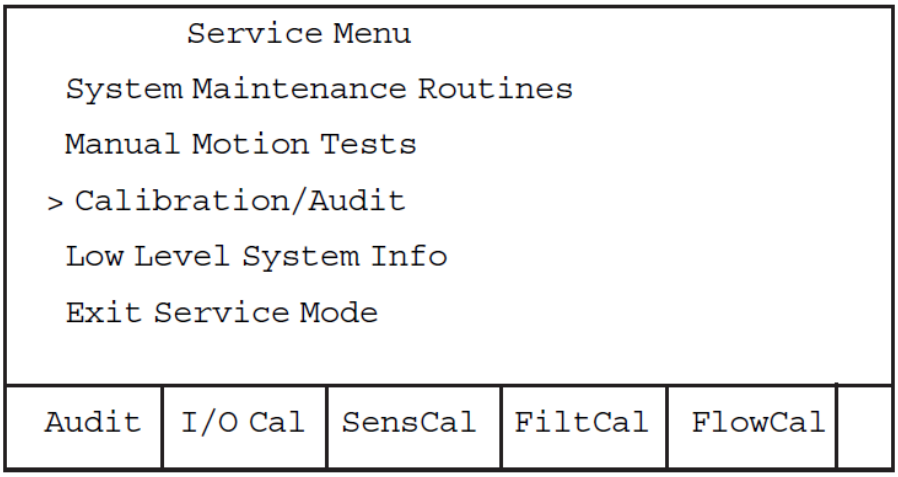

Figure 8: Service menu (Thermo 2006).

6.2.2. Ambient temperature calibration

1. Press <Menu> to enter Service Menu. Scroll to the **Calibration/Audit** option, as shown in Figure 8, press <F3: SensCal> to access the Sensor Calibration screen.

2. LInsert the probe of the thermometer standard into the sampler's ambient temperature radiation shield on the upper left side of the sampler. Wait for the temperature on the standard to stabilize and record the current temperature in degrees Celsius. This is the **actual** ambient temperature.

3. Press <Edit> then enter the average temperature of the **reference standard** in °C from Step 2 in the Actual column of the Amb Temp row on the screen and press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input.

4. Perform a single point temperature verification to confirm the calibration.

6.2.3. Filter temperature calibration

1. Press <Menu> to enter the Service Menu. Scroll to the **Calibration/Audit** option, press <F4: FiltCal> to enter the Filter Temperature Calibration Screen.

2. Open the top compartment of the sampler and remove the VSCC™ ($PM_{2.5}$) or downtube (PM_{10}).

3. Using a thermometer standard, insert the probe into the tube from which the VSCC™ or downtube was removed and measure the current temperature at the location of the filter temperature probe in the sampler.

4. Press <Edit> and enter the measured filter temperature from the **reference standard** in °C in the Actual column of the Filt Temp row on the screen and press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input.

5. Perform a single point temperature verification to verify the calibration.

6.2.4. Ambient pressure calibration

1. Press <Menu> to enter the Service Menu. Scroll to the **Calibration/Audit** option, press <F3: SensCal> to enter the Sensor Calibration Screen.

2. Record the current ambient pressure in mmHg from the reference standard.

3. Press <Edit> and enter the measured ambient pressure in the Actual column of the Amb Pres row of the Sensor Calibration Screen, press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input.

6.2.5. Troubleshoot leak check

A leak check must be performed any time a seal in the sampler is disturbed. A failed leak check cannot be “calibrated” and must be resolved by identifying the leak source. This subsection describes basic procedures to troubleshoot a failed leak check during a calibration or QC check.

1. Follow leak check procedures in Section 6.1.4 and 6.1.5 if needed.

2. If a leak check fail message is displayed on the screen:

   - External
     Insert a new filter cassette containing a new 47 mm filter in the topmost position of

the supply magazine. From the Service Menu, go to <F1: Audit> to advance the cassette (<F4: FiltAdv>) into the sample position. Repeat the leak check procedure.

- Internal
  Clean the cassette and leak check disk carefully. Examine the cassette and disk for any external nicks or scratches. Discard any damaged cassette or disks, and re-run the test with a clean, undamaged cassette and leak check disk.

3. If the leak check fails again, attempt to find the leak and repair. Failure in both external and internal leak checks may indicate a defected bottom V seal or poor hose connection to the pump. A failed external but passed internal may indicate a leak above the filter position, such as the top V seal or inlet assembly.
4. If you can't locate the source of the leak, contact the Calibration & Repair Lab for assistance.
5. When the leak check is complete and passed, slowly open the valve on the leak check adapter to release vacuum.
6. If performing a flow verification immediately, retain the filter cassette with filter in the sampling position. Otherwise, remove the adapter, reinstall the PM_{10} head and remove the blank test filter cassette in the sampling position (see Section 6.1.10, Steps 1-7).

6.2.6. Clock calibration

Depending on the mode prior to entering Stop Mode, follow the steps in which they are described below to perform clock adjustment. Bring a blank cassette for this procedure.

From Wait Mode:

1. Press <Run/Stop> and go to Stop Mode.
2. Press <F5: Setup> and then <F5: System> to enter the System Setup screen (Figure 4).
3. Press <Edit> and move the cursor to Curr Time. Adjust time using keypad or <+List> and <-List>.
4. Press <Enter> to save the change. This will take about 15 seconds to post in the system. Press <Esc> to return to the Main screen.
5. To ensure the sample matches the correct filter ID, go to the Filter List screen. Press <F3: FiltSet> and then <F4: FiltLst>.
6. With the cursor on filter #1, click <F4: Insert> to insert a new row. Enter the very next scheduled filter and cassette numbers and press <Enter> to save.
7. Press <Esc> once and then <F1: Times> to display the scheduled run. Curr and #1 should have the same date.
8. Swap the two magazines in position, then place a blank cassette on top of the left magazine.

9. Advance the filter. Press <Menu>, select <Service Mode>, select <F1: Audit>, then <F4: FilterAdv>. This advances the blank cassette to the sample chamber and pushes the actual sample to the magazine on the right.

10. Swap the two magazines again so the supply magazine is now on the left side with the sample previously in the sample chamber at the topmost position.

11. Press <Esc> to Main screen and press <Run/Stop>. Sampler should go back to Wait Mode. The next scheduled run will push out the blank cassette in the sample chamber.

From Done Mode:

1. After all the filters sampled and the sampler is in Done Mode with "No filter" error.

2. Adjust the time following steps 1-4 above. If you are entering the next batch of sample and cassette IDs, follow instructions in Section 5.1.

3. Clear error and hit <Run/Stop> to put it back to Wait Mode.

6.2.7. Flow calibration

Perform the temperature calibration, pressure calibration and leak check described above before performing the three-point flow calibration procedure.

1. Remove the PM_{10} head from the down tube and install a leak check adapter with its valve open.

2. Attach a certified flow standard to the leak check adapter.

3. Press <Edit> and enter the desired minimum and maximum calibration flow rates (Min. Flow and Max. Flow). The recommended flows are **15.0** lpm for Min Flow and **18.4** lpm for Max Flow. These values are 10 % below and 10 % above **16.7** lpm, respectively.

4. For Num Points, enter 3 for three calibration points.

5. Press <F5: More> and then <F4: Start> to initiate the flow.

6. Wait for the flow to stabilize, then press <Edit> and enter the measured flow (lpm) from the flow standard in the "Act Flow" field. Move to the next calibration point. Press <Enter> to save.

7. The sampler automatically adjusts the Offset and Span values in the Flow Calibration Screen once the calibration is complete.

8. Perform a single point flow rate verification to confirm the calibration.

7. Maintenance

This section describes the minimum routine maintenance that must take place to ensure proper instrument operation and is intended to be used with the model-specific service manual and instructions provided by the manufacturer. Depending on the sampling environment, maintenance may need to be conducted more frequently. All maintenance activities must be documented in the electronic logbook. Table 4 summarizes the required maintenance procedures and frequencies.

See Appendix D for the Maintenance Check Sheet which is used to document required maintenance and help the operator track when required maintenance is due. The Maintenance Check Sheet must be kept at the station and filled out as items are completed.

*Important: Operator must perform a final as-left external leak check after maintenance involving disrupting the V seals and document the results in the electronic logbook or QC Check Form.

Table 4: Required maintenance activities

Procedure	Minimum Required Frequency	Section
Clean the PM_{10} head	Every 30 days (monthly)	7.1
Inspect the condensation jar	Every 5 sampling days; clean as needed	7.1, Step 8.
Clean the VSCC™ ($PM_{2.5}$ only)	Every 30 days	7.2
Inspect the V seals	Every 30 days	7.3
Clean interior sample case	Every 30 days	7.4
Clean air intake screens	Every 180 days (semi-annually)	7.5
Exchange particle trap filters	Every 365 days (annually)	7.6
Clean the downtube	Every 365 days	7.7
Multi-point ambient temperature verification	Every 365 days	7.8
Filter compartment temperature verification	Every 365 days	7.9
Multi-point flow rate verification	Every 365 days	6.2.7
Ambient pressure calibration	Every 365 days	6.2.4
Replace batteries	Every 365 days	7.10

7.1. Clean the PM_{10} head

1. Unscrew the collector assembly from the acceleration assembly as shown in Figure 9.

Acceleration Assembly

2. Remove the four screws on the underside of the lower plate of the assembly and separate the top plate from the insect screen and assembly body.
3. Clean the plates and insect screen using brushes, lint-free cloth and/or compressed air. The parts may be cleaned with water, but they must be dried thoroughly before reassembly.
4. Reassemble the plates and screen, and secure with screws back on the assembly body.
5. Inspect the O-ring for damage. Replace if necessary. Some aluminum shards may stick on the O-ring from assembly misalignments; clean with brushes or lint-free cloth as needed. Apply a thin grease coating on the O-ring and the aluminum threads of the acceleration assembly using silicone grease.

Collector Assembly

6. Clean the collector plate and walls around the three vent tubes using brushes, lint-free cloth, and cotton swabs. Likewise, wipe clean the bottom side of the collector assembly.
7. Using cotton swabs, clean the weep hole in the collector plate where the moisture runs out to the moisture trap.
8. Remove the condensation jar and wipe clean the jar and cap. Inspect the brass fitting to ensure tightness and non-blockage. When reinstalling the jar, grease the gasket inside the cap of the jar to ensure a leak-free seal.
9. Inspect the two inlet-to-inlet tube sealing O-rings for damage. Replace if necessary. Apply a thin grease coating on the O-rings to ensure that a proper seal.
10. Hand-tighten the acceleration assembly and collector assembly.

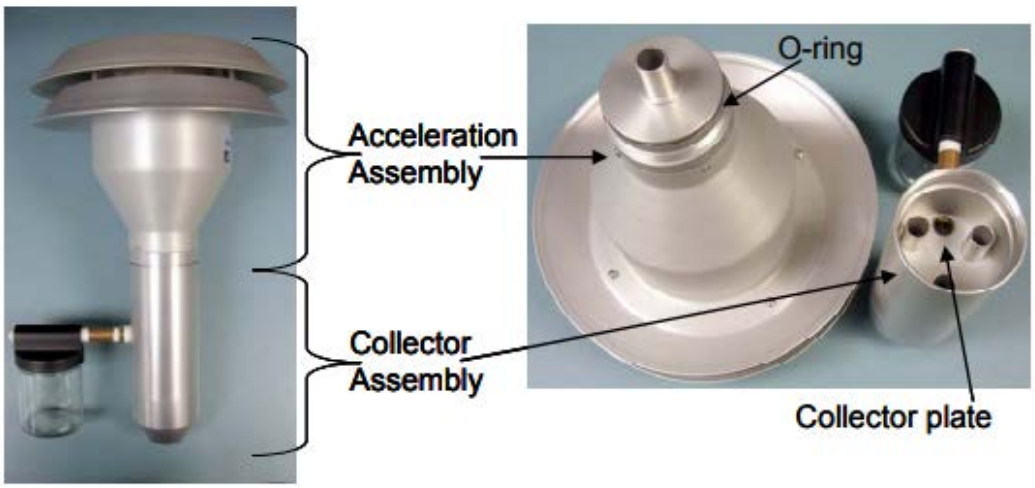

Figure 9: PM_{10} inlet head components (Vaughn 2009)

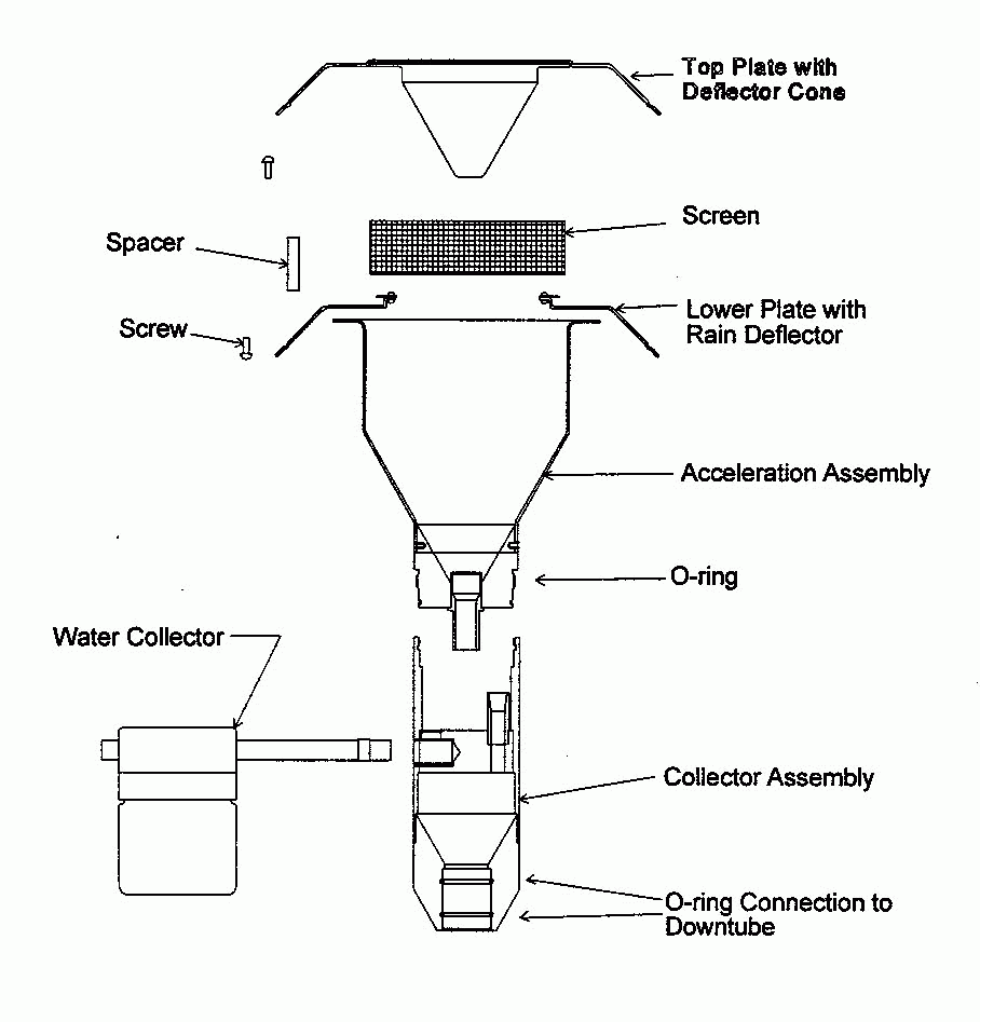

Figure 10: Exploded cross-sectional view of PM_{10} inlet (EPA 2016).

7.2. Clean the VSCC™ ($PM_{2.5}$ only)

1. Remove the top cap and the emptying cup as shown in Figure 11.
2. Use a damp lint-free wipe (e.g. Kimwipe) to remove visible dirt and debris, paying close attention to the emptying cup and the cone inside the top cap. To clean the VSCC™ cyclone's smaller tubing, use a cotton-tip swab as applicator to push the wipe through.
3. Inspect the O-rings for damage and adequate lubrication. Replace O-rings and apply silicone grease if necessary.
4. Reinstall the VSCC™ on the inlet.

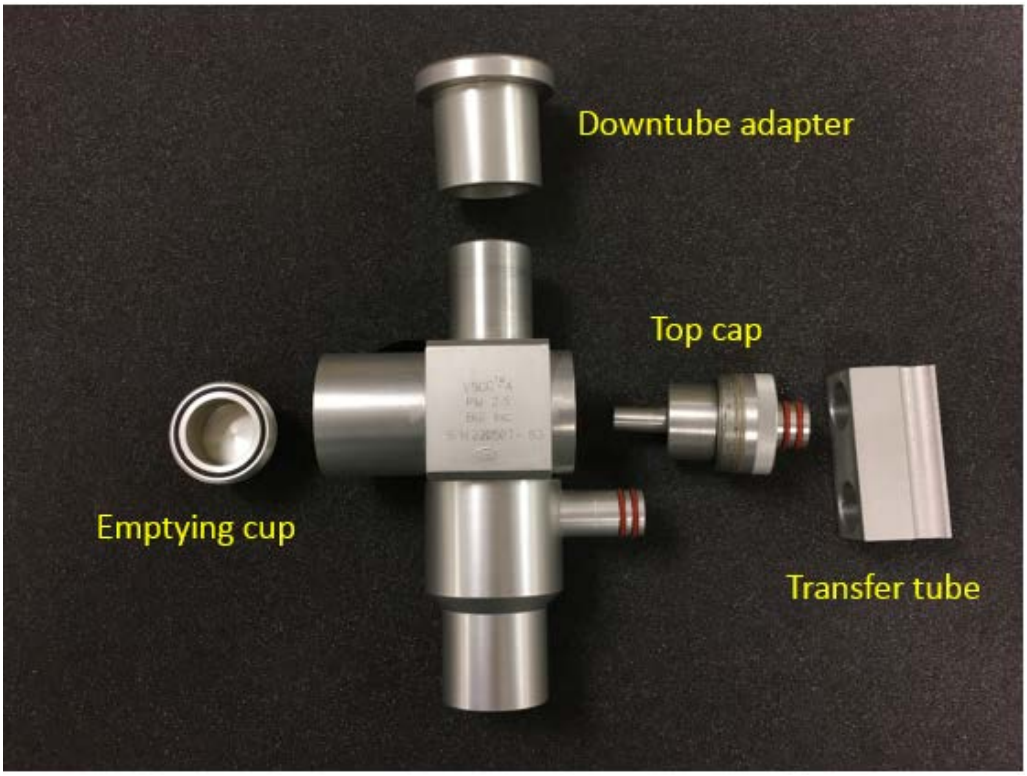

Figure 11: Exploded view of VSCC™ components and downtube adapter.

7.3. Inspect the V seals

1. Ensure the instrument is in Stop Mode.
2. Open the top cover of the sampler. Removing the PM_{10} inlet is optional when opening the cover.
3. Remove the VSCC™ ($PM_{2.5}$) or downtube assembly (PM_{10}) inside the sampler enclosure.
4. Locate the downtube mount V seal that is at the bottom of the enclosure lid as shown in Figure 12. Examine seal for drying and/or cracking. Apply a light coating of silicone grease to the seal or replace as necessary.
5. Remove the electronics cover from the top enclosure. Depending on the sampler models, you may have to remove the exit cylinder cover first before removing the electronics cover.
6. Remove the front cover of the electronics compartment by removing the four screws.
7. Enter Service Mode.
8. Scroll the pointer to the System Maintenance Routines option, select <F2: LeakChk> and then <F3: ClnSeal> to initiate the seal cleaning procedure.
9. Following the instructions on the screen, remove the mounting plate where the top head is attached and the cassette in the sampling position from the enclosure. Press <F4:

Done> when complete. The filter exchange assembly will push up so the bottom V seal is more accessible for cleaning.

10. The top and bottom V seals are now exposed. The top seal is located at the bottom of the top head. Examine both seals for drying and/or cracking. Grease the seals with a light coating of silicone grease or replace as necessary.
11. When cleaning is done, press <F4: Done>, then follow the instructions to re-install the components. Press <F4: Done> again when complete. The assembly will push back up to create the seal.
12. Replace all electronics covers and the VSCC™. Close the top cover.
13. Perform an external leak check following Sections 6.1.4.
14. Resume normal operation.

Figure 12: Location of downtube mount V seal

7.4. Clean interior sample case

At a minimum of every 30 days, wipe down the interior of the sampler to remove bugs, dirt, and/or water deposits that may have collected inside the enclosure. This may be required more frequently during summer months. Examine the tubing fitting to ensure proper seal and tightness. Inspect the cooling air intake filter during the summer months and clean as necessary.

7.5. Clean air intake screens

The two screens, one in the filter compartment and one in the pump compartment, should be cleaned at a minimum of every 6 months, and more frequently in highly polluted areas.

1. Locate the two air-intake fans. Each of these has an associated air intake screen.
2. Snap off the covers enclosing the air intake screens.
3. Take out the screens and clean them with a brush or wash them with a mild soap solution and water (must be dried thoroughly before reassembly).
4. Reinstall the screens in their holders and remount the covers.

7.6. Exchange particle trap filters

The particle trap filters are located behind the filter exchange assembly. Perform the procedure below to inspect and exchange the particle trap filters once a year.

1. Turn off the sampler.
2. Locate the bowl-style filter behind the filter exchange assembly. Remove the filter bowl by unscrewing it from the filter manifold.
3. Carefully remove the filter stand by unscrewing it from the filter. The O-ring usually remains in the filter manifold.
4. Remove the gasket and top disk from the filter stand. The gasket might sometimes remain inside the filter manifold.
5. Inspect the filter element for cleanliness. To replace, remove the filter element from the filter stand and install a new element.
6. Install the top disk and gasket if necessary into the filter stand.
7. Install the filter stand into the filter manifold. Install the O-ring into the filter manifold, if necessary.
8. Install the filter bowl into the filter manifold.
9. Turn on the sampler and perform a system (external) leak check.

7.7. Clean the downtube

Inspect the outer and inner surfaces of the tip (closest to the sampler inlet) of the downtube. Remove any particulate deposits using isopropyl rubbing alcohol or water and lint-free wipes or brushes. Dry the downtube completely before reinstallation.

7.8. Multi-point ambient temperature verification

1. Press <Menu> to enter Service Menu. Scroll to the *Calibration/Audit* option, as shown in Figure 8, press <F3: SensCal> to access the Sensor Calibration screen.
2. Loosen the two screws on either side of the temperature probe on the ambient temperature assembly and remove the probe from the radiation shield. Band together the reference and sampler probe and immerse them into the same depth in an insulated container of water.
3. Take measurements about 1 minute apart in **three** temperature conditions: in an ice slurry, at ambient conditions, and in warm water at approximately 50°C (~120°F). Allow the reference and sampler probes to equilibrate for at least 3 minutes at each temperature before taking the reading. Record the **actual** temperature from the reference standard and **indicated** temperature from the sampler menu screen in °C.
4. If any set of temperature readings between the reference standard and sampler differs more than 2.1°C, follow Section 6.2.2 to calibrate ambient temperature.
5. Reinstall the ambient temperature probe in the radiation shield and tighten the two screws on either side of the probe.

7.9. Filter compartment temperature verification

1. Press <Menu> to enter the Service Menu. Scroll to the *Calibration/Audit* option, press <F4: FiltCal> to enter the Filter Temperature Calibration Screen.
2. Locate the filter compartment temperature probe to the left hand side of the supply magazine. Carefully place the reference thermometer probe close to the sampler probe. Allow the reference and sampler probes to equilibrate for at least 3 minutes before taking the reading. Record the **actual** temperature from the reference standard and **indicated** temperature from the sampler menu screen in °C.
3. If the temperature reading between the reference standard and sampler differs more than 2.1°C, the sampler temperature needs to be calibrated.
4. To calibrate, enter the temperature of the reference standard in °C in the Actual column of the Filt Comp row on the screen and press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input.
5. Perform a single point temperature verification to confirm the calibration.

7.10. Replace batteries

The three alkaline AA batteries in the electronics provide backup power for internal data storage and the clock/calendar. The expected lifetime of the batteries in the instrument is 1 year. Batteries must be tested annually and be replaced as needed. Operators should always wear appropriate anti-static gloves when working with the system electronics.

1. Remove the three screws securing the Pump Compartment Cover and the cover.

2. Open the electronics compartment of the sampling unit and locate the batteries.

3. Check whether the batteries need replacing by measuring the voltage across the test point labeled “BATT” (red) on the interface board and the ground test point labeled “188_PGND”. If the measured voltage is less than 4.2 VDC, the batteries need to be replaced. Skip to Step 6 if the voltage is acceptable.

4. Remove the clip that holds batteries in their mounting and pull the old batteries out and replace them with new ones, noting the proper polarity. Perform this exchange within an elapsed time of 5 minutes to avoid the loss of data stored in the battery-backed RAM.

5. Reinstall the clips that hold the batteries in position. Test for a voltage of 4.2 VDC as in Step 3.

6. Close the electronics compartment of the sampling unit.

8. Laboratory Activities

The Manchester Environmental Laboratory's (MEL) $PM_{2.5}$/PM_{10} gravimetric laboratory processes all Washington Network $PM_{2.5}$ and PM_{10} samples from Sequential Samplers operated within the Washington Network. This work is performed in accordance with all requirements described in:

- 40 CFR Part 50, Appendix J and L,
- EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II,
- EPA Quality Assurance Guidance Document 2.12, and
- EPA Technical Note (Oct 2015) on Holding Time Requirement for $PM_{2.5}$ Filter Samples

The personnel responsible for the laboratory activities will perform tasks including, but not limited to:

- Ship and receive the samples to and from the operators
- Verify the integrity of the samples upon receipt, including visual check of the filter samples and storage/cooler conditions
- Verify information on the Chain of Custody Form (COC) upon receipt of samples and record cooler conditions on the same COC
- Perform gravimetric analysis, including pre-weighing and post-weighing
- Record any noticeable aspects of the filter sample and/or weighing conditions
- Generate summary reports based on information gathered from the Sequential Sampler Data Run Sheet and gravimetric analysis
- •Periodically review and verify the mathematical formula used in the software to calculate mass concentrations and generate the summary reports are accurate

A more detailed description of the laboratory activities can be found in MEL's $PM_{2.5}$/PM_{10} Gravimetric Laboratory Standard Operating Procedure. Contact the MEL technician for the most recent version.

Following gravimetric analysis, the MEL technician sends PM10 samples collected at the Seattle-Beacon Hill monitoring site (1-in-6 samples) to Eastern Research Group Inc. (ERG) for lead (Pb) analysis as part of the National Air Toxics Trends Stations (NATTS) Network requirements.

9. Data Validation and Reporting

9.1. Data validation

The MEL technician conducts the initial sample validation following a laboratory validation protocol prescribed in MEL's Gravimetric Laboratory SOP. The reviewed data is reported to the Ecology Quality Assurance (QA) unit who is responsible for final data validation. Data validity is evaluated using a number of criteria including, but not limited to, the results of quality control checks and performance audits. Refer to Ecology Air Quality Program's Air Monitoring Documentation, Data Review, and Validation Procedure which describes further data validation activities.

Table 5 summarizes the tolerance limits for critical and operational criteria for field activities, and Table 6 summarized those for laboratory activities. The criteria listed in Table 6 are implemented by the MEL technician and are described more extensively in MEL's Gravimetric Laboratory SOP and EPA Method 2.12.

The criteria that trigger invalidation of samples outside of tolerance limits are marked with a ✓. The validity of samples outside of the remaining limits is evaluated using a weight-of-evidence approach. The full table of critical and operational criteria can be found in EPA's Validation Templates in the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II.

Table 5: Summary of critical and operational validation criteria in field activities

Criteria	Frequency	Tolerance limits	Invalid
Filter holding time	All filters	Pre-sampling ≤ 30 days. Sample recovery: ≤ 177 hours from sample end date.	✓
Sampling duration	All filters	1380-1500 minutes, unless value <1380 and PM result exceeds NAAQS (must be flagged)	✓
Average flow rate	24 hours of operation (midnight to midnight)	< ± 5.1 % design flow (16.67 lpm)	✓
Variability in flow rate	24 hours of operation (midnight to midnight)	Coefficient of variation (CV) ≤ 2 %	✓
Flow verification	Monthly QC semi-annual audit	< ± 4.1 % of actual flow; < ± 5.1 % of design flow	✓
External leak check	Monthly QC semi-annual audit	< 80.1 mL/min (≤ 25 mmHg/min)	✓
Internal leak check	Monthly QC semi-annual audit	< 80.1 mL/min (≤ 140 mmHg/min)	✓
Clock verification	Monthly QC semi-annual audit	± 1 min. of data logger	Weight of evidence
Temperature verification	Monthly QC semi-annual audit	< ± 2.1 °C	Weight of evidence
Pressure verification	Monthly QC semi-annual audit	< ± 10.1 mmHg	Weight of evidence

Table 6: Summary of critical and operational validation criteria in lab activities

Criteria	Frequency	Tolerance limits	Invalid
Filter temperatures	All filters	< 25 °C from sample recovery to conditioning	✓
Filter holding time from sample end date to post-conditioning and weighing	All filters	T_{max}: maximum temperature recorded in the cooler and must be < 25 °C T_{avg}: average temperature during the 24-hr sampling period ≤ 30 days if $T_{max} \leq T_{avg}$ ≤ 10 days if $T_{max} > T_{avg}$	✓
Conditioning	All filters	24 hours minimum	✓
Temperature	All filters	24-hr mean within 20-23 °C and < ±2.1 °C over 24 hours	✓
Humidity (RH)	All filters	24-hr mean within 30-40 %, or within ± 5 % sampling RH but ≥ 20 % RH	✓
Exposure lot blanks	3 filters/lot	< ± 15.1 µg change between weighings	Weight-of-evidence

9.2. Data reporting

Sample data is reported in calendar month increments. After the MEL technician has completed its review and initial validation of the sample data, the following information is sent to Ecology's QA unit:

- A gravimetric analysis report listing mass concentration by site and by date, laboratory flags where a sample has been deemed invalid by MEL, and a brief note on why the sample was invalidated or voided.
- A summary letter detailing high concentration samples as well as notes on invalidated or voided samples.
- A re-engineered AIRS files containing final mass concentrations to.

QA personnel load re-engineered AIRS files into the Envista Air Resources Manager (EnvistaARM) to facilitate the subsequent data review and validation processes.

Following final data validation by QA personnel, the Air Quality System (AQS) Coordinator electronically submits all valid data to EPA's AQS. Invalid data are flagged in the EnvistaARM and not sent to AQS.

Additionally, the MEL technician sends quarterly cooler and control chart of the laboratory to field operators and Ecology's QA Coordinator to inform the quality control of the filter samples and laboratory conditions.

10. References

40 C.F.R. Part 50 Appendix J. *Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere.* 2016.

40 C.F.R. Part 50 Appendix L. *Reference Method for the Determination of Fine Particulate Matter as $PM_{2.5}$ in the Atmosphere*. 2016.

40 C.F.R. Part 58 Appendix A. *Quality Assurance Requirements for Monitors used in Evaluations of National Ambient Air Quality Standards.* 2016.

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Appendix A. Sequential Sampler Run Data Sheet

AQS Number		**Filter ID Number**	
Station Name			
Station Location			
Sampler Serial #			
Sample Date		Cassette ID Number	
Sample Removal Date & Time	PST	Sample Ship Date & Time	PST
Operator			
Start Time	PST	Start Date	
Stop Time	PST	Stop Date	
Total Sample Time	min		
Sampled Volume	m^3	Flow Rate, CV	%
Status Codes			
Average Flow Rate	lpm		
Min. Ambient Temp.	°C	Min. Ambient Press.	mmHg
Avg. Ambient Temp.	°C	Avg. Ambient Press.	mmHg
Max. Ambient Temp.	°C	Max. Ambient Press.	mmHg

Operator Comments

Area below for lab use only

Sample temp. upon receipt	°C	Sample Receipt Date	
		Sample Receipt Time	PST
Gross Weight (M_f)	µg	Calculated Concentration	µg/m^3
Tare Weight (M_i)	µg		

$$\mu g/m^3 = \frac{(Mf - Mi)}{Total\ Volume} \times 10^3$$

Comments by laboratory analyst

Text…

Appendix B. Chain of Custody Form

PM 2.5/ PMc Chain of Custody

Project _____ ___ of ___

Number of Tubes _____ **AIRS #** _____

Filter Number (s)

Filter ID	Sample Date

Filter ID	Sample Date

Relinquished By:	Received By:	Date	Time	Temp °C	Seal ID	Condition of Seals	Comments
	Fed Ex						
Fed Ex							

Appendix C. Quality Control Check Forms

Washington State Department of Ecology
2025 Sequential Sampler $PM_{2.5}$ Quality Control Check Form

Revised 09262019

AQS ID		Date	
Location		Operator	
Sampler Serial No.		QC Start Time	
State Tag No.		QC Stop Time	
R&P Software Version			
		Temp Std. Serial No.	
Flow Std. Model		Temp Std. Cert. Date	
Flow Std. Serial No.		Pressure Std. Serial No.	
Flow Std. Cert. Date		Pressure Std. Cert. Date	

Temperature and Pressure QC

Ambient Temperature (< ±2.1 °C)	Act:	°C	Filter Temperature (< ±2.1 °C)	Act:	°C
	Ind:	°C		Ind:	°C
	Diff:	°C		Diff:	°C

Barometric Pressure (< ±10.1 mmHg)	Act:	mmHg	Time ± 1 minute of data logger?	
	Ind:	mmHg	Is the inlet head clean?	
	Diff:	mmHg		

Flow QC

Indicated Flow lpm	Actual Flow lpm	Flow Difference < ±4.1%	Design Flow Difference < ±5.1%

External Leak Check

	Vacuum Pressure Loss mmHg	Pass/Fail
As-Found Leak Check (≤ 25 mmHg)		
As-Left Leak Check (≤ 25 mmHg)		

*Internal leak check only needed if external leak check failed.

Comments:

QC Result:

Washington State Department of Ecology
2025 Sequential Sampler PM_{10} Quality Control Check Form

Revised 09262019

AQS ID		Date	
Location		Operator	
Sampler Serial No.		QC Start Time	
State Tag No.		QC Stop Time	
R&P Software Version			
		Temp Std. Serial No.	
Flow Std. Model		Temp Std. Cert. Date	
Flow Std. Serial No.		Pressure Std. Serial No.	
Flow Std. Cert. Date		Pressure Std. Cert. Date	

Temperature and Pressure QC

Ambient Temperature (< ±2.1 °C)	Act:	°C	Filter Temperature (< ±2.1 °C)	Act:	°C
	Ind:	°C		Ind:	°C
	Diff:	°C		Diff:	°C

Barometric Pressure (< ±10.1 mmHg)	Act:	mmHg	Time ± 1 minute of data logger?	
	Ind:	mmHg	Is the inlet head clean?	
	Diff:	mmHg		

Flow QC

	Indicated Flow lpm	Actual Flow lpm	Flow Difference < ±4.1%	Design Flow Difference < ±5.1%
Actual:				
Standard:				

External Leak Check

	Vacuum Pressure Loss mmHg	Pass/Fail
As-Found Leak Check (≤ 25 mmHg)		
As-Left Leak Check (≤ 25 mmHg)		

*Internal leak check only needed if external leak check failed.

Comments:

QC Result:

Appendix D. Maintenance Check Sheet

Parameter	Frequency	Initial and date boxes after each check is completed																						Acceptance Criteria
		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		
One-Point Flow Rate Verification	1/ every 4 weeks																							< ± 4.1 % of the Transfer Standard
Multi-Point Flow Rate Verification	Annual or if One-Point Failure																							< ± 4.1 % of the Transfer Standard
Flow Rate Calibration	If Multi-Point Failure																							< ± 4.1 % of the Transfer Standard
One-Point Ambient Temperature Verification	1/ every 4 weeks																							< ± 2.1 ˚C of Standard
Multi-Point Ambient Temperature Verification	Annual																							< ± 2.1 ˚C of Standard
Filter Temperature Verification	1/ every 4 weeks																							< ± 2.1 ˚C of Standard
Filter Compartment Temperature Verification	Annual																							< ± 2.1 ˚C of Standard
Pressure Verification	1/ every 4 weeks																							< ± 10.1 mmHg
Pressure Calibration	Annual																							< ± 10.1 mmHg

Parameter	Frequency	Initial and date boxes after each check is completed																						Acceptance Criteria
		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		
Clock/timer Verification	1/ every 4 weeks																							± 1 minute
External Leak Check	1/ every 4 weeks																							≤ 25 mmHg/min
Internal Leak Check	If External Leak Failure																							≤ 140 mmHg/min
Inspect and Clean PM_{10} inlet	1/ every 4 weeks																							--
Inspect and Clean VSCC™ ($PM_{2.5}$ only)	1/ every 4 weeks																							--
Inspect the V Seals	1/ every 4 weeks																							--
Clean Interior of Sample Case	1/ every 4 weeks																							--
Clean Air Intake Screens	1 / every 6 months																							--
Exchange Particle Trap Filters	Annual																							--
Water Collector Bottle Inspection	Every 5 sampling events																							--