Collection of Air Samples for LEED v4 and v4.1 Indoor Air Quality Assessment and Indoor Air Quality Investigations

BkA Guide 19-02
June 2019

Introduction

This guide is intended for LEED v4 and v4.1 Indoor Air Quality assessments and for other Indoor Air Quality (IAQ) investigations. It covers air sampling onto commercial DNPH cartridges for subsequent laboratory analysis of formaldehyde and acetaldehyde by High Performance Liquid Chromatography (HPLC) and air sampling of volatile organic compounds (VOCs) onto sorbent tubes for subsequent laboratory analysis of individual and total VOCs (TVOC) by thermal desorption GC/MS. Establishing an appropriate sampling strategy is the critical first step to achieving the study's objectives. Additionally, field air samples must be collected properly to obtain meaningful results.

This guide includes procedures for the control and monitoring of the sampling process, and also for minimizing sources of contamination. The guide refers to ASTM D5197, Standard Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology), and U.S. EPA Method TO-17, Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling onto Sorbent Tubes.

Sampling Strategy

1. For LEED v4 and v4.1 IAQ assessments, testing locations are to be selected that have the least ventilation with potentially the greatest concentration of VOCs and other air contaminants. The number of testing locations to be selected depends upon the size of the building and the number of ventilation systems but must include all occupied spaces. The measuring equipment is to be positioned in the breathing zone, between 3 and 6 feet (0.9 – 1.8 m) above the floor. The test shall occur during normal occupied hours with the HVAC system starting at the normal start time and delivering outdoor air at the minimum rate. An IAQ test report shall include two major elements:

    - Narrative describing procedures and how locations were determined
    - Dates, times and results of each test

    There are significant changes in VOC testing requirements between LEED v4 and LEED v4.1. With LEED v4.1, the contaminant list has been shortened to consist of only 12 VOCs (including formaldehyde) with defined threshold concentration limits that must be met; however, the TVOC limit has been removed. Exemplary performance is offered to projects that test for all of the target VOCs specified in CDPH Standard Method v1.2- 2017, Table 4-1 and that do not exceed the full CREL levels for these compounds. The maximum allowable concentrations of formaldehyde, acetaldehyde, and other VOCs can be found in USGBC LEED v4.1

Building Design and Construction April 9, 2019, EQ Credit: Indoor Air Quality Assessment Table 2, page 127 (https://new.usgbc.org/leed-v41).

2. For other building IAQ investigations, it is recommended that air samples be collected from several indoor locations and from one outdoor location or one indoor location as a reference. If you are investigating a complaint building, you may consider collecting samples from the areas in the building with the highest complaint levels and at least one sample from an area in the building with a low complaint level to serve as a control. An outdoor sample may be collected to serve as a background reference. The outdoor location should be carefully selected to be representative of the ventilation air entering the building. For example, avoid hanging samplers immediately outside of open windows since air may be flowing out of the building at the windows.
3. If a measure of sampling and analysis precision is required, collect two samples at one or more locations. These duplicate samples ideally should be co-located and collected simultaneously.
4. It may be desirable to have a field blank in addition to an outdoor reference sample. Often only one blank sample is needed per building. The blank sampler should be unopened, but handled, transported and stored identically to the other samplers.

Descriptions of the Samplers

1. We recommend using Sep-Pak® XPoSure™ Aldehyde Samplers (Part No. WAT047205, Waters Corp) as these samplers are designed for air sampling with a very small pressure drop in vacuum sampling mode (20" water). They come with a manufacturer's 'Certificate of Analysis' and have low background levels of formaldehyde, acetaldehyde and acetone. XPoSure samplers are packed with 350 mg of acid treated 500-1000 µm chromatographic grade silica, coated with 1.0 mg of purified 2,4-dinitrophenylhydrazine (DNPH). It is recommended that the female Luer end serve as the air inlet end during sampling. BkA may be able to supply samplers in small quantities (inquire in advance).

2. The multi-sorbent samplers (Custom order, Markes International) for VOCs consist of a 3 ½ inch (90 mm) long by ¼ inch (6.4 mm) passivated stainless-steel tubes packed with two sorbent materials. At the inlet, there is a section of Tenax™ TA (60/80 mesh), ~125 mg; this is backed up with a section of a carbon molecular sieve (60/80 mesh), ~100 mg. There is one engraved ring at the inlet end. The air sample ***must*** enter the sampler from the engraved ring end then escape through the other end connected to a vacuum pump. ***Reverse installation will result in a blank/false sample***. Each sampler has a unique identification number (alpha-numeric) engraved on the body of the sampler. This number should be used to identify the sampler in logs and on the chain-of-custody (COC) form.

Handling, Storage and Transport

1. For long-term storage prior to use of the aldehyde samplers, keep the factory sealed pouches in a refrigerator at 4° C. The shelf life of the samplers is 12 months according to the technical data sheet. For short-term storage, the sealed pouches may be kept at room temperature (20-25° C). After sample collection, tightly reseal the sampler with the Luer cap and plug. Place the sampler in the re-sealable foil-lined pouch and label the outside of the pouch. If possible, use a refrigerator for storage of collected samples. Properly resealed samplers can be stored prior to analysis for two weeks at room temperature, or longer if refrigerated. However, it is best to return the samplers to BkA for analysis as soon as possible after the collection of samples.
2. When storing, transporting and shipping the Multi-sorbent VOC samplers, make sure that they are well isolated from aldehyde samplers as the aldehyde samplers can be a source of acetonitrile contamination. At a minimum, it is recommended that capped multi-sorbent samplers and aldehyde samplers be contained in separate, sealed polyethylene bags.
3. Avoid subjecting Multi-sorbent VOC samplers to elevated temperatures such as might occur in closed vehicles parked in the sun. It is recommended that these samplers be transported and shipped in a cooler using an ice pack to keep the samplers cool. Return the samplers to BkA for analysis as soon as possible after the collection of samples.
4. Multi-sorbent samplers typically can be handled with ungloved hands. However, care must be taken to avoid contamination. For example, if your hands are dirty, oily or treated with hand lotion, wash them and/or use gloves. Clean white cotton or nylon gloves are recommended. Hold the samplers by the middle and try to minimize touching the ends near the openings. Do ***not*** attach labels directly to the samplers as these labels are a source of contamination. Also, do ***not*** write on the acrylic tubes with marking pens as these tubes are reused. If it is necessary to put labels on the outside of the acrylic tubes, please be sure that these are easy to remove and do not leave an adhesive residue.
5. When submitting samplers to BkA for analysis, be sure to clearly indicate what services are desired. An IAQ services Chain-of-Custody Record is available from BkA website (https://berkeleyanalytical.com/forms) for submitting samples.

Sampling Apparatus

1. If possible, draw air directly into the VOC or aldehyde sampler to avoid connecting tubing to the inlet of the sampler. The only types of tubing that are acceptable for use upstream of the sampler are clean Teflon, stainless steel and copper. Prior to use, any inlet tubing should be cleaned by flushing it with methanol and then thoroughly dried.
2. All samplers should be connected upstream of the sample pump. In some cases, the sampler can be connected directly to the inlet of the pump. Often it is desirable to locate the sampler away from the pump and connect the sampler to the pump

with tubing. For aldehyde samplers, Luer fittings with hose barbs suitable for small diameter flexible tubing are available from Cole-Parmer Instrument Co., Chicago, IL.

3. Most field investigators use battery-operated personal sampling pumps for sample collection. The recommended aldehyde samplers have relatively low pressure drops and are suitable for use with this type of pump. These pumps and sampling pump accessories can be purchased or rented from industrial hygiene supply houses. Please see Figures 1 and 2 showing typical air sampling assembly including personal sampling pump (SKC AirChek Touch Pump) with both single tube and tri-tube holders. This kit can be rented through SKC, Inc., which has several offices in the U.S. (https://www.skcinc.com/catalog/infopage.php?id=8000).

Ozone Scrubber for Aldehyde Sampling

1. Ozone reacts with the carbonyl-hydrazone derivative and can result in a significant negative interference for formaldehyde and other carbonyls when using the aldehyde sampler. This is a particularly important consideration when sampling outdoors in locations with high ozone concentrations.
2. A scrubber can be used upstream of the aldehyde sampler to remove ozone from the sample-gas stream. It is most convenient to use Sep-Pak Ozone Scrubbers (Part No. WAT054420, Waters Corp.). Each ozone scrubber cartridge contains 1.4 grams of granular potassium iodide. When air containing ozone is drawn through this packed bed, iodide is oxidized to iodine, consuming the ozone.

Sample Volume and Airflow Rate

1. Aldehyde sampling volume and airflow rate
   - The minimum sample volume for aldehyde sampling is determined by the sensitivity of the analytical system, the blank level and the concentration of the target compound(s). Blank values for aldehyde samplers are <50 ng of formaldehyde per sampler and typically are around 20 ng. A sample volume of 60 L produces a lower limit of quantitation of about 1 ppb for formaldehyde assuming a blank value of <20 ng and using the criterion that the mass collected should be at least four or five times the mass of the blank.
   - Approximately 75 µg of formaldehyde will consume one half of the DNPH on the sampler which is a safe upper limit for DNPH depletion. This is equivalent to a formaldehyde concentration of about 1.0 ppm for a 60 L sample. However, the maximum safe sample volume is determined by the combined concentration of all of the carbonyl compounds in the sampled air. Therefore, if there are significant concentrations of other carbonyl compounds such as acetone present (ppm levels), it will be necessary to use a smaller sample volume to prevent DNPH depletion and sample breakthrough (typically not an issue in building investigations).
   - Each new aldehyde sampler contains residual acetonitrile which is used as the solvent in the coating of the silica with DNPH. During sampling, this acetonitrile is volatilized. If air samples also are being collected for the analysis of VOCs, the acetonitrile emitted to the air may contaminate the VOC samples. Berkeley Analytical excludes the acetonitrile peak in the analysis of field collected VOC

samples. To prevent this contamination, a charcoal tube may be attached to the exit of the pump to trap the acetonitrile.

- Airflow rates for aldehyde samples typically are in the range of 0.125 to 1.5 L/min. The lower airflow rates can be used to collect integrated samples over longer time intervals. Collection efficiencies are greater than 95 percent within this airflow rate range.
- For LEED v4 and v4.1 indoor air quality assessment, a 60-L air sample collected at 0.5 L/min for 120 min (2 h) is recommended (Table 1).

2. VOC sampling volume and airflow rate

- The correct sample volume for VOC sampling depends upon the concentrations of individual VOCs in the space being sampled. The analytical system has exceptional sensitivity, but limited range. Therefore, it is important to avoid collecting a sample volume that is too large and that may result in overloading of the GC/MS system and in the loss of data for the sample. For most investigations conducted in office buildings or homes, the optimal sample volume is 5 – 6 L, or less. The same volume can be used for outdoor samples. This volume produces lower limits of detection for many individual VOCs that are 1 to 2 µg/m^3, or <0.5 ppb for many compounds. If there is reason to suspect that the TVOC concentration exceeds several mg/m^3, then a correspondingly smaller sample volume should be used. Examples are sampling locations with recent use of solvent-containing products or with strong odors due to VOCs. In situations in which there is uncertainty about the concentration, at least two samples of different volumes should be collected. For example, volumes of 1 and 5 L typically would cover the situation in which the concentration of TVOC could range up to about 10 mg/m^3. Please consult with BkA if you have questions regarding the selection of a sample volume.
- The VOC sampling airflow rate can range from a low of about 10 cm^3/min up to about 200 cm^3/min. If it is desired to measure the integrated concentration of VOCs over an eight-hour work day, a sample airflow rate of 10 cm^3/min results in a 4.8-L sample volume. The maximum airflow rate is limited by the pressure drop across the sampler and the capacity of the sampling pump.
- For LEED v4 and v4.1 indoor air quality assessment, a 6-L air sample collected at 50 cm^3/min for 120 min (2 h) is recommended (Table 1).

Airflow Rate Measurement and Leak Checking

1. The sampling system should be checked for air leaks prior to use, preferably with the sampler in place. With some types of pumps, this can be accomplished by capping the inlet of the sampler and checking that the airflow rate at the outlet of the pump drops to zero.
2. It is imperative to know the airflow rate of air through the sampler and the sampling interval elapsed time in order to calculate the sample volume. For highest accuracy and precision, the airflow rate through the sampler should be maintained at a constant rate and monitored continuously, or at least frequently, during sampling. These objectives are best accomplished using electronic mass flow controllers in

combination with a vacuum pump or a calibrated personal sampling pump. Alternately, a pump with integrated flow control or a separate needle valve may be used to maintain constant airflow rate.

3. The airflow rate through each sampler should be measured during sampling. For airflow regulation schemes other than those using individual electronic mass-flow controllers, it is necessary to directly measure the airflow rate. At a minimum, this measurement should be made both near the beginning and the end of the sampling interval. If possible, the measurement should be made downstream of the sampler, preferably at the outlet of the pump. For downstream measurements, a bubble flow meter, positive displacement device, or a calibrated rotameter may be used. If the measurement must be made upstream of the sampler, briefly attach a calibrated rotameter with an appropriate range to the inlet of the sampler. ***Do not attach a bubble flow meter upstream of the sampler as this will contaminate the sampler.*** Additionally, record the air temperature and the atmospheric pressure so that the airflow rate can be converted to standard indoor conditions (*i.e.*, 25° C, 1 atm). Appropriately sized rotameters can be purchased from Cole-Parmer – 150-mm correlated flowmeter w/o valve, 60.5 cm^3/min for VOC sampling (P/N EW-03267-02) and 2313 cm^3/min for aldehyde sampling (P/N EW-03267-20).

Sample Collection for LEED v4 & 4.1 IAQ Assessment

1. A typical indoor air sampling assembly for LEED v4 and v4.1 indoor air quality assessment is shown in Figure 3. The assembly includes:
   - Tripod used to position air samplers in the breathing zone, 3 to 6 feet above the floor
   - Battery-powered sampling pump (500 to 5000 mL/min)
   - Constant pressure controller (CPC) 20” water
   - Tygon Tubing with Luer fittings as required
   - Adjustable low flow Tri-tube manifold (5 to 500 mL/min) which holds two multi-sorbent tubes and one aldehyde sampler. If using single low flow tube holder, two tripods with two pumps are recommended to sample VOCs and aldehydes simultaneously.
2. Recommended procedures:
   - If the Tri-tube manifold is used, set the sampling pump to approximately 800 cm^3/min to accommodate sampling flow of two sorbent tubes at ~50 cm^3/min each and one aldehyde sampling flow at ~500 cm^3/min. If the single low flow tube holder is used, set the sampling pump to the desired airflow rate.
   - The sampling report should record the sampling date, the sampling locations, the start and end times of the sampling intervals, the sampling airflow rates near the beginning and end of the sampling intervals, the average sampling airflow rates for the sampling intervals, and the sampling location temperatures and the atmospheric pressure (See attachment – LEED v4 & v4.1 Indoor Air Quality Sampling Log).

- The samplers need to be warmed to room temperature before use. Retain all of the sampler caps, plugs and tubes as they are needed to reseal the samplers.
- Check the sampling airflow rates near the beginning and end of the sampling intervals using appropriately-sized rotameters.
- After sampling, tightly reseal each aldehyde sampler with the Luer cap and plug, place the sampler in the reusable foil-lined pouch and label the pouch with the sample identification. Tightly reseal each VOC sampler inside its tube container. Do not overtighten the caps as this will damage the seals. Record the sampling information in a chain-of-custody form including the number printed on the tube. ***Do not write on the body of the sampler or attach labels to the sampler.***
- A photographic record of the sampling set up at each sampling location is recommended.
- See attachment – IAQ Air Sampling Assembly and Shipping Instructions

Other Sampling Precautions

1. Do not expose samplers used outdoors to direct sunlight. Aluminum foil can be used to make a simple sun shield.
2. If possible, avoid collecting samples in the rain or in very high humidity situations. The VOC sampler will collect excess water vapor, which may result in the loss of the sample during GC/MS analysis. If such a sampling situation is unavoidable, be sure to indicate the humidity conditions on the sample COC form as excess humidity can be removed in the laboratory by purging with dry helium prior to an analysis.

Table 1. Suggested sampling airflow rates and volumes

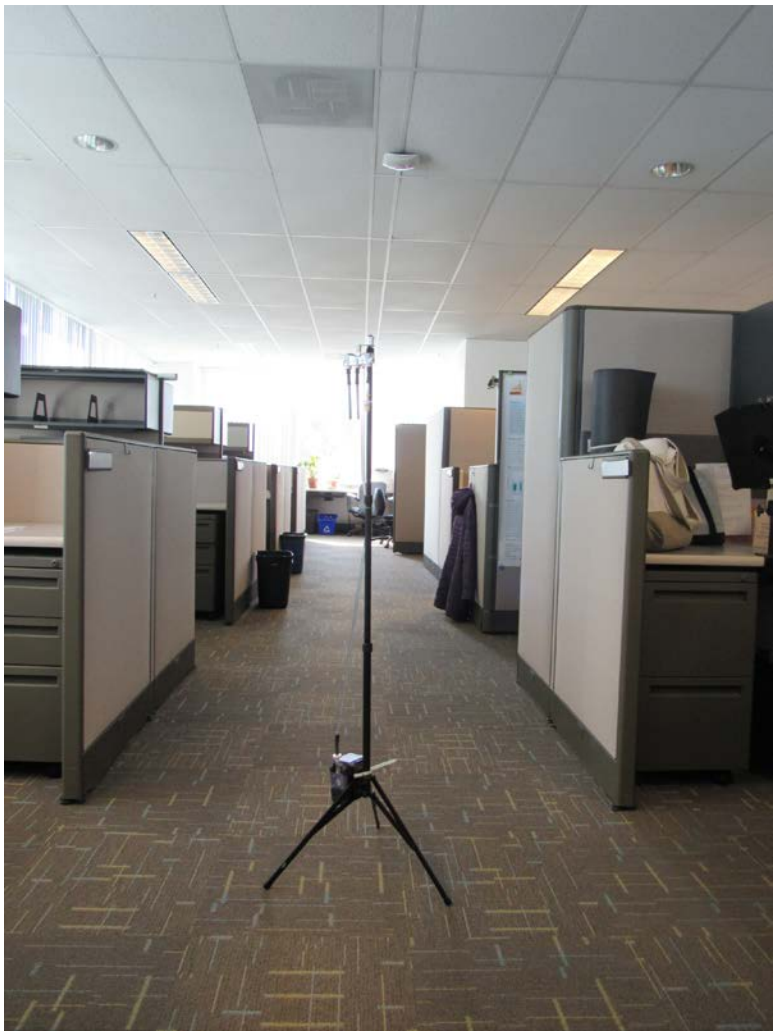
Project Type	Aldehyde Sampling			VOC Sampling		
	Airflow Rate, cm^3/min	Duration, Min	Volume, L	Airflow Rate, cm^3/min	Duration, Min	Volume, L
IAQ Investigation (8-h day)	125	480	60	10	480	4.8
LEED v4 & v4.1 (2 h)	500	120	60	50	120	6
LEED v4 &v4.1 (1 h)	1000	60	60	100	60	6

*For LEED v4 and v4.1 Indoor Air Quality assessment, the 4-h minimum sampling time required in LEED 2009 is removed.

Figure 1. Air Sampling Assembly Using SKC AirChek Touch Pump, CPC, and Tri-tube manifold

Figure 2. Air Sampling Assembly of SKC AirChek Touch Pump, CPC, and Single Tube Holder

Figure 3. A sampling tripod was set up in an open plan office.



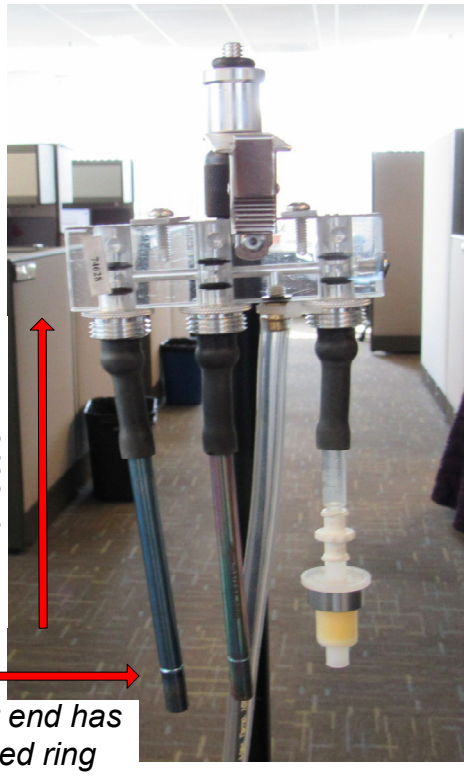
Attachments:

1. IAQ Air Sampling Assembly and Shipping Instructions
2. LEED v4 & v4.1 Indoor Air Quality Assessment Sampling Log (Example)

berkeley analytical

chemistry • testing • compliance

IAQ Air Sampling Assembly and Shipping Instructions



Sampling airflow direction

Air inlet end has grooved ring

***Airflow check using correlated flowmeters is recommended at beginning and near the end of air sampling*

***Please pay attention to VOC sampler installation. Reverse installation will cause blank/false sample.*

Pack and ship your sampling media:

1. *Multi-sorbent tube samplers*
2. *Aldehyde cartridge samplers*
3. *Complete Chain-of-custody form*
4. *Pack in a cooler with one ice pack*

Ship FedEx or UPS Standard Overnight to:

Berkeley Analytical
Attn: Sample Custodian
815 Harbour Way South, Unit 6
Richmond, CA 94804 USA

Please email us for assistance: info@berkeleyanalytical.com or call 510-236-2325

LEED v4 & v4.1 Indoor Air Quality Assessment Sampling Log (Example)

Project No.
Field Technician:
Signature:
Date:

Date	Location	Sampler ID/Tube#	Sampling Interval & Duration			Airflow Rate, Units ( )			Room Air	
			Start Time	End Time	Pump Run Time	Start	End	Average	Units ( )	Units ( )
									Temperature	Pressure