Title: Standard Operating Procedure for Ambient Air Sampling Using a Versatile Air Pollution Sampler (VAPS) with Annular Denuder System (ADS)		
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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 for simultaneously collecting a variety of reactive gases and atmospheric fine particles in ambient air is used. The Versatile Air Pollution Sampler (VAPS) consisting of the commercially available URG™ Model 3000-02N computerized sampling pump and annular denuder system (ADS) are used in this method.

"At this stage, this method is a unified, consensus, tentative, draft method intended for further application and testing. Users should be advised that the method has not yet been adequately tested, optimized, or standardized. Many of the specifications have been initially established by technical judgment but have not been subjected to ruggedness testing. In some cases, alternative techniques, equipment, or specifications may be acceptable or superior. In applying the method, users are encouraged to consider alternatives, with the understanding that they should test any such alternatives to determine their adequacy and confirm and document their advantages."

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 VAPS may be configured to measure a variety of air quality parameters. Annular denuders, filter packs, and polyurethane foam (puf) cartridges can be installed in a variety of configurations depending on the sampling objective. The annular denuder system (ADS) consists of (1) an inlet with an impactor or cyclone preseparator designed to remove all particles with a diameter (aerodynamic) of 2.5 µm or greater, (2) annular denuders to quantitate acidic and basic gases, and (3) a filter pack for atmospheric acidity and particles. In operation, ambient air is drawn, by the sampling pump, through an elutriator-accelerator jet assembly, an impactor frit and coupler assembly, and past glass denuder walls that have been etched and coated with chemicals that absorb the

gaseous species of interest. The remaining air stream is then filtered through Teflon® and Nylasorb® membrane filters. Teflon® and nylon membrane filters are used to capture ammonium and nitrate aerosol and sulfate particulate matter. Nitric acid and sulfur dioxide will also be collected by the nylon filter but these measurements are treated as interference. (USEPA, 1999).

3. MEASUREMENT RANGE AND SENSITIVITY

The impactor or cyclone preseparator is designed to remove all particles with a diameter (aerodynamic) of 2.5 µm or greater. Gaseous species of interest are absorbed onto the denuder walls that have been etched and coated with chemicals.

The chemical species that can be determined by this method are gaseous SO2, HNO2, HNO3, and NH3 and particulate SO=4, NO-3, NH+4, and H+ (USEPA, 1999).

4. EQUIPMENT AND APPARATUS

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

- Annular denuder cartridges, filter packs, puf cartridges.
- URG™ Model 3000-02N computerized sampling pump.
- Cyclone adaptor.
- Various fittings, couplers, and tubing.
- Data logger/timer

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

5. INTERFERENCES

Operation below 20% relative humidity may result in less than quantitative collection of SO2. Also, the presence of ozone (O3) is known to oxidize nitrous acid (HNO2) to nitric acid (HNO3); therefore, HNO2 measurements are often underestimates. Calculations have been developed to adjust for this oxidation process and to provide more accurate estimations of HNO2 concentrations in the atmosphere (USEPA, 1999).

Some studies include the possible chemical reactions (organic and inorganic) that may occur with selected coating solutions that interfere with the accurate measurement of the chemical species of interest. The efficiency of impactor collection decreases when the impactor surface is loaded (USEPA, 1999).

Filter integrity is compromised by handling, which causes pieces of the filter to be lost after the pre-exposure weighing. Filter contamination results from material other than sampled aerosol and gases being deposited on the filter (e.g. fingerprints, dirt).

6. PRECISION AND ACCURACY

The sample filters are 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 through the sampler at a fixed rate of between 5 and 20 standard L/min (typically 10 L/min).

7. SITE REQUIREMENTS

Site location for VAPS systems 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.

- 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).

8. INSTALLATION REQUIREMENTS

A sampling train from the lab comes in two sections. The filter pack/cyclone assembly and the denuder tube assembly. The denuder tube assembly can have up to 5 glass tubes in series. More than one sample train may be required for a sample period; therefore each section will have some type of identification that will tell the operator which filter/pack assembly goes with which denuder tube assembly (AENV, 1998).

Denuder Sampling Train Assembly

1. Assemble each sample train by removing the end caps of the tube assembly and the parafilm covering one end of the filter pack/cyclone assembly (the quick connect end is self-sealing). Label the end caps if they are not labeled and store in a clean container.

   Note: The denuder tube assembly is different at both ends. On one end the inner tube is indented and on the other end it is flush.

2. Install the base coupling ("V" seal) on the flush side of the assembly. Install the filter pack/cyclone assembly on the indented side of the assembly.
3. Fill in the tube identification #'s for each tube and filter pack assembly in channel #1 or 5 on the data sheet provided. If only 1 sample train is used then use channel # 1 (AENV, 1998).

Denuder Installation

1. Before installing the denuder assembly, ensure that the unit is on and in the "READY" mode. This is visible in the upper right hand corner of the Main Screen (default screen after unit is turned on). If it is not in the "READY" mode press the Start/Stop keypad key to put it in the "READY" mode.
2. Install the denuder assembly in Channel #1 (one sample train used) and #5 (if more than one sample train is used).
3. On the Main Screen the channel/s that the denuder assembly was installed should say "NEW". This indicates a new sample is ready to run.
4. Press the Run/Stop key to put the unit in the "RUN" mode. The unit is now ready to sample on an event (AENV, 1998).

Field Blank Installation

1. Install the assembled denuder train in any channel other than #1 or 5.
2. Do not expose it to a sample stream.
3. Note the installation and removal date and enter it into the data sheet along with the type of sample (AENV, 1998).

9. OPERATIONAL REQUIREMENTS

9.1 Denuder Operation

1. To start sampling, flip the switch located underneath the unit on the computer side to "On" and leave it on for the duration of the sampling period.
2. To end the sample period, turn the switch underneath "Off" and wait until the flap doors have shut.
3. The Main Screen indicates "FIN" (finished sample) for those channels sampled.
4. Remove the samples. The Main Screen will indicate "EMP" (empty channel).
5. Press the Run/Stop key to put the unit in the "READY" mode.
6. Disassemble the samples in the reverse order of #1 and 2 of The Denuder Sampling Train Assembly instructions above.
7. Place the samples in the protective cases.

8. Press F4 to access the "DATA" screen and record the channel data on the data sheet provided. Also indicate the type of sample taken on the sheet.
9. Ensure that the Installation/Start/Stop/Removal dates and times are accurate. If not, make sure that the sample/s were removed (the data record is not updated until this is done) or press F1/F2 to look at stored data records (AENV, 1998).

9.2 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 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).

9.3 System Leak Procedure

The following steps should be followed when failure occurs during testing at the laboratory before transport to the field and in the field before testing.

Sampler Leaks

Note the problem on the Field Test Data Sheet. Check assembly of ADS components. Replace gaskets. Check for proper seating of denuder surfaces. Replace any defective parts.

Cracked or Chipped Denuders or Elutriator Assemblies

Note problem on Field Test Data Sheet. Discard defective pieces. Do not try to extract cracked pieces. WARNING--USE CAUTION WHEN DISASSEMBLING CRACKED GLASSWARE. Pieces may shatter and cause severe cuts. Wear protective clothing.

Contaminated Blank Solutions

Note problem on Field Test Data Sheet. Follow parts-cleaning procedures closely. Examine the sampler preparation area for possible sources of contamination and

remove source. Check DDW being used in the solution preparations and extractions. Fill a clean 25 mL polyethylene extraction bottle with the DDW used in solution preparation and extraction; send to lab for analysis. If contaminated, correct deionization system.

Flow Rate Disagreement

Note problem on Field Test Data Sheet. Check vacuum gauge on flow module. If a high vacuum exists, the sampler has become blocked. This blockage may be due to dust or smoke particles clogging the filters or to obstructions in the system or tubing. Check flow module. Repair as needed.

Inadequate Flow Rate

Note problem on Field Test Data Sheet. Check rotameter on flow controller. If adequate flow is shown here, a leak exists between the controller and the DGM. If no flow is shown on rotameter, check vacuum gauge on controller. If no vacuum exists, pump needs repair. If a high vacuum is shown, an obstruction exists in the system. Check to see that the paper filter dividers were not accidentally installed with the filters in the filter pack. Check tubing for kinks (USEPA, 1999).

9.4 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 inlet's water collector jar and drain it if water is present (CARB, 1999).

9.5 Quality Assurance

It is recommended that the flow rates of each denuder system be audited at least quarterly.

9.6 Shipping Sample Filters

Sample filters are not removed from the filter pack assemblies. Filter packs, denuder tubes and puf cartridges are removed from the sampler and capped. Sampled components are shipped for analysis in cases designed to carry them. A copy of the sample data sheet will accompany the samples and lso be sent to AENV Air Monitoring Section. Always ship filter/s back to the contracted lab as soon as possible after sampling is completed (AENV, 2002).

9.7 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 log sheet”. Also indicate that the sample is a blank sample in the “Comments portion of the log 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

Calibrations of the flow control system should be completed on a quarterly basis. Refer to the operations manual for instructions on this process.

Site Records

A weekly checklist work sheet is a record of the instrument performance from week to week. When completed, the work sheet must be returned to the designated location where it is kept for reference. The site logbook must indicate when operational and maintenance activities are done and the results obtained.

Abnormal Local Events

It is important to make logbook entries whenever anything out of the ordinary may be affecting any of the samples collected. Unusual odors, idling cars and trucks, forest fires etc. all can have large impacts on local particulate and pollutant concentrations.

11. APPLICABLE DOCUMENTS

- **EM-019a** Alberta Environment (AENV). *ChemSpec 2500 (Denuder) Operating Instructions,* March, 1998.
- **EM-019b** URG™ Model 3000-02N Computerized Sampling Pump Operating Manual.

12. LITERATURE REFERENCES

- United States Environmental Protection Agency (USEPA). *Compendium Method IO-4.2 - Determination of Reactive Acidic and Basic Gases and Strong Acidity of Atmospheric Fine Particles (<2.5 µm),* June, 1999.
- Alberta Environment (AENV). *Ambient Air Sampling for Particulate concentration (Gravimetric), Organics, and Heavy Metals. Version 1.0,* September, 2002.

13. REVISION HISTORY

Revision 0 (new document)

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14. APPROVAL

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

Title: **Air Monitoring Team Leader**

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