SUB-SLAB VENTILATION TECHNOLOGY INFORMATION SHEET

Active mitigation system (uses electric fan)

This Interstate Technology & Regulatory Council (ITRC) technology information sheet provides basic information when using a fan to ventilate the sub-slab environment to prevent and/or reduce sub-slab vapor concentrations and mitigate the potential for vapor intrusion (VI) at a given building. Any system that draws gas from below a floor slab for the purpose of sub-slab depressurization (SSD) will also result in some degree of sub-slab ventilation (SSV). SSV can be installed in buildings at or near VI sites where the permeability of the material below the floor is high, such that ventilation reduces sub-slab concentrations to levels too low to pose a potential indoor air quality concern. Ventilation will occur at these properties even in areas where the sub-slab vacuum is too low to be reliably measured given instrument sensitivity and baseline fluctuations. The key differences between SSD and SSV are the performance goals and metrics, and the importance of the relative permeability of the floor slab and the material below the slab.

Overview

SSV is an active engineering control employed to mitigate potential VI for vapor-forming compounds (VFCs) into buildings. The difference between SSV and SSD is that the design objective for SSV is to reduce vapor concentrations below a building's slab to levels that are low enough to maintain acceptable indoor air concentrations above the slab, regardless of whether there is a consistent or measurable vacuum below the floor. Generally, this is practical where the material below the slab has a high permeability (e.g., coarse-textured, granular fill materials, geocomposites, aerated floors) that allows high airflow rates to be induced below the slab with minimal applied vacuum. SSV is best suited to cases where sub-slab vapor concentrations are relatively low to begin with, and reduction to concentrations less than levels of concern can be readily achieved.

SSV occurs to some extent during the operation of an SSD system and vice versa. The **Sub-Slab Depressurization Technology Information Sheet** should be reviewed for additional information that may apply to SSD systems. SSV performance may not be quantified if performance monitoring only involves measurements of vent-pipe vacuum or cross-slab differential pressures. If the ventilation rate (i.e., flow rate) below the slab is sufficient to reduce the VFC concentrations to very low levels, then an occasional reversal of the cross-slab pressure gradient will not result in substantial VFC transport into the building. As such, continuously maintaining the more conventional minimum sub-slab vacuum may not be necessary to prevent unacceptable exposures due to VI.

SSV systems can be used in both existing and new construction. For existing buildings, SSV is most suitable where the sub-slab fill material is highly permeable to allow for appreciable air exchange rates below the slab. If grade beams or wall footings are present that may restrict horizontal vapor flow below the floor slab, they will need to be accounted for in the system design. In a new-construction scenario, SSV systems include many components similar to those used in SSD systems, including gas-permeable layers (or aerated floors), horizontal perforated pipes, and/or vapor barriers. The designs of new-construction SSV systems are similar to those of SSD systems, although an SSV system may include the addition of air inlets to allow dilution air to enter below the slab. Dilution air is needed to reduce sub-slab VFC concentrations to levels less than screening levels (e.g., building-specific sub-slab screening levels). In many cases, SSV is also capable of reducing sub-slab vapors to concentrations less than generic sub-slab screening levels published by states or other regulatory entities.

Selection of a membrane for new-construction SSV is similar to the process discussed for new construction in the **Sub-Slab Depressurization Technology Information Sheet**. The addition of a properly installed membrane should reduce cross-slab leakage and expand the radius of influence of each SSV suction point. For existing buildings, it is valuable to consider sealing the floor, particularly at expansion joints, floor drains, and obvious stress fractures.

Components

SSV system components are essentially the same as SSD system components—a fan or blower connected to piping that is engineered to evacuate air from the sub-slab area. The main difference between SSD and SSV is in the performance objectives; that is, reducing concentrations below the slab instead of reducing pressure, and associated monitoring (concentrations and mass emissions rather than static vacuum). The electric fan or blower should be installed outside. It is important to note that fans installed on the outside of a building are subject to changing weather conditions that, depending on the geographic region, may result in condensate issues and additional wear on the fan. Installation of a condensate bypass and/or insulation of the exterior piping may be needed to address this concern.

For systems in which the fans must be installed inside of the building envelope, they must not be located within, adjacent to, or below an occupiable area of the building to prevent a potential for leak in the fan's vent from entering an occupied space. Accessibility to the fan should also be considered to ensure access during both system inspections and to allow for ongoing operations, maintenance, and monitoring (OM&M). Fans installed in protected spaces, such as attics, have a longer and more consistent operating life because they are protected from extreme weather conditions; however, they also require obtaining permission from the property owner to access the system for each OM&M visit.

When the subfloor materials are not very permeable, the resistance to flow will be measurable as a vacuum. Conversely, appreciable flow can be achieved at vacuum levels that may be too low to measure consistently when subfloor materials are highly permeable. An SSV system can also be integrated with other technologies, such as an aerated floor, to reduce airflow resistance in the sub-slab zone.

Components of SSV include the following:

- High-permeability materials below the floor slab to allow for high vapor flow velocity and air exchange rates below the floor, which can be measured using pneumatic and tracer tests (McAlary et al. 2018).
- System piping, including a sampling port(s) for conducting system diagnostic testing (i.e., vacuum and air velocity/flow) and for collecting samples to measure VFC concentrations in the effluent to support mass removal rate calculations.
- Sub-slab sample ports located away from exhaust and inlet pipes and perforated sub-slab piping for measurement of reductions in sub-slab concentrations at worst case locations.
- In general, SSV needs fan(s) or blower(s) capable of higher flow rates than what would typically be needed for SSD.
- Air inlet pipes.
- Permanent u-tube manometer, vacuum gauge, or pressure sensor on the system piping to monitor system vacuum where and if appropriate.
- Balancing valves on the system piping, which provide an efficient way to adjust the system flow from multiple areas and/or reconfigure the system footprint over time if needed. Fans or blowers that have variable speeds may also be used to balance or rebalance a system over its operational life.
- Qualified personnel to conduct design, installation, and OM&M of control systems.

Advantages

SSV as an active mitigation technology has the following advantages:

- SSV is an easily deployable engineering control.
- In higher permeable sub-slab soils, small low-vacuum high-flow fans or blowers can be used.
- Many different types of fans and blowers are available, making system applications widespread.
- Energy costs for operation are usually low because the highly permeable material below the floor imposes minimal resistance to flow.
- Performance monitoring devices can easily be connected to remote telemetry technologies.
- SSV can readily be installed with other engineering controls on or around the building.
- If sub-slab VFC concentrations, measured at worst-case locations, are reduced to levels that pose no risk to indoor air quality, it may not be necessary to collect indoor air samples for performance monitoring, which avoids potential forensic analysis of background sources and disruption to occupants.

Limitations

SSV as an active mitigation technology has the following limitations:

- Installation of an SSV system impacts the occupants of the building in that coordination with and cooperation of the building occupants is needed during system installation (for existing buildings) and ongoing OM&M (both new construction and existing buildings).
- Low-permeability soils below the slab will limit ventilation rates and radius of influence. SSD is a more appropriate technology in these cases.
- Sub-slab differential pressure measurements may not be useful for direct measurement of system performance (i.e., sub-slab VFC concentration, airflow, and/or SSV rates are required). Additional communication may be needed with the local agency if they are expecting differential pressure readings because SSVs need to be evaluated with other performance criteria.
- Poor concrete slab construction, excessive cracks in the slab, or utility penetrations/floor drains/pipes may create short circuiting of airflow and potentially have a high energy penalty through loss of conditioned indoor air to the sub-slab. A substantial amount of sealing to limit indoor air from being drawn into the system and to enable overall system effectiveness may therefore be needed.
- SSV may not be continuously effective during high water table conditions if water is in contact with or within a few inches of the slab.
- SSV systems may not meet performance requirements if required design and construction practices are not followed. There are important differences in mitigation design and practitioner qualifications for VI and radon mitigation that should be recognized.
- For some properties, it may be difficult to prevent property owners from tampering with and possibly damaging system components.
- SSV systems will not necessarily prevent diffusion of VFCs across slabs and some vapor barriers if high concentrations are present immediately below the slab. SSV will not address some preferential

pathway conditions such as conduit VI (i.e., vapors emanating from a closed conduit and discharging into a building). This condition is more likely to occur at existing buildings where solvent-impacted soils are present immediately below the slab and is less likely to occur in new construction where clean materials (e.g., gravel) are placed below the slab and a barrier designed to limit diffusion is installed.

Cost Considerations

In addition to construction costs, it is important to remember potential costs such as predesign testing; preparation of a work plan, design, and specifications; installation monitoring; regulatory agency and stakeholder liaising; post-installation verification testing; and reporting.

Factors affecting cost include but are not limited to the following:

- Sub-slab permeability and floor leakage rates
- Building size
- The number of suction points and the type, number, and size of fans or blowers
- Ducted fresh air supply to the sub-slab (if needed)
- Electrical power requirements and local utility rates
- Building construction features
- Aesthetic considerations
- Exhaust carbon filtration or other emissions control device (if needed)
- Monitoring and reporting requirements
- Permitting, regulatory, and legal oversight

Special Circumstances

Special circumstances for construction of an SSV include the following:

- In new construction, SSV systems can be designed using engineered plenums or aerated floors to facilitate airflow.
- In existing construction, the permeability of the material below the floor is fixed and may or may not be adequate for SSV, in which case it may be necessary to design an active SSD system instead of SSV.
- It may be challenging to gain regulatory acceptance and approval of SSV systems because performance is documented using metrics that may be different from standard acceptable SSD system performance metrics. The use and acceptance of SSV systems appears to be increasing.
- Precautions should be taken to ensure that new tenants and/or construction activities (e.g., accessing sub-slab utilities, service pits) do not damage the SSV system.
- Precautions to understand and monitor changes in building use/building modifications should also be taken.

Occupant, Community, and Stakeholder Considerations

It is essential to develop and implement a site-specific community involvement plan that addresses how to win trust and gain access to properties, communicate risk to potentially exposed individuals, and minimize the disruption of people's lives and businesses. For more details see **Chapter 3: Community Engagement**.

REFERENCES

McAlary, T. A., W. Wertz, and D. Mali. 2018. *Demonstration/Validation of More Cost-Effective Methods for Mitigating Radon and VOC Subsurface Vapor Intrusion to Indoor Air*. U.S. Department of Defense: ESTCP. **https://clu-in.org/download/issues/vi/ER-201322-Final-Report.pdf**.