Chapter 7
Measurement of Particulates

Part One
Intermittent PM$_{2.5}$ and PM$_{10}$ Monitoring

Part Two
Total Suspended Particulate Monitoring for Metals

Part Three
Continuous Particulate PM$_{2.5}$ and PM$_{10}$ Monitoring

Part Four
PM$_{2.5}$ Chemical Speciation Monitoring

Part Five
Continuous PM$_{2.5}$ Chemical Speciation Monitoring
# Chapter 7
## Part One – Intermittent PM$_{2.5}$ and PM$_{10}$ Monitoring
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1.0 Introduction

Between the years 1900 and 1970, the emission of six principal ambient air pollutants increased significantly. The principal pollutants, also called criteria pollutants, are: particulate matter (PM\textsubscript{10} & PM\textsubscript{2.5}), sulfur dioxide (SO\textsubscript{2}), carbon monoxide (CO), nitrogen dioxide (NO\textsubscript{2}), ozone (O\textsubscript{3}), and lead (Pb). In 1970 the Clean Air Act (CAA) was signed into law. The CAA and its amendments provide the framework for all pertinent organizations to protect air quality. This framework provides for the monitoring of these criteria pollutants by State and local organizations through the Air Quality Monitoring Program.

The criteria pollutant defined as particulate matter is a general term used to describe a broad class of substances that exist as liquid or solid particles over a wide range of sizes. As part of its Ambient Air Quality Monitoring Program, the Indiana Department of Environmental Management, Office of Air Quality (IDEM, OAQ) will measure two particle size fractions; those less than or equal to 10 micrometers (PM\textsubscript{10}), and those less than or equal to 2.5 micrometers (PM\textsubscript{2.5}). Part One of Chapter 7 focuses on the activities associated with intermittent PM\textsubscript{2.5} and PM\textsubscript{10} sampling using the Partisol-Plus.

The background and rationale for the implementation of Indiana’s PM\textsubscript{2.5/10} ambient air monitoring network are found in the Federal Register. In general, some of the findings are listed below.

- The characteristics, sources, and potential health effects of larger or “coarse” particles (from 2.5 to 10 micrometers in diameter) and smaller or “fine” particles (smaller than 2.5 micrometers in diameter) are very different.
- Coarse particles come from sources such as windblown dust from agricultural fields and dust kicked up on unpaved roads from vehicle traffic.
- Fine particles are generally emitted from activities such as industrial and residential combustion and from vehicle exhaust. Fine particles are also formed in the atmosphere from gases such as sulfur dioxide, nitrogen oxides, and volatile organic compounds that are emitted from combustion activities and then become particles as a result of chemical transformations in the air.
- Coarse particles can deposit in the respiratory system and contribute to health effects such as aggravation of asthma. USEPA's “staff paper” concludes that fine particles, which also deposit deeply in the lungs, are more likely than coarse particles to contribute to the health effects (e.g., premature mortality and hospital admissions) found in a number of recently published community epidemiological studies.
- These community studies find that adverse public health effects are associated with exposure to particles at levels well below the current standards for both short-term (e.g., less than 1 day to up to 5 days) and long-term (generally a year to several years) periods.
• Health effects include premature death, increased hospital admissions and emergency room visits (primarily among the elderly and individuals with cardiopulmonary disease); increased respiratory symptoms and disease (among children and individuals with cardiopulmonary disease such as asthma); decreased lung function (particularly in children and individuals with asthma); and alterations in lung tissue and structure and in respiratory tract defense mechanisms

Air quality samples are generally collected for one or more of the following purposes:

1. To judge compliance with and/or progress made towards meeting the NAAQS.
2. To develop, modify or activate control strategies that prevent or alleviate air pollution episodes.
3. To observe pollution trends throughout the region, including non-urban areas.
4. To provide a data base for research and evaluation of effects.

With the end use of the air quality samples as a prime consideration, various networks can be designed to meet one of six basic monitoring objectives listed below:

• Determine the highest concentrations to occur in the area covered by the network
• Determine representative concentrations in areas of high population density
• Determine the impact on ambient pollution levels of significant source or source categories
• Determine general background concentration levels
• Determine the extent of Regional pollutant transport among populated areas, and in support of secondary standards
• Determine the welfare related impacts in more rural and remote areas

The reference method for sampling PM_{2.5} is found in 40 CFR Part 50, Appendix L, while PM_{10} is covered in CFR Part 50, Appendix J. Both are referenced in 40 CFR Part 53, Subpart E. In general, the sampling involves drawing a measured quantity of ambient air at a constant volumetric flow rate through a specially designed particulate size selective inlet. PM_{2.5} particles are those with an aerodynamic diameter of less than or equal to 2.5 \mu m. Particles are collected on a 46.2-millimeter polytetrafluoreoethylene filter during the specified 23 to 25-hour sampling period. Each filter is weighed before and after sampling. From these measurements, the mass of the collected PM_{2.5/10} sample is calculated.

The total volume of air sampled is determined from the measured volumetric flow rate and the sampling time. The concentration of PM_{2.5/10} in the ambient air is computed as the total mass of collected particles in the PM_{2.5/10} size range divided by the total volume of air sampled and measured under the ambient (actual) conditions of temperature and pressure. The PM_{2.5/10} concentrations are expressed as micrograms per cubic meter (\mu g/m^3) of air.
1.1 Sampling Overview

Indiana uses Thermo Scientific Partisol-Plus Model 2025 Sequential Air Samplers to meet the measurement goals of the PM$_{2.5/10}$ Ambient Air Quality Monitoring Program. Most monitoring stations sample either a one in three day or a one in six day schedule with a few PM$_{2.5}$ sites conducting daily (one in one day) sampling.

All PM$_{2.5/10}$ filters used in state agency operated Ambient Air Quality Monitoring Program are conditioned, weighed, and loaded into filter cassette assemblies (storage magazines) in the Office of Air Quality’s Analytical laboratory in Indianapolis prior to distribution into the field. Exposed filters are returned to the Office of Air Quality’s laboratory for post sampling conditioning and analysis. This process is documented to ensure no data is lost due to inadequate or improper handling of the sampling media.

Additional information regarding permissible sample holding times is specified in the USEPA QA Handbook (40 CFR Part 50, Appendices J and L, Section 8), the Indiana Department of Environmental Management’s SOP on filter transport, and Table 1 of this document.

Figure 1
Sample Inlet

![Sample Inlet Diagram]
Figure 2
PM$_{2.5}$ Very Sharp Cut Cyclone (VSCC)

Figure 3
PM$_{2.5}$, PM$_{10}$ Inlet Downtube & VSCC
2.0 Facility Requirements

Facility requirements for PM$_{2.5/10}$ sampling include a central laboratory that includes a filter conditioning and weighing area, a calibration and maintenance area, and individual field sampling stations.

2.1 Filter Conditioning and Weighing Area

Two rooms or “clean rooms” specifically designed for the conditioning and weighing of the filters have been constructed at the Indiana Department of Environmental Management, Office of Air Quality. One clean room is used for the PM$_{2.5}$ program while the second is used for PM$_{10}$ activities. Each clean room is a restricted access area, and it meets the criteria in 40 CFR Part 50, Appendix L and Section 2.12 of the Quality Assurance Handbook for Air Pollution Measurements Systems. These criteria include:

- mean temperature of 20-23 °C
- temperature controlled to within ±2 °C over 24 hours
- mean humidity 30-40%
- humidity control ±5 % relative humidity over 24 hours
- temperature and relative humidity is continuously monitored with 5-minute averages, collected by a data logger and information saved to a computer hard drive

In addition, certified relative humidity and temperature measurement instruments must be maintained.

Each year, an audit on the clean room and all of its processes will be performed by the Quality Assurance Section Chief (see Form 4).

2.2 Calibration and Maintenance Area

A sufficiently large area should be designated as the calibration and maintenance test area. It should be equipped with the tools required for routine sampler maintenance and ancillary equipment maintenance and repair.

2.3 Sampling Sites

As with any type of air monitoring study in which the sample data are to be used to draw conclusions about a geographic area, the validity of those conclusions depends on the representativeness of the sampling data. Therefore, an initial goal of the Indiana’s monitoring project is to select a site where the PM$_{2.5}$ and/or PM$_{10}$ measurements are representative of the monitoring area.
Spatial and temporal scale considerations are important in PM$_{2.5/10}$ sampler siting. Spatial scales may range from a small (0.1 - to 0.5 km$^2$) area to large regional areas exceeding tens of hundreds of square kilometers. Whether the potential impact of particulate pollution is generated by a local or general source category will affect the decision on the size of the spatial monitoring scale. In addition, the siting of the samplers within the monitoring network should reflect whether the expected impact is limited to a small area (a few city blocks) or will extend to larger areas (metropolitan and rural). With regard to the temporal scale, interest focuses on either the annual or the geometric mean concentration or a 24-hour average concentration. Because siting of a PM$_{2.5/10}$ sampler requires considering the prevailing wind direction, a sampler sited for monitoring trends in air quality over a period of a year will not necessarily be ideal for measuring 24-hour concentrations. Thus, the choice of temporal aspects of the network design and optimum exposure are more completely explained in 40 CFR Part 50, Appendix L and Part 58, Appendix D and in the siting guidelines outlined in Chapter 1 Section 4.0, of the Indiana Department of Environmental Management, Office of Air Quality’s Quality Assurance Manual.

3.0 Filter Preparation and Analysis

Upon delivery of approved 46.2 mm Teflon filters for use in the IDEM network, the receipt is documented and the filters are stored in the conditioning/weighing room/laboratory “clean room”. Storing filters in the laboratory makes it easier to maximize the amount of time available for conditioning. Upon receipt, cases of filters are labeled with the date of receipt, opened one at a time, and used completely before opening another case. All filters in a lot are used before a case containing another lot is opened. When more than one case is available to open, then the “First In - First Out” rule applies.

Filters are taken out of the case when there is enough room for them in the pre-sampling weighing section of the clean room. Filters are inspected according to the FRM criteria to determine compliance. Filters are then stored in the clean room in labeled petri dishes.

3.1 Conditioning/Equilibration

A room or “clean room” specifically designed for the conditioning and weighing of the filters has been constructed at the Indiana Department of Environmental Management, Office of Air Quality. This clean room is a restricted access area and it meets the criteria in 40 CFR Part 50, Appendix L and Section 2.12 of the Quality Assurance Handbook for Air Pollution Measurements Systems. These criteria include:

- mean temperature of 20-23 °C
- temperature controlled to within ±2 °C over 24 hours
- mean humidity 30-40%
- humidity control ±5 % relative humidity over 24 hours
- temperature and relative humidity is continuously monitored with 5-minute averages, collected by a data logger and information saved to a computer hard drive
3.2 Sample Weighing

IDEM uses a Mettler Model XP2U microbalance for the gravimetric analysis of the PM$_{2.5}$ samples and a Mettler Model MT5 microbalance for the gravimetric analysis of the PM$_{10}$ samples. The instruments meet all criteria set forth in 40 CFR Part 50, Appendix L and they are maintained under agreement with the manufacturer. A set of Troemner weights is used as the lab’s primary standards for both the PM$_{2.5/10}$ clean rooms. These weights are then used to do quarterly checks on the 100 mg and 500 mg working standards in each room. The detailed procedure for the handling and analysis of samples is found in the laboratory SOP “Analysis of Both PM$_{2.5}$ and PM$_{10}$ Particulate Matter Using GLIMS Software”, S-006-OAQ-M-AT-14-T-R2. Both pre and post sample filters are weighed on the same Mettler balance, and all weighing is done by the same laboratory personnel whenever possible. Refer to Table 1 below for additional filter preparation and analysis checks.

Photo 1
Filter Weighing
<table>
<thead>
<tr>
<th>Activity</th>
<th>Method and Frequency</th>
<th>Requirements</th>
<th>Action if the requirements are not met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microbalance Use</td>
<td>Yearly Vendor calibration/certification</td>
<td>Resolution of 1 μg, repeatability of 1 μg.</td>
<td>Obtain proper microbalance.</td>
</tr>
<tr>
<td>Control of balance environment</td>
<td>QC checks to keep conditions within +/-2°C and +/-5% RH</td>
<td>Climate-controlled, draft-free room or chamber or equivalent.</td>
<td>Modify the environment.</td>
</tr>
<tr>
<td>Use of Mass reference standards</td>
<td>Working standards checked every 3 to 6 months against laboratory primary standards.</td>
<td>Standards bracket weight of filter, individual standard's tolerance less than 25 μg, handle with smooth, nonmetallic forceps.</td>
<td>Obtain proper standards or forceps.</td>
</tr>
<tr>
<td>Filter handling</td>
<td>Observe handling procedure.</td>
<td>Use smooth, clean forceps. Replace 210Po antistatic strips every 6 months or when determined to be needed.</td>
<td>Discard mishandled filter or old antistatic strip.</td>
</tr>
<tr>
<td>Filter integrity check</td>
<td>Visually inspect each filter.</td>
<td>No pinholes, separation, chaff, loose material, discoloration, or filter nonuniformity.</td>
<td>Discard defective filter.</td>
</tr>
<tr>
<td>Filter identification</td>
<td>Write filter number on filter handling container, sampler number on protective container, and both numbers on laboratory data form in permanent ink.</td>
<td>Make sure numbers are written legibly.</td>
<td>Replace label or correct Form.</td>
</tr>
<tr>
<td>Pre-sampling filter equilibration</td>
<td>Determine the correct equilibration conditions and period (at least 24 hours) for each new lot of filters. Observe and record the equilibration chamber relative humidity and temperature; enter to lab data form.</td>
<td>Check for stability of laboratory blank filter weights. Weight changes must be &lt;15 μg before and after equilibration. Mean relative humidity between 30 and (40 CFR Part 50, Appendix L) percent, with a variability of not more than ±5 percent over 24 hours. Mean temperature is held between 20 and 23 °C, with a variability of not more than ±2 °C over 24 hours.</td>
<td>Revise equilibration conditions and period. Repeat equilibration.</td>
</tr>
<tr>
<td>Initial filter weighing</td>
<td>Observe all weighing procedures. Perform all QC checks.</td>
<td>Neutralize electrostatic charge on filters. Wait long enough so that the balance indicates a stable reading (oscillates no more than ±2, drifts no more than 3 μg, in 5-10 sec).</td>
<td>Repeat weighing.</td>
</tr>
<tr>
<td>Internal QC</td>
<td>At the beginning of a weighing session, weigh the two working standards. After approximately every tenth filter, zero the microbalance and reweigh one of the two working standards. Weigh three laboratory filter blanks. Reweigh one duplicate filter with each sample batch (duplicate weighing).</td>
<td>The working standard measurements must agree to within 3 μg of the certified values. The blank and duplicate measurements must agree to within 15 μg.</td>
<td>Flag values for validation activities.</td>
</tr>
<tr>
<td>Post-sampling inspection, documentation and verification</td>
<td>Examine the filter and field data sheet for correct and complete entries. If sample was shipped in a cooled container, verify that low temperature was maintained.</td>
<td>No damage to filter. Field data sheet complete. Sampler worked OK.</td>
<td>Notify Lab Manager. Discard filter. Void sample.</td>
</tr>
<tr>
<td>Filter Archival</td>
<td>Packed and kept in cold storage for 3 years. Once removed, kept onsite for an additional 10 years</td>
<td>Cold storage kept &lt;4°C. Onsite storage in a dry protected location.</td>
<td>Notify Lab Manager.</td>
</tr>
</tbody>
</table>
3.3 Environmental Control Requirements

The temperature requirements of the PM$_{2.5}$ network are explicitly detailed in 40 CFR Part 50, Appendix L. PM$_{10}$ samples are handled the same as PM$_{2.5}$ samples during the pre and post laboratory weighing but there are no temperature requirements from the time the samples are collected up to when they are conditioned. In the weigh-room laboratory, the filters must be conditioned for a minimum of 24 hours prior to pre-weighing; although, a longer period of conditioning may be required. The weigh-room laboratory temperature must be maintained between 20 and 23 °C, with no more than a $\pm2$ °C change over the 24 period prior to weighing the filters. During transport from the weigh-room to the sample location, there are no specific requirements for temperature control; however, the filters are located in their protective container and excessive heat/cold is avoided. Temperature requirements for the sampling and post sampling periods are detailed in 40 CFR Part 50, Appendix L Section 7.4.10. These requirements state that the temperature of the filter cassette during sampler operation and in the period from the end of sampling to the time of sample recovery shall not exceed that of the ambient temperature by more than 5 °C for more than 30 minutes. After retrieval from the sampler, the exposed filter containing the PM$_{2.5}$ sample should be transported to the filter conditioning environment as soon as possible, ideally to arrive at the conditioning environment within 24 hours for conditioning and subsequent weighing. During the period between filter retrieval from the sampler and the start of the conditioning, the filter shall be maintained as cool as practical and continuously protected from exposure to temperatures over 25 °C to protect the integrity of the sample and minimize loss of volatile components during transport and storage. A certified thermometer is transported inside the protective container to document the temperatures.

The specifics of temperature preservation requirements are clearly detailed in 40 CFR Part 50, Appendix L. These requirements pertain to media both before and after the samples have been collected. Additionally, during the sample collection there are requirements for temperature control. The temperature requirements are detailed below in Table 2:

<table>
<thead>
<tr>
<th>Item</th>
<th>Temperature Requirement</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weigh Room</td>
<td>20 – 23 °C</td>
<td>(40 CFR Part 50, Appendix L), Section 8.3.1</td>
</tr>
<tr>
<td>Pre-weighed Filter</td>
<td>±2 °C for 24 hours prior to weighing</td>
<td>(40 CFR Part 50, Appendix L), Section 8.3.2</td>
</tr>
<tr>
<td>Filter Temperature Control during sampling and until recovery</td>
<td>No more than 5 °C above ambient temperature</td>
<td>(40 CFR Part 50, Appendix L), Section 7.4.10</td>
</tr>
<tr>
<td>Filter Temperature Control from time of collection to conditioning environment (ideally within 24 hours)</td>
<td>25 °C or less</td>
<td>(40 CFR part 50 Appendix L), Section 10.13</td>
</tr>
<tr>
<td>Post Sample Transport so that final weight may be determined up to 30 days after end of sample period</td>
<td>4 °C or less</td>
<td>(40 CFR Part 50, Appendix L), Section 8.3.6</td>
</tr>
</tbody>
</table>
3.4 Permissible Holding Times

IDEM adheres to the permissible holding times for the samples which are clearly detailed in 40 CFR Part 50, Appendix L, QA Guidance Document 2.12, and the QA Handbook for Air Pollution Measurement Systems. Holding times are listed in Table 3.

<table>
<thead>
<tr>
<th>Item</th>
<th>Holding Time</th>
<th>From:</th>
<th>To:</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-weighed Filter</td>
<td>≤30 days</td>
<td>Date of Pre-weigh</td>
<td>Date of Sample</td>
<td>40 CFR Part 50, Appendix L, Section 8.3.5</td>
</tr>
<tr>
<td>Recovery of Filter</td>
<td>≤7 days, 9 hours</td>
<td>Completion of sample period</td>
<td>Time of sample recovery</td>
<td>40 CFR Part 50, Appendix L, Section 10.10</td>
</tr>
<tr>
<td>Transport of Filter</td>
<td>&lt;24 Hours (ideally)</td>
<td>Time of recovery</td>
<td>Time placed in conditioning room</td>
<td>40 CFR Part 50, Appendix L, Section 10.13</td>
</tr>
<tr>
<td>Post Sample Filter stored at &lt;4 °C.</td>
<td>≤30 days</td>
<td>Sample end date/time</td>
<td>Date of Post Weigh</td>
<td>40 CFR Part 50, Appendix L, Section 8.3.6</td>
</tr>
<tr>
<td>Post Sample Filter continuously stored at &lt;25 °C.</td>
<td>≤10 days</td>
<td>Sample end date/time</td>
<td>Date of Post Weigh</td>
<td>40 CFR Part 50, Appendix L, Section 8.3.6</td>
</tr>
</tbody>
</table>

4.0 Sampler Operation

Procedures in this section are intended as guidelines for use in a PM$_{2.5/10}$ monitoring program that will accurately reflect trends in local or regional air quality. The effectiveness of the monitoring program depends largely on the responsible day-to-day operation of the monitoring site. More detailed information is available within the Office of Air Quality’s related SOPs.

4.1 Siting Requirements

Detailed siting criteria are presented in 40 CFR Part 50, Appendix L, CFR Part 58, Appendix E and Chapter 1 of this manual. Some general site factors listed below:

- The PM$_{2.5/10}$ samplers have an unobstructed airflow for a minimum of 2 m in all directions
- The sampler inlet is placed at a height of 2 to 15 m above ground level
- When a PM$_{2.5/10}$ sampler is collocated with any other particulate matter sampler, the spacing between the sampler inlets is at least 1 m and no more than 4 m. The heights of the inlets should be within 1 m as measured in a vertical direction

The IDEM, OAQ also considers the following additional factors when determining sampler
location at a site. These factors include:

- Accessibility under all weather conditions. All IDEM, OAQ, PM$_{2.5/10}$ samplers used for routine sampling are situated where the operator can reach it safely regardless of weather conditions. Samplers located on rooftops are placed so that an operator’s personal safety is not jeopardized by a slippery roof surface during inclement weather. Considerations are also given to the fact that routine operations (e.g., calibrations, sampler filter installation and recovery, flow checks and audits) involve transporting equipment and supplies to and from the monitoring site.

- Availability of adequate electricity. 40 CFR Part 50, Appendix L, specifies that a PM$_{2.5/10}$ sampler is required to operate at 105-125 volts, AC and at a frequency of 59-61 Hz. The sampler may pull a higher current when the pump starts, possibly necessitating a slow-blow fuse. Although PM$_{2.5/10}$ samplers are required to indicate power interruptions, every effort is made to provide a stable source for the monitoring site.

- Security of monitoring personnel and equipment. The security of personal and the sampler itself depends largely on location. The IDEM, OAQ utilizes rooftop sites with locked access and ground level sites with fences whenever possible.

4.2 Sampler Installation

- Secure the sampler onto a platform
- Plug the power cord into the voltage outlet and energize the sampler. Electrical connections should be waterproofed to ensure operator safety and to avoid short-circuit and/or power interruptions. All electrical connections must be installed so as not to become submerged in water during periods of inclement weather.
- Perform calibrations of the temperature and pressure sensors
- Perform flow calibrations according to the manufacturer’s instructions
- Install a VSCC (PM$_{2.5}$) or downtube (PM$_{10}$) in the sampler
- Program sample frequency, start date
- Load sampler with filter magazines

The sampler is now ready for routine sample collection.

4.3 Sampling Operations

All filters are kept in protective cassette cartridges/magazines until installation in the sampler. Filter cassette magazines may be installed or exchanged in any of the sampler’s operating modes.

The Partisol-Plus Sampler allows magazines for filter cassette supply and storage. Any
scheduled maintenance (e.g., impactor replacement, pressure and temperature checks etc.) is performed prior to the installation of a new filter storage magazine. The only holding time that affects sample set-up is the 30 day window from the time a filter is pre-weighed to the time it is installed in the monitor. At collocated sites the second monitor is set up to run at a sample frequency of 1 in 6 days; sample set-up takes place on the same day as the primary (reporting) sampler. Detailed sample set-up procedures are available in the IDEM PM$_{2.5}$ SOP, “2025 Filter Pickup and Setup”, S-016-OAQ-M-AM-13-T-R.

4.4 Sampling Procedures

Upon arrival at a monitoring site (initial sample setup, no previous sample):

1. Annotate the following on a Single Filter PM Data Sheet:
   - Date and time of the sampler set-up visit
   - Site designation and location
   - Sampler model, ID number, and filter ID number
   - Sample start date and time
   - Current ambient temperature and barometric pressure indicated by the sampler
   - Unusual conditions that may affect the samples (e.g., construction activity, weather)
   - Set-up operator’s signature or initials

   Note: Each data sheet is individually labeled with a bar code sticker printed with a site name, site code number and sample run month/day/year.

2. Open the sampler enclosure.

3. Ensure proper placement of the filter magazines. Supply magazine is on the left side and the storage magazine is on the right side.

4. Ensure that the air connection fitting of the cassette magazine is facing toward the operator and attach the magazine using the mounting studs on the sampler.

5. Lock the magazine into place.

6. Remove and cap the filter storage magazine (right) and replace it with an empty storage magazine.

7. Prepare the storage filter magazine for transport back to the laboratory facility.
5.0 Calibration Procedures

Calibration is defined as the relationship between an instrument’s output and the output of a known reference standard.

The following equipment is necessary for proper calibration of the Partisol Plus sampler:

- NIST-certified traceable thermometer or temperature probe with an accuracy of ±0.5 °C capable of a measuring ambient air over a range of -30 to 45 °C to the nearest 0.1 °C
- Aneroid or digital barometer capable of measuring barometric pressure over the range of 600 to 800 mmHg to the nearest millimeter of Hg and referenced at least annually to a standard of known accuracy with ±5 mmHg
- Certified Flow Transfer Standard (FTS) capable of calibrating the sampler’s flow rate with an accuracy of ±2 percent and with a flow range that covers the flow rate of the sampler
- Digital, water, or oil manometer with a range of at least 0 to 12 inches and 0.1 inch resolution
- Standard time piece of known accuracy within ±2 min/24hr
- Filter cartridge(s) and magazine(s)
- PM$_{2.5}$/PM$_{10}$ Calibration Sheet

Flow rate determination as described in this section is made using a Chinook Flow Transfer Standard (FTS) that has been certified according to the procedure presented in Section 2.2.2 of the USEPA’s “Quality Assurance Guidance Document 2.11” and Chapter 6 “Certification Methods of Transfer Standards” of this manual.

Consistency of temperature and barometric pressure units is required and will be expressed in Kelvin (°C + 273) and millimeters of mercury (mmHg).

5.1 Calibration Procedure

1. Record calibration date and time, sampler serial number, and calibration equipment serial numbers and certification information on the calibration sheet.
2. Ensure that the 2025 is in STOP mode. If found in mode other than STOP, press the RUN/STOP button until STOP is displayed.
3. Place a magazine of audit cassettes on the supply side of the sampler. Remove the inlet on the down tube.
4. Press the “MENU” key to enter the Master Menu.
5. Arrow down to Service Mode, and press ENTER to enter Service Mode. Hit the F4 “Yes” soft key when prompted “Are You Sure?”
6. Arrow down to Calibration/Audit and press ENTER. This will bring up the Analog I/O calibration.

7. Press F1 to begin the I/O calibration. This is an automated process that lasts several minutes. Once complete, record the Input, User, and Output values for the offset and span on the calibration worksheet.

8. Next perform the ambient temperature and barometric pressure calibration by hitting F3 “SensCal”. Place the reference thermometer/temperature probe into/under the ambient temperature shield.

9. Enter the reference values from a certified thermometer/temperature probe and barometer into the 2025 by using the arrows and keypad. Record the values along with the offset on the calibration form.

10. Press the F4 “FiltCal” button to calibrate the internal temperature sensors. The Filt Comp sensor reads the temperature within the 2025, while the Filter 1 sensor monitors temperature within the sampling line where the filter cartridge sits during sampling.

11. Open the top of the sampler by releasing the two latches located on the upper right side and remove the VSCC (PM2.5) or WINS bypass (PM10). Place a thermometer/temperature probe into the sample cartridge space.

12. Enter the reference values into the 2025 by using the arrows and keypad. Record the values along with the offset on the calibration form.

13. Hit the ESC button to return to the Service Menu. Press the F1 “Audit” button to enter the Audit screen. Press the F4 “FiltAdv” to advance an audit cassette into the sampling position.

14. Return the VSCC or down WINS bypass into place and lock the lid. Press ESC to return to the Service Menu.

15. Press the F2 “LeakChk” button to begin the leak check process. A leak check should always precede a flow audit.

16. Press the F2 “Start” button followed by the F1 “External”. Ensure that a filter is in place and press F1 “Yes”.

17. Install and close a flow audit adapter onto the downtube. Once in place, press any key to start the leak check. Once the process is complete, record the leak value, in mmHg/min, on the calibration form. Slowly open and remove the flow audit adapter.

18. Return to the Calibration/Audit screen by hitting ESC and arrowing down to Calibration/Audit.

19. Press the F5 “FlowCal” button to calibrate the instrument’s flow.

20. Arrow down to “Const m” and enter the slope and intercept as found on the FTS’s certification sticker. Repeat the process for “Const b”.
21. Press the F5 “More” button followed by F4 “Start”. Enter the reference values for 3 points (15.0, 16.7, and 18.4 lpm) into the 2025. Allow the flow to equilibrate at each point. Record flow on calibration form.

22. Perform a post calibration flow verification. This verification should be ±2%. For detailed audit instructions, see section 6.1 of this document.

23. Remove the audit cassette(s) and magazine. Return the inlet to the down-tube. Once finished, exit service mode to return the sampler to its normal operating status by pressing the ESC button until back to the Service Menu. Arrow down to “Exit Service Mode” and hit ENTER.

24. Press the RUN/STOP button until the sampler is in OK/WAIT.

6.0 Performance Audit Procedures

The primary goal of an auditing program is to identify problems that may result in suspect or invalid data. Performance audits should be conducted under the following guidelines:

- Audits must be performed without special preparation or adjustments made to the system
- The individual performing the audit must be someone other than the routine operator and have a thorough knowledge of all instruments or processes being evaluated
- All aspects of the audit must be completely documented including the types of instruments and transfer standards, model and serial numbers, calibration information, etc.
- It is recommended that performance audits be done with the operator in attendance
- The Partisol-Plus samplers in the State of Indiana’s Ambient Monitoring Network have flow verifications performed monthly by the Ambient Monitoring Sections, and system audits performed quarterly by the Quality Assurance Section.

6.1 Partisol Plus Audit Procedure

The following equipment is necessary for proper audit of the Partisol Plus sampler:

- NIST-certified traceable thermometer or temperature probe with an accuracy of ±0.5 °C capable of measuring ambient air over a range of -30 to 45 °C to the nearest 0.1 °C
- Aneroid or digital barometer capable of measuring barometric pressure over the range of 600 to 800 mmHg to the nearest millimeter of Hg and referenced at least annually to a standard of known accuracy with ±5 mmHg
- Certified Flow Transfer Standard (FTS) with a flow range that covers the flow rate of the sampler
• Digital, water, or oil manometer with a range of at least 0 to 12 inches and 0.1 inch resolution
• Standard time piece of known accuracy within ±2 min/24 hr
• Filter cartridge(s) and magazine(s)
• PM$_{2.5}$/PM$_{10}$ Audit Form

Flow rate determination as described in this section is made using a Chinook Flow Transfer Standard (FTS) that has been certified according to the procedure presented in Section 2.2.2 of the USEPA’s “Quality Assurance Guidance Document 2.11” and Chapter 6 “Certification Methods of Transfer Standards” of this manual.

Consistency of temperature and barometric pressure units is required and will be expressed in Kelvin (°C + 273) and millimeters of mercury (mmHg).

1. Place a certified thermometer or temperature probe into/under the ambient temperature sensor shield.
2. Replace the supply and storage magazines within the Partisol-Plus with the corresponding QA magazines.
3. Record audit date and time, sampler serial number, and certification equipment serial numbers and certification information on the audit form.
4. Enter the Audit screen by pressing RUN/STOP twice, MENU twice, then ENTER.
5. Record the reference and observed ambient temperature and pressure on the audit form.
6. Press the F4 “FiltAdv” to advance an audit cassette into the sampling position. Remove the first stage inlet and fix the FTS to the top of the down-tube. Attach and zero a manometer.
7. Press the F2 “Valve” followed by F1 “Pump” to turn the pump on.
8. Allow sufficient time for the flow to stabilize. Record the “CurFlow” value from the Partisol-Plus as well as the QA manometer reading on the audit sheet.
9. Press F1 “Pump” followed by F2 “Valve” to turn the pump off. Remove the FTS from the down-tube.
10. Calculate the percent difference between the observed and reference flows using the following formulas. The observed flow should be within 4% of the transfer standard **AND** 5% of the design flow (16.67 liters per minute).
Reference Flow

\[ Q_{Ref} = m \cdot \left( \sqrt{\frac{\Delta P \cdot T_{amb}}{P_{amb}}} \right) + b \]

Where:
- \( Q_{Ref} \) = Reference flow (liters per minute)
- \( m \) = FTS Slope
- \( b \) = FTS Intercept
- \( \Delta P \) = Manometer reading ("H₂O")
- \( T_{amb} \) = Reference ambient temperature (K)
- \( P_{amb} \) = Reference ambient pressure (atm)

Temperature Conversion, Celsius to Kelvin

\[ T_K = T_C + 273 \]

Where:
- \( T_K \) = Temperature in Kelvin
- \( T_C \) = Temperature in Celsius

Barometric Pressure Conversion, mmHg to atm

\[ P_{atm} = \frac{P_{mmhg}}{760} \]

Where:
- \( P_{atm} \) = Pressure in atm
- \( P_{mmhg} \) = Pressure in mmHg

11. Press F5 “LeakChk” to begin the leak check procedure.

12. Press the F2 “Start” button followed by the F1 “External”. Ensure that a filter is in place and press F1 “Yes”.

13. Install and close a flow audit adapter onto the downtube. Once in place, press any key to start the leak check. Once the process is complete, record the leak value, in mmHg/min, on the audit form. Slowly open and remove the flow audit adapter.

14. Press the F4 “FiltAdv” to advance the next audit cassette (empty) into the sampling position.

15. Open the top of the sampler by releasing the two latches located on the upper right side and remove the VSCC (PM₂₅) or WINS bypass (PM₁₀). Place a thermometer/temperature probe into the sample cartridge space.

16. Record the filter reference and observed temperatures. Replace the VSCC (PM₂₅) or WINS bypass (PM₁₀) and close the top of the sampler.
17. Repeat the leak check procedure then replace the inlet on top of the down-tube. Remove the QA audit cassettes and replace the supply/storage magazines. Press RUN/STOP to return the sampler to the mode (OK/WAIT or OK/SAMP) that it was in prior to the audit.

18. Note audit results in the sampler’s logbook.

6.2 Audit Data Reporting

Audit results should be reported to appropriate personnel as soon as possible after audit completion. A paper copy of the audit may be forwarded to the operator or personnel may view the audit in the database. If data is invalid (> ±4 percent flow difference of flow transfer standard or > ±5 percent flow difference of flow rate design value), the auditor should promptly inform the operator verbally and in written form (memo or e-mail).

6.3 Audit Frequency

The USEPA requires that SLAMS monitoring networks audit at least 25 percent of the samplers each quarter thereby auditing each sampler in the network once per year.

The Indiana Department of Environmental Management conducts audits of all PM_{2.5}/10 samplers in its monitoring network at least once each quarter to ensure minimal data loss.

6.4 Systems Audits

System audits are an on-site inspection and review of the total monitoring process from initial filter preparation and sampling to final analysis and data reporting. System reviews are generally done at the initial setup of a network then on an annual or on an as needed basis. The specific guidelines and procedures for this type of audit are found in Chapter 15 of this manual, System Audit Criteria and Procedures for Evaluating Ambient Air Monitoring Networks.

7.0 Precision and Accuracy Assessment

7.1 Precision

Precision is the measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is estimated by the use of a duplicate or collocated sampler at a selected monitoring location in a measurement network. One sampler is designated as the reporting sampler and one sampler is designated as the collocated sampler. The collocated sampler must be maintained, operated, calibrated, and audited in the same manner as the reporting sampler. Precision is calculated from the difference in the concentrations from the reporting and collocated samplers over a calendar quarter. All collocated samplers operate on a 1 in 6 day (1/6) frequency. This allows for approximately 15 data pairs (reporting & collocated concentrations) over each quarter for each site with collocated samplers. Estimates of network precision are made from three years of data.
Data is reported to the USEPA AQS database for both the reporting and collocated sampler, regardless of concentration. However, CV is calculated only from data pairs (reporting and collocated concentrations) when both values are greater than 6 micrograms per cubic meter (μg/m³).

### 7.2 Collocated Sampler Requirements

The duplicated sampler’s inlet must be within 1 to 4 meters from the inlet of the reporting sampler’s inlet and must be at least 2 meters from the inlet of any other sampler inlets such as high volume (TSP or older style PM₁₀) samples. Eight IDEM PM₂.₅ and three PM₁₀ sites have collocated samplers. These numbers meet the Federal Register/USEPA requirement.

Two types of precision estimates are used in the program.

1. Collocated monitoring
2. Filter duplicates

The following formulas are used to calculate precision from reporting and collocated data pairs. These formulas are also stated in 40 CFR Part 50, Appendix L and 40 CFR Part 58 Appendix A.

Percent Difference for a Single Check ($d_i$). The percentage difference, $d_i$, for each check is calculated by using Equation 1, where $X_i$ represents the concentration produced from the primary sampler and $Y_i$ represents the concentration reported for the duplicate sampler.

**Equation 1:**

$$d_i = \frac{Y_i - X_i}{(Y_i + X_i)} \times 100$$

Coefficient of Variation (CV) for a Single Check ($CV_i$). The coefficient of variation, $CV_i$, for each check is calculated by dividing the absolute value of the percentage difference, $d_i$, by the square root of two as shown in Equation 2.

**Equation 2:**

$$CV_i = \frac{|d_i|}{\sqrt{2}}$$

Precision of a Single Sampler - Quarterly Basis ($CV_{j,q}$). For particulate sampler $j$, the individual coefficients of variation ($CV_{j,q}$) during the quarter are pooled using Equation 3, where $n_{j,q}$ is the number of pairs of measurements from collocated samplers during the quarter.

**Equation 3:**

$$CV_{j,q} = \sqrt{\frac{\sum_{i=1}^{n_j} CV_i^2}{n_{j,q}}}$$
The 90 percent confidence limits for the single sampler’s CV are calculated using Equations 4 and 5, where $\chi^2_{0.05, df}$ and $\chi^2_{0.95, df}$ are the 0.05 and 0.95 quantiles of the chi-square ($\chi^2$) distribution with $n_{j,q}$ degrees of freedom.

**Equation 4:**

Lower Confidence Limit = $CV_{j,q} \sqrt{\frac{n_{j,q}}{\chi^2_{0.95, n_{j,q}}}}$

Upper Confidence Limit = $CV_{j,q} \sqrt{\frac{n_{j,q}}{\chi^2_{0.05, n_{j,q}}}}$

Precision of a Single Sampler Annual Basis - For particulate sampler $j$, the individual coefficients of variation, $CV_i$, produced during the calendar year are pooled using Equation 3, where $n_j$ is the number of checks made during the calendar year. The 90 percent confidence limits for the single sampler’s CV are calculated using Equations 4 and 5, where $\chi^2_{0.05, df}$ and $\chi^2_{0.95, df}$ are the 0.05 and 0.95 quantiles of the chi-square ($\chi^2$) distribution with $n_j$ degrees of freedom.

Corrective Action: Single Monitor - The precision data quality objective of 10% coefficient of variation (CV) is based upon the evaluation of three years of collocated precision data. CV values of greater than 10% may occur within that three year period. Single collocated pairs with values greater than 10% are flagged (FCS) and filters are re-weighed. If the CV remains between 10-20% the field technician is alerted to the problem and other operation solutions are investigated. If the CV is greater than 20% for both the initial and reweigh, all the primary sampler data is flagged (FCS) from the last precision check and corrective action is initiated. Paired CVs and percent differences are control charted to determine trends (Section 14.2).

Corrective Action: Quarter - Corrective action is usually initiated and imprecision rectified before a calendar quarter of data fails to meet the 10% CV limit. However, in the case where a quarter’s CV is greater than 20% data for that monitor for that quarter is flagged. The USEPA Regional Office is alerted of the issue and may be asked to help find a common solution.

Duplicate Laboratory Measurements - During laboratory pre-weighing and post-weighing sessions, a filter from a batch is selected for a second weighing. The acceptable limit for the difference between the first post-weight and the second post-weight is 15 µg for clean filters and 30 µg for exposed filters. If this limit is not met, the pair of values is flagged FLD. Failure may be due to transcription errors, microbalance malfunction, or the samples have not reached equilibrium. Other QC checks (balance standards and lab blanks) will eliminate microbalance malfunction. If the duplicate does not meet the criterion, a second sample is selected and re-weighed as a second duplicate check. If this second check fails the acceptance criterion and the possibility of balance malfunction and transcription errors have been eliminated, all samples in the batch are equilibrated for an additional 24 hours and re-weighed. Corrective actions continue until duplicate weights for the batch meet acceptance criteria.
7.3 Accuracy

Accuracy is defined as the degree of agreement between an observed value and an accepted reference value. Four accuracy checks are used:

1. Collocated sampler
2. Flow rate audit
3. Balance check
4. Performance Evaluation Program (PEP Audit)

Collocated Samplers - Collocated samplers are primarily used for estimating precision; however, they also can be used to determine accuracy or bias. Equation 1 is used to determine percent difference so that bias may be calculated. Use of the FRM performance evaluation information (discussed below) in conjunction with collocation data is used to improve the data quality.

Corrective Action - The percent difference of the paired values is reviewed to determine trends. If it appears that there is a statistically significant bias (> 10% at the 90% confidence level) between the pairs, corrective action is initiated. The process includes eliminating uncertainties that may be occurring at filter handling, transport and laboratory stages, in order to determine that the bias is truly at the instrument. Corrective actions at the instrument include multi-point temperature, pressure, and flow rate checks as well as complete maintenance activities. Additional corrective action includes a request for vendor repairs or a request to Region 5 for a FRM performance evaluation.

Flow Rate Audit - IDEM conducts a flow rate audit on all samplers once each calendar quarter. The sampler's normal operating flow rate is measured with a certified flow transfer standard (FTS) audit device. The audit flow rate (true flow) is in actual conditions and the corresponding sampler’s flow rate (observed) is indicated on its LCD display. The procedures used to calculate measurement uncertainty are described below.

Accuracy of a Single Sampler - Single Check (Quarterly) Basis ($d_i$) - The percentage difference ($d_i$) for a single flow rate audit $i$ is calculated using Equation 6, where $X_i$ represents the audit standard flow rate (true flow) and $Y_i$ represents the sampler’s flow rate (observed).

\[
\text{Equation 6: } \quad d_i = \frac{Y_i - X_i}{X_i} \times 100
\]

Bias of a Single Sampler - Annual Basis ($D_j$) - For an individual particulate sampler $j$, the average ($D_j$) of the individual percentage differences ($d_i$) during the year is calculated using Equation 7, where $n_j$ is the number of individual percentage differences produced for sampler $j$ during the year.

\[
\text{Equation 7: } \quad D_j = \frac{1}{n_j} \sum_{i=1}^{n_j} d_i
\]
Bias for Each USEPA Federal Reference and Equivalent Method Designation employed by IDEM - Quarterly Basis \((D_{k,q})\) - For method designation \(k\) used by the reporting organization, quarter \(q\)’s single sampler percentage differences \((d_i)\) are averaged using Equation 8, where \(n_{k,q}\) is the number of individual percentage differences produced for method designation \(k\) in quarter \(q\).

\[ D_{k,q} = \frac{1}{n_{k,q}} \sum_{i=1}^{n_{k,q}} d_i \]

Corrective Action - The single sampler accuracy acceptable limit is ±4% (pass if ≤ ±4% and fail if > ±4%) of the known standard and also ±5% (pass if ≤ ±5% and fail if > ±5%) of the design flow rate. If the sampler fails an audit, an external/internal leak check is performed. Temperature and pressure sensors are also audited and then the flow audit is repeated. If the audit is still unacceptable, a multi-point calibration followed by a one-point verification is performed. Routinely, data back to the last passing audit or verification is flagged and reviewed to determine validity (see Section 23). A verification is an audit performed by the site operator once each month (see Section 16).

Balance Checks - Balance checks are routine verifications using working standard weights (100 and 500 mg) to ensure that the balance is within acceptance criteria throughout the pre- and post-sampling weighing sessions. IDEM uses Troemner Class 1 weights for its primary and secondary (working) standards. Working standards are used at the beginning and end of each batch of weighed samples. In addition, one standard is selected for a check comparison after every 10 filters.

Balance Check Evaluation - The following formula is used to evaluate the balance checks.

**Difference for a single check \((d_y)\)** - The difference, \(d_y\), for each check is calculated using Equation 9, where \(X\) represents the certified mass weight and \(Y\) represents the reported weight.

\[ d_y = Y - X \]

Corrective Action - The difference between the reported weight and the certified weight must be ≤ 3 \(\mu\)g. Since this is the first check before any pre- or post-sampling weighings, if the acceptance criterion is not met, corrective action is initiated. Corrective action may be as simple as allowing the balance to perform internal calibrations or to sufficiently warm-up, which may require checking the balance weights a number of times. If the acceptance criteria are still not met, the laboratory technician is required to verify the working standards against the primary standards.

Finally, if it is established that the balance does not meet acceptance criteria for both the working and primary standards, and other trouble shooting techniques fail, a Mettler service technician (see Section 15) is called to perform corrective action. If the balance check fails acceptance criteria during a run, the 10 filters weighed prior to the failure are re-weighed. If the balance check continues to fail, troubleshooting procedures are initiated. The values of the 10 sample filters weighed prior to the failure are recorded but will remain with the un-weighed samples in
the batch to be re-weighed when the balance meets the acceptance criteria.

Performance Evaluation Program (PEP) - The Federal Reference Method (FRM) Performance Evaluation Program is a national quality assurance activity that is used to evaluate measurement system bias of all monitoring networks. The strategy is to collocate a portable FRM PEP sampling instrument with an established air monitoring site, operate both monitors in the same manner, and then compare the concentrations of the PEP sampler with the established network sampler. The USEPA Region V office oversees this program for Indiana’s samplers. They contract with a third party to operate the PEP sampler. The contractor informs IDEM when an evaluation is scheduled, sets up one or more samplers at one or more sites, then collects sample(s) on the normal sampling schedule. PEP sampler filters are sent to a national laboratory in Region 10 for gravimetric analysis. USEPA evaluates this data by using the IDEM concentrations reported to the AQS database and the data from the Region 10 analysis. This performance evaluation is an estimate of the uncertainty of the agency’s measurement system but may also be used to compare different models and brands of samplers. Biases may be attributed to sample handling, transportation and laboratory activities as well as to the instrument.

Corrective Action - USEPA notifies IDEM of the evaluation results. The bias acceptance limit for the data comparison is ±10%. If it appears that there is a bias, corrective action is initiated. Corrective actions usually begin with evaluating the data collection procedures and then the laboratory procedures. USEPA Region V may conduct additional PEP audits to provide additional data to troubleshoot the process.

8.0 Maintenance


2. VSCC - clean or change the VSCC every thirty days or generally once a month. It is the policy of the Indiana Department of Environmental Management to perform maintenance in a separate controlled environment (laboratory, field office etc.) whenever possible. Refer to the SOP “Air Monitoring Very Sharp Cut Cyclone Cleaning”, S-028-OAQ-M-AM-13-T-R1.

3. Internal Leak Check - An internal leak check is only necessary if the external leak check fails and further information is needed to determine where a leak exists within the sampler.

4. External Leak Check - Perform an external leak check according to the Ambient SOP “2025 Sequential Air Sampler External Leak”, S-014-OAQ-M-AM-14-T-R1. Check after every five sampling episodes or as indicated by sampler diagnostics.

5. 1st Stage Inlet - Monthly, disassemble the Partisol-Plus Air Sampler sample inlet and clean with a soft brush or cloth. See SOP “Particulate Inlet Cleaning”, S-011-OAQ-M-AM-13-T-R1
6. In-line Filter - Replace the in-line filter annually according to the Partisol-Plus Air Sampler operating manual or IDEM SOPs.

7. V Seals - Check V seals monthly and clean or replace if necessary.

8. Air Screens - Clean or replace the samplers air screen (located under the sampler rain hoods) every month.

9. Battery Voltage - Check the voltage of the batteries on the main computer board in the electronics compartment annually.

### Table 4
**Inspection of Field Items**

<table>
<thead>
<tr>
<th>Item</th>
<th>Inspection Frequency</th>
<th>Inspection Parameter</th>
<th>Action if Item Fails Inspection</th>
<th>Documentation Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample downtube</td>
<td>Every site visit</td>
<td>Visible particulate</td>
<td>Clean with a clean dry cloth.</td>
<td>Document in logbook</td>
</tr>
<tr>
<td>VSCC</td>
<td>Monthly</td>
<td>Particulate buildup</td>
<td>Clean.</td>
<td>Document in logbook</td>
</tr>
<tr>
<td>Rain collector</td>
<td>Every site visit</td>
<td>&gt;1/3 full</td>
<td>Empty.</td>
<td>Document in logbook</td>
</tr>
<tr>
<td>O-rings</td>
<td>Monthly</td>
<td>Any damage</td>
<td>Replace.</td>
<td>Document in logbook</td>
</tr>
<tr>
<td>Filter Cassettes</td>
<td>After each sample run</td>
<td>Visible particulate</td>
<td>Clean with a clean dry cloth, or replace as needed.</td>
<td>Document in logbook</td>
</tr>
<tr>
<td>V Seals</td>
<td>Monthly</td>
<td>Clean and no cracks</td>
<td>Discard if damaged.</td>
<td>Document when replaced</td>
</tr>
<tr>
<td>In-line filter</td>
<td>Annual</td>
<td>Loaded particulate</td>
<td>Replace.</td>
<td>Document in logbook</td>
</tr>
<tr>
<td>Battery</td>
<td>Annual</td>
<td>Decrease in voltage</td>
<td>Replace.</td>
<td>Document in logbook</td>
</tr>
</tbody>
</table>

Sample recovery must be performed within 168 hours from the end of the sample period. The table below illustrates set-up, run, and recovery dates based on sample frequency requirements of a 1 in 3 day sampling frequency.
### Table 5
Sample Set-up, Run, and Recovery Example Schedule*

<table>
<thead>
<tr>
<th>Sample Frequency</th>
<th>Sampler Type</th>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in 3 Week 1</td>
<td>Multiple Day</td>
<td>Sample Day 1</td>
<td></td>
<td></td>
<td></td>
<td>Sample Day 2</td>
<td>Recovery &amp; Set-up</td>
<td>Sample Day 3</td>
</tr>
<tr>
<td>1 in 3 Week 2</td>
<td>Multiple Day</td>
<td>Sample Day 4</td>
<td>Sample Day 6</td>
<td></td>
<td>Recovery &amp; Set-up</td>
<td></td>
<td>Sample Day 5</td>
<td></td>
</tr>
<tr>
<td>1 in 3 Week 3</td>
<td>Multiple Day</td>
<td>Sample Day 8</td>
<td>Recovery &amp; Set-up</td>
<td></td>
<td>Sample Day 9</td>
<td>Recovery &amp; Set-up</td>
<td>Sample Day 10</td>
<td></td>
</tr>
<tr>
<td>1 in 3 Week 4</td>
<td>Multiple Day</td>
<td>Sample Day 11</td>
<td>Sample Day 13</td>
<td>Recovery &amp; Set-up</td>
<td></td>
<td>Sample Day 12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9.0 Forms

Form 1
PM$_{2.5}$ Calibration Sheet

Operator Initials: ________

PM$_{2.5}$ CALIBRATION SHEET

Date/Time: __________/__________ Site ID/County: ________________
AIRS #: ________________ Sampler SN: ________________
MODE (upon arrival): ________________ Status Codes: ________________
Temperature Probe Mfr./SN: ________________ Cert. Date: ________________
Pressure Sensor Mfr./SN: ________________ Cert. Date: ________________
Flow Transfer Std. SN: ________________ Cert. Date: ________________

Slope (m): ___________ Intercept (b): ___________

<table>
<thead>
<tr>
<th>Analog I/O Calibration (after cal.)</th>
<th>INPUT</th>
<th>USER</th>
<th>ANALOG</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset:</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Span:</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensor Calibration</th>
<th>CURRENT</th>
<th>ACTUAL</th>
<th>OFFSET (after cal.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amb Temp (°C)</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Amb Pres (mmHg)</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Temperature Calibration</th>
<th>CURRENT</th>
<th>ACTUAL</th>
<th>OFFSET (after cal.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Comp (°C)</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Filter 1 (°C)</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>
External Leak Check

Monitor Response: ___________(mm Hg/min)

PASS or FAIL (Passing is less than 25 mm Hg/min)

Flow Calibration

<table>
<thead>
<tr>
<th>Set Flow (lpm)</th>
<th>Current Flow on Monitor (vgl. L/pm)</th>
<th>Actual Flow on Standard (vgl. L/pm)</th>
<th>Offset (after cal.)</th>
<th>Span (after cal.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.0</td>
<td></td>
<td></td>
<td></td>
<td>1.000</td>
</tr>
<tr>
<td>16.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Monitor in WAIT or SAMPLING mode prior to leaving site? YES NO
Air supply hose reconnected to the Supply magazine? YES NO
YSOC Impactor and First Stage Inlet installed and secure? YES NO
Temperature probes installed and secure? YES NO
Maintenance and sample set-up/pick-up recorded in monitor logbook? YES NO

NOTES: __________________________________________

__________________________________________

Page 2 of 2
Form 2
PM$_{2.5}$ Audit Sheet

Office of Air Quality of Environmental Management
Office of Air Quality
Quality Assurance Section
PM$_{2.5}$ Audit

Site Information
Site:  
Audit Date:  
AQS #: 18 -  
Auditor:  

Sampler Information
R&P Partisol Sampler SN: 2025A  
VSCC:  

Screen Display on Arrival
Stat:  
Mode:  
Current Time:  
Date:  

Sampler Calibration Date  
Last Audit/Verification Date:  
Comments  

Audit Devices Information
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Audit Device/Model</th>
<th>Serial No.</th>
<th>Cert Date</th>
<th>Slope (m)</th>
<th>Intercept (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Rate</td>
<td>Chinook FTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp</td>
<td>VWR Scientific Model 100A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baro Press</td>
<td>Digital Barometer AIR HB-1A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Difference = Observed − True  
Audit Data  
% Diff = (Observed − True) / True * 100

<table>
<thead>
<tr>
<th>Parameter</th>
<th>True</th>
<th>Observed</th>
<th>Difference</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amb Temp (°C)</td>
<td></td>
<td></td>
<td></td>
<td>± 2 °C</td>
</tr>
<tr>
<td>Filter Temp (°C)</td>
<td></td>
<td></td>
<td></td>
<td>± 2 °C</td>
</tr>
<tr>
<td>Baro Press (mmHg)</td>
<td></td>
<td></td>
<td></td>
<td>± 10 mmHg</td>
</tr>
<tr>
<td>Flow Rate (l/min)</td>
<td></td>
<td></td>
<td></td>
<td>± 4%</td>
</tr>
</tbody>
</table>

Manometer (ΔP in "H$_2$O"):  
Amb Temp (°K)  
Baro Press (atm)

Leak Check, mm Hg/min
External: PASS  
FAIL  
Pass if < 25 mmHg/min
* Internal: PASS  
FAIL  
*Performed only if external check fails

Site & Sampler Checks
Y  
N  
Comments  

Site log present & up-to-date  
Sampler interior clean  
Sampler date & time correct  

Useful Equations

\[
X_{me} = \sqrt{V} \times \left( \frac{P_{in} + P_{res}}{T_{amb}} \right) + b
\]

\[
T_{amb} = \text{Amb Temp}(°C) + 273
\]

\[
P_{amb} = \text{Baro Press (mmHg)/760}
\]

COMMENTS
Form 3
PM$_{2.5}$ Audit Form

Single Filter PM$_{2.5}$ Data Sheet

Place SAMPLE label here

LABORATORY INFORMATION:

Operator initials: ___________        Cassette ID:_______________

FIELD INFORMATION:

SETUP:    Date/Time of Sample Setup: _________________(____:____) Operator:

VSCC #:_______    Time is Correct? Yes   No              Adjusted? Yes
No
(Within 5 minutes of standard time)

PICKUP:    Date/Time of Sample Pickup: _________________ (____:____) Operator:

Sampler Mode on Arrival:   STOP   DONE   ERR    WAIT   SAMP

If ERR is indicated, please circle which one(s) from the list below:

D (Audit Performed)      F (Flow out of Range)
P (Elapsed Sample Period) S1 (Flow Halt)
T (Filter Temperature)   X (Filter Exchange) liftdn1     liftup1     pushdn1     pushup1     shutrdy

Despite the error codes, is the sample still valid? (Circle one):    Valid        Invalid

Valid Elapsed Time: ________ hrs.    Volume _______ m$^3$    % CV

<table>
<thead>
<tr>
<th>PM$_{2.5}$ Only</th>
<th>Minimum</th>
<th>Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temp. (AmbT)</td>
<td>°C</td>
<td>°C</td>
<td>°C</td>
</tr>
<tr>
<td>Ambient Pressure (Pres)</td>
<td>mmHg</td>
<td>mmHg</td>
<td>mmHg</td>
</tr>
</tbody>
</table>

Any status conditions or power failures should be recorded in notes as well as in the monitor logbook
Was Sample Shipped Cold?  

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
</table>

Monitor in WAIT or SAMPLING mode prior to leaving site?  

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
</table>

Air supply hose reconnected to the Supply magazine?  

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
</table>

VSCC and First Stage Inlet installed and secure?  

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
</table>

All procedures recorded in monitor logbook?  

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
</table>

RETURN:  
Date/Time of Sample Return: _______________  
Receiver: _______________  

Temperature of filter during transport (Min/Max): _______ / _______ °C

NOTES:  

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Form 4
Annual Internal Audit of the PM$_{2.5}$ Filter Weighing Program

Site: ____________________________________________________________

Auditor: _____________________________ Date: _________________________

<table>
<thead>
<tr>
<th>Audit Question</th>
<th>Y</th>
<th>N</th>
<th>N/A</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Balance Maintenance and Weighing Procedures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the filter preparation and weighing area neat and clean?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are logbooks kept up to date and properly filled in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the balance on a service agreement for regular professional maintenance?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the analytical balance used to weigh filters have a readability of +1 µg?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there a formal logbook or file for balance maintenance? Are entries current?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are regular (e.g., daily, when is use) calibration checks made and recorded?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are filters conditioned immediately before both the pre and post sampling weighings? Conditions are: Mean T 20-23 deg C; T Control ±2 deg C over 24 hrs; Avg. humidity 30-40 percent RH; humidity control ±5 percent RH over 24 hrs.; Conditioning time not less than 24 hrs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are new filters placed in the conditioning environment immediately upon arrival and stored there until the pre sampling weighing?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the analytical balance located in the same controlled environment in which the filters are conditioned?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the filters weighed immediately following the conditioning period without intermediate or transient exposure to other conditions or environments?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are filters conditioned at the same environmental conditions before both the pre and post sampling weighings?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are both the pre and post sampling weighings performed on the same analytical balance?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are both the pre and post sampling weighings using an effective technique to neutralize static charges on the filter?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are both weighings performed by the same analyst? (If not, have results of the different analysts been compared statistically?)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are pre sampling weighings done within 30 days of the sampling period in which filters are to be exposed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If filters are stored at ambient temperature, is the post sampling conditions and weighings completed within 240 hours (10 days) after the end of the sample period?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If filters are stored at 4 deg C or below during the entire time between retrieval from the sampler and start of conditioning, are the post sampling conditioning and weighings completed within 30 days after the end of the sample period?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are new field blank filters weighed along with the pre sampling (tare) weighing of each lot of PM2.5 filters?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are QC field blank filters routinely used, observing the following handling steps: transport to the sampling site, installation in the sampler, retrieval from the sampler (without sampling), and reweighing?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are QC laboratory blank filters weighed along with the pre sampling (tare) weighing of each set of PM2.5 filters and reweighed when the exposed filters are received from the field? (These laboratory blank filters should remain in the laboratory in protective containers during the field sampling and should be reweighed as a QC check.)</td>
<td></td>
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</tr>
<tr>
<td>Was the balance calibrated as specified by the manufacturer at installation and recalibrated immediately prior to each weighing session?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Recordkeeping and Calculations</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Are logs and/or charts of the balance room temperature and humidity on file?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Are records of shipments (incoming and outgoing) maintained?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are records of sample filter condition upon arrival at laboratory kept (e.g., temperature)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Are data management files in order?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there evidence that data validation, internal QA review, and complete data reporting have occurred?</td>
<td></td>
<td></td>
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<tr>
<td>Is the personnel management structure sound?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Laboratory QC/QA Checks</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>--------------------------------------------</td>
<td>--</td>
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<tr>
<td>Has the balance been calibrated by the manufacturer once per year?</td>
<td></td>
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<tr>
<td>Has the lab temperature been calibrated once every three months?</td>
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</tr>
<tr>
<td>Has the lab humidity been calibrated once every three months?</td>
<td></td>
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</tr>
<tr>
<td>Has there been an audit performed on the balance annually to show that it is accurate?</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Acceptance Checks for Procurement of Equipment and Supplies</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Are filters of correct type and undamaged?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are filter cassettes of correct type and undamaged?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are filter/cassette protective containers of correct type and undamaged?</td>
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<tr>
<td>Are filter-handling containers of correct type and undamaged?</td>
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<tr>
<td>Does Analytical Microbalance have a current certificate?</td>
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<tr>
<td>Do Mass Reference Standards have a current certificate showing traceability to NIST-traceable primary standards?</td>
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