ACTIVE VAPOR INTRUSION MITIGATION SYSTEMS FACT SHEET

Active Mitigation Types

This fact sheet includes a brief description of five of the most common types of active vapor intrusion mitigation systems (VIMS). Each system is also described in a supporting technology information sheet as follows:

- Aerated Floors Void Space Systems (VSS)—see **Aerated Floor Void Space Systems Technology Information Sheet**
- Crawl-Space Ventilation (CSV)—see **Crawl-Space Ventilation Technology Information Sheet**
- Sub-Membrane Depressurization (SMD)—see **Sub-Membrane Depressurization Technology Information Sheet**
- Sub-Slab Depressurization (SSD)—see **Sub-Slab Depressurization Technology Information Sheet**
- Sub-Slab Ventilation (SSV)—see **Sub-Slab Ventilation Technology Information Sheet**

In addition to or in conjunction with the five types of active VIMS noted above, the following active VIMS approaches may be used to assist in addressing vapor intrusion (VI) risk. These methods may be used for temporary mitigation or rapid response mitigation, or in building-specific situations where the main methods (SSD, SSV, SMD, or CSV) may not be effective or may not be effective on their own. Some of these technologies are described in other technology information sheets, which are referenced below:

- Indoor air filtration—see the **Indoor Air Treatment Technology Information Sheet** and the U.S. Environmental Protection Agency's (USEPA's) *Adsorption-based Treatment Systems for Removing Chemical Vapors from Indoor Air* (Schumacher et al. 2017).
- Aerobic Vapor Migration Barriers (AVMB)—see the **Aerobic Vapor Mitigation Barrier Technology Information Sheet**.
- Building pressurization/ventilation—see the **Heating, Ventilation, and Air Conditioning Modification Technology Information Sheet** and the **Preferential Pathway Sealing and Ad Hoc Ventilation Technology Information Sheet**.

Existing in-depth standards for the mitigation of most building types have been developed and published by the American Association of Radon Scientists and Technologists (AARST), also known as the Indoor Environments Association (IEA), which is accredited as a standards development organization by the American National Standards Institute (ANSI). These ANSI/AARST Standards have been expanded to address both radon and soil vapor to incorporate considerations for VI. These documents can be viewed/accessed for free on the AARST Standards website (AARST 2025) and are generally updated every three years. These standards will continue to be labeled as ANSI/AARST due to historic name recognition for AARST, despite the rebranding of AARST to IEA.

Common Active Mitigation Strategies

This section provides a summary of the primary active VIMS technologies that are typically employed.

SSD uses an electric fan/blower to continuously create a negative pressure beneath the building envelope, relative to inside the building envelope, to prevent vapors from migrating from the subsurface into the building through advection. When a negative pressure is present within the building envelope relative to surrounding soil, advective gas flow from the soil into the indoor air can occur. Soil vapor entry pathways can be cracks through the slab or wall(s), improperly sealed utilities, etc. Depressurization of the subsurface below the slab with an SSD system will create a low pressure that reverses or alters the direction of soil vapor flow, thus mitigating VI. The types of fans/blowers used for SSD can vary depending on sub-slab material permeability, as well as the building type, construction quality, and size of the building being mitigated. SSD may be limited to the portion of the floor slab where vapor-forming chemical (VFC) concentrations exceed generic or building-specific action levels. Depending on the VFC concentrations, emission rates, proximity of receptors, and state or federal regulations, air pollution controls may be needed.

SSV is an active engineering control employed to mitigate buildings at or near VI sites. SSV system components are essentially the same as SSD system components — a fan or blower connected to perforated piping or low-profile geogrids that are engineered to evacuate air from the sub-slab area. The goal 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 even measurable vacuum below the floor. Generally, this is practical where the material below the slab has a high permeability (such as coarse-textured granular fill materials, drainage mats, and aerated floors) that results in high airflow below the slab. SSV is also generally practical where the sub-slab concentrations are low to begin with and reduction to concentrations below generic or building-specific screening or building-specific action levels is easily achieved. Depending on the vapor concentrations, emission rates, proximity of receptors, and state or federal regulations, air pollution controls may be needed.

SMD systems can be used as an active VIMS for buildings or portions of buildings built over accessible dirt-floor crawl spaces (or dirt-floor basements). SMD relies on the ability to install a durable, vapor-resistant membrane over the exposed soil in the crawlspace (or basement) to enable a negative pressure to be generated below the membrane.

SMD is applicable if the basement or crawlspace will not be accessed (or will not be accessed frequently) so that the membrane is not disturbed or damaged. Prior to placing and sealing the membrane, a venting mechanism (e.g., perforated pipe, low-profile soil vapor collection mat, etc.) is installed under the membrane and connected to a vertical section of solid piping, leading to a fan located outside the occupied building envelope. The types of fans/blowers used for SMD will vary depending on the size of the crawl space/basement; how well sealed the membrane is; and the size, age, and condition of the building being mitigated.

CSV may be warranted for buildings with crawl spaces that are too shallow to enter. This technology focuses on moving a minimal amount of air out of the crawlspace to create a modest but consistent air exchange rate for the space. As crawl spaces are often not sealed and are usually connected to other parts of the basement, or connected to the living space above, this venting strategy is used because it may not be possible, practical, or desirable to remove enough air from a crawl space to create a significantly depressurized space. Ventilation may consist of opening existing vents around the crawl space, if present, and usually includes connecting an exterior-mounted fan to piping that is extended into the crawl space. Care is needed to avoid freezing water lines in cold climate areas. Care should also be taken to avoid pulling outside air into the CSV; this can be accomplished by sealing openings between the basement and crawl space.

Aerated floor VSS are concrete slabs installed with a continuous void space under the slab that can be used for sub-slab venting or depressurization in lieu of the sand or gravel venting layer commonly associated with traditional mitigation systems. Because the void space has very low resistance to air flow, air exchange rates in the void space are generally higher and vacuum levels are generally more uniform than in sand or gravel layers. Aerated floors can be constructed in various ways, including open void spaces below structural slabs, but are more typically constructed using proprietary plastic forms that are placed on the subgrade prior to pouring of the concrete slab. Aerated floors can be used in either active or passive mode, depending on the degree of venting or depressurization needed to mitigate VI. Generally, these systems do not employ the use of barrier system technology (refer to the **Building Design for Passive Vapor Intrusion Mitigation Technology Information Sheet** for more information) due to the presence of the void space and plastic forms below the slab. Therefore, sealing of floor penetrations, slab joints, and other potential subsurface-to-indoor air transport pathways with caulking, pipe boots, or similar mechanisms is an important design consideration for a VSS. Aerated floor VSS are most applicable to new construction, although aerated floors can also be used for complete floor replacement or placed over existing slabs if a higher finished floor elevation can be accommodated. Aerated floor VSS can be used in both passive and active applications; see the **Aerated Floor Void Space Systems Technology Information Sheet** for further information.

Other Active Mitigation Strategies

This section provides a summary of other mitigation technologies that may be employed either on their own or in conjunction with the five main mitigation technologies detailed above.

Indoor Air Filtration — Indoor air filtration involves portable filtration units equipped with granular activated carbon, zeolites, or other filter media to remove vapor contamination from the indoor air. Indoor air filtration is primarily used for rapid response actions as a temporary way to reduce indoor air levels until a more permanent vapor mitigation technology can be implemented. Indoor air filtration can also be used as a supplemental degree of protection for SSD/SSV systems in the early stages if active mitigation systems are being installed to mitigate high sub-slab vapor concentrations. See USEPA's *Adsorption-based Treatment Systems for Removing Chemical Vapors from Indoor Air* (Schumacher et al. 2017) and the **Indoor Air Treatment Technology Information Sheet**.

AVMB — AVMB is a combination in situ VI mitigation and remediation technology for sites with aerobically degradable compounds (e.g., petroleum hydrocarbons, methane, and vinyl chloride). AVMB involves the slow delivery or circulation of atmospheric air at low pressure or negative gauge pressure (i.e., sub-slab extraction combined with ambient pressure air inlets) below and around a building foundation through either sub-slab vents or horizontal wells installed below the building foundation. The delivery of air creates elevated oxygen conditions in the shallow soil around the foundation that are favorable for aerobic biodegradation. A successful AVMB will mitigate the potential for VI by aerobically biodegrading compounds susceptible to the enhanced aerobic conditions. See the **Aerobic Vapor Mitigation Barrier Technology Information Sheet** for more information.

Building Pressurization/Ventilation — Building pressurization/ventilation involves using the building's heating ventilation, and air conditioning (HVAC) system to pressurize the interior space sufficiently to prevent VI or provide sufficient make-up air to reduce indoor air concentrations to acceptable levels. See USEPA's *Indoor Air VI Mitigation Approaches Engineering Issue* for a summary of building pressurization/ventilation (USEPA 2008).

Pressurization is typically only feasible for commercial or industrial buildings with controlled door and window access so the positive building pressure can be maintained. Buildings with garage bay doors that open frequently or where tenants have free access to open and close doors and windows will not be able to consistently maintain building pressurization. This approach requires regular air balancing and maintenance and may have high operation and maintenance costs related to heating and air conditioning. See the **Heating, Ventilation, and Air Conditioning Modification Technology Information Sheet** and **Preferential Pathway Sealing and Ad Hoc Ventilation Technology Information Sheet**.

Drain Tile Depressurization — Drain tile depressurization is similar to SSD; however, it uses the presence of sub-slab sumps and associated drain tile systems to depressurize beneath the building slab to mitigate the potential for VI. If the drain tile system is not adequate to reach all portions of the building needing mitigation or is not structurally conducive to maintain sufficient pressure, SSD can typically be used to supplement this method, except where the water table is very shallow. See *USEPA's Indoor Air VI Mitigation Approaches Engineering Issue* for more information on drain tile depressurization (USEPA 2008).

Block Wall Depressurization — Block wall depressurization uses an electric fan connected to the voids and the network within hollow block walls to create a depressurized zone to mitigate the potential for VI through foundation walls. Uniform depressurization of block walls can be difficult. This approach is typically only recommended to supplement a traditional SSD system if the SSD is not addressing VI through the foundation walls and it is believed that this pathway is significantly contributing to indoor air concentrations. See *USEPA's Indoor Air VI Mitigation Approaches Engineering Issue* for more information on block wall depressurization (USEPA 2008).

Barrier Systems – Barrier systems can be used in both active and passive VIMS applications. Barrier technologies can enhance the efficiency of the active VIMS by reducing the advective and diffusive transport pathways through a concrete slab. In effect, this may enhance the active VIMS radius of influence and may result in a reduction in the number of mitigation fans and/or system energy requirements. Depending upon several factors (e.g., VI conceptual site model [CSM], mitigation design objectives, building design), barrier systems may not be practical or warranted for all active VIMS. A more detailed discussion of barrier technologies is included in the **Passive Vapor Intrusion Barriers Fact Sheet**, the **Composite Membranes Technology Information Sheet**, and the **Single-Sheet Membranes Technology Information Sheet**.

Considerations for Active VIMS

Many considerations and decisions are necessary to select, design, install, operate, and eventually decommission an effective active VIMS. The approach outlined below provides a summary of information to consider during each step in the active VIMS process. More details regarding each consideration can be found in the Considerations for Design and Implementation of Mitigation Approaches (collectively, the process fact sheets), which include the following:

- **Design and Implementation Considerations for Vapor Intrusion Mitigation Approaches Fact Sheet**
- **Vapor Intrusion Mitigation System Construction Quality Assurance Fact Sheet**
- **Vapor Intrusion Mitigation Systems Post-Installation Verification Fact Sheet**
- **Vapor Intrusion Mitigation System Operation, Maintenance, and Monitoring Fact Sheet**
- **Vapor Intrusion Mitigation System Curtailment and Shutdown Fact Sheet**

The process fact sheets are written to include all VI mitigation technology types and go into more detail on the considerations to be made at each point in the stepwise process and the relative impact each consideration may have for each type of mitigation technology.

Design Considerations

Prior to VIMS design, it is common to perform a building survey and predesign diagnostic testing to understand building-specific issues that will need to be incorporated into the system design. This typically includes pressure field extension or radius of influence testing that helps confirm the number and placement of sub-slab suction points and the fan/blower sizes required to meet the desired minimum pressure differential. The larger and more complicated a building, the more predesign work is likely to be performed to create an effective system design. Design considerations for existing large buildings should comport with the ANSI/AARST Standards (AARST 2025).

For many existing small buildings (for example, single-family homes), it may be common to do very little predesign work prior to design and installation of a VIMS. This occurs because it is often mistakenly assumed that single-family homes can be actively mitigated with a single fan and single suction point. This may be true for homes with a smaller footprint and with concrete and a sub-base that are in good condition, but care should be taken because this may not be true in all cases. Design considerations for existing small buildings should comport with the ANSI/AARST Standards (AARST 2025).

For systems installed during new building construction, design considerations may be different, as there is much more control over the building and its infrastructure. Design considerations for new buildings should comport with the ANSI/AARST Standards (AARST 2025).

Special design considerations may also be needed if looking to convert and modify a previously installed passive VIMS to an active VIMS. The practitioner or designer must understand the air flow and the potential for short circuiting prior to converting a passive VIMS to an active VIMS. Designs should account for more than just adding a fan/blower to a passive system's vent stack(s). Depending on vapor concentrations, emission rates, and proximity of receptors, air pollution controls may need to be installed.

The **Design and Implementation Considerations for Vapor Intrusion Mitigation Approaches Fact Sheet** provides details about factors that could be considered for various VI mitigation approaches, including active mitigation, passive mitigation, remediation, and rapid response. Factors that could be considered for active mitigation include the following:

- VI CSM considerations
  - Vapor source
  - Geology and hydrogeology
  - Building conditions and age
- Design investigation and diagnostic testing
  - Sub-slab diagnostic tests
  - Barrier or membrane material tests
  - HVAC tests
- Mitigation system design
  - Design basis
  - Design layout and components
  - Permit requirements
  - Stakeholder requirements
- System construction and implementation
  - System effectiveness and reliability
  - Operation and maintenance considerations
- VIMS management and exit strategy considerations

System design and documentation checklists have been created as guides through the considerations relative to both active and passive VIMS strategies and can be found in the **Active Mitigation Checklist** and the **Passive Mitigation Checklist**.

During this stage in the mitigation process, the installation and installation oversight (also referred to as construction quality assurance [CQA]) of the system should be considered as it relates to the design and the components of completing a design (e.g., implementability, permitting, construction quality objectives, etc.). Additional installation considerations are summarized in the CQA and post-installation verification process step.

Construction Quality Assurance Considerations

Following the design stage, preconstruction planning and CQA monitoring are important considerations to support the long-term integrity of the VIMS. Attention to these items will greatly improve the post-installation evaluation and will likely lead to more successful long-term system operation and performance. The formality of preconstruction planning and CQA during installation will depend on the size and complexity of the building and the VIMS to be constructed.

The primary purposes of preconstruction planning and CQA of a VIMS are listed below:

- Document that the materials used in the construction of the VIMS are consistent with the design documents and/or otherwise approved by the designer
- Inspect the installation of the VIMS components during construction for conformance to the design documents
- Provide a plan to manage unforeseen construction scenarios in collaboration with, and with approval from, the designer

The **Vapor Intrusion Mitigation System Construction Quality Assurance Fact Sheet** provides details of the above factors that could be considered for active VIMS and includes the following:

- A more detailed overview of and description of the purpose of CQA
- Considerations for state- or federal agency-specific CQA requirements
- VIMS product manufacturer CQA requirements
- Typical CQA tasks
- CQA documentation considerations

Please also refer to **Appendix J: Vapor Intrusion Mitigation System Construction Quality Assurance Plan Outline** for a guide to developing a CQA plan.

Post-Installation System Verification Considerations

Following design and installation, the VIMS will be turned on and verification will be needed to document that the system is operating according to the objectives set out in the design. Verification of system installation and effective operation may include multiple criteria. It is also important during this step, as well as in the future during operation, maintenance, and monitoring (OM&M), to validate the VI CSM for which the system was designed. Below is a summary of possible post-installation verification considerations that may be needed for active VIMS approaches.

Initial system commissioning data may be collected immediately upon start-up and system balancing. It is also common to collect (or recollect) commissioning data and rebalance the system if needed, up to

30–90 days after system start-up. This is due to changing conditions in the subsurface soils where soil may dry out and/or sub-slab vapor concentrations may be reduced. Often this process results in more permeable soils and an increase in the distances of the pressure field extension for an active VIMS (SSD, SMD, and SSV). If indoor air samples are going to be collected as part of verification testing, the time frame for sampling may be different than initial system commissioning flow and vacuum data collection. Some regulatory agencies have recommended data collection time frames in their VI guidance to be followed as applicable.

For systems installed during new building construction, post-installation verification testing may be easier to perform prior to occupation, especially if any retrofits are needed to enhance system performance. These verification methods (i.e., system parameter readings, pressure field extension tests, tracer tests, checking for leaks, etc.) can be performed relatively quickly in an empty building to minimize delay in the continued construction and occupancy schedule.

The **Vapor Intrusion Mitigation Systems Post-Installation Verification Fact Sheet** provides details of the factors that could be considered for active VIMS and includes the following:

- Groundwater elevation
- Building information and survey
- System design and specification confirmation considerations
- Confirmation testing
- Permitting
- Communications
- OM&M planning

Please also see the **Post-Installation Vapor Intrusion Mitigation System Verification Checklist** for a checklist guide to verification considerations.

Operation, Maintenance, and Monitoring Considerations

An OM&M plan provides instructions for system operation and upkeep and should be prepared for each installed mitigation strategy. The goal of OM&M is to verify performance of the system as compared to performance during system commissioning and to inspect and, if needed, repair issues with the system due to system malfunction (i.e., system not meeting performance objectives) or due to system equipment life expectancy.

The **Vapor Intrusion Mitigation System Operation, Maintenance, and Monitoring Checklist** includes a list of considerations that may be reviewed, inspected, and/or measured during an OM&M site visit. Considerations during OM&M inspections of active VIMS may also need to include OM&M of any passive components to VI mitigation activities completed at the property, such as maintenance of passive membranes or maintenance of crack sealants or preferential pathway sealants that were installed or completed in combination with the active mitigation approach.

The **Vapor Intrusion Mitigation System Operation, Maintenance, and Monitoring Fact Sheet** provides details of the factors that could be considered for active mitigation and includes the following:

- Mitigation system operation
- System start-up and shutdown
- Building conditions and use

- System inspections and performance metrics
- Communication and reporting
- Telemetry system / remote data acquisition functionality

The **Vapor Intrusion Mitigation System Operation, Maintenance, and Monitoring Checklist** includes a list of questions designed to assess VIMS operation and the need for corrective actions identified during regularly scheduled VIMS inspections.

VIMS Management and Exit Strategy Considerations

A key concept throughout the process of designing, implementing, and operating an active VIMS is evaluating whether the monitoring data and VI CSM support a potential reduction in monitoring scope and/or optimization of system operation over time. In some cases, the data may even support eliminating ongoing system operation and monitoring requirements entirely. The **Vapor Intrusion Mitigation System Curtailment and Shutdown Fact Sheet** presents a framework to consider for optimizing the monitoring and operation of a VIMS based upon long-term site management objectives. It is important to note that the objectives below may not be appropriate to consider for every site. Further, state, federal, and local regulatory requirements may preclude the implementation of some of the strategies and processes discussed herein. Regardless, the **Vapor Intrusion Mitigation System Curtailment and Shutdown Fact Sheet** discusses three common site management objectives and conceptual approaches that can be considered to achieve those objectives, as follows.

- Objective 1: Reduction of ongoing system monitoring requirements
  - After multiple rounds of VIMS performance monitoring, there may be increased confidence in the operation of the VIMS and understanding of the VI CSM, which collectively may support a reduced monitoring scope of work.
- Objective 2: Transition from active to passive system operation
  - Multiple lines of evidence (MLE) may support the transition of an active mitigation system to passive operation, or in the case of a large building, the transition of a targeted portion of a building from active to passive operation.
- Objective 3: Exit strategy to terminate ongoing VIMS monitoring
  - MLE may indicate ongoing monitoring of a VIMS is no longer warranted because, for example, the source of VFC vapors may be remediated or may biodegrade within the life cycle of a mitigation strategy and therefore, in some cases, render the system unnecessary.

One or each of these scenarios could exist for a given building. For example, there are often cases where VIMS are operated out of an abundance of caution but are not actually necessary because of uncertainties associated with spatial and temporal variability in sampling and analysis of data, background sources, and/or conservative regulatory guidance. In this scenario, the performance monitoring data could support initially reducing the scope of ongoing monitoring, then lead to transitioning the system from active to passive operation, and eventually, eliminate the requirement for future monitoring because the MLE indicate the building is protective of VI without a mitigation system. Alternatively, the MLE may be sufficient to support an immediate transition from active operation to terminating system operation and monitoring (i.e., progressing through the three objectives presented above in a step-by-step, sequential sequence may not be necessary). Regardless of the exact scenario, VIMS management decisions should be considered only when MLE are supportive of system modifications and/or scope reductions and in accordance with applicable regulatory requirements. See the **Multiple Lines of Evidence Fact Sheet** for more information.

The details for VIMS management and exit strategy considerations can be found in the **Vapor Intrusion Mitigation System Curtailment and Shutdown Fact Sheet**. It includes scenarios for possible reduction in monitoring, transition from active to passive operation, transition from passive operation to no additional monitoring, and descriptions of the following:

- Types of monitoring and timing
- Stepdown strategies
- Decommissioning considerations
- Communication

Summary

Active VIMS involves the use of energized controls (e.g., a fan/blower) to maintain acceptable indoor air quality by mitigating the potential for VI into a building. As described in this fact sheet, multiple different methods for active mitigation are available; the most common methods are CSV, SMD, SSD, SSV, and VSS.

Buildings vary widely in their size, function, and use. Because of this variability, implementation of active VIMS technologies will also vary widely, depending on the type of building and the design objectives for the VIMS. This fact sheet and associated process fact sheets summarize the many considerations for the design, installation, verification, and OM&M of each of the most common active VIMS technologies as they relate to some of the more common building types and uses. Depending on vapor concentrations, emission rates, and proximity of receptors, air pollution controls may need to be installed.

The details and considerations discussed are part of the long-term stewardship of active VIMS. Systems should not only be carefully designed and installed, but procedures or guidance (or in some cases, institutional controls) should be put in place to maintain the operation of these systems until such a time that the system can be considered for shutdown.

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

AARST. 2025. "ANSI/AARST National Consensus Standards." **https://standards.aarst.org/**.

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