Title: Standard Operating Procedure for Measurement of Particulate Matter in Ambient Air Using the Partisol 2000H		
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1. INTRODUCTION AND SCOPE

To obtain timely data for the purpose of air quality assessment, air quality trend reporting and to meet the requirements for inclusion of the data in provincial and national air quality databases, a method of analyzing particulate matter (PM) in ambient air is used. The commercially available Partisol™ Model 2000 low flow rate sampler consisting of a hub station and up to three satellite stations is used in this method.

The method described in this Standard Operating Procedure (SOP) is applicable for measuring a range of PM sizes. The units can be fitted with TSP, PM10, or PM2.5 inlet heads to provide more selective sampling of particulate.

This method adheres to the requirements of the current Air Monitoring Directive (AMD) drafted by Alberta Environment in 1989. In some cases the limits and specifications exceed the requirements of the current AMD and subsequent amendments. It should be considered that the current and any future amendments or drafts of the AMD will be used as the benchmark for requirements and criteria for ambient air monitoring practices conducted in the Province of Alberta. Information used to write this procedure was also taken from sources identified in the reference section.

2. PRINCIPLE OF THE METHOD

The Partisol™ Model 2000 low flow rate sampler consists of a hub station and up to three satellite stations. The hub unit contains a microprocessor with internal data storage, an active flow control system and a pump. Satellite units are fitted with a sample inlet and a 47 mm filter exchange mechanism, which may employ quartz fibre, Teflon-coated glass fibre or Teflon filters. Only one satellite unit can operate at a time. Menu-driven software can be used to determine conditions, such as wind speed and wind direction, under which the hub or satellite units are active. Flow is controlled at 16.67 L/min, which conforms to the physical requirements of the fractioning head. The Partisol™ satellite units can be fitted with TSP, PM10, or PM2.5 inlet heads to provide more selective sampling of particulate. The hub unit can operate as a stand-alone unit without the need for 1 or more satellites if there is only one particulate size of interest to sample and upwind/downwind samples are not required during the same sampling period (AENV, 2002).

The sampler draws ambient air through its inlet head, and a 47 millimeter (mm) diameter sample filter, which traps the desired fraction. The sample filter is conditioned and weighed before and after sampling. The resulting difference in weight is the collected PM mass in micrograms (mg). Electronic systems in the sampler are designed to monitor and maintain the volumetric flow rate as well as record the elapsed sampling time

enabling the R&P Model 2000 to calculate the total sample volume in cubic meters (m3). With this information, the analyzing laboratory will calculate and report the average PM concentration for the sampling period in mg/m3 (CARB, 1999).

3. MEASUREMENT RANGE AND SENSITIVITY

This method is applicable for measuring a range of PM sizes. The units can be fitted with TSP, PM10, or PM2.5 inlet heads to provide more selective sampling of particulate.

4. EQUIPMENT AND APPARATUS

The following is a commercially available particulate sampler suitable for use in this method, and currently in use in the AENV network:

- Rupprecht & Patashnick Partisol™ Model 2000 Air Sampler.

This list does not exclude the use of other equipment that has received the USEPA Reference and Equivalent Method designation.

5. INTERFERENCES

Sample contamination can interfere with the quality of the measured results. To minimize the possibility of contaminating the sample filter prior to the sampling event, load the sample filter(s) at a time as close as practical to the start of the sampling event. Although the sample cassette(s) may remain in the sampler up to 96 hours (4 days) after the end of the sampling event, remove them from the sampler as soon as practical.

Air leaks in the sample system can affect the measured PM concentrations. Leak checks are done as per the R&P manual, Section 10.2.4. See Section 9.2 below.

6. PRECISION AND ACCURACY

The sample filter is conditioned and weighed both before and after sample collection to determine the amount of mass collected during the sampling period. As is the case with all filter-based manual samplers, proper filter handling is an important element in computing accurate, valid mass concentration results.

Flow is controlled at 16.67 L/min to ensure the accuracy of the calculated concentration in the laboratory.

7. SITE REQUIREMENTS

Site location for PM samplers should be determined according to the intended application of the monitoring data. Unobstructed sites should be chosen with the following characteristics:

- There must be unrestricted access to the sampler and site during the monitoring period and the site and equipment must be safely accessible in all weather conditions for the duration of monitoring operations.
- There must be unrestricted airflow in an arc of at least 270° around the sampler and no obstructions in the source direction of prime interest.
- Avoid topographic hollows where air circulation is restricted.
- Interference from buildings and trees must be avoided. There must be no trees or structures closer than a distance of two times the height of the obstruction from the sampler or a distance of 20meters, whichever is greater.
- The sampler must be elevated above the expected maximum flood stage in areas subject to flooding.
- The sample inlet must be kept within 2 to 7 meters from the surface, unless the project terms of reference specifically require measurements above these limits.
- Line Power must be available as these samplers require 120VAC at up to 2.2 amps when sampling. A standard 110V 15A household type receptacle is required. Line power must be supplied on a dedicated circuit or circuits equipped with a fuse breaker.
- Adequate safeguards must be taken to ensure security of monitoring equipment.
- The site must be inspected for unsafe conditions.
- Particulate monitors must be located well away from obvious local sources of sample contamination such as areas of high vehicle activity, dusty roads, roof top flues and vents, or close to local wood burning sources, unless monitoring is being conducted primarily to capture the impact of such sources.
- A roof top mounted sampler must be a minimum of 2 meters away from a wall or parapet. If the sampler is installed on a building that is lower than surrounding structures, then the “two times the height” rule for local obstruction is used (AENV, 2002).

- Consideration and accommodations should be made in siting to avoid disturbance by vandals or livestock.

8. INSTALLATION REQUIREMENTS

The installation procedures of the Partisol™ Model 2000 air sampler are detailed in the R&P Operating Manual. All the steps outlined therein must be followed closely. Programming the sampler is comprehensive, as stated in this SOP, and will be based on the programming mode desired (see Section 9.3 below). Once the mode of sampling is established, a quick guide for programming will be available to the operator. The sampler may be programmed to operate before or after installing sample filters, however, filter(s) must be installed before the first sampling cycle begins (AENV, 2002). A customized thermal insulating jacket should be installed on the hub units when sampling during the winter months.

Installing a Filter in the Hub

1. Record the filter identification number located on the petri dish (plastic container) that the filter and filter cassette came in into the appropriate portion of the sampling data sheet ". An example sampling data sheet is located on the last page of this SOP.
2. Open the petri dish (top side of dish has the filter # label) and keeping the same orientation, remove the filter cassette containing the filter and install into the metal filter holder plate provided. The filter in the filter cassette should be recessed when looking at it from above for proper orientation.
3. The filter holder plate has a screw on the side to hold the filter cassette snug. Do not over tighten.
4. Open the filter exchange mechanism in the Hub unit and install the plate in the filter carriage using the orientation pins.
5. Close the filter exchange mechanism. Store the petri dish in the briefcase provided or in a safe place.

Installing a Filter in the Satellite

Follow the same procedure as above for installing a filter into the Hub unit but use the "appropriate portion of the sample data sheet to record the info.

Data Recording

All sample data sheets will have an area to record “Start Time”, and “Date”. Enter this information and any comments (such as meteorological conditions) at the beginning of the sample cycle (AENV, 2002). Once the sample has been taken all remaining sections of the data sheet should be completed. If appropriate, enter an N/A rather than leave a section blank.

9. OPERATIONAL REQUIREMENTS

The sampling procedures are specified by the manufacturer in the Operating Manual, as well as the CARB SOP. All sections of the log sheet shall be completed when operating a Partisol™ PM sampler. Comments should include any observations that may affect the interpretation of the results at the sampling location or other helpful information related to the sample taken.

All operational activities conducted at any ambient monitoring station, must be documented in the station logbook, and/or station checklists. This allows other operators to access a history of the station if the regular technician is not available. The following documentation must be available to the operators on site: operational and maintenance manual(s), quality system manual and station site documentation.

9.1 Operational Checks

Maintenance procedures (checks) are designed to help assure that valid data is produced as a result of proper sampler operation and maintenance in accordance with its provincial designation and the manufacturer’s operating manual. The maintenance frequency presented in these standard operating procedures should be considered the minimum required even though the actual frequency of performing some of these checks may vary from site to site due to different environmental factors. These may include the sampling schedule, particulate concentrations, or seasonal factors, which may require an increase in maintenance frequency (CARB, 1999).

9.2 System Leak Check

The system leak check should be completed every three months following the manufacturer’s instructions laid out in the operating manual. This is done to ensure air is being pulled through the sample inlet only.

9.3 Programming Modes for Sampling

Basic Operation

In this mode each collection filter is exposed for one 24-hour period, from midnight to midnight. In this mode, the hardware can be set up to sample every 6 days (or other interval) without the need for any further programming input by the operator (AENV, 2002).

Manual Operation

In this mode the operator can specify which flow channel (hub or one of the satellites) is currently active by pressing function keys in the hub unit. This mode can be used for "Event" based sampling when air quality is perceived to be adverse. If event based sampling is preferred, then if possible, at least two samplers should be used, sited on opposite sides of the source so a few upwind samples can be collected at the same time as the downwind ones. If this sampler arrangement is not possible the sampler can be moved to the upwind site when appropriate or, alternatively, samples can be taken at the same site both during a pollution event and on perceived good days (AENV, 2002).

Time Intervals

The operator can specify for each sampling station (hub or satellite) up to two time intervals each day (for example 9:00 to 12:00 and 18:00 to 22:00) during which a sample is to be collected. A date range is also entered, so that this type of sampling can be performed on either a single day or on a desired number of consecutive days. In addition, this programming mode makes it possible to perform comparisons between two or more size-selective inlets. When the user sets up the sampler for "time sequenced" operation, the sample stream alternates between two or more sampling stations. For example, the system can be programmed so that the sample stream flows alternately for five minutes through a hub unit equipped with a PM-10 inlet and a satellite equipped with a PM-2.5 inlet (AENV, 2002).

Meteorology

In this mode the operator can define under which wind speed and wind direction conditions each sampling station is activated during a selected range of days. A wind vane/anemometer is connected directly through a special cable to the analog input connector in the back of the hub unit. This mode is ideal for sampling

in and out of the source quadrant. When operating in this mode, however, it may be necessary to extend the sample time to collect sufficient sample on each filter (AENV, 2002).

Analog Input

The sampler's analog input capability allows for remote control through an analog signal generated by an external device such as a data logger or specially equipped personal computer. By sending the appropriate voltage level to the sampler, the external device controls which sampling station is currently active (AENV, 2002).

Serial Input

Using the sampler's two-way serial RS-232 capability, the operator can control which sampling station is currently active from a remote device by changing the value of a control variable (AENV, 2002).

9.4 Sample Filter Change

Upon sample completion the following steps should be followed:

1. Open the filter exchange mechanism in the Hub unit and remove the plate with the filter cassette in the filter carriage.
2. Close the filter exchange mechanism.
3. Keeping the same orientation the plate was installed, loosen the screw on the side of the plate and remove the filter cassette that contains the filter.
4. Put the filter and filter cassette back into the petri dish that it was removed from and tape the cover (lid) closed but do not cover the filter number on top of the lid.
5. Repeat the same procedure for the Satellite unit (AENV, 2002).

9.5 Filter Cassette and Inlet Maintenance

The following maintenance procedures shall be followed:

- Keep the filter cassettes clean; wipe with a clean dry cloth as required.
- Examine the upper and lower rubber cassette seals and replace if they are cracked or damaged.

- Keep the rubber seals clean.
- Visually inspect the PM10 inlet's water collector jar and drain it if water is present (CARB, 1999).

9.6 Impactor Maintenance

PM10 - Remove the PM10 head from the sampler and open to expose the impaction well. Inspect impaction well to determine size of particulate cone, which may have formed in the center of the well. A cone taller than two (2) millimeters or a cone with its top broken off indicates a need for more frequent well cleaning to minimize the possibility of particle bounce and re-entrainment of particles larger than 10 microns. Clean the impactor well with water only and blow dry. Refer to the procedures in Appendix H.2 of the R&P manual for instructions on servicing the impactor (CARB, 1999).

PM 2.5 - Remove the PM2.5 sharp cut cyclone from the sampler and open to expose the cyclone surfaces. Inspect for buildup of particulate in the cyclone and flow paths. Excessive buildup indicates more frequent cleaning should be scheduled to minimize the possibility of particle bounce and re-entrainment of particles larger than 2.5 microns. Clean the cyclone with water only and blow dry. Refer to the procedures in Appendix H.2 of the R&P manual for instructions on servicing the cyclone (CARB, 1999).

9.7 Monthly Maintenance

Clean the interior of the sampler chassis with a damp cloth. Remove the air intake filter and clean it with soap and water. Clean air intake fan blades with a damp cloth or brush if necessary. Inspect the sampler o-rings and gaskets.

Verify that the sampler's clock time is within ten (10) minutes of standard time as compared to a clock standard time. If there is a difference of more than 10 minutes, reset the sampler's clock to within one (1) minute of the standard according to instructions given in Section 4.3 of the R&P manual. Record the date that these procedures were performed and the results obtained onto the sampler's QC Check sheet.

Perform the single-point flow check using an actual flow rate or volume measuring device having an accuracy of at least +/-2 percent (%) of full scale (0-20 LPM vol-o-flow, mass flow meter, etc.) and which is calibrated or certified annually against a NIST-traceable standard. If the sampler's flow rate measurement is not within +/-5% of the standard's measurement, investigate the cause. Record the date that these procedures were performed and results of the single-point flow check onto the sampler's QC Check sheet.

Perform a single-point check of ambient pressure and ambient temperature sensors using a temperature and pressure standard, which is calibrated or certified annually against a NIST-traceable standard. Ensure the sampler's measurements are within the acceptance criteria, (+/-4% for flow rate, <80 mL/min for leak check, +10 mm Hg for pressure, and +2°C for temperature) (CARB, 1999).

9.8 Semi-Annual Checks

Every six (6) months, inspections should be done on the sampler's interior, inlet, and impactor, for cleanliness and condition, after an as-is calibration verification check for temperature, pressure, and flow has been performed. (See Section 10 below for calibration procedures). Replace the large in-line filter. It is recommended that the sampler be turned off for this procedure. Check the voltage level of the main computer board's battery. See Appendix F.1 of the R&P manual for details (CARB, 1999).

9.9 Annual Checks

The flow rate, temperature, and pressure QC verification check measurement standards should be re-certified or calibrated against a NIST-traceable standard. The date that these procedures are performed will be recorded onto the sampler's QC Check sheet (CARB, 1999).

9.10 Shipping Sample Filters

Samples must be shipped in the original petri dish they came in and with the filter number visible (not covered over). The sample data sheet must also accompany the sample filter back to the contracted lab. Samples must be handled and shipped in such a way as to minimize the loss of sampled particulate matter from the filter surface. If samples are shipped in a cardboard container, pack petri dishes tight and facing up (filter # on top) to restrict movement. Use bubble packing or other shock absorbing material and pack around the samples on all sides. Using "this side up" stickers on the carton may help in proper handling by the shipping company. If samples are shipped in an envelope, bubble insulated envelopes are recommended to protect the samples. A copy of the log sheet will also be provided to the AENV Air Monitoring Section. This copy is stored in a file for that project. Always ship filter/s back to the contracted lab as soon as possible after sampling is completed (AENV, 2002).

9.11 Blank Samples

1. Record the filter identification number located on the plastic container that the filter and blue filter holder came in into the "Comments portion of the sample data sheet". Also indicate that the sample is a blank sample in the "Comments portion of the sample data sheet".
2. Take the filter (still in the filter cassette) to the sampler and open the petri dish (top side of dish has the filter # label) and keeping the same orientation, remove the filter cassette containing the filter for a few seconds, then put the filter holder with the filter back into the petri dish. Tape the cover (lid) closed but do not cover the filter number on top of the lid (AENV, 2002).

10. CALIBRATION

The R&P 2000 is a PM filter sampler that is required to control a volumetric flow, and to monitor the temperature of the exposed filter while still in the sampling position. To perform these tasks, the sampler uses an ambient temperature sensor (AmbT), a filter temperature sensor (FltT), a pressure sensor (Pres) and a mass flow controller (MFC). These sensors and MFC require calibration when the sampler is installed/replaced and require verification/calibration every six months or sooner if necessary. If the AmbT sensor or the Pres sensor require calibration (an adjustment), then the flow must also be verified and probably recalibrated. (CARB, 1999).

The following is a brief list of the calibration procedures that need to be completed:

As-Is Flow Check

The "as-is" flow verification is the first step for routine calibration of the R&P 2000 (initial sampler setup does not require an as-is flow verification since a full instrument calibration is required). The as-is flow check procedure (R&P manual, Section 10.2.6) is performed to verify the working status of the sampler by ensuring that the calculated true flow at the inlet of the sampler is +/- 2% of 16.7 LPM. If the calculated true flow of the sampler is between 16.4 - 17.0 LPM, flow calibration is not necessary unless any subsequent sensor or electronic board adjustments alter the flow (CARB, 1999).

Leak Check

The next step is to perform an internal leak check (R&P manual, Section 10.2.4) on the sampler. The leak check procedure is performed to determine if leaks in the sampler exist and to ensure correct installation of the flow measuring equipment. If the following

leak check fails, locate and remedy the problem, then go back and re-verify the flow (CARB, 1999).

Interface Board Verification / Calibration

When installing or replacing an R&P 2000, the interface electronics board (I board) should be checked and adjusted as needed (R&P manual, section 11.1) (CARB, 1999).

Analog Input (A/I) Verification / Calibration

After checking/calibrating the I board, the A/I board must be checked and calibrated as needed (R&P manual section 11.2) (CARB, 1999).

Ambient Pressure Calibration

The ambient pressure calibration (R&P manual, section 11.5) requires a certified pressure sensor (CARB, 1999).

Flow Calibration

To calibrate flow (R&P manual, section 11.6.2) a minimum of three points are required. The R&P 2000 flow calibration is software driven and offers the option of a one-point or a five-point calibration (CARB, 1999).

Verification of Calibrated Flow

The procedure used to verify the sampler flow rate after calibration is identical to the flow check procedure described above (section AJ.2.1.1) for both the mass flow meter (MFM) and pressure drop (FTS) methods. This post calibration flow check is essential to verify the accuracy of the sampler flow. Record the final flow value (CARB, 1999).

11. APPLICABLE DOCUMENTS

- **EM-028a** Rupprecht & Patashnick Partisol™ Model 2000 Air Sampler Operating Manual.

12. LITERATURE REFERENCES

- Alberta Environment (AENV). *Ambient Air Sampling for Particulate concentration (Gravimetric), Organics, and Heavy Metals. Version 1.0,* September, 2002.
- State of California Air Resources Board (CARB). *Air Monitoring Quality Assurance Volume II - Standard Operating Procedures for Air Quality Monitoring - Appendix AJ - Rupprecht & Patashnick Partisol - FRM Model 2000 PM 2.5 Air Sampler Monitoring and Laboratory Division*, May 1999.

13. REVISION HISTORY

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14. APPROVAL

Approved by: **Harry Benders** **Date: June 20, 2008**

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