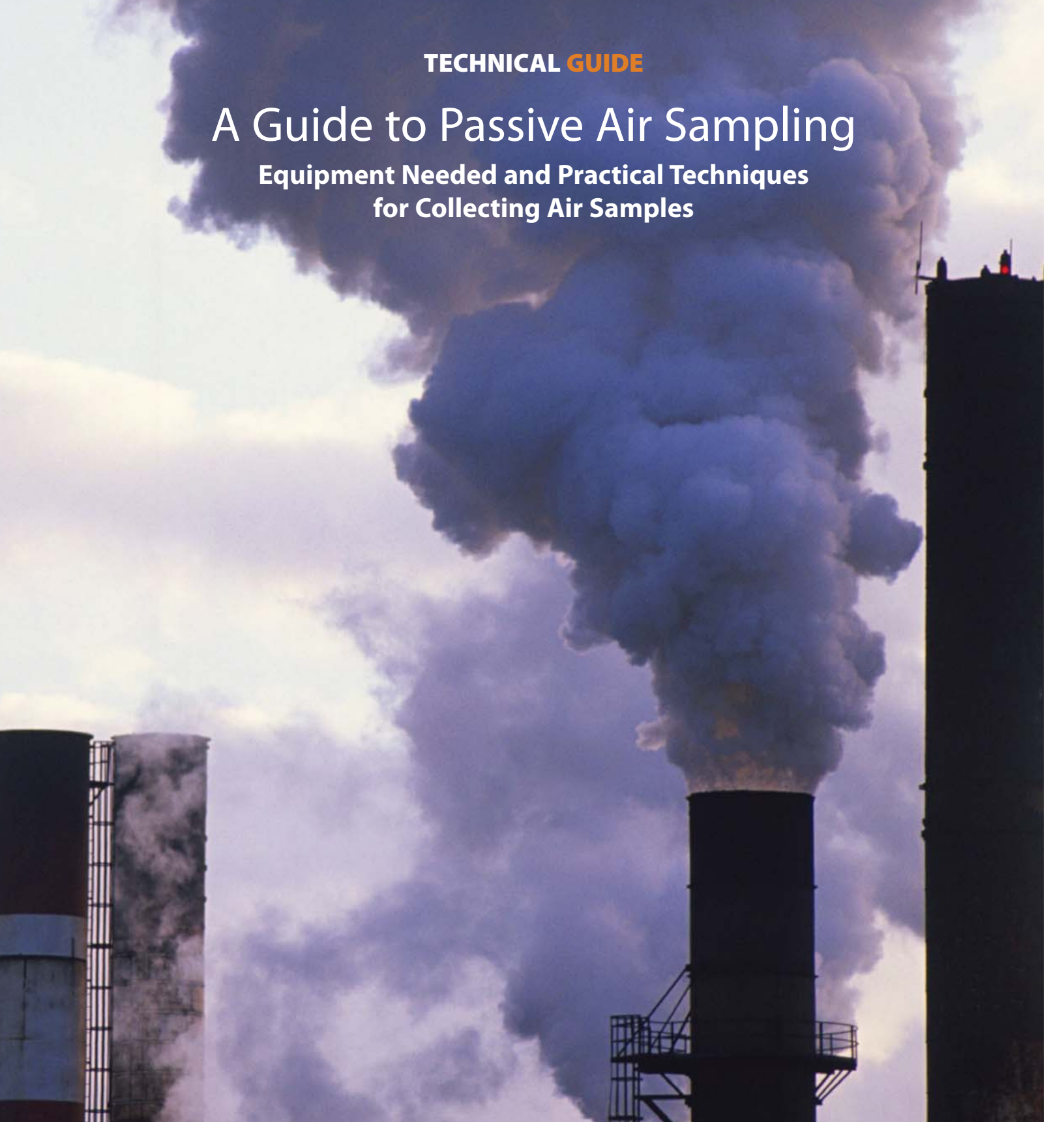


TECHNICAL **GUIDE**

A Guide to Passive Air Sampling

Equipment Needed and Practical Techniques
for Collecting Air Samples



HROMalytic Chromatography
Australian Distributors **ECH**nology Products '08



www.chromtech.net.au E-mail : info@chromtech.net.au Tel : +61 3 9762 2034 Fax : +61 3 9761 1169



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dependable execution

One of our standing goals is to provide you with practical information to help you obtain reliable data from your chromatographic and peripheral systems. This guide describes equipment needed and practical techniques to follow when collecting passive air samples, using canisters. It is a compilation of information based on our experience and that of experts in this field. We would like to thank the individuals who provided invaluable assistance in the development of this guide: Dr. Eric Winegar of Applied Measurements Science, Joachim Pleil of the US Environmental Protection Agency, John Yokoyama of Performance Analytical, and Jerry Winberry of Envirotech Solutions.

If you have any questions, or have input for future editions of this guide, please feel free to contact us at Restek Corporation.



David M. Shelow

Air Monitoring Products

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I. Introduction

Ambient air sampling involves collecting a representative sample of ambient air for analysis. If the environment is not changing, or if only a qualitative sample is needed, a simple “grab” sample can be obtained. For example, an evacuated sample canister can be opened and sample rapidly collected at a non-controlled rate, usually over several seconds, until the container attains equilibrium with atmospheric pressure. Generally this qualitative approach is used when unknown analytes must be identified, when the air contains high concentrations of analytes at certain (short) times, or when an odor is noticed and a sample must be obtained quickly. Paired grab samples (before/after or smell/no smell) often are employed to qualitatively diagnose a perceived problem.

To obtain a more representative sample requires time-integrated sampling. A flow restrictor is used to spread the sample collection flow over a specific time period, to ensure an “average” composited 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.

There are two general approaches to collecting air samples: 1) “whole air” sampling with canisters or Tedlar® bags and 2) “in-field concentration” sampling using sorbent tubes or cold traps. In this guide we focus on collecting whole air samples in canisters. Within this approach, two sampling techniques commonly are used: passive sampling and non-passive (active) sampling, distinguished by the absence or use of an active pumping device, respectively.

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 the flow rate determine the canister volume required. In active sampling, a pump is used to push the sample through a mass flow controller and into the canister. Additional sample can be collected, relative to the amount that can be collected by passive sampling, by pressurizing the canister with sample. Commonly the sample is pressurized to 15psig, effectively doubling the sample volume. Sampling can be time-integrated (e.g., an 8-hour sample), or a dip tube design can be used to establish a flow through the system and flush the sample container with sample, then, after a specified time, the exit valve is closed and the container is pressurized with sample.

Although active sampling is very flexible, a drawback to using a pump is the need for additional quality assurance requirements for sample integrity (i.e., no artifacts or loss of analytes). Additionally, a pump requires a battery or line power source, which may pose logistic difficulty in remote field-site sampling.

II. Equipment Used for Passive Air Sampling

To ensure a valid sample when using a passive sampling technique, it is important that the flow rate not change greatly during the time interval specified for the integrated sample. The proper sampling equipment helps accomplish this objective. A typical passive sampling train should include the following components, all constructed of stainless steel: a sampling inlet, a sintered metal particle filter, a critical orifice, a flow controlling device, a vacuum gauge, and a canister (Figure 1).

Sampling Inlet

The sampling inlet - the entrance to the sampling train - typically is cleaned stainless steel tubing, either 1/4" ID or 1/8" ID. US EPA Compendium Method TO-14/15 recommends sampling at a height of 2 meters above the ground. In a highly trafficked area, this would minimize the problem of dust particles entering the sampling train. This height is not mandatory, however, and it is common practice to use an inlet that is 12" (approximately 1/3 meter) high. The EPA also recommends having the entrance of the sampling inlet face

downward, to prevent raindrops from entering the inlet. In some sampling trains a 1/8" or 1/4" nut at the entrance of the inlet keeps water droplets away from the edge of the inlet, where they could be drawn into the sampling train with the sample.

Particle Filter

Installed in the sampling train prior to the flow-controlling device, the particle filter prevents airborne particles from entering the sample flow path. Particles could partially obstruct the flow path and alter the flow rate during sampling. In extreme cases, particles could plug the flow path and stop the sample flow. The smallest orifice commonly used in a passive sampling train is 0.0012" (approximately 30 micrometers). Without a particle filter, dust particles could occlude this opening as they accumulate in the orifice fitting. Particles also can affect the leak integrity of the valve, and possibly can damage the valve. Two types of filters are used for this application, frit filters and in-line filters (Figure 2). A variety of models of each type are available; most are of sintered stainless steel and have 2-, 5-, or 7-micron pores. Obviously, the smaller the pores, the less likely are potential problems from airborne particles. EPA Compendium Method TO-14A/15 recommends using a particle filter with 2-micron pores.

Critical Orifice

The critical orifice (Figure 3, page 4) restricts the flow to a specified range. In conjunction with the flow controller, this allows the canister to fill at a specified rate over a specified time period. The most common critical orifice design is a series of interchangeable stainless steel 1/4" NPT to 1/4" compression unions, each fitted with a precisely bored sapphire orifice. Each orifice provides a specific flow range (Table 1). Stability over a wide range of temperatures makes sapphire the construction material of choice. Typically during field sampling, the sampling train is subjected to temperature fluctuations that would cause metals to contract or expand, affecting the diameter of the aperture and thereby affecting flow. Sapphire will not expand or contract across any ambient temperature extremes incurred during sampling.

A critical orifice can be used as the sole flow-restricting device, but it cannot ensure uniform flow. The source pressure of the flow changes during sampling, and the flow rate through the orifice also would change, producing an invalid time-integrated sample. It is important that a highly consistent flow rate be maintained during passive sampling. This is accomplished by the flow controller that incorporates the critical orifice.

Flow Controller

The flow controller (Figure 3, page 4) maintains a constant sample flow over the integrated time period, despite changes in the vacuum in the canister or in the environmental temperature (Figure 4, page 5). In the Veriflo™ Model SC423 XL Flow Controller shown in Figure 3, the critical orifice acts as a flow restrictor, upstream of a constant back pressure. This constant back pressure is established by the balance between the mechanical spring rate of the diaphragm and the pressure differential across the diaphragm. The latter is established by the pressure difference between the atmospheric pressure and the vacuum in the canister and the flow through the critical orifice. The net result is a constant flow.

Table 1 Critical orifice diameter vs flow rate.

Orifice Diameter (in.)	Flow Rate Range (sccm)	Canister Volume / Sampling Time			
		1L	3L	6L	15L
0.0008	0.5-2	24 hr.	48 hr.	125 hr.	--
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.	3 hr.

Figure 1 A complete sampling train is needed for reliable passive sampling.

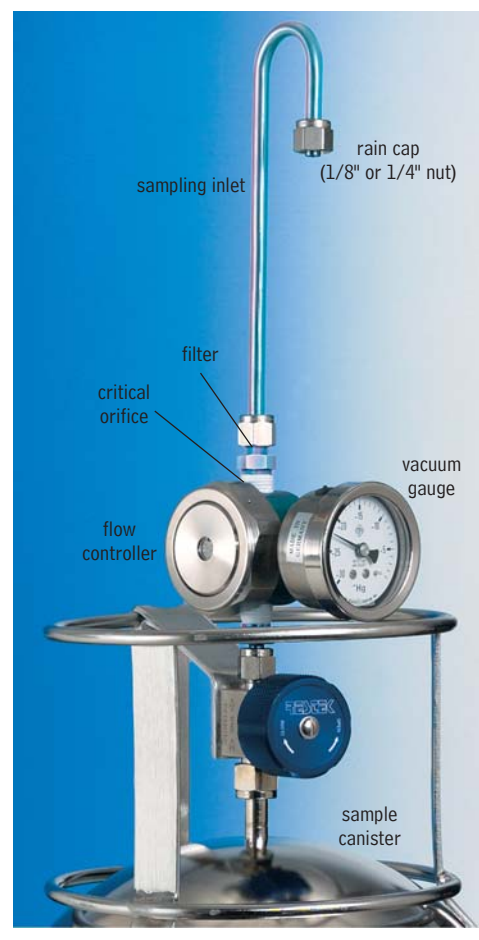


Figure 2 Filters used in sampling trains.



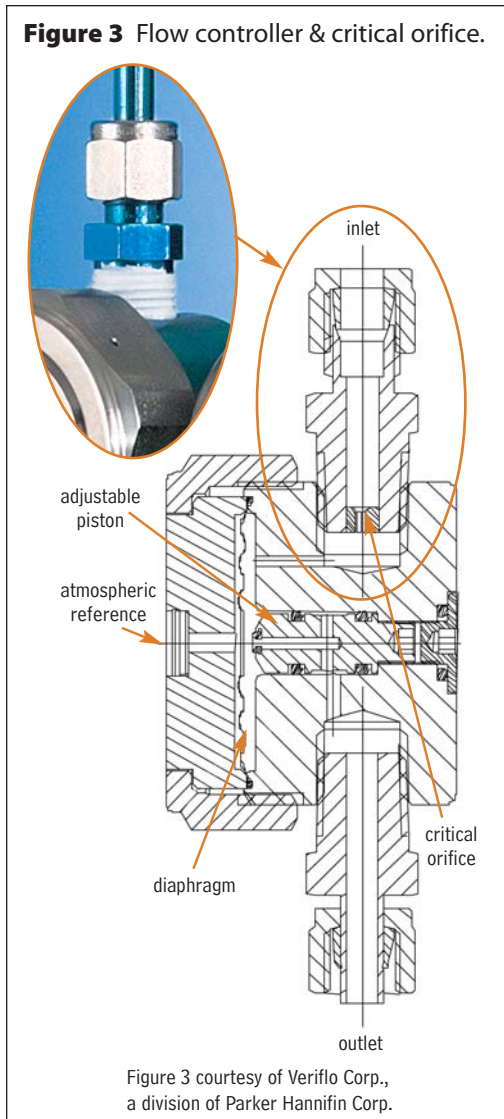
Figure 3 Flow controller & critical orifice.

Figure 3 courtesy of Veriflo Corp.,
a division of Parker Hannifin Corp.

The critical orifice determines the flow range. The adjustable piston is used to set a specific, fixed flow rate within the flow range. An adjustment to the position of the piston changes the back pressure, which changes the pressure differential across the critical orifice. If the piston is lowered away from the diaphragm, the flow rate will increase. If the piston is raised toward the diaphragm, the flow rate will decrease. This flow controller will accurately maintain a constant flow despite changes in vacuum over a range of 30" Hg to 7" Hg. Flow is constant until the vacuum range of the device is exceeded, making the flow controller unable to maintain the constant pressure differential. In Figure 5, for example, the flow rate is constant from 29.9" Hg to approximately 7" Hg, at which point the flow rate decreases because the flow controller is unable to maintain the proper pressure differential. This control will allow the user to collect approximately 5 liters of sample in a 6-liter canister. This is an extremely important factor in obtaining valid time-integrated samples through passive sampling. We will discuss this point further in the Field Sampling section of this guide.

Vacuum Gauge

A vacuum gauge enables sampling personnel to visually monitor changes in the vacuum in the canister during sampling. If the flow rate changes unexpectedly (e.g., due to a leak or an incorrect setting), the vacuum gauge will indicate a disproportionately high or low vacuum in the canister, and corrective action can be taken (i.e., flow adjusted) in time to ensure a valid sample. This type of vacuum gauge is attached to the sampling train, for use in the field. The vacuum gauge should be of high quality, to ensure that it does not introduce contaminants into the sample. All wetted parts in the vacuum gauge shown in Figure 6 (page 7) are constructed of stainless steel; the gauge is accurate to within 1% of full scale.

To monitor pressure in the canister before and after sampling, use a more accurate measuring device. Test gauges built by Ashcroft are accurate to 0.25% of full scale. These sensitive gauges should not be used in the field - they typically are wall mounted in the lab. Once used for sampling, a gauge must be cleaned, and should be certified clean. Procedures are described later in this guide.

Canister

The canister is a stainless steel vessel designed to hold vacuum to less than 10 mTorr or pressure to 40 psig. Canisters are available in a range of volumes: 850 mL, 1.0 liter, 1.8 liter, 3.0 liter, 6.0 liter, 15 liter, and 35 liter. The size of canister used usually depends on the concentration of the analytes in the sample, the sampling time, the flow rate, and the sample volume required for the sampling period (Table 1, page 3). Typically, smaller canisters are used for more concentrated samples, such as soil gas collection, 3-liter and 6-liter canisters are used to obtain integrated (TWA) ambient air samples at sampling times of up to 24 hours, and large 15-liter and 35-liter canisters are used for reference standards. Sampling time will be limited by the combination of canister size and the flow rate at which the sample is to be collected.

A well-designed canister is essential to the success of the sampling project. First, the canister should be made of stainless steel, so the collected sample will not permeate through the vessel wall or degrade due to exposure to light during shipment to the analytical laboratory. Second, the interior surface of the canister should be inert, to reduce the potential for interactions with the analytes in the sample. Third, all canisters involved in a particular application should be of consistent volume, to simplify calculating sample volumes. Finally, the canister should have a high quality valve that resists abuse in the field (e.g., overtightening that potentially could cause leaks). An inferior valve can fail, causing sample loss and incurring replacement costs. It can be more expensive to sample again than to replace a valve.

Two types of canisters are available, the difference being the interior surface. The traditional canister is the stainless steel SUMMA® canister. The interior of

Figure 4 A flow controller will maintain a constant sample flow despite changes in canister pressure or environmental temperature.

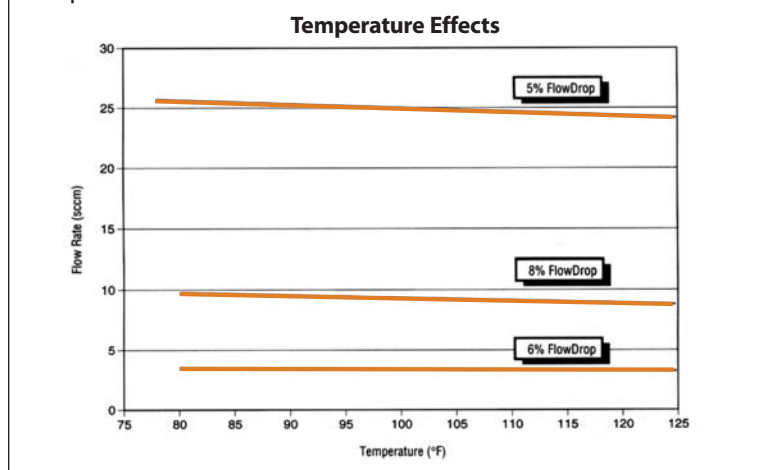
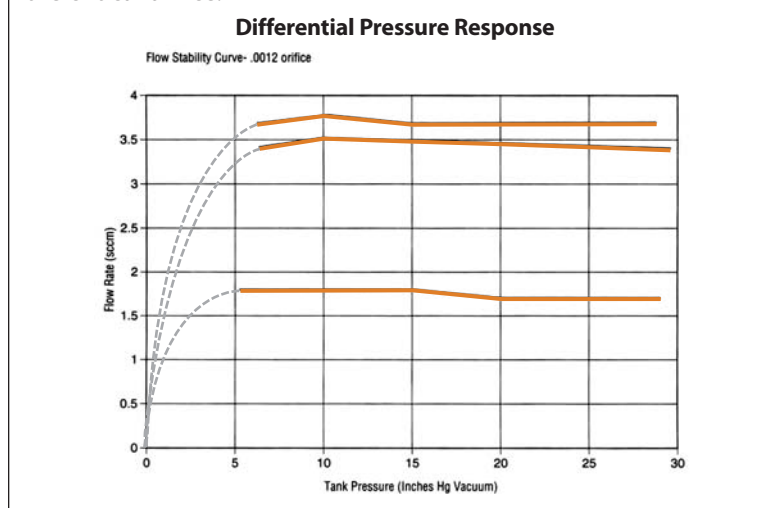


Figure 5 A flow controller will maintain a constant sample flow until it is unable to maintain a stable pressure differential across the critical orifice.



Figures 4 and 5 courtesy of Veriflo Corp., a division of Parker Hannifin Corp.

a SUMMA® canister is electropolished, using a polishing procedure (developed by Molecotrics) that enriches the nickel and chromium surface and makes it more inert than untreated stainless steel. The new generation of sampling canister is typified by the SilcoCan™ canister. Like the SUMMA® canister, the SilcoCan™ canister is made of stainless steel, and the interior is electropolished, but in an additional step - Siltek® treatment - an inert layer is chemically bonded to the interior surface. Siltek® treatment makes the surface inert not only for relatively inactive organic compounds, but also for compounds that are reactive with metal surfaces, such as sulfur-containing compounds. Thus, surface deactivation for SilcoCan™ canisters exceeds that for SUMMA® canisters.

Canister Valve

The valve on a sampling canister must be of high quality, with the following characteristics: leak integrity, a metal seat (to eliminate offgassing of seat components into the sample and memory effects in the seat material), stainless



a plus 1 story

Barry was asked to build and test 20 air sampling canisters, for shipping the same day at 11:30am. He worked nonstop, until the canisters were assembled, quality checked, and packaged for shipment, ensuring a customer had the canisters in time for an important project.

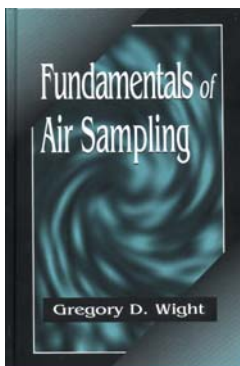
Barry Spicer, Jr.,
Restek Performance Coatings Technician

steel wetted surfaces, and a packless design (a completely enclosed system, to ensure no contamination from lubricants or packing material). Various valves are used on various models of canisters; the most commonly used valves are the Nupro 4H4 series metal bellows valve and the Parker Hannafin diaphragm valve with metal seat. At Restek we incorporate the Parker Hannafin diaphragm valve on canisters because of its ability to hold vacuum, its durability and longevity, and a maximum temperature limit (250°C) that is much higher than that for a bellows valve. Further, a Parker Hannafin diaphragm valve can be rebuilt if it is damaged; it does not have to be replaced.

The connection of the valve to the canister is critical. The connection must be leak tight, to ensure a correct sampling flow rate, but extreme caution must be taken to prevent overtightening the tube compression fittings.

Siltek® and Sulfinert® Treatment

Siltek® treatment is a proprietary process, developed by Restek Corporation, through which an inert layer is chemically bonded to a metal surface. The surface produced by this treatment is virtually inert to active compounds. The stainless steel pathway described in this guide is sufficient for sampling atmospheres containing only non-reactive compounds, but for reactive compounds the entire sampling pathway should be Siltek® treated to eliminate contact between the reactive analytes and the metal surfaces. Siltek® treatment can be applied to the interior surfaces of the canister and valve, to ensure an inert sample pathway. If the samples will contain reduced sulfur-containing analytes, an alternative proprietary Restek deactivation process, Sulfinert® treatment, is the most effective means of deactivating the sample pathway and canister.



Fundamentals of Air Sampling

This book explains the fundamentals of air sampling, develops the theory of gas measurement, and presents several how-to examples of calibration and use of air and gas sampling devices. Other topics include the basics of pressure measurement and units conversion, and specific discussions regarding the use of a Volatile Organic Sampling Train or a SUMMA®-polished canister sampling system.

G. D. Wight, CRC Press LLC, 1994, 272pp., cat.# 20492

III. Preparing the Sampling Train for Use

The sampling train must be prepared in the laboratory before it can be used in the field. The train must be assembled and leak tested, the flow rate must be set, and the train must be certified clean. All of the following information should be documented for the chain of custody for the passive sampling train and the sample collected with it.

Assemble, Leak Test, and Set the Flow Rate of the Passive Sampling Train

Choose the critical orifice (Table 1, page 3) according to the sampling period and flow rate you anticipate using (Table 2). This will ensure an accurate and valid sample. There should be a marking on the outside of the critical orifice fitting indicating the size of the orifice. In a clean environment, assemble the sampling train components as shown in Figure 1 (page 3). It is imperative that you leak test the assembled train. If the sampling train leaks during sampling, the final partial pressure in the canister will not be the desired final partial pressure, making the sample invalid. The most common reason for invalid samples is leaks within the sampling train. There are two ways to leak test the train:

1. Pass helium gas through the flow controller and use a sensitive helium leak detector to test for leaks (e.g., Restek Leak Detector).
2. Cap the inlet, attach the sampling train to an evacuated canister, open the valve on the canister and evacuate the sampling train.

Close the valve and monitor any pressure change in the static sampling train. Leaks of less than 1 mL/min. can be detected in 1-2 minutes.

This is a good practical test - the small internal volume of the passive sampling train, combined with even a small leak, will produce a large change in monitored pressure.

After you are certain the sampling train is leak-free, set the desired sampling flow rate.

To set the desired flow rate follow these steps:

1. Remove the protective cap from the back of the Veriflo™ Flow Controller SC423XL body.
2. Connect either an evacuated canister or a vacuum source to the outlet of the sampling train.
3. Connect a high quality calibrated flow meter (i.e., mass flow meter, rotameter, GC-type flow sensor, e.g., Restek Flowmeter 6000, cat. #21622) to the inlet of the train.
4. Apply vacuum by opening the canister or turning on the vacuum source.
5. With a 3mm hex (Allen) wrench, adjust the piston gap screw to achieve the desired flow rate (Table 2). Between adjustments allow the flow to equilibrate for several minutes.
6. Replace the protective cap onto the back of the Veriflo™ Flow Controller body.

Cleanliness: Certifying the Sampling Train for Use

US EPA Compendium Method TO-14A/TO-15 requires that the sampling train be certified clean prior to use. Certify the train by passing a humidified, high-purity air stream through the train, concentrating the exit gas on a trap, and analyzing the gas by gas chromatography / mass spectroscopy or other selective detector. For the sampling train to pass certification the analytical system should not detect greater than 0.2ppbv of any target VOC.

The certified sampling train should be carefully packaged in aluminum foil or in a clean container for storage or for shipment into the field. Care in packaging is critical. Careless handling could affect the preset flow rate. When the sampling train is ready for sampling, prepare the canister.

IV. Preparing the Canister for Sampling

Preparing a canister for sampling involves certifying the canister clean, evacuating the canister to final pressure for use, and identifying the canister. All information acquired during these processes is needed for the chain of custody.

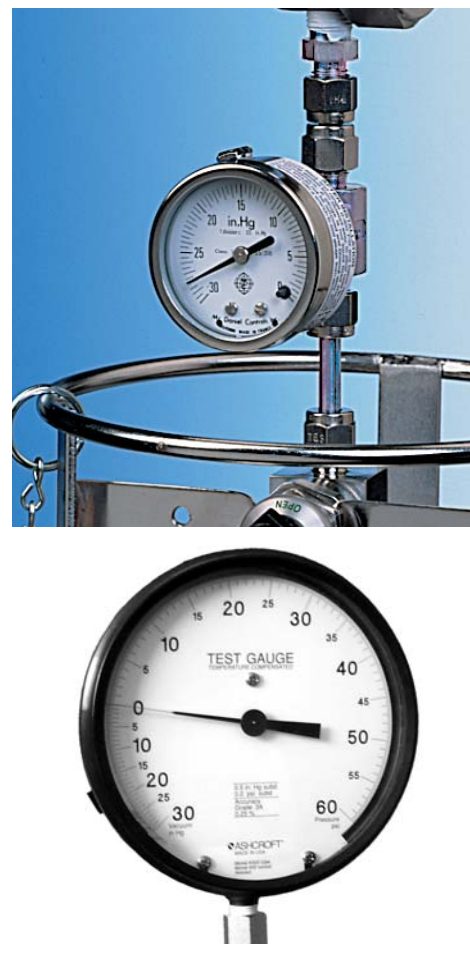
Certifying the cleanliness of the canister is important toward ensuring that results reported are solely from the site sampled, and not admixed with residue from a previous site or from contaminated laboratory air. To certify a canister clean, fill the canister with humidified air, pass the air from the canister through an adsorbent trap and analyze the adsorbent for target VOCs by GC/MS or other selective detector. Two US EPA methods discuss canister certification: EPA Compendium TO-12 and EPA Compendium TO-14A/TO-15. To comply with EPA Compendium Methods TO-14A/TO-15, the analytical system should not detect greater than 0.2ppbv of any target VOC. To comply with EPA Compendium Method TO-12 the analytical system, GC/FID, should not detect greater than 0.02ppmvC hydrocarbons. Although batch certification of canister cleanliness is a relatively common practice, we recommend certifying and documenting each canister individually. Detailed cleaning instructions are presented in Section VIII. Cleaning the Canister (page 12).

Table 2 Flow rates for integrated sampling, using a 6-liter canister and sampling on the flat portion of the flow curve for the flow controller (Figure 5).

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

Collected volume is 4-5 liters (flow = volume in mL / sampling time in min.).

Figure 6 Conventional vacuum gauge and high-accuracy test gauge.



Some laboratories certify a canister for VOC stability by introducing a low concentration test mixture into the canister and measuring degradation over a specified time period. If the canister meets the specification, it is certified for use. We recommend using such studies to ensure the effectiveness of a canister or group of canisters for a proposed application.

Once the canister is certified clean, evacuate the canister to a final vacuum of 10-50mtorr, using either the canister cleaning system or a clean final vacuum system. This vacuum is critical to ensure the correct amount of sample is collected. Use an accurate test gauge or digital pressure tester to ensure final vacuum has been reached and document the final vacuum reading for the chain of custody. Install a brass plug nut into the canister valve to ensure no contamination can enter the sample pathway during shipment to the field.

Allot an individual identity to the canister, either with a label and serial number or with a bar code.

Some analysts prefer to introduce surrogate standards into the canister prior to sampling. Debate on this practice revolves around theories that there are potential loss issues due to low humidity and inadequate surface passivation by water. Neither Restek chemists nor our consulting experts recommend adding surrogates to the canisters. If you choose to introduce surrogates into your canisters prior to sampling be sure to recheck the vacuum reading for each canister after adding the surrogates, and record the reading.

did you know?

Restek canisters are shipped in boxes with handles for ease of carrying and transporting, eliminating costly carrying cases.



V. Field Sampling, Using a Passive Sampling Train and Canister

It is important to mention again that the sampling train and canister must be leak tested and certified clean prior to use. To properly begin field sampling, we recommend bringing a "practice" evacuated canister and a flow measuring device with you to the field. Use this canister to verify the flow rate through the passive sampling train prior to using the train to obtain samples of record. To verify the flow rate, connect the passive sampling train to the "practice" canister. Attach a flow meter to the inlet of the sampling train. Open the canister, and measure the flow rate through the sampling train. If the flow rate is within +/- 10% of the flow rate set in the lab, the train is ready to be used on the formal sampling canister. If the flow rate is not within these limits, adjust the flow rate by adjusting the piston gap screw.

When the flow rate is confirmed, record the rate as the canister flow rate for the chain of custody form.

To begin sampling, using the formal sampling canister, follow these steps:

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 the reading on the vacuum gauge that is part of the passive sampling train.
3. Attach the verified passive sampling train to the canister.
4. Record the begin 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 valve and remove the sampling train. Check the final partial pressure within the canister, using the test gauge or the vacuum gauge in the sampling train.

There are four possible scenarios:

- A. Ideally there will be a vacuum of 7"-4" Hg in the canister (see, e.g., Table 3 on page 10).
- B. If more than 7" Hg vacuum remains, less sample was collected than initially anticipated. The sample will be valid, but the detection limit may be higher than expected. You might have to pressurize the canister prior to the analysis, which will dilute the sample, then you will have to use a dilution factor to determine final concentrations of target compounds.
- C. A vacuum of less than 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 5, page 5), 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 interval.
- D. If the ending vacuum is less than 1" Hg the sample should be considered invalid because it will be impossible to tell when the sample flow stopped.
8. Record the final partial pressure in the canister and replace the plug nut.

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

After sampling, the canisters are sent back to the laboratory, where the final vacuum is measured once again, with a test gauge. Using the initial vacuum and final vacuum, 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 29.92" Hg vacuum; the final gauge pressure reading when the canister was returned to the lab was 7" Hg vacuum.

$$\text{sample volume} = [(29.92\text{''Hg} - 7\text{''Hg}) / 29.92\text{''Hg}] \times 6\text{L} = 4.59 \text{ liters collected.}$$

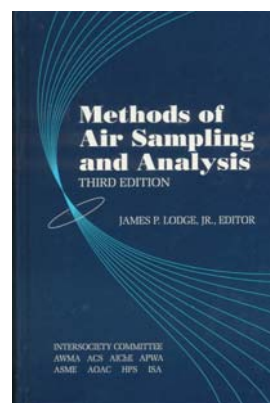
It is also a good practice to recheck the flow rate after sampling, because this will affect the sample volume (Equation 2). Laboratories typically allow a maximum deviation of +/-10% to +/-25% between the initial flow rate and the post-sampling flow rate.

Equation 2:

$$\text{sample volume} = [(\text{initial flow rate} + \text{post-sampling flow rate})/2] \times \text{sampling time}$$

Example: A flow controller was set at 3.3mL/min. After obtaining a 24 hour sample the flow rate was 3.0mL/min.

$$\text{sample volume} = [(3.3\text{mL/min.} + 3.0\text{mL/min.}) / 2] \times 1440 \text{ min.} = 4536\text{mL.}$$



Methods of Air Sampling and Analysis, 3rd Edition

This book includes precise directions for analyzing a long list of air contaminants. All contaminants one can analyze or monitor using a given method are consolidated to facilitate use. An excellent reference manual for all analytical laboratories conducting air analyses.

J. P. Lodge, CRC Press LLC, 1988, 784pp., **cat.# 20493**

VI. Analysis of Collected Samples

Once received by the lab, each canister is identified from the information in the chain of custody report. The final partial pressure is checked to ensure no leaks appeared during transport. It might be necessary to pressurize a canister prior to the analysis; do this by adding humidified nitrogen or air to the canister to a pressure greater than 5 psig or higher, depending on the sample volume needed for analysis or for suitably diluting the sample (e.g., Table 4). The need to dilute is determined by the preconcentrator instrument. Some air preconcentrators can be operated while the canister is under slight vacuum. Check with your instrument manuals, or with the manufacturer, to determine if you must dilute your samples prior to analysis.

Equation 3:

$$\text{dilution factor} = (P_{\text{after dilution}} + P_{\text{lab atmosphere}}) / (P_{\text{lab atmosphere}} - P_{\text{before dilution}})$$

The dilution factor is calculated from the post-sampling pressure (before dilution), the final pressure (after dilution), and the atmospheric pressure in the laboratory. The factor for converting "Hg to psi = 0.491.

Example: At the end of a sampling period the gauge pressure in a canister was 7"Hg. The canister was pressurized with nitrogen to 14.7psig (1 Atm.).

The dilution factor is $(14.7 + 14.7) / (14.7 - (7 \times 0.491)) = 2.61$

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	0.58L	0.99L	1.39L	1.99L	2.59L	2.99L	3.59L	3.99L	4.60L	5.0L	5.40L	6L

To analyze the sample, withdraw an aliquot of the sample from the canister. For low level ambient air analysis, withdraw 250-500 mL of sample from the canister and concentrate the analytes by using a mass flow controller and a cryogenically cooled trap (e.g., glass beads and/or a solid sorbent). Desorb the concentrated analytes from the trap and deliver them to a cryofocuser, to focus the sample bandwidth prior to introduction onto the GC column. A 60m x 0.32mm ID x 1.0µm Rtx®-1 column typically is used for EPA Method TO-14A or Method TO-15 ambient air analysis; an MSD is a common detector. Figure 7 shows a typical TIC spectrum for a TO-14A/TO15 ambient air analysis.

Procedures used in these chromatographic analyses generally include a multi-point calibration, using gas standards. Therefore calculations of organic compounds in collected samples are straightforward - only volumes analyzed and dilution rates are needed to determine sample concentrations. High concentration calibration gas standards are commercially available (e.g., 1ppmv or 100ppbv); introduce an aliquot of stock material into a canister and dilute with humidified air or nitrogen. After analyzing the calibration standards, determine the response factor for each analyte, using the peak area counts per concentration.

After analyzing the multipoint calibration standards and calculating peak area/concentration response factors, analyze the "real world" samples. If an "unknown" sample has not been diluted apply the corresponding response fac-

Table 4 Dilution factors to adjust final sampling pressure to **14.7psig** for a 6-liter canister.

Final Vacuum ("Hg)	29"	27"	25"	23"	20"	17"	15"	12"	10"	7"	5"	3"	0"
Sample Volume (liters)	0	0.58L	0.99L	1.39L	1.99L	2.59L	2.99L	3.59L	3.99L	4.60L	5.0L	5.40L	6L
Dilution Factor	63.77	20.37	12.12	8.63	6.02	4.63	4.01	3.34	3.00	2.61	2.40	2.22	2.00

frequently asked question

Where can I find EPA Air Toxic Methods?

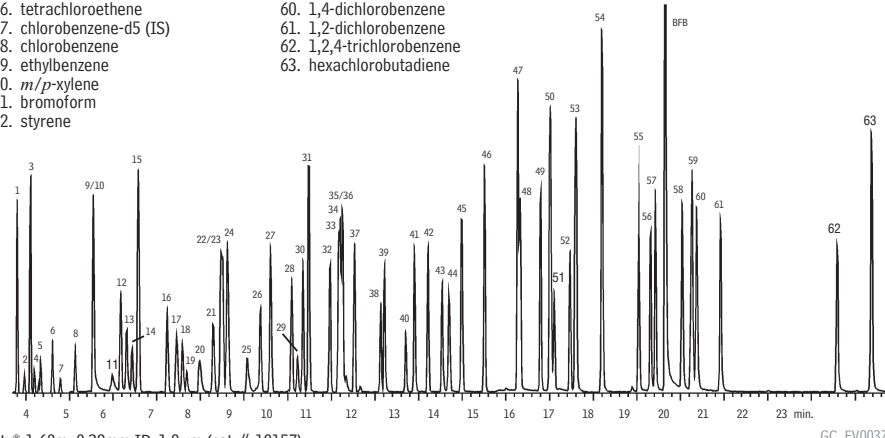
pdf files of US EPA Air Toxic Methods are available at this web address: www.epa.gov/ttn/amtic/airtox.html

Figure 7 TLC spectrum for a TO-14/TO-15 ambient air analysis.

1. dichlorofluoromethane
2. chloromethane
3. dichlorotetrafluoroethane
4. vinyl chloride
5. 1,3-butadiene
6. bromomethane
7. chloroethane
8. bromoethene
9. acetone
10. trichlorofluoromethane
11. isopropyl alcohol
12. 1,1-dichloroethene
13. methylene chloride
14. 3-chloropropene
15. carbon disulfide
16. Freon® TF
17. *trans*-1,2-dichloroethene
18. 1,1-dichloroethane
19. methyl *tert*-butyl ether
20. methyl ethyl ketone
21. *cis*-1,2-dichloroethene
22. bromochloromethane (IS)
23. *n*-hexane
24. chloroform
25. tetrahydrofuran
26. 1,2-dichloroethane
27. 1,1,1-trichloroethane
28. benzene
29. carbon tetrachloride
30. cyclohexane
31. 1,4-difluorobenzene (IS)
32. 1,2-dichloropropane
33. bromodichloromethane
34. trichloroethene
35. 1,4-dioxane
36. 2,2,4-trimethylpentane
37. *n*-heptane
38. *cis*-1,3-dichloropropene

39. methyl isobutyl ketone
40. *trans*-1,3-dichloropropene
41. 1,1,2-trichloroethane
42. toluene
43. methyl butyl ketone
44. dibromochloromethane
45. 1,2-dibromoethane
46. tetrachloroethene
47. chlorobenzene-d5 (IS)
48. chlorobenzene
49. ethylbenzene
50. *m/p*-xylene
51. bromoform
52. styrene

53. 1,1,2,2-tetrachloroethane
54. *o*-xylene
55. 2-chlorotoluene
56. 4-ethyltoluene
57. 1,3,5-trimethylbenzene
58. 1,2,4-trimethylbenzene
59. 1,3-dichlorobenzene
60. 1,4-dichlorobenzene
61. 1,2-dichlorobenzene
62. 1,2,4-trichlorobenzene
63. hexachlorobutadiene



Rtx®-1 60m, 0.32mm ID, 1.0µm (cat.# 10157).
 Sample: 200mL of 10ppbv TO-15 standard (cat.# 34436), injected into TO-Can™ canister and humidified to 70% RH.
 Concentrator: Nutech 3550 Preconcentrator
 200mL of sample concentrated at -160°C, thermally desorbed at 150°C, and cryofocused at -185°C.
 Oven temp.: 30°C (hold 4 min.) to 175°C @ 9°C/min. to 220°C @ 40°C/min.
 Carrier gas: helium @ 1.2mL/min.
 Det.: Agilent 5971 MS
 Scan range: 35-265amu

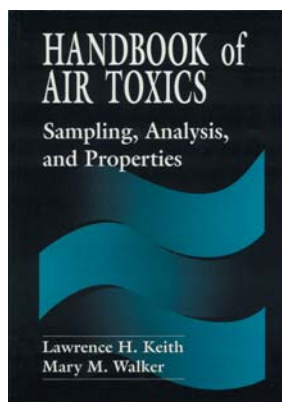
tor to each “unknown” analyte peak area to get the reporting limit concentration of the “unknown” in the analysis (typically in ppbv). If you have diluted the canister to get a positive pressure, however, you must apply the dilution factor to the concentration values. This is done by multiplying the reporting limit by the dilution factor.

VII. Cleaning the Passive Sampling Train

The cleanliness of the sampling train is critical to collecting accurately representative samples. Practices followed for cleaning passive sampling equipment between uses range from purging the sampling pathway with humidified nitrogen or air for many hours to heating the pathway during a purge to disassembling each component, sonicating the pieces in solvent, and oven baking the pieces prior to re-assembly. The most suitable mode of cleaning depends on the concentrations of analytes of interest, and contaminants, in the previous sample collected.

The particle filter must be thoroughly cleaned between uses. Disassemble the filter, then remove the larger particles from the frit by blowing particle-free nitrogen through the frit from the outlet surface toward the inlet surface. After the larger particles are removed sonicate or rinse the filter parts in methanol, then bake the parts in an oven at 130°C to remove any residual organic vapors.

The critical orifice and flow controller can be cleaned in either of two ways. The first method is to disassemble the flow controller and clean all the metal parts with methanol. This will remove any high boiling compounds that have condensed onto the wetted areas of the controller. Heat the cleaned parts in an oven at 130°C to remove residual organic vapors. Do not sonicate in solvent or bake any of the non-metallic parts, such as O-rings; they will be damaged during these steps. Do not rinse the vacuum gauge with methanol. The vacuum gauge may be heated, but do not exceed 80°C; higher temperatures will damage the face and the laminated safety glass lens. Heating to 80°C will not affect the mechanical operation of the spiral bourdon tube in the vacuum gauge.



**Handbook of Air Toxics.
Sampling, Analysis and Properties**

This reference book contains physical and chemical data for all the chemicals in the National Toxicology Program's Chemical Database and all substances indicated in the US EPA Clean Air Act Amendments.

L. H. Keith and M. M. Walker, CRC Press LLC, 1995, 640pp., cat.# 21373

A less involved method of cleaning the flow controller is to use a heating jacket or heat gun to heat the components of the assembled sampling train, while purging the system with nitrogen. As organic compounds are heated and desorbed from the interior surfaces the nitrogen gas sweeps them out of the sampling equipment.

Preparing the Clean Passive Sampling Train for Re-use

After the sampling train components have been cleaned, reassemble the system, check for leaks, set the desired flow rate, and certify the sampling system clean. Follow the procedures described previously in this guide. Package the clean sampling train to prevent contact with airborne contaminants.

VIII. Cleaning the Canister

Every air sampling canister, whether new or previously used, must be cleaned and certified before it is used for sampling. Some laboratories batch test and certify canisters, in which after cleaning, one canister out of 10 is tested and certified clean. We recommend certifying each canister clean prior to use, however, especially if there is potential for litigation.

For many years there has been much discussion as to what constitutes a proper procedure for cleaning canisters. US EPA Method TO-14A has provided guidance, and in the last 5-10 years many automated commercially available canister cleaning systems have evolved. Unfortunately, because these systems are quite expensive, and some designs have limitations, many analysts design their own systems and methodologies for cleaning canisters. The cleaning procedure described in this section is a practical approach that will ensure canisters are suitably cleaned for ambient air sampling, whether you are using a commercially available cleaning system or a system of your own design. There are minor differences when cleaning SilcoCan™ or SUMMA® canisters. We will discuss these differences in this procedure.

Air Versus Nitrogen

The two gases recommended for cleaning canisters are humidified ultra-high purity air and ultra-high purity nitrogen. The water in the humidified gas hydrolyzes impurities in the canister and, according to theory, will occupy the active sites on the interior surface, displacing the impurities and allowing them to be removed. Air is recommended when oxidation of the interior surface is desired. The oxygen content of air, 21%, is sufficient for this surface oxidation; it is not necessary to use pure oxygen gas. Nitrogen is equally effective for cleaning ambient air canisters, but, of course, nitrogen will not oxidize the surface of the canister.

Heat or No Heat

Many user-designed canister cleaning systems do not heat the canisters. Typically this does not create a problem when cleaning canisters that are used in ambient air collection, but as a safeguard we recommend heating the canisters during the cleaning process. Compounds collected in most ambient air samples are in the low ppbv range, and can be removed from a canister by multiple cycles of pressurization with humidified air or nitrogen followed by evacuation. If there are higher concentrations of contaminants in the canister, however, heat might be required to clean the canister satisfactorily.

Be aware that adding heat and humidified gas to a canister potentially can create a steam pressure vessel. Some commercial cleaning systems incorporate a pressure release valve to ensure the pressure does not exceed the pressure rating of the canisters.

A heating option can be added to a user-designed canister cleaning system by using an oven, heat bands, insulated jackets, or an infrared source.

Oven

Some canister cleaning systems are incorporated within an oven. The supply line for the humidified air stream and the line to the vacuum system are plumbed directly into the oven. In this arrangement the entire canister, including the valve, will be heated, and this will help remove contaminants if both the valve and the canister are dirty. Typically, when using heat, it is helpful to create steam from the humidified air stream. An oven temperature of at least 120°C is required, but higher temperatures often are used. Remember that heat can shorten the lifetime of the Nupro valve on a SUMMA® canister (see step 3 in Cleaning Method, below).

Space is a concern with oven systems. Most commercial ovens are not very large and this restricts the number of canisters that can be cleaned at one time. However, clean-up times are shorter with heat than without heat, so more cleaning cycles can be completed in a week.

Heat Bands

A band heater placed around the equator of the canister typically will be capable of heating the canister to approximately 130°C. There is a heat gradient, and the valve might only receive radiant heat (approximately 70-100°C). In most sampling situations, however, this lower temperature should be sufficient for effectively removing contaminants from the valve.

Insulated Heat Jackets

Insulated heat jackets can be obtained to surround and heat each canister. These jackets typically have a silicone or Teflon®-coated fiberglass fabric exterior and a fiberglass insulation interior. Some operate at a fixed temperature; others can provide variable temperature, up to 400-500°F. Restek's heating jacket, described at right on this page, offers significant advantages over most other commercial designs, which do not encompass the valve area.

Infrared Heat

An infrared heating system includes an infrared heat source and a reflective panel similar to the cylinder drying rack on a gas cylinder system. The infrared source and the reflective panel are placed on opposing sides of the canisters. Infrared rays from the source heat the canisters; rays that pass the canisters strike the reflective panel and heat the canisters from the opposing side.

The Cleaning System

The cleaning system must provide a humidified air stream and include a good vacuum source, a cold trap to collect impurities during cleaning, and accurate gauges to read vacuum and pressure. A heat source is optional, but is highly recommended in some circumstances, as discussed above. The system can be designed to clean 4 to 24 six-liter canisters. Figure 8 (page 14) shows an example of a "homemade" system designed to clean 24 six-liter canisters. This design does not employ heat, but a heater easily can be added (see Heat or No Heat, page 12). It provides a humidified air stream to all canisters and the roughing pump on the bottom shelf is the vacuum source. This system is computer operated to minimize labor, but this is not necessary.

Cleaning Method

1. Connect all canisters to the cleaning system, then release any pressure within any of the canisters. Put the system under vacuum, to evacuate the canisters. US EPA Method TO-14A/15 recommends evacuating the system to 50 mTorr for 1 hour, but a reduced pressure of 23-25" Hg is sufficient for general cleaning.
2. After the canisters have been under vacuum for approximately 1 hour, pressurize the canisters with humidified air or nitrogen*. Pressurization will dilute the impurities and the moist air will hydrolyze them. Pressurize canisters to 5 psig if they will be heated or to 30 psig if they will not be heated. Proceed to step 3 when the system has equilibrated at the designated pressure.



The ultimate in controlled heating, for reliably cleaning your air canisters!

Air Canister Heating Jacket

- Closely simulates oven environment—heats entire canister.
- Two temperature settings, 75°C and 150°C.
- Prevents sample condensation, for accurate sub-sampling.
- Easily fits canister up to 6 liters.
- Lightweight; comfortable to the touch when heated.
- Connect up to five Canister Heating Jackets to one 15 amp circuit.

The Restek Canister Heating Jacket will help you clean your canisters faster and more efficiently. The novel design ensures the entire canister, including the valve, is heated during the cleaning cycle, to remove contaminants most effectively. It also can be used to keep the sample heated during aliquot removal, which helps prevent condensation and assure accurate data for larger molecules. The two heat settings let you match the temperature to the volatility of your sample components. If you try one in your system, we think you'll want more.

Description	qty.	cat.#
Air Canister Heating Jacket (110 volt)	ea.	24123

*please note

If you are cleaning SilcoCan™ canisters, and will be using heat, use humidified nitrogen, not air.

Figure 8 User-designed system for cleaning 24 six-liter canisters.



- Heat the pressurized canisters to 120 - 250°C, depending on the type of canister being cleaned. Do not allow the temperature of a SUMMA® canister to exceed 155°C, because the Nupro valve it employs has Viton® O-rings and requires greases that cannot be exposed to high temperatures. Many commercial cleaning systems avoid this problem by ensuring the valve is not within the heated zone. The canister below the valve is heated but the valve receives only radiant heat. In contrast, the Parker Hannifin diaphragm valve in a SilcoCan™ canister is far less heat sensitive, allowing the canister to be cleaned at temperatures up to 250°C, to help remove less labile impurities.

Heat the canisters filled with humidified air for at least 1 hour.

- Re-evacuate the canisters to remove the desorbed impurities. Allow the canisters to equilibrate for 1 hour.
- Determine if the canisters have been cleaned effectively by following the procedure in Certifying the Canister, below. US EPA methods recommend testing every canister until a reliable procedure is developed.

Repeat steps 1-5 as necessary; the number of cycles will be determined by how dirty the canisters are and how easily they are cleaned. We recommend developing a cleaning procedure that matches your specific sampling procedure, by testing the canisters for cleanliness after each cycle and determining the number of cycles necessary for proper cleaning. If the canisters are not heated, the number of cycles required to clean the canisters might be higher.

- Once a canister is clean, prepare it for collecting a sample by evacuating it to 10-50 mTorr. If your system is leak-tight, you can do this by using a roughing pump, but many commercial systems include a molecular drag pump to reach final vacuum quickly.

IX. Certifying the Canister

We recommend certifying canisters for both cleanliness and for analyte stability. To certify a canister clean, pressurize the canister to 14.7 psig with humidified ultra-high purity air or nitrogen after it has gone through the cleaning cycles. The humid air or nitrogen stream must be certified clean before it can be used for canister certification. Analyze an aliquot of the canister content by GC/MS or GC/FID/ECD. US EPA Method TO-14A/15 specifies a canister must contain less than 0.2 ppbv of any target VOC compound (Figure 9); EPA Method TO-12 specifies less than 0.02 ppmC, as detected by GC/FID. If a canister does not meet specification, it must be re-cleaned and re-tested for certification.

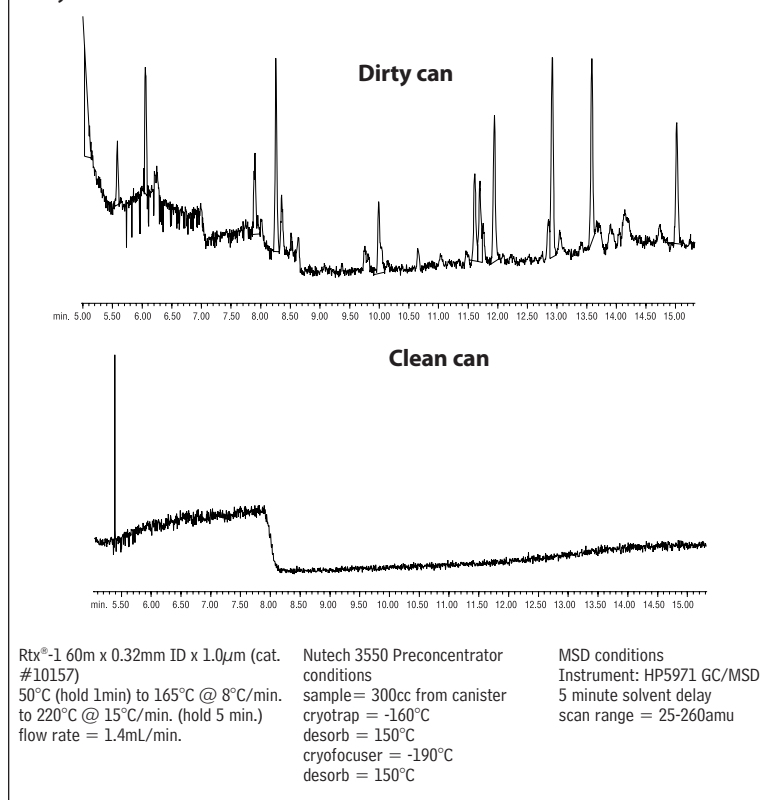
To certify a canister for analyte stability, introduce a low working concentration of a characterized test mix into the canister. Analyze an aliquot of the contents of the canister immediately after introducing the test mixture and at periodic intervals. We recommend monitoring for changes for a minimum of 2 weeks, or for a timeframe similar to your anticipated holding period. Responses should not decrease more than 20% over this period.

Commercially available standards are available for stability testing, but we recommend you make your own test mixture that is comparable to the target compound list that the canister will hold. For example, if you are analyzing sulfur compound content in ambient air, prepare a sulfur-specific test mix and evaluate the canister's performance for sulfurs. Maintain a log sheet for each canister, and record the test results and certification. This will be a permanent record for each canister. Some labs certify canisters for certain compounds and use a canister only for this specific application.

X. Conclusion

A well designed and properly prepared passive sampling system helps ensure accurate, useful information is obtained from an air sampling project. In this guide, we describe the components of the system, procedures for assembling the system and preparing it for sampling, and the sampling procedure. Cleaning system options and procedures for cleaning a used sampling train and canister for certification prior to a subsequent sampling also are presented. The following section describes Restek products designed to help collect and analyze air samples.

Figure 9 Aliquots from a canister before and after cleaning with 2 cycles of humidified air while heated to 200°C.



Pressure Conversion Table

Pressure	PSI	atm	kg/cm ²	torr	kPa	bar	inches Hg
PSI =	1	0.068	0.0703	51.713	6.8948	0.06895	2.0359
atm =	14.696	1	1.0332	760	101.32	1.0133	29.921
kg/cm ² =	14.223	0.967	1	735.5	98.06	0.9806	28.958
torr =	0.0193	0.00132	0.00136	1	0.1330	0.00133	0.0394
kPa =	0.1450	0.00987	0.0102	7.52	1	0.0100	0.2962
bar =	14.5038	0.9869	1.0197	751.88	100	1	29.5300
in Hg =	0.49612	0.0334	0.0345	25.400	3.376	0.03376	1

Multiply units in the left-most column by the conversion factors listed in the columns to the right.
 e.g., 10PSI x 0.068 = 0.68atm, 10 bar x 29.5300 = 295.300 inches Hg

XI. Air Sampling Products

SilcoCan™ Air Monitoring Canisters

Siltek® treated - ideal for low-level reactive sulfur compounds (1-20ppb)

- Unsurpassed inertness, even for sulfur-containing or brominated compounds.
- Sizes from 1 to 15 liters support a wide range of sampling needs.
- Optional 3-port valve allows attachment of vacuum/pressure gauge for monitoring canister pressure.
- For critical applications, order a Siltek® treated valve - add suffix "-650" to the catalog number of the canister.



Alternative Vacuum/Pressure Gauges

The standard vacuum/pressure range on a SilcoCan™ or TO-Can™ canister fitted with a gauge is 30" Hg to 60psig. To order a different gauge for the canister, add the appropriate suffix number to the canister catalog number. There is no price difference for these alternative gauges.

Gauge	Suffix
30" Hg/15psi	-651
30" Hg/30psi	-652

For ultimate inertness, we treat SilcoCan™ air monitoring canisters with our unique Siltek® passivation technology. Even highly active components, at low parts-per-billion concentrations, can be readily sampled and stored without loss. The valve is a high quality, metal-to-metal seal, 2/3-turn valve with metal diaphragms. Both stainless steel and Siltek® treated valves are available, in both the 2-port and 3-port configurations.

Description	qty.	cat.#
1L Volume		
SilcoCan™ Canister, 1/4" Valve	ea.	24180
SilcoCan™ Canister, Siltek®-Treated 1/4" Valve	ea.	24180-650
SilcoCan™ Canister with Gauge, 1/4" Valve	ea.	24140
SilcoCan™ Canister with Gauge, Siltek®-Treated 1/4" Valve	ea.	24140-650
3L Volume		
SilcoCan™ Canister, 1/4" Valve	ea.	24181
SilcoCan™ Canister, Siltek®-Treated 1/4" Valve	ea.	24181-650
SilcoCan™ Canister with Gauge, 1/4" Valve	ea.	24141
SilcoCan™ Canister with Gauge, Siltek®-Treated 1/4" Valve	ea.	24141-650
6L Volume		
SilcoCan™ Canister, 1/4" Valve	ea.	24182
SilcoCan™ Canister, Siltek®-Treated 1/4" Valve	ea.	24182-650
SilcoCan™ Canister with Gauge, 1/4" Valve	ea.	24142
SilcoCan™ Canister with Gauge, Siltek®-Treated 1/4" Valve	ea.	24142-650
15L Volume		
SilcoCan™ Canister, 1/4" Valve	ea.	24183
SilcoCan™ Canister, Siltek®-Treated 1/4" Valve	ea.	24183-650
SilcoCan™ Canister with Gauge, 1/4" Valve	ea.	24143
SilcoCan™ Canister with Gauge, Siltek®-Treated 1/4" Valve	ea.	24143-650

TO-Can™ Air Monitoring Canisters

Optimized for US EPA Methods TO-14 and TO-15

- High quality, metal-to-metal seal, 2/3-turn valve with metal diaphragms.
- Sizes from 1 to 15 liters.
- Optional 30" Hg/60psig vacuum/pressure gauge (other gauges available).

Description	qty.	cat.#
1L Volume		
TO-Can™ Canister, 1/4" Valve	ea.	24172
TO-Can™ Canister with Gauge, 1/4" Valve	ea.	24176
3L Volume		
TO-Can™ Canister, 1/4" Valve	ea.	24173
TO-Can™ Canister with Gauge, 1/4" Valve	ea.	24177
6L Volume		
TO-Can™ Canister, 1/4" Valve	ea.	24174
TO-Can™ Canister with Gauge, 1/4" Valve	ea.	24178
15L Volume		
TO-Can™ Canister, 1/4" Valve	ea.	24175
TO-Can™ Canister with Gauge, 1/4" Valve	ea.	24179

did you know?

We ship our canisters cleaned, batch-tested per USEPA TO-14, and under 30psig pressure with dry nitrogens.

Refer to our catalog or our website for replacement pressure gauges.

1/4" Replacement Valves for Air Monitoring Canisters*



Description	Stainless Steel Valve		Siltek®-Treated Valve	
	qty.	cat.#	qty.	cat.#
1/4" Replacement Valve (2-port)	ea.	24145	ea.	24144
1/4" Replacement Valve (3-port)	ea.	24147	ea.	24146

*All Restek canisters are originally equipped with these high-quality Parker Hannifin diaphragm valves. Each valve is helium leak-tested to 4 x 10⁻⁶cc/sec. The all-stainless steel construction eliminates contamination and withstands temperatures from -100°C to 250°C. Compression outlet fitting, indicator plate to display open or closed position, 1/4" inlet and outlet.

Miniature Air Sampling Canisters—an alternative to tube and pump samplers

- Ideal for indoor air, personal, emergency response, or soil gas sampling (applications ≤ 40psig).
- Available with quick-connect (1/4" tube) fitting, compatible with sampling and analysis instruments.
- Available with non-treated or Sulfinert®-treated valve.
- 1000cc canister suitable for US EPA Methods TO-14 and TO-15.

Description	Volume	qty.	cat.#
Electro-Polished Miniature Canister with Quick-Connect Stem Fitting	400cc	ea.	24188
	1000cc	ea.	24194
Sulfinert®-Treated Miniature Canister with Quick-Connect Stem Fitting	400cc	ea.	24189
	1000cc	ea.	24195
Sulfinert®-Treated Miniature Canister with Sulfinert®-Treated Quick-Connect Stem Fitting	400cc	ea.	24190
	1000cc	ea.	24196
Electro-Polished Miniature Canister with Metal-Seated Diaphragm Valve	400cc	ea.	24191
	1000cc	ea.	24197
Sulfinert®-Treated Miniature Canister with Metal-Seated Diaphragm Valve	400cc	ea.	24192
	1000cc	ea.	24198
Sulfinert®-Treated Miniature Canister with Sulfinert®-Treated Diaphragm Valve	400cc	ea.	24193
	1000cc	ea.	24199
Electro-Polished Miniature Canister with Nut & Ferrule	400cc	ea.	24205
	1000cc	ea.	24206
Sulfinert®-Treated Miniature Canister with Nut & Ferrule	400cc	ea.	24207
	1000cc	ea.	24208



Dimensions:
400cc = 2.75" diameter,
5.35" long
1000cc = 2.75" diameter,
11.92" long

Quick-Connect Fittings for Miniature Air Sampling Canisters (1/4" tube fitting)

Description	qty.	cat.#
Quick-Connect Stem Fitting	ea.	24185
Sulfinert®-Treated Quick-Connect Stem Fitting	ea.	24186
Quick-Connect Body Fitting	ea.	24187

Air Monitoring Gas Standards (see our catalog or website for others)

TO-14A Calibration Mix (39 components)

benzene	ethyl chloride
bromomethane	hexachloro-1,3 butadiene
carbon tetrachloride	methylene chloride
chlorobenzene	styrene
chloroform	1,1,2,2-tetrachloroethane
chloromethane	tetrachloroethylene
1,2-dibromoethane	toluene
<i>m</i> -dichlorobenzene	1,2,4-trichlorobenzene
<i>o</i> -dichlorobenzene	1,1,1-trichloroethane
<i>p</i> -dichlorobenzene	1,1,2-trichloroethane
dichlorodifluoromethane	trichloroethene
1,1-dichloroethane	trichlorofluoromethane
1,2-dichloroethane	1,1,2 trichlorotrifluoroethane
1,1-dichloroethene	1,2,4-trimethylbenzene
<i>cis</i> -1,2-dichloroethene	1,3,5-trimethylbenzene
1,2-dichloropropane	vinyl chloride
<i>cis</i> -1,3-dichloropropene	<i>m</i> -xylene
<i>trans</i> -1,3-dichloropropene	<i>o</i> -xylene
dichlorotetrafluoroethane	<i>p</i> -xylene
ethyl benzene	

In nitrogen, 104 liters @ 1800psig

1ppm	100ppb
34400 (ea.)	34421 (ea.)

did you know?

Spectra Gas manufactures our high-quality air monitoring gas standards and is:

- Official supplier of PAMS (ozone precursor) calibration gas to US EPA.
- Only vendor of 62-component TO-15 gas standard.
- Rigorous quality control guarantees the stability and reproducibility of every Spectra Gases mix.

TO-15 62 Component Mix (62 components)

acetone	4-ethyltoluene
benzene	trichlorofluoromethane (Freon® 11)
benzyl chloride*	dichlorodifluoromethane (Freon® 12)
bromodichloromethane	1,1,2-trichloro-1,2,2-trifluoroethane (Freon® 113)
bromoform	1,2-dichlorotetrafluoroethane (Freon® 114)
bromomethane	heptane
1,3-butadiene	hexachloro-1,3-butadiene
2-butanone (MEK)	hexane
carbon disulfide*	2-hexanone (MBK)
carbon tetrachloride	4-methyl-2-pentanone (MIBK)
chlorobenzene	methylene chloride
chloroethane	methyl <i>tert</i> -butyl ether (MTBE)
chloroform	2-propanol
chloromethane	propylene
cyclohexane	styrene
dibromochloromethane	1,1,2,2-tetrachloroethane
1,2-dichlorobenzene	tetrachloroethene
1,3-dichlorobenzene	tetrahydrofuran
1,4-dichlorobenzene	toluene
1,1-dichloroethane	1,2,4-trichlorobenzene
1,2-dichloroethane	1,1,1-trichloroethane
1,1-dichloroethene	1,1,2-trichloroethane
<i>cis</i> -1,2-dichloroethene	trichloroethene
<i>trans</i> -1,2-dichloroethene	1,2,4-trimethylbenzene
1,2-dichloropropane	1,3,5-trimethylbenzene
<i>cis</i> -1,3-dichloropropene	vinyl acetate
<i>trans</i> -1,3-dichloropropene	vinyl chloride
1,4-dioxane	<i>m</i> -xylene
ethanol*	<i>o</i> -xylene
ethyl acetate	<i>p</i> -xylene
ethyl benzene	
ethyl dibromide (1,1-dibromoethane)	

In nitrogen, 104 liters @ 1800psig

6-month stability

1ppm	100ppb
34436 (ea.)	34437 (ea.)

*Stability of this compound cannot be guaranteed.

cylinder design

Aluminum construction.

Size: 8 x 24 cm.

Volume/Pressure: 104 liters of gas @ 1800psig.

Outlet Fitting: CGA-180.

Weight: 1.5 lbs.



Passive Air Sampling Kits

Better Performance at a Better Value

- Improved design eliminates leaks at the filter.
- Siltek®-treated components ensure a very inert surface.
- Excellent for sampling times from 1 hour to 125 hours, or grab sampling.

Restek's passive air sampling kit incorporates all hardware necessary to collect air samples, and is easy to assemble for field sampling.* The improved filter design greatly reduces the number of potential leak sites.

The passive air sampling kit is available in six sampling flow ranges, and in stainless steel or Siltek® treated finish. The stainless steel kit is ideal to partner with the Restek TO-Can™ air sampling canister for TO-14A and TO-15 methods. Use the Siltek®-treated version with the Restek SilcoCan™ air sampling canister when collecting low-level volatile sulfur compounds, or other active compounds.

Air Sampling Kits

400cc	Canister Volume*/Sampling Time				Flow (sccm)	Orifice size	Siltek®-Treated Sampling Kits	Stainless Steel Sampling Kits
	1 Liter	3 Liter	6 Liter	15 Liter				
8 hour	24 hour	48 hour	125 hour	—	0.5–2	0.0008"	24217	24216
2 hour	4 hour	12 hour	24 hour	60 hour	2–4	0.0012"	24160	24165
1 hour	2 hour	6 hour	12 hour	30 hour	4–8	0.0016"	24161	24166
—	1 hour	4 hour	8 hour	20 hour	8–20	0.0020"	24162	24167
—	—	2 hour	3 hour	8 hour	20–40	0.0030"	24163	24168
—	—	—	1 hour	3 hour	40–80	0.0060"	24164	24169

*Air sampling canisters sold separately.

1. Veriflo™ SC423XL flow controller

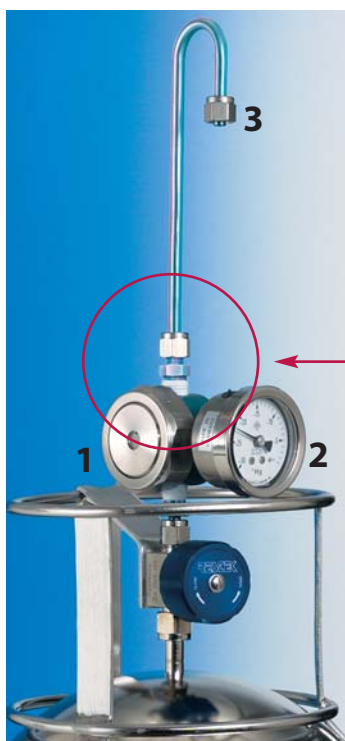
This flow controller is the heart of the sampling train. It is a high-quality device designed to maintain a constant mass flow as the pressure changes from 30" Hg to 5" Hg (we recommend you stop sampling at or before 5" Hg of vacuum). All wetted parts of the flow controller can be Siltek®-treated.

2. Stainless steel vacuum gauge

Fitted to the flow controller, the gauge monitors canister pressure change during sampling.

3. 1/4-inch Siltek® sample inlet

The 2m x 1/4-inch tubing includes a stainless steel nut on the inlet end, to prevent water droplets from accumulating at the edge of the tubing, where they could be pulled into the sampling train.



All fitting connections are 1/4" tube, except where noted.



4. 2-micron frit filter and washer

Located prior to the critical orifice to prevent airborne particles from clogging the critical orifice. Replaceable. Available in stainless steel, or Siltek®-treated for optimum inertness.

5. Interchangeable critical orifice

An interchangeable sapphire critical orifice allows you to control the flow with very high precision. To select the correct critical orifice for your sample, see table above. Available in stainless steel, or Siltek®-treated for optimum inertness.

a plus 1 story

"Restek has consistently provided high quality chromatography columns and supplies to me for well over a decade. Over the last two years, I have extensively been involved with air analysis, TO-15, etc., and Restek provides the highest quality canisters, mini-cans, and flow controllers in the market today."

Scott Van Etten, IH Laboratory Manager, EMSL Analytical

Buy only the parts you need!

Replacement Orifices

Use these orifices to change the flow range for alternative sampling times. Interchangeable with Veriflo™ 423XL orifices.

Flow (sccm)	Orifice size	Siltek®-Treated cat.#	Stainless Steel cat.#
0.5–2	0.0008"	24219	24218
2–4	0.0012"	24233	24245
4–8	0.0016"	24234	24246
8–20	0.0020"	24235	24247
20–40	0.0030"	24236	24248
40–80	0.0060"	24237	24249



Siltek®
critical orifice

2µm Frit Filters

For use in critical orifice fitting. Includes washers.

Description	qty.	cat.#
Siltek® Replacement Frit Filter	3-pk.	24171
Stainless Steel Replacement Frit Filter	3-pk.	24170



Veriflo™ Flow Controllers

Veriflo™ 423XL flow controllers are offered in a Siltek® and a stainless steel version, with or without a critical orifice. (Vacuum gauge sold separately.) The critical orifice is interchangeable. Order replacement orifices or orifices for alternate sampling times separately.

Flow (sccm)	Orifice size	Siltek®-Treated cat.#	Stainless Steel cat.#
0.5–2	0.0008"	24232	24229
2–4	0.0012"	24255	24260
4–8	0.0016"	24256	24261
8–20	0.0020"	24257	24262
20–40	0.0030"	24258	24263
40–80	0.0060"	24259	24264
—	no orifice	24238	24239

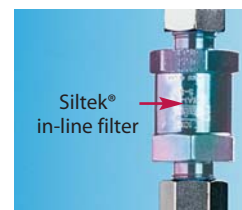


Veriflo SC423XL
flow controller

7µm In-Line Filter

This 316 stainless steel filter is designed to collect particles larger than 7 microns. We offer a Siltek® version and a stainless steel version.

Description	qty.	cat.#
Siltek® 7µm In-Line Filter	ea.	24265
Stainless Steel 7µm In-Line Filter	ea.	24266



Siltek®
in-line filter

Siltek® tee

2-Inch Vacuum Gauge

Restek's high-quality 2-inch vacuum gauge incorporates 316 stainless steel wetted surfaces.

Description	qty.	cat.#
2-Inch Vacuum Gauge; 1/8" NPT	ea.	24269
2-Inch Vacuum Gauge; 1/4" NPT	ea.	24270



High-quality
vacuum gauge

Three simple words...

Plus 1™

Exceeding your expectations in everything we do.

Innovation

Turning visions into reality.

Execution

On-time delivery of products and services.

Restek's vision is to be the company that chromatographers trust, by providing the highest quality, most innovative products and services throughout the world.

We will soon reach our goal of 100% employee ownership. As owners, our success depends on your success.



Lit. Cat.# 59977B
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