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Peter A. Reynolds
URS Corporation

Chapter 38

THE USE OF TRACER GAS IN SOIL VAPOR INTRUSION STUDIES

Peter A. Reynolds
URS Corporation, 201 Willowbrook Boulevard, Wayne, N J 07470

Abstract: There has been a rapid rise in the need for soil vapor intrusion (SVI) assessments to meet environmental compliance requirements regarding brownfields development and asset improvement in both the commercial and private sectors of the marketplace. As these requirements become more pervasive throughout the country, planners and stakeholders are approaching environmental professionals for solutions.

Our approach to SVI sub-slab testing for existing structure interiors incorporates a tracer gas monitoring technique that has proven to be very cost effective. This method allows for the verification that the sample collected from beneath an impervious surface is truly isolated from the ambient air inside the building. Implementation of this method has met with the approval of New York regulators and is consistent with their Soil Vapor Intrusion Guidance, which was published in 2005.

1. INTRODUCTION

Sub slab samples are typically collected by drilling through the impervious surface, slightly into the material below the slab, installing a sample probe, sealing the probe from the area above the slab, and purging the sampling probe at low flow rates (typically at or below 200cc/min). The potential exists for unchecked leakage of ambient air into the subslab soil vapor sampling zone. Because of this condition, the need to measure the potential influence of ambient air on a discrete subslab sample was identified. Researchers recommended the use of tracer gas to detect and measure potential ambient air intrusion into the subslab sampling space:

> *"When collecting soil vapor samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance / quality control device to verify the integrity of the soil vapor probe seal. Without the use of a tracer, there is no way to verify that a soil vapor sample has not been diluted by surface air."*[1]

General guidance suggest a few techniques for using tracer gas for sub slab sampling including the use of tracer gas shrouds and plastic sheeting to contain the tracer gas above the sampling point. This sampling method is intended as an application of the suggested tracer gas procedure using commonly available equipment.

2. APPLICABILITY/ASSUMPTIONS

This is considered an active vapor sample collection method. This technique pertains to the withdrawal and collection of soil gas vapors by vacuum for immediate screening and subsequent laboratory analyses. This method may be used with an assortment of ground probes as a means to estimate the level of isolation of the subslab soil vapor sample from the ambient air to detect and control potential short circuiting from a poor annular seal.

This sampling method is principally intended to be used for the collection of Volatile Organic Contaminants (VOCs) from subslab media to SUMMA canisters for subsequent analyses by EPA TO-15. Subslab samples are considered to be taken at depths of 5 feet or less.

3. DESCRIPTION OF METHOD

An inert tracer gas is used to first blanket the surface of the slab and a gas tight seal is formed between atmosphere and the sub-slab sample targeting point, sometimes just inches below the ambient space. The sample point is isolated with a small enclosure that is then charged with the tracer gas until the gas concentration exceeds 80%. The isolated sampling point below grade is then purged and tested for the same tracer gas to measure the potential for sampling influence (or bias) from the ambient space above. Once it has been determined that the target sample is relatively free from bias (by a measured tracer gas concentration of 10% or less), sampling proceeds. The tracer gas blanket and sampling space are monitored throughout the sampling period to ensure that the potential for ambient air to migrate into the sampling zone is minimized.

Helium is used as a tracer gas due to its availability and ease of detection. The approach to using tracer gas to measure sample isolation incorporates the use of a portable enclosure equipped with a soft gasket similar to the type suggested in the guidance, with the following improvements:

- The enclosure is equipped with a replaceable rubber grommet to greatly reduce the migration of helium out of the enclosure by minimizing leakage from around the sampling line protruding from the top of the enclosure.
- The enclosure has a gas tight quick connect port located at the top for the introduction of helium.
- A gas tight quick connect port is also installed close to the base of the enclosure to act a purge valve during the exchange of ambient air with helium, and to serve as a monitoring port for direct connection to the helium detector.
- The soft gasket on the base of the enclosure is roughly ½ inches thick and seals well on rough and uneven surfaces such as brick or asphalt.

The enclosure can be rapidly set up and broken down, and eliminates the use and subsequent cleanup of wet sealers.

4. TYPICAL SAMPLING PROCEDURE

The sampling procedure used in most applications is listed below:

1. A hole is drilled or cored through the slab 3 to 6 inches into the subsurface material or void space beneath the slab.
2. A ¼-inch sampling tube attached to a stainless steel sampling screen is advanced through the hole. Sand (Morie No. 1 or No. 2) is added to surround and cover the sampling zone.
3. The sampling point is isolated from the atmosphere above by the use of modeling clay or beeswax (for small diameter holes) and grout or hydrated bentonite for larger holes.
4. The ¼-inch OD sample tube is passed through the enclosure, the enclosure is placed over the sampling point, and weights are added to the enclosure to compress the gasket between the enclosure and the slab.
5. The lower helium port is opened, and the upper port is connected via a ⅛ inch Teflon line to the helium supply.

6. Helium is introduced through the upper port and the air is allowed to escape through the lower port.
7. The concentration of helium is directly measured at the lower port until the concentration reaches at least 80 percent, then both ports are closed.
8. The helium detector is operated in ambient air to clear the unit of helium.
9. Using a portable pump, the sampling tube is purged at 200 cc/min to remove approximately three volumes of air within the sampling tube and the sampling point.
10. A Tedlar bag is connected to the exhaust port of the sampling pump, and a sample is collected to measure helium. The helium concentration inside the bag is measured. If the helium concentration is 10 percent or less, sampling is allowed to proceed. If the helium concentration is greater than 10 percent, then the seal to atmosphere is checked and/or repaired and the process is repeated.
11. The sampling tube is directly connected to a certified clean SUMMA canister provided by the laboratory, and then a sample is collected following the laboratory's Standard Operating Procedures.
12. Sampling may be interrupted to monitor the presence of tracer gas in the sample depending on the sampling duration, but for short sampling periods (1-hour or less), a minimum of a final tracer gas check should be performed. If the enclosure looses a significant amount of helium over the sampling point it may be recharged and the short circuiting check repeated.

5. RECOMMENDED EQUIPMENT

In addition to the enclosure described above, the following equipment is recommended to perform the sampling method.

5.1 Helium Tracer Gas

Technical grade helium is used as a tracer gas. Refill helium is a readily available and economical choice for this use. Typically, empty tanks are exchanged for full tanks by the helium supplier. One 20 cubic foot helium tank is roughly 20 inches tall and weighs about 10 pounds, and will cover at least four sampling locations. For sites with numerous sampling points, larger tanks may be used; however, these tanks must be secured to a tank cart when being transported around the site.

One must consider proper safety procedures for tank storage, transfer, and handling. Helium is a simple asphyxiant, as such, safety measures, such as properly protecting the cylinder valve and securing the gas cylinder must be performed. A broken valve could turn the pressurized cylinder into a dangerous projectile. The cylinder should never be transported within the passenger compartment of a vehicle without plenty of ventilation, and the cylinder should be secured by straps during transport.

The use of a gas regulator is highly recommended for the safe discharge of helium to the enclosure. Gas delivery and control are controlled by the regulator and a needle valve connected to the helium cylinder via a Compressed Gas Association (CGA) No. 580 fitting. A valve or toggle switch at the regulator outlet is easier to operate than the bottle valve alone. Pipe tape should not be needed for the connection, but is good to have on hand if fitting on your particular tank has been worn.

5.2 Helium Detector

The portable helium detector used in this application is a Radiodetection Dielectric Technologies Model HDP 9900. The instrument uses Thermo Conductivity Detection to measure helium concentrations. Used in historical gas chromatography experiments, the Thermo Conductivity Detector (TCD) consists of two matched thermisters, one exposed to the sample gas stream, the other employed as a reference current. During instrument operation, the two thermisters are compared for their difference in output, and this difference is amplified and reported as a response.

To reduce interferences caused by moisture, carbon monoxide, carbon dioxide, ozone and the potential presence of ambient VOCs, the detector is equipped with a replaceable moisture trap which contains indicating silica gel, molecular sieve, activated carbon and other filtering media. Additionally, the detector is equipped with High Efficiency Particulate Air filters to protect its internal components.

It is important to note that the typical sampling flow rates for this detector may exceed 500 cc/min. Therefore, the direct connection of the helium detector to the sampling line is not recommended. The use of a personal pump connected to a Tedlar bag for subsequent tracer gas monitoring is suggested to prevent over purging of the sampling point.

5.3 Purge Pump

For sample purging, a personal pump (SKC Model 224-PCXR4 or equivalent) commonly employed in industrial hygiene monitoring activities is used. These pumps typically run for eight hours on a single battery charge cycle and are capable of maintaining a stable 200cc/min flow rate over time. For the referenced pump, a low range is set on the pump flow regulator and fine adjusted by use of an inlet valve. Pump designs and capabilities vary, so the user should performance test any new pump system prior to sampling. Also, these pumps have a potential to fail during field activities due to a variety of conditions (obstructions, low batteries, etc.) so the use of a back up pump is recommended.

The personal pump is calibrated by use of a dry flow calibrator (BIOS DCL-ML or equivalent). The outlet port of the calibrator is connected to the inlet port on the pump, the pump is started, and the inlet needle valve is adjusted until a 200cc/min air flow is maintained. It is recommended to check the purge rate repeatedly during purging and/or sampling activities to verify that the flow has not changed significantly.

5.4 Other Equipment Considerations

Dedicated, disposable equipment should be used to prevent cross contamination between sampling points. A general equipment list is provided below:

1. Disposable Nitrile gloves.
2. Fresh Teflon tubing for each sampling point (⅜ in. ID X ¼ in. OD).
3. Tedlar Bags equipped with inlet valves (SKC 232-03 or equivalent).
4. Sealing Materials such as modeling clay, grout, beeswax and bentonite.
5. Gas Tight fittings for sample line connections (Swagelok).

Table 1. Typical Swagelok Fittings

Description	**Swagelok Part No.**	**Approx. Unit Cost (USD)**
¼ in. nut (each)	SS-402-1	1.37
¼ in. ferrule sets (100)	SS-400-Set	126.00
¼ in. union	SS-400-6	7.31
¼ in. Tee	SS-400-3	16.12
¼ in. Plug	SS-400-P	3.91
¼ in. Cap	SS-400-C	4.30
⅜ in. to ¼ in reducing union	SS-600-6-4	13.30

6. QUALITY ASSURANCE CONSIDERATIONS

In addition to the use of tracer gas to determine the contribution of ambient air to the subslab sample, the following Quality Assurance (QA) measures are recommended.

6.1 Ambient (background) Air Samples

Ambient air samples collected in the area above the subslab sampling location are recommended as a means to compare sampling results with background conditions.

- For building interior subslab sampling, at least one ambient air sample should be collected from above each sub surface study area within the building.
- At least one ambient air sample should be collected from an area outside the building.

6.2 Duplicate Samples

Duplicate sampling is recommended to measure the precision of the sampling and analytical technique. Duplicates samples should be collected at a frequency of at least 5 percent. Duplicates are collected by the use of a stainless steel tee connecting two Summa Canisters to a common flow controller.

6.3 Additional QA Considerations

Additionally, the following quality control measure considerations are recommended when collecting soil vapor samples:

1. Usually the area beneath the building is comprised of open voids or loose fill. As such, the vacuum created by sample pumps would be considered to be negligable. However, sampling consolidated soils beneath the slab may produce a vacuum. Suspect sampling points should be monitored with an in-line vacuum gauge.
2. Consider the elevation of neighboring sample points and the horizontal pathway to the sampling point. Dips in the surface material could also cause short circuiting.
3. Mark out underground utilities and identify the potential for soil vapor migration. As-built drawings are very useful for this purpose.
4. Building survey forms should be completed to determine possible contribution to sample results from stored products and human activity.
5. Interior and ambient air pressures and temperatures should be recorded during the sampling period.
6. Whenever possible, sampling activities should be scheduled around work activities in an occupied building.
7. A steady state should be maintained in building interior by minimizing or eliminating door movement, exhaust fan operation, etc.
8. The groundwater elevation below the slab should be accurately determined or at least estimated when choosing the sampling depth.

7. CONTRACTOR PREPAREDNESS

Drilling through concrete and asphalt is normally accomplished with a construction grade hammer drill and masonry bit available at most equipment rental centers. However, for special applications, a drilling contractor may be required.

Drilling contractors use different methods for sample probe installation. It is important that your drilling contractor is comfortable with your scope of work and will be capable of stocking and deploying the sampling train that you specify. This could be as simple as an angle cut tube for site screening or as complex as a permanent vapor sampling well for long term studies. Allow planning time to ensure that your drilling contractor will:

1. Have a clear understanding of your work scope.
2. Use clean sampling point installation procedures.

3. Have the ability to mobilize in tight urban situations.
4. Be flexible with regard to unexpected building construction and environmental conditions, which may require additional equipment.

Drilling is preferred due to the reduced diameter of the hole and a minimum amount sealing of materials used. However, coring gives the site investigator the option of obtaining discrete soil samples at multiple depths below the floor which could be used for further site characterization. Most concrete coring activities employ water as a coring bit coolant. Care should be taken to ensure that the sampling point has not been exposed to heat and/or moisture. It is recommended that cored sampling points are kept dry and allowed to cool down. The sampling point should be installed, sealed to the atmosphere (by use of a gas tight plug) and allowed to stand prior to sampling, preferably over night.

8. SUMMARY

The use of tracer gas for the purpose of obtaining representative subslab samples has been considered and recommended by a growing number of members of the regulatory community. The use of a portable helium enclosure is a fast, effective, economical sub slab sample isolation monitoring technique that can be deployed under a variety of sampling environments. This method has been used to perform the technique rapidly while addressing the need to collect a discrete, representative sample. Tied to a technically sound scope of work, this subslab sampling method addresses the detection and control of short circuiting under a variety of field conditions.

REFERENCES

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