



General Guide to Joint Sealants for Architects

A fundamental design requirement for any building is protection against the elements of nature. Joint sealants create both a primary and secondary barrier to rain, snow, air, and debris ingress, and are commonly overlooked as a critical component of both the aesthetic design and functionality of the building envelope. Joint sealants are also a vital component of air barrier and vapor retarder systems that are intended to retain a building's interior environment within the building. The large number of sealant types available on the market today coupled with misinformation about how to design and install sealant joints properly often result in improper specification by architects and poor field application by contractors.

The Adhesive and Sealant Council (ASC) and Sealants, Waterproofing and Restoration Institute (SWR Institute) are pleased to provide this guide to assist the architectural community in understanding the basics of designing and specifying joint sealants in building construction applications. This general guide is brief in nature and is intended to provide an overview for the reader of significant joint design issues. For more in-depth information on sealant joint design refer to ASTM Guides C1193 and C1472. For additional design and installation information, refer to "Sealants: The Professional's Guide," and a training program for installers entitled "Applying Liquid Sealants" both by SWR Institute, and other related publications.

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STEP 1: Understand the Major Causes of Sealant Joint Failure

- Unaccommodated joint movement.
- Incompatibility with substrates and other joint components.
- Inadequate consideration of the sealant's service environment.
- Insufficient substrate cleaning, priming or other preparation.
- Improper or no installation of backer rod.
- Poor sealant installation, particularly, lack of or improper tooling of joint.
- Poor design or construction of sealant joint geometry (profile).
- Poor or no design for joints experiencing movement.
- Over-reliance on a single sealant joint as the only water resistance barrier in the exterior envelope.



STEP 2: Determine the Selection Criteria for Joint Sealants

- **Primary Concerns**
 1. What is the expected durability (service life) required of the sealant?
 2. How much and what type of joint movement is expected?
 3. What is the best sealant chemistry for the application?
 4. What substrates need to be evaluated?
 5. Is substrate staining a concern?
 6. What is the service environment?
 7. What is the application environment?
 8. Will resistance to atypical wall or floor cleaning chemicals be required?
- **Secondary Concerns**
 1. What non-fading colors are available?
 2. Is a single- or multi-component sealant required?
 3. Is a gun-grade or self-levelling sealant required or both?



STEP 3: Analyze Sealant Joint Movement (Calculate Type and Magnitude of Movements to be Accommodated)

AS A MINIMUM, refer to the simple example below, which accommodates only thermal movement. Calculate the expected thermal movement(s) of the substrates as a linear measurement (in inches or mm).

Minimum joint width at the maximum mid summer temperature	3/4 inch (20mm)
Maximum joint width at the minimum mid winter temperature	1 inch (25mm)
Total joint movement summer to winter	1/4 inch (6mm)
Total joint movement expressed as % of minimum joint width	33%

Note: Joint width measurements should take into account casting and other tolerances (e.g. fabrication and erection) and any movement due to shrinkage or settlement. Temperature movements alone are not the only cause of joint movement. Many other factors cause joint movement and should be considered when designing a sealant joint. Such factors include: irreversible expansion of brick, shrinkage of concrete masonry units (CMU) and concrete creep of columns and particularly slabs, elastic deformation of structural members due to varying loads, and building movements due to earthquake and wind (lateral loads)

In the example above, the sealant which will be selected for this application must therefore have a cyclic movement capability throughout the stated temperature range of at least 33%. This assumes that none of the factors discussed above will be an issue in this joint. However, this is rarely the case. Another consideration is that some organic sealants experience hardening or loss of elasticity over time, which can result in joint failure. While the ASTM testing required to establish sealant movement capability includes laboratory aging, consideration should be given to additional loss of elasticity in real life service environments.

It is **STRONGLY** recommended that the joint width be calculated using the guidelines explained and illustrated in *ASTM C1472 Standard Guide for Calculating movement and Other Effects When Establishing Sealant Joint Width*. The procedures in this guide will assist in establishing, among others, minimum and maximum temperatures, substrate and installation temperatures, and accommodating the effects of tolerances and any applicable live and dead loads.



STEP 4: Analyze SUBSTRATE Issues

- Common substrates such as concrete and brick pose few problems for most sealants; however, most sealants require a primer for adequate adhesion to cementitious and sometimes to other porous substrates such as brick. Other substrates (such as asphalt, marble, some natural stone, certain plastics, metal alloys and factory-applied organic coatings) can present adhesion and staining issues.
- It is important at the specifying stage to determine with the sealant manufacturer the level of substrate preparation, including primer, required to achieve optimum performance. The substrate preparation method needs to be included in the sealant specification. In some cases, it may be beneficial to construct mock-ups (laboratory and/or field) to evaluate the need for primers and surface preparation methods. After their construction, the mock-ups can be subjected to sealant peel tests to evaluate adhesion of the sealant to the substrate.
- What type of joint backing is most compatible with the sealant considering its service environment?



STEP 5: Analyze Service and Application Environment Issues

- Consider the effects of weather (e.g. temperature extremes, humidity, UV, acid rain, pollution).
- Is resistance to chemicals, required (e.g. oil, fuels, and hydraulic fluids)?
- Is resistance to biodegradation and color fading required?
- Is resistance to abrasion, wear-and-tear, mold and mildew, and dirt pick-up required?
- Does the sealant joint need to be vandal resistant?
- Determine the loading to be resisted for pavement and floor joints (e.g. pedestrian or wheeled vehicles).
- Does the sealant need to be NSF approved for potable water or food service applications?
- At what temperature (can it be reliably attained?) is the sealant likely to be installed?
- Can the sealant achieve proper curing under the application conditions?
- How can the sealant be protected from environmental elements and movement until it is cured?
- Can the sealant properly cure at the depth specified for its joint design?
- How does sealant working time (pot life) affect application?



STEP 6: Application Considerations

- The joint substrate surfaces should be clean, dry, frost-free, and free of contaminants and surface tension reducing materials such as water repellents and other coatings.
- The joint backing should be correctly sized for the opening and should be compatible with the sealant.
- The joint backing or bond breaker should be carefully and properly installed to result in a consistent joint profile. Variations in backer rod setting depth can greatly affect joint geometry and performance.
- The sealant should be installed using proper tools to result in a consistent and uniform application.
- The sealant should be tooled as soon as possible after application. Tooling is a critical step to compact the sealant, thereby providing an appropriate profile and ensuring adhesion to the substrates.
- All sealant materials have a shelf-life. One-component sealants slowly cure in their containers. Always confirm that the sealants are within their shelf life limit before being used.



STEP 7: Additional Guidelines to Consider

- Select low-modulus sealants for low-tensile strength substrates and rapid thermal response lightweight structures, including building facades such as EIFS (Exterior Insulation & Finish System) and metal curtain walls.
- Use ASTM C1472 to determine the technical requirements for the sealant joint including thermal movement, effect of tolerances and substrate and installation temperature differentials.
- Consider chemical resistance for sealants used below grade.
- The sealant may have to accommodate significant movement during its curing cycle. This may require using a sealant at far less than its rated movement capacity.
- Avoid selecting a sealant simply by reference to its data sheet technology.
- Shrinkage of solvent or water based sealants may create stress at the substrate bond. Such sealants are more susceptible to creating bond line stress when they are applied in larger profiles.
- Understand that in some cases low technology “plastic” sealants can provide good performance below grade and are less sensitive to application abuse.
- Be aware that oils, plasticizers, and unreacted polymer from many sealants may migrate, stain and permanently affect porous and non-porous building components.
- Design pavement and floor joints and select sealants for them that have good puncture and tear resistance.
- Consider that moisture curing single-component sealants may take considerable time to cure in dry environments and where a closed cell backer rod is used.
- Where possible, select environmentally friendly (“green”) sealants, but be aware of their performance tradeoffs.
- Use multi-component sealants if fast predictable cure rates are required, but be aware of problems associated with improper mixing.
- Use primers when sealants are used for pavement joints and when subject to total immersion.
- Question the sealant manufacturer’s movement and long-term performance claims.
- Consider the track record of the sealant being considered (if using proprietary specifications).
- Require a current sealant validation certificate from the *SWR Institute Liquid Sealant Validation Program*.
- Bear in mind that joints open in colder weather, putting sealants under tension, which creates stress at the substrate bond. The low temperature modulus of a sealant should be considered before specifying.

Background Information by Sealant Chemistry

- **Latex (water-based, including EVA, acrylic – sometimes referred to as caulk)**
 - Used mainly in residential and light commercial construction applications.
 - Interior and exterior use.
 - Premium products meet $\pm 25\%$ movement (ASTM C 920, Class 25).
 - Excellent paintability (with latex paints).
 - Very good exterior durability.
 - Exhibit some shrinkage after cure.
 - Not used for exterior applications, particularly on high rise construction, for applications undergoing significant cyclic movement, or for high-profile structures.

- **Acrylics (solvent-based)**
 - Used in residential and light commercial construction, mainly for exterior applications.
 - Generally meet $\pm 12.5\%$ movement (ASTM C 920, Class 12-1/2).
 - May need special handling for flammability and regulatory compliance.
 - Can be painted.
 - Short open time; difficult to tool.
 - Exhibit some shrinkage upon cure.
 - Often used for perimeter sealing and low movement joints.

- **Butyls (solvent-based)**
 - Excellent adhesion to most substrates.
 - Excellent water vapor transmission resistance.
 - Limited movement capabilities, generally up to $\pm 10\%$
 - Excellent weathering.
 - Sometimes used in curtain wall applications where adhesion to rubber compounds is needed.
 - Most are stringy and difficult to apply neatly.
 - May show some shrinkage after cure; may harden and crack over time on exposed surfaces.
 - Some are not suitable for application where exposed to UV.
 - Some are non-hardening and are suitable for concealed application where sealant needs to remain pliable.

- **Polysulfides**
 - First “high performance” sealant; mainly used in industrial applications (ASTM C920, Class 12-1/2 or 25).
 - Poor recovery limits their use in joints with high cyclic movements.
 - Can be formulated for excellent chemical resistance (especially for aviation fuel).
 - Good performance in submerged applications.
 - Require a primer on almost all substrates.

- **Silicones**
 - Structural bonding and structural sealant glazing (SSG) of glass to frames.
 - Excellent joint movement capabilities; can exceed $\pm 50\%$ (ASTM C 920, Class 50 and Class 100/50).
 - Excellent low temperature movement capability.
 - Excellent UV and heat stability.
 - Good adhesion for many substrates especially glass; a primer is recommended on certain substrates, particularly porous substrates.
 - Not paintable.
 - Used in protective glazing systems and insulating glass units to improve thermal performance (reduce heat loss). Also used for missile impact and bomb blast situations.
 - Acetoxy chemistry based sealants have strong odor, but newer chemistries have very low odor.
 - Adhesion, as for all sealant types, is adversely affected by less than perfect application conditions.
 - High, medium and low modulus sealants available.
 - May stain some types of natural stone without primers. Low staining potential formulations are available.

- **Polyurethanes (PU)**
 - Used in industrial and commercial applications.
 - Very good movement capabilities, up to $\pm 50\%$ (ASTM C 920, Class 25 and 50).
 - Not used in SSG applications (avoid direct contact to glass).
 - Excellent bonding, generally without a primer for many surfaces.
 - Can be formulated for good UV resistance, which may be compromised by a selected color.
 - Paintable.
 - Some formulations may contain low levels of solvent.

Appendix A Sample Specification Information

After analyzing at least these three key sealant joint design criteria -- expected **movements, substrate adhesion and compatibility and service environment** – a specification should include, as a minimum, the following in the appropriate sealant specification sections.

Rather than developing a sealant specification from “scratch” use should be made of specification sections from established systems such as Masterspec[®] and then edited for the application.

- The sealant shall be a (*specify sealant chemistry, e.g. silicone, polyurethane, polysulfide, etc.*) formulation meeting the performance requirements of ASTM C 920, Grade NS Class 25 or ISO 11600 –F- 25LM and shall submit evidence of having a current validation certificate from the SWR Institute Liquid Sealant Validation Program.
- Indicate what other sealant certifications may be required (e.g. meets ASTM Specification C920, has adequate adhesion to proposed substrates, and is compatibility with other joint components).
- The sealant shall be capable of accommodating movement of at least X% of the minimum joint width.
- The sealant must adhere to and be compatible with the specified substrates.
- Primers, if required, shall not stain and shall be compatible with the substrates.
- The sealant shall be stable when exposed to UV, joint movements, and the particular environment prevailing at the project location. Indicate if resistance is required to certain cleaning or other chemicals.
- The sealant shall be (*specify the color*).
- If required, indicate if the sealant should be either a single or multi- component product.

Additionally:

1. Don't mix sealant chemistries when specifying. If a silicone is needed; don't include other chemistries.
2. Include preconstruction laboratory sealant testing for substrate(s) adhesion and compatibility with backer rod and other joint components.
3. Include on-site mock-up construction and testing for aesthetic considerations, evaluation of sealant adhesion to substrates, and to establish workmanship criteria.
4. Include periodic construction-site testing for sealant adhesion to the constructed substrate(s) to verify at least workmanship.

Appendix B

Relevant Standards

ASTM has developed various standard test methods, specifications, and guides that are used for the design, manufacture, testing, and installation of joint sealants. A brief description of selected standards follows. For more information, log onto www.astm.org and select “Standards”. When specifying list the standard with no date reference. Doing so will always reference the most current issue of the standard since they are potentially revised no more than every 5 years.

C834 Standard Specification for Latex Sealants - This specification covers one component latex sealants used for sealing joints in building construction.

C920 Standard Specification for Elastomeric Joint Sealants - This specification covers the properties of a cured single- or multi-component cold-applied elastomeric joint sealant for sealing, caulking, or glazing operations on buildings, plazas, and decks for vehicular or pedestrian use, and types of construction other than highway and airfield pavements and bridges.

C1184 Standard Specification for Structural Silicone Sealants - This specification describes the properties of cold liquid applied, single-component or multi-component, chemically curing elastomeric structural silicone sealants herein referred to as the sealant. These sealants are intended to structurally adhere components of structural sealant glazing systems.

C1193 Standard Guide for Use of Joint Sealants - This guide describes the use of single and multi-component, cold-applied joint sealants for parallel joint sealing applications in buildings and related adjacent areas, such as plazas, decks, and pavements for vehicular or pedestrian use, and types of construction other than highways and airfield pavements and bridges

C1247 Standard Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids - This test method covers a laboratory procedure that assists in determining the durability of a sealant and its adhesion to a substrate while continuously immersed in a liquid. This test method tests the influence of a liquid on the sealant and its adhesion to a substrate. It does not test the added influence of constant stress from hydrostatic pressure that is often present with sealants used in submerged and below-grade applications, nor does it test the added influence of stress from joint movement while immersed. This test method also does not (in its standard form) test the added influence of acids or caustics or other materials that may be in the liquid, in many applications.

C1249 Standard Guide for Secondary Seal for Sealed Insulating Glass Units for Structural Sealant Glazing Applications - This guide covers design and fabrication considerations for the edge seal of conventionally sealed insulating glass units, herein referred to as IG units. The IG units described are used in structural silicone sealant glazing systems, herein referred to as SSG systems, SSG systems typically are either two or four sided, glazed with a structural sealant. Other conditions such as one, three, five, six sided may be used.

C1299 Standard Guide for Use in Selection of Liquid-Applied Sealants - This guide covers general background information for the comparative evaluation and selection of liquid-applied sealants for use in building construction.

C1401 Standard Guide for Structural Sealant Glazing - Structural sealant glazing, hereinafter referred to as SSG, is an application where a sealant not only can function as a barrier against the passage of air and water through a building envelope, but also primarily provides structural support and attachment of glazing or other components to a window, curtain wall, or other framing system.

C1472 Standard Guide for Calculating movement and Other Effects When Establishing Sealant Joint Width - This guide provides information on performance factors such as movement, construction tolerances, and other effects that should be accounted for to properly establish sealant joint size. It also provides procedures to assist in calculating and determining the required width of a sealant joint enabling it to respond properly to those movements and effects.

C1481 Standard Guide for Use of Joint Sealants with Exterior Insulation and Finish Systems (EIFS) - This guide describes the use of single and multi-component, cold-applied joint sealants, or pre-cured sealant systems for joint sealing applications, or both, in buildings using exterior insulation and finish systems (EIFS) on one or both sides of the joint.

D5893 Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements - This specification covers cold applied, single component, chemically curing silicone sealants that are based on polymers of polysiloxane structures and are intended for use in sealing joints and cracks in portland cement concrete highway and airfield pavements. The specification includes both non-sag and self-leveling types of sealants.

E330 Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference - This test method describes the determination of the structural performance of exterior windows, curtain walls, and doors under uniform static air pressure differences, using a test chamber. This test method is applicable to curtain wall assemblies including, but not limited to, metal, glass, masonry, and stone components.

E331 Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference - This test method covers the determination of the resistance of exterior windows, curtain walls, skylights, and doors to water penetration when water is applied to the outdoor face and exposed edges simultaneously with a uniform static air pressure at the outdoor face higher than the pressure at the indoor face.

Appendix C

Additional Resources

Trade Associations and Other Organizations:

- The Adhesive and Sealant Council (www.ascouncil.org)
- Sealant, Waterproofing & Restoration Institute (SWR Institute) (www.swrionline.org)
 - Sealants: The Professional's Guide
 - Liquid Sealant Validation Program
 - The Applicator Magazine
- ASTM International (www.astm.org)
 - Committee C24 on Building Seals and Sealants for various Specifications, Guides, Test Methods, and Practices related to sealant specifying and application
 - Committee E6 on Building Performance for various Specifications, Guides, Test Methods, and Practices related to sealant use with air barriers, vapor retarders, and exterior enclosure systems and materials.

Trade Publications:

- Adhesives & Sealants Industry Magazine (www.adhesivesmag.com)
- The Applicator Magazine