



WASHINGTON STATE
DEPARTMENT OF
E C O L O G Y

PM₁₀ Tapered Element Oscillating Microbalance Operating Procedure

Air Quality Program

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If you need this information in an alternate format, please contact Tami Dahlgren at (360) 407-6800. If you are a person with a speech or hearing impairment, call 711, or 1-800-833-6388 for TTY.

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1 INTRODUCTION

This document describes the procedures used to sample PM₁₀ (particulate matter that has an aerodynamic diameter of 10 micrometers or less) using the Rupprecht and Patashnick (R&P) 1400a Tapered Element Oscillating Microbalance (TEOM) ® by the Washington State Department of Ecology Air Quality Program.

The TEOM is configured to sample PM₁₀ and generate concentrations in standard conditions and provides continuous data that will be used to determine diurnal cycles, identify the need to alter sampling frequency, evaluate real-time data to issue alerts or implement control strategies, and provide data when the FRM sampler is not sampling.

This section of Quality Assurance Manual covers the operation and maintenance of the R&P 1400a TEOM. This document is intended to be used together with the sampler-specific information and instructions provided by the manufacturer of the PM₁₀ monitor in the sampler's operation.

1.1 Theory of Operation

The first step of TEOM operation is particle separation, which occurs by drawing a controlled volume of air (16.67 L/min) through a size selective inlet. Figure 1.1 is a schematic drawing showing the size selective inlet head of the PM₁₀ sampler. It depicts the size selective inlet head that removes particles greater than 10 µm and allows 10 µm in diameter and smaller particles to be collected on a Teflon® coated glass fiber filter surface. The design flow rate through the inlet is 16.67 L/min. At the exit of the inlet, the flow is split isokinetically into a 3.0 L/min and a 13.67 L/min air stream called the main flow and bypass flow respectively. The main flow, which contains the analyte fraction of particulate, is sent to the instrument's mass transducer.

The mass transducer in the sensor unit has a thin, hollow ceramic tapered tube fixed at the downstream end and a filter attached on the upstream end. Figure 1.2 is a schematic diagram of the flow splitter. As air is drawn through it, the element oscillates like a tuning fork. The frequency of oscillation is dependent upon the physical characteristics of the tapered tube and the mass on its free end i.e. the filter. As the filter progressively loads with particulate matter, the oscillation frequency of the element changes proportionally. The sensor unit computes the oscillation frequency into a particulate concentration by dividing the mass rate by the flow rate.

To minimize a bias caused by atmospheric moisture, the sample stream entering the TEOM sensor unit is heated to minimize water collection on the sample filter. As the air is drawn into the TEOM, the sample stream (main flow) is heated at the base of the air inlet (Air temperature). The temperature of the upper part of the mass transducer (Cap temperature) and the rest of the mass transducer (Case temperature) and the temperature inside the sensor unit (Enclosure temperature) are all controlled at specific temperature set points.

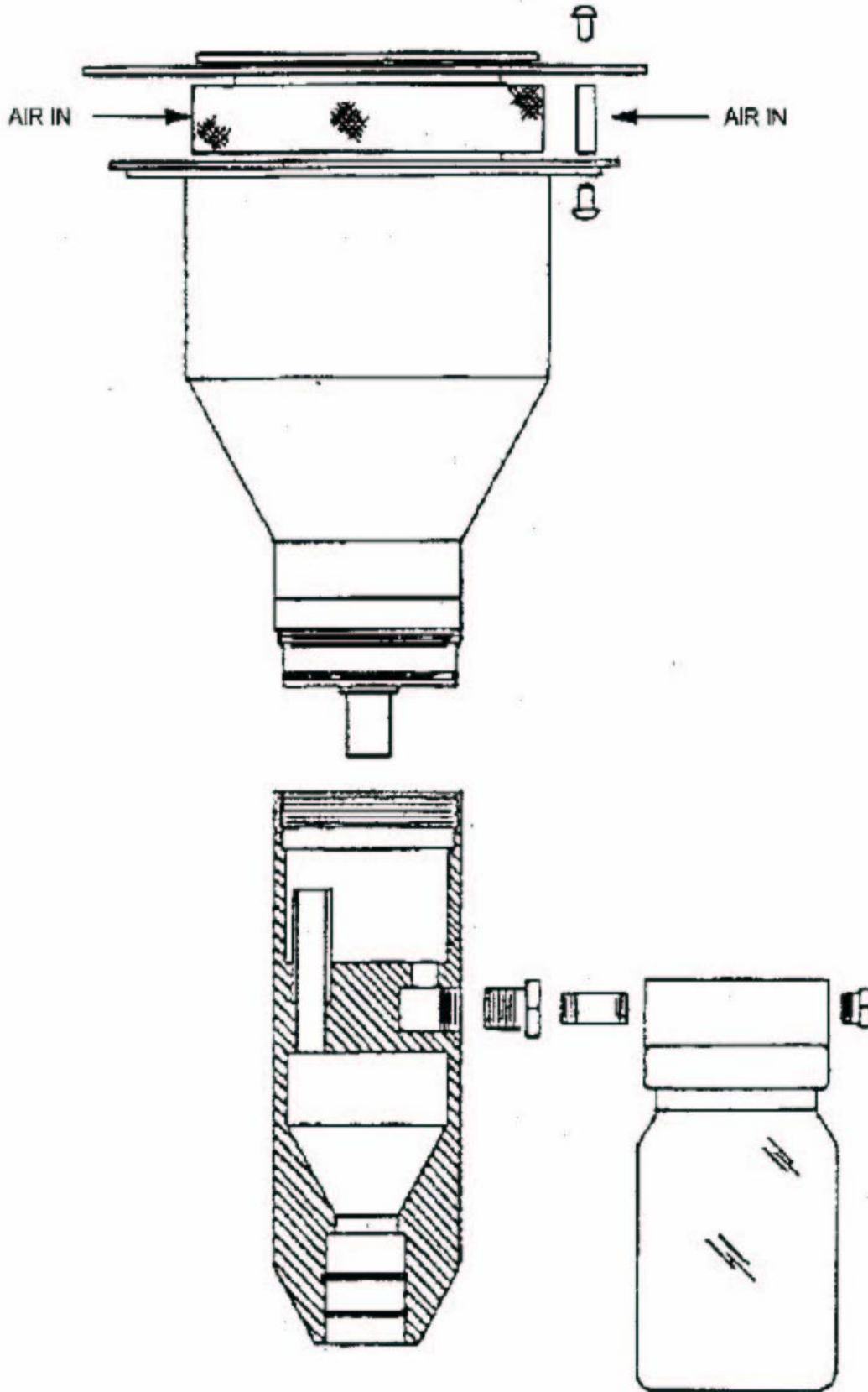
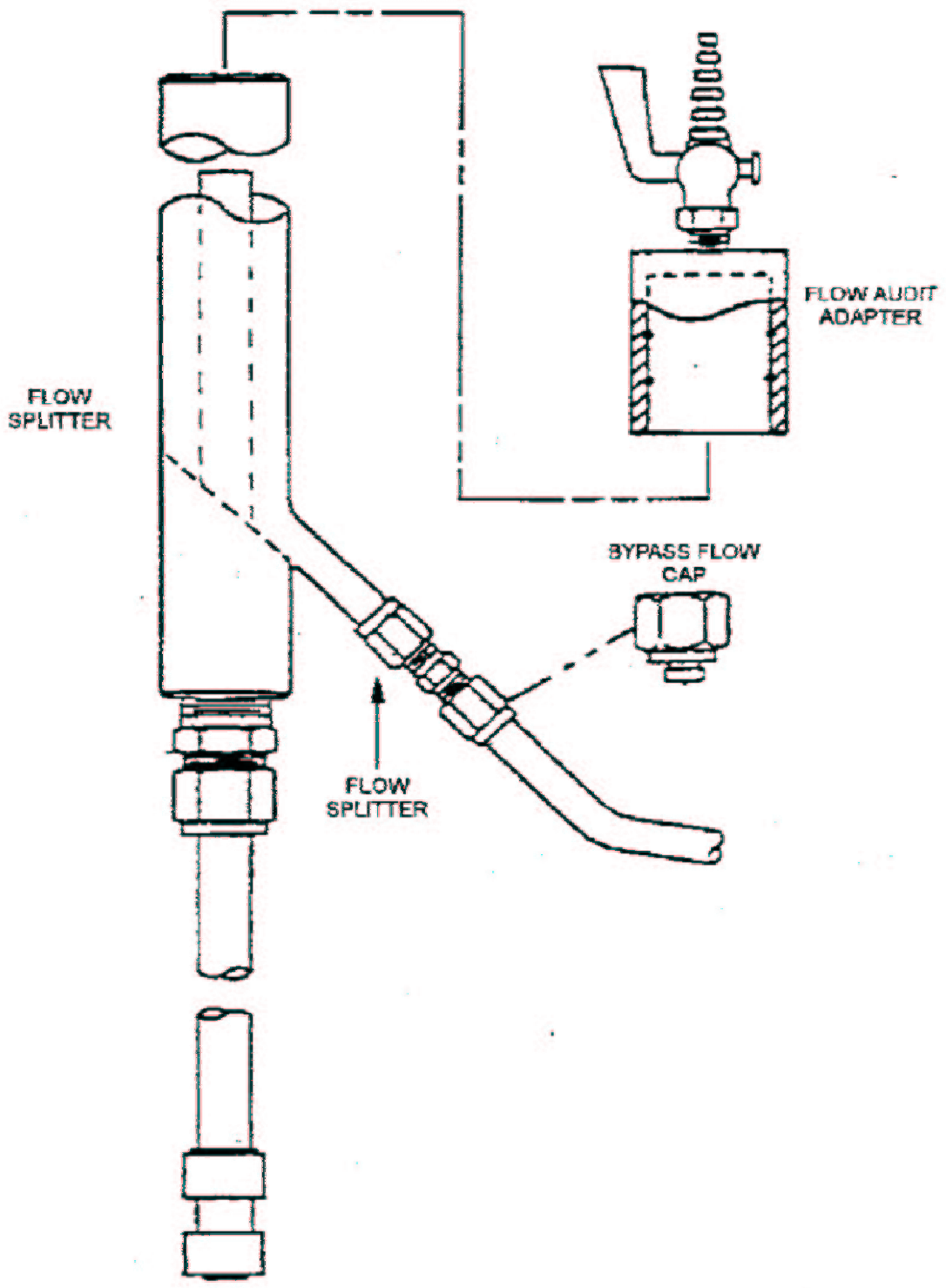


Figure 1-1 Exploded View of PM₁₀ Size Selective Inlet Head



TEOM® flow splitter assembly.

Figure 1-2 Schematic Diagram of Flow Splitter

2 EQUIPMENT & SUPPLIES

- The TEOM Series 1400a Monitor with PM₁₀ inlet.
- Additional monitor parts and supplies consisting of TEOM filter, filter exchange tool, bypass in-line filters, flow controller filters, sample tube extensions.
- Calibration equipment as defined in Section 3.0.
- Periodic maintenance equipment as defined in Section 6.0.
- Miscellaneous hand tools, miscellaneous monitor spare parts including additional gaskets/seals, flat screwdriver, soft brushes & cotton swabs, calculator, Kim wipes, and worksheets.
- Logbook

3 CALIBRATION PROCEDURES

This section describes the procedures involved in calibration of the TEOM 1400a monitor. Because PM₁₀ concentration standards are not available for determining calibration relationships, individual components of the sampling method must be calibrated to ensure integrity of reported data.

3.1 Discussion Of Flow-Rate Measurement And General Aspects Of Calibration

The monitor's mass flow controllers operate under the control of the monitor's microprocessor which maintains the total sampled air stream at a constant volumetric flow rate of 16.67 L/minute. The PM₁₀ inlet is designed to allow only particulate matter of 10 µm diameter or less to remain suspended in the sample air stream as long as the flow rate of the system is maintained at 16.67 L/min.

3.2 Basic Calibration Procedure For A TEOM Series 1400a Monitor

3.2.1 Calibration Equipment

- A transfer standard (bubble meter, BIOS or an orifice) with proper calibration traceable to NIST.
- A thermometer capable of accurately measuring temperature over the range of -30 to 50°C (243°K to 323°K) to the nearest ± 0.1°C and referenced to an NIST thermometer within ± 0.5 °C at least annually.
- A portable, aneroid barometer (e.g., a climber's or engineer's altimeter), capable of accurately measuring ambient barometric pressure within ± 1 mm Hg resolution and referenced within ±5 mm Hg to a barometer referenced to a NIST standard.
- Table 3-2 TEOM PM₁₀ Calibration Sheet and Table 3-1 Calibration And Verification Check Intervals

- A clean filter.

3.2.2 Flow Controller Calibration (Software)

The required interval to perform the software procedure to calibrate the main and auxiliary flow rates is every six months. Follow the steps below to perform a software calibration of the flow controllers.

- 1) Turn off the TEOM Control Unit.
- 2) Disconnect the electric cable that links the control unit with the sensor unit.
- 3) Remove the main and bypass flow lines from their connections on the back panel of the TEOM Control Unit.
- 4) Turn on the TEOM Control Unit, and make sure the pump is on.
- 5) Display the Set Temps/Flows Screen on the instrument by selecting “Set Temps/Flows” from the Menu Screen. This can also be accomplished by entering 19<Enter>. Press <↓> and <↑> to position the screen so that “F-Main” and “F-Aux” appear. Record the set points for the main and auxiliary flows.
- 6) Press <↓> and <↑> to position the cursor so that the lines entitled “T-A/S” and “P-A/S” appear on the screen. Record the existing settings for Average Temperature and Average Pressure. If the monitor is not in the Setup Mode, press <Data Stop>. Then set the Average Temperature and Average Pressure to the current local conditions at the station.

NOTE: Do **NOT** leave the temperature and pressure settings at 99 °C and 9 atm respectively during a mass flow controller calibration.
- 7) Press <↓> and <↑> to position the cursor so that the lines “FAdj Main” and “FAdj Aux” appear on the screen. Attach a flow meter to the location labeled “Sensor Flow” on the back panel of the TEOM Control Unit.
- 8) Compare the set point recorded in step 5 above with the flow rate indicated by the flow meter. This set point indicator is in volumetric liters per minute.
- 9) If necessary, edit the values for “FAdj Main” so that the volumetric flow rates indicated by the flow meter matches the set point recorded in step 5 above. The value for “FAdj Main” can be incremented and decreased by pressing <↓> and <↑> keys during editing.
- 10) If a step adjustment of greater than ±10% is required then it is necessary to calibrate the mass flow controller: a hardware calibration must be performed. For hardware calibration contact the Air Monitoring Unit with the Dept. of Ecology.
- 11) Repeat steps 7 to 10 above, replacing the references to the Main Flow with Auxiliary (Bypass) Flow. Connect the flow meter to the port labeled “Bypass Flow” on the rear panel of the TEOM Control Unit.

- 12) Change the values for Average Temperature and Average Pressure back to their original values recorded in step 6.
- 13) Turn off the TEOM Control Unit and re-attach the air lines to the back panel of the TEOM Control Unit. Reconnect the electric cable that links the control unit with the sensor unit and turn on the TEOM Control Unit.
- 14) Perform a system leak test as described in section 3.2.3.

3.2.3 Leak Check

Perform the following steps to test for leaks.

- 1) Operate the monitor in the usual fashion with the sample pump running.
- 2) Remove the TEOM sample filter from the mass transducer to prevent accidental damage from occurring to the sample filter when exposed to the high pressure drop in the sample line that the leak check creates.
- 3) With the instrument displaying the Main Screen, press the <↓> and <↑> keys to show the Main Flow and Auxiliary Flow on the four line alphanumeric display.
- 4) Remove the size-selective inlet from the flow splitter and replace it with the Flow Audit Adapter contained in the Flow Audit Adapter kit supplied with the instrument. Close the valve on the Flow Audit Adapter.
- 5) For the 16.7 l/min system, both the Main Flow and Auxiliary Flow readings on the display should read less than 0.15 l/min.
- 6) If the leak test indicates a problem, check hose fittings and other critical locations in the flow system for leaks.
- 7) Remove the Flow Audit Adapter.
- 8) Replace the sample inlet.
- 9) Replace the TEOM filter.

3.2.4 Mass Transducer Calibration Verification

This procedure is used to confirm the mass calibration of the monitor using a single pre-weighted filter as a calibration weight. Since the mass of the filter with particulate differs from the mass of a new filter by only a small fraction, calibrating the system with a calibration mass equivalent to the filter mass allows all measurements to be made at essentially the same operating point as the original calibration.

The monitor is calibrated using a Calibration Verification Kit consisting of a pre-weighed calibration filter, filter exchange tool, desiccant for humidity protection and a humidity indicator available from R&P under part number 59-002017.

Perform the following steps to confirm the system's mass calibration using the Mass Calibration Verification Kit with the K_O Calibration Screen displayed on the monitor:

- 1) Check the humidity indicator included in the Kit before proceeding with the mass transducer calibration verification.
- 2) From any screen press 17<Enter> to access the K_O Confirmation screen. Confirm the Calibration Constant shown on the Set Hardware Screen is the same as that shown on the nameplate located on the left side of the mass transducer support cage.
- 3) Warm up the monitor with any filter that is not the calibration filter so that all the temperatures are at their normal operating conditions for at least one hour. The airflow through the system should be at its normal value during this period.
- 4) Disable the average for the TEOM at the data logger. Enter the Setup Mode on the control unit by pressing the keypad "Data Stop". Turn off the air tube heater by setting the set point to 0 on the Set Temps/Flows Screen.
- 5) Unplug the vacuum pump so there is no flow through the instrument. This prevents particulate contamination of the calibration filter.
- 6) Scroll through the Menu Screen (using "Stop Screen" and the down arrow on the keypad of the control unit) and select the last item, "K_O Confirmation".
- 7) When K_O Confirmation is selected, the following screen will appear:

K _O confirm	251.54104	(This is the current frequency output and will vary by instrument.)
Filt Wght	0.00000	
0.00000	0.00000	
Audit KO	0	

- 8) Use the down arrow keypad to move to the "Filt Wght". Input the weight of the pre-weighed calibration filter, as recorded on the Kit data, on the line labeled "Filt Wght" by pressing the "Edit" keypad and then the value.
- 9) Open the mass transducer and remove the media filter from the tip of the tapered element using the filter exchange procedure described in Section 4.3.1. Close the mass transducer and sensor unit door. Operate the system without a filter and wait for the oscillating frequency shown in the upper right-hand corner of the screen to reach a maximum value. Observe the frequency output next to "K_O confirm" on the first line of the K_O Confirmation screen. The frequency will increase, peak and then start to decrease in value. When the frequency stabilizes, press the "First/Last" keypad (in the center of the arrow keys) to record this frequency f_o value in the first slot and the third line of the screen.

- 10) Remove the filter tool and filter box containing the calibration filter from the Mass Transducer Calibration Verification Kit. (Note: The calibration tool can be distinguished from a normal filter tool by its red handle. Do NOT use the calibration filter tool to remove or install any filters except for the calibration filter.)
- 11) Install the calibration verification filter using the filter exchange tool provided with the kit. Note that the filter exchanges are normally performed with the pump on to help the filter become properly seated on the tapered element. Since the pump is not on, take special care to ensure that the filter is properly seated. Close the mass transducer and sensor unit door. Return the calibration tool immediately to the kit and reseal the bag. Again watch the frequency output and the control unit's screen and when it stabilizes to reach a new maximum value.
- 12) Press the <First/Last> key again to record the frequency f1.
- 13) The instrument then automatically computes and displays the audit value of the calibration constant, K₀ on the line entitled "Audit K₀". An example of the final screen display is as follows.

K ₀ confirm	252.36530
Filt Wght	0.08226
336.67858	252.36538
 Audit K ₀	 11957

- 14) The K₀ confirmation Screen also displays the current K₀ value entered in the monitor and the percentage difference between the audit and currently entered value. Contact Ecology's Air Monitoring Unit if the results of the verification procedure indicate a difference of more than 2.5% from the original R&P calibration constant. QC %

$$\text{Difference} = \left[\frac{\text{Audit}K_0 - \text{CalConst.}}{\text{CalConst.}} \right] * 100$$

- 15) Record this information on Initial Calibration Sheet Table 3-2 .

3.2.5 Analog and Flow Controller Hardware Calibration

For analog and mass flow controller hardware calibration contact the Air Monitoring Unit with the Dept. of Ecology.

3.2.6 Setting and Verifying the TEOM Clock

The time on the data logger will be used to verify accurate time on the TEOM monitors.

The system time and date can be verified in the Set Time Screen. To enter this screen, press 03<Enter> from any screen. Verify the time on the screen with the time on the data logger and that the time on TEOM is within ± 1 minute of the time on data logger.

If the time is not within ± 1 minute of the data logger, then follow the steps below to adjust the time.

- 1) The time can only be changed when the instrument is in Setup Mode. Press <Data/Stop> to enter the Setup Mode.
- 2) Use the <↓> and <↑> keys to adjust the time.
- 3) Allow the unit to run for at least 48 hours. If, after 48 hours, the clock has drifted from the reference time, press the <Data Stop> key on the instrument keypad to enter Setup Mode.
- 4) Press the <Time/Date> key on the instrument keypad to enter the Set Time Screen.
- 5) Press the <CTRL> and <INIT> keys simultaneously on the instrument keypad. An asterix will appear in the upper left corner of the screen.
- 6) Set the hour, minute and second variables to a time one minute later than the reference time: the time on the data logger.
- 7) At the very moment the data logger time reaches the time set on the instrument, press the <CTRL> and <INIT> keys simultaneously on the instrument keypad.
- 8) The system then calculates the rate of change constants (“Soft Rate” and Hard Rate”) for the clock. These constants can be viewed from the Setup Screen.
- 9) Return the instrument to normal operation.

NOTE: If it is found that the clock on the 1400a monitor is drifting significantly, software version 3.009 or higher should be downloaded into the instrument and then the clock adjustment procedure should be performed.

3.3 Monitor Calibration Frequency

Table 3.1, below summarizes the calibration and verification frequencies.

Table 3-1 Calibration And Verification Check Intervals

	Frequency	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Acceptance Criteria
Flow Rate Verification Main Flow Auxiliary Flow	Once every two weeks													± 10% of the Transfer Standard
Flow Controller Calibration (Software)	Twice a year													
Clock/timer Verification	Once in 30 days													±2 min
Mass transducer calibration verification	Once a year													
Leak Check	Once in 30 days													0.15 L/min

Table 3-2 TEOM PM₁₀ Calibration Sheet

AIRS Station # _____ Date: _____
 Location: _____ Time: _____
 Serial # : _____ Operator: _____
 State ID: _____

Flow Calibration

Total Actual _____ L/min Indicated _____ L/min % Difference _____
 Main Actual _____ L/min Indicated _____ L/min % Difference _____
 Aux. Actual _____ L/min Indicated _____ L/min % Difference _____

$$QC \% \text{ Difference} = \left[\frac{Ind - Act}{Act} \right] \times 100$$

Mass Flow Controller Calibration (Software) _____

Time Calibration

Actual Time _____ Indicated _____ Soft & Hard
 Rate _____

Mail to Quality Assurance Unit

4 FIELD OPERATIONS

This section presents information pertinent to the routine operation of the TEOM. It covers an array of topics, ranging from site selection to monitor installation to filter exchanges.

4.1 Siting Requirements

The TEOM will be sited so that the primary goal of monitoring is to collect sample data which is representative of the monitored area. The monitor can be installed at the site in the R&P shelter or in the monitoring station.

Basic siting criteria for the placement of ambient air samplers are documented in Table 4-1. Complete siting criteria are presented in 40 CFR 58, Appendix E.

4.1.1 Other Requirements And Installation Considerations

The Series 1400a TEOM consists of two basic components: the sensor unit (containing the sample inlet and mass transducer) and the control unit (containing the operator terminal and control electronics). There are 2 configurations for network installations. When installing the TEOM in a shelter, the monitoring station must be maintained between 10 and 30 °C. These units are connected by a 10 meter (optionally 2 or 20 m) cable/ tube assembly. A sampling tube is fed through the roof to the sampler inlet. The sample line must be in a straight line from the inlet to the inlet of the sensor unit through a 4 cm diameter hole in the roof.

The second installation configuration requires the use of the R&P environmentally controlled outdoor enclosure, maintained between 10 °C and 30 °C, located atop the monitoring station. The monitor should be located so that the operator can load the filter without rain or snow landing on the filter.

Several additional factors must also be considered in determining placement of the monitor. For installation in the R&P outdoor enclosure the primary factor of concern determining the placement of the sensor unit is the need for sturdy, vibration free mounting that will be as independent as possible from other activities in the area. Since the TEOM operates on the principle of an oscillating element, it is vibrationally sensitive and hence consideration of nearby vibrational sources must be addressed. Also, when locating the TEOM Sensor Unit inside a monitoring station, avoid locations with direct exposure to sun or in proximity to an air conditioning outlet.

Accessibility to the site under all weather conditions, availability of adequate and stable power source of 110 Volts, security of the monitoring personnel and equipment must be taken into consideration.

The monitor must be situated where the operator can reach it safely despite adverse weather conditions. If the monitor is located on a rooftop, care should be taken that the operator's personal safety is not jeopardized by a slippery roof surface during inclement weather. Consideration also should be given to the fact that routine operation (i.e., calibrations, filter installation, flow checks, and audits) involves transporting supplies and equipment to and from the monitoring site.

The security of the monitor itself depends mostly on its location. Rooftop sites with locked access and ground-level sites with fences are common. The security of the operating personnel, as well as that of the monitor must always be considered.

Table 4-1 Minimum TEOM PM₁₀ Sampler Siting Criteria

Scale	Height Above Ground (Meters)	Vertical and Horizontal Distance from supporting structure (Meters)	Other Spacing Criteria
Micro	2 to 7	>2	Should be >20 meters from trees.
Middle, neighborhood, urban, and regional scale.	2 to 15	>2	Distance from sampler to obstacle, such as buildings, must be twice the height that the obstacle protrudes above the sampler.
			Must have unrestricted airflow 270 degrees around the sampler inlet.
			Sampler is maintained in a horizontal plane and is 2.0+/-0.2 meters above the floor or horizontal surface.
			Sampler inlet is at least 2 m but not greater than 4 m from any collocated PM ₁₀ sampler. (See 40 CFR 58, Appendix A.)

4.2 Monitor Installation

4.2.1 Installation of a TEOM without the R&P Enclosure

- 1) On receipt of a TEOM monitor, visually inspect it to ensure that all components are accounted for. Notify the monitoring unit immediately of any missing or damaged equipment.
- 2) Carefully transport the monitor to the field site. Secure the monitor in its location keeping it level.
- 3) Mount the Flow Splitter Adapter on the end of the inner tube inside the Flow Splitter and adjust the inner tube of the Flow Splitter so that the end of the inner tube is 15 cm from the open end of the outer tube. The adjustment is made by loosening the ½” nut holding the sample tube, and sliding the tube into the proper position. Avoid crimping the sample tube by over-tightening the nut during re-assembly.
- 4) Connect the exit of the Flow Splitter with the inlet of the sensor unit by installing additional lengths of sample tube, as needed, through the roof opening. The connecting sample tube may be cut to length as necessary. The connection between the sensor unit and the lowest segment of sample tube must be made using the 5 cm length of conductive rubber tubing provided with the

instrument. It is imperative that the weight of the sampling system not rest on the sensor unit, and that the dimensions shown in Figure 4-1 be maintained.

- 5) The Flow Splitter may be moved vertically in the optional tripod mount to make final height adjustments.
- 6) Install the bypass flow tubing of the Electric and Air Connecting Cable from the control unit to the exit of the Flow Splitter through the same hole in the roof as the sample tube.
- 7) Connect the ambient temperature sensor to the Flow Splitter or at a representative outdoor location.
- 8) Install the sample inlet over the open end of the Flow Splitter and verify that the entrance to the sampling head is 1.8 to 2.2 m above the roof. Weather seal the opening in the roof.

4.2.2 Installation of a TEOM with the R&P Enclosure

Follow the R&P instruction manual.

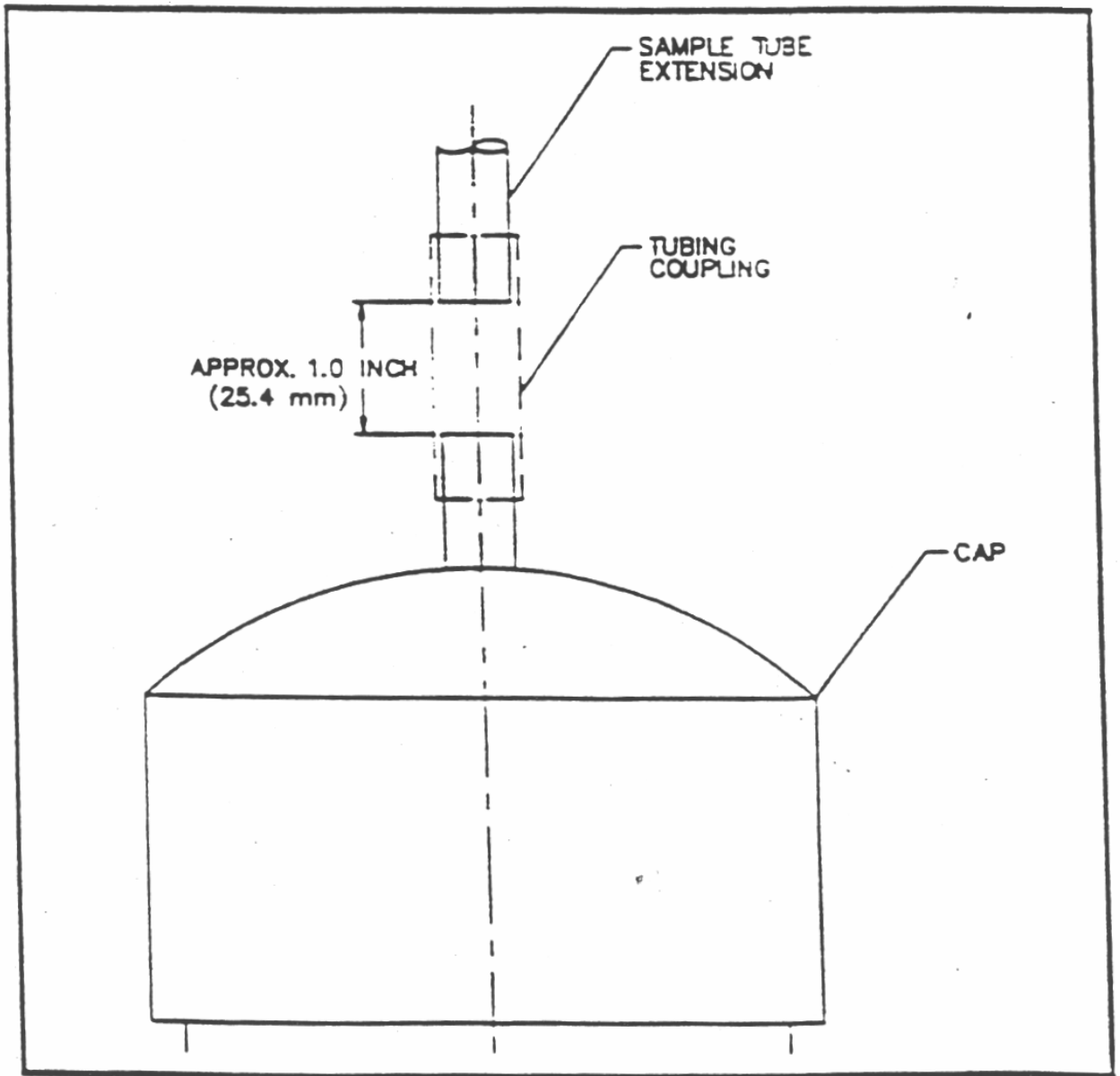


Figure 4-1 Installation of Tube Coupling Between the Sensor Unit and Sample Tube Extension

4.2.3 System Operation And Setup Of Internal Data Storage

This section describes the operation of the TEOM Series 1400a Monitor including topics such as changing the instrument operating parameters and how to store data in the unit's internal data logger.

After the system installation is completed, turn the instrument ON by pressing the "Power" button on the front panel of the TEOM Control Unit. A screen appears on the instrument's four line display showing the name of the instrument and then the Main Screen appears.

Turn on the pump to draw the sample stream through the system. The monitor is always in operating mode 1 when it is first turned ON. In this mode, the instrument waits until temperature and flows have equilibrated before entering modes 2, 3, and finally mode 4. The unit normally resides in operating mode 4 and this is the fully operational setting.

4.2.3.1 Automatic Operation

The Series 1400a Monitor uses mass flow controllers to ensure a constant and precise flow through the instrument. The mass flow controllers use the actual or average temperature and pressure values to regulate the volumetric flow through the system. The instrument is delivered with the following temperatures and pressures settings:

Standard temperature..... 25° C Standard pressure ... 1 atmosphere (atm)
Average temperature 25° C Average pressure ... 1 atmosphere (atm)

If the operator receives the Series 1400a Monitor directly from R&P, the only change that the operator must make, before using the instrument for U.S. EPA-equivalent PM-10 measurements, is to choose ensure that the standard temperature is set to 25° C, and the standard pressure is set to 1 atm, regardless of the values that they entered for the average temperature and average pressure settings.

The unit also uses the parameters in the Set Temps/Flows screen to determine how to report the measured mass concentration levels. The operator can choose to report the mass concentration levels to actual or standard conditions. The unit must be set to report the mass concentration levels to standard conditions, they must set the standard temperatures and pressures to the appropriate standard regulatory values when in the Set Temps/Flows screen. This will cause the monitor to use the standard temperature and pressure values in its sample volume calculations.

4.2.3.2 Reporting to Standard Conditions

Follow these steps to use the standard temperature and pressure values in flow rate calculations:

- 1) Press the <DATA STOP> key.
- 2) When in the Main screen, press the <STEP SCREEN> key to display the Menu screen.
- 3) When in the Menu screen, press the up (<(<↑>) >) and down (<(<↓>) >) arrow keys to select "SetTemps/Flows," and then press the <ENTER> key to display the Set Temps/Flows screen. This can also be done by pressing the <1> and <9> keys, and then press the <ENTER> key to display the Set Temps/Flows screen.

- 4) Press the <EDIT> key.
- 5) When in the Set Temps/Flows screen, set the unit's volumetric flow control setting.
- 6) Press the arrow keys to select the right-hand column in the "T-A/ S" field.
- 7) Enter the standard temperature value in this field. To report to the U.S. EPA-equivalent PM-10 measurements, press the <2> and <5> keys ("25") on the monitor's keypad. This sets the standard temperature to "25," which causes the monitor to use the standard temperature in flow rate calculations.
- 8) Press the arrow keys to select the right-hand column in the "P-A/S" field.
- 9) Enter the standard pressure value in this field. If you are setting the unit to report to the U.S. EPA equivalent PM-10 measurements, press the <1> key on the monitor's keypad. This sets the standard pressure to "1," which causes the monitor to use the standard pressure in flow rate calculations.
- 10) Press the <ENTER> key.
- 11) Press the <F1> or <RUN> key to restart data collection.

Follow the steps below to make use of the monitor's ambient temperature and pressure sensors to maintain correct volumetric flow rate:

The temperatures for case, air, cap and enclosure will be set according to following table.

Seasonal Parameters	November 1 to March 31 Winter / Spring	April 1 to October 31 Summer / Fall
Case Temperature	30 °C	50 °C
Air Temperature	30 °C	50 °C
Cap Temperature	0 °C	50 °C
Enclosure Temperature	25 °C	40 °C

4.2.3.3 Setting Hardware Parameters

Enter the "Set Hardware" screen by typing 13<Enter> from any screen.

- 1) The Total mass averaging time (TM) is set at 300 seconds.
- 2) The mass rate/mass concentration averaging time (Mc) is set at 300 seconds.
- 3) The wait time is set at 1800 seconds.

4.2.3.4 Set Analog Outputs

This section describes the analog outputs to provide to the datalogger.

The Set Analog Outputs screen allows the operator to define the analog outputs transmitted by the monitor. The display on the Set Analog Outputs screen, can be displayed in three different ways:

1. Press the <A/O> key on the monitor's keypad.
2. When in the Main screen, press the <STEP SCREEN> key to display the Menu screen. When in the Menu screen, press the up (<↑>) and down (<↓>) arrow keys to select "Set Analog Outputs," and then press the <ENTER> key.
3. Press the <0> and <4> keys, and then press the <ENTER> key. The Set Analog Outputs screen contains additional lines that cannot be seen when the screen first displays on the control unit's four-line display. Press the up (<↑>) and down (<↓>) arrow keys to view the additional lines of the Set Analog Outputs screen.

The Set Analog Outputs screen contains the following information:

Max Volt This field contains the full scale voltage setting. The range for this variable is 1, 2, 5, or 10 VDC. If unable to select 5 or 10 VDC while setting this variable, then must change the setting for the jumpers variable to 10 VDC.

AO1 Var This field contains the PRC value of analog output1, that will be output. Whenever a variable is assigned to one of the analog output channels, the program register codes (PRCs) for the variable's name, minimum value, and maximum value are all assigned to that channel. In the case of a 10 VDC output, the minimum value for the selected output variable is set to 0 VDC and the maximum value is set to 10 VDC. The behavior of analog output channel 1 can be modified if the operator chooses to use the channel as a status indicator.

AO1 Min This field contains the minimum value setting of the output PRC for analog output 1.

AO2 Max This field contains the maximum value setting of the output PRC for analog output 1.

AO2 Var This field contains the PRC value of analog output2, that will be output. Whenever a variable is assigned to one of the analog output channels, the program register codes (PRCs) for the variable's name, minimum value, and maximum value are all assigned to that channel. In the case of a 10 VDC output, the minimum value for the selected output variable is set to 0 VDC and the maximum value is set to 10 VDC.

AO2 Min This field contains the minimum value setting of the output PRC for analog output 2.

AO2 Max This field contains the maximum value setting of the output PRC for analog output 2.

AO3 Var This field contains the PRC value of analog output3, that will be output. Whenever a variable is assigned to one of the analog output channels, the program register codes (PRCs) for the variable's name, minimum value, and maximum value are all assigned to that channel. In the case of a 10 VDC output, the minimum value for the selected output variable is set to 0 VDC and the maximum value is set to 10 VDC.

AO3 Min This field contains the minimum value setting of the output PRC for analog output 3.

AO3 Max This field contains the maximum value setting of the output PRC for analog output 3. This field contains the jumper settings of the three analog output channels in the analog output hardware. In the default configuration, the analog output jumpers are set to 10 VDC. In most cases, the value for the jumpers variable should remain at 10 VDC, and no change must be made to the hardware.

In a typical installation, one of the monitor's three analog outputs will be defined as the instantaneous mass concentration average (PRC 8), and this output will be scaled for output over a range of -100 to +900. This output is transmitted to a data logger that is set for a 1-hour averaging time. The instrument has an analog output resolution of 12 bits including the sign. If the operator wants the monitor to produce 1 or 2 VDC analog outputs, the operator can change the jumpers in the monitor to their alternate setting of 2 VDC to receive the best voltage resolution.

An appropriate analog output voltage setting depends on the input characteristics of the instrument receiving the signal (for example, the data logger) from the monitor. Consult the operating instructions that came with that instrument to determine what range of voltages it will accept, and adjust the Series 1400a Monitor's analog output voltage levels from their factory settings (10 VDC) to correspond with it, if necessary.

4.3 Sample Filter Installation and Exchange

This section discusses the steps to take to install and exchange filters and the sample filter lifetime. The Series 1400a monitor must always be operated with a Teflon coated glass fiber filter, installed on the mass transducer, except when performing certain maintenance and diagnostic procedures.

The TEOM sample filter must be exchanged when the "Check Status" light turns on and status code X is shown on the status line of the Main Screen when the filter loading percentage is greater than 90%. TEOM sample filter must be exchanged before the filter loading percentage reaches 100% to ensure the validity of the data generated by the TEOM.

4.3.1 Filter Exchange

When replacing the TEOM sample filter, care must be taken not to handle the new TEOM sample filter with hands. Use the filter exchange tool provided with the instrument to exchange filters. Always store the TEOM filter box within the heated sensor unit enclosure for pre-conditioning to avoid moisture build-up. Keep the sample pump running to facilitate filter exchanges.

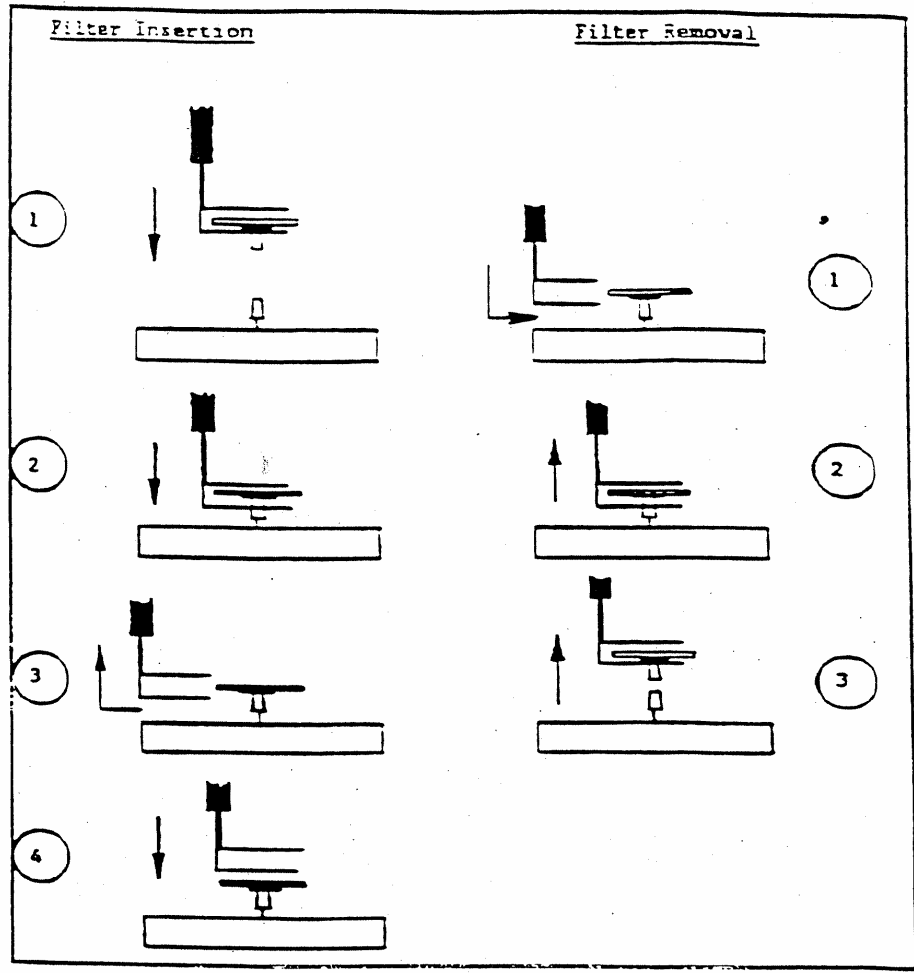


Figure 4-2 Filter Insertion and Removal

Exchange sample filter in the following manner: Disable the data logger and press the <Data Stop> key on the Control Unit.

- 1) Open the door of the Sensor Unit.
- 2) Locate the silver handle mounted on the front surface of the mass transducer. Move the latch upwards and lift up on the bottom of the handle. Gently swing the mass transducer downward using the black knob. The mass transducer then swings into its filter changing position.
- 3) Refer to Figure 4-2 to remove a filter using the filter exchange tool. Place the filter exchange tool so that the filter straddles between the tines of the filter exchange tool and gently lift the filter from the tapered element with a straight pull without twisting or applying lateral force to the tapered element.
- 4) During the filter removal process, the filter may be heavily loaded with particulate and when the tool comes in contact with the filter, the particulate will transfer to the tool. Cleaning the filter exchange tool will prevent any particulate from being transferred to a new filter and thus increase filter life. Use a Kim wipe to remove any particulate from the back side of the metal disc and the tines of the fork on the filter exchange tool.
- 5) Grab a new filter in the filter exchange tool so that the filter disk lies between the fork and upper disk of the tool with the hub of the filter between the tines of the lower fork. Do not touch the filter.
- 6) Hold the filter exchange tool in line with the tapered element and lightly insert the hub of the filter onto the tip of the tapered element. Ensure that the filter is seated properly and apply light downward pressure to set it firmly in place.
- 7) Remove the filter exchange tool by retracting it sideways, without disturbing the filter.
- 8) Gently raise the mass transducer to the closed position using the black knob. Position the silver handle so that it engages the latch plate and push the handle down until the latch is secure.
- 9) Close and latch the door to the Sensor Unit. Keep the door open for as short time as possible to minimize the temperature upset to the system.
- 10) **IMPORTANT:** After five minutes have elapsed, open the sensor unit and mass transducer again. Press gently straight down on the sample filter with the bottom of the filter exchange tool. This ensures that the sample filter is properly seated after it has experienced an increase in temperature. Then close the mass transducer and enclosure. New filters generally exhibit figures of 15-30% for initial filter loading.
- 11) Reset the TEOM by pressing <F1: Run> on the keypad of the TEOM Control Unit and enable the data logger.

NOTE: If the filter loading percentage is high when a new TEOM filter is placed on the mass transducer, or if the lifetime of TEOM sample filter becomes noticeably shorter, this indicates that the in-line filter in the main flow line needs to be exchanged.

5 QUALITY CONTROL

Scheduled visits to the monitoring station to verify the operational status of the monitoring system are essential to acquiring quality data. Biweekly visits are made to the station to inspect the shelter and monitoring equipment. Ensure Table 5-1 is completed and mailed to Quality Assurance Unit.

5.1 Logbook Requirements

All stations are required to maintain site specific instrument logbooks. These are used as an official record for documenting all TEOM maintenance activities, quality control checks, site visits etc. Documentation will indicate the dates and times of all site visits. Also note the status condition and operating mode, filter loading percentage and mass concentration. The operator will also indicate all activities such as filter exchange, any maintenance, and QC checks that are performed in the logbook and operators initials. Keeping the logbook up to date is imperative for data validation requirements.

5.2 QC Flow-Check Procedure

The flow rate quality control check must be performed upon installation and after any maintenance activity with an external flow rate transfer standard. This quality control check must be performed once every 2 weeks, not to exceed 14 days. It is permissible to perform every other bi-monthly flow check (electronic check) without an external flow rate transfer standard provided that:

- a) The 3 most recent consecutive flow rate quality control checks with a flow rate transfer standard confirm that the flow meter is stable, verifiable and accurate within 4%
- b) The instrument and flow meter give no indication of improper operation

In the case of an electronic check, report the set point flow rate as the actual flow rate and the flow rate measured or indicated by the TEOM as the indicated flow rate. These flow rates should be recorded in the "Total" row on the QC Check Data Sheet.

The following describes the procedures involved in performing the flow rate check using a flow transfer standard.

- 1) Disable the data logger and reset the monitor by pressing the <DATA STOP>keys on the front panel of the control unit.
- 2) Remove the PM₁₀ sample inlet and replace it with Flow Audit Adapter. Turn the valve of the Flow Audit Adapter to OPEN position to allow for air flow before installing the adapter. This step must be performed to avoid damage to the filter.
- 3) Scroll the Main Screen using <↓>and <↑> keys until the Main Flow and Auxiliary Flow appear on the four-line display. Confirm that these flows are within $\pm 4\%$ of their set points (3.0 l/min for the Main Flow and 16.7 l/min for the Main Flow plus Auxiliary Flow). Any greater deviation may indicate plugged in-line filters, air blockages in the system or other malfunctions.
- 4) Connect the Flow Audit Adapter to a flow transfer standard such as a Gilibrator, dry gas meter etc.

- 5) Read the total flow (nominally 16.7 l/min) on the flow meter and record it on the QC check form. The volumetric flow measured by the audit flow meter must be 16.7 ± 1.67 l/min to be acceptable.
- 6) Disconnect the Auxiliary Flow Line where it connects to the Flow Splitter. Plug the exit of the Flow Splitter with the 3/8" Swagelok cap supplied as part of the Flow Audit Adapter kit.
- 7) Read the Main Flow on the flow meter and record on the QC check form. The volumetric flow indicated by the audit flow meter must be 3.0 ± 0.3 l/min to be acceptable.
- 8) Connect the audit device to the Auxiliary flow line.
- 9) Read the Auxiliary Flow on the flow meter and record it on the QC check form. The volumetric flow indicated by the audit flow meter must be 13.67 ± 1.36 l/min to be acceptable.
- 10) If either the Main or Auxiliary Flow is outside the acceptable limits, a leak check must be performed (see step 12). If necessary follow with repairs and a flow check. If this doesn't rectify the problem, then a calibration must be performed.
- 11) Remove the cap from the exit of the Flow Splitter and replace the Bypass Flow Line.
- 12) Optional: To perform a system leak check, Remove the sampling filter and close the valve on the Flow Audit Adapter. Both the Main Flow and Auxiliary Flow should read less than 0.15 l/min on Main Screen. If one of the flows is greater than 0.15 l/min then the system is not leak tight. In this case, check hose fittings and other critical locations in the flow system for leaks.
- 13) Remove the Flow Audit Adapter and replace the inlet on the top of the Flow Splitter.
- 14) Insert a new TEOM filter into the mass transducer if needed and reset the monitor by pressing <F1> or <Run>. The instrument will automatically begin data collection after temperature and flow rates have remained stable at their set points for one-half hour.
- 15) Enable the data logger.

Changes in flow rate calibration of more than 10 % as determined by a monthly field flow rate verification check may cause invalidation of all data collected since the last acceptable flow rate check.

Deviation of 10% or greater from the design value in flow rate during sampling require that the data be flagged for potential invalidation.

- 1) Record the **actual** flow rate measured by the flow verification check device and the flow rate **indicated** by the sampler.
- 2) Using the above information, calculate the percentage difference for both the Total , Main and Auxiliary flow as:

$$\text{QC \% Difference (Total Flow)} = \left[\frac{16.67 - Act}{Act} \right] \times 100$$

$$\text{QC \% Difference (Main Flow)} = \left[\frac{3.0 - Act}{Act} \right] \times 100$$

$$\text{QC \% Difference (Auxiliary Flow)} = \left[\frac{13.67 - Act}{Act} \right] \times 100$$

- 3) If the monitor flow rate is within 90 to 110 percent of the measured flow rate at actual conditions and if the monitor flow rate is within 90 to 110 percent of the design flow rate of 16.67 L/min, the monitor is operating properly.

If either limit is exceeded, repeat the leak check procedure, as described in Section 3.2.3. Investigate and correct any malfunction and recheck the flow. If necessary, recalibrate the flow controller (Software and then if necessary perform hardware calibration) before sampling again.

Table 5-1 TEOM PM₁₀ QC Check Data Sheet

Station # _____ Date: _____
 Location: _____ Time: _____
 Serial # _____ Operator: _____
 Flow Standard Serial # _____
 • Certification Date: _____

Leak Check

Main _____ L/min Auxiliary _____ L/min (should be less than 0.15 L/min)

Flow Check

Main Actual _____ L/min Indicated _____ L/min % Difference _____
 Aux Actual _____ L/min Indicated _____ L/min % Difference _____
 Total Actual _____ L/min Indicated _____ L/min % Difference _____

$$QC \% \text{ Difference} = \left[\frac{Ind - Act}{Act} \right] \times 100 \quad \text{Design \% Difference} = \frac{Actual - 16.67}{16.67} (100)$$

Mail to Quality Assurance Unit

6 MAINTENANCE PROCEDURES

This section presents the routine maintenance procedures for the TEOM Series 1400a monitor. The operator may find that routine maintenance is site-specific and can vary from location to location. Increases in the routine maintenance frequencies might be necessary due to the operational demands on the samplers. All maintenance activities are to be documented in the monitor logbook. Table 6-1 is a summary of required maintenance procedures and frequencies.

6.1 Supplies And Tools Recommended For Maintenance

- 1) Ammonia based general purpose cleaner
- 2) Cotton swabs
- 3) Small soft-bristle brush
- 4) Paper towels
- 5) Distilled water
- 6) Silicone-based stopcock grease
- 7) Small screwdriver
- 8) Small crescent wrench
- 9) Pocket knife
- 10) Flat tip and Phillips head screwdriver
- 11) Adjustable wrench

6.2 Cleaning The PM₁₀ Inlet

The PM₁₀ Inlet must remain free of significant contamination to ensure a correct particulate size cut-off at 10 µm or less. The inlet of the R&P PM₁₀ must be cleaned periodically to prevent buildup of particulate matter and contaminants. The inlet cleaning is best done before an exchange of a TEOM sample filter. This allows for the cleaning procedure to be carried out during the one-half hour flow and temperature stabilization period following the instrument reset.

Follow the procedure below to maintain the PM₁₀ inlet:

- 1) Disassemble the inlet and the bottom of the inlet from the main body.
- 2) Soak in soapy water. Do not scrub, since scrubbing may damage the Teflon coating.

- 3) Rinse with deionized water several times and the last rinse may be with alcohol to facilitate drying. The inlet can also be dried with air.
- 4) Re-assemble and cap until ready for re-use, or reinstall on the 1 ¼" OD sample tube.

6.3 Replacing The Large Bypass In-Line Filter

There are two large bypass in-line filters used with the TEOM 1400a monitor. Both are located on the back of the TEOM control unit, one on the main and one on the Auxiliary flow lines. These filters prevent contamination from reaching the flow controllers. Replacement of the filter is best done immediately following an exchange of the TEOM sample filter. The maximum interval for replacing the large bypass in-line filter is six months.

To replace the filters, remove the existing filters with their quick-connect fittings and replace them with the new filter assemblies. Ensure that the arrows on the filters point away from the control unit. If the filters are installed in this way, the operator can visually see the dust as it is collected in the filter.

NOTE: If the filter loading percentage is high when a new TEOM filter is placed on the mass the transducer, or if the lifetime of TEOM sample filter becomes noticeably shorter, this indicates that the in-line filter in the main flow line needs to be exchanged.

6.4 Replacing The Flow Control Filters

The flow controller filters attached to the mass flow controllers in the control unit provide a particle free air supply to the flow regulation hardware, and are essential for reliable, long-term instrument operation. Replacement of the filter is best done immediately following an exchange of the TEOM sample filter.

To replace the filters, unscrew and remove the existing filters from the mass flow controllers in the TEOM control unit and install the new filters to the mass flow controller.

6.5 Pump Test

This test is intended to help the operator determine whether the pump is still capable of providing adequate vacuum to run the series 1400a monitor. The average lifetime of the pump is 1 to 1.5 years. This test is performed every 6 months or if any of the following is true:

- ◆ The main flow drops off at filter loading of less than 90%.
- ◆ The filter loading percentage fluctuates.

To check the pump, perform the following steps.

- 1) Operate the Series 1400a monitor in the usual fashion with the sample pump running.
- 2) Remove the TEOM sample filter from the mass transducer.
- 3) Remove the size selective inlet from the flow splitter and replace it with the flow audit adapter contained in the flow audit adapter kit supplied with the instrument.
- 4) Display the main and auxiliary flows on the main screen of the four line display.
- 5) Begin slowly closing the valve on the flow adapter so the incoming flow is restricted.
- 6) Watch the filter loading percentage along with the main and auxiliary flow readings. Note the percentage at which either or both flows begin to decrease.
- 7) If either flow begins to decrease at a filter percentage of less than 90% the pump should be rebuilt.

6.6 Rebuild Sample Pump

The instructions for rebuilding the pump are provided with the compressor service kit. Follow the assembly procedures provided with the kit to rebuild the pump.

6.7 Cleaning The Air Inlet System

The heated Air Inlet in the monitor must be cleaned periodically to remove the build-up of particulate on its inner walls.

Perform the following steps to clean the Air Inlet System:

- 1) Turn off the TEOM control unit.
- 2) With the mass transducer in its closed upright position, carefully remove the air thermistor from the “cap” of the TEOM mass transducer by pressing in on the metal locking clip. The cap is located immediately above the part of the mass transducer that swivels downward.
- 3) Open the mass transducer by pulling upward on its silver handle.
- 4) Place clean plastic or any protective material over the exposed part of the mass transducer.
- 5) Using alcohol, clean the Air Inlet. A soft brush may also be used to remove particulate on the inside walls.
- 6) Allow the Air Inlet to dry.
- 7) Remove the plastic or any protective material from the exposed part of the microbalance.

- 8) Pivot the mass transducer into its closed position by pressing the closing mechanism.
- 9) Carefully re-insert the air thermistor into the cap of the mass transducer assembly.
- 10) Turn on the TEOM Control Unit.

6.8 TEOM Shelter Maintenance

The TEOM shelter air conditioner has an external filter on it to keep the dust out. This filter needs to be taken out and cleaned on a monthly basis. To clean this filter is to blow it out with compressed air or vacuum it out. It can be washed out with water, but it has to be completely dry when it is re-installed. Replace this filter about every 2 years.

6.9 Leak Testing

Refer to Section 3.2.3

6.10 Software Update

The operator must update software to the latest version by the deadline approved by the Air Monitoring Coordinator at Dept. of Ecology.

Table 6-1 Routine Maintenance Activities

ACTIVITY	REQUIRED FREQUENCY
Clean PM ₁₀ inlet	With each TEOM filter exchange
Replace large bypass in-line filters	Every six months
Replace flow controllers filters	Every six months
Pump Test	Every six months
Clean air inlet system	Once a year
Clock adjustment procedure	Check monthly and adjust as needed
Resetting the system	As needed
Updating system software	When approved by the Air Monitoring Coordinator at Dept. of Ecology As needed
Rebuild sample pump	Once in eighteen months

7 DATA VALIDATIONS AND REPORTING OF PM₁₀ DATA

This section discusses validations and reporting of PM₁₀ data.

7.1 Data Assessment and Validation

Data must be validated to ensure that all reported PM₁₀ measurements are accurate relative to the overall scope of the quality assurance program. The data validation process is based on specific criteria and when found to satisfy all the criteria, will be considered valid. The data that does not meet all the criteria will be invalidated.

7.1.1 Monthly

The station operator will generate the preliminary, "Monthly Average Report", Table 7-1 1-hour running averages with flags. The Report will be reviewed for reasonableness and comparability.

1. Invalid data will be marked on the printout with an "X" through all inclusive hours. Invalid data include periods of calibrations, QC activities, missing data, excessive negative drift (values > -1 µg/m³, values > -1 µg/m³ but < 0 will be assigned a 0), spiking, analyzer malfunctions, etc. Anomalous data periods will be reviewed and investigated with logbook entries, compared to other data parameters that maybe measured at the monitoring station, and any other tool available to ensure validity.
2. Submit the Report to the Quality Assurance Unit. All Reports must be submitted no later than the 10th of the following month. If the Report cannot be submitted on time notify the Quality Assurance Unit immediately and make arrangements for submittal.
3. The Quality Assurance Unit will review the Report, validate the data utilizing all Quality Control and Quality Assurance information, and then submit it to the Monitoring Unit for online editing. The Quality Assurance Unit will review and certify the final Report.

7.2 Final Data Validation

Data that have been reviewed by the Quality Assurance Unit and found to satisfy the requirements of this procedure and the criteria defined in the Washington State Department of Ecology Air Monitoring Quality Assurance Plan will be certified as valid.

7.3 Data Reporting And Final Data Validation

After the data are logged, edited, and validated the Quality Assurance Unit will prepare quarterly and annual summary reports and the Monitoring Unit will transmit the data to EPA. Data that has been reviewed by the Quality Assurance Unit and found to satisfy the requirements of this procedure and the criteria defined in the Washington State Department of Ecology Air Monitoring Quality Assurance Plan will be certified as valid.

Table 7-1 Monthly Average Report

Facility Name: State of Washington Ambient
 Monthly Running Average Report
 Run Date: 10/12/99 10:10
 (1 Hour Rolling Averages)

SITE NAME: KNTJC : 53-033-2004 PARAMETER NAME: TP-10 MONTH: August
 ADDRESS: JAMES ST & CENTRAL AVE, KENT PARAMETER CODE: 21104 YEAR: 1999
 LAT/LONG: 047 23' 11" / 122 13' 49" METHOD: 79 UNITS: UG/M3 DECIMAL POSITIONER: 0
 ELEVATION: 20 PROJECT: 01

Hourly Averages
 Beginning hour (PST)

DA	C	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	AVG	MAX	RDS
21	SU	11	12	14	17	17	15	17	15	13	12	14	15	15	14	15	22	18	20	17	17	19	15	14	13	15	22	24
22	MO	11	12	12	12	14	16	18	13	12	15	16	15	17	16	15	17	19	18	21	29	26	15	16	15	16	29	24
23	TU	18	17	14	15	15	17	18	16	11	12	12	13	21	24	24	20	18	16	17	23	23	22	18	14	17	24	24
24	WE	13	13	13	13	13	15	15	16	22	20	17	22	17	12	18	9	10	13	16	19	15	14	15	15	15	22	24
25	TH	13	10	15	13	11	9	10	13	22	21	17	16	13	12	19	20	14	26	27	24	14	16	18	16	27	23	
26	FR	18	19	18	15	14	15	13	10	9	10	11	9	11	20	21	16	14	19	20	10	12	10	7	9	14	21	24
27	SA	5	8	6	7	8	14	14	14	11	11	7	8	6	7	9	8	10	9	9	8	6	8	8	7	9	14	24
28	SU	7	7	6	5	6	6	7	7	5	6	8	7	5	6	6	5	5	7	9	11	10	8	8	7	7	11	24
29	MO	6	4	6	7	7	10	10	14	14	14	10	21	11	10	9	9	8	12	15	14	15	12	13	11	21	23	
30	TU	12	12	12	13	11	13	14	14	16	8	8	10	10	10	10	8	9	10	11	16	21	16	17	16	12	21	24
31	WE	10	7	6	6	10	10	8	7	8	10	12	13	14	11	11	8	9	8	9	7	10	9	8	6	9	14	24
12	TH	9	6	6	7	6	8	8	8	6	8	8	9	10	9	7	9	10	5	4	6	7	7	4	5	7	10	24
13	FR	7	7	7	6	7	9	10	11	9	7	12	8	7	6	9	9	15	12	5	5	5	5	5	5	8	15	24
14	SA	5	5	5	6	6	6	4	5	2	3	5	2	2	5	3	3	4	4	5	7	7	6	5	7	5	7	24
15	SU	7	7	6	5	5	5	5	6	5	3	4	5	6	7	5	6	6	6	7	6	6	4	5	5	5	7	24
16	MO	5	5	6	6	7	8	10	12	6	7	6	5	4	1	3	6	8	10	13	10	8	8	9	7	13	23	
17	TU	8	7	9	10	11	11	8	8	12	14	15	13	14	12	13	13	12	13	12	18	17	16	16	12	18	24	
18	WE	13	8	7	8	9	11	12	13	12	13	13	17	16	22	24	20	23	15	14	11	9	7	5	5	13	24	24
19	TH	7	7	7	8	9	9	10	7	8	47	14	8	8	9	7	6	9	10	8	13	14	10	10	9	11	47	24
20	FR	8	8	9	10	11	13	22	13	13	15	14	11	11	11	9	6	8	9	16	11	10	8	7	7	11	22	24
21	SA	4	5	4	5	4	5	7	5	6	6	8	4	4	4	2	4	7	10	12	12	10	8	9	8	6	12	24
22	SU	10	7	8	7	7	7	8	4	3	6	6	7	8	9	10	9	8	10	12	18	19	18	16	15	10	19	24
23	MO	13	12	14	14	15	18	19	19	20	17	11	25	18	15	14	16	15	14	15	24	20	21	19	17	17	25	24
24	TU	16	14	12	14	12	12	11	12	12	14	15	13	13	14	9	7	8	7	5	5	5	3	5	6	10	16	24
25	WE	6	5	4	4	10	6	2P	6	5	6	7	5	7	9	6	6	8	8	9	14	10	10	11	8	7	14	24
26	TH	7	6	6	6	9	12	17	7	8	11	13	10	12	10	8	10	15	14	13	17	12	9	9	10	10	17	24
27	FR	6	5	7	7	8	12	17	16	14	13	16	16	16	18	18	18	16	18	20	28	27	25	25	24	16	28	24
28	SA	24	23	21	20	19	21	9	7	8	10	11	9	9	10	6	4	3	5	4	6	9	12	9	7	11	24	24
29	SU	8	4	3	3	2	5	4	4	6	6	5	5	4	2	2	2	5	3	6	6	8	8	5	5	5	8	24
30	MO	7	7	7	7	9	9	13	12	12	8	7	7	7	6	8	9	8	4	6	7	8	8	8	7	8	13	24
31	TU	6	6	5	6	6	7	7	8	7	7	5	7	7	7	11	8	4	5	10	11	14	14	10	10	8	14	24
AVG		10	9	9	9	10	11	11	10	10	12	11	10	11	11	10	10	11	10	12	14	13	11	11	10	10		
MAX		24	23	21	20	19	21	22	19	22	47	17	25	21	24	24	22	23	20	26	29	27	25	25	24		47	
DAYS		31	31	31	31	31	31	31	31	31	31	31	31	29	30	31	31	31	31	31	31	31	31	31	31			741

STANDARD DEVIATION : 7

NOTES:

NOTES: *** INDICATE INVALID DATA OR LESS THAN 75 PERCENT VALID DATA INCLUDED.
 STATUS CODES 'P' - POWER DOWN, 'D' - DISABLED, 'B' - BAD STATUS, 'C' - CALIBRATION, 'M' - MINIMUM, 'X' - MAXIMUM,

7 DATA FORMS

Blank data forms are provided on the following pages for the convenience of the manual operator.

Table 7-1 Calibration And Verification Check Intervals

	Frequency	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Acceptance Criteria
Flow Rate Verification Main Flow Auxiliary Flow	Once every two weeks													± 10% of the Transfer Standard
Flow Controller Calibration (Software)	Twice a year													
Clock/timer Verification	Once in 30 days													±2 min
Mass transducer calibration verification	Once a year													
Leak Check	Once in 30 days													0.15 L/min

Table 7-2 TEOM PM₁₀ Calibration Sheet

AIRS Station #	_____	Date:	_____
Location:	_____	Time:	_____
Serial # :	_____	Operator:	_____
State ID:	_____		

Flow Calibration

Total Actual	_____ L/min	Indicated	_____ L/min	% Difference	_____
Main Actual	_____ L/min	Indicated	_____ L/min	% Difference	_____
Aux. Actual	_____ L/min	Indicated	_____ L/min	% Difference	_____

$$QC \% \text{ Difference} = \left[\frac{Ind - Act}{Act} \right] \times 100$$

Mass Flow Controller Calibration (Software) _____

Time Calibration

Actual Time	_____	Indicated	_____	Soft & Hard	_____
				Rate	_____

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Table 7-3 TEOM PM₁₀ QC Check Data Sheet

Station # _____	Date: _____
Location: _____	Time: _____
Serial # _____	Operator: _____
Flow Standard Serial # _____	
Certification Date: _____	

Leak Check

Main	L/min	Auxiliary	L/min	(should be less than 0.15 L/min)
_____		_____		

Flow Check

Main Actual	_____ L/min	Indicated	_____ L/min	% Difference	_____
Aux Actual	_____ L/min	Indicated	_____ L/min	% Difference	_____
Total Actual	_____ L/min	Indicated	_____ L/min	% Difference	_____

QC % Difference = $\left[\frac{Ind - Act}{Act} \right] \times 100$ Design % Difference =

$\frac{Actual - 16.67}{16.67} (100)$

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