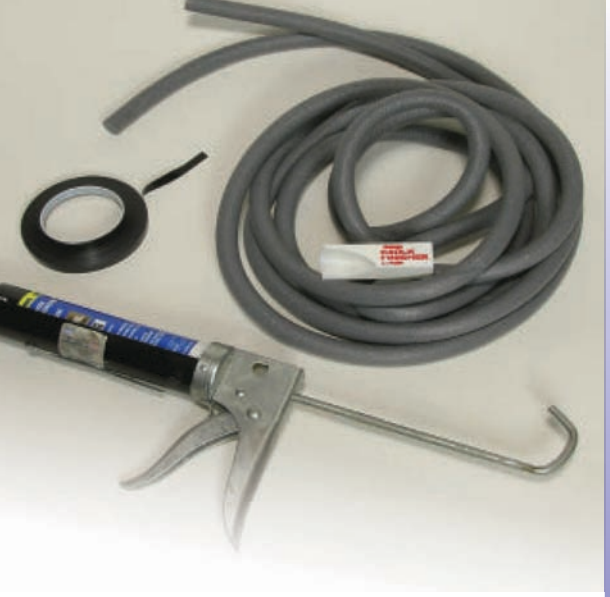

Caulking Compounds and Sealants

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Caulking compounds (also called caulks) and sealants are used to fill gaps or holes in surfaces or seal joints between surfaces.[1] Compatibility with a given substrate, including adequate adhesion to the substrate, is an important consideration because two dissimilar surfaces may be involved. Caulk or sealant manufacturers or the substrate manufacturers (for example, a window manufacturer) may provide instructions about compatibility. Sealants and caulking compounds are available in different chemistries (polyurethanes, silicones, acrylics, and modified acrylics, for example) and a range of qualities. Compliance with standard specifications ensures the quality of some of these products.

DEFINITION OF TERMS

Sealants

For purposes of this document, the term "sealant" refers to an elastomeric material that adheres to a given substrate, creating a seal between them, with the seal remaining functional after repeated movement of the substrates relative to each other. Stated another way, the sealant will undergo neither cohesive failure nor will it become de-bonded from either of the substrates after repeated strain/relaxation cycles. The original dimensions of an elastomeric sealant will be recovered after deformation cycles. The degree of deformation (extension and compression) that the material can withstand is the characterization criterion for a sealant. If the material can withstand roughly ± 25% (or more) deformation, it is commonly called a sealant.

Caulking Compounds

For our purposes, the term caulking compound (caulks) refers to a material with limited ability to maintain seal integrity while undergoing deformation. Caulking compounds are not elastomeric; they do not recover their original dimension after deformation as well as sealants. Caulking compounds can be considered crack and hole fillers, useful where the hole or crack dimensions are anticipated to change by relatively small proportions over time.

USE OF CAULKS AND SEALANTS

As indicated, caulks and sealants are used to fill gaps or holes in surfaces or to seal joints between surfaces. For example, surface indentation from over-driven fasteners may occur in new construction, cracks and holes in substrates may develop over time, and gaps between substrates will be found at expansion joints. Gaps at expan-

sion joints are necessary and will occur even with perfect craftsmanship. Other gaps resulting from acceptable margins of error in construction will also be present. Filling holes, gaps, and cracks is often desirable for aesthetic reasons. Caulks and sealants can also serve functional purposes. By limiting water intrusion through holes, cracks, and gaps, well designed and properly applied sealant joints can enhance building serviceability and durability. In some cases, sealant joints are essential to building durability. Caulks and sealants may also be essential components of building air-barrier systems, which, if adequately designed, can lower building energy consumption and enhance building durability.

STANDARDS FOR CAULKS AND SEALANTS

Caulks and sealants are commonly marketed as conforming to ASTM International specifications. ASTM International is a not-for-profit organization that provides a global forum for development and publication of voluntary consensus standards for materials, products, systems, and services.

Members of ASTM International typically represent entities such as product producers, commercial testing laboratories, commercial users of products or services, government agencies, trade associations, building code organizations, and academia. Task groups develop individual standards within ASTM International and operate within the auspices of subcommittees, which in turn operate within committees.

Committee C24 is the committee within ASTM International concerned with building seals (caulks and sealants). Through its task groups, Committee C24 has developed product specifications. These include the following:

- Designation C 834, Standard Specification for Latex Sealants
- Designation C 920, Standard Specification for Elastomeric Joint Sealants
- Designation C 1311-02, Standard Specification for Solvent-Release Sealants

Solvent-release sealants are not commonly used in joints for wood or wood-based substrates. Therefore, standard specifications C 834 and C 920 are discussed in some detail below, whereas C 1311 is not. Conformance of a sealant with the applicable specification is typically indicated by labeling on the product packaging (on the tubes of sealant).

Committee C24, through its task groups, has also developed a guide for use of joint sealants (Designation C 1193) and a listing of standard terminology related to building seals and sealants (Designation C 717). The standard terminology (C 717) does not make a distinction between "sealant" and "caulk." Nonetheless, the term "sealant" is commonly used when referring to high-performance (elastomeric) products. A sizable number of people interpret this as meaning that the term "caulk" (as a noun) does not refer to elastomeric products.

Bargain Quality Products

Caulk or sealant products with packaging that shows no indication of conforming to an ASTM specification tends to be of low performance.

Good Quality Products

Caulks and sealants that conform to Specification C 834 perform well in most uses. Standard C 834 specifies required performance in eight different ASTM standard test methods. The specification recognizes two different sealant types based on degree of opacity of the cured sealant, either opaque (type OP) or clear/translucent (type C), and three different sealant grades based on flexibility at low temperature (grades –18, 0, and NF). Grades –18 and 0 are required to meet the flexibility criterion of ASTM Test Method C 734 at –18°C (0°F) and at 0°C (32°F), respectively. Grade NF is not required to meet a performance criterion for flexibility at low temperature.

Required performance in some of the test methods is dependent on type and grade. The test methods include evaluation of extrudability (ability of the material to be forced, pressed, or pushed out), performance after artificial weathering, volumetric shrinkage upon cure, low temperature flexibility, extension-recovery, adhesion, slump, stain resistance, and of time during cure to loss of tack. In general, the standard test methods referenced in C 834 are specifically for evaluation of water-emulsion (latex) sealants.

Top Quality Products

Caulks or sealants that conform to Specification C 920 are top quality (high performance) products. Seven use categories are listed in C 920. Two categories relate to joints in paving and one relates to joints that are submerged continuously in liquid. Three categories relate to specific substrates (Uses M, G, and A for mortar, glass, and aluminum substrates, respectively). The seventh use category (Use O), relates to uses not addressed by the other categories. Standard C 920 specifies performance in nine different ASTM standard test methods. Test methods referenced in C 920 are typically more strenuous than are those referenced in C 834. Specification C 920 covers a wide variety of elastomeric building sealants categorized by type, grade (viscosity), class (resistance to cyclic fatigue), and use. Type refers to whether the sealant is single-component or multi-component. Viscosity has two

"Conformance with an ASTM specification indicates that the product has been evaluated for performance in standard test procedures under well-controlled and documented conditions during its development."

categories: pourable (also known as "self-leveling") and non-sag (also known as "gunnable"). Five different classes define the degree to which the sealant can withstand cyclic movement without failing cohesively or becoming de-bonded from the substrates. Classes with higher numbers can withstand greater cyclic movement. The standard defines seven different use categories depending on the substrates for which the sealant is intended. In residential construction, the sealants used with wood and wood-based substrates are Type S (single component), Grade NS (non-sag), and Use O (other).

Sealants used in residential construction that conform to C 920 have traditionally been polyurethanes or silicones; over the last two decades, high-performance acrylic and modified acrylic latex sealants have been developed that meet the requirements for certain classes of C 920. C 920 was first released in 1979. At that time, emulsion (latex) sealants were generally unable to meet the performance requirements of the standard.

Formation of effective sealant joints using polyurethanes and silicones may require appreciable skill. Contractors specializing in sealant application to curtain walls of high-rise structures generally use these sealants. Homeowners do not always fully realize the high-performance attributes of these sealants. As we have indicated, high-performing latex sealants are available; they meet the performance requirements of certain classes outlined in C 920. Persons with limited training generally find these to be more user-friendly than silicone and polyurethane sealants. To ensure that the caulk or sealant you intend to use for your project is appropriate for specific substrates, we recommend that you follow the manufacturer's installation instructions.

Importance of ASTM Rating

Conformance with an ASTM specification indicates that the product has been evaluated for performance in standard test procedures under well-controlled and documented conditions during its development. Commercial testing laboratories (laboratories hired by, but otherwise independent of, the product manufacturer) often conduct performance evaluations, although ASTM does not require this. Contractors that perform specialized services (for example, contractors that specialize in window installation) may indicate in contract documents that the sealants they use conform to ASTM specifications.

INTERIOR APPLICATIONS

In virtually every building or home are gaps where molding contacts the walls or where pieces of molding join. Paints usually cannot fill gaps more than 2 mm (1/16 in.); therefore, it is best to seal these gaps with caulk, which is easier to use than spackle or wood filler. Some examples where caulk can be used are around crown molding, chair rails, baseboards, door and window frames, gaps in mitered corners, and small wall cracks. We recommend caulking around the top and sides of panels, but leaving bottom joints open to allow water to drain from behind panels if they get wet.

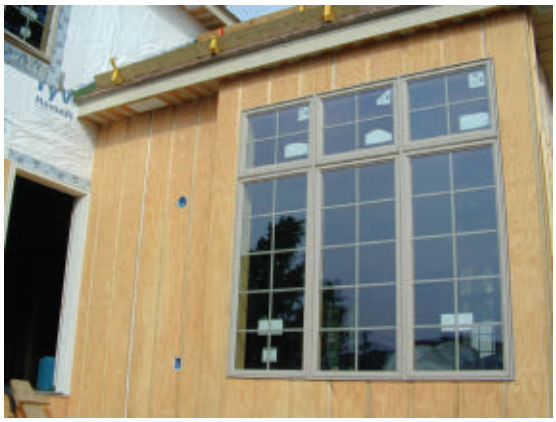
Latex caulking compounds are well suited for filling cracks in plaster and drywall. Filling the cracks with latex caulk is less time-consuming than making repairs using tape and drywall joint compound. If the wall has a textured surface, it is difficult to blend the edges of a repair made with drywall joint compound and tape into the surrounding wall texture pattern. In contrast, repairs using latex caulk can usually be easily "tooled" with a wetted finger or rag, and the repair blended into the texture pattern of the wall.

Sealant joints commonly serve functional purposes in "wet" interior rooms such as bathrooms, kitchens, laundry rooms, and commercial utility rooms. They protect walls, wall finishes, cabinets, and floors from water seepage at joints. Caulking not only protects these areas, but provides an attractive, finished appearance.

The following places require sealants to protect against water damage: where countertops meet splashboards; where splashboards meet walls; where sinks meet countertops; around bathtubs; in showers where walls and floor meet; and around drains in sinks, tubs, and shower stalls.

CONCEALED APPLICATIONS

The majority of windows used in contemporary residential construction are flanged or "nail-fin" windows, which are anchored by driving fasteners through the flanges. The exterior cladding system or exterior trim is subsequently installed over the flanges; the flanges are concealed once construction is complete. Two consensus documents address window installation in residential construction: ASTM E 2112-07, *Standard Practice for Installation of Exterior Windows, Doors, and Skylights;* and AAMA 2400-02, *Standard Practice for Installation of Windows with a Mounting Flange in Stud Frame Construction*. Each of these documents specifies that the jamb and head flanges of nail-fin windows be embedded in sealant. ASTM E 2112 also recognizes the benefit of a perimeter air seal, between



the window frame and the rough opening, situated at the interior edge of the window frame. The air seal is made after the window is anchored; the seal is installed from the interior. The two most effective ways to form this interior air seal are with aerosol-dispensed foam or with backer rod and sealant. Finally, ASTM E 2112 also addresses installation of non-flanged windows. The document recommends that this type of window be installed with a sill-pan flashing. There are various types of sill-pan flashings and various means of installing them. Most installations of sill-pan flashings involve use of sealant. In some installations, backer rod and sealant are used to form a back dam for the sill-pan.

Uncontrolled air leakage between living spaces and attics or cathedral ceilings ("roof spaces") can influence energy use in residential buildings, particularly in temperate and cold climates. Because uncontrolled air movement almost always occurs in three dimensions through inter-connected passageways, air leakage between living spaces and roof spaces is often through pathways that involve both walls and ceilings. Interior partition walls that enclose plumbing vents, electrical wiring, or ducts may serve as important "ceiling bypasses" through which large amounts of air leakage occur. Holes drilled in framing for utilities (plumbing and electrical wiring) may contribute substantially to air leakage, inasmuch as the holes are commonly oversized. One can restrict air movement through ceiling bypasses by using a combination of rigid or semi-rigid blocking materials, aerosol-dispensed foams, and sealants. Aerosol-dispensed foams are typically more rigid after cure than are cured sealants. The rigidity of aerosol-dispensed foams sometimes poses problems (for example, where relative movement between framing and a plumbing vent stack may occur seasonally). Generally, perimeter seals should be installed anywhere plumbing or wiring penetrates a wall top plate. This is obviously easiest to do during construction, but provided the attic is accessible, one can seal these holes after construction is completed. Air leakage commonly occurs through interconnected walls and ceilings; therefore, limiting air exchange between the living space and wall cavities limits air leakage. We recommend sealing around the perimeter of electrical boxes and places where plumbing lines emerge from walls.

Air leakage by duct systems can result in substantial energy loss; therefore, we recommend that duct systems be sealed. Among the places where a duct system can leak are the interfaces of register boots with walls or ceilings. Duct contractors do not typically concern themselves with these interfaces; they typically concentrate on joints in sections of duct and on joints between duct sections. A homeowner or a general contractor can form seals between register boots and the wall or ceiling by using caulk or sealant. They commonly use latex caulks because they are easy to apply, allow for convenient clean up, emit the least smell, and have adequate properties for the application. Register grilles typically conceal the joints between register boots and the wall or ceiling surface.

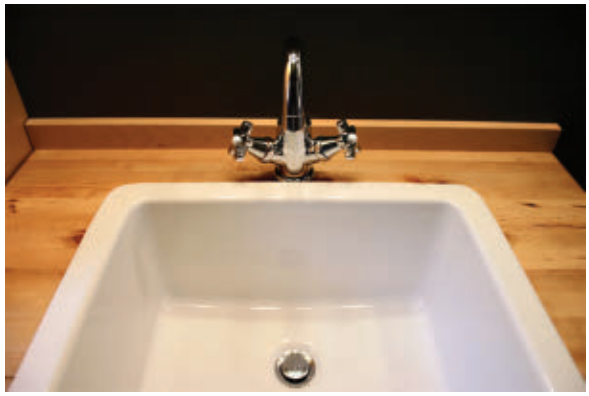
EXTERIOR APPLICATIONS

On building exteriors, well-designed joints and properly applied sealant can inhibit water intrusion. Some exterior-wall cladding systems rely on sealant joints where they interface with other components such as windows and doors; others do not. Regardless of the type of cladding system, sealant joints are typically desirable where the wall is penetrated by a pipe, conduit, or vent.

Sealants are not an adequate substitute for good design and proper flashing of wall cladding. Sealants are a means to limit water intrusion, not a means to eliminate it, because it is virtually impossible to exclude water completely from penetrating the cladding system. Sealants must be used in concert with flashing, design details that encourage water shedding at the outer surface (*Figure* 1), and cladding installation methods that encourage drying when water penetrates the cladding system. The figure shows a flashing above the door's head casing and a capillary break (air gap) between the flashing and the siding. Note that sealant is not merely a fillet bead but rather the sealant was tooled into the gap between the siding

Figure 1—Corner of door showing flashing above the door's head casing, z-flashing at the horizontal joint between the sheets of plywood panel siding, and sealant between siding and the door's jamb casing.

and molding. A backer rod behind the sealant eliminates shear stress, which greatly decreases potential de-bonding of the sealant. The door corner that can be seen in the *Figure* 1 photo (below the head casing and to the left of the jamb casing) is a wood storm door. The primary door is hidden from view by the storm door. Even under the best circumstances, portions of sealant joints may fail prior to a maintenance cycle. When this occurs, it is imperative that the remaining sealant does not inhibit dissipation of water.[2]



Sealants have been used successfully in high-rise structures in conjunction with metals, glass, and masonry for decades. In successful high-rise installations, the joint is designed to minimize shear stresses on the sealant; a cyclic movement of the joint is calculated (and determined to be within tolerances for the sealant); and a quality assurance program is in place. Joint design includes means to avoid strain concentrations in the sealant (use of backer rod or bond-breaker tape behind the sealant) and control of joint width and shape (to limit cyclic stressing on the sealant). Architects and engineers design sealant joints and specialized tradesmen install them. A third party often inspects the completed installation, and the inspection sometimes includes disassembly. In residential construction, the wind-driven rain loads are lower than in high-rise construction. Successful use of exterior sealants in residential construction is nonetheless dependent on attention to joint design and on careful workmanship. Inadequately designed sealant joints between siding and a window or an exterior window casing often fail within a year or two. In typical residential construction the joints are often too narrow, and a means to avoid strain concentration (a bond-breaking tape behind the sealant) is often omitted. Shear forces on the sealant are thus excessive and the joint fails.

Though some caulking compounds and sealants can be applied at temperatures as low as –35°C (–30°F), it is best to avoid applying these products at temperatures below 5°C (40°F).

SURFACE PREPARATION

Caulking compounds and sealants must adhere well to substrates to perform well. They will not adhere well to a surface contaminated with dirt, mildew, oil or grease, failing paint, or old caulk.[3] Sealants generally do not adhere well to surfaces that are extremely smooth or that may crumble or disintegrate.

Failing paint and old caulk must be removed. This is generally done by mechanical methods (scraping and use of abrasive materials). Paint that has a chalked surface but is otherwise intact may be stabilized with a primer paint formulated for adhesion to chalked surfaces. Oil or grease can often be removed with alcohol. Hydrocarbon solvents like naphtha or xylol (paint thinner) are effective for removal of oil or grease but typically do not evaporate as rapidly as alcohol, and pose greater health risks. Mildew may be removed with a bleach solution. Dirt can typically be removed with water and a mildly abrasive pad. Soap or detergent solutions tend to leave a residue that can interfere with adhesion, and thus we do not recommend their use.

APPLICATION CONDITIONS AND TECHNIQUES

The ambient conditions during application of caulks and sealants are important. Recommendations on product packaging usually indicate suitable weather conditions during application and for 24 hr following application. Generally, waterborne (latex) caulks and sealants should not be applied if you expect rain or a temperature below 40°F (~5°C) within 24 hr of application.

Adhesion to substrates is improved by tooling the sealant before it cures, because tooling ensures uniform sealant contact with the substrate materials and works air bubbles from the sealant. Tooling usually results in a more aesthetically pleasing joint as well. Tooling will push sealant into the joint. A backer rod prevents excessive depth of sealant in tooled joints and also provides a non-adhered interface at the back of the sealant, which minimizes shear stress within the joint. The techniques for fitting backing materials (such as backer rod) into joints and for tooling sealant joints can be complex; therefore, we recommend that detailed installation instructions be obtained from sealant suppliers.[4]

Table 1—Guidelines for the best caulking compounds and sealants for a given application.

Specific Property	Siliconized Acrylic	Acrylic	Vinyl Acrylic	Silicone Rubber	Solvent-Release Butyl Rubber	Polyurethane	Clear Solventborne
Superior adhesion to a wide range of building materials (wet)	X	X			X	X	X
Superior adhesion to a wide range of building materials (dry)	X	X	X		X	X	X
Maintains pliability over time	X	X		X		X	
Paintable with latex and oil-based paints	X	X	X		X	X	X
Flexible at low temperatures	X	X		X		X	X
Easy to apply—does not stick to fingers and clothes	X	X	X				
Easy to clean up	X	X	X				
Low odor	X	X	X	Some			
Can be applied to at <0°C				X	X	X	X
Flammable				X	X	X	X
Fast setting—can be sprayed with water after application				X	X	X	X
Good water resistance	X	X		X	X	X	X

PAINTING

Paints are likely to come in contact with caulks and sealants, whether by accident or choice. Most sealants can be painted with interior or exterior paints. The exception is silicone sealant. Siliconized acrylics are not the same as silicones; they can be painted with a latex paint or some stains.[5, 6] As with any other task, using top-quality paint will provide superior long-term performance (*Table* 1).

COMMON MISCONCEPTIONS

Misconception: Caulks and sealants often shrink objectionably.

FACT: Shrinkage varies with the type of caulk or sealant. Water emulsion (latex) caulk or sealant compounds will shrink after application. The shrinkage occurs by evaporation of water. With some latex products and in some applications, the degree of shrinkage may be objectionable. However, this is not common. High-solids caulks and sealants such as silicone or polyurethane sealants, which typically contain around 95% + solids, do not noticeably shrink.

Misconception: Siliconized acrylic and silicone caulks and sealants are the same.

FACT: Siliconized acrylic caulks and sealants contain a small amount of a silicone-like material to give them better adhesion. A silicone caulk or sealant is about 95% or more silicone polymer.

Misconception: Caulks and sealants can be applied regardless of air temperature.

FACT: Though some caulking compounds and sealants can be applied at temperatures as low as –35°C (–30°F), it is best to avoid applying these products at temperatures below 5°C (40°F). Below this temperature, the likelihood of frost presence on substrate surfaces is high; this will interfere with adhesion. If it is necessary to apply material below 5°C (40°F), then standard architectural solventborne and silicone sealants are likely to be more suitable than latex caulks or sealants.

Misconception: If the caulk or sealant does not stick to your hands, tools, or clothes, it will not adhere well to the applied surface.

FACT: Most water-emulsion latex caulks and sealants are designed to wash off your hands, clothes, and tools easily. The high-quality latex emulsions have outstanding adhesion. The easy cleanup does not translate to adhesion performance.

Misconception: Caulking compounds and sealants are only used to seal joints and cracks.

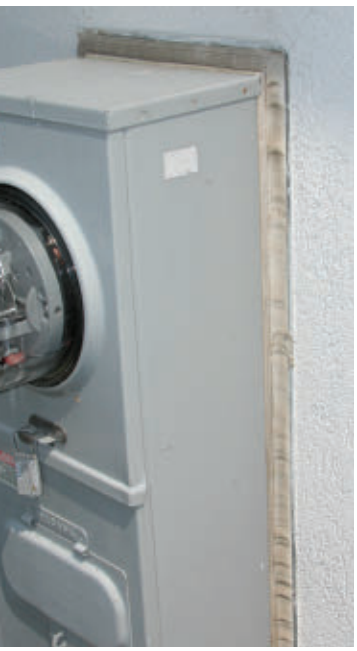
FACT: Lately, contractors and Do-It-Yourselfers (DIY) have discovered that these materials can be used in preparing walls and trim for painting. If the cracks are small enough, caulking compounds and sealants can replace traditional putties and muds that require several coats and sanding before painting. A wet finger or a tool need only smooth caulking compounds and sealants. It is important that only high-quality water-based caulking compounds be used. Low-quality latex or solventborne caulking compounds and sealants will be prone to leach through the paint.

Misconception: Solvent-based caulks and sealants are flammable forever.

FACT: While wet, solventborne caulks and sealants and their fumes are flammable (combustible). This is because the solvent carrier is flammable; the caulk or sealant itself is not. Once dry, the caulk or sealant is no longer flammable. When applying solventborne caulks and sealants, one should take care to maintain good ventilation and eliminate all ignition sources such as water heater and oven pilot lights and avoid lighting cigarettes and using electric tools. Follow safety recommendations listed on the package.

This does NOT mean that the caulks and sealants are intumescent or prevent flame spread. Testing has shown that cured caulk and sealant films do not contribute to flammability of a substrate, but neither will they prevent the substrate from burning.

Misconception: Any caulk or sealant can be applied over any substrate.



FACT: Not all caulks or sealants can be used with all substrates. Some caulks or sealants could be incompatible with the surface. For example, acid-cure silicones are slightly corrosive and thus not compatible with metals or alkaline substrates such as brick, stucco, or concrete. The details of all substrate-caulk/sealant interactions are too great to be addressed in this article. The best course of action is to read the label recommendations on the product. The label recommendations will typically indicate the substrates with which the material is compatible. Producers of building components will, over time, introduce new substrates, which may not be compatible with existing caulks or sealants (i.e., they may not adhere to them). Performing in-house DIY adhesion tests with unfamiliar substrate materials can be instructive.

CONCLUSION

Caulking compounds and sealants are widely used in building construction and renovation. They have a wide range of possible uses, some of which are largely aesthetic and some of which are functional. When used properly according to manufacturer's instructions and when attention is paid to workmanship, caulks and sealants can provide substantial benefits. To ensure the best quality job, we recommend that the user check for the most up-to-date practices through articles in *Journal of Light Construction*[7]; Adhesive and Sealant Council[8]; Sealants, Waterproofing, and Restoration Institute[9]; or other trade sources[10]; and comply with building codes.

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Authors are members of the Joint Coatings/Forest Product Committee. The American Coatings Association and the Forest Products Laboratory co-sponsor the committee, and it is comprised of representatives from the wood and coatings industries. The committee functions through task groups organized to write articles on wood/paint interaction. **Doug Mall** is the chair of the Caulks & Sealants Task Group.

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