

Calscience Air Sampling Guide

A Guide to Whole Air Sampling
and Analysis



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1.0 Introduction

The purpose of this guide is to provide our clients with a resource for information on the collection and analysis of whole air samples. The introduction describes different types of air samples and sampling techniques, while the remainder of the document describes equipment and techniques for collecting and analyzing whole air samples.

1.1 Types of Air Samples

Air samples and sampling methods are typically categorized by the air or emissions source and/or by the type of pollutant measured. Common sources for air samples fall into five categories: indoor air, ambient air, stationary sources, soil vapor, and mobile sources (automobiles). Mobile source emissions are collected during the development and testing of vehicle engines, and are outside the scope of this document.

1.1.1 Indoor Air Samples

Indoor air samples are collected in all types of living and/or workplace environments, including industrial facilities, office buildings, and homes. Indoor air sampling is most frequently performed for worker safety and is regulated by the Occupational Safety and Health Administration (OSHA).

More recently, the migration of pollutants into confined indoor spaces via soil vapor has prompted indoor air sampling. OSHA, NIOSH (National Institute of Occupational Safety and Health) and/or EPA methods are typically referenced for collecting indoor air samples.

1.1.2 Ambient Air Samples

Ambient samples are collected from outdoor locations, usually in the vicinity of known or suspected sources of air pollutants at ambient temperature and humidity. Typical locations for ambient air sampling include soil remediation sites, landfills and manufacturing facilities.

1.1.3 Stationary Source Samples

Stationary source samples are also mainly collected outdoors, but may also occur at indoor locations in industrial settings. Stationary source samples are collected from a single point source of emissions, such as an exhaust stack. Typical locations for source testing include industrial boilers, various manufacturing facilities, power plants, and Soil Gas Vapor Extraction (SVE) and Landfill Gas (LFG) collection systems.

Regulatory agencies that have developed methods or guidelines for ambient and stationary source testing include EPA, CARB, DTSC, and various RWQCBs and AQMDs.

1.1.4 Soil Vapor Samples

Engineering investigations of possible soil and/or groundwater contamination often include the collection and analysis of soil vapor. Analysis of these whole air samples can occur both in the field (using mobile testing laboratories) and in fixed base laboratories. Although analytical methods have yet to be published specifically for soil vapor, ambient air methods are typically used.

1.2 Types of Pollutants

Air pollutants are categorized by the regulations controlling them and their chemical and physical properties. National air standards divide air pollutants into two categories:

- Criteria pollutants with established national regulatory limits: NO_x, SO_x, CO, lead, ozone, and particulate matter
- Hazardous Air Pollutants (HAPs), some of which have national, state or local regulatory limits: 189 compounds including Volatile Organic Compounds (69%) and Semi-Volatile Organic Compounds (19%)

HAPs, which are usually collected using whole air sampling, can be divided in the following categories based on their chemical composition and physical properties:

- Non-volatiles (metals and heavy organics, etc.) - BP>300°C
- Semi-volatile Organic Compounds (SVOCs) - BP 120-300°C
- Volatile Organic Compounds (VOCs) - BP<120°C

1.3 Air Sampling Media

This figure presents common air sampling media for organic compounds. Non-volatile and most SVOCs are present in air in a form that cannot be collected and analyzed using whole air sampling. Sampling for these compounds usually involves trapping the compounds on solid and/or liquid media, then extracting or desorbing the media for analysis.



Figure 1: Air Sampling Media^{1,4}

By comparison, whole air sampling, in which air samples are collected and analyzed in the gaseous phase, is a simpler technique. Whole air sampling is best suited for volatile, non-polar compounds and fixed gases. However, VOCs are also collected on solid sorbent materials (i.e., activated carbon), most often as part of industrial hygiene applications.

Some SVOCs with boiling points as high as 170°C can be collected using whole air sampling, depending on the temperature and reactivity of the sample matrix and the sampling media.

Generally, high-temperature, high moisture samples, such as those collected from exhaust stacks, require special sampling considerations to prevent losses due to condensation. Selection of whole air sampling media depends on a number of considerations. The two most commonly used media for whole air sampling are SUMMA canisters and Tedlar bags, both of which are discussed in greater detail in later sections.

1.4 Sampling Techniques

Collection of whole air sampling can be either active (requires a pump) or passive (no pump required). SUMMA canisters use passive sampling, in which a vacuum is used to draw air into the canister, whereas Tedlar bags use active sampling, in which a pump discharges sample into the bag.

Collection of whole air samples can be taken as a grab sample (taken over short period of time, usually < 5 minutes) or as an integrated sample (taken over a longer period of time, usually ½ hour to 24 hours).

1.4.1 Grab Sampling

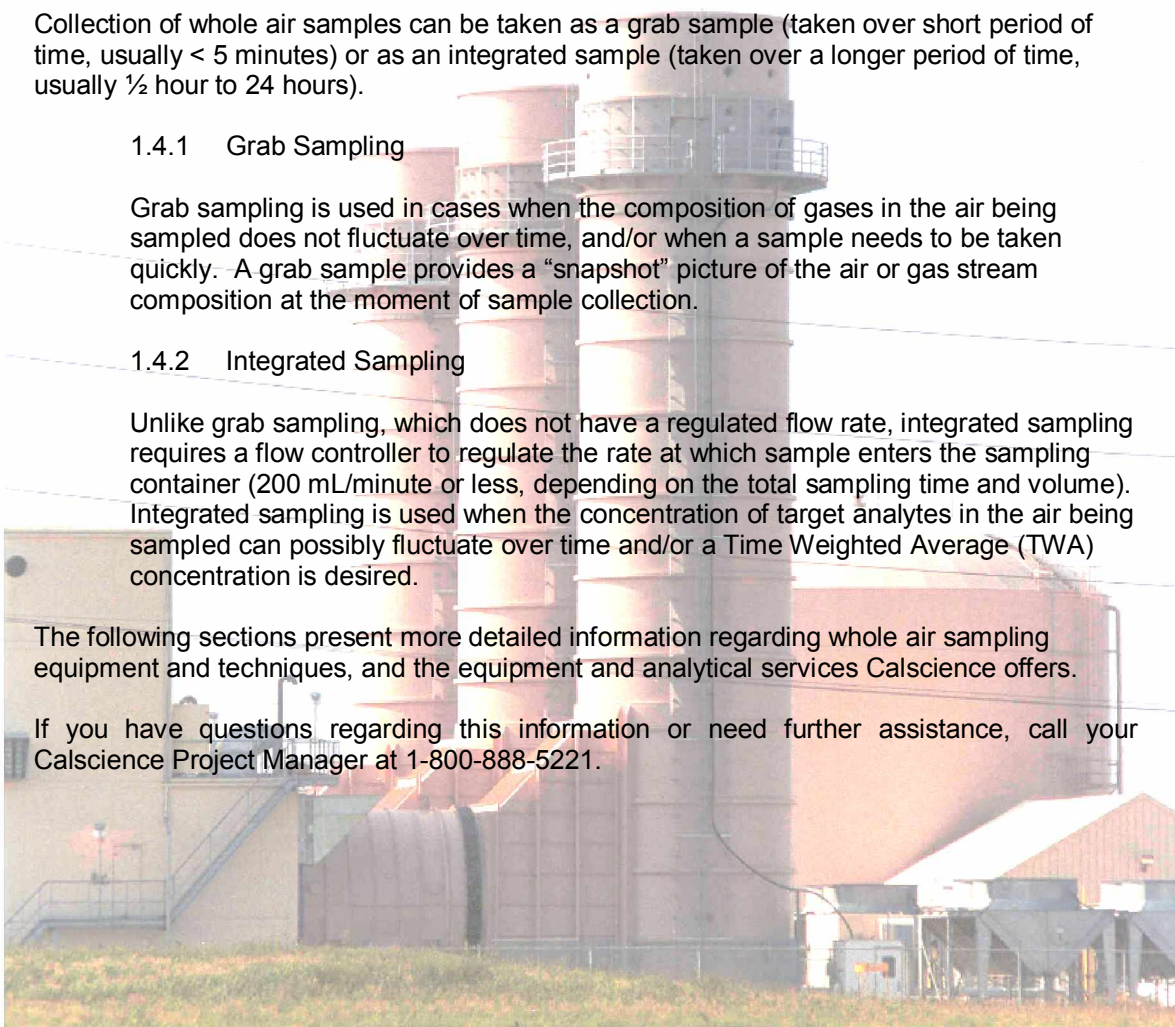
Grab sampling is used in cases when the composition of gases in the air being sampled does not fluctuate over time, and/or when a sample needs to be taken quickly. A grab sample provides a “snapshot” picture of the air or gas stream composition at the moment of sample collection.

1.4.2 Integrated Sampling

Unlike grab sampling, which does not have a regulated flow rate, integrated sampling requires a flow controller to regulate the rate at which sample enters the sampling container (200 mL/minute or less, depending on the total sampling time and volume). Integrated sampling is used when the concentration of target analytes in the air being sampled can possibly fluctuate over time and/or a Time Weighted Average (TWA) concentration is desired.

The following sections present more detailed information regarding whole air sampling equipment and techniques, and the equipment and analytical services Calscience offers.

If you have questions regarding this information or need further assistance, call your Calscience Project Manager at 1-800-888-5221.



2.0 Whole Air Sampling Media

Calscience provides sampling media and equipment for both grab and integrated sampling, including Tedlar bags and SUMMA canisters. In addition, specially cleaned and prescreened canisters are available for projects where low concentrations of constituents (low ppb or ppt) need to be quantified. The following describes the types of whole air sampling media currently offered by Calscience.

2.1 SUMMA Canisters

SUMMA canisters are stainless steel canisters with passivated interiors that have been electropolished to reduce the number of active sites for sample components to interact. These canisters can be used to collect TO-14A and TO-15 analytes, as well as fixed gases like methane, CO, CO₂, O₂ and N₂. Canisters are cleaned and analyzed for cleanliness prior to use, and may be cleaned and reused many times. Holding times for most analytes in SUMMA canisters has been shown to be stable for up to 30 days².

SUMMA canisters come in sizes ranging from 400 ml to greater than 6L. Calscience offers 1L and 6L SUMMA canisters. To the right is a schematic of a 6L SUMMA canister. Shown are the sample valve (1), inlet (2), and vacuum/pressure gauge (3). Alternatively, the gauge may be connected to a second sample valve. The inlet of the canister can be connected to the sample source by ¼ inch Swagelok fittings and Teflon tubing, or left open if sampling ambient air.

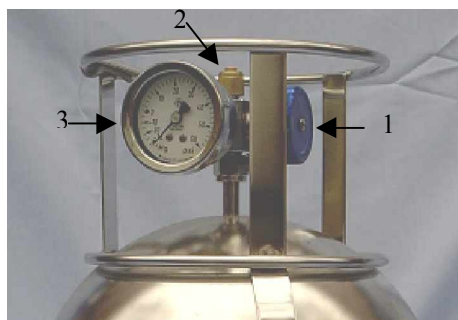


Figure 2: SUMMA canister

SUMMA canisters are completely evacuated prior to use. During sampling, the valve is opened and air is drawn into the canister through the inlet until the canister pressure has equilibrated with that of the source being sampled. The vacuum/pressure gauge is used to monitor the canister pressure, and indicates when there is an air flow problem or when sampling is complete.

2.2 Fused Silica-Lined SUMMA Canisters

Fused silica-lined (FSL) canisters were developed to collect reactive organic compounds not stable in SUMMA canisters. These canisters are made the same way as SUMMA canisters, but have been treated with an inert silica glass lining that extends the holding time for polar or oxygenated compounds such as MTBE and sulfur-containing compounds such as mercaptans. FSL canisters can be used to collect the same compounds as SUMMA canisters, as well as these additional compounds.

Many of the 1L and 6L canisters provided by Calscience are silica-lined.

2.3 High-Pressure Cylinders

A high-pressure cylinder is a thick-walled stainless steel container with an untreated interior and a valve at each end. These cylinders were originally designed for the petroleum industry to collect samples from pressurized lines. Silica-lined cylinders are used to collect sulfur and other reactive compounds such as formaldehyde. High pressure cylinders are not recommended for low (sub ppm) sample concentrations.



Figure 3: High-Pressure Cylinder

Calscience does not provide these cylinders, but can analyze samples collected in them in some instances.

2.4 Tedlar Bags

Tedlar bags consist of two layers of Tedlar film sealed together at the edges and a sampling valve. Since Tedlar is inert to most substances, it can be used to collect reactive and more stable organic compounds as long as all sampling components (including the valve) are non-metallic.



Figure 4: Tedlar Bags³

The holding time for most compounds in Tedlar bags varies depending on the compound, but is significantly less than that for canisters; typically one day or less for sulfur compounds, and three days for other compounds. Some regulatory agencies impose their own holding time criteria, which may be more conservative than those generally accepted by the industry.

Prior to use, VOC concentrations in Tedlar bags are generally low or not detectable (<1 ppbv). Conditioning bags prior to use by purging with nitrogen further reduces contaminants. Once a Tedlar bag has been used, however, it cannot be reused for low concentration (sub-ppm) sampling because the Tedlar may absorb VOCs, which can off-gas at a later time.

Tedlar bags come in a variety of sizes from <1L to 30L. Calscience stocks only 1L Tedlar bags, but can supply other sizes upon request.

Generally speaking, Tedlar bags are less expensive and easy to handle and transport, but have a short holding time and are fragile. SUMMA canisters have a much longer holding time and are more rugged, but are more expensive and cannot be used for more reactive compounds such as those containing sulfur and nitrogen unless they have been modified with an inert lining.

Finally, Tedlar bag sampling requires a pump, while SUMMA canister sampling does not. SUMMA canisters are completely evacuated prior to use, and utilize this vacuum to draw sample into the canister. This may be an important consideration at locations where portability or access to power is an issue. A summary comparison of Tedlar bags and SUMMA canisters can be found in Table 1 below.

Table 1: Summary comparison of SUMMA Canisters vs. Tedlar Bags

	SUMMA Canister	Tedlar Bag
Sampling Type	Passive (vacuum, no pump required)	Active (pump required)
Analysis Hold Time	~30 days (variable depending on analytes tested)	1-3 days
Surface Inertness	Excellent	Fair
Cleanliness	Individual or Batch Certified to <0.5ppbv; can be SIM Certified for lower RLs	VOCs may be present (low ppbv concentrations)
Advantages	Inert, rugged, long holding time, portable (no pump/air moving device required)	Shipping ease, low cost

3.0 Things to Consider Before Sampling

3.1 Sampling Conditions

Variations in temperature, pressure and moisture content of the air being sampled have a great effect on how samples are collected. Extremes in these conditions can compromise sample integrity and cause problems with sample collection.

3.1.1 Pressure

Negative Pressure - If the pressure at the sampling source is significantly negative (sample location is under vacuum), the vacuum in a SUMMA canister will not be sufficient to draw sample into the canister. In this case, it may be necessary to use a pump to collect the sample. If a sampling pump is required, it is important that all areas of the pump and sampling line exposed to the sample are clean and will not react with the sample in any way. In some instances, Tedlar bag sampling using a lung sampler may be more appropriate (see Section 5.0).

Positive Pressure – If the sampling location has a positive pressure, it may be necessary to reduce the pressure with a valve or regulator. At no time should a SUMMA canister be pressured to more than 40 psig.

3.1.2 Moisture

Modifications should be made for sample streams containing excess moisture (saturated or nearly saturated). Water vapor condenses in a canister or Tedlar bag, reducing the recovery of polar and non-polar compounds. Some test methods recommend the use of a condensate knockout. The solution collected in the knockout is then analyzed in addition to the whole air samples.

3.1.3 Particulate Matter

Excess particulate in a sampling stream will plug the inlet filter of SUMMA canisters and damage flow controllers and valves. Excess particulate should be removed prior to sample collection. All flow controllers and restrictors supplied by Calscience come with a particulate filter installed at the inlet (see Section 4.1.4).

3.1.4 Temperature

SUMMA canisters and Tedlar bags are designed to collect samples at near ambient temperature and should not be subjected to temperatures above 100°C or below 0°C. In addition, severe temperature swings will affect the flow rate of flow controllers, and should be avoided.

3.1.5 Altitude

The altitude at which samples are collected affects the local barometric pressure, which in turn affects gauge vacuum/pressure readings. A canister gauge that reads -29.9" Hg at sea level will read -25" Hg at 5000 ft elevation because gauges are calibrated to read at sea level. Generally speaking, every 1000-foot rise in elevation results in a 1" drop in gauge pressure.

Another consequence of the lower ambient pressure at higher elevations is that the volume of air a SUMMA canister will collect is reduced by approximately 1/5L for every 1000 ft. In other words, at 5000 ft the maximum sample volume a 6L canister can collect is 5L. A larger volume can be collected by using a pump; however, care must be taken to avoid contamination from the pump.

3.2 Quality Control

Some regulatory agencies (e.g. DTSC, LARWQCB) require additional canister samples be collected for QC purposes. A description of various QC samples is provided in Section 6.0.

3.3 Target Reporting Limits

There can be variation in reporting limits (RLs) for SUMMA canister samples depending on the final vacuum of the sample canister. Calculations for sample volumes, dilution factors, and final reporting limits are discussed in Section 7.0.

To ensure your sampling and analysis needs are met, please discuss the specific requirements of your sampling program with your Calscience Project Manager when ordering sampling equipment.

4.0 Canister Sampling

4.1 Sampling Hardware

4.1.1 Vacuum/Pressure Gauge

The gauge, which may be built into the SUMMA canister or attached using a separate valve, is used to monitor the vacuum in the SUMMA canister before, during, and after sampling.

The scale of the gauge ranges from -30" Hg to, generally, 30 psig. Gauges provided by Calscience are not designed for high accuracy pressure measurements; rather they are used for checking initial and final vacuums, and for observing relative change in vacuum/pressure readings.



Figure 5: Vacuum/Pressure Gauge

4.1.2 Brass Dust Cap

Each canister valve comes with a ¼ inch Swagelok brass cap attached to the inlet. The cap protects the canister from loss of vacuum and contamination during transport, and protects the threads on the valve inlet. The brass cap should be removed prior to sampling and replaced when sampling is complete.

4.1.3 Flow controllers (Integrated Sampling Only)

4.1.3.1 Critical Orifice

A critical orifice consists of a stainless steel fitting encompassing a ruby disk that has been precision drilled to create an opening through which air is drawn.



Figure 6: Critical Orifice⁴

The size of the opening determines how quickly air will pass through, and therefore, the sampling rate. Upstream of the orifice is a micro-filter (see Section 4.1.4) which protects the orifice from clogging.

The flow rate through a critical orifice is relatively constant until the canister pressure reaches about -5" Hg; beyond this, the flow significantly decreases. For more uniform sampling, a diaphragm flow controller is recommended. Calscience offers critical orifice flow controllers ranging from ½ hour to 8 hour sampling times for a 6L SUMMA canister.

4.1.3.2 Diaphragm Flow Controller

Diaphragm flow controllers combine a critical orifice with a flexible diaphragm to maintain constant sample flow over longer periods, regardless of changes in canister vacuum and environmental temperature.

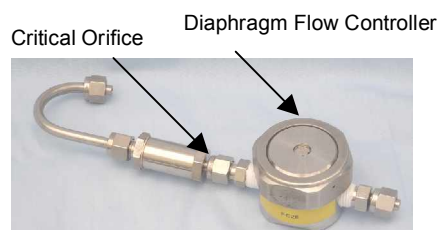


Figure 7: Diaphragm Flow Controller + Critical Orifice

The flow rate for a diaphragm flow controller can be adjusted by changing the size of the critical orifice installed in the controller. Some diaphragm controllers can be adjusted using a set screw to establish a flow to match the required sampling time (see Table 2 below). Calscience can provide diaphragm flow controllers for sampling up to 24 hours in a 6L canister.

Table 2: Flow rates (standard cubic centimeters per minute) and orifice sizes (inches) for varying sample times

Sampling Time		Flow	Orifice
1L	6L	(sccm)	size
4 hr	24 hr	2 - 4	0.0012"
2 hr	12 hr	4 - 8	0.0016"
1 hr	8 hr	8 - 20	0.0020"
-	3 hr	20 - 40	0.0030"
-	1 hr	40 - 80	0.0060"

4.1.4 Particulate Filter

Flow controllers are provided with a 2 or 7-micron filter, which is a stainless steel frit compressed into a Swagelok fitting. These filters are designed to prevent the flow controller from being damaged or plugged by particulate matter, without significantly restricting the sample flow.

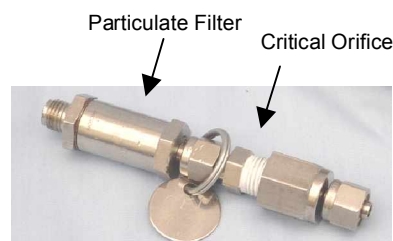


Figure 8: Particulate Filter + Critical Orifice

4.1.5 Tubing/Connecting Fittings

Teflon tubing equipped with ¼ inch Swagelok fittings is recommended for connecting canisters to sampling ports. Plastic tubing is not recommended since it can absorb VOCs, has severe memory effects, and is prone to cracking and breakage.

Teflon tubing is available on request.

4.2 Avoiding Sampling Problems

Following are some guidelines for collecting samples with canisters:

- Tighten fittings properly – Swagelok fittings are designed to be tightened ¼-turn past hand tight. Under or over-tightening may result in leaks in the sample train. In addition, over-tightening may deform the fittings, which then may need to be replaced.
- Verify gauge operation – Following grab sampling, check to see that the vacuum/pressure gauge reads near zero at ambient pressure. If it does not, it may be damaged and unusable.
- Eliminate sources of contamination – Return equipment between sampling events for cleaning. Use the shortest possible sample lines and purge them between uses. When tubing has been exposed to high concentrations in previous sampling, do not reuse it for sampling events in which low concentrations are expected.
- Adequately purge sampling ports and tubing prior to sample collection. Ambient air may be introduced into stationary source samples unless sample lines are purged prior to connecting with the canister or bag used to collect sample.

4.3 Steps for Collecting a Grab Canister Sample

Before you get to the field:

1. Make sure you have all the necessary equipment, including SUMMA canisters, gauges, tubing/accessories (if needed), and a 9/16-inch wrench. The figure below presents typical grab sampling equipment.



Figure 9: Air Sampling Equipment (canisters, tubing¹, nut & ferrule⁵, wrench)

2. If the vacuum/pressure gauge is not already attached, attach the gauge to the valve extending horizontally from the canister. Use a wrench to tighten ¼-turn past hand tight. Do not over tighten.
3. Read the vacuum/pressure gauge and record the initial vacuum reading on the chain-of-custody form. If the gauge is attached to a separate (horizontal) valve, you will need to open the valve. The vacuum should read between -28" and -30" Hg for most applications (see Section 3.1.5 for vacuum readings at high altitudes).

When you are ready to sample:

4. Check the canister gauge again to see that the vacuum matches the initial reading taken above. If it does not, there may be a leak, or the gauge may be defective.
5. Remove the brass dust cap from the top of the Summa canister.
6. If using sample tubing, attach it to the inlet of the SUMMA canister and tighten ¼-turn past hand tight. Do not over tighten.
7. To open valve and begin sampling, turn knob on valve counterclockwise one full turn.
8. Note start time. Complete sample label attached to the canister.

At end of sampling interval:

9. Once the vacuum reaches approximately -15" Hg, close the Summa canister valve by turning clockwise until snug. Do not over tighten.
10. After closing the valve, record the final vacuum of the canister gauge on the chain-of-custody form.
11. Remove tubing from the inlet to the canister, if present, and replace the brass dust cap.
12. Complete the chain-of-custody form and, after relinquishing, retain a copy.
13. Return the SUMMA canisters and vacuum/pressure gauges in the boxes or packages provided. Tape or secure the boxes or containers and return to Calscience.

4.4 Steps for Collecting an Integrated Canister Sample

Before you get to the field:

1. Follow steps 1-3 in Section 4.3. Make sure you have all the equipment mentioned in Section 4.3 plus flow controllers set to the desired flow rate.

When you are ready to sample:

2. Check the pressure gauge again to see that the vacuum matches the initial reading taken above. Remove the brass dust cap from the top of the Summa canister.
3. Attach the flow controller assembly to the top of the canister. Tighten the nut by turning ¼-turn beyond hand tight. Do not over tighten, as this may damage the ferrule fitting inside the flow controller and compromise the sampling effect.
4. If using tubing, connect to the inlet of the flow controller assembly and tighten fitting turning ¼-turn beyond hand tight. Do not over tighten.

5. To begin sampling, turn canister valve counter-clockwise one full turn.
6. Note start time. Complete sample label attached to the canister.
7. Monitor the canister vacuum periodically to ensure steady flow into the canister. If the canister vacuum nears 0" Hg before the end of the sampling time, sampling should be ended early to prevent bias toward the beginning of the sampling period.

At end of sampling interval:

8. At the end of the desired sampling time (approx. -5 inches Hg on gauge), close the canister valve by turning clockwise until snug. Do not over-tighten. If vacuum is much lower than -5" Hg, consider sampling longer (collecting more sample) to avoid elevated reporting limits.
9. After closing the valve, record the final vacuum of the canister gauge on the chain-of-custody form.
10. Disconnect tubing if used and remove flow controller assembly from the canister. Replace the brass dust cap and tighten.
11. Complete the chain-of-custody form and, after relinquishing, retain a copy.
12. Return the Summa canisters and flow controllers to the boxes or packages provided. Tape or secure the boxes or containers and return to Calscience.

5.0 Tedlar Bag Sampling

5.1 Sampling Equipment

Tedlar bag samples are collected using "active" sampling, in which the sample is discharged into the Tedlar bag by a pump. There are two types of samplers used for Tedlar bag samples: in-line samplers and lung samplers.

5.1.1 In-line Sampler

With in-line sampling, air is drawn in through a pump into the Tedlar bag at a low flow rate (<1/2 L/min.). This technique is most often used for indoor air sampling and is specified by some NIOSH and OSHA methods. The pumps used are portable and usually battery operated.



Figure 10: Tedlar Bag and In-line Pump¹

A disadvantage of this technique is the potential for sample contamination from the pump. If a pump has been used previously for a contaminated site, it must be cleaned thoroughly before being reused. While flushing for an extended period with nitrogen is usually effective, there is no guarantee the contamination has been removed unless a QC bag is collected and analyzed.

5.1.2 Lung Sampler

The sampling pump is connected to an airtight chamber large enough to hold the Tedlar bag. The valve opening on the Tedlar bag is connected to the sample source. The pump evacuates the chamber containing the Tedlar bag, causing sample to be drawn into the bag from the source. With the lung sampler, contamination issues from a pump (as mentioned in Section 5.1.1) are eliminated.



Figure 11: Lung Sampler¹

Calscience can provide Tedlar bags but does not provide pumps or lung samplers. Low flow in-line pumps and lung samplers can be rented or purchased from a variety of vendors.

5.2 Sampling Techniques

Both grab and integrated samples can be collected using Tedlar bags. Integrated samples can be collected by lowering the flow rate at which samples are collected, and/or by using larger bags. The pumps draw sample at a constant rate, so the major problem with sampling over longer periods is power loss or pump malfunction.

6.0 Quality Control

6.1 Equipment Cleaning and Calibration

Sampling media and equipment supplied by Calscience is either new or cleaned prior to use. Tedlar bags and tubing are supplied new. Tedlar bags used for low concentration sampling may be flushed and leak checked prior to use for a nominal fee.

Pressure gauges, filters, flow controllers and canisters are all heat cleaned and flushed with air prior to use.

After cleaning and prior to being sent to the field, flow controllers are leak checked and tested for proper flow using a calibrated flow meter.

All canisters receive either batch or individual testing (see Section 6.2) and are leak checked prior to use.

6.2 Canister Screening (Analysis)

One of every six canisters is analyzed by EPA TO-15 to check for contamination prior to field use; Calscience requires the target analytes' concentrations to be lower than 0.5ppbv. On request, individually screened ("certified") canisters can be provided. SIM screened canisters are also available for ultra low (ppt) concentration testing.

6.3 Blanks

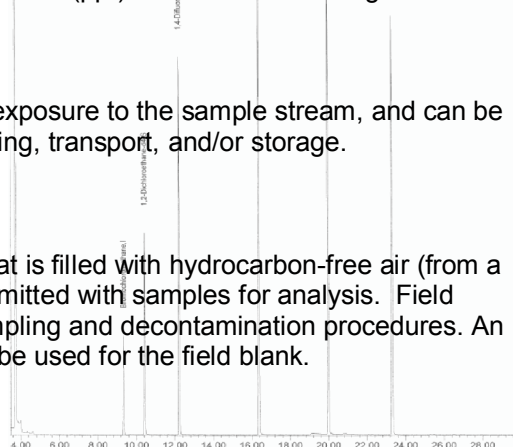
Blanks are samples that are kept free from exposure to the sample stream, and can be used to monitor contamination during sampling, transport, and/or storage.

6.3.1 Field Blank

A field blank is an empty canister that is filled with hydrocarbon-free air (from a certified source) in the field and submitted with samples for analysis. Field blanks are used to monitor field sampling and decontamination procedures. An individually screened canister must be used for the field blank.

6.3.2 Trip Blank

A trip blank is a canister that is filled with hydrocarbon-free air prior to being transported to the field. The canister is returned with sample canisters for analysis.



6.4 Duplicate and Split Samples

Duplicate samples are submitted to the same laboratory for analysis to assess sampling precision. Split samples are submitted to two separate laboratories to assess reproducibility and consistency between laboratories.

Field duplicate and split samples are usually collected simultaneously from a common inlet using a Swagelok tee to split the inlet stream. A less desirable approach is to collect duplicates and splits in sequence.

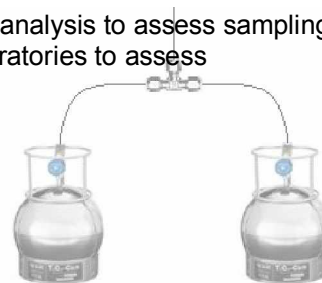


Figure 12: Split tee setup^{4,5}

6.5 Special Reporting Requirements (J Flags and TICs)

On request, trace concentrations ("J flags") and Tentatively Identified Compounds (TICs) can be reported. Trace concentrations are estimated values that are below the laboratory Reporting Limit (quantitation limit) but are greater than or equal to the Method Detection Limit (MDL).

When TICs are requested, unidentified peaks found in the sample are tentatively identified using a GC/MS library search. Because no standards are used, identification of these peaks is tentative and concentrations reported are estimates.

7.0 Reporting Limits, Units and Conversion Factors

7.1 Reporting Units and Unit Conversions

Units used for reporting analysis results are chosen based on convenience and regulatory requirements. Most often, whole air sample concentrations are measured and reported in units of parts per million, ppm (v/v), and parts per billion, ppb(v/v). Sometimes ppmv and ppbv are used. The “v/v” indicates reporting is on a volume per volume basis.

Regulatory agencies sometimes require that results be reported in other units, such as $\mu\text{g}/\text{m}^3$ and $\mu\text{g}/\text{L}$. Conversions to these mass-based units are not as straightforward as for soil and water, as corrections must be made based on temperature and molecular weight using the ideal gas law.

Extreme caution should be used in converting units for laboratory data; unit conversions for air are the most commonly occurring error in the industry.

Following is an example of a typical conversion from ppb to $\mu\text{g}/\text{L}$ at 1 atmosphere (ATM) and 25°C, for an MTBE concentration of 100ppbv:

$\mu\text{g}/\text{L} = \text{ppb} \times \text{g mol}/\text{L} \times \text{MW} \times 10^6 \mu\text{g}/\text{g}$, where:

g mol = gram moles

MW = molecular weight (g/g mol)

1 ppbv = $1\text{L}/10^9 \text{L}$; 100ppbv = $100\text{L}/10^9 \text{L}$;

$100\text{L}/10^9 \text{L} \times 1 \text{g mol}/24.04 \text{L} \times 88.15 \text{g}/\text{g mol} \times 10^6 \mu\text{g}/\text{g} = 0.366 \mu\text{g}/\text{L}$

Most analytical results are reported at Standard Temperature and Pressure (STP). Standard pressure is 1 ATM. Standard temperatures vary depending on the regulatory agency; for example, EPA often uses 68°F (20°C) as standard, while OSHA uses 77°F (25°C) as standard.

Table 3 below gives conversion factors for the most commonly used reporting units at 25°C and 1 ATM.

Table 3: Conversions for commonly used reporting units

Starting unit	Conversion factor	Ending unit
ppbv	*MW/24.46	$\mu\text{g}/\text{m}^3$
$\mu\text{g}/\text{m}^3$	*24.46/MW	ppbv
$\mu\text{g}/\text{L}$	*1000	$\mu\text{g}/\text{m}^3$
$\mu\text{g}/\text{m}^3$	/1000	$\mu\text{g}/\text{L}$
ppbv	/1000	ppmv
ppbv	(*MW/24.46)/1000	$\mu\text{g}/\text{L}$

7.2 Reporting Limits

Tedlar bag samples generally do not require dilution for analysis unless the concentration of a target analyte exceeds the calibration range. In these cases, the RLs for other analytes not detected in the sample will be elevated.

SUMMA canisters often require dilution on receipt by the laboratory regardless of analyte concentration. Because the pressure of a SUMMA canister sample received by the laboratory is often slightly negative (approx. -5" Hg), dilution gas is added until a final pressure of 5 psi is reached. The resulting dilution factor, known as pressurization factor, must be used to calculate final sample concentrations.

The final reporting limit for a specific analyte would be calculated as:

Final RL = nRL x PF x DF, where:

nRL = normal laboratory reporting limit

PF = pressurization factor (dilution due to pressurization)

DF = dilution factor (for dilutions due to high sample concentrations)

The Pressurization Factor (PF) would be calculated as follows:

$$PF = \frac{14.7 \text{ psig} + AP \text{ psig}}{14.7[1 - (RV / 29.9 \text{ inHg})]}$$

AP = analysis pressure

RV = vacuum of received can (in. Hg)

Table 4 below shows the relationship between the final vacuum of a canister (as received by the laboratory) and PF, based on a final analysis pressure of 5 psig.

Table 4: Pressurization Factors, based on the received vacuum of canisters

Final Vacuum (in. Hg)	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
PF	2.01	1.92	1.83	1.75	1.68	1.61	1.55	1.49	1.44	1.39	1.34

Table 5 below shows Calscience’s typical RLs for some of the TO-14A/TO-15 analytes. These RLs, which are presented without dilution, are periodically subject to change, so we suggest checking with your Calscience Project Manager to verify these values prior to testing.

Table 5: Reporting limits for a standard TO-15 list, in ppbv and ug/m³

Compound	RL (ppb)	RL (ug/m3)	Compound	RL (ppb)	RL (ug/m3)
1,1,1-Trichloroethane	0.50	2.7	c-1,2-Dichloroethene	0.50	2.0
1,1,2,2-Tetrachloroethane	1.00	6.9	c-1,3-Dichloropropene	0.50	2.3
1,1,2-Trichloro-1,2,2-Trifluoroethane	1.00	7.7	Carbon Disulfide	0.50	1.6
1,1,2-Trichloroethane	0.50	2.7	Carbon Tetrachloride	0.50	3.1
1,1-Dichloroethane	0.50	2.0	Chlorobenzene	0.50	2.3
1,1-Dichloroethene	0.50	2.0	Chloroethane	0.50	1.3
1,2,4-Trichlorobenzene	1.00	7.4	Chloroform	0.50	2.4
1,2,4-Trimethylbenzene	1.00	4.9	Chloromethane	0.50	1.0
1,2-Dibromoethane	0.50	3.8	Dibromochloromethane	0.50	4.3
1,2-Dichloro-1,1,2,2-Tetrafluoroethane	2.00	14	Dichlorodifluoromethane	0.50	2.5
1,2-Dichlorobenzene	0.50	3.0	Ethylbenzene	0.50	2.2
1,2-Dichloroethane	0.50	2.0	Hexachloro-1,3-Butadiene	1.00	10.7
1,2-Dichloropropane	0.50	2.3	Methylene Chloride	10.00	34.7
1,3,5-Trimethylbenzene	0.50	2.5	Methyl-tert Butyl Ether (MTBE)	2.00	7.2
1,3-Dichlorobenzene	0.50	3.0	o-Xylene	0.50	2.2
1,4-Dichlorobenzene	0.50	3.0	p/m-Xylene	1.00	4.3
2-Butanone	1.00	2.9	Styrene	1.00	4.3
2-Hexanone	1.00	4.1	t-1,2-Dichloroethene	0.50	2.0
4-Ethyltoluene	0.50	2.5	t-1,3-Dichloropropene	1.00	4.5
4-Methyl-2-Pentanone	1.00	4.1	Tetrachloroethene	0.50	3.4
Acetone	2.00	4.7	Toluene	0.50	1.9
Benzene	0.50	1.6	Trichloroethene	0.50	2.7
Benzyl Chloride	1.00	5.2	Trichlorofluoromethane	0.50	2.8
Bromodichloromethane	0.50	3.4	Vinyl Acetate	1.00	3.5
Bromoform	0.50	5.2	Vinyl Chloride	0.50	1.3
Bromomethane	0.50	1.9			

Note that this table does not represent the complete list of compounds Calscience can determine. Reporting limits for many of these compounds can also be lowered substantially by operating in SIM mode, and if SIM-certified canisters are used. To ensure your analysis needs are met, please discuss the specific requirements of your project with your Calscience Project Manager.

References

1. SKC Inc. <www.skcinc.com>
2. Brymer, D.A., Ogle, L.D., Jones, C.J., and Lewis, D.L. (1995) Viability of Using SUMMA Polished Canisters for the Collection and Storage of Parts per Billion by Volume Level Volatile Organics. *Environmental Science & Technology*, 30(1), 188-195.
3. Environmental Supply Company, Inc. <www.environsupply.com>
4. Restek Corporation <www.restek.com>
5. Swagelok Company <www.swagelok.com>

Additional Sources of Information

- U.S. Environmental Protection Agency (EPA) <www.epa.gov>
- National Institute for Occupational Safety and Health (NIOSH) <www.cdc.gov/niosh/>
- Occupational Safety and Health Administration (OSHA) <www.osha.gov>
- South Coast Air Quality Management District (SCAQMD) <www.aqmd.gov>