Pennsylvania's Land Recycling Program

Vapor Intrusion Technical Guidance

Appendix Z: Vapor Intrusion Sampling Methods

1.0 Introduction

This appendix provides guidance on sampling and testing procedures to support vapor intrusion (VI) investigations and mitigation. It describes recommendations for collecting VI-related samples, and it is not meant to be a manual with step-by-step instructions for VI sampling requirements. Professional judgment should be exercised during the development of sampling plans considering that every site will have its own unique conditions. Remediators are encouraged to communicate with the Department Project Manager in order to determine the best path forward for VI sampling.

This appendix provides guidance on the methods and quality assurance to be used when collecting and analyzing VI-related samples. It also provides guidance on testing to confirm the effectiveness of sub-slab depressurization systems which are the most commonly used VI mitigation technology for existing buildings.

1.1 Applicability

The guidance provided in this appendix applies whenever sampling and analysis of soil gas or indoor air is performed:

- During site characterization;
- During site monitoring following site characterization;
- Following remediation; or
- When mitigation is performed using sub-slab depressurization (SSD) systems.

The information provided in this appendix may be used to address VI sampling or mitigation activities under either the Statewide health standard (SHS) or the site-specific standard (SSS) or under a combination of these two standards. These procedures also apply regardless of the size or scope of the VI evaluation when sampling and analysis of indoor air or soil gas is performed or a SSD System is used to mitigate VI.

1.2 Conceptual Site Model Development

A comprehensive conceptual site model (CSM) is an important tool in the development of a sampling and analysis plan. The CSM is needed to determine the locations and types of samples that are to be taken. More information on the development of a comprehensive conceptual site model can be found in Section B.1 of the Vapor Intrusion Guidance.

1.3 Spatial and Temporal Variability Considerations

When preparing a vapor intrusion sampling plan it is important to consider the spatial and temporal variability of contamination in soil gas and indoor air. Spatial variability refers to non-uniform concentrations at different locations within or beneath the same building. Temporal variability involves concentrations that change from one sampling event to the next. Compared to groundwater concentrations, there are many complicating factors that can cause significant variability in vapor data.

Some causes of spatial variability include:

- Distribution of the source in soil or groundwater
- Natural heterogeneity (different soil types, soil moisture, bedrock fractures)
- Oxygen distribution in the soil (aerobic/anaerobic conditions)
- Subsurface building structures (footers, utilities)
- Surface features (pavement)

Some causes of temporal variability include:

- Wind, barometric pressure, temperature
- Precipitation, infiltration, soil moisture, frozen ground
- Building ventilation, heating, cooling
- Ambient contaminants (indoor and outdoor sources)
- Sampling errors (equipment leaks)

Research studies have been conducted regarding the spatial variability of vapor concentrations by collecting multiple samples beneath, around, or within buildings (e.g., McHugh et al., 2007; Luo et al., 2009; U.S. EPA, 2012a). The results of these studies have shown that sub-slab and soil gas concentrations can span orders of magnitude at a given building, even for moderately sized homes. Indoor air concentrations tend to show less variability as indoor air is typically well mixed in homes and smaller nonresidential buildings. Larger buildings may show greater room-to-room variability influenced by spatial heterogeneity of vapor intrusion in those areas, possible indoor sources, and different ventilation conditions. For the same reasons, a sample collected at one building may not be representative of conditions at a neighboring building.

Accounting for VI spatial variability in the sampling plan is similar to adequately characterizing soil contamination at a site: a sufficient number of sample points must be installed to evaluate representative concentrations. The conceptual site model should be the guide for choosing these locations. The horizontal and vertical distribution of the vapor source relative to the building, the soil and bedrock conditions, likely pathways to and through the foundation, and the building characteristics (construction, ventilation, etc.) should be considered by the environmental professional developing the sampling approach. Based on site-specific conditions, a single sample location may not be adequate.

Repeat sampling of the same location at several study sites has similarly demonstrated substantial changes in vapor concentrations over time (e.g., Folkes et al., 2009; U.S. EPA, 2010, 2012a, 2012b; Holton et al., 2013). Soil gas, sub-slab, and indoor air concentrations have been found to vary by up to three orders of magnitude over periods of months to years. Shallow soil gas tends to have much greater variability than deeper soil gas, making near-source soil gas a more reliable measure of vapor intrusion. Much of the variability of indoor air data can be attributed to conditions other than vapor intrusion.

Temporal and spatial variability in soil gas and indoor air sample results is addressed by using a combination of multiple rounds of samples and multiple sample locations. The goal is to collect sufficient data to determine representative concentrations beneath or within the building. Refer to Section G.3 and Table 7 of the VI Guidance for recommendations on the appropriate number of sampling events and sample locations.

2.0 Near-Source Soil Gas Sampling

2.1 Description

Near-source soil gas is soil gas collected from within the vadose zone, specifically from nominally within 1 foot of the contamination source (contaminated soil or groundwater). For a groundwater source, near-source soil gas samples should be collected within 1 foot of the top of the capillary zone if the water table occurs in soil. If the water table occurs in bedrock, the near-source soil gas samples should be collected within 1 foot of the soil–bedrock interface.

2.2 Sample Point Installation

Near-source soil gas sampling points can be temporary (used for one sampling event and decommissioned) or semi-permanent (used for multiple sampling events). Recommended resources for soil gas points include API (2005), California EPA (2012), ASTM (2012), Hawaii DoH (2014), and ITRC (2014).

2.2.1 Installation of Temporary Points

Installation and construction of temporary points may be less time and cost sensitive. However, these potential savings may be offset over the life of the project as new points must be installed for each round of sampling. In general, temporary points rely on the use of boring advancement tools for the collection of the soil gas sample and the sealing of the point from the atmosphere. This is accomplished with the compression of the soil along the sides of the boring against the boring advancement tools. Use of temporary points is not recommended but may be necessary due to site conditions or site development. Prior to the utilization of temporary points, the feasibility of the following factors should be carefully considered:

- Proper sealing of the sampling interval from the surface,
- Isolation of the sampling interval within the boring, and
- Potential of negative effects of boring advancement using drive-point techniques (e.g., decrease of soil gas permeability due to smearing or compression).
- Unknown correlation of analytical results for multiple sampling rounds.

2.2.2 Installation and Construction of Semi-Permanent Points

Semi-permanent points are generally constructed in borings advanced using conventional drilling technologies and sealing of the point is accomplished using bentonite or grout in the annulus of the boring. Boring advancement techniques should attempt to minimize disturbance of the vadose zone geologic strata and soil vapor column. Drilling methods that introduce air (e.g., air rotary) or liquid (e.g., mud-rotary) should be avoided.

3.0 Sub-Slab Soil Gas Sampling

3.1 Description

Sub-slab soil gas is soil gas located immediately below the floor slab of a building. The slab can be at grade (slab-on-grade) or below grade (basement).

3.2 Location

Sub-slab soil gas is located beneath the slab in the porosity of the native soil, ballast stone, or gravel that the building slab was placed over. Sub-slab soil gas sampling locations should be determined based on the specific characteristics of the building being sampled and the objectives of the sampling plan. Whenever possible, sampling locations should be biased toward areas of the building with the greatest expected VI impact, based on a combination of the location of VI sources and building occupancy and use. In general, sampling locations are at least five feet from perimeter foundation walls and sampling next to footers, large floor cracks, and apparent slab penetrations (e.g., sumps, floor drains) should be avoided.

3.3 Sample Point Installation

Sub-slab soil gas sampling points can be temporary (used for one sampling event and decommissioned) or semi-permanent (used for multiple sampling events). The building occupancy, use, and project goals are influential in the determination of which type of sampling point to use. A pre-survey, as described in Section 6.1.1., can be completed to assist in determining this information. Generally, installation and construction of temporary points is less time and cost intensive. However, these potential savings may be offset over the life of the project as new points must be installed for each round of sampling.

Sub-slab soil gas sampling points are generally installed inside penetrations through the building slab. Penetrating the floor slab can be accomplished using a hammer drill and bit, a core drill, or direct-push technology. Care should be taken during the floor slab penetration activities to avoid the creation of cracks in the slab. Additionally, the use of water or other lubricants and coolants during the advancement of the floor slab penetration should be compatible with the sampling analyte list and may result in the need for additional point equilibration time (see Section 6.1.4) or the need to develop the sampling point to limit potential interaction of the sample with the water or lubricants.

Recommended resources for sub-slab points include California EPA (2011a), New Jersey DEP (2013), Hawaii DoH (2014), and ITRC (2014).

4.0 Indoor Air Sampling

4.1 Sampling Indoor Air

Indoor air sampling is performed when the potential for VI exists through demonstration via the other lines of evidence, and other investigative tools are not able to eliminate the VI pathway. Indoor air sampling may also be considered as a method for mitigation system verification. When compared to the other investigative tools available, indoor air sampling represents the most direct measure of exposure due to the VI pathway however it also can be heavily influenced by background conditions.

Recommended resources for indoor air sampling include New York DoH (2006), California EPA (2011a), New Jersey DEP (2013), Hawaii DoH (2014), and ITRC (2014).

When collecting indoor air samples, it is preferable to collect samples at a time and location that will result in the highest potential concentrations. Samples should be collected from the lowest level of the structure with appropriate accessibility where vapors are expected to enter, including basements, crawl spaces, and where preferential pathways have been identified. Existing environmental data (e.g., groundwater, soil, sub-slab soil gas, etc.), site background information, building construction (e.g., basement, slab-on-grade, or multiple types of foundations, elevator shafts, tunnels, etc.), and building operation details (e.g., number and operation of HVAC systems) as evaluated through the development of the CSM should be considered when selecting locations within the building for indoor air sampling. Indoor air samples may be collected concurrently and collocated with sub-slab soil gas sampling locations, and concurrently with an outdoor ambient air sample.

To characterize contaminant concentrations trends and potential exposures, indoor air samples are commonly collected:

- From the crawl space area;
- From the basement (where vapor infiltration is suspected, such as near sump pumps or indoor wells, or in a central location);
- From the lowest level living space (in centrally-located, high activity use areas);
- From multiple tenant spaces if in a commercial setting.

If a building or a portion of the building uses, handles or stores the same substances being investigated, then indoor air sampling should not be collected in this area of the building, as determination of whether the contaminants are present due to operations or due to a completed VI pathway is complicated. Other lines of evidence are used in these situations to confirm if the building uses the substances, and other comparative methods may be used with collocated sub-slab soil gas and indoor air locations.

4.2 Outdoor Ambient Air Sampling

To understand potential background influences during indoor air sampling an outdoor ambient air sample is commonly collected. This sample provides background concentrations outside of the building being investigated at the time of the indoor air sampling event. The investigator commonly designates a sample location and the site conditions at the time of sampling. The investigator also should be aware of the weather conditions during the sampling event. Thus, the sampler should be placed in a secure outside location.

Atmospheric pressure and temperature details from nearby weather reporting stations or through portable meteorological equipment should be collected in conjunction with the ambient air samples. Two web sites that may be useful to the investigator are the National Oceanic and Atmospheric Administration, National Weather Service web site at http://www.weather.gov and the Weather Underground at http://www.wunderground.com/.

The following actions are commonly taken to document conditions during outdoor air sampling and ultimately to aid in the interpretation of the sampling results:

- Outdoor plot sketches are drawn that include the building site, area streets, outdoor air sampling location(s), the location of potential interferences (e.g., gasoline stations, dry cleaners, factories, lawn mowers, etc.), compass orientation (north), and paved areas;
- Weather conditions (e.g., precipitation and outdoor temperature) are reported;
- Predominant wind direction(s) based upon wind rose diagrams; and
- Pertinent observations, such as odors, readings from field instrumentation, and significant activities in the vicinity are recorded.

5.0 Sampling Soil Gas for Oxygen Content

Note: *This section of the guidance is intended only for remediators using the vertical proximity distances for petroleum hydrocarbons.*

If the remediator chooses to screen a site using the vertical proximity distances for petroleum hydrocarbons, the acceptable soil or soil-like material should contain greater than 2% oxygen, on a volumetric basis (VI Guidance Section D). Oxygen content above this level indicates an aerobic environment that enables biodegradation of petroleum vapors. The investigator measures the oxygen concentration in the vadose zone at buildings that are potential receptors to demonstrate that the aerobic soil condition is met.

The Department recommends collecting the soil gas sample beneath the building for oxygen content. Only one grab sample collected at a single location is sufficient. A hole should be drilled approximately 12 inches into acceptable soil or soil-like material (i.e., beneath any gravel or similar fill material underlying the slab). Tubing with a probe tip is dropped into the hole which is then filled with clean sand (e.g., Hawaii DoH, 2014, Section 7.9.3).

When it is not feasible to obtain the soil gas sample beneath the building, a near-slab soil gas sample may be collected. The sample point should be as close to the building as practical, and no farther than 10 feet. It should be located in the area of greatest anticipated soil vapor contamination. The screen depth should be above the top of the soil or groundwater contamination (e.g., smear zone) and below the bottom of the building foundation. The screen should also be at least 5 feet below the ground surface. The investigator may also collect samples at multiple depths to obtain a concentration profile demonstrating biodegradation. The sample probe should be allowed to equilibrate with the subsurface and purged.

In addition to analysis of oxygen (O_2), additional compounds such as carbon dioxide (CO_2) and methane (CH_4) can be measured to document biodegradation. One grab sample is sufficient to demonstrate that the 2% O_2 criterion is satisfied. The sample may be analyzed using a properly calibrated portable instrument. Oxygen should be calibrated at around 2% and 21%. Alternatively, the sample may be collected using a Tedlar bag or a Summa canister and analyzed at a mobile or offsite laboratory using EPA Reference Method 3C.

6.0 Quality Assurance and Quality Control Procedures and Methods

6.1 Sampling Procedures and Methods

6.1.1 Pre-Sampling Survey

Prior to the installation and construction of indoor air and sub-slab soil gas sampling points and the collection of samples, a pre-sampling survey should be conducted. The survey should include a short interview with a representative of the owner/occupant of the building and a visual review of accessible portions of at least the lowest level of the building (basement or first floor). Results of the survey are documented in a survey questionnaire and supplemented by sketch maps and photographs as necessary. The investigator may also choose to use a photoionization detector (PID) or flame ionization detector (FID) during the survey to screen for the presence of VOCs in the building (Note: The non-compound specific VOC detection levels of PIDs and FIDs are much higher than compound-specific laboratory reporting limits). The pre-sampling survey should review building-specific factors that could influence VOC concentrations in indoor air including:

- Building construction characteristics;
- Building features, such as the condition of the floor slab, floor penetrations, and floor cracks;
- Heating and ventilations systems;
- Items within the lowest level of the building that could serve as potential VOC sources (paint cans, solvents, fuel containers, etc.);
- Occupant activities in the building (painting, smoking, etc.); and
- Exterior characteristics and items or occupant activities outside the building that could serve as potential VOC sources (mowing, paving, etc.).

These observations and others should be documented on a building survey form.

For additional information see ITRC (2007), California EPA (2011a), and New Jersey DEP (2013).

6.1.2 Sampling Equipment

Near-source soil gas, sub-slab gas, and indoor air samples are commonly collected in passivated stainless steel canisters (e.g., SUMMA) with laboratory-calibrated flow controllers for USEPA Method TO-15, or other appropriate USEPA methods if TO-15 is not applicable. Other types of sampling containers (e.g., Tedlar bags, glass bulbs, syringes) may be used but stainless steel canisters are preferred.

Canister volumes should be selected to minimize sample volume while still meeting data quality objectives. Minimizing sampling volumes for near-source soil gas and sub-slab gas reduces the potential for ambient air entering around the sampling point and limits the potential for migration of soil gas from relatively long distances away from the sampling point during sample collection. Generally, 1-L canisters are used for near-source soil gas and sub-slab soil gas sample collection and 6-L canisters are used for indoor air and ambient sampling.

Canisters should be connected to the soil gas sampling point using small diameter stainless steel, nylon, or PTFE (Teflon) tubing and stainless steel compression-type fittings. (Other appropriate non-reactive materials may be used. Polyethylene and Tygon are not acceptable tubing materials.) The number of connections in the sampling system is should be minimized to reduce the number of locations where leaks could occur. Minimizing the length and diameter of the tubing reduces the sample residence time and the required purge volume.

6.1.3 Sampling Point Construction

Near-source and sub-slab soil gas sampling point construction materials should be selected to minimize potential interaction with the sample. The probe should be connected to small diameter tubing; the tubing and all fittings should be clean and dry. The tubing is recommended to be capped or plugged at the surface to isolate the sample from the atmosphere or indoor air.

Sub-slab sample points are sealed in the penetration to eliminate short circuiting of air from inside the building through the slab penetration and into the sample. The materials and methods used to create this seal will depend on site-specific factors such as the condition of the slab and the type and volume of traffic in the building as well as the data quality objectives and planned quality assurance and quality control protocols. Temporary points may be sealed in the penetration with silicone sleeves, silicone rubber stoppers, sculpting clay, putty, or wax. Semi-permanent points may involve the drilling of nested holes in the slab and the use of hydraulic cement or epoxy to seal the tubing and possibly additional fittings in the penetration below the finished elevation. All materials used for construction and completion of the sub-slab soil gas sampling point should be clean, dry and free of materials that could affected the sampling or analysis.

The diameter of the floor slab penetration should be minimized (generally between 3/8 and 1inch). The surface and sidewalls of the penetration should be cleaned with a stiff bristle brush to remove material created by the advancement of the penetration. Removal of this material is important to limit entrainment of dust in the sub-slab soil gas sample and to promote adherence of the sealing materials to the sidewalls of the penetration or the surface of the slab. Care should be taken to limit interaction with the sub-slab soil gas beneath the slab if a vacuum is used to remove dust during/after advancement of the penetration. If a vacuum is used, additional point equilibration time may be necessary.

Some manufacturers offer alternative sub-slab soil gas sampling point equipment that relies on driving (hammering) a specialized barbed-metal fitting into the slab penetration. The metal fitting is sealed inside the slab penetration by the compression of a sleeve of flexible tubing between the fitting's barbs and the sidewalls of the penetration. These "hammer-in" points may be considered for use during VI investigations.

For indoor and outdoor air sampling, the sampling port should be placed in the breathing zone, approximately 3 to 5 feet from the floor. Mount the canister on a stable platform or attach a length of inert tubing to the flow controller inlet and support it such that the sample inlets will be at the proper height.

Ambient air samples should be collected at breathing zone height (if possible) and in close proximity to the building being tested. For nonresidential buildings, the investigator may elect to collect the ambient air sample near representative heating, ventilation and air conditioning (HVAC) intake locations (i.e., on the roof). Other locations for an ambient sampling could be upwind of the building to be sampled. The ambient air sample should have the same sample collection time and be analyzed in the same manner as the interior sample collection method.

6.1.4 Equilibration

After installation, near-source and sub-slab soil gas points should be allowed to equilibrate to natural conditions. This is commonly a minimum of 2 up to 24 hours.

6.1.5 Leak Testing/Detection for Subsurface Sample Collection

Leakage during soil gas sampling may dilute samples with ambient air resulting in data that underestimates actual site concentrations or causes false negatives. A shut-in check (sampling assembly integrity) and a leak check (surface seal integrity) can be conducted to determine whether leakage is present and then corrected in the field prior to collecting the sample. Recommended resources for leak testing include California EPA (2012), New Jersey DEP (2013), Hawaii DoH (2014), and ITRC (2014).

6.1.5.1 Shut-in Check

A shut-in test of the sampling train is recommended to be completed at each location and during each sampling event to verify aboveground fittings do not contain leaks. A shut-in test consists of assembling the above-ground apparatus (valves, lines, and fittings downstream of the top of the probe), and evacuating the lines to a measured vacuum of about 100 inches ofH_2O, then shutting the vacuum in with closed valves on opposite ends of the sample train.

The vacuum gauge is observed for at least 1 min, and if there is any observable loss of vacuum, the fittings should be adjusted as needed until the vacuum in the aboveground portion of the sample train does not noticeably dissipate.

6.1.5.2 Leak Check

Leak check tests are recommended for near-source and sub-slab soil gas points after construction and equilibration. One method employs a shroud placed over the point. An inert tracer gas (such as helium) is released into the shroud with a target concentration of 10–20%. With the canister valve closed, collect a soil gas sample. A leak is occurring when the helium concentration is greater than 10% of the concentration within the shroud. In this case, the leak must be fixed and the leak check repeated.

Helium is the preferred tracer as it is readily available, non-toxic, and easily measured in the field provided high methane levels are not present (false positives).

***Note**: Balloon-grade helium may contain hydrocarbons that could interfere with sample analysis.*

6.1.6 Purging

Purging occurs after the sampling system has been assembled (i.e., the canister has been connected to the flow controller and the sampling point has been connected to the canister/flow controller). A "T" fitting can be placed in the sampling train to allow for purging of the connected sampling system. The purging leg of the "T" is commonly isolated from the rest of the sampling train using a valve. There are several acceptable methods for purging the system. For example, either a graduated syringe or a personal sampling pump can be used.

Purge rates for near source and sub-slab soil gas samples should be less than 200 mL/min to limit the potential for short-circuiting or desorbing VOCs from soil particles. Purging volumes should be about three times the volume of the total sampling system (i.e., the sampling point and tubing connected to the sampling canister).

If water is encountered in the soil gas sampling point or observed in the sample tubing during purging then sampling of the point should not be performed. Commonly, when water is encountered during purging an effort is made to evacuate the water from the soil gas sampling point and then allow a minimum of 48 hours before reattempting purging and sampling.

6.1.7 Sampling Rates

Sampling rates for near-source and sub slab soil gas samples should be less than 200 mL/min. Sample rates are determined by the laboratory-calibrated flow controller attached to the canister.

Vacuum levels during sampling should not exceed 100 inches of water. If low permeability materials are encountered during point installation or if there are issues during purging or sampling that suggest low permeability, testing should be performed to measure flow rates and vacuum levels in the near-source soil gas sampling point to determine acceptable purging and sampling flow rates.

Indoor air and ambient air samples are typically collected over a 24 hour period; however, in a nonresidential setting an 8-hour sampling period may be used to coincide with the hours of operation and thus the period of exposure. The sampling flow rate should always be less than 200 mL/min.

Sample duration should be determined by sample volume, but it is recommended to be at least 30 minutes.

If water is observed in the sample tubing during sampling then sampling should be discontinued. Commonly, when water is encountered during sampling an effort is made to evacuate the water from the soil gas sampling point and then allow a minimum of 48 hours before reattempting purging and sampling.

6.1.8 Sample Recordation

The field sampling team should maintain a sample log sheet summarizing the following:

- Sample identification;
- Date and time of sample collection;
- Sample location;
- Identity of samplers;
- Sampling methods and devices;
- Volume and duration of sample;
- Canister vacuum before and after samples are collected; and
- Chain of custody protocols and records used to track samples from sampling point to analysis.

6.2 Data Quality Objective (DQO) Process, Sampling and Data Quality Assessment Process

The DQO process allows a person to define the data requirements and acceptable levels of decision errors prior to data collection. The DQO process should be considered in developing the sampling and analysis plan, including the quality assurance plan. The implementation phase includes sampling execution and sample analysis. The assessment phase includes Data Quality Assessment (DQA). (See Section 250.702(a) of the regulations and Technical Guidance Manual Section IV.B.2.)

6.3 QA/QC Samples

Canister integrity as a result of shipping should be examined prior to use. The canisters should be received in the field with the laboratory-measured pressure as part of the documentation. Field check the pressure of the canister before collecting the sample. The field-measured pressure should be within 10% of the laboratory recorded value. If this is not the case, the canister should be rejected and another canister used. There may be some minor difference in measured pressures (for instance with changes in altitude and barometric pressure) of less than 5% that does not reflect a canister integrity problem.

On completion of sample collection, the final pressure reading should be recorded. This should be about 5 inches of mercury. The reading should be recorded on the chain of custody or other field documentation. If the final pressure is zero (atmospheric), it should still be recorded and sent to the laboratory for verification.

A field duplicate sample may be collected by using a "T" fitting at the point of collection to divide the sample stream into two separate sample containers.

Trip Blanks for canisters are not typically required.

Dependent on the sampling equipment it may be desirable to perform an equipment blank. The sample collection media should be certified clean. Materials used in setting up a sampling train should be VOC-free and stored and transported in a VOC-free environment.

Field method blanks can be used to verify the effectiveness of decontamination procedures and to detect any possible interference from ambient air. If samples are collected using a sorbent media it is recommended that a blank media sample accompanies the batch of sample media to the field and is returned to the laboratory for analysis. This demonstrates the media is free from compounds of concern from preparation through shipping and handling.

6.4 Analytical Methods

A variety of analytical methods are available to measure vapor samples (subsurface vapor, indoor and ambient air), all of which can provide useable data when reported with QA/QC. The laboratory QA/QC will include blanks, calibration, and system performance samples that define and verify the quality of the data reported. Although not a guarantee of quality data, the laboratory engaged for air and vapor analysis should have NELAC or similar accreditation for the methods reported. There may be cases where certification for the method that will be used is not available. In this case, a laboratory standard operating procedure should be available and appropriate QA/QC be reported with the results.

The methods offered for air and vapor analysis were developed for alternative applications and may have been modified to report vapor intrusion data. If the laboratory does not have certification for the air/vapor methods they have proposed then a description of the method and an evaluation of the anticipated data quality should be available before samples are analyzed.

For the data assessment process it is suggested at a minimum for the laboratory to provide summary QA/QC results with the data reported. A full validated data package can be requested if necessary.

Engage with the laboratory during the planning stages of the investigation to ensure the appropriate analytical method is used. Additional information can be found in California EPA (2012, Appendix F) and Massachusetts DEP (2002, Appendix 1).

Key elements for choosing the appropriate method are:

- The contaminants of concern;
- The concentrations that may be encountered during sampling and source strength;
- Screening levels/detection levels and other DQOs;
- Sampling considerations;
- Cost of sampling and analysis.

For EPA Method TO-15 VOCs the passivated canister is the only container allowed by the method; any other containers (e.g., Tedlar bags) are considered a modification. There is no standard list for TO-15. As a performance-based method, any compound that has sufficient volatility and recoveries may be validated for accreditation and reporting, provided a demonstration of capability is performed. TO-15 is the preferred method used for vapor intrusion investigations.

Method TO-17 is a sister method to TO-15. Samples are collected with active sampling onto an absorbent media. This method offers lower reporting limits and extends the compound list to include semivolatile compounds. However, this media has a limited capacity, which is further limited if screening is done for a broad range of compounds and sampling requires more field expertise.

Fixed gases, typically defined as O_2, nitrogen, CH_4, CO_2, and CO, can readily be analyzed using laboratory-based methods that use a thermal conductivity detector for detection, and also using field monitoring devices (landfill gas monitors). ASTM D1946 and USEPA Method 3C are two of the more common analytical methods and can typically detect concentrations as low as 0.1%. They can also be used to analyze for helium, which is often used as a tracer gas during leak check procedures in subsurface sampling. Analysis for these gases can be run from the same canister as VOCs.

Contact your laboratory for analyte lists and reporting levels applicable to these methods.

Table Z.1 Analytical Methods for VOCs in Soil Gas, Indoor and Ambient Air Samples

Parameter	Method	Sample Media/Storage	Description	Method Holding Time	Reporting Limits
Polar & non-polar VOCs	TO-15	canister/ambient temperature	GC/MS	30 days	1–3 μg/m^3
Low level VOCs	TO-15 SIM	canister/ambient temperature	GC/MS	30 days	0.011–0.5 μg/m^3
Polar & non-polar VOCs and SVOCs to C-28	TO-17	sorbent tube/chilled <4°C	GC/MS	30 days	1–3 μg/m^3
Fixed Gases (methane, helium, nitrogen, oxygen, carbon dioxide, carbon monoxide)	USEPA 3C or ASTM 1946	canister or Tedlar bag/ambient temperature	GC/TCD/FID GC/FID	3 days for Tedlar bag 30 days for canister	1000–2000 μg/m^3

6.5 Data Evaluation

If the project was planned using the DQO process (USEPA, 2006) or other standard project planning process, the quantity and quality of data, including the measurement quality objectives, will have been specified in the sampling and analysis plan. All of the data should be examined for these types of issues to ensure that data are of adequate quality prior to using the data to evaluate the VI pathway.

7.0 Active Sub-Slab Depressurization System Testing

Details regarding the application, design, installation, and performance testing of sub-slab depressurization (SSD) systems and other VI mitigation systems are available in the following references: U.S. EPA (1991, 1993, 1994a, 1994b, 2001, 2008), Massachusetts DEP (1995), Pennsylvania DEP (1997), California EPA (2011b), and ASTM (2007, 2008, 2009, 2010).

7.1 Description

This section applies to performance testing of active sub-slab depressurization systems installed as an engineering control on buildings where the VI pathway is a potential concern. For existing buildings, active SSD systems are the VI mitigation method preferred by the Department. However, the performance and testing requirements described below may also apply for other active VI mitigation technologies such as sub-membrane depressurization, sub-slab pressurization, and building pressurization systems.

Installation of SSD systems consist of the sealing of potential soil vapor infiltration points combined with the use of a fan or blower that creates a continuous negative pressure field (vacuum) beneath the concrete floor slab of the lowest level of the building (basement or first floor). The fan or blower pulls the soil vapor from beneath the slab and vents it to the atmosphere at a height well above the outdoor breathing zone (ITRC, 2007). The presence of a continuous negative pressure field beneath the slab results in the movement of indoor air down into the subsurface, thereby eliminating the VI pathway as a potential concern.

Installation of SSD systems in existing buildings is generally completed in three steps, including:

Step 1: Inspection and Design-Support Diagnostic Testing-This step typically includes visual inspection of the lowest level of the building to assess the condition of the foundation, to identify potential soil vapor entry points that require sealing, and to review building-specific design considerations such as the location and type of construction of extraction points, possible discharge piping routes, and exhaust fan locations. This step also includes diagnostic testing to support siting of extraction points, sizing of the exhaust fan/blower and piping, and evaluation of stack effects and the potential for back-drafting of heating systems. The results of the diagnostic tests or communication tests are used to confirm the ability of the SSD to depressurize beneath the entire building.

Step 2: Design and Construction of the SSD System—Preparation of a design applicable to the building characteristics and results of diagnostic testing. Elements of the construction include installation of extraction point(s), exhaust piping, exhaust fans/blowers, and sealing of potential soil vapor entry points. This step in the process should be performed by a qualified professional.

Step 3: Commissioning of the SSD System—The commissioning step includes post-construction performance testing consisting of pressure differential measurements to demonstrate the system is working as designed. During this step, smoke testing is also performed to confirm operation of the SSD system does not result in back-drafting of combustion appliances (heating systems). Adjustments or augments to the SSD system may be completed during this final installation step. Post-construction performance testing methods completed as part of commissioning of active SSD systems are described below.

7.2 Performance Testing Methods

The primary method of performance testing of active sub-slab depressurization systems consists of differential pressure field extension tests that provide confirmation of a continuous negative pressure field (vacuum) beneath the concrete floor slab of the lowest level of the building. If the differential pressure field extension tests demonstrate the operating SSD system is providing depressurization throughout the sub-slab, the remediator is not required to perform indoor air confirmation sampling.

Differential pressure field extension tests are performed by operating the SSD system and simultaneously measuring the sub-slab pressure at different locations across the floor slab including, if accessible, building corners and building perimeters. The pressure measurements should be performed by drilling a small hole through the slab (e.g., 3/8-inch diameter) and measuring the differential pressure using a digital micromanometer. In general, for active SSD systems a pressure differential of at least 0.004 inches of water (1 Pascal) should be achieved (New Jersey DEP, 2013). As such, vacuum measurements using a digital micromanometer may need to be as low as 0.001 inches of water (0.25 Pascal). Smoke testing can be performed as a qualitative test but it may not be as reliable with low vacuums.