Title: Standard Operating Procedure for Sample Collection Using Tedlar Bags and Adsorbent Tubes		
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1. INTRODUCTION AND SCOPE

To obtain timely data for the purpose of air quality assessment, air quality trend reporting Tedlar® bags and adsorbent tubes are the mediums used in this method of sampling VOCs (volatile organic compounds), Semi-VOCs, light hydrocarbons C1-C6, and sulphurs in ambient air are used.

Tedlar® sample bags are a convenient and accurate means of sampling gases and vapors when concentrations are expected to be higher (>20ppmv) than the detection limits of common analytical instruments.

Sorbent tube sampling is an appropriate monitoring method for volatile organic compounds (VOCs) in ambient air at 0.5 to 25 parts per billion (ppbv) concentration levels.

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

This method includes sampling at one location, storage and transport of the sample, and analysis at another, typically more favorable site. This method is consistent whether using the Tedlar® bag or adsorbent tube for sample collection. A Teflon sampling pump is used to push ambient air into the sampling bag, or pull ambient air across the sorbent material in the case of the sampling tubes. The pump can be configured for Tedlar® bag or adsorbent tube sampling. A second method of sampling into a Tedlar bag is using a “lung” sampler. This method utilizes a large sealed container constructed of clear plastic with an airtight lid and two air line fittings. The Tedlar bag is inserted into the box and the sample line connected to the Tedlar bag. A vacuum is applied to the cavity in the container which, through pressure differential, draws sample air into the Tedlar sample bag.

The bag type recommended for all samples except for light hydrocarbon C1-C6 samples are the SKC series 233 bags that employ a single stainless steel fitting through which the bag can be filled and the sample removed for analysis. AENV lung samplers accommodate 5 litre sample bags

The sorbent tube monitoring procedure involves pulling a volume of air through a sorbent packing to collect VOCs followed by a thermal desorption-capillary GC/MS analytical procedure. The sorbent or sorbent mix must be tailored for a target compound list, data quality objectives and sampling environment.

Portable samplers have been specially constructed for use by AENV to operate on 12volt DC with timers and flow control adjustment. These samplers are used to draw the air through the tube at the specified flowrate for the determined sampling time or can be used to evacuate the lung sampler box to cause the Tedlar® bag to fill. Consult the manual for the sampler for more information.

SKC pumps can be used to draw air through the sorbent tubes.

Analyze the sample within 24-48 hours after sampling.

3. MEASUREMENT RANGE AND SENSITIVITY

Tedlar® sample bags provide an accurate means of sampling gases and vapors when concentrations are expected to be higher (>20ppmv) than the detection limits of common analytical instruments.

Sorbent tube sampling is an appropriate monitoring method for volatile organic compounds (VOCs) in ambient air at 0.5 to 25 parts per billion (ppbv) concentration levels.

4. EQUIPMENT AND APPARATUS

Commercially available air sampling equipment suitable for use in this method, and currently in use in the AENV network, include:

- AENV lung sampler
- Tedlar® sample bag.
- SKC air sample pump Model 224-PCXR7.
- SKC sorbent tube.
- Teflon® tubing.
- Stainless steel fittings.

- AENV portable tube samplers

5. INTERFERENCES

Long term storage of air-contaminated mixtures in Tedlar® bags is not recommended. Even if cleaned for reuse, absorbed contaminants can cause significant off gassing into subsequent samples.

A new bag is recommended for each ambient sample.

The materials from which the Tedlar® bag is constructed may contribute background hydrocarbon contamination. Purging the bag with air or N_2 may reduce the concentration of these hydrocarbons. Exposure of the bag to direct sunlight may increase the concentration of these hydrocarbons. Therefore, the bag must be protected from exposure to sunlight by using an opaque container to house the bag during sampling and shipping.

Components of the source emissions other than the target compounds may interfere. Interferents may be differentiated from the target compounds during mass spectrometric analysis.

Available stability data suggest that this method may not perform well in sampling streams containing polar and reactive compounds like methyl ethyl ketone, formaldehyde, methanol, 1-butene, and acetone. The use of this method to sample these compounds needs to be evaluated before sampling.

Tedlar® bags are not recommended for SO_2 sampling due to rapid degradation of the SO_2 gas.

Other problems that can invalidate Tedlar® bag sampling are condensation of the gases or water vapor in the bag; leaks developing in the bag during testing, transport, and/or analysis; and hydrocarbon contamination.

Some varieties of charcoal used in sorbent tubes contain metals, which will catalyze the degradation of some organic analytes during thermal desorption at elevated temperatures thus producing artifacts and resulting in low analyte recoveries.

6. PRECISION AND ACCURACY

The precision of a measurement is generally considered to be the "repeatability of the measurement", and the accuracy, the "deviation from true". As this method is based on sample collection, precision and accuracy in this method apply more to the calculated measurements in the laboratory. However, knowledge of the interferences and limitations of the method will allow for appropriate action, ensuring the accuracy of the calculated measurements.

7. SITE REQUIREMENTS

Site location for sampling gases and vapors using Tedlar® bags and sorbent tubes should be determined according to the intended application of the monitoring data. Unobstructed sites should be chosen with:

- An ideal distance of 5-30 m downwind from the source or at a complainant's residence. Distances will vary depending on meteorological, physical, and other source interference restrictions.
- Sample train set on a level surface.
- Intake height 0.2 to 10 meters above the ground.
- Location well away from obvious local sources of sample contamination such as areas of high vehicle activity (15 meters min), dusty roads, roof top flues and vents, or close to local wood burning sources, unless sampling is being conducted primarily to capture the impact of such sources.
- Distance from sampler to any obstacle at least twice the height of the obstacle above the sampler.
- Unrestricted airflow in an arc of at least 270° around the sampler and no obstructions in the source direction of prime interest.
- No topographic hollows where air circulation is restricted.
- No interference from buildings and trees. 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.
- At least 2 meters from any wall, parapet, penthouse, etc., if placed on a roof, and no nearby flues that may significantly impact sampling.

If there is a power source nearby, a standard 110VAC, 15A household type receptacle is required. In areas where 110 VAC outlets are not accessible use the battery pack.

8. INSTALLATION REQUIREMENTS

The Tedlar® bags and sorbent tubes should be set up in order to collect 2 samples downwind of the source and 1 sample upwind of the source, if necessary, to isolate the source from other possible interferences.

The set up procedures for Tedlar® bags and sorbent tubes are typically specified by the analytical method employed depending on the compounds being sampled for. Considerations for site requirements can be found in section 7.0 above. The general requirements for both methods of Tedlar® bag sampling are listed below:

Pressure Sampling:

1. If more than one sample is needed, label each bag with a unique sample number and mark this unique sample number on the sample data sheet.
2. The bag must be flushed thoroughly at least 3 times with purified air or nitrogen before use.
3. Connect the Teflon pump (SKC or AENV) intake port to the sample manifold or open to the sampling location and the output to the connector on the Tedlar bag using the tubing supplied with the pump.

The system is now ready to sample.

Vacuum Sampling for sorbent tubes:

1. If more than one sample is needed, label each tube with a unique sample number and mark this unique sample number on the sample data sheet.
2. Connect the sorbent tube intake to the sample manifold or leave it open to the sampling location. Connect the output of the sorbent tube using the tubing supplied with the pump to the Teflon pump (SKC or AENV) intake port. Observe the flow direction arrow on the sorbent tube or device.

The system is now ready to sample.

Lung Sampler

1. If more than one sample is needed, label each bag with a unique number and mark the sample number on the sample data sheet.

2. The bag must be flushed thoroughly at least 3 times with purified air or nitrogen before use.
3. Connect the pump (SKC or AENV pump) intake port to the vacuum chamber stainless steel connector using the tubing supplied with the pump. The connector on the chamber has no other line connected to it.
4. Open the vacuum chamber cover and connect the Tedlar® bag stem to the Teflon® tubing. The other end of the tubing is connected to the side of the vacuum chamber, which is open to ambient air. Ensure that there is no blockage of this air line.
5. Open the bag valve by turning the knurled disc on the stem counterclockwise, one full revolution.
6. Close the cover making sure it is sealed properly.

The system is now ready to sample.

In all cases, fill out the information required on the field sample log sheet for that purpose. Ensure the log sheet accompanies the sample.

For both pressure and lung sampling, the pump low can be calculated and set so that the bag is filled over a period of time creating an integrated sample.

The following list specifies the general set up requirements for sampling with sorbent tubes. A more detailed description of requirements can be found in the USEPA's Compendium Method TO-17.

1. Once at ambient temperature, remove the tubes from the storage container, uncap and connect them to the monitoring pumps as quickly as possible using clean, non-outgassing flexible tubing. Multi-bed sorbent tubes must be orientated so that the air sample passes through the series of sorbents in order of increasing sorbent strength (i.e., weaker sorbent first). This prevents contamination of the stronger adsorbent with less volatile components. Most sample devices will have the proper flow direction indicated on them.
2. In all cases the sampling end of the tube must be clearly identified and recorded.
3. Pump flow rate must be set to the manufacturer's requirement for that device.
4. Pump flow should be calibrated according to the manufacturer's instructions, preferably at the monitoring location immediately before sampling begins or, alternatively, in a clean environment before the tubes and pumps are transported to the monitoring site.

9. OPERATIONAL REQUIREMENTS

The operational requirements and sampling procedures for Tedlar® bags and sorbent tubes are specified by the analytical method employed depending on the compounds being sampled for and the USEPA's Compendium Method TO-17 for sorbent tubes.

All sections of the sample data sheet shall be completed when sampling ambient air using Tedlar® bags and sorbent tubes. 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.

9.1 Sampling Frequency

Sampling can be conducted on a predetermined schedule or taken during air pollution 'events' 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.

Consideration should be given to lab costs when planning a sampling schedule. Further samples may be required once analysis results are received from the lab.

9.2 Sample Collection Procedure

The following list specifies the procedure for collecting samples with either Tedlar® bags or sorbent tubes:

1. Either program the pump to operate for a specific amount of time (for 1 or more hours) or manually start the pump.
2. Avoid filling any bag to more than about 80% of its maximum volume. Use the following table as a guideline for sampling time using the AENV or SKC pump and AENV's vacuum chamber volume of 33,567 mls.

Pump Type	Sample time and/or volume for 5L bag and 33,567 mls volume			
	Grab sample	1 hour	8 hours	24 hours
AENV (10-1500 ml/min)	15 min @ 1.5 l/min	450 ml/min	55 ml/min	20 ml/min
SKC (1-5000 ml/min)	5 min @ 5 l/min	450 ml/min	55 ml/min	20 ml/min

3. Enter the appropriate beginning of sampling information into the sample data sheet provided.
4. Make sure you enter any possible sources that could interfere with the interpretation of the data.
5. After sampling is completed, either the pump will turn off by itself via the program or you must manually turn the pump off.
6. Disconnect the line from the pump to the vacuum enclosure by slowly loosening off the tube fitting. This will bring the chamber back up to atmospheric pressure.
7. For Tedlar® bags open the chamber and close the bag valve stem by turning the knurled disk clockwise until snug. For sorbent tubes immediately remove the sampling tubes with clean gloves, recap the tubes withtight fitting caps, rewrap the tubes with uncoated Aluminum foil, and place the tubes in a clean, opaque, airtight container. If not to be analyzed during the same day, place the container in a clean, cool (<4 ˚C), organic solvent-free environment and leave there until time for analysis.
8. Complete the sample data sheet and make note again about any unusual conditions that may affect the sample.
9. The sample data sheet/s must accompany all samples to the lab. A photocopy should be sent to AENV air monitoring section. This copy is stored in a file for that project.

9.3 Transporting Tedlar® Bags

To ensure sampling integrity, perform sample recovery in a manner that prevents contamination of the bag sample. Protect the bag from sharp objects, direct sunlight and low ambient temperatures (below 0˚C) that could cause condensation of any of the analytes. Store the bags in an area that has restricted access to prevent damage to or tampering with the sample before analysis.

Analyze the bag samples within 24 to 48 hours of sample collection unless it can be shown that significant (> 20%) sample degradation does not occur over a longer period of sample storage. Upon completion of the testing and sample recovery, check all the data forms for completeness and the sample bags for proper identification. Store the bags in rigid, opaque containers during all sampling, storage and transport procedures. Ship the bags using ground transportation. Follow all hazardous materials shipping procedures.

9.4 Transporting Sorbent Tubes

Sampled tubes should be recapped with the metal, Swagelok®-type caps and combined PTFE ferrules, rewrapped in the aluminum foil (if appropriate) or clean plastic tight fitting caps and replaced in the storage container immediately after sampling. They should not be removed from the sampling container until they are in the laboratory and about to be analyzed.

10. CALIBRATION

Both the SKC sampling pump and AENV's sampling pump can be configured for Tedlar® bag and adsorbent tube sampling among others. The only calibration procedures that can be completed are to verify the flow through the pump agrees with the settings on the flow controller. Complete the following steps:

Connect a primary flow meter to the inlet of the sample pump

Set the pump to sample at the lowest flow rate and measure the flow with the flow meter. These readings should be converted to standard temperature and pressure (STP) using the following calculation:

$$\text{STP Flow (ccm)} = \frac{Q * P * 298}{760 * (273 + T)}$$

Where:

Q = actual flow measured

P = local atmospheric pressure in mm Hg

T = local station temperature

Take a series of readings over the range of the sample pump and plot the results.

Statistical analysis of the points should indicate a correlation of 0.99 or better.

11. APPLICABLE DOCUMENTS

- **EM-015a** Tedlar® Sampling Bag Operating Manual.
- **EM-015b** SKC Sampling Tube Operating Manual.
- **EM-015c** SKC Sampling Pump Model 224-PCXR7 Operating Manual.
- **EM-015d** Programming manual for AENV tube sampler timers.
- U.S. Environmental Protection Agency, Method 0040, *Sampling of Principal Organic Hazardous Constituents from Combustion Sources Using Tedlar® Bags.* 1996
- U.S. Environmental Protection Agency, *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method TO-17, Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes.* 1999.

12. LITERATURE REFERENCES

- U.S. Environmental Protection Agency, Method 0040, *Sampling of Principal Organic Hazardous Constituents from Combustion Sources Using Tedlar® Bags.* 1996
- U.S. Environmental Protection Agency, *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method TO-17, Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes.* 1999.

13. REVISION HISTORY

Revision 1.0 (January 19, 2011):

Section 2; add description of AENV lung box.

Section 8; add reference to field log sheets, change pressure and add vacuum pumping steps

14. APPROVAL

Harry Benders

Approved by: **Harry Benders** **Date: January 19, 2011**

Title: **Air Monitoring Manager**