HOW TO COLLECT AN AMBIENT AIR SAMPLE USING CANISTERS AND PASSIVE SAMPLING TECHNIQUES

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ABSTRACT

Passive air sampling involves drawing an ambient air sample into an evacuated canister. Time-integrated sampling incorporates a flow device to control the flow entering the canister. This allows the sample to be collected over a specific time period, e.g., a 24-hour sample.

This presentation is an introduction to passive sampling techniques.

INTRODUCTION

Ambient air sampling involves collecting a representative sample of ambient air for analysis. This requires time-integrated sampling. A flow restrictor is used to spread the sample volume over a specific time period, to ensure an "average" composite or time-weighted average (TWA) sample. A TWA sample will accurately reflect the mean conditions of the ambient air in the environment and is preferred when, for regulatory or health reasons, a typical exposure concentration is required for a situation that may have high variability, as in an occupational setting.

In passive sampling an air sample is pulled through a flow controller into an evacuated canister over a chosen period of time, ranging from 5 minutes to 24 hours. The sampling period and flow rate determine the canister volume required.

EQUIPMENT USED IN PASSIVE SAMPLING

To ensure a valid sample, it is important that the flow rate not change greatly during the time interval specified for obtaining the integrated sample. The proper sampling equipment (Figure 1) helps accomplish this objective. A typical passive sampling train should include the following components, all constructed of stainless steel:

- **sampling inlet** – This is the entrance to the sampling train. It is typically stainless steel tubing, either 1/4" or 1/8" ID.
- **particle filter** – Installed prior to the flow controlling device, the particle filter prevents airborne particles from entering the sample flow path and altering the flow rate. Most commonly used are sintered stainless steel filters having 2-, 5-, or 7-micron pores.
- **critical orifice** – The critical orifice restricts the flow to a known flow range (Table 1) but, when used by itself, it cannot restrict flow to a specific rate. Therefore, it is used in conjunction with the flow controller; this allows the canister to fill at a uniform flow rate.
- **flow controller** – The flow controller maintains a constant flow rate over the integrated time period. When a flow controller is used with a critical orifice, an adjustable piston is used to set the flow to a specific rate
- **vacuum gauge** – The vacuum gauge enables sampling personnel to visually monitor changes in the vacuum in the canister during sampling.

- **canister** – The canister should be made of electropolished stainless steel, should be inert, should not to contribute any contaminants, and should be a stable environment for storage. Commercial treatments, such as SilcosteelR, are used to increase inertness.
- **canister valve** – It is important that the canister valve incorporate a metal seat and have high sealing integrity.

The desired function of the sampling train is to ensure a constant flow over the sampling period. However, the flow controller works on a pressure differential, and if this differential is exceeded, the flow rate will change. Figure 2 shows the flow rate through the flow controller as the pressure within the canister changes. It is imperative that the sampling period fall on the flat portion of the curve. Practically, the flow controller can maintain constant flow from 29" Hg vacuum to 7" Hg vacuum. This means that sampling should be completed before the canister pressure reaches 7" Hg vacuum.

Figure # 1: Passive Sampling Train

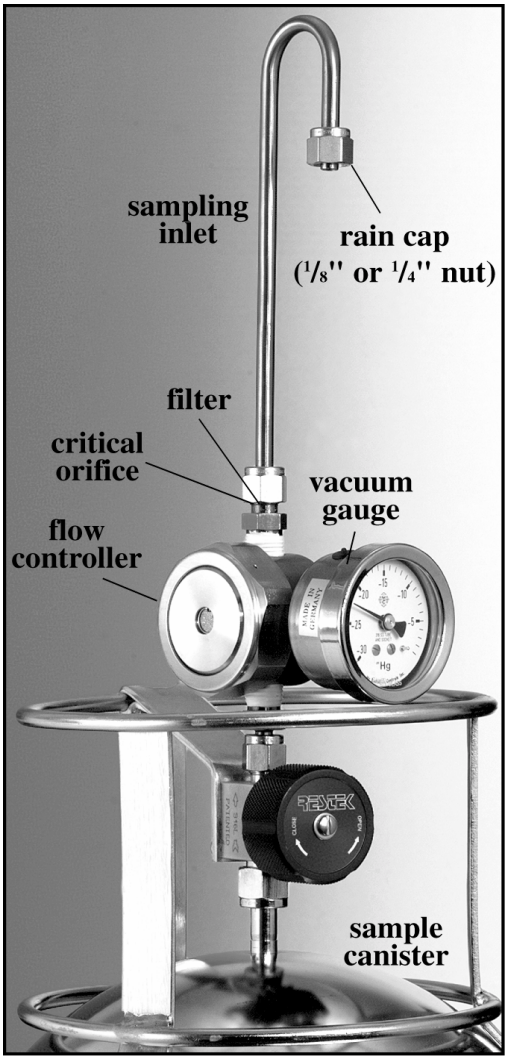
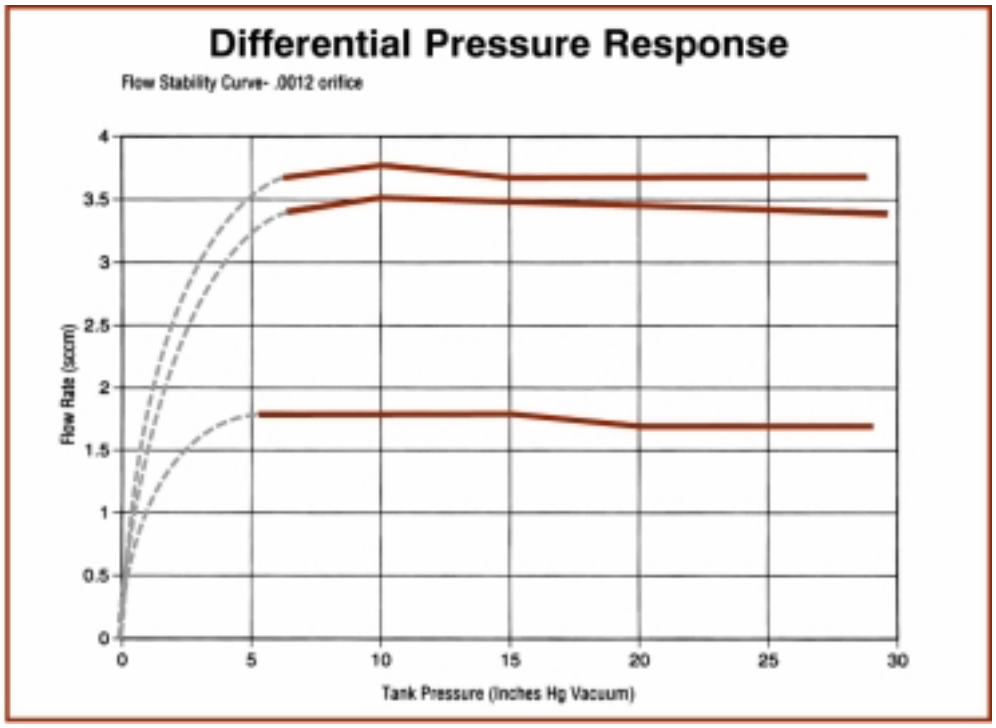


Table 1. Critical orifice diameter vs flow rate.

Orifice Diameter (in.)	Flow Rate Range (sccm)	Canister Volume/ Sampling Time 1L	3L	6L	15L
0.0012	2-4	4 hr.	12 hr.	24 hr.	60 hr.
0.0016	4-8	2 hr.	6 hr.	12 hr.	30 hr.
0.0020	8-20	1 hr.	4 hr.	8 hr.	20 hr.
0.0030	20-40	--	2 hr.	3 hr.	8 hr.
0.0060	40-80	--	--	1 hr.	

Figure 2: Flow rate through flow controller as pressure changes within canister.



PREPARING THE SAMPLING TRAIN

The passive sampling train is typically prepared in the laboratory. The train must be assembled and leak tested, the flow rate must be set, and the train must be certified clean before it can be used in the field.

Step 1: Choose the correct critical orifice (Table 1) and assemble the sampling train.

Step 2: Leak test the sampling train by passing helium gas through the assembled kit and monitoring with a helium leak detector, or by performing a pressure decay test (cap sampling inlet and connect the sampling train to an evacuated canister, open the canister valve, and monitor for pressure change).

Step 3: Using a vacuum source and a calibrated flow meter, set the flow rate. Table 2 shows the flow rates for specific sampling periods for a 6-liter canister.

Step 4: To certify the sampling train clean, connect the sampling train to your analytical system, collect and concentrate the exit gas on a trap, and analyze.

Table 2. Flow rates for integrated sampling, when using a 6-liter canister and sampling on the flat portion of the flow curve for the flow controller. Collected volume is 4-5 liters (flow = volume in mL / sampling time in min.).

Sampling Period	0.5hr.	0.75hr.	1hr.	2hr.	4hr.	8hr.	12hr.	16hr.	24hr.
Flow Rate Range	133-167	89-111	67-83	33-42	17-21	8.0-10	5.6-6.9	4.2-5.2	2.8-3.5
(ml/min)									

PREPARING THE CANISTER

Preparing a canister for use involves certifying the canister clean, evacuating the canister to final pressure and identifying the canister. This information is needed for the chain of custody.

To certify a canister, clean the canister, then fill it with humidified air or nitrogen. Connect the canister to the analytical system and collect , concentrate, and analyze an aliquot of the air within the canister. Two US EPA Compendium methods discuss canister cleanliness testing, EPA TO-12 and TO-14A/15. Refer to these methods for specifications on cleanliness. Some laboratories require only batch testing; we recommend testing every canister prior to use.

Once a canister has been tested and certified clean, evacuate it to a final vacuum of 10-50mtorr. Use an accurate test gauge to ensure the final vacuum is correct.

Identify the canister, using a labeling or serial numbering system that enable the canister to be tracked easily throughout its lifetime.

FIELD SAMPLING, USING A PASSIVE SAMPLING TRAIN AND CANISTER

1. Remove the brass plug nut from the canister valve.
2. If you are using a test gauge, attach the gauge to the canister and record the vacuum reading. If you choose not to use a test gauge under field conditions, record at Step 5 the reading on the vacuum gauge that is part of the passive sampling train.
3. Attach the verified sampling train to the canister.
4. Record the beginning sampling time and necessary meteorological data.*
5. Open the canister valve and begin sampling.
6. Periodically check the canister throughout the sampling period to ensure the partial pressure reading is accurate and sampling is proceeding as planned.
7. Once the sampling period is complete, close the canister valve and remove the sampling train. Check the final partial pressure within the canister,

using a test gauge or, before closing the valve, read the vacuum gauge in the sampling train.

Once sampling is completed, there are four possible scenarios:

A. Ideally there will be a vacuum of 7”-4” Hg in the canister.
B. If more than 7” Hg vacuum remains, less sample was collected than anticipated. The sample will be valid, but the detection limit might be higher than expected. You might have to pressurize the canister prior to analysis, which will dilute the sample, then use a dilution factor to determine the concentrations of target compounds.
C. A vacuum of less that 4” Hg indicates the sample might be skewed toward the initial part of the sampling period. This assumption usually is valid because the flow rate through the flow controller will fall once the vacuum falls below 5” Hg (Figure 2), when the change in pressure across the flow controller diaphragm becomes too small and the flow controller is unable to maintain a constant flow. Although flow was not constant over the entire sampling period, the sample might be usable because sample was collected over the entire period.
D. If the ending vacuum is less than 1” Hg the sample should be considered invalid because it will be impossible to know when the sample flow stopped.

8. Record the final pressure in the canister and replace the brass plug nut.

*Other information that should be acquired at the sampling site includes the interval time, the stop time, atmospheric pressure, temperature, and wind direction. Include elevation if it is a factor. These parameters often prove useful toward interpreting results.

After sampling, the canisters are returned to the laboratory, where the final vacuum is measured once again, with a test gauge. Using the initial vacuum and final vacuum readings, the sample volume collected can be determined from Equation 1:

Equation 1:

$$\text{Sample Volume} = \frac{\text{Pressure change*}}{\text{Atmospheric reference pressure}} \times \text{canister volume}$$

*Initial pressure - final pressure

Example: A sample is collected in a 6-liter canister. The initial gauge pressure reading when the canister left the lab was 29” Hg vacuum; the final gauge pressure reading when the canister was returned to the lab was 7” Hg vacuum.
Sample volume= [(29” Hg - 7” Hg)/29” Hg] x 6L = 4.55 liters collected

Table 3 is a reference chart summarizing sample volumes collected in a 6 liter canister at specific final vacuum readings.

Table 3. Final vacuum and volume of sample collected in 6-liter canister.

Final Vacuum ("Hg)	**29**	**27**	**25**	**23**	**20**	**17**	**15**	**12**	**10**	**7**	**5**	**3**	**0**
Sample Volume (liters)	**0**	**0.41**	**0.8**	**1.2**	**1.9**	**2.5**	**2.9**	**3.5**	**3.9**	**4.6**	**5**	**5.4**	**6**

Another approach to determining sample volume collected is through the flow rate and sampling time (Equation 2). This is done by rechecking the flow rate of the sampling train after sampling. Laboratories typically will allow a maximum deviation of +/-10% to +/-25% between initial flow rate and post sampling flow rate.

Equation 2:
Sample Volume=[(initial flow rate + post-sampling flow rate)/2] x sampling time

Example: A flow controller was set at 3.3mL/min. After obtaining a 24 hour sample, the flow rate was 3.0ml/min.
Sample volume = [(3.3mL/min.+ 3.0mL/min.)/ 2] x 1440min. = 4536mL

CONCLUSION
A well designed and properly prepared passive sampling system helps ensure accurate, useful information is obtained from an air sampling project. The sampling system should include a 1/4-inch or 1/8-inch inlet, a particulate filter, a critical orifice, a flow controller, a vacuum gauge, and a canister with a valve. Procedures described here summarize correct approaches to assembling, certifying, and using the sampling system.