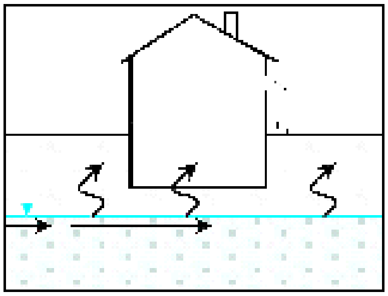

# Sub-Slab Vapor Sampling Procedures

**RR-986** **July 2014**

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## I. Introduction

Collection of vapor samples in order to assess the vapor intrusion pathway has become a routine part of contaminated site investigations for environmental consultants in Wisconsin. When conditions indicate chemical vapors may be accumulating beneath a building, measuring the vapor concentrations is critical to understanding whether the building is at risk of vapor intrusion and to designing a vapor mitigation system, if one is needed. This guidance discusses installation of sub-slab vapor ports, leak testing of ports and the sample train, sample collection, sampling to rule out vapor intrusion and reporting results.

Prior to collecting vapor samples, a work plan should be prepared. Ch. NR 716.09(2)(f), Wis. Adm. Code, requires that the work plan document the sampling methods, parameters analyzed, procedures used to prevent cross-contamination, the quality control/quality assurance program used to collect environmental samples, along with other requirements.

For information on assessing the vapor intrusion pathway, soil vapor, indoor and outdoor air sampling, and many other topics, please see the Department's vapor intrusion website and guidance, Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin (RR-800).

## II. Installing Sub-Slab Ports

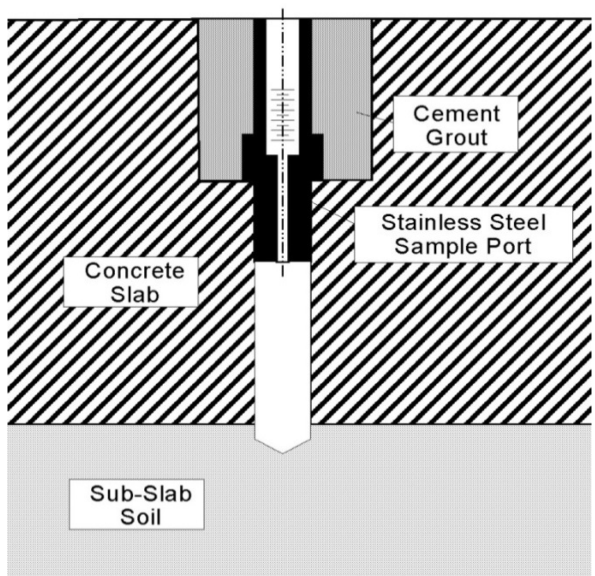
Sub-slab ports consist of drilling a small hole through a building foundation into the underlying soil. A brass or stainless steel probe is placed in the hole and an airtight seal is created around the metal probe. The sealing material can be cement grout or other non-chemical reacting sealing material. Probes with pre-manufactured silicon seals that are hammered into the probe hole are also acceptable. The goal is to allow collection of a sub-slab vapor sample while preventing any air leakage around the probe. Probes should be protected from any traffic that would dislodge the probe. In most cases, the probe should be constructed to allow for multiple samples over several months and securely sealed to prevent additional vapor intrusion. Flush mount covers or counter sunk caps are preferable.

Figure 1 is an illustration of a sub-slab probe. Installation involves drilling a small hole (~5/8" diameter) through the foundation into the sub-slab soil, then over drilling the pilot hole to create a 1" diameter hole about 1" to 2" deep into the foundation (the holes can be drilled in reverse order). This creates a ledge for the sampling probe and allows the concrete or other sealing material to be placed around the metal probe. The thickness of the foundation slab should be measured and recorded at each sub-slab sampling location to document site conditions.

It is important to vacuum the concrete dust out of the hole. A small amount of non-VOC putty is sometimes placed around the probe at the interface of the larger and smaller diameter holes to ensure that the cement does not seep below the probe and clog the pilot hole.

Vapor probes can be placed through poured or hollow-block basement walls in situations where volatile organic contaminants (VOCs) may move laterally toward the building rather than from beneath the building foundation.

Figure 1 – Illustration of Sub-slab Probe Design




Components of the sub-slab probe: 1) small diameter hole drilled through the concrete slab 2) larger diameter hole to place and seal probe; 3) stainless steel or brass probe through which sub-slab vapor will be collected 4) sealing material such as cement grout.

After installation allow adequate time for curing of the seal. Allow sub-slab vapors to equilibrate prior to sampling. This can be achieved by allowing the probe to "rest" one to two hours OR by purging the sub-slab probe and screening the sub-slab vapors until PID readings are stable. Probe construction and location must be documented to DNR when reporting test results.

A. Distribution of sub-slab sample probes

The DNR recommends the following distribution of sub-slab sample probes:

1. Single family homes – one sub-slab probe near the center of the foundation is usually acceptable. Two probes should be placed in homes with a building footprint greater than 1,500 $ft^2$.
2. Commercial and small industrial buildings – three sub-slab probes are recommended for a footprint of 5,000 $ft^2$ with one probe for each additional 2,000 $ft^2$.

3. Large buildings where this sample distribution is unworkable should consider using a high purge volume sampling procedure for collecting sub-slab vapor samples[1].

B. Permanent versus temporary sub-slab probes

Consultants often install sub-slab probes, collect a sub-slab sample, remove the probe point and fill the hole with cement in one mobilization. Because multiple sub-slab samples may be necessary (see Section IV below), DNR recommends that sampling probes be established as semi-permanent points. The sub-slab probes should be removed after it is determined whether further action is needed to mitigate vapor intrusion risk.

**The DNR strongly recommends that plastic tubing NOT be used in place of brass or stainless steel vapor ports**. It is difficult to create and maintain an airtight seal around the plastic tubing. (See Section 3 regarding leak testing.) Because the integrity of the tubing and seal cannot be maintained over time, vapor ports constructed with plastic tubing are only temporary installations and require abandonment after a single sampling event.

C. Tubing used in the sample train

Typically, tubing is used to connect the sub-slab probe and the collection container (usually a Summa canister). Inert, small diameter tubing, such as 1/8” or 1/4”OD rigid wall nylon, stainless steel, PEEK (polyetheretherketone) or Teflon is preferred. Tygon, LDPE (low density polyethylene), vinyl and copper tubing should be avoided.[2]

D. Abandoning sub-slab probes

Plans for abandoning sub-slab probes should be included in the sampling work plan. If an access agreement is needed to gain access to the building, attempt to secure access for multiple sample rounds and for future probe abandonment. Abandonment consists of removing the probe and permanently sealing the hole with neat cement or alternate material identified in the work plan and approved by DNR. The surface of the abandoned hole should be flush with the rest of the floor.

E. Sub-slab vapor samples collected from a sump pit

In some cases, contaminated groundwater exists immediately below the building foundation making it difficult to use sub-slab probes. Where it is not possible to install a sub-slab probe due to high groundwater conditions, sub-slab vapor samples can be collected from a sump pit. Sump pit vapor sampling should be avoided unless this is the only route for collecting a sub-slab vapor sample.

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[1] McAlary, T., et.al., High purge volume sampling – a new paradigm for subslab soil gas monitoring, Ground Water Monitoring & Remediation, v. 30, no. 2, Spring 2010, pp. 73 – 85.

[2] Ohio EPA, Sample Collection and Evaluation of Vapor Intrusion to Indoor Air, Appendix G, www.epa.ohio.gov/portals/30/rules/vapor%20intrusion%20to%20indoor%20air.pdf

The sump pump may need to be removed in order to collect a vapor sample. If an airtight cover exists over the sump pit, collect the vapor sample through an opening in the cover. Otherwise, the sump pit must be sealed airtight. A rigid material may be best for sealing the pit. The sealing adhesive and cover material must be VOC-free. A shop-vac or air pump (vented outside the building) must be attached to a sealed port through the sump cover. At least three to five volumes of air should be removed from the sump pit. The air inside the sump should be allowed to equilibrate for 24 hours. A Summa canister sample (attached through an airtight entry into the sump) can then be collected from the sump. A flow regulator is not needed when collecting a vapor sample from a sump – the Summa canister valve can be partially opened to allow the canister to fill.

Due to the configuration of the sump pit cover, it may or may not be possible to perform a leak test on the probe seal through the sump cover. A shut-in test should be performed to ensure that any compression fittings along the sample train are airtight. A water sample from the sump should also be collected and analyzed for the contaminants of concern.

If a sump pit is not available in situations where groundwater is in nearly direct contact with the foundation slab, groundwater samples should be collected from near the building and analyzed for the contaminants of concern. The consultant may also consider sampling basement sidewalls for vapor.

An unsealed sump pit presents a major entry way for vapor migration into a building (regardless of the method used to collect the sub-slab sample). The default attenuation factor of 0.1 for sub-slab to indoor air vapor concentrations for residential homes may not apply to homes with an unsealed sump pit. However, a properly sealed sump pit should provide adequate (0.1) attenuation of soil gas. Sub-slab soil gas and indoor air concentrations collected from homes with unsealed sump pits should be assessed to determine whether the default attenuation factor of 0.1 is protective of the pathway. The indoor air sample should be collected on the same level in the home where the sump pit is located.

## III. Leak Testing Prior to Collecting a Sub-slab Sample

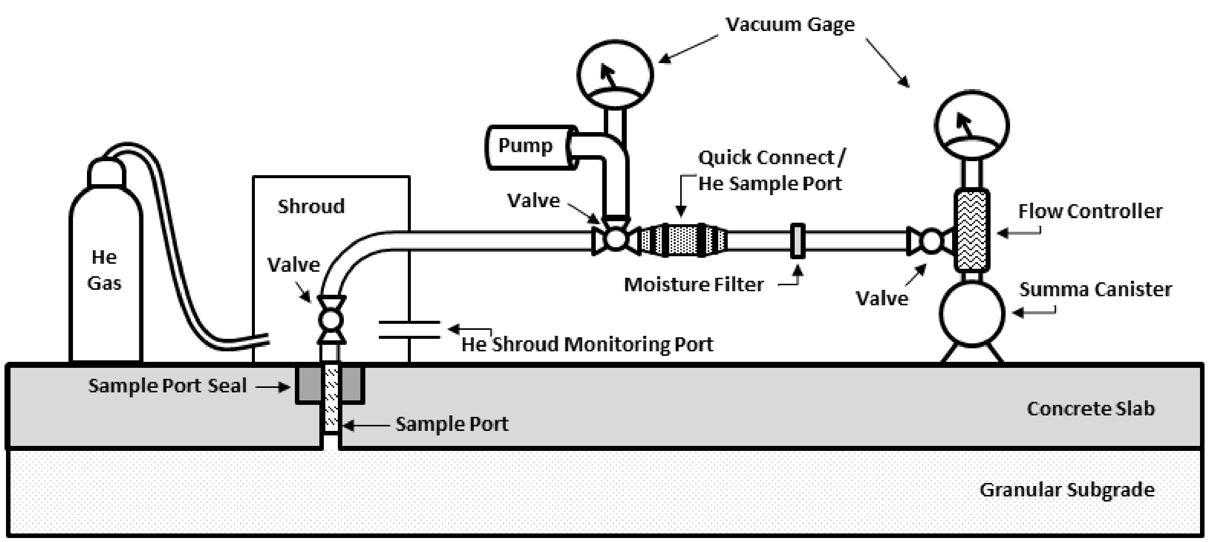
Two leak tests (one for the sampling train and one for the sample probe) should be conducted for every sub-slab vapor sample in order to establish air tightness. Fittings typically connect the tubing between the sub-slab probe and the collection container (usually a Summa canister). These fittings, along with the probe seal, must be airtight or ambient air can leak into the Summa canister and significantly bias the measured sub-slab vapor concentration results.

Leak detection methods are described below[3]. These tests allow the consultant to determine if leaks are present and to correct the condition creating the leak prior to collection of the sub-slab vapor sample.

[3] A discussion of leak detection techniques can be found in McAlary, T.A., P. Nicholson, H. Groenevelt, and D. Bertrand, 2009. A Case-Study of Soil Gas Sampling in Silt and Clay-rich (Low-Permeability) Materials, Groundwater Monitoring and Remediation, 29, no. 1/ Winter 2009/pages 144–152.

Consultants are free to choose the leak detection methods. Leak testing methods must be documented when reporting results to DNR. Sample results are likely to be rejected if quality control measures have not been performed or are not documented**. The DNR generally recommends the Helium shroud method for testing the probe seal along with the shut-in test for leak testing the fittings between the probe and sampling canister.** Collaborate with the assigned DNR project manager prior to using leak testing methods not outlined below. Additionally, non-disposable fittings may be used for assembly of sample train, shut-in testing, or sampling. However, document the fitting type (single use or multiple use fittings) and decontamination procedures applied for reused fittings that are not provided by the laboratory with the sample canisters.

Figure 2 - Example of Sub-slab Vapor Sample Train




Components of sample train: 1. Sealed sample port with connection to inert tubing; 2. Shroud with inlet opening to introduce helium gas and an opening for measuring helium concentration; 3. Hand or electric pump with vacuum gage to purge sample train and port and create vacuum on sample lines for shut-in test; 4. Quick connect valve allows access to the sample port to screen sub-slab vapor for helium, organic vapors, oxygen and carbon dioxide, etc. as well as connection to the Summa canister; 5. Summa canister (or sampling container) with flow controller and vacuum gage, moisture and particulate filters may also be attached.

A. Shut-in test

A shut-in test measures the airtightness of the fittings between the sample probe and the sample container. A vacuum gage should be connected to the sampling line between the sub-slab probe and the Summa canister. Valves to the probe and Summa canister are shut and air is removed (using a hand-pump or other device) from the sampling line, inducing a vacuum in the line of 50 to 100 inches of water. When all the external valves to the sampling line are shut, the vacuum gage should remain steady – indicating no leaks at any fitting – for at least one minute. Loss of vacuum indicates a leak and the fittings need to be adjusted until the line can hold a vacuum.

B. Helium shroud

Helium[4] is a non-toxic, readily available, easily field-screened gas that is absent from the subsurface environment. As with any pressurized gas, tanks must be carefully handled during transport and use. Prior to collecting the vapor sample, helium gas[5] is introduced to a concentration of 20% to 50% percent by volume into a shroud covering the sub-slab probe. The helium concentration inside the shroud is measured using a hand-held helium meter. A sub-slab vapor sample is withdrawn and screened with the helium detector. Helium concentration from the probe greater than 5% of the shroud concentration indicates the probe should be resealed and retested. Helium probe concentration less than 5% of the shroud concentration indicates that the probe is sealed and collection of the vapor sample can proceed.

Hand-held helium meters typically use a thermal conductivity detector (TCD) that is not specific to helium. To eliminate the most common interferences, a filter on the meter is required to remove water and hydrocarbons. If the consultant believes the helium meter is giving a false positive reading from the probe, helium can be added to the laboratory analysis of the Summa canister to confirm that the probe seal had leakage of 5% or less.

C. Other leak detection methods for probe seals

1. Non-Helium Tracers. Other leak detection methods exist. The most common is the use of tracer compounds other than helium gas, such as isopropyl alcohol (IPA) or 1,1-difluoroethane (DFE). This technique is fairly easy to use because towels soaked in IPA or shrouds with DFE (duster gas or “compressed air”) can easily be placed over the sampling probe. If a leak occurs, the laboratory will detect the tracer gas in the Summa canister. If there is no leak, the tracer gas will be absent.

   **Non-helium tracers have several disadvantages. The first and most important being that field screening methods are not typically available for these other tracers and leaks, if present, are not discovered until after the sampling is finished and the laboratory analysis received**. **If a leak is determined to be significant, remobilization and resampling may be required.** Second, while the tracer gas may be identified in the Summa canister, it is very difficult or impossible to determine how big the leak was – that is, how much ambient air entered the Summa canister versus vapor from the sub-slab probe. Therefore the data quality can be significantly compromised. If a tracer gas besides helium is used, DNR recommends that a shroud be used to isolate the probe and that a Summa canister sample be collected within the shroud to measure the concentration of the tracer gas. Quantitation of leakage through the probe seal can then be calculated. In all cases a separate shut-in test should be conducted rather than relying on tracer soaked towels placed on valves or fittings.

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[4] Refer to ITRC’s Vapor Intrusion Pathway: A Practical Guide”, Appendix D.4.7 for more information on gaseous tracers used in leak detection.
[5] Technical grade helium (>99% purity) should be used for leak testing.

2. Water Dam Method. Another method used to establish airtightness of probe seals is a water dam. A small enclosure (a short section of a 2 inch PVC pipe, for instance) is sealed to the floor around the sub-slab vapor probe and filled with water. Alternatively, the vapor probe can be sunk below the grade of the floor, and the core-hole above the probe can be used as the casing to hold the water. If the water placed in the casing maintains a constant level, the test confirms that no leaks are present in the vapor sample probe. **The main disadvantage is that if the water leaks through the probe seal, a new vapor probe must be established and tested**. **Water can permanently damage a Summa canister so it is important to make sure that water does not enter the Summa canister**. In addition, not all foundations lend themselves to this method – the foundation material may be uneven or may be covered with carpet or other materials not conducive to standing water.

D. Sample collection after leak testing

After the probe leak test and shut-in test are successfully performed, purge at least three volumes of air from the sample train. The sub-slab vapor is then usually screened with a PID meter. It is also useful to screen the sub-slab vapor for $O_2$ and $CO_2$, especially if petroleum VOCs are suspected. After screening, a sub-slab vapor sample is drawn into the Summa canister. A flow controller on the Summa canister is necessary to ensure that an excessive vacuum is not placed on the sampling probe. Typically, 100 to 200 ml/min of flow is recommended for sub-slab sampling, which means that a 6 liter canister[6] will take 30 to 60 minutes to fill. A vacuum gage should be used to verify and record vacuum measurements of sampling canisters before and after sample collection. Canisters should not be used if the initial vacuum reading is less than 25 inches of mercury (in Hg). Because sub-slab vapor samples are collected while an investigator is present and only the flow rate is of concern the canister can be filled to ambient pressure. (This is not the case for 8 and 24 hour indoor air samples, where some vacuum should remain in the canister at the end of the sample period to ensure that the sample was collected over the full 8 or 24 hours.). Usual chain-of-custody procedures should be followed for tracking the sample container delivery to the laboratory.

Care should be taken to limit the release of purged sub-slab vapors into the indoor air space. Indoor samples should be collected before or after, not during, sub-slab vapor sampling.

[6] DNR prefers 6 L Summa canisters for indoor, outdoor and sub-slab samples. Smaller canisters may be used. The 6L canister is recommended in order to achieve detection limits (10 times less than VRSL or VAL preferred) and account for the possibility that more than one laboratory analysis may be necessary.

## IV. Temporal Sub-Slab Sampling Considerations to Evaluate Vapor Intrusion Risk

U.S. EPA has conducted long-term, in-depth vapor intrusion studies on two homes in the U.S. An important finding of those studies is the significant variability of sub-slab and indoor air vapor concentrations over both time and space at residential buildings[7]. The Department recommends the following sampling guidelines for residential buildings:

1. Collect sub-slab and indoor air vapor samples during the winter months (snow cover and/or frozen ground conditions), **if possible**. Samples collected in the fall, winter and spring seasons are more likely to reveal the presence of vapors while samples collected in the summer are the least likely to reveal the presence of vapor.

2. If sub-slab vapor concentrations exceed the Department's vapor risk screening levels (VRSL)[8] in a residential setting[9], mitigation[10] of the vapor risk is recommended. Refer to RR-800, Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin (RR-800), for more information on responses to vapor concentrations that exceed screening levels.

3. If sub-slab vapor concentrations do not exceed VRSL, additional sub-slab samples should be collected to verify the initial sample results. The Department recommends three sub-slab sampling events be conducted to rule-out vapor intrusion, with at least one of the sampling event during the late fall/winter/early spring seasons. Sample intervals can be as short as 4 weeks or as long as 4 – 5 months, depending on the season of the year when the first sub-slab sample is collected. The actual number of sub-slab samples collected to rule-out vapor intrusion may be less than three. The investigator can recommend an alternate sampling plan for Department approval at specific residential properties based on site specific conditions such as:
   - vapor concentrations in the initial sub-slab and indoor air samples;
   - location of the residence in relationship to the contaminated soil and groundwater source;
   - sub-slab results from nearby residents or soil vapor probes;
   - season of the year when the first sub-slab sample is collected;
   - pattern of water table fluctuations, etc.

The need for repeated sub-slab sampling to rule out vapor intrusion at commercial/industrial properties will be based on the building use, sampling methodology, and other site specific considerations.

[7] For further information on this research, see Holtan, C., et.al., Temporal Variability of Indoor Air Concentrations under Natural Conditions in a House Overlying a Dilute Chlorinated Solvent Groundwater Plume, ES&T, 2013, Vol. 47, pp. 13347 – 13354; and https://iavi.rti.org/WorkshopsAndConferences.cfm for studies by Paul Johnson and Brian Schumacher.

[8] See the following for VRSL: NR 700.03(66w); dnr.wi.gov/topic/brownfields/vapor.html

[9] Vapor mitigation is also usually recommended if sub-slab concentrations exceed VRSL in commercial and industrial settings.

[10] More information on mitigation of the VI pathway can be found in Indoor Air Vapor Intrusion Mitigation Approaches, U.S. EPA, 2008.

## V. Reporting Results

In accordance with s. NR 716.14, laboratory results[11] from sub-slab sampling (as well as other environmental samples that may be collected) must be reported by the responsible party to the property owner, occupant and DNR within 10 business days of receipt. Ch. NR 716.14(2)(c) lists the information that must be provided in the notification, including:

1. Responsible party name, address, and phone number
2. Site name and source property address
3. Department BRRTS number
4. Department contact person name and phone number
5. Reason for sampling
6. Contaminant type
7. Sample type
8. A map showing sampling locations (can be hand drawn)
9. Collection date, specific contaminant levels for each collection location and a data table when multiple samples are collected
10. Copy of the laboratory results

The responsible party can send a letter with the above information or can use the Site Investigation Sample Results Notification (4400-249) form. Ch. NR 716.14(3) allows the Department to approve a different notification schedule on a case-by-case basis. Submit the request[12] prior to sampling, state the reasons for the different notification schedule and propose an alternate schedule. Health concerns should be specifically addressed in the request.

In addition to the above, the notification to the Department must include a preliminary analysis of the cause and significance of any contaminant concentrations observed. The investigator's understanding of the site will evolve as more data become available. It is expected that the preliminary analysis will also evolve over time. A new analysis is not necessary with the reporting of each sampling event if there is no change from the original preliminary analysis. A photograph of the sampling port and equipment may also be helpful as well as a short discussion of the quality control procedures used in collecting the sub-slab vapor samples.

Questions about this guidance can be referred to Alyssa Sellwood, 608-266-3084, alyssa.sellwood@wisconsin.gov.



[11] DNR does not certify or accredit air laboratories. The Department recommends that vapor and air samples be analyzed by a laboratory accredited by the National Environmental Laboratory Accreditation Program (NELAP)
[12] Chapter NR 749.04(1): Appropriate fees shall accompany all requests for specific Department assistance