DEPARTMENT OF
ECOLOGY
State of Washington

E-SAMPLER Operating Procedure

Revised June 2019

Publication 18-02-044

Publication and Contact Information

This document is available on the Department of Ecology's website at:
https://fortress.wa.gov/ecy/publications/summarypages/1802044.html

For more information contact:

Will Wallace

Air Quality Program
P.O. Box 47600
Olympia, WA 98504-7600
Phone: 360-407-6800

Washington State Department of Ecology — www.ecology.wa.gov

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Union Gap 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

To request ADA accommodation including materials in a format for the visually impaired, call Ecology at 360-407-6800 or visit https://ecology.wa.gov/accessibility. People with impaired hearing may call Washington Relay Service at 711. People with speech disability may call TTY at 877-833-6341.

E-SAMPLER Operating Procedure

Air Quality Program

Washington State Department of Ecology

Olympia, Washington

This page is purposely left blank

Table of Contents

Figures

Tables

1. Introduction

This document describes the Washington State Department of Ecology's Standard Operating Procedure (SOP) for sampling ambient air for particulate matter with aerodynamic diameter 2.5 µm or less ($PM_{2.5}$) using a Met One E-SAMPLER. It covers the configuration, operation, and maintenance of E-SAMPLER and is intended to be used with the manufacturer's manual.

2. Intended Uses

E-SAMPLERs are a low cost, readily deployable means to assess $PM_{2.5}$ concentrations in communities without permanent monitoring sites. The Washington State Department of Ecology (Ecology) intends to use its E-SAMPLERs for temporary, short-term, monitoring when Federal Reference Method (FRM) or Federal Equivalent Method (FEM) monitoring is not needed. The primary uses of the E-SAMPLERs are:

- **Monitoring of $PM_{2.5}$ during wildfires**
- **Monitoring the impact of isolated events**
- **Surveys of communities without fixed-site monitors**
- **Monitoring for agricultural burn team**
- **Correlation development and performance development**

Uses of the E-Samplers during wildfire season and outside of wildfire season are defined by Air Quality Program monitoring policies AAM 1a Wildfire_Assistance_031318 and AAM 1b Non_Wildfire_Assistance_05012019.

2.1 Management of air quality program E-SAMPLERs

2.1.1 Collocation

Ensuring and demonstrating that collected data are sufficiently accurate is critical to understanding true pollution levels and variability in a given study area. Understanding data quality is also critical to decision makers when considering where to focus control strategies and allocate resources. Collocation with a FEM will help to ensure that E-SAMPLER precision and bias is understood and quantified prior to conducting a study and that spatial differences in pollution concentrations are not due to variability of the E-SAMPLERs. A more detailed description of the collocation procedure and a description of the development of the E-SAMPLER scaling factor (k-factor) can be found in section 11.1 of this SOP.

2.1.2 Annual service

Each winter, the Calibration and Repair laboratory will calibrate and perform annual maintenance on the E-SAMPLERs. This includes recalibration by MetOne Instruments every two years. After being serviced by the Calibration and Repair personnel, the E-SAMPLERs may be used at various periods during the fall and winter for surveys and saturation studies. E-SAMPLERs used for this purpose will be operated by an experienced Ecology air monitoring operator to ensure adequate data quality. As described in the Air Quality Program monitoring policy AAM-1, the lab will supply all available E-SAMPLERs to Ecology's Central and Eastern Regional Office staff prior to the start of wildfire season which typically begins in June. Assigned Air Quality Program staff, with training and expertise on E-SAMPLER operation, will either operate the E-SAMPLERs or provide operational training to temporary site operators from local health departments and other entities.

Regional staff will promptly return the monitor(s) by March 1st of each year to the Ecology Air Quality Program's Calibration and Repair laboratory at:

Washington State Department of Ecology

Air Quality Program Calibration and Repair Laboratory

300 Desmond Dr. SE

Lacey WA 98503

3. Principles of Operation

The E-SAMPLER is a type of nephelometer that uses forward scatter of laser light by suspended particulate to provide a continuous real-time measurement of airborne particulate. An internal visible laser diode operating at 670 nm wavelength is collimated and directed through sample air. This sample air is drawn into the E-SAMPLER by an internal rotary vane pump. Flow rate is controlled based on actual conditions (ambient temperature and pressure) for accurate cut-points through the sharp-cut cyclone. When particulate laden sample air intersects the laser beam, a portion of the light is scattered. The scattered light is collected at a near forward angle and focused on a photo diode that converts the light to an electric signal proportional to the amount of scattered light. The E-SAMPLER uses an internal algorithm to convert the measure of scattered light to a $PM_{2.5}$ mass concentration (µg/m3). A picture of the E-SAMPLER with the optional met package is presented below:

Figure 1: E-SAMPLER with EX-034 meteorological attachment

While the E-SAMPLER is equipped with an additional filter-based method that is used to obtain airborne particulate mass concentration data, the Department of Ecology **does not** use this to determine the k-factor as described in the E-SAMPLER Manual. Filter based sampling is impractical and reduces the utility of the E-SAMPLER due to the high labor and laboratory costs associated with it. Instead, the Department of Ecology’s Air Quality program uses collocation with an FEM or FRM to determine the k-factor. This process is described in section 11.1 of this SOP.

4. Equipment and Supplies

The diagnostic tools, parts and supplies necessary to operate and maintain the E-SAMPLER are summarized below.

Table 1: Tools and supplies for installation of E-SAMPLER

Category	Equipment
Tools and Equipment	Approved, certified flow standard
	Flow audit adapter
	NIST-Traceable thermometer
	Handheld barometer
	Digital multi-meter
	Various hand tools (screwdriver, 3/16" Allen wrench, etc.)
	Rubbing alcohol
	Lint-free lab wipes

Each E-SAMPLER should come from the Calibration and Repair laboratory equipped with the following materials. If any of these items are missing, contact the Calibration and Repair laboratory immediately.

- E-SAMPLER Smoke Particulate Monitor
- Weatherproof universal AC to 12VDC power supply
- 47 mm filter cassette assembly
- Weatherproof TSP inlet with debris screen
- TSP inlet cap
- Sharp Cut Cyclone for $PM_{2.5}$
- AIRSIS telemetry system
    - Modem kit
    - Power cord
    - Serial communication cable
    - Mounting hardware
- Instruction manual
- Laptop with serial port or serial to USB
- Two extension cords or a 2+port power tap
- EX-905 Aluminum Tripod
- EX-034 Wind Speed and Wind Direction sensor. (Available upon request from Calibration and Repair laboratory)

5. Site Selection

Selection of a proper site for the E-SAMPLER is critical for accurate measurements. Ecology primarily uses its E-SAMPLERs to conduct saturation studies and to provide information on ambient $PM_{2.5}$ concentrations in communities impacted by smoke from wildfires. Therefore, to the extent possible and/or practical, E-SAMPLERs should be placed in accordance with the most current $PM_{2.5}$ monitoring siting criteria found in 40 CFR 58, Appendix E. In the vast majority of cases, E-SAMPLER monitors should be sited according to neighborhood-scale (0.5 to 4 km) siting criteria. One additional consideration is that the telemetry antenna must have a clear view of the southern sky to transmit data. Thus, it must be sited in an open area free from obstructions such as trees, buildings, signs, etc.

The following is a summary of general ambient particulate monitoring site requirements that will be appropriate for use with the E-SAMPLER in many cases. Some of these criteria may not be appropriate in some applications, due to the versatile nature of the E-SAMPLER:

Table 2: Summary of E-SAMPLER siting requirements

Parameter	Category	Siting Requirement
Inlet height	General	2-15m above ground
	On rooftop	2m above roof
	Collocated samplers	Within 1 vertical m of each other
	Inlet tube length	≤ 16 ft (4.9 m)
Inlet radius clearance	General	≥ 1 m radius clearance
	Collocated samplers	1-4 m between inlets
	Near Hi-Vol	≥ 3 m between FDMS TEOM and Hi-Vol inlets
	Near small obstructions (fences, walls, etc.)	≥ 2 m
	Near large obstructions (buildings, sound walls, billboards, etc.)	Distance ≥ 2x height of obstruction
	Near overhanging trees	≥ 20 m from tree drip line
	Arc of air flow	Unrestricted 270° arc that includes prevailing direction of high concentrations
Nearby air sources	General	As far away as possible from vents
Distance from roadway	≥ 3,000 vehicles per day	≥ 18 m from nearest traffic lane
	< 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

Additional information on site selection can be found in Ecology's Air Monitoring Project Approval, Site Selection, and Installation Procedure.

Fall Hazard and Security Cautions

The E-SAMPLER tripod should be secured to the mounting surface in windy conditions to prevent the unit from falling over, even at ground level. This is especially important in winds over 30 mph. If bolt-down is not possible, then the tripod legs may be secured with sand bags or cinder blocks. Damage resulting from being blown over is not covered under warranty.

The E-SAMPLER should be secured from theft or vandalism to the extent possible. A limited-access rooftop or a fenced, gravel or paved, lot are often good places to deploy the unit.

6. Initial Installation and Configuration

When setting up the E-SAMPLER, follow the instructions in the manufacturer's manual. The following installation/configuration procedure can be used in conjunction with the manufacturer's manual. A schematic of an E-SAMPLER set up with all of the auxiliary components is below in figure 2.

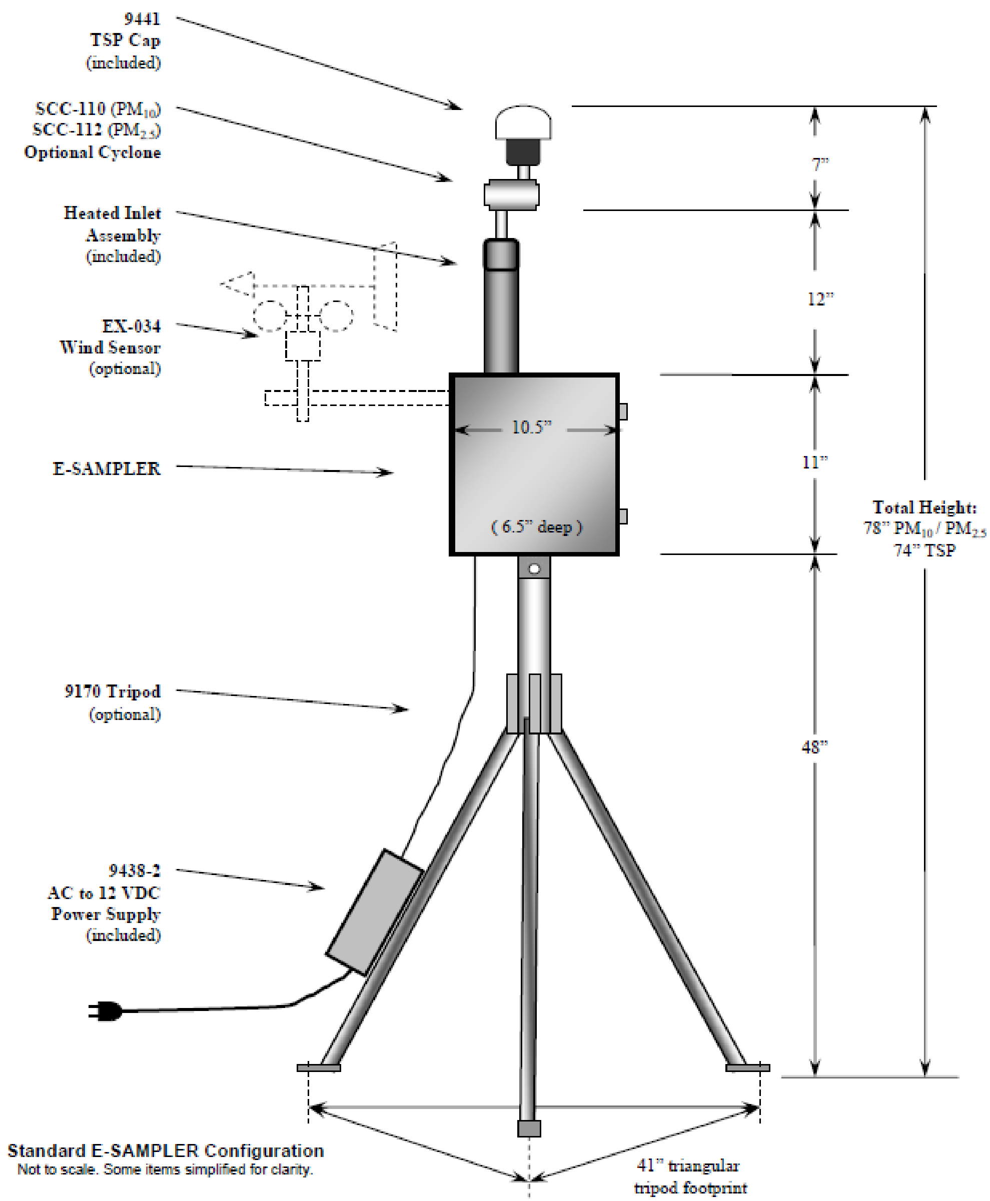

Figure 2: Schematic of the E-SAMPLER

Physical installation:

1. Remove the three pins from the E-SAMPLER tripod and unfold the legs until they are fully extended. Replace the detent pins in the holes in the leg flanges.

Figure 3: E-SAMPLER tripod and detent pins

2. Ensure E-SAMPLER is adequately attached and anchored to roof/ground to avoid blowing over in strong winds.
3. Attach the E-SAMPLER control unit to the tripod by sliding the slot on the back of the E-Sampler over the mounting tab on the tripod.
4. Attach the bottom of the E-SAMPLER control unit to the tripod by sliding the ¼-inch bolt through the bottom flange and through the tripod. Hand tighten the nut on the bolt.
5. Affix the $PM_{2.5}$ sharp cut cyclone to the inlet of the E-SAMPLER.
6. Affix the TSP cap to the $PM_{2.5}$ sharp cut cyclone.
7. Ensure that the empty 47mm cassette is in place. An empty 47 mm filter cassette assembly must be installed in the filter sampler position at all times, in order to seal the flow system.
8. Attach the power supply/battery charger to the tripod (if it's not already attached).
9. Connect the power supply to the bottom of the E-SAMPLER control unit.

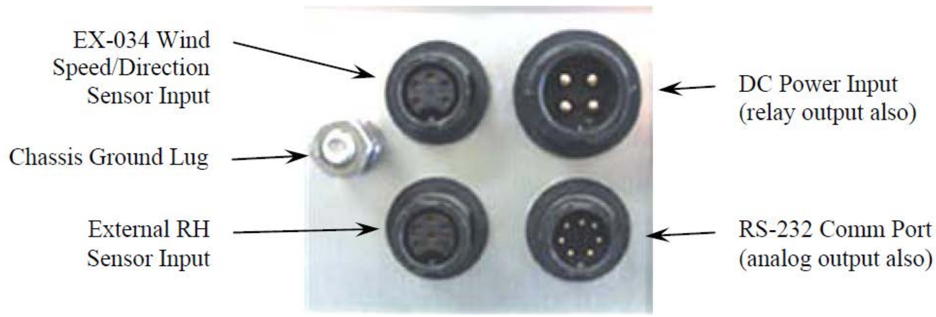

Figure 4: E-SAMPLER connector layout

10. Attach the telemetry system to the tripod, using the supplied hardware.
11. Plug the communication cable (7-contact circular plastic connector (CPC)) from telemetry system to the appropriate connector on the bottom of the E-Sampler.
12. Attach the power cord (4 pin CPC) from the power supply and telemetry system to the extension cord and plug in the extension cord to line power. From the main screen (see below), press the MENU/SELECT button to check the settings.

E-SAMPLER Settings

A picture of the E-SAMPLER user interface is shown below.

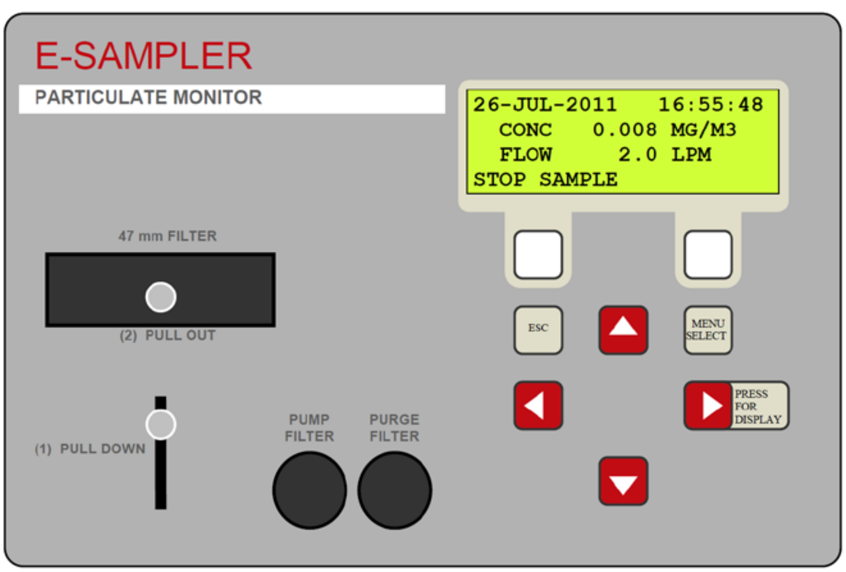

Figure 5: E-SAMPLER control unit user interface

The MENU/SELECT, ESC, left, right, up, and down arrows are used to traverse the screens on the E-Sampler. The blank white buttons under the screen are used to save or exit settings. Settings on the E-Sampler should have been set already. The instrument stores these settings.

13. Press STOP to exit sample mode if the instrument is running and check/ adjust parameters.

Inside the SETUP menu use the up and down arrow buttons to move the cursor to the desired setting and press MENU/SELECT. Once in a menu, the left/right buttons navigate the value and the up/down buttons change the value. Confirm the following settings and adjust if necessary:

a. Set E-SAMPLER clock to Greenwich Mean Time (GMT).
b. Average Period = 60 minutes
c. Concentration = mg/m^3 (conversion to $\mu g/m^3$ will be done by AIRSIS or Ecology telemetry system)
d. K factor = 1
e. Sampling Mode = Continuous
f. RH Set Point = 50%
g. Concentration Range = 10 mg/m
h. Baud Rate = 9600
i. Self Test Interval = 24 hour
j. Span check = on
k. Engineering units = Metric

***** Before you turn on the satellite communication, contact Chuck Pierce (HQ IT) at (360) 407-6851 or CHUP461@ECY.WA.GOV . He needs to know the, E-Sampler ID number, the site name (keep it short) and the start date of the measurement. *****

14. Power up AIRSIS unit.
    a. Look for red power light.
    b. Wait for 3 green lights to confirm satellite communication (satellite communication occurs only when sampler is in run mode) as shown below:

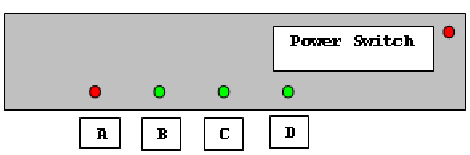

Figure 6: AIRSIS display LEDs

A. Modem initialized light is on.
B. Serial Data measurement Digital 0 from E-SAMPLER light is on.
C. Serial Data measurement Digital 1 from E-SAMPLER light is on.
D. Light is ON when satellite is in view and OFF between satellite passes. (If this green LED light does not turn on within 30 minutes, move the telemetry system to a higher unobstructed position.)

15. Allow the sampler to warm up for about one hour.
16. After E-SAMPLER has warmed up, conduct a full calibration check (see section 7 below).
17. If calibration check results are not within the specifications described in this procedure, re-calibrate the E-SAMPLER (see section 8 below).

***** When shutting down the E-Sampler at the end of a deployment you need to again contact IT to let them know what's going on. Contact Chuck Pierce (HQ IT) at (360) 407-6851 or CHUP461@ECY.WA.GOV and let him know the E-Sampler ID number and the end date of measurement. *****

6.1 Optional Meteorological Sensors

An optional wind speed/direction sensor (model EX-034) may be requested from the Calibration and Repair laboratory. The EX-034 wind sensor sits atop a cross-arm that can be mounted to a stud atop the E-SAMPLER's tripod.

Install the wind sensor on the end of the cross-arm. The wind sensor should usually be as far from the E-SAMPLER unit as possible without affecting the tripod balance, and the wind vane must be able to rotate fully without hitting anything. Plug the wind sensor into the corresponding wind connector on the bottom of the E-SAMPLER. Upon installation, the sensor must be oriented to true north in order to collect reliable and accurate wind speed and direction data using the GPS method that is described in the Air Quality Program's Meteorological Procedure. For additional information on the configuration of the wind sensor, consult the separate manual that comes with the EX-034.

Short of collocation with one of the Washington Network PSD-quality wind monitors, there is no quality control procedure for the wind sensor. Therefore, as the data collected from the E-SAMPLER is not sent to AQS it should be treated as qualitative rather than quantitative and used with caution.

7. Quality Control / Maintenance

The following sections describe the automated and manual quality control and maintenance of E-SAMPLERs.

7.1 Automatic Zero and Span Self-Test for the Optical System

The E-SAMPLER performs optical system zero and span self-tests at a user-selected frequency of every 15 minutes, 1 hour, 2 hours, 12 hours, or 24 hours. Washington Network E-SAMPLERs are set to perform the self-test at 24-hour intervals.

At the onset of the self-test, a separate zero air pump within the E-SAMPLER activates and circulates clean air through the optical system. The air passes through a 0.2-micron pore size, 99.99% efficient filter element before it enters the sensor. This is the PURGE FILTER located in the front panel of the instrument. The E-SAMPLER zeros itself based on this clean air condition.

The E-SAMPLER then activates a solenoid shutter which allows a small amount of laser light from the light trap to feed back into the detector using fiber optics. This span level is used to check the response of the detector and related electronics.

7.2 Manual Quality Control

In order to ensure proper operation of the E-SAMPLER and reasonably accurate data, quality control (QC) and routine maintenance must be performed by the monitoring operator at regular intervals. The following QC and routine maintenance must be performed upon initial installation, every 30 days thereafter, and just prior to completing sampling at a given location:

Table 3: E-SAMPLER 30-day Maintenance/QC

Maintenance Item	Frequency
System leak check	Every 30 Days
Flow, temperature, and pressure verifications	Every 30 Days
Clean sharp-cut cyclone, particle trap, and TSP inlet	Every 30 Days
Check digital alarm log	Every 30 Days
Clean 47 mm filter holder screen	Every 30 Days

Additional maintenance must be performed at frequencies ranging anywhere from 6 months to 5 years as shown below. These less frequent maintenance items will be performed by Calibration and Repair laboratory personnel unless other arrangements are made with the E-SAMPLER operator.

Table 4: E-SAMPLER Maintenance Schedule

Maintenance Item	Schedule
Check filter RH sensors	Every 6 Months
Replace PUMP filter and PURGE filter	Every 12 Months
Factory service, recalibration, and optical system cleaning	Every 24 Months
Replace lithium backup battery, as needed	Every 5 Years

Table 5: E-SAMPLER Quality Control Check Acceptance Limits

Item	Action Level	Acceptance Limit
Leak Check	NA	≤ 0.3 LPM
Temperature:	± 1.8 C	± 2 C
Pressure:	± 930 Pa (7 mmHg)	± 1330 Pa (10 mmHg)
Flow:	± 5 % of 2.0 LPM	± 10 % of 2.0 LPM

If any of the 30-day QC check parameters are operating near or at the Action Level or outside the Acceptance Limits listed in Table 5, the parameter in question must be recalibrated. Data collected during periods when the instrument was operating outside of acceptance will be reviewed closely to ensure it is of sufficient quality for intended uses. Data of insufficient quality will be invalidated.

8. Quality Control Check Procedure

NOTE: A quality control (QC) check is different than a calibration. A complete “as found” quality control check must be conducted prior to making any instrument adjustments or performing any calibrations. A full “as left” calibration check must also be completed following any instrument adjustments or calibrations.

The quality control procedure is described below. The steps should be performed in the order listed and the results should be documented in the Washington State Department of Ecology MetOne E-Sampler Quality Control Check Results form (included in section 12 of this SOP). The operator should check with either the Calibration and Repair Laboratory or The QA team to make sure they have the most recent form. The completed form must then be sent to the QA team.

QC checks are conducted by accessing the CALIBRATE menu on the E-SAMPLER. If currently sampling, the operator must select STOP SAMPLE before performing a quality control check. The CALIBRATE menu is accessed from the main E-SAMPLER menu. Use the arrow keys (▲▼) to select the CALIBRATE option in the main menu, then press the MENU/SELECT key to enter the menu. Use the ▲▼ keys to select the desired sub-menu and press the SELECT key again to enter. The CALIBRATE menu is shown below:

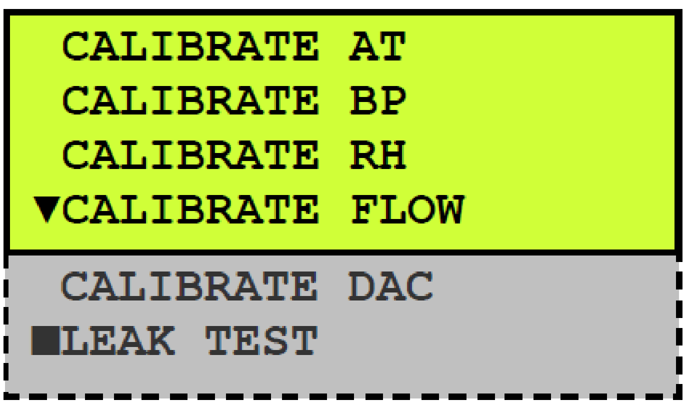

Figure 7: E-Sampler menu screen

8.1 Leak Check Procedure

The leak check is performed in order to check the E-SAMPLER’s sample train for leaks that could affect the accuracy of flow measurements and result in unwanted bias in pollution measurements.

Using the ▲▼, navigate to the LEAK CHECK screen. The readings on the screen will change as the E-SAMPLER progresses through the leak check as shown below:

1. Remove TSP inlet and sharp cut cyclone. Cap off the top of the E-Sampler inlet tube with a vinyl or rubber cap.
2. Open the front door and remove the battery cover plate. Locate the purge cutoff value on the left side. Rotate it to the closed position as shown in Figure 6 below.

Figure 8: Purge valve closed (Left) and open (Right). Located inside the battery compartment

3. Wait for the flow sensor reading to reach zero. This step is omitted if steps 1 and 2 take longer than the zero flow sensor process (~25 seconds). The software will automatically proceed to the step 4 when the zero flow sensor process has completed.
4. The pump is turned on. Wait about 2 minutes for the flow reading to stabilize. The leak test result will read PASS if the reading is less than 0.3 LPM. The leak test result will read FAIL if the reading is greater than 0.3 LPM. **NOTE**: Do not run this test for more than 5 minutes because it will reduce the lifetime of the pump motor.
5. The pump is turned off. Rotate the purge cutoff valve back to the open position as shown. Remove the cap from inlet and re-install the $PM_{2.5}$ sharp cut cyclone.

8.2 Ambient Temperature Verification

Place an NIST-traceable ambient temperature sensor adjacent to the E-SAMPLER's temperature sensor, located at the bottom of the enclosure. Navigate to the CALIBRATE AT screen (shown below). Allow the temperature readings on both the temperature standard and the E-SAMPLER (E-SAM) to stabilize. Record the reading from the temperature standard (Actual) and the E-SAM (Indicated) on the Met One E-SAMPLER Quality Control Check Results form.

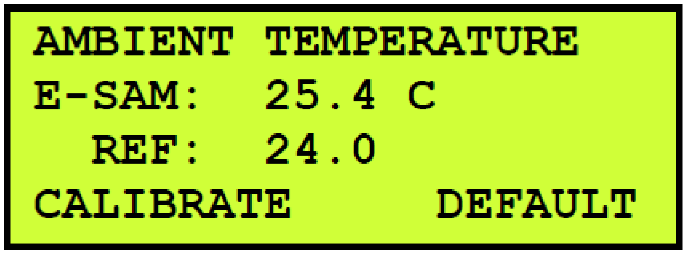

Figure 9: Ambient temperature calibration screen

8.3 Ambient Pressure Verification

Navigate to the CALIBRATE BP screen (shown below). Record the Thommen hand-held altimeter/barometer (or other NIST-traceable ambient pressure device) pressure as the Actual reading on the Met One E-SAMPLER Quality Control Check Results form. Convert the E-SAM pressure reading from PA to mmHg using and record it as the Indicated reading on the form (PA= mmHg X 133.32).

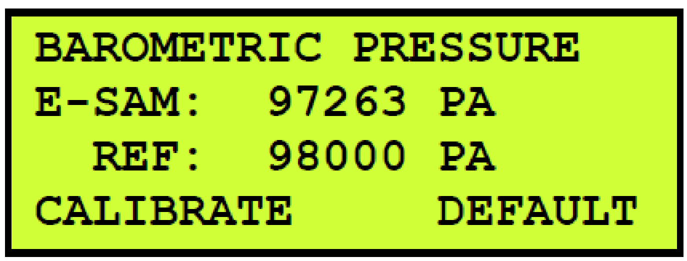

Figure 10: Ambient pressure calibration screen

8.4 Flow Verification

Navigate to the CALIBRATE FLOW screen (shown below) to verify the E-SAMPLER's flow. Remove the TSP cap and $PM_{2.5}$ cyclone from the E-SAMPLER's inlet. Using an appropriate length of flexible tubing, connect an NIST-traceable flow device to the top of the E-SAMPLER's inlet. The E-Sampler flow rate should be maintained to within ±0.1 LPM (1.9 to 2.1 LPM) in order for the sampler to correctly calculate its total air volume and ensure proper cut-point performance of the $PM_{2.5}$ (or PM_{10}) cyclones.

The SETPOINT parameter is the target flow rate that the E-SAMPLER will attempt to regulate to. The E-SAM parameter is the current reading from the E-SAMPLER flow sensor, in actual volumetric liters per minute. The E-SAMPLER should automatically adjust to 2.0 LPM when the flow calibration screen is entered but allow a few moments for this to occur. Once the flow reading has stabilized record the NIST-traceable flow device reading (Actual) and the E-SAM (Indicated) on the Met One E-SAMPLER Quality Control Check Results form.

NOTE: The flow reading that you enter must be in local conditions.

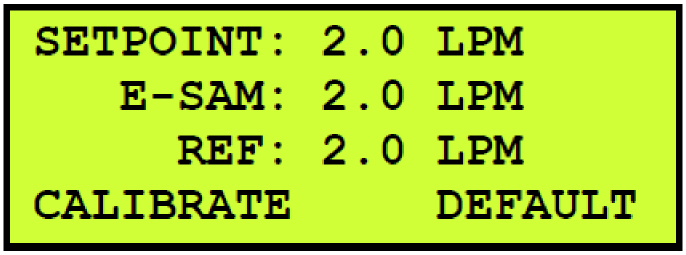

Figure 11: Flow calibration screen

Once the QC check is complete, recalibrate any parameter that is close to failing or failing the Acceptance Limits listed in Table 5. Follow the steps outlined in the Calibration Procedure below.

If all parameters passed the QC check, select ESC to reach main menu. Select START SAMPLE to begin sampling. The E-SAMPLER will display SELF-TEST RUNNING for 3 minutes and then begin sampling if no errors are detected.

8.5 Cleaning the $PM_{2.5}$ Cyclone

The $PM_{2.5}$ cyclone provides a particle size cut of 2.5 µm to particles passing through it. This means that particles with an aerodynamic diameter of 2.5 µm or smaller will make it through the cyclone and to the detector. For this to occur as it has been designed, 2.0 ± 0.1 liters per minute of air must be flowing through the cyclone and there must not be significant buildup of material in the cyclone. Regular cleaning of the cyclone is recommended and cleaning of the $PM_{2.5}$ cyclone must be performed during a QC. To clean the $PM_{2.5}$ cyclone, you will need the following supplies (see figure 12 below): Cotton swabs, 3/32” hex key, and alcohol or deionized water. First stop the instrument flow. Next, remove the cyclone from the E-SAMPLER and remove the screw cap and the three hex head screws. Using cotton swabs and a solvent if necessary, remove any dust or debris. Then, reassemble the $PM_{2.5}$ cyclone and place it on the E-SAMPLER’s inlet.

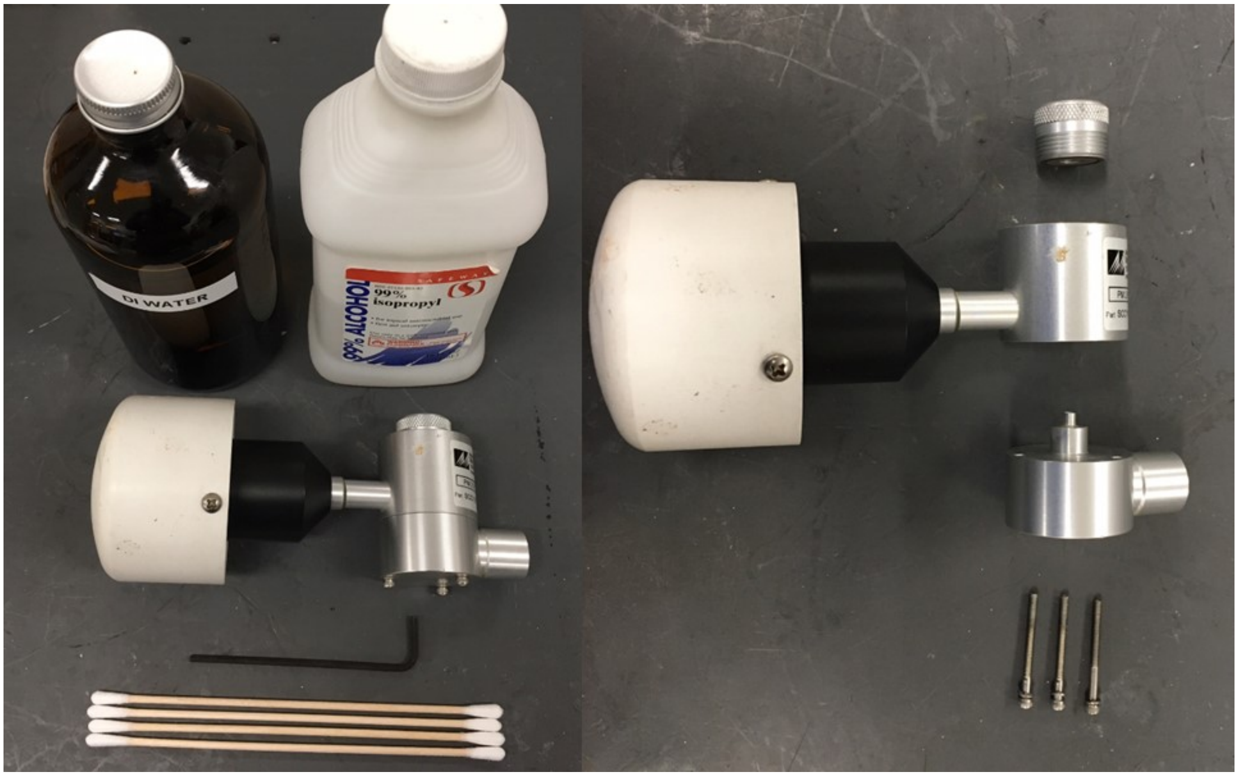

Figure 12: PM2.5 cyclone cleaning supplies (Left) and a disassembled PM2.5 cyclone (Right).

9. Calibration Procedure

The CALIBRATE menu is accessed from the main E-SAMPLER menu. Use the arrow keys (▲▼) to select the CALIBRATE option in the main menu, then press the MENU/SELECT key to enter the menu. Use the ▲▼ keys to select the desired sub-menu and press the SELECT key again to enter. The CALIBRATE menu is shown below:

9.1 Ambient Temperature Calibration Procedure

Place an NIST-Traceable ambient temperature sensor adjacent to the E-SAMPLER's temperature sensor, located at the bottom of the enclosure. Navigate to the CALIBRATE AT screen (shown below). Allow the temperature readings on both the temperature standard and the E-SAMPLER (E-SAM) to stabilize. Before calibration of the temperature sensor, press the DEFAULT key which returns the calibration settings to the factory settings. Allow the sensor and standard to stabilize. In many cases this may result in acceptable agreement between the reference and sensor. If not, allow the sensors to stabilize and use the arrow keys to navigate to "REF", enter the temperature standard reading, and press the CALIBRATE soft key.

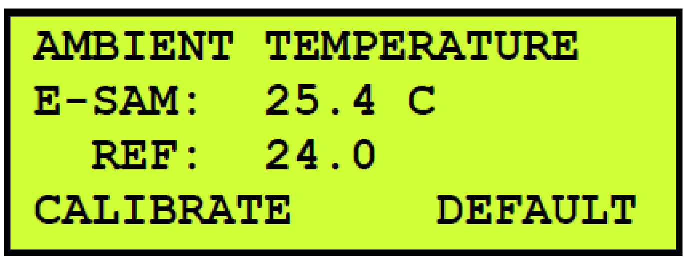

Figure 13: Ambient temperature calibration screen

9.2 Ambient Pressure Calibration Procedure

Navigate to the CALIBRATE BP screen (shown below). Before calibration of the pressure sensor, press the DEFAULT key which returns the calibration settings to the factory settings. Allow the sensor and standard to stabilize. In many cases this may result in acceptable agreement between the reference and sensor. If not, navigate to REF, enter the reading from a Thommen hand-held altimeter/barometer or other NIST-traceable ambient pressure device converted from mmHg to PA, and press the CALIBRATE soft key.

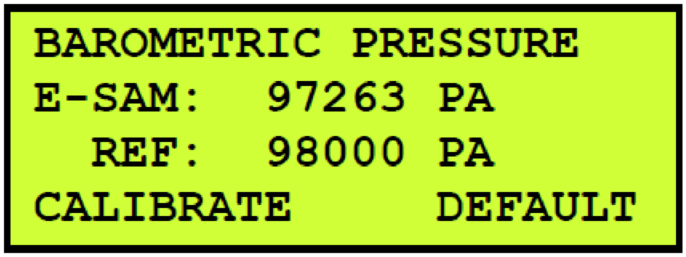

Figure 14: Ambient pressure calibration screen

9.3 Flow Sensor Calibration Procedure

NOTE: The E-SAMPLER temperature, pressure, and leak status must be verified/calibrated before performing any flow calibrations in order to prevent errors.

After the temperature, pressure, and leak status have been verified as operating within acceptance limits, navigate to the CALIBRATE FLOW screen (shown below) to calibrate the E-SAMPLER's flow.

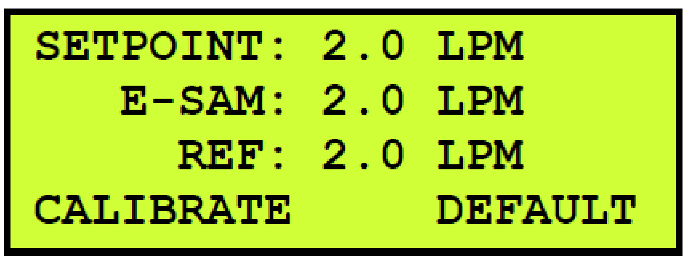

Figure 15: Flow calibration screen

Remove the TSP cap and $PM_{2.5}$ cyclone from the E-SAMPLER's inlet. Using an appropriate length of flexible tubing, connect the NIST-traceable flow device to the top of the E-SAMPLER's inlet. The E-SAMPLER flow rate should be maintained within ±0.1 LPM (1.9 to 2.1 LPM) in order for the sampler to correctly calculate its total air volume and ensure proper cut-point performance of the $PM_{2.5}$ (or PM_{10}) cyclones.

The SETPOINT parameter is the target flow rate that the E-SAMPLER will attempt to regulate to. The E-SAM parameter is the current reading from the E-SAMPLER flow sensor, in actual volumetric liters per minute. The E-SAMPLER should automatically adjust to 2.0 LPM when the flow calibration screen is entered but allow a few moments for this to occur.

NOTE: The flow reading that you enter must be in local conditions.

First, reset the flow settings to the factory default settings by pressing the DEFAULT key. **DO NOT** repeat calibrations without resetting the instrument to default flow settings. This can generate unstable flow calibration parameters and the flows will not remain stable over time. If calibration is still needed, navigate to REF, enter the reading from an NIST-traceable flow standard, and press the CALIBRATE soft key.

10. Data Collection and Storage

Data from the E-SAMPLERs will be collected via one of two methods:

1. **AIRSIS satellite communication**. This method uses the AIRSIS communication package that comes with the E-SAMPLER. AIRSIS satellite time has to be purchased in 6 month increments.

   This communications option is used for wildfire and other emergency monitoring response and when less expensive telecommunications options are not available. The Air Quality Program's Information Technology (IT) unit has established automatic downloading of the AIRSIS satellite E-SAMPLER data to the Air Quality Program (AQP) public air monitoring data website. This method is well-suited for emergency-type monitoring as data are typically available to the public within an hour of deployment of the E-SAMPLER and no AQP personnel time is needed other than that of the site operator.

2. **AQP modem polled via AQP telemetry system**. This method of communication involves AQP staff and typically takes a bit longer to establish than communication via AIRSIS. This communication method is less expensive and is better-suited for saturation studies and other non-emergency monitoring.

All data that is collected from the AQP's E-SAMPLERs is stored in the AQP's SQL database and can be accessed through the EnvistaARM software.

11. Data Validation and Quality Assurance

The Ecology Quality Assurance unit is responsible for final data validation. E-SAMPLER data validity is evaluated by QA personnel through a thorough review of quality control check results and comparisons with other area/regional $PM_{2.5}$ monitors.

Data collected from an E-SAMPLER that has been documented to be operating within the acceptance limits defined in Table 5 of this SOP and in a manner consistent with the quality system requirements described in the AQP Quality Assurance Plan, will be retained on the AQP SQL database and be accessible to data users through the EnvistaARM. Data collected while an E-SAMPLER was not operating within the acceptance limits as defined in Table 5 of this SOP or otherwise not meeting AQP quality system requirements will be flagged as invalid in the EnvistaARM.

E-SAMPLER data will not be submitted to EPA's Air Quality System (AQS). There are a few reasons for this:

- Relatively larger uncertainty associated with the E-SAMPLER's $PM_{2.5}$ measurements as compared to the AQP's FRM, FEM, and nephelometer-$PM_{2.5}$ measurements,
- Relative uncertainty of meteorological measurements as compared to the rest of the Washington Network PSD-quality meteorological monitoring, and
- Likelihood of a large number of emergent (e.g., wildfires) and short-term instances (e.g., saturation studies) of E-SAMPLER monitoring and managing the sheer number of sites will be prohibitive for the AQP's AQS coordinator.

11.1 Determination of the Scaling Factor

The response of the E-SAMPLER to various types of airborne particulate can vary drastically. This is because the scattering function of light by particles varies drastically as a function of both chemical composition and particle diameter. Thus, determination of a scaling factor or k-factor for a particular airshed greatly improves the accuracy of the E-sampler. K-factor determination is recommended for any deployment of the E-SAMPLER and required in select cases. To determine if a k-factor is required for the deployment, consult the Monitoring Advisory Committee's AAM 1b Non_Wildfire_Assistance_05012019 policy.

Determination of the E-SAMPLER's k-factor is done by collocation with a FEM or FRM in a representative airshed. Operators should work with the QA coordinator to determine which site meets the definition of representative airshed for the desired final destination of the E-SAMPLER. The siting requirements for the E-SAMPLER and FEM/FRM to be considered collocated are: (≤ 4 m) of each other horizontally and (≤ 1 m) of each other vertically. The duration of the collocation shall be no less than 21 days of valid data. To ensure that the data are valid during the collocation period passing QC's must be performed at the beginning and end of the 21 day period. The operator may to want to perform multiple QCs at the beginning of the collocation period to ensure that the data are valid. If the instrument does not pass the QC at the end of the 21 collocation the fit will not be considered valid and the period will need to be repeated. This can delay final deployment of the E-SAMPLER in some cases. Once sufficient data have been collected for the collocation, the QA coordinator will calculate the K-factor and determine if the fit meets the acceptance criteria ($r^2 \geq 0.85$) using the method outlined in the Correlation Guidance document.

12. QC Form

Washington State Department of Ecology
MetOne E-Sampler Quality Control Check Results

Site Name	______	Date	______
Location	______	Operator	______
Sampler Serial No.	______		
QC Start Time	______		
QC Stop Time	______		
		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	______

Leak Check

	Leak Check Flow Lpm	Pass/Fail
Leak Check (<0.3 Lpm)		

Temperature and Pressure QC

Ambient Temperature (±2°C)		
	Act:	°C
	Ind:	°C
	Diff:	°C

Barometric Pressure (±1330 PA)		
	Act:	PA
	Ind:	PA
	Diff:	PA

Convert mmHg to PA (mmHg X 133.32)=PA

Time ± 1 minute of cell phone?	
Is the inlet head clean?	

Flow QC

Indicated Flow lpm	Actual Flow lpm	Flow Difference ±5%	Design Flow Difference ±10%

Comments:

QC Result:

13. References

"Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring." *Code of Federal Regulations* Title 40, Pt. 58, Appendix E, 2013 ed.

U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. "Quality Assurance Guidance Document 2.12: Monitoring PM2.5 in Ambient Air Using Designated Reference or Class I Equivalent Methods." https://www3.epa.gov/ttn/amtic/files/ambient/pm25/qa/m212.pdf

U.S. Department of Agriculture, Forest Service. "Quick Sheet for Operating the E-Sampler Smoke Particulate Monitor and Airsis Satellite Telemetry System." Missoula, MT: 2009 (USDAFS 0925 2M11).

U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. *Quality Assurance Handbook for Air Pollution Measurement Systems Volume II: Ambient Air Quality Monitoring Program*. Research Triangle Park, 2013 (*EPA-454/B-13-003).*