When Sealants Meet Waterproofing: A Sticky Situation

Adhesion, Compatibility, and Discoloration of Silicone Sealant in Contact with Bituminous Waterproofing Materials

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A COMMON CONVERSATION in design team meetings and on project sites during construction involves compatibility of materials. In a world where product formulations are ever changing, supply chains are disrupted, and product manufacturers merge, it can be hard to keep track of what materials will adhere to one another. Many design professionals are told that "silicone sticks to everything, but nothing sticks to silicone." While this rule of thumb may hold true for construction materials in many applications, it cannot be applied to all project conditions. To identify instances where the rule of thumb does not hold true, specifiers will often require adhesion testing to evaluate project-specific conditions, and many product manufacturers will complete this testing for their products in-house. Without question, this testing can be very valuable, but oftentimes it is completed within a few weeks of materials being installed and does not paint the full picture of what happens when materials are in contact with one another in the long term. What happens when those materials have been installed for months or years? Can the adhesion or aesthetics of those materials change based on their interaction over time?

For an example of when this rule of thumb may not hold true, consider a building with large fenestration assemblies that look out onto an outdoor terrace that is landscaped with planters and contains other tenant amenities—common features trending in current building design and construction. On such a terrace, there are many opportunities for the fenestration and its associated perimeter sealant (which is often silicone) to interface with waterproofing materials (which are often bitumen based). There are discrepancies in the industry as to whether silicone sealant should be installed in direct contact with bitumen-based products. Typically, these conditions are addressed on a project-by-project and product-by-product basis where the specific sealant and waterproofing manufacturers are contacted regarding compatibility. It is not uncommon for silicone sealants to stain or discolor when in contact with the bitumen-based materials (**Fig. 1** and **Fig. 2**). The phenomenon is often believed to be an aesthetic concern only and some sealant manufacturers claim that the discoloration of the sealant does not impact sealant performance. At least one manufacturer has published that a dark-colored silicone sealant should be used, or the sealant should be put in a non-visible location if installed in contact with bitumen-based materials to minimize the aesthetic impacts of the potential staining. There are other manufacturers that recommend avoiding use of silicone sealants in contact with materials that may have the tendency to bleed oils, plasticizers, or materials that are uncured.

ASTM C1193, *Standard Guide for Use of Joint Sealants,*[1] states that sealants in general (not just silicone) should not be put in contact or proximity to materials with which the sealant is not compatible. ASTM C1193 further recommends compatibility testing in accordance with ASTM C1087, *Standard Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems.*[2] These standards suggest that color change is sufficient evidence to warrant additional testing for other adverse effects, that color change is evidence of a potentially detrimental chemical reaction, and that although adhesion may not be

Figure 1. *Example of in-service silicone sealant installed in joint between bitumen-based waterproofing and curtainwall frame.*

Figure 2. *Example of discolored in-service silicone sealant in contact with bitumen-based waterproofing.*

initially lost, the color change could be predictive of a future loss of adhesion. Other than changes in aesthetic qualities, sealant characteristics that could also be affected by material incompatibilities include the ability of a sealant to cure fully and develop its ultimate strength.

There is very little published information regarding the impacts of adhesion, compatibility, and discoloration of exterior silicone sealant in contact with bitumen-based waterproofing materials. The following independent study was undertaken to more broadly understand:

- How long the discoloration takes to occur,
- How discoloration impacts both immediate and long-term performance characteristics of the sealant, and
- If different formulations and/or colors of silicone sealants have an impact on discoloration or performance.

TEST SPECIMEN PREPARATION

With the assistance of a contractor familiar with sealant and waterproofing installation, multiple test specimens were fabricated for the study. Silicone sealants from three different manufacturers commonly used in commercial construction were selected for test specimen construction and were generally identified as follows:

- Manufacturer A
- Manufacturer B
- Manufacturer C

A minimum of two different formulations of silicone sealant from each manufacturer, one product formulated to minimize potential staining and one product formulated with a plasticizer that is likely to migrate into a porous substrate, were selected for the study and identified as follows:

- Sealant Type A1 – one part, Class 50, neutral curing, non-staining
- Sealant Type A2 – one part, Class 50, neutral curing
- Sealant Type A3 – one part, Class 25, neutral curing
- Sealant Type B1 – one part, Class 50, neutral curing
- Sealant Type B2 – one part, Class 50, neutral curing, non-staining
- Sealant Type C1 – one part, Class 50, neutral curing, non-staining
- Sealant Type C2 – one part, Class 50/100, neutral curing, non-staining

Three colors of each silicone type were selected, if available. The three colors were typically white, black, and limestone. For one sealant type (Type B2), gray was used in lieu of limestone based on material availability at the time of specimen construction. Sealant Type A3 was only available in white color.

Specimen construction consisted of a dimensional wood frame with intermediate 24 in. (610 mm) long anodized aluminum angles secured to and spaced evenly across the frame. Sealant was installed in the joint between back-to-back aluminum angles. The substrate at one side (A side) of each test specimen consisted of the primed anodized aluminum. The substrate on the other side (B side) of each test specimen consisted of either anodized aluminum (Control), bitumen-based self-adhering membrane with plastic facer (Condition W+F), or the same bitumen-based membrane but with the plastic facer removed (Condition W-F) to simulate a fluid-applied bitumen-based membrane. In addition, smaller (approximately 2 in. [50 mm] long) reference samples of each material were constructed and set aside in the laboratory to be used to establish the baseline chemical properties of the sealants and waterproofing. Sealant was installed over a bicellular backer rod in a ½ in. (13 mm) wide joint and tooled to a concave profile with a 2:1 width-to-depth ratio. Two samples of each sealant and waterproofing combination were installed on each test frame (specimen) for a total of six samples on each frame (two with control condition on the B side, two with Condition W+F on the B side, and two with Condition W-F on the B side). In total, 19 test frames, each with a unique sealant formulation and color, were constructed (**Fig. 3** and **Fig. 4**).

After fabrication, the sealant was allowed to cure inside a conditioned warehouse for 1 month. In July 2023, the specimens were transported to an outdoor open-air enclosure located in the Washington, DC, metro area, which is in IECC Climate Zone 4A: Mixed Humid. The enclosure was partially shaded to prevent ultraviolet deterioration of the waterproofing over the course of testing/monitoring (**Fig. 5**).

The test specimens were documented when they were moved outside once a week for 1 year. The following items were reviewed and documented:

- The time from initial construction to initial discoloration of the sealant, noting pigmentation of the discoloration where present
- The severity/intensity of discoloration over time
- The impact the original color and/or type of silicone sealant has on the discoloration (rate of discoloration, severity/intensity of discoloration, etc.)
- The immediate and long-term impacts of discoloration on performance characteristics of the sealant

- Nondestructive adhesion testing per ASTM C1521, *Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints*,[3] (both Spot Method and Continuous Method)

MONITORING

No discoloration was noted throughout testing at the control or Condition W+F samples. The following general visual observations and nondestructive adhesion testing observations were made of the Condition W-F specimens during the first year (**Fig. 6**):

- At Week 6, a slight discoloration at the edge of the sealant in direct contact with the exposed bitumen material (Condition W-F) was observed at nine specimens. A subtle yellow haze at the edge of the sealant in direct contact with the exposed bitumen material was noted at an additional three specimens (Sealant Types A1 and B1). Discoloration of some degree was noted at all white- and limestone-colored specimens. In general, discoloration was noted along the full length of the edge of the joint in direct contact with the bitumen-based material (**Fig. 7[a]**).
- By Week 9, a subtle haze was observed at the edge of two black-colored sealants (Types C1 and C2).
- By Week 11, three of the specimens developed a bright orange discoloration at the edge of the sealant in direct contact with the exposed bitumen material; the discoloration lightened across the width of the joint (**Fig. 7[b]**).
- At Week 28, localized adhesion failure was noted at the edge of Sealant Type C1 at both black-colored samples (**Fig. 7[c]**).
- At Week 52, only two samples (Sealant Types A2 and B1, both black colored) did not have visible discoloration to some degree.
- No discoloration or adhesion loss was recorded for the specimens installed in direct contact with the self-adhered membrane facer (Condition W+F), except at the ends of the specimens where the sealant interfaced with the cut ends of the self-adhered membrane.
- No discoloration or adhesion loss was recorded for the specimens installed in direct contact with the aluminum (Control).

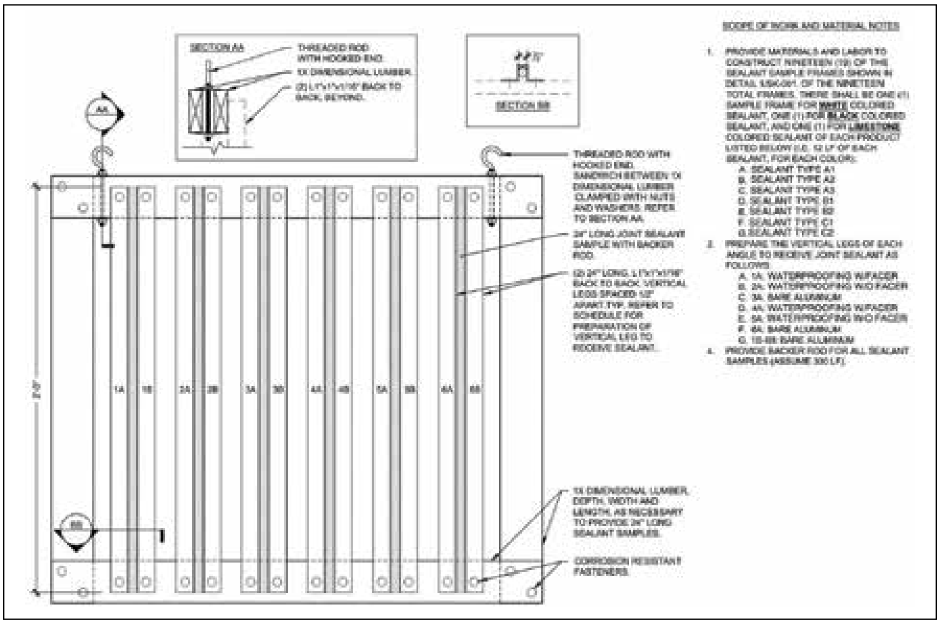


Figure 3. *Schematic sketch of sealant sample frame.*

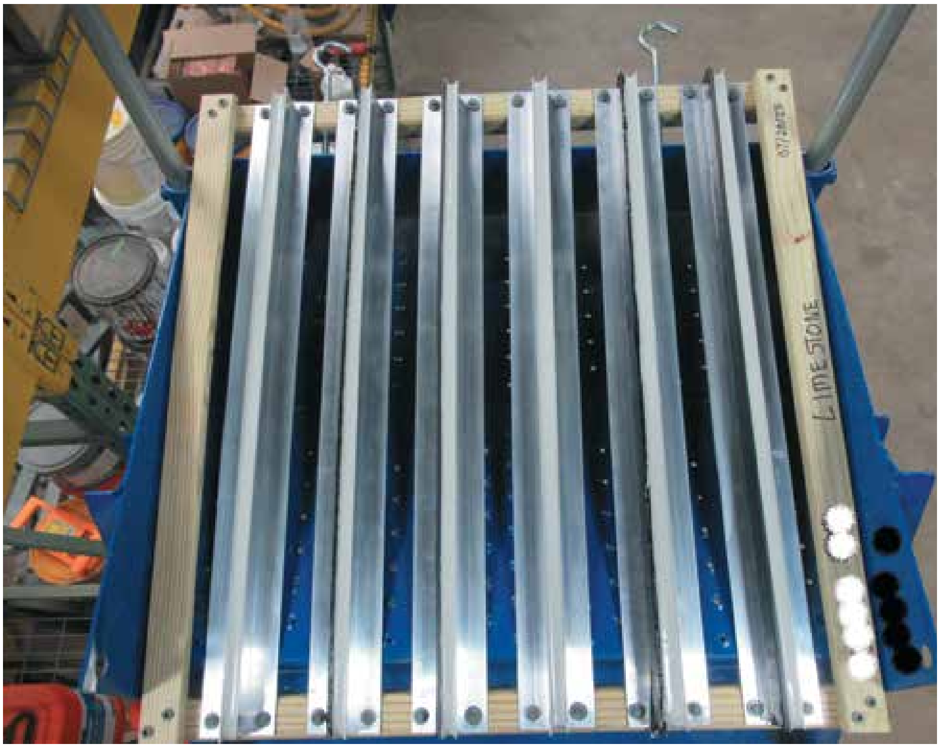
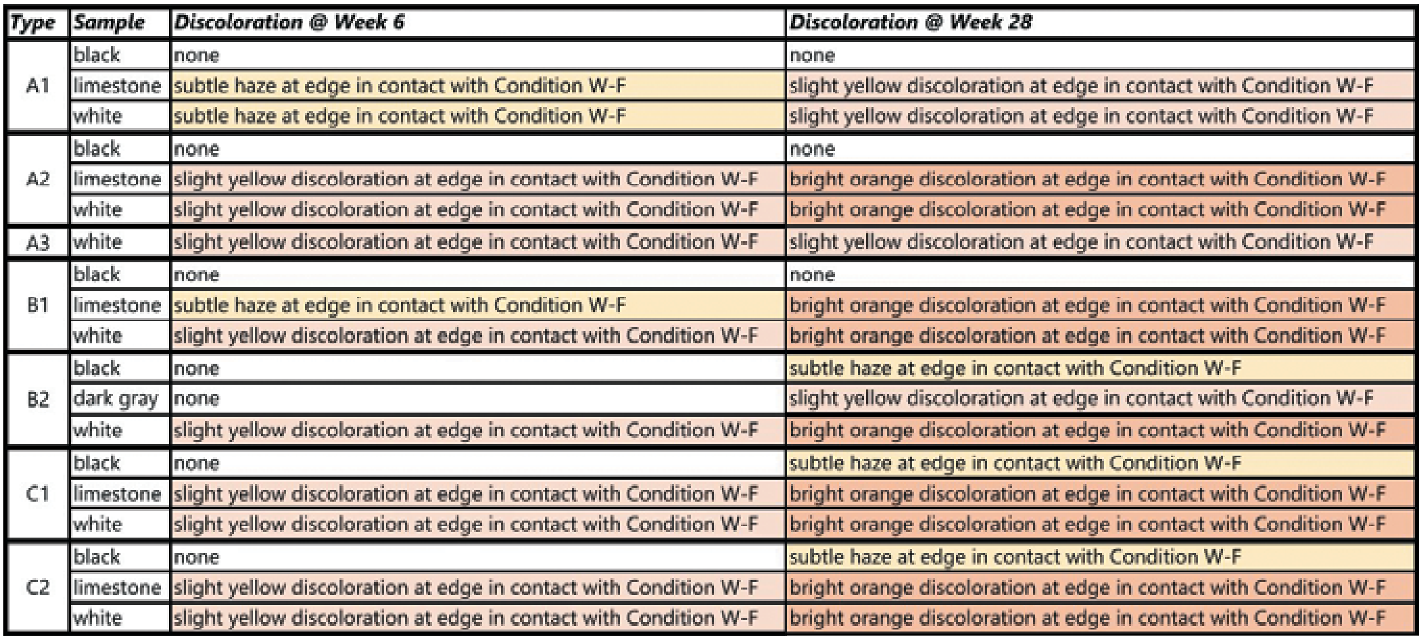


Figure 4. *Example of frame shortly after fabrication.*

Figure 5. *Frames hanging within outdoor enclosure.*



Type	Sample	Discoloration @ Week 6	Discoloration @ Week 28
A1	black	none	none
	limestone	subtle haze at edge in contact with Condition W-F	slight yellow discoloration at edge in contact with Condition W-F
	white	subtle haze at edge in contact with Condition W-F	slight yellow discoloration at edge in contact with Condition W-F
A2	black	none	none
	limestone	slight yellow discoloration at edge in contact with Condition W-F	bright orange discoloration at edge in contact with Condition W-F
	white	slight yellow discoloration at edge in contact with Condition W-F	bright orange discoloration at edge in contact with Condition W-F
A3	white	slight yellow discoloration at edge in contact with Condition W-F	slight yellow discoloration at edge in contact with Condition W-F
B1	black	none	none
	limestone	subtle haze at edge in contact with Condition W-F	bright orange discoloration at edge in contact with Condition W-F
	white	slight yellow discoloration at edge in contact with Condition W-F	bright orange discoloration at edge in contact with Condition W-F
B2	black	none	subtle haze at edge in contact with Condition W-F
	dark gray	none	slight yellow discoloration at edge in contact with Condition W-F
	white	slight yellow discoloration at edge in contact with Condition W-F	bright orange discoloration at edge in contact with Condition W-F
C1	black	none	subtle haze at edge in contact with Condition W-F
	limestone	slight yellow discoloration at edge in contact with Condition W-F	bright orange discoloration at edge in contact with Condition W-F
	white	slight yellow discoloration at edge in contact with Condition W-F	bright orange discoloration at edge in contact with Condition W-F
C2	black	none	subtle haze at edge in contact with Condition W-F
	limestone	slight yellow discoloration at edge in contact with Condition W-F	bright orange discoloration at edge in contact with Condition W-F
	white	slight yellow discoloration at edge in contact with Condition W-F	bright orange discoloration at edge in contact with Condition W-F

Figure 6. *Table summarizing discoloration of Condition W-F sealant samples within first 6 months.*

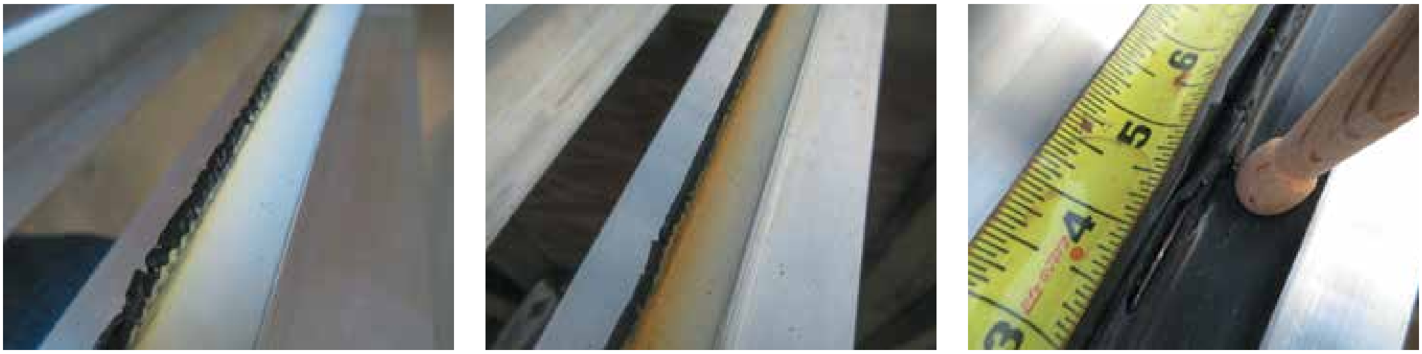


Figure 7. *Photo examples of sealant at: (a) Week 6, slight yellow discoloration at Condition W-F, (b) Week 28, bright orange discoloration at Condition W-F, and (c) Week 28 with localized adhesive failure along edge in contact with bitumen-based waterproofing (Condition W-F).*

After 1 year, the specimens were brought indoors for destructive testing (**Fig. 8**). Destructive adhesion testing per ASTM C1521[3] was completed, and a 12 in. (305 mm) long sample of each specimen was removed and sent to the lab. The 12 in. (305 mm) long sample includes the section that was destructively tested (**Fig. 9** and **Fig. 10**). The remaining samples were left on the test frame and returned outdoors. Of the 19 specimens, 8 were found to be fully unadhered at the edge of the sealant in direct contact with the exposed bitumen material (Condition W-F). Interestingly, many of these specimens were believed to have been adhered based on visual observation and nondestructive adhesion testing; however, upon destructive testing and sample extraction, the sealant cleanly debonded from the waterproofing.

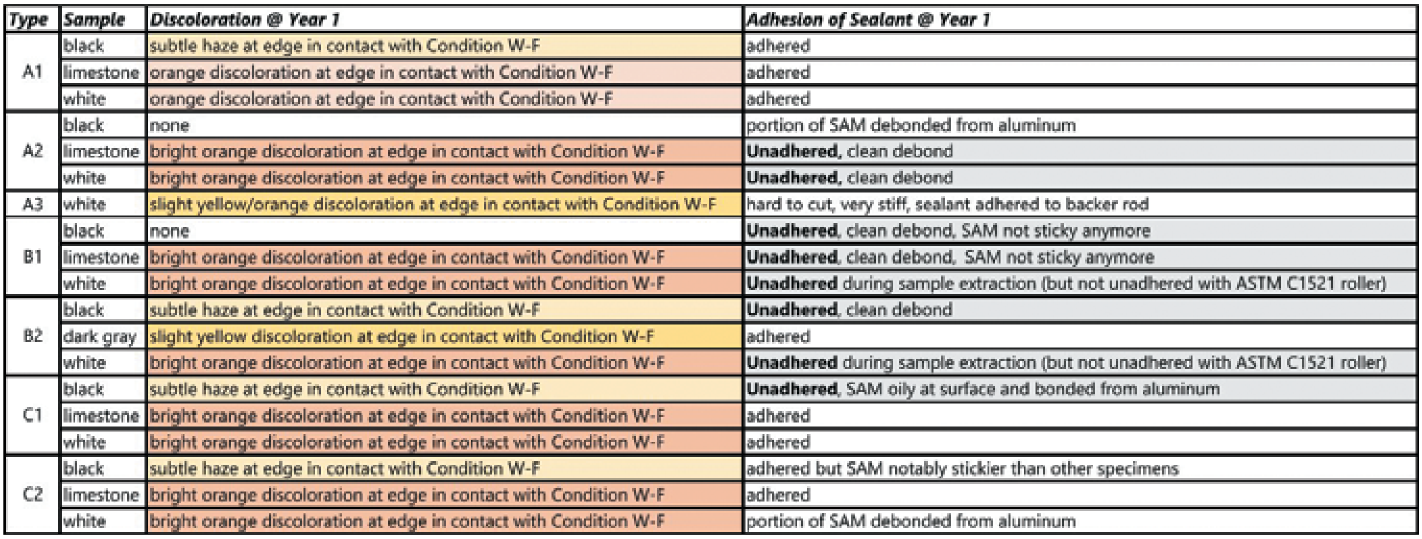
Among the 11 specimens where the sealant remained adhered to the waterproofing, 2 specimens (Sealant Types A2 and C2) contained waterproofing that had visually debonded from the aluminum substrate, 1 specimen (Sealant Type C2) contained waterproofing that was notably tackier than the other specimens, and 1 specimen (Sealant Type A3) contained sealant that was perceived to be very stiff (low elasticity). Note: The control sample of Sealant Type A3 was also found to be stiffer than the other sealant types. In general, the observed discoloration was present only on the air-exposed surface, not at the bond surface with the waterproofing or through the depth of the joint. At least one of the unadhered specimens (Sealant Type B1) did not have any noticeable discoloration. At least three specimens with bright orange discoloration remained well adhered after 1 year.

The specimens remaining on the test frames were returned outside to the open-air enclosure. After 2 years, only 8 of the 19 specimens were found to be adhered to the waterproofing. The discoloration observed on the samples after 2 years did not differ significantly from the discoloration observed after 1 year.

LABORATORY TESTING

Qualitative Examination

Sealant discoloration for each specimen was first compared across the three sealant colors (black versus limestone versus white). Although initial field observations indicated that discoloration varied by sealant color, laboratory analysis revealed that the overall extent of discoloration was consistent across all sealant colors, as shown in **Fig. 11.** Hues of orange were the predominant form of discoloration. While less apparent in black sealants, the orange hue was still present. Under controlled lighting conditions in the laboratory, discoloration in black sealants became more discernible and was comparable in extent to the discoloration noted in lighter colors.



Type	Sample	Discoloration @ Year 1	Adhesion of Sealant @ Year 1
A1	black	subtle haze at edge in contact with Condition W-F	adhered
	limestone	orange discoloration at edge in contact with Condition W-F	adhered
	white	orange discoloration at edge in contact with Condition W-F	adhered
A2	black	none	portion of SAM debonded from aluminum
	limestone	bright orange discoloration at edge in contact with Condition W-F	**Unadhered,** clean debond
	white	bright orange discoloration at edge in contact with Condition W-F	**Unadhered,** clean debond
A3	white	slight yellow/orange discoloration at edge in contact with Condition W-F	hard to cut, very stiff, sealant adhered to backer rod
B1	black	none	**Unadhered**, clean debond, SAM not sticky anymore
	limestone	bright orange discoloration at edge in contact with Condition W-F	**Unadhered**, clean debond, SAM not sticky anymore
	white	bright orange discoloration at edge in contact with Condition W-F	**Unadhered** during sample extraction (but not unadhered with ASTM C1521 roller)
B2	black	subtle haze at edge in contact with Condition W-F	**Unadhered**, clean debond
	dark gray	slight yellow discoloration at edge in contact with Condition W-F	adhered
	white	bright orange discoloration at edge in contact with Condition W-F	**Unadhered** during sample extraction (but not unadhered with ASTM C1521 roller)
C1	black	subtle haze at edge in contact with Condition W-F	**Unadhered**, SAM oily at surface and bonded from aluminum
	limestone	bright orange discoloration at edge in contact with Condition W-F	adhered
	white	bright orange discoloration at edge in contact with Condition W-F	adhered
C2	black	subtle haze at edge in contact with Condition W-F	adhered but SAM notably stickier than other specimens
	limestone	bright orange discoloration at edge in contact with Condition W-F	adhered
	white	bright orange discoloration at edge in contact with Condition W-F	portion of SAM debonded from aluminum

Figure 8. *Summary table after 1 year.*

Figure 9. *ASTM C1521 continuous nondestructive test at location of unadhered sealant.*

Figure 10. *Top and side of sealant sample during extraction from the aluminum angles.*

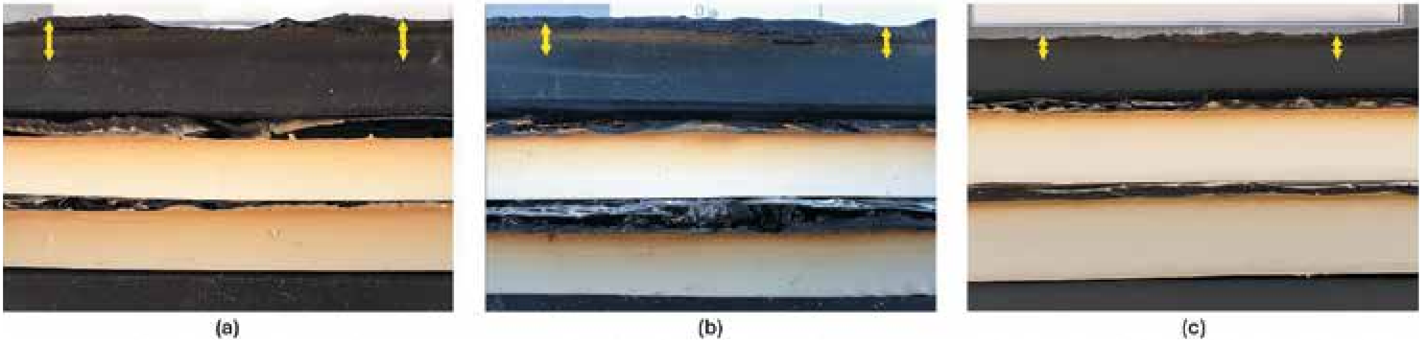


Figure 11. *Comparison of sealant discoloration among color variants (black, white, and limestone, from top to bottom) for three products: (a) Type A2, (b) Type C2, and (c) Type A1. The area of most pronounced discoloration observed in the black sealants is marked by yellow arrows.*

The relative severity of discoloration for each product, evaluated based on the width of visible discoloration from the membrane edge (across all three sealant colors), was ranked based on severity:

- (most severe staining) A2 > B1 > B2 > C2 > C1 > A1 > A3 (least severe staining)

The nature of discoloration was then investigated in depth through microscopic examination and chemical identification by micro-attenuated total reflectance Fourier transform infrared spectroscopy (micro-ATR FTIR). Potential impacts of the discoloration were also assessed via mechanical testing such as Shore A hardness, tensile testing, and dynamic mechanical analysis (DMA), comparing discolored and corresponding control sealant samples. Laboratory-prepared reference samples, for each sealant type in the color black, were also included for baseline comparison. The color black was used because information for this sealant color was already stored in our laboratory's internal database.

DISCOLORATION IDENTIFICATION

Microscopic Examination by Scanning Electron Microscopy and Energy-Dispersive X-Ray Spectroscopy

Figure 12 illustrates differences in color noted at various surface regions of the sealant samples. The top surface showed a discoloration gradient, which was most pronounced near the edge previously adhered to the exposed bitumen (Condition W-F) and gradually fading across the width of the joint. In contrast, the bond surface (in contact with the exposed bitumen) displayed a glossy texture with no visible discoloration after extraction. A cross-sectional cut revealed a dull, intact interior surface. These distinct surface regions were further analyzed using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS), with corresponding secondary electron images included in Fig. 12.

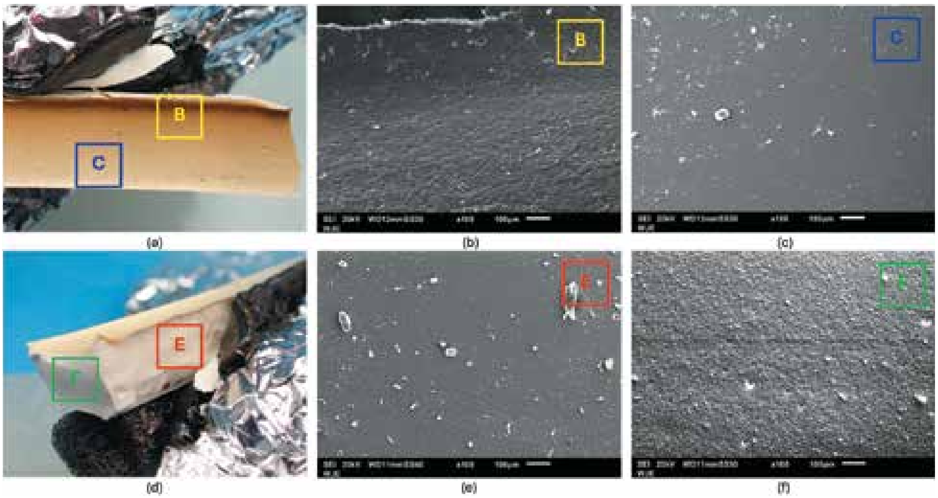


Figure 12. *Close-up views of Sealant Type B1 showing (a) the surface and (d) the interior, with corresponding secondary electron images: (b) intense discoloration near the membrane edge (yellow), (c) light discoloration near the opposite edge (blue), (e) glossy interface with the membrane (red), and (f) intact sealant cross section (green).*

EDS analysis results are summarized in **Fig. 13.** The intact cross section served as the internal sealant reference. The bitumen-based portion of the waterproofing membrane was also analyzed for reference. Elemental results indicated the following:

- Silicon (Si), oxygen (O), and calcium (Ca) were primarily associated with the sealant.
- Carbon (C) and sulfur (S) were mainly associated with the membrane.

Based on this comparison, membrane-related materials (rich in carbon) were strongly present in areas of intense discoloration, less pronounced in areas with lighter discoloration, and nearly absent at the glossy interface.

For better visualization, the top (discolored) surface of the sealant was further subjected to elemental mapping. The elemental mapping images shown in **Fig. 14** displayed color-coded maps of carbon (Fig. 14[b]), silicon (Fig. 14 [c]), and oxygen (Fig. 14 [d]), alongside a corresponding secondary electron image (Fig. 14 [a]). The intensely discolored region revealed a "mud crack" pattern near the bond surface previously in contact with exposed bitumen that gradually transitioned into a smoother surface across the width of the joint. The surface of the sealant covered with a solid-like contaminant, referred to as "mud," which likely originated from oxidized membrane oils based on the high carbon and oxygen content. When this oxidized layer "cracked," the subsurface became visible in the crevices, where the sealant, having the high silicone content, is exposed.

This comparative image analysis indicates that both the top and side surfaces of the sealant were coated with varying amounts of carbon-rich materials, likely originating from the bitumen-based membrane. Compared to smoother surfaces, the mud crack pattern with elevated oxygen content reflects degradation of this carbon-rich layer. As shown in Fig. 13, the relative ratios of oxygen and carbon on the discolored surfaces are notably higher than on the cross-sectioned intact sealant surface. Over time, the material forming the carbon-rich layer degraded and cracked, exposing the underlying sealant surface. Carbon-rich materials degrade more readily than silicone-based ones, leading to increased oxygen content through oxidation, which corresponds to the heavier discoloration and cracking near the edge in contact with the exposed bitumen.

These observations support that the discoloration and associated mud crack morphology are consequences of chemical and physical degradation of the carbon-rich bitumen-based layer that migrated onto the silicone and then oxidized, rather than from intrinsic sealant failure alone.

Note that the waterproofing membrane is a complex mixture, containing not only

	Primary source*	Waterproofing Membrane	Intense Discoloration	Light Discoloration	Glossy Interface	Intact Cross-section
C	Membrane	84.3	44.7	34.3	24.6	26.3
O	Sealant	9.9	26.9	32.4	28.4	30.8
Si	Sealant	1.3	13.7	18.9	25.4	24.0
S	Membrane	1.8	1.1	-	1.8	-
Ca	Sealant	2.7	8.2	11.9	19.5	13.7
Ti	Sealant		0.8	1.0	2.0	1.0
Chemical Identification	-	Membrane	Close to membrane	Less sealant	Close to sealant	Sealant

**Primary source estimates are based on published documentation and the elemental composition observed in the intact cross-section.*

Figure 13. *Scanning electron microscopy and energy-dispersive X-ray spectroscopy quantitative elemental analysis results (relative mass %) for Sealant Type B1 by surface location. Note: C = carbon; Ca = calcium; O = oxygen; S = sulfur; Si = silicone; and Ti = titanium.*

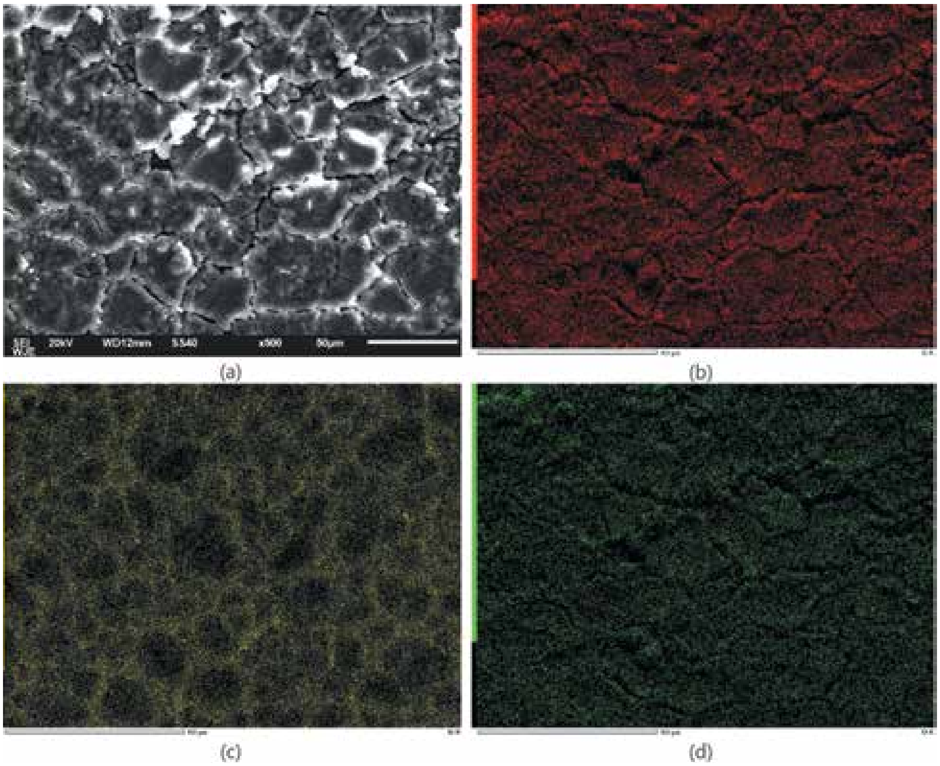


Figure 14. *High-resolution of elemental mapping images of Type C2 showing trace element distribution: (a) secondary electron image, (b) carbon, (c) silicon, and (d) oxygen.*

aliphatic hydrocarbon oils but also naphthenes, asphaltenes, and other complex aromatic compounds. These aromatics can also absorb light in the visible spectrum, which may further contribute to the observed discoloration.

Chemical Identification by Micro-ATR FTIR

To trace the invasion of the carbon-rich material and its progression of degradation, chemical imaging techniques using micro-ATR FTIR were employed. These techniques chemically characterized discoloration and evaluated correlations between the extent of discoloration and chemical degradation across various surface regions.

The bitumen membrane exhibited characteristic peaks at the wavenumbers 3,387, 1,711, and 1,605 cm^{-1} (representing vibrations of chemical bonds), which were absent in the sealant. After these peaks were eliminated by hexane extraction, the resulting spectrum matched well with petroleum hydrocarbon oil. However, these bitumen-specific peaks, which were likely associated with low-molecular-weight compounds, were consistently observed on discolored sealant surfaces. In particular, the peaks at 1,711 cm^{-1} and 1,605 cm^{-1} merged into a broad band between 1,810 cm^{-1} and 1,500 cm^{-1}, which varied systematically in line with the severity of discoloration. These changes likely reflect oxidative degradation of hydrocarbon-based membrane material. Note that a chloroform-soluble, hexane-insoluble extraction of the reference membrane sample was not completed.

Using this membrane-specific spectral signature, chemical imaging was conducted to identify the spread of discoloration distribution across the sealant surface. As shown in **Fig. 15,** measurements were performed on predetermined positions under an optical microscope, with three to five measurements per position. The resulting peak intensities were quantified and averaged at each position. Although proper attenuated total reflectance crystal contact was limited near the edge due to the concave surface profile and softness of the sealant, the integrated peak area between 1,810 cm^{-1} and 1,500 cm^{-1} generally showed a decreasing trend with distance from the membrane edge. Position 1 (nearest the edge) showed lower intensity despite severe discoloration, likely due to the curved surface profile causing poor contact upon crystal engagement.

These results confirm the presence of a bitumen-derived surface layer originating from migrating low-molecular weight materials from the membrane formulation. These chemical findings are in strong agreement with the microscopic observations and indicate that the discoloration is not intrinsic to the sealant itself but rather results from the bleed and accumulation of these residues.

DISCOLORATION IMPACT

To evaluate the potential impact of discoloration on sealant physical characteristics, Shore A hardness, tensile testing, and DMA were conducted. Again, laboratory reference samples were included for baseline comparison.

Shore A Hardness Testing

Shore A hardness testing, a widely used method for characterizing the cured properties of sealants or elastomers, was conducted in accordance with as defined in ASTM D2240, *Standard Test Method for Rubber Property—Durometer Hardness.*[4] Discolored sealant samples exhibited comparable hardness to control samples. While the results were generally consistent, measurement variability due to an arched profile and lack of flat surfaces reduced sensitivity for distinguishing subtle differences.

Tensile Testing

The extracted sealant samples could not be machined into standard shapes and were instead

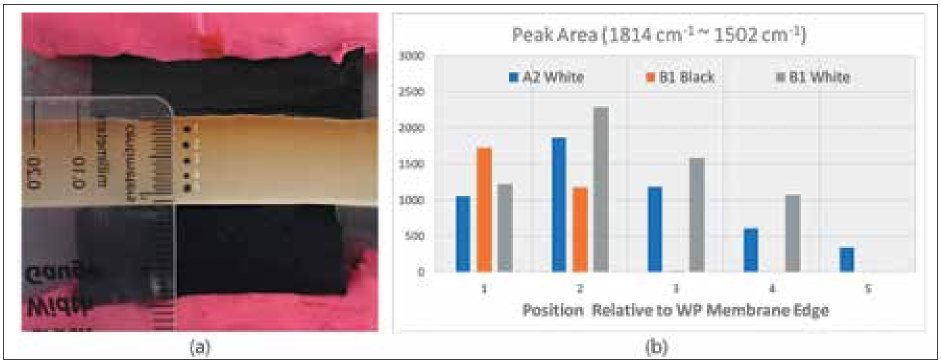


Figure 15. *(a) Photograph showing the alignment of a sealant sample beneath the microscope, with black marks indicating designated chemical imaging positions. Five positions were selected uniformly along the flatter surface, from Position 1 (nearest the membrane edge) to Position 5 (farthest from the edge). (b) Fourier transform infrared spectroscopy peak area measurements between 1,814 cm^{-1} and 1,502 cm^{-1} plotted as a function of distance from the membrane edge: Sealant Type A2-white (blue), Sealant Type B1-black (orange), and Sealant Type B1-white (grey).*

tested in their original strip form, following ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension,*[5] with modifications to accommodate the nonstandard geometry and gripping method. Tensile testing of these samples, comparing discolored and control samples, showed no conclusive difference in strength. Both groups underperformed relative to manufacturer specifications, but these deviations were attributed to the nonstandard sample geometry and gripping issues, not the discoloration itself.

DMA

To overcome the limitations of direct mechanical testing, dynamic mechanical analysis (DMA) was employed to capture surface-level changes by combining thermal and mechanical characterization. DMA is a highly sensitive technique for evaluating the mechanical behavior of materials under oscillatory loading as a function of temperature and frequency. Testing was conducted in accordance with ASTM D4065, *Standard Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures.*[6] Rectangular strip specimens, approximately 5 mm × 9 mm × 4 mm (0.20 in. × 0.35 in. × 0.16 in.), were excised from beneath discolored surfaces near the contact edge. Testing was performed in tension mode, from −85°C to 160°C (−121°F to 320°F), at a frequency of 1.0 Hz and a displacement amplitude of 10 μm (0.0004 in.), with a heating rate of 5°C (41°F) per minute.

A sharp drop in storage modulus near −40°C (−40°F) marked the glass transition temperature (T_g), the point where the sealant transitions from a rigid, glassy state to a soft, rubbery state. Beyond this transition temperature, the storage modulus continued to decline with increasing temperature, reflecting typical softening behavior. In this context, storage modulus represents the energy stored and recovered per deformation cycle under oscillatory loading and is analogous to the material's stiffness or modulus of elasticity under dynamic conditions. In comparison to the lab reference sample (the black line in **Fig. 16**), both discolored and control samples (white colored) showed a lower storage modulus. Notably, the discolored sample exhibited a slightly lower storage modulus than the control sample, particularly within the service temperature range, as shown in Fig. 16(a). All other samples exhibited similar behavior.

In Fig. 16(b), a collective comparison of storage modulus values (MPa) across all tested sealant samples demonstrated this trend: discolored samples that had been in contact with bitumen-based waterproofing exhibited lower storage modulus (lower stiffness) than both control and lab reference samples.

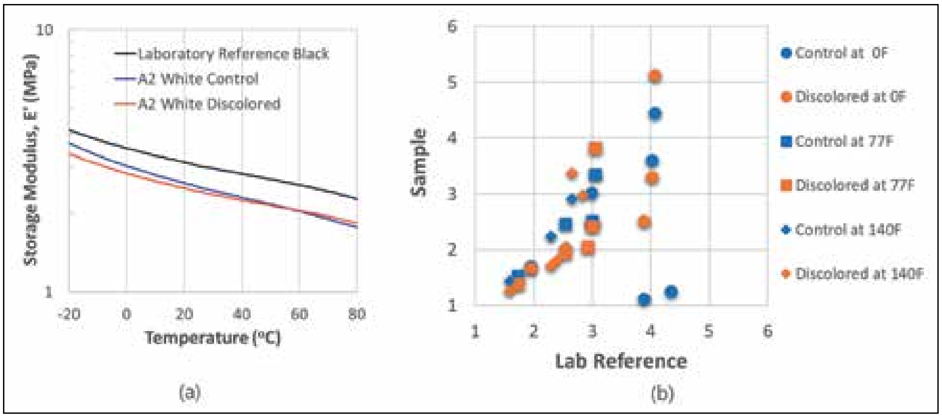


Figure 16. *(a) Close-up view of storage modulus as a function of temperature from dynamic mechanical analysis for control (blue) and discolored (red) samples against corresponding lab reference samples (black). (b) Collective comparison of storage modulus (MPa) for control (blue) and discolored (orange) samples, relative to corresponding lab reference samples, across all sealant types at three temperatures: 0°F (−17.8°C) (circle), 77°F (25°C) (square), and 140°F (60°C) (diamond).*

Summary of Findings

- There was not a definitive correlation between sealant discoloration, non-staining formulations of silicone sealant, and sealant adhesion properties. Nearly all samples in contact with bitumen-based material (Condition W-F) exhibited some discoloration, but only 42% and 58% of specimens in direct contact with bitumen-based material failed adhesively within the first and second year, respectively. None of the control samples or samples installed in contact with the self-adhered membrane facer (Condition W+F) experienced discoloration or adhesive failure.
- Discoloration of the silicone sealants in direct contact with the bitumen-based material was first noted after 6 weeks.
- There were no significant differences in adhesion between sealant colors, although sealant discoloration was most notable in the field, to the naked eye, with lighter-colored sealants. Laboratory analysis confirmed consistent discoloration across all sealant colors in direct contact with the bitumen-based material, including black sealants.
- Laboratory analysis determined the sealant itself does not change colors, but rather the discoloration occurs when bituminous deposits (containing carbon) migrate into the bond surface between the sealant and waterproofing. These deposits then migrate onto the sealant surface, and some degree of chemical change, including possible oxidation, may contribute to the visible discoloration.
- Nondestructive adhesion methods outlined in ASTM C1521[3] do not always identify adhesive failure.
- Adhesive failure was partially impacted by sealant manufacturer selection. Of note, five of the eight specimens that failed adhesively in the first year of testing were from a single manufacturer (Manufacturer B). In total, five of the six sealant formulations supplied by Manufacturer B failed adhesively.
- There was no conclusive difference in measured Shore A hardness and tensile strength between discolored samples that had been in contact with bitumen-based waterproofing (Condition W-F) and control samples.
- Discolored samples that had been in contact with bitumen-based waterproofing (Condition W-F) exhibited lower storage modulus (lower stiffness) than both control and lab reference samples.

CONCLUSIONS

When specifying and selecting joint sealants, it is critical to consider sealant material properties and compatibility with adjacent building materials to ensure long-term performance and durability.

Based on the study findings, the authors recommend against installing silicone sealant in direct contact with bitumen-based materials. If these materials must interface, the authors recommend a separation layer, such as a membrane with polyethene facer or sheet metal flashing bed in an appropriate sealant or mastic, be provided to avoid direct contact between the components. Consideration should be given to the treatment of any joints or seams in the separation layer to provide a continuous substrate for sealant installation and limit contact with the bitumen-based material. While many bitumen-based membranes include a polyethene facer bonded to the surface of the membrane that can function as separation layer across the majority of the sheet, exposed waterproofing often exists at membrane seams and terminations that create localized areas where the bitumen-based material may come into contact with silicone sealants. This localized exposure of sealant to bitumen-based materials is not a condition that was intentionally replicated in the study. The study found that the polyethene facer itself may be sufficient to act as a separation layer.

Considering the observed failure mechanism involves bleeding, migration, and accumulation of bitumen-based compounds, utilization of a physical barrier helps mitigate long-term risks by preventing compound migration and avoiding direct contact between potentially incompatible materials.

The authors further recommend destructive adhesion testing be performed as a quality assurance/quality control procedure for installation of silicone joint sealants. Adhesion testing is often required in some regard by sealant manufacturers, although this testing does not always reflect all unique project interfaces. Tests should be conducted for each unique sealant type and for each unique substrate condition. Discretion is needed when evaluating adhesion test results, as adhesion loss may not occur immediately, or even within the first several weeks, following installation. If contact with bitumen-based materials cannot be avoided, consideration should be given to evaluating sealant adhesion via destructive testing upon initial cure following installation and after several weeks of in-service performance, if possible. Where testing after several weeks of in-service performance may not be possible or practical, any testing should be sequenced as early as possible to limit long-term effects on construction activities. Discoloration should be anticipated but is not a predictor of adhesive performance.

The findings suggest that discoloration resulted from migration and degradation of bitumen-based compounds from the waterproofing membrane substrate. The degradation appeared to be limited to the surface of the sealant and only marginally affected the sealant's physical properties, aligning with visual and chemical observations. Given the observations, the primary mechanism for the discoloration appears to be the bleeding and accumulation of bitumen-based compounds, rather than deep penetration into the sealant. The discoloration becomes more discernible through the degradation of these surface deposits. However, the main reservoir of these materials resides at the bond interface and can negatively impact sealant adhesion. Although not structurally compromising under current service conditions, the long-term implications of sealant surface degradation warrant further study.

Test samples provided in this study only included silicone sealants and did not reflect other building materials such as silicone-based air barriers, coatings, or preformed silicone extrusions. Additional study should be performed for adhesion of other silicone products in contact with bitumen-based materials. The study also only included a single type of bitumen-based waterproofing as a proxy for all bitumen-based waterproofing and different membranes may have different material formulations that may alter results. Additional study is warranted of the effects on waterproofing performance of the migration of bitumen-based compounds out of the waterproofing membrane.

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REFERENCES

1. ASTM International. 2025. *Standard Guide for Use of Joint Sealants.* ASTM C1193-25. West Conshohocken, PA: ASTM International.
2. ASTM International. 2023. *Standard Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems.* ASTM C1087-23. West Conshohocken, PA: ASTM International.
3. ASTM International. 2020. *Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.* ASTM C1521-19(2020). West Conshohocken, PA: ASTM International.
4. ASTM International. 2021. *Standard Test Method for Rubber Property—Durometer Hardness.* ASTM D2240-15(2021). West Conshohocken, PA: ASTM International.
5. ASTM International. 2021. *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.* ASTM D412-16(2021). West Conshohocken, PA: ASTM International.
6. ASTM International. 2020. *Standard Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures.* ASTM D4065-20. West Conshohocken, PA: ASTM International.

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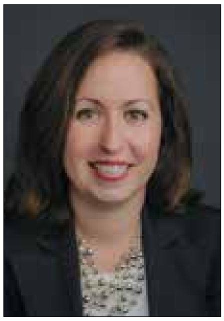

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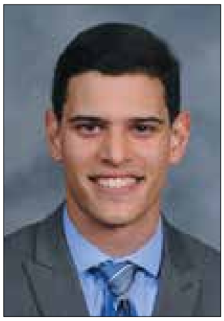

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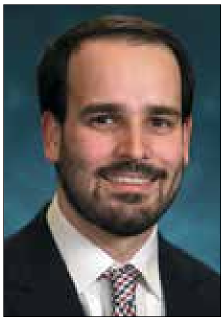

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