This document references Chapters and Sections from the ITRC Vapor Intrusion Technical and Regulatory Guidance, and Fact Sheets and Technology Information Sheets from the ITRC Vapor Intrusion Toolkit, published January 2026. These resources can be accessed at: **https://itrcweb.org/vapor-intrusion-toolkit**.

SINGLE-SHEET MEMBRANES TECHNOLOGY INFORMATION SHEET

Technology Description

Single-sheet membranes (SSM) are composed of one or more materials that are applied in sheet form and seamed together in the field to achieve a uniform barrier. Historically, these membranes have consisted of high-density polyethylene (HDPE), but variations such as linear low-density polyethylene (LLDPE) are also available. New variations of SSMs now exist that incorporate materials such as ethyl vinyl alcohol (EVOH) or metalized films to decrease the vapor-forming chemical (VFC) flux through these materials. These membranes can also incorporate protective materials to increase durability; examples can include geotextiles and reinforcement grids. The thickness of SSMs can range between 20 and 60 mils. The key to these SSMs is the seal of the seam, which can be accomplished through heat welding, spray membranes, and tapes.

A welding device is used to thermally seal the seams of the SSM together. Heat-welding methodologies can vary depending on the thickness of the SSM. Thicker SSMs will require more robust equipment to achieve the goal of a uniform and continuous welded seam. Prefabricated “boots” made of the same SSM material are used to seal around pipe penetrations and protrusions. Steel clamps and sealants are used to create a compressive seal between the penetration and the SSM. Heat-welded seams are generally considered the strongest seam because the two adjoining sheets are melted together to form a continuous sheet.

A spray membrane is used to seal the seam by spraying a nominal mil thickness in-between the overlapping seams. The completion of the seam seal occurs when an additional layer of spray membrane is applied over the overlapped seam as depicted in **Figure 1**. Seals around pipe penetrations and protrusions also use spray membranes to achieve the desired seal. The same spray-applied membrane is also used to seal the SSM to concrete footings or other termination points. Spray membranes take less time than heat-welded seams, but the strength of the seal is not as robust. Spray membranes are less sensitive to environmental factors than heat welding or tape.

Figure 1. Application of asphalt latex membrane within the single-seam membrane seam (left) and single-seam membrane passive barrier with asphalt latex membrane over the top of the seam overlap (right).

Source: EPRO, used with permission.

A taped seam can also be used on SSM. Manufacturers of taped SSM systems have a range of detailing methods that can be used, from lapping the top of the seam overlap (single lap), to applying tape within the seam overlap and on top of the seam overlap. The latter method is referred to as the “dual lap” seam. Dual lap seams are preferred for vapor intrusion mitigation system (VIMS) applications as they provide a more robust seal; the single-lap method is common for installing water vapor barriers. The type of tape used will vary in quality, and the quality of the tape used can impact the sealing of the SSM. Tapes can be susceptible to delamination if moisture is present or the SSM substrate is dirty.

Since most passive barrier applications also require the use of a sub-membrane vapor collection system, SSMs are commonly installed over a gravel substrate. To prevent damage during the installation process, it is common to install a nonwoven geotextile (between 6 and 12 ounces per square yard in weight) under the SSM if a geotextile is not already incorporated into the SSM. Additional protection geotextiles should be considered above the SSM to prevent damage to the system from subsequent work.

When terminating the SSM to building footings, grade beams, stem walls, etc., a termination bar should be considered if heat welding or a tape-seamed approach is used. The termination bar’s purpose is to create a compressive seal between the desired SSM and substrate. Proper compression between the termination bar and the termination substrate is required to create an effective seal. Stainless steel termination bars are generally specified due to their longevity, physical strength, and resistance to moisture and chemicals. Aluminum termination bars are discouraged due to their propensity to corrode. The fasteners and washers should be the same material as the termination bar.

Advantages

- SSMs may provide factory quality assurance documentation, ensuring uniform quality of the base material.
- The material cost for an SSM can be low when compared to the material cost of composite membrane (CM).
- Puncture resistance can be increased by using thicker membranes and protective geotextiles.
- Due to advancements in polymer science, some materials will achieve a higher chemical resistance at a lower overall mil thickness (McWatters and Rowe 2018).
- SSMs can be combined with CMs to create a higher level of protection from chemical diffusion.

Limitations

- The use of SSMs is primarily limited to new construction projects.
- SSMs have a wide range of seaming methods; taped-based SSMs may be subject to delamination in high-moisture environments and may have difficulty passing a smoke test.
- Thicker SSMs decrease the likelihood of damage during the construction process; however, they are more difficult to install properly. Generally, large, flat, open areas are more conducive to SSM installation.
- SSMs can be susceptible to thermal expansion and contraction, thus potentially compromising penetration and termination seals.
- Thinner SSM effectiveness can be compromised if not properly protected, as they are more prone to damage.

- Some SSMs may contain an aluminum foil component that may be susceptible to corrosion if in direct contact with concrete as this can cause corrosion of the foil layer from tears or other punctures in the membrane (NHBC 2023).

Design and Installation Considerations

Design and installation considerations for SSMs are similar to other passive barriers. The primary methods for design evaluation should focus on chemical resistance, constructability, and cost. The evaluation for chemical resistance should include diffusion testing for representative chemical contaminants. In addition, other testing methods should be used in combination with chemical resistance testing to evaluate the following parameters of SSMs:

- Composite mil thickness
- Tensile strength
- Tear strength
- Puncture resistance
- Elongation

These physical properties should be used in combination with diffusion testing to create a better understanding of the overall robustness of the SSM. These barriers will be installed in construction traffic environments and must demonstrate sufficient durability to prevent punctures and/or tears prior to concrete slab pour. Installation is best completed by certified installers who are familiar with the application of the SSM. In addition, it is best practice to have third-party inspectors present during installation to ensure the installation is performed per the designed technical specification.

Quality Assurance / Quality Control

SSM design should consider foundation complexity, contaminants of concern, and weather conditions at the anticipated time of installation. The most common quality assurance/quality control (QA/QC) methods are listed below:

- **Smoke test:** The process of injecting nontoxic smoke underneath the membrane, checking for any smoke penetrating the membrane, and then patching the membrane to ensure no more smoke penetrates the membrane. Care should be taken when using a smoke test of a passive VIMS with taped seams. Pressure from the smoke test can cause the seams to separate.
- **Mechanical point stress test:** Testing the integrity of each seam using a handheld seam probing tool after the seam has cooled.

ASTM quality assurance standards for heat-welded seams are listed below:

- ASTM D4437—Air Lance Test (ASTM International 2018a)
- ASTM D4437—Vacuum Box Test (ASTM International 2018a)
- ASTM D5820—Conductive Geomembrane Spark Test (ASTM International 2018b)
- ASTM D5820—Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes (ASTM International 2018b)

Typical Barrier Selection Considerations

Thickness

The barrier material, properties, and application affect the appropriate thickness, and these factors should be considered when selecting a barrier for any particular purpose. It should also be noted that some vapor intrusion (VI) guidance documents do not specify an appropriate minimum thickness but state that passive barriers should be thick enough to withstand construction and diffusion from the chemicals of concern. State and federal VI guidance documents that do suggest an acceptable minimum thickness vary from 30 to 100 mils. A thickness of 40 mils is commonly referenced for SSMs and 60 mils is referenced for CMs. A 30-mil minimum thickness is referenced in some guidance for passive systems (USEPA 2008); however, since 2008 some 20-mil barriers, specifically designed for VI mitigation, have been developed and successfully implemented. Vapor barriers less than 20 mils are more prone to puncture, tearing, and incomplete seals, thus limiting their effectiveness. Membranes less than 20 mils may be appropriate when combined with active systems. Depending on expected traffic on the barrier, the designer should consider the addition of a protection layer (e.g., geotextile) above and/or below the barrier.

Chemical Resistance and Diffusion

Universally accepted standards do not exist for the chemical resistance to chemical vapor or diffusive properties of passive barrier materials. Existing ASTM standards used to evaluate water vapor barriers (ASTM E96) or short-term free product chemical exposure do not adequately address the intended use of VI barrier systems and may differ due to the molecular size and attraction of the solvent vapor barrier material (Wilson et al. 2014).

Manufacturers of VI barrier products publish chemical vapor resistance testing and/or diffusion results. These tests should be evaluated on their own merits. Best practice testing method reporting may include a mass-flux rate, barrier thickness, test duration, and challenge gas concentration. Testing methodologies can vary among manufacturers, but there are independent laboratories and universities, such as Geokinetics of Irvine, California, and Queens University in Ontario, Canada, using proprietary testing methods and equipment applied equally to all materials to determine chemical diffusion rates for various commercially available passive barriers.

Puncture and Tensile Strength

Testing the strength of a membrane system helps predict a membrane's ability to resist damage during the construction process. Damage to membranes after they are installed often occurs when small objects (hand tools, rebar, etc.) are dropped onto the membrane. Puncture resistance by ASTM D1709, which measures the amount of force required to fully penetrate the membrane material, is commonly used (NJDEP 2021).

Tensile strength (ASTM D882) is a measure of a material's resistance failure due to stretching (NJDEP 2021). Tensile strength can be used to evaluate a membrane's ability to resist failure due to tension that may be caused by differential settlement of the underlying soil.

Constructability

Constructability of a passive barrier system is a subjective term that attempts to convey to users how easy a passive barrier is to install versus its ability to withstand the construction process as well as its usability in a wide variety of situations. SSMs are typically provided in large rolls. The material's stiffness and thickness make it more difficult to work with in areas requiring a lot of detail work. The large rolls facilitate fast installation in open areas without pipe penetration and foundation elements to detail. CMs are efficient for use in areas that require detail work because they are spray applied and rapidly seal to the substrate. In large, open areas CMs typically take longer to install than SSMs seamed with spray-on materials, as compared to welded seams.

Special Circumstances

The presence of a high water table or perched aquifer may adversely affect the performance of both passive and active mitigation systems installed under buildings constructed below grade. Slab-on-grade buildings are not often affected unless they are built in a flood zone, but below-grade buildings will need protection against both water and VI. Local building code requirements will dictate a building owner's ability to artificially lower the water table to an elevation that does not affect the foundation or mitigation system; however, in many cases this is not economically feasible when contaminated groundwater is encountered. When dewatering systems are used, a passive barrier with waterproofing capabilities should still be used in the event of dewatering system failure and to prevent the migration of nuisance water. Water intrusion into the building indicates that a potentially complete VI pathway exists. Waterproofing materials used on contaminated sites must also demonstrate effectiveness to contaminated vapor.

Settlement of soils beneath buildings may occur for a variety of reasons. Therefore, passive barriers should demonstrate their ability to adhere directly to the concrete slab, as this will prevent the barrier from settling with the soil. Likewise, peel adhesion and tensile stress on the passive barrier material and its seals and seams may compromise the system.

Occupant, Community, and Stakeholder Considerations

Occupants of buildings with existing passive barriers should be made aware of potential VI risks and that the barrier provides a level of protection designed to prevent VI from occurring. Occupants should be instructed to avoid modifying the concrete slab to prevent affecting the function of the passive barrier. When planning modifications to a building with a passive barrier, consideration should be given to whether the modifications will affect the integrity of the barrier.

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**.

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