Silicone sealants and coatings for building construction and restoration

By: Dow Building Science

Course #0DOW002

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COURSE DESCRIPTION

This course examines the differences between silicone and organic sealant chemistries, key sealant properties, how and why sealants fail, appropriate sealant systems and installation techniques, and the primary benefits of silicone sealants and coatings for building restoration.

Learning objectives

Upon completion of this course, participants will be able to:

- Describe the differences between silicone and organic sealant chemistries.
- Identify key sealant properties.
- Explain the functions of nonstructural glazing sealants and select appropriate sealing systems for new construction and renovation applications.
- Explain the function of silicone structural glazing and identify appropriate applications.

Learning objectives

- Describe appropriate designs for structural vs. weathersealing sealant joints.
- Explain how and why sealants fail.
- Select appropriate sealant systems for different building construction and restoration applications and describe appropriate installation techniques.
- Identify the primary benefits of silicone sealants and coatings for building construction and restoration.

COURSE OUTLINE

- Sealant choices
- Sealant chemistry
- The role sealants play
- Properties
- Applications
- Sealant failure
- Demonstrated silicone performance
- References

You have many choices when specifying sealants

- Sealants available: One- and two-part polyurethane, polysulfide, acrylic, hybrid and silicone
- What are the differences, and why does it matter?
- How important is the longevity of a sealant?
- Restoration can cost 2 to 3 times the cost of an original installation … can the building owner afford to do it a third time?

SEALANT CHEMISTRIES

TWO BROAD CATEGORIES AVAILABLE

- **Organic,** which consist of a carbon-based polymer (-C-C-O-C-C-)
  - Single-component and multicomponent polyurethane
  - Polysulfide
  - Acrylic
  - Hybrid
- **Inorganic,** which consist of noncarbon-based polymer (-Si-O-Si-O-Si-)
  - Silicone

Why is sealant chemistry important?

- Ultraviolet (UV) light will degrade the carbon-carbon or carbon-oxygen bond of an organic sealant
- There is not enough energy in UV light to degrade the Si-O bond of a silicone sealant
- Therefore, an organic (polyurethane) sealant will degrade in sunlight, and a silicone sealant will be virtually unaffected

Polyurethane sealant deterioration

How a polyurethane sealant deteriorates from exposure to UV light:

- Hardening
- Chalking
- Crazing
- Cracking
- Reverting

What causes reversion?

- 1991 study evaluated 5 multicomponent polyurethane sealants and 2 silicone sealants
- 4 of 5 polyurethane sealants reverted after accelerated weathering; silicones did not
- 1 polyurethane sealant doubled in modulus
- Conclusion: Ultraviolet light triggers reversion

What is the role of a sealant?

- Stop water and air intrusion
- Accommodate differential thermal movement and other structural movements

- Coefficient of thermal expansion (in/in/ºF)
  - Aluminum = 12.9 x 10^{-6}
  - Glass = 5.1 x 10^{-6}
  - Concrete = 6.5 x 10^{-6}
  - Polycarbonate = 38 x 10^{-6}

IMPORTANT SEALANT PROPERTIES

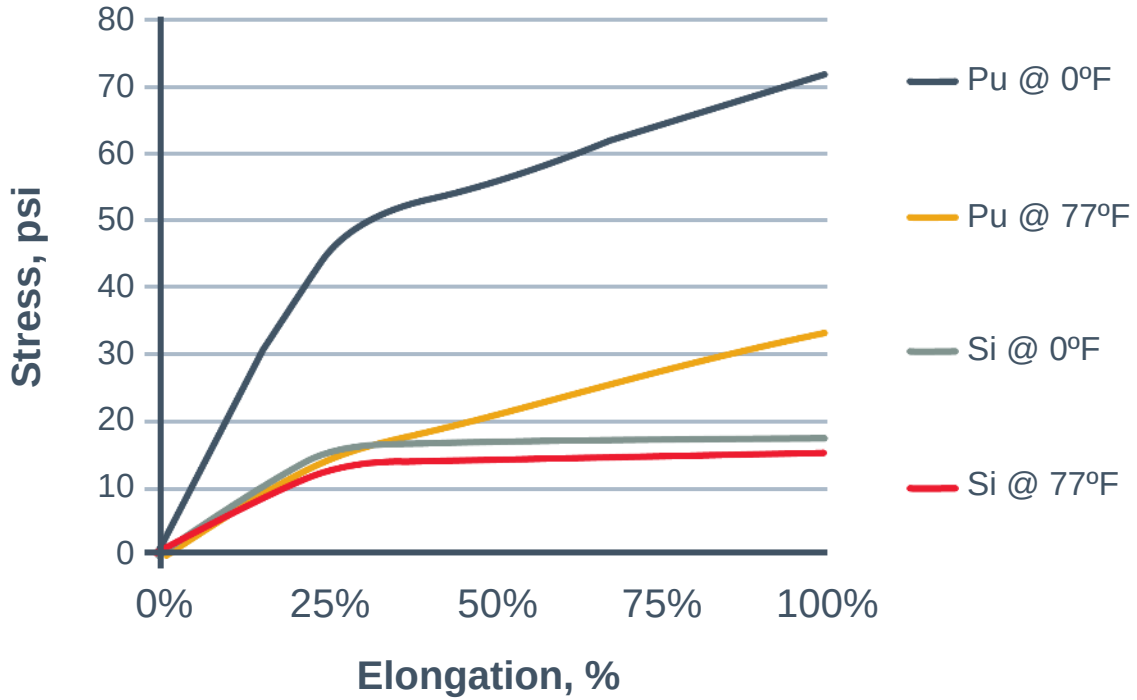
- **Adhesion** to a variety of materials
  - Primers may be required
- **Modulus** – high modulus (stiffest) to ultralow modulus (for high-movement joints)
- **Movement capability** (determined by ASTM C719)
- **Durability** when exposed to UV light, moisture and temperature extremes
  - What are the property changes?

Silicone sealant properties

- Excellent UV resistance and physical property retention
- Properties vary with polymers, crosslinkers, fillers, adhesion promoters, fluids, etc.
- Properties that vary include:
  - Adhesion
  - Stain potential
  - Movement capability
  - Modulus

Silicone sealant properties

Sealant modulus vs. temperature

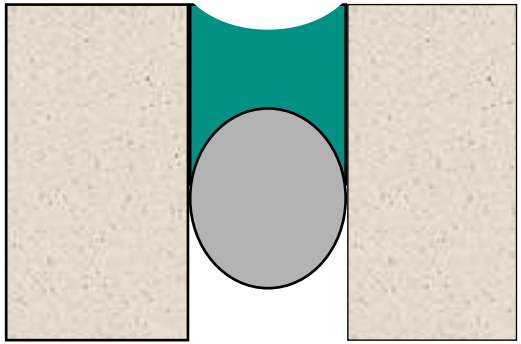


APPLICATIONS

- Weatherseals
- Nonstructural glazing
- Restoration
- Precured silicone sealants
- Exterior insulation and finish systems (EIFS)
- EIFS restoration
- Silicone coatings
- Sensitive substrates
- Parking structures
- Stadiums
- Structural glazing
- Protective glazing

WEATHERSEALS

- Use an hourglass-shaped butt joint for best performance
- 2-to-1 width-to-depth ratio minimum
- Maintain 1/4" contact to each joint surface
- Avoid 3-sided adhesion; use backer rod or bond breaker tape
- Other joint types: fillet joint, bridge joint, double weatherseal



JOINT DESIGN BASICS

- Minimum depth of 1/4" sealant/substrate bond to help ensure adequate adhesion
- Minimum width of 1/4" opening to help ensure sealant flow into joints
- Ensure joint design allows moisture from environmental humidity access to one-part silicone sealants for full cure

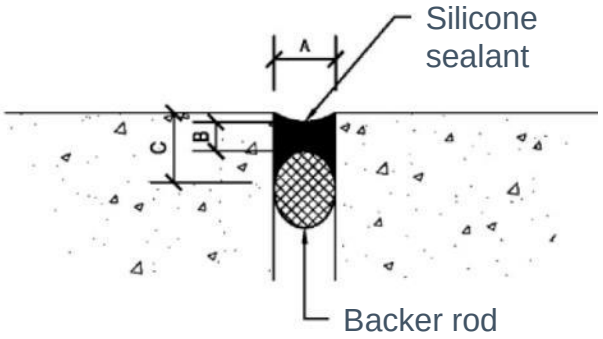
Design of moving joints

- A minimum 1/4" joint width is recommended
- Eliminate three-sided adhesion using a bond breaker tape or backer rod
- A properly designed moving joint with a 2:1 width to depth ratio will accommodate more movement than a thick joint
- As the sealant joint width becomes larger than 1", the depth should be held at approximately 3/8" to 1/2" at maximum
- Joint widths up to 4" can be accommodated with silicone sealants

Typical Joint Designs

Conventional moving weatherseal

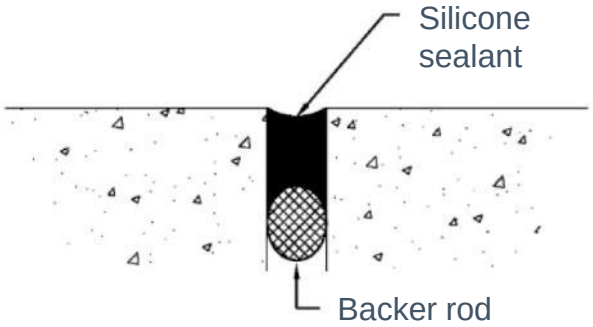
Good joint design



Good joint design – Key points:

1. Dimension A must be at least 1/4" (6 mm).
2. Dimension B must be at least 1/8" (3 mm).
3. Dimension C must be at least 1/4" (6 mm).
4. Ratio of A:B should be 2:1 minimum.
5. Joint surface tooled.
6. Dimension B suggested maximum = 1/2" (12.7 mm).
7. Dimension A maximum = 4" (100 mm). Joints wider than 2" (50 mm) may slump slightly; therefore, double application techniques of the sealant may be required.

Poor joint design

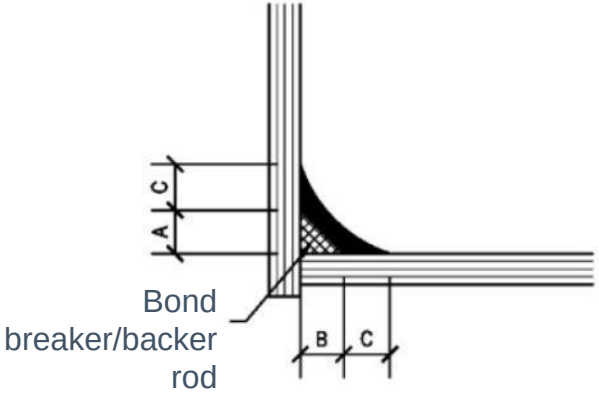


Poor joint design – Concerns:

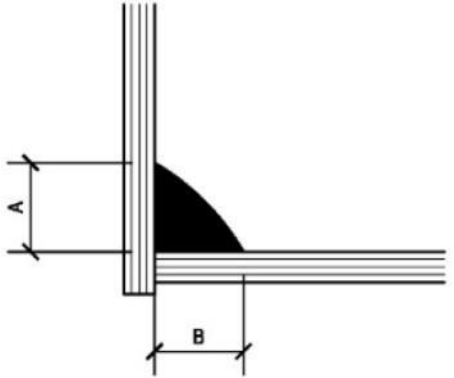
1. A deep sealant joint will not have the same movement capability as a properly designed joint.
2. Slow cure due to excessive sealant depth.

TYPICAL JOINT DESIGNS
MOVING CORNER JOINTS

Good joint design



Poor joint design



Good joint design – Key points:

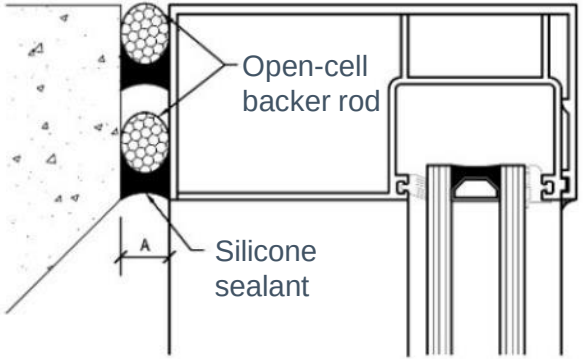
1. Dimensions A and B must be at least 1/4" (6 mm).
2. A bond breaker tape or backer rod must be present if joint movement is anticipated.
3. Joint must be tooled flat or slightly concave.
4. Dimension C must be at least 1/4" (6 mm).

Poor joint design – Concerns:

1. Dimension A or B less than 1/4" (6 mm).
2. Joint not properly tooled.
3. No bond breaker material; therefore, the joint will not accept movement.

TYPICAL JOINT DESIGNS
DUAL-SEAL MOVING WEATHERSEAL

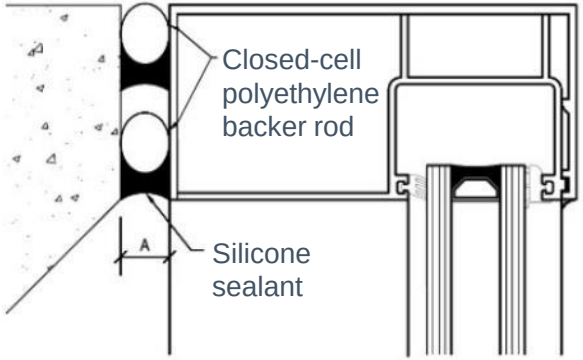
Good joint design



Good joint design – Key points:

1. Both weatherseals comply with the requirements for conventional moving weatherseals (addressed previously).
2. Open-cell backer rod is used to help ensure full cure of the back weatherseal.
3. If closed-cell backer rod is used, the back weatherseal must be fully cured prior to the installation of the exterior seal.
4. Dimension A is at least 3/4" wide to assist application of the rear sealant joint.

Poor joint design

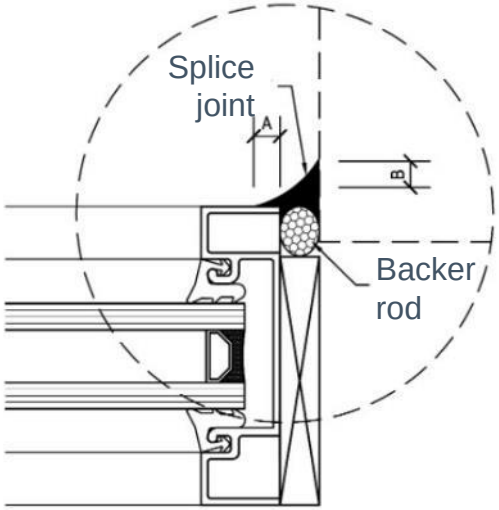


Poor joint design – Concerns:

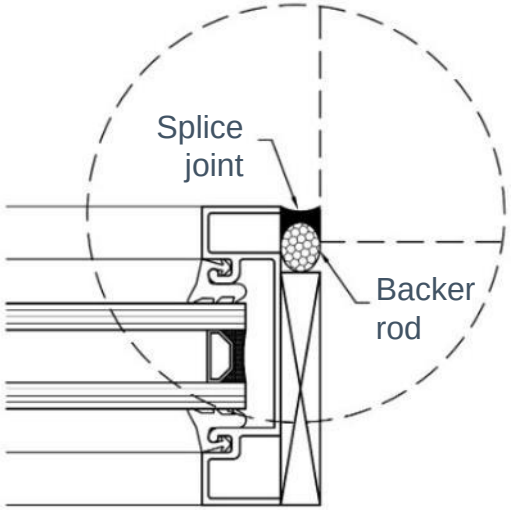
1. If both joints are sealed at or near the same time, the closed-cell backer rod will help prevent moisture from reaching the rear sealant joint, and the sealant will not cure.
2. Dimension A is less than 3/4", making application of rear joint difficult.
3. Exterior joint seal to aesthetic snap-on cap.

TYPICAL JOINT DESIGNS
WINDOW PERIMETER JOINTS

Good joint design



Poor joint design



Good joint design – Key points:

1. Dimensions A and B are each 1/4" (6 mm) or larger.

Poor joint design – Concerns:

1. Attempting to apply sealant onto the edge of (or behind) thin-gauge metal results in inadequate sealant/substrate contact and water leakage.

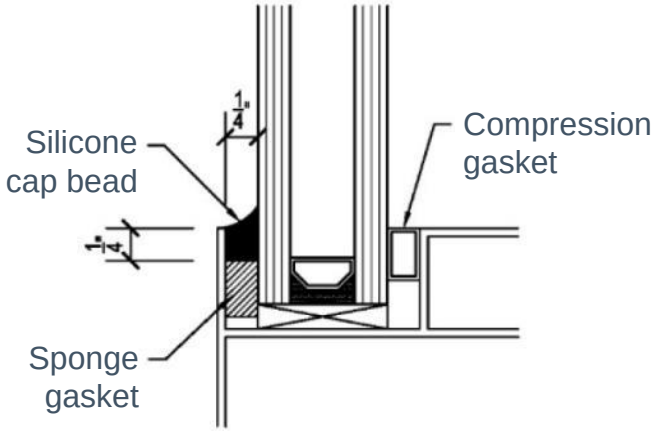
NONSTRUCTURAL GLAZING

- Glass-to-glass butt joints
- Silicone cap beads
- Internal seals
  - End dams
  - Screw heads
  - Splice joints

TYPICAL GLAZING JOINT DESIGNS

SILICONE CAP BEADS

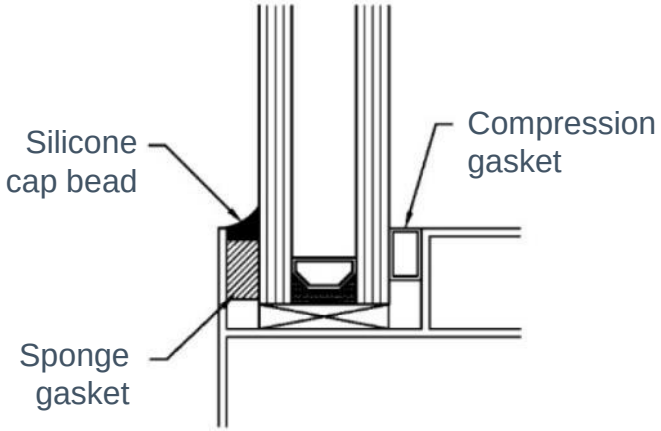
Good joint design



Good joint design – Key points:

1. Adhesion contact on glass and metal is at least 1/4" (6 mm).
2. Silicone is compatible with gasket.
3. Dark-colored sealant masks possible discoloration from the gasket.

Poor joint design



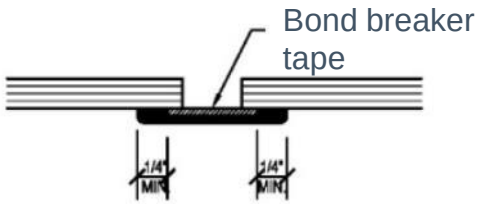
Poor joint design – Concerns:

1. Inadequate contact between sealant and external metal.
2. Gray sealant is prone to discoloration.

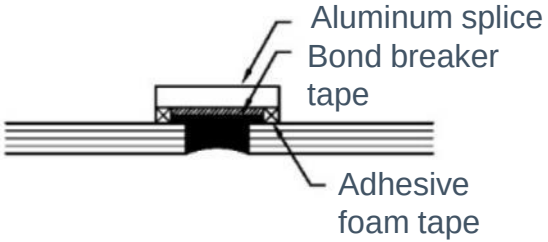
TYPICAL GLAZING JOINT DESIGNS

SPLICE JOINTS

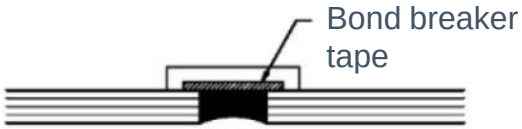
Good joint design



Good joint design



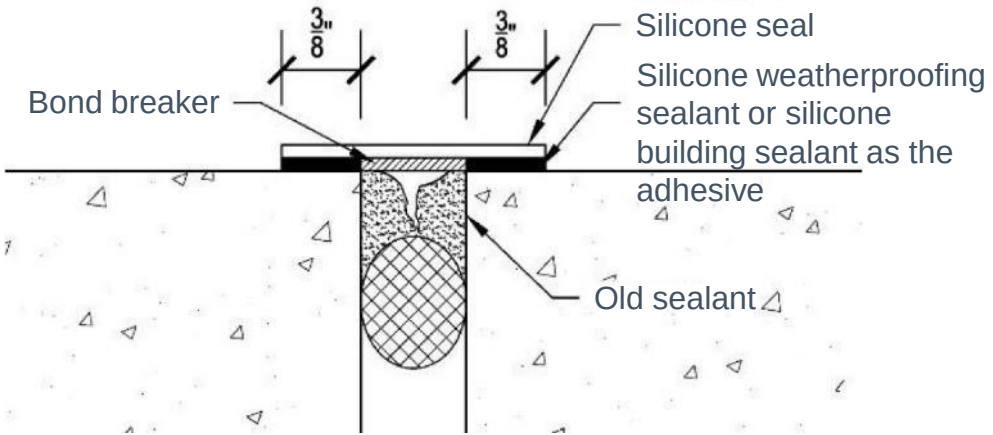
Poor joint design



Key Points:

1. Joint is very difficult to clean.
2. Bond breaker hard to position/size correctly.
3. Movement during cure can cause joint failure.

Best joint design



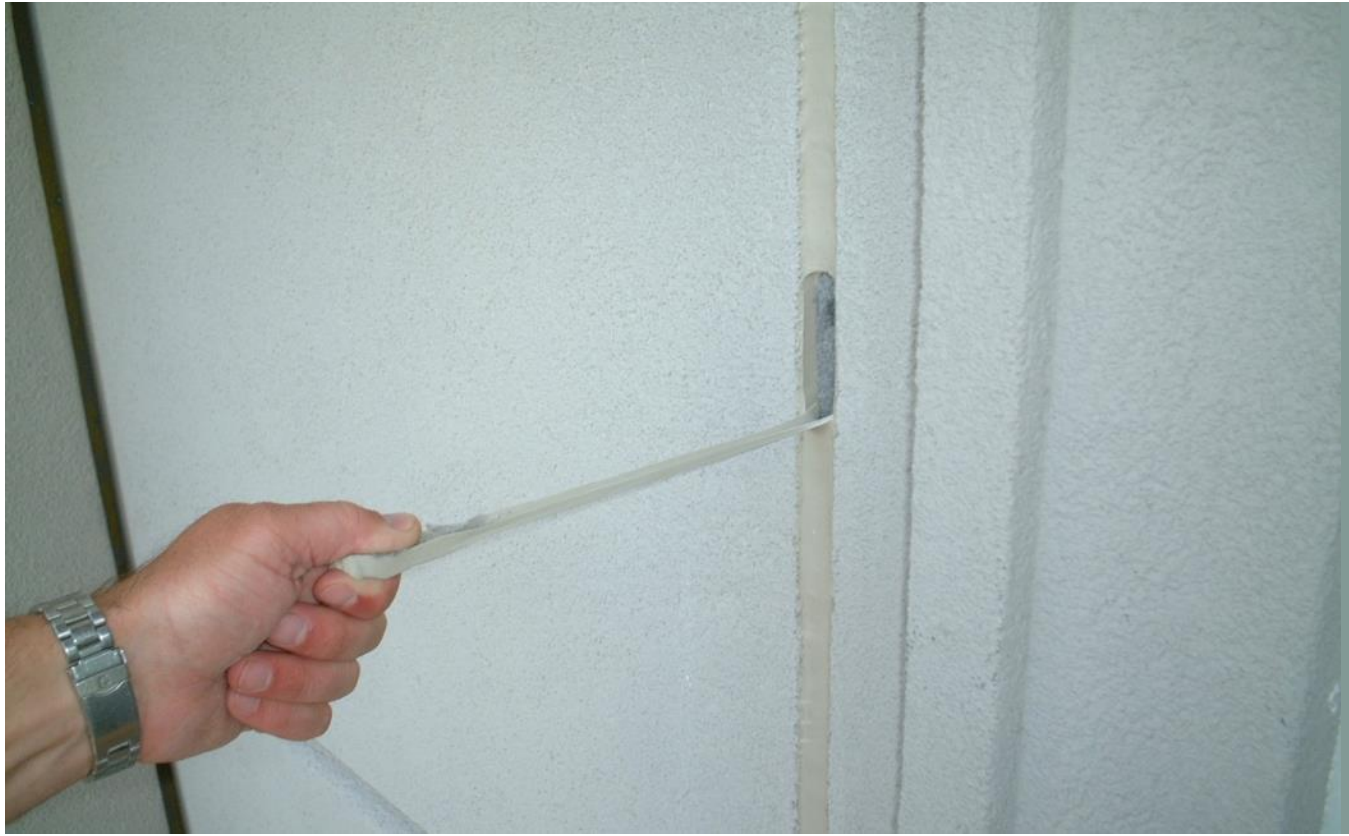
Sealant installation

- Clean – clean, dry, frost-free substrates
- Prime as recommended by the sealant manufacturer
- Install backer material sized 25% larger than the joint
- Install sealant and tool
- Perform field adhesion testing – document in quality assurance log





Sealant installation: Adhesion testing



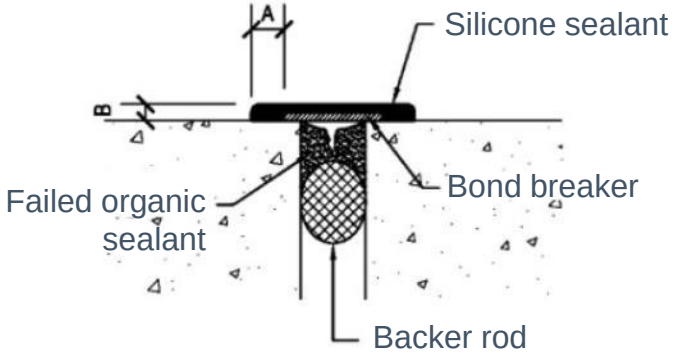
Field adhesion testing verifies sealant adhesion at the job site

Restoration

- Grind off old sealant
- Install test joints before starting the restoration project
- Wet seals – to replace failed gaskets
- Bridge joints – disengage existing sealant joints that are hardened and/or difficult to remove

RESTORATION
BRIDGE JOINTS – WET SEALANTS

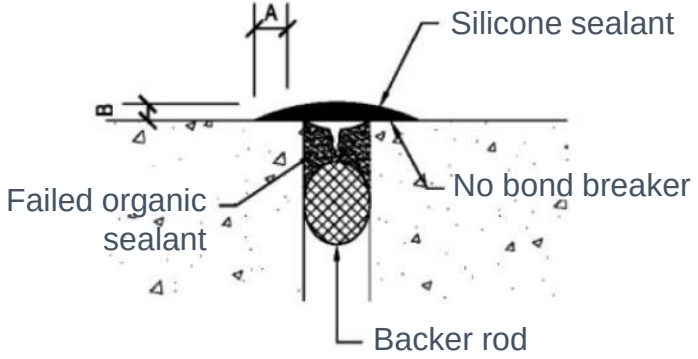
Good joint design



Good joint design – Key points:

1. Dimension A must be at least 1/4" (6 mm).
2. Dimension B must be at least 1/8" (3 mm).
3. Bond breaker tape must be used to isolate fresh sealant from failed organic weatherseal and to allow joint movement.
4. If existing sealant has not lost adhesion to the substrate, disengage it before applying silicone sealant.

Poor joint design



Poor Joint Design – Concerns:

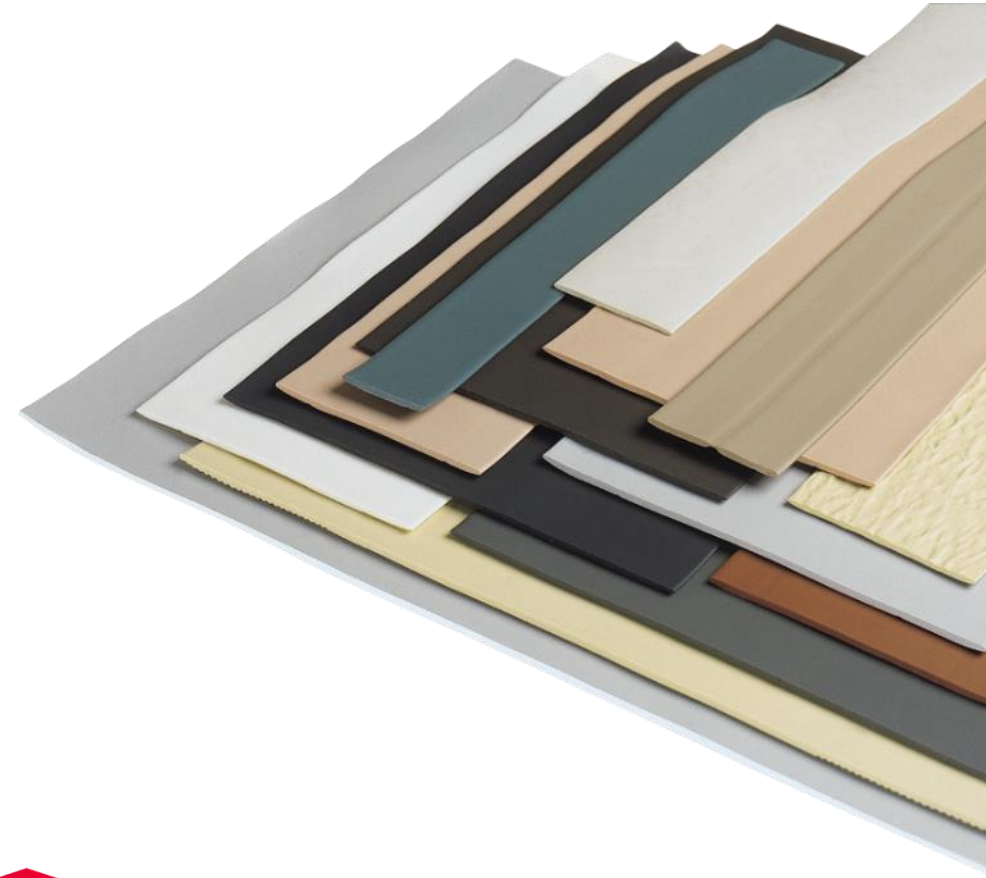
1. Dimension A less than 1/4" (6 mm) increases difficulty in obtaining adhesion and increases the likelihood for voids.
2. Dimension B less than 1/8" (3 mm) increases the likelihood of pinholes or voids in tooling; poor cohesive integrity.
3. No bond breaker material; therefore, the joint will not accept movement.

Bridge joints

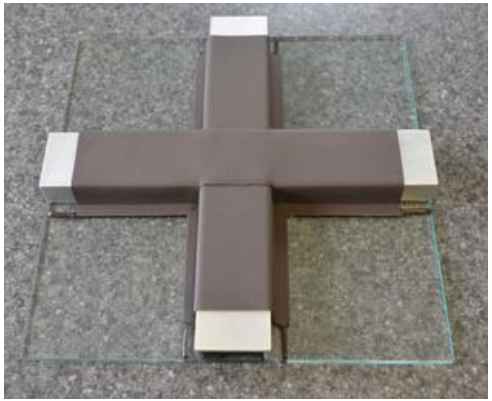
PRECURED SILICONE SEALANTS

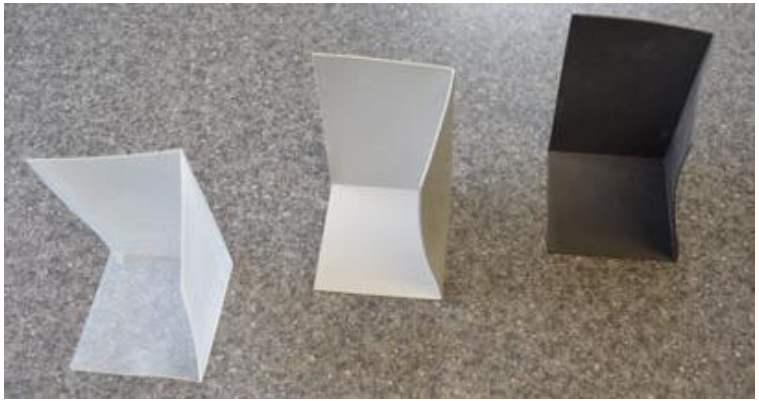
PRECURED SILICONE SEALANTS

- Weatherseals over difficult-to-remove polyurethane sealant
- Glazing splice joints
- Roof parapet caps
- Aluminum composite panels
- Custom silicone extrusions and molded designs now available



PRECURED SILICONE SEALANTS





Exterior Insulation and Finish Systems (EIFS)

- EIFS is a softer substrate requiring sealants that produce less stress on the substrate
- Silicone sealants offer long-term durability, high movement capability and low modulus, particularly in cold temperatures

Exterior Insulation and Finish Systems (EIFS)

- EIFS coating delamination can be caused by the stiffness of the sealant
- A low-modulus silicone sealant applies less stress to the substrate

EIFS JOINT RESTORATION

- EIFS joint restoration is complex due to the difficulty in removing failed polyurethane sealant without damaging the EIFS substrate
- The use of a precured silicone sealant bridge joint and silicone elastomeric coating offers a cost-effective, aesthetically pleasing, watertight result

Silicone elastomeric coating

- Water-based, one-part silicone emulsion
- 50% solids by weight
- Easily applied by roller, brush or spray
- At least 10 mil dry film thickness
- VOC compliant

Silicone elastomeric coating

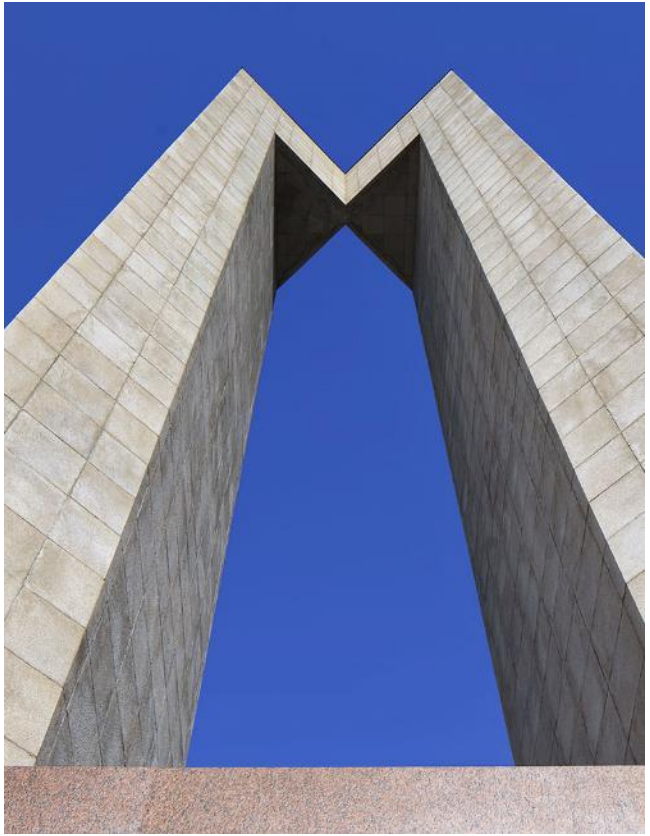
- Long-term silicone flexibility
- High permeability (average 43 metric perms at 10 mil dry film thickness)
- Suitable for use on concrete, stucco, EIFS, brick

Staining of sensitive substrates

- Staining is caused by nonreacted fluids in the sealant formulation
- Any sealant can stain if poorly formulated or used on a nonrecommended substrate
- Require stain testing per ASTM C1248 and a nonstaining warranty from the sealant manufacturer

Clean silicone sealants

- Silicone sealants are available for sensitive substrates
- These sealants will not stain the most porous stone types, including Vermont and Italian white marbles
- Surface modifiers reduce dirt pickup and minimize streaking on metal panel systems



Parking structures

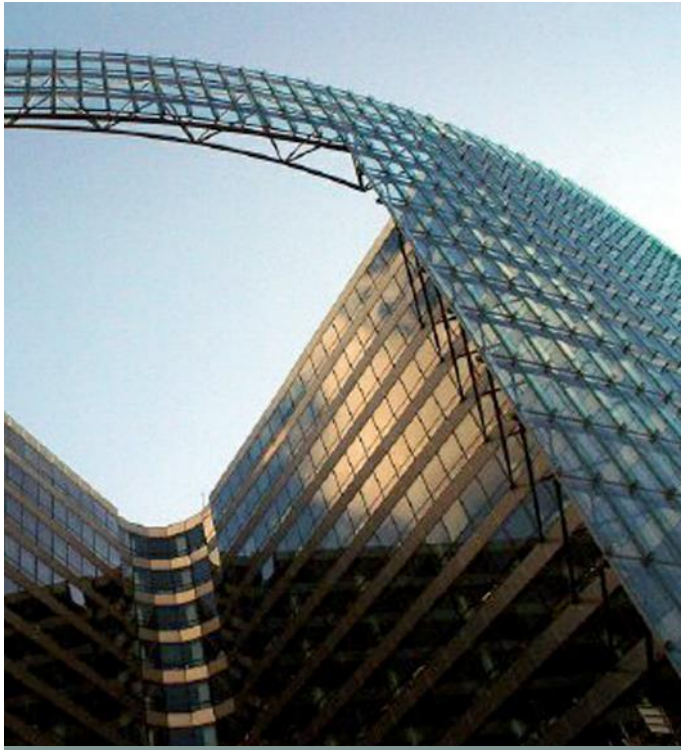
- Expansion joints
  - Fast-cure sealant
- Control joints
  - Self-leveling
- Cove beads
- Vertical joints
  - Nonsag sealant

STRUCTURAL GLAZING

- Silicone sealant adheres glass to the structure
- Sealant allows wind load to be transferred to the structure
- Sealant must be strong but flexible to accommodate thermal expansion
- Sealant must have a long life
- Only silicones can be used for structural glazing

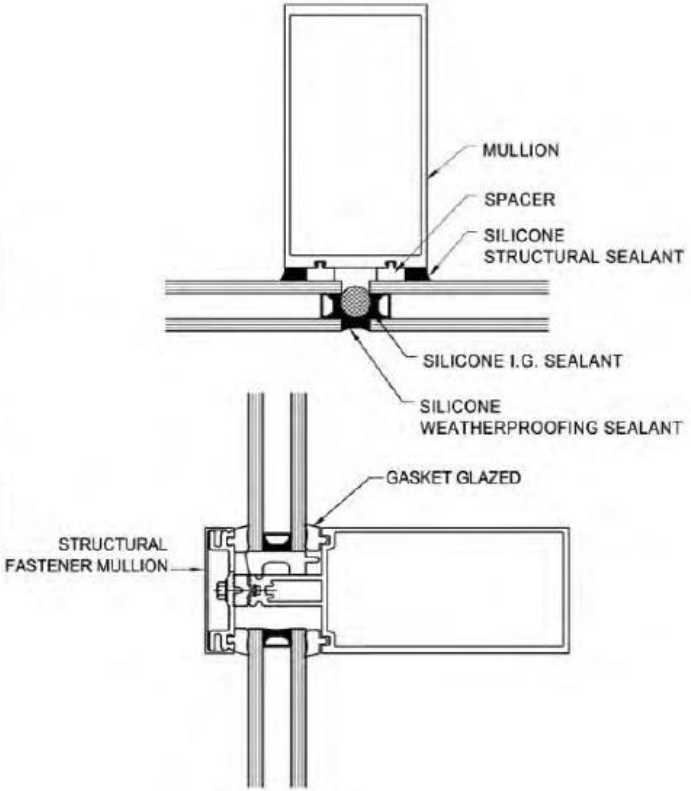
STRUCTURAL GLAZING

4-sided silicone structural glazing

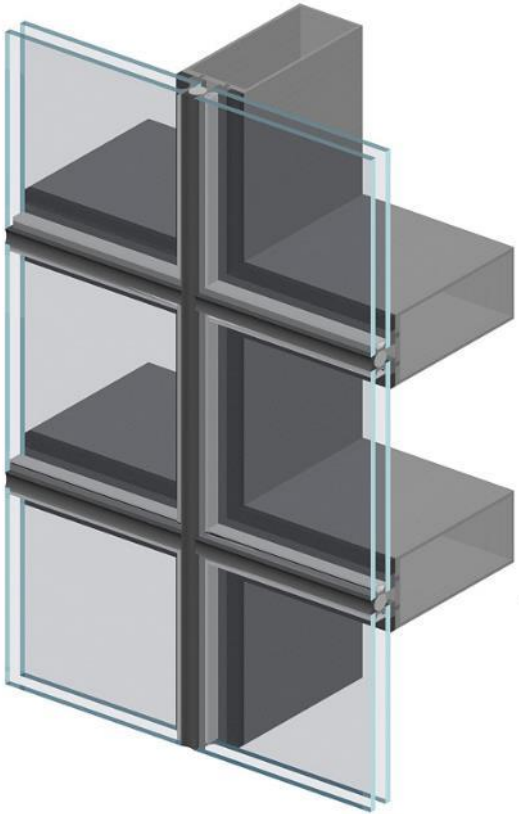


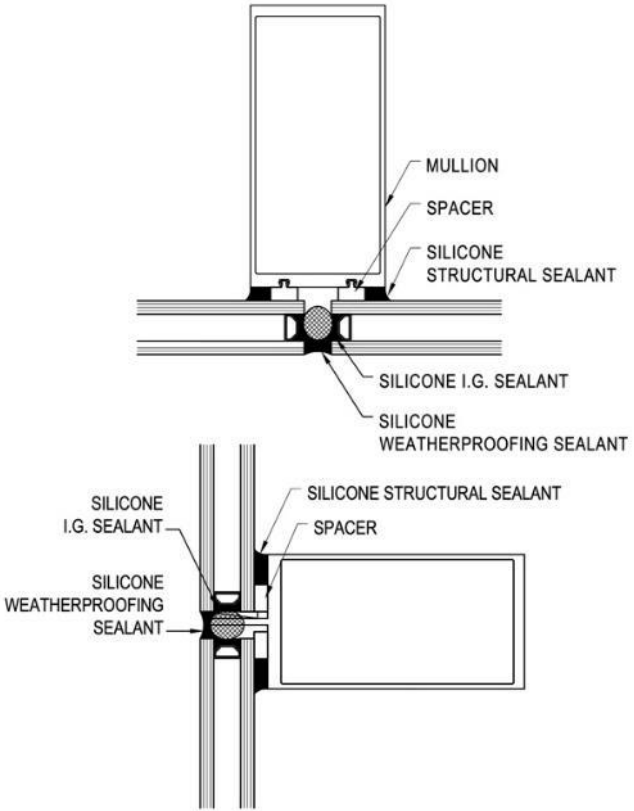
2-sided silicone structural glazing

2-SIDED STRUCTURAL GLAZING



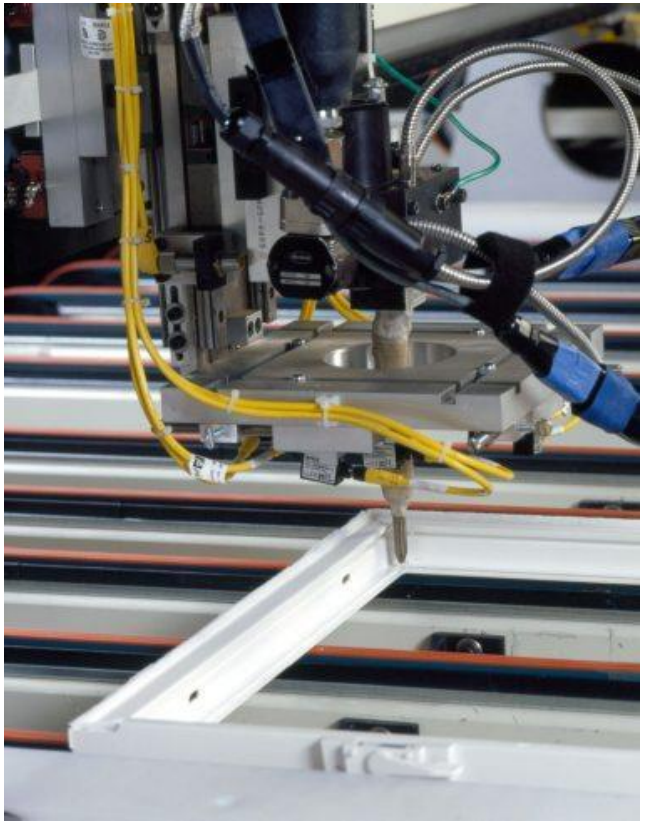
4-SIDED STRUCTURAL GLAZING





Application methods

- Factory (shop) glazing
- Site (field) glazing



Application methods

- Structural glass systems (bolted or point-fixed glazing)
- Total vision systems (fin glazing)
- Structural attachment of nonglass materials
- Panel stiffeners
- Protective glazing systems

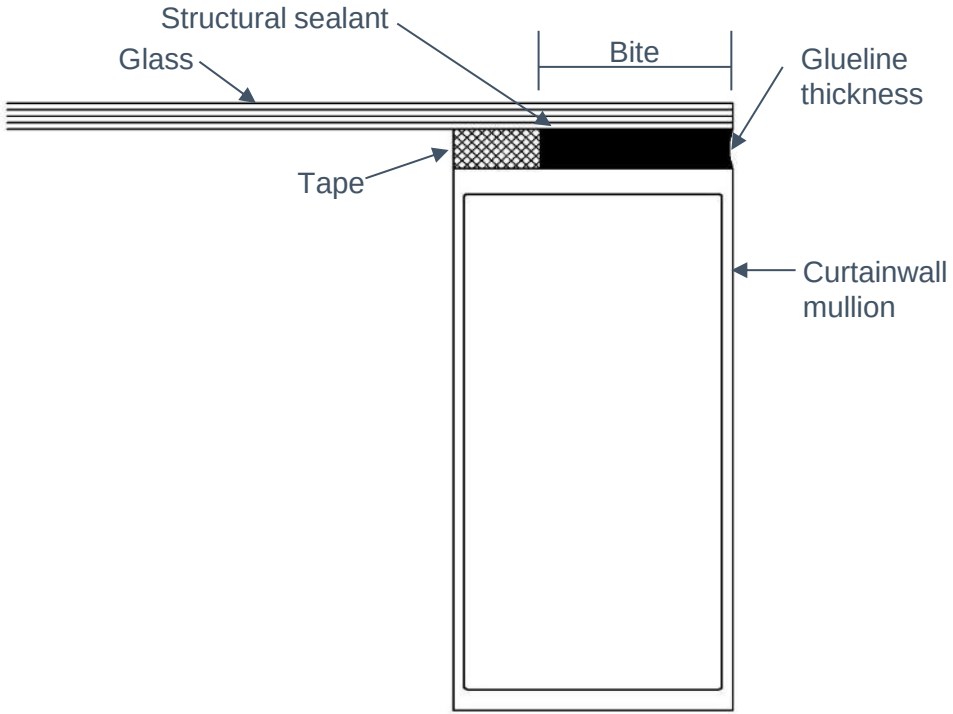
Structural glazing design guidelines

- The structural bite must be a minimum of 1/4"
- The glueline thickness must be a minimum of 1/4"
- The structural bite must be equal to or greater than the glueline thickness
- For one-part sealant, the bite-to-glueline ratio must be between 1:1 and 3:1
- The structural sealant joint must be able to be filled using standard sealant application procedures

Structural glazing design guidelines

- The joint design must allow the sealant exposure to air so it can cure and obtain its ultimate physical properties
- For two-part sealant, the bite-to-glueline ratio may be greater than 3:1 with the understanding that the joint can be properly filled and the two-part materials are mixed at proper ratio during application
- The structural sealant joint must be fully cured and adhered prior to removing temporary fasteners in the field
- Before moving units in-shop, fabricators should verify that substantial cure has occurred and adhesion has been achieved

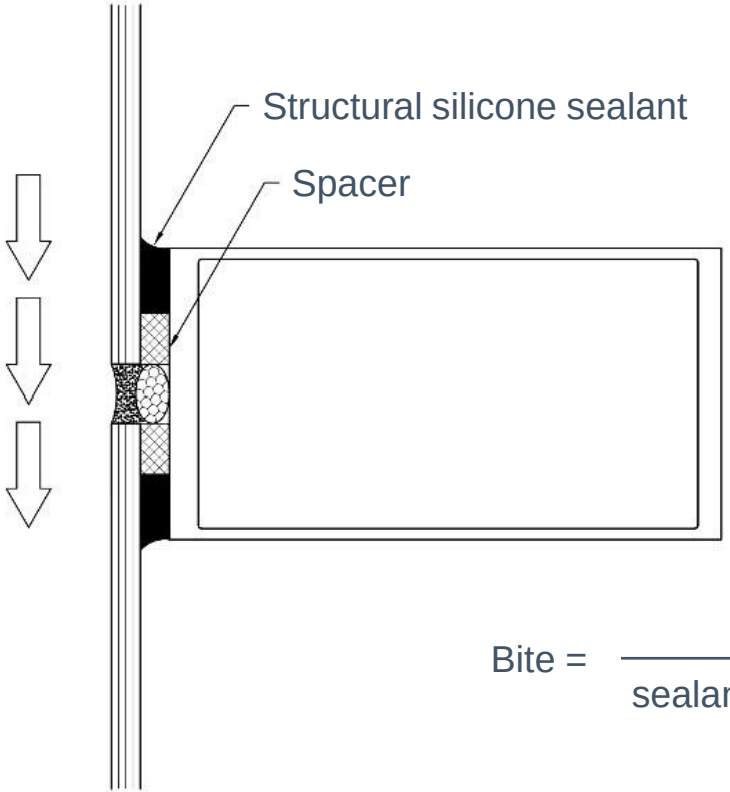
STRUCTURAL GLAZING DESIGN



Bite ≥ Glueline thickness ≥ 1/4 in.

$$\text{Bite} = \frac{\text{1/2 glass shortspan x design wind load}}{\text{sealant design strength}}$$

Structural glazing design
Deadload



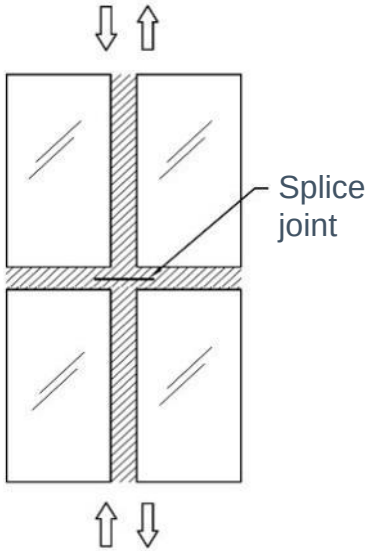
$$\text{Bite} = \frac{\text{weight of glass in lb}}{\text{sealant contact length in inches} * \text{sealant design strength (1 psi)}}$$

Structural glazing design

Splice joint in curtainwalls

Best design

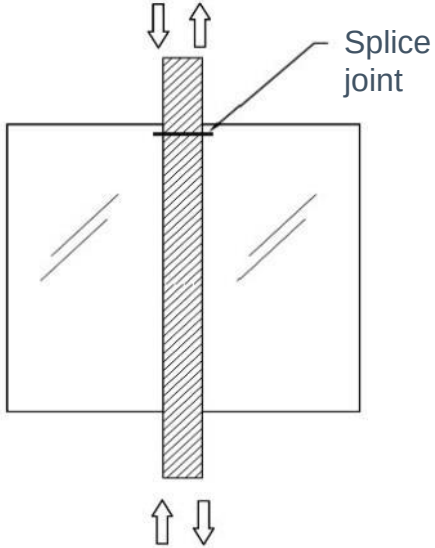
Live load and thermal movement from above



Live load and thermal movement from below

Better design

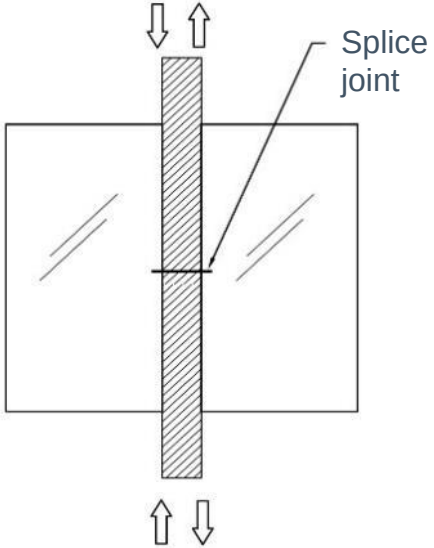
Live load and thermal movement from above



Live load and thermal movement from below

Poor design

Live load and thermal movement from above



Live load and thermal movement from below

PROTECTIVE GLAZING

- Building codes require the use of windows that can withstand flying debris from hurricanes or other severe weather
- Window systems that use laminated glass and a silicone sealant to anchor the laminated glass in the window frame have successfully passed the demanding missile-impact test

BLAST-RESISTANT
GLAZING

- Silicone sealant is used to anchor laminated glass or a protective film in a window frame during bomb-blast testing or computer-simulated evaluations

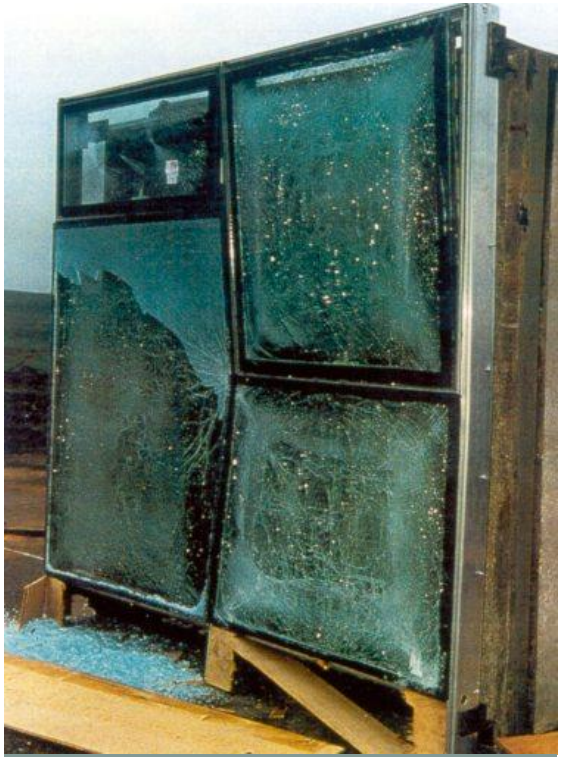
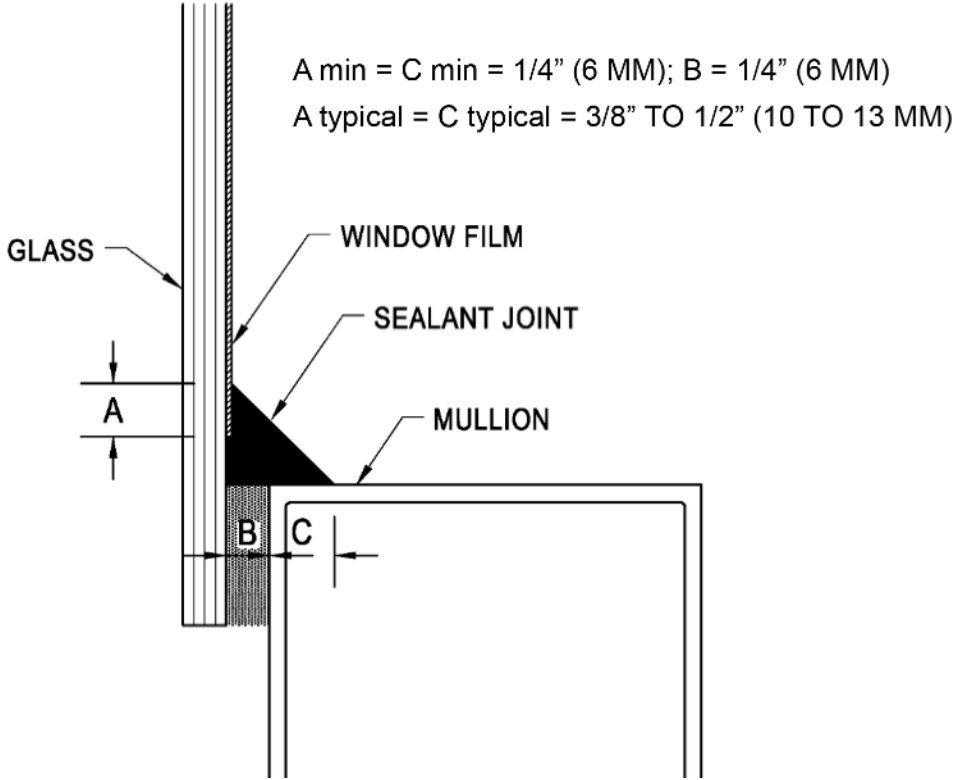


Image courtesy of Grendon Design Agency

IMPACT-RESISTANT GLAZING JOINT DESIGN



References

- ASTM C719 Movement Capability Test Method
- ASTM C794 Adhesion in Peel Test Method
- ASTM C920 Standard Sealant Specification
- ASTM C1184 Structural Glazing Specification
- ASTM C1193 Guide for Use of Sealants
- ASTM C1248 Stain Test Method
- ASTM C1299 Guide for Selection of Sealants
- ASTM C1401 Guide to Structural Glazing
- ASTM C1472 Guide for Calculating Joint Movement
- ASTM C1481 Guide to Use of Sealants with EIFS

In Summary, silicone sealants offer …

- Longevity
- Versatility
- Aesthetics
- Value
- Demonstrated performance

THANK YOU

This concludes the American Institute of Architects Continuing Education System Program “Silicone Sealants and Coatings for Building Construction and Restoration.”

For more information, contact:
dow.com/buildingscience

Any

questions?

DOWSIL™ Brand Weatherseal Sealants

- **DOWSIL™ 790 Silicone Building Sealant** (+100/-50%) – ultralow-modulus expansion joint sealant; well-suited for porous substrates
- **DOWSIL™ 791 Silicone Weatherproofing Sealant** (±50%) – economical, medium-modulus general weatherseal sealant
- **DOWSIL™ 795 Silicone Building Sealant** (±50%) – versatile industry standard for use as structural and weatherseal sealant
- **DOWSIL™ Contractors Weatherproofing Sealant** (±25%) – excellent silicone performance at a urethane-competitive price
- **DOWSIL™ Contractors Concrete Sealant** (±50%) – excellent primerless adhesion to most porous substrates at a urethane-competitive price

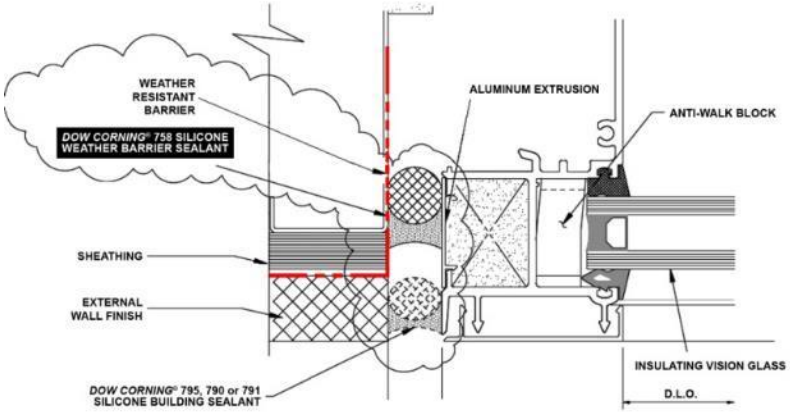
DOWSIL™ 756 SM Building Sealant

- Clean sealant technology for weathersealing sensitive substrates
- One-part formulation
- Low staining potential
- Reduced dirt pickup
- Unprimed adhesion to both porous and fluoropolymer-painted substrates
- ±50% extension/compression capability

Image courtesy of the city of San Jose

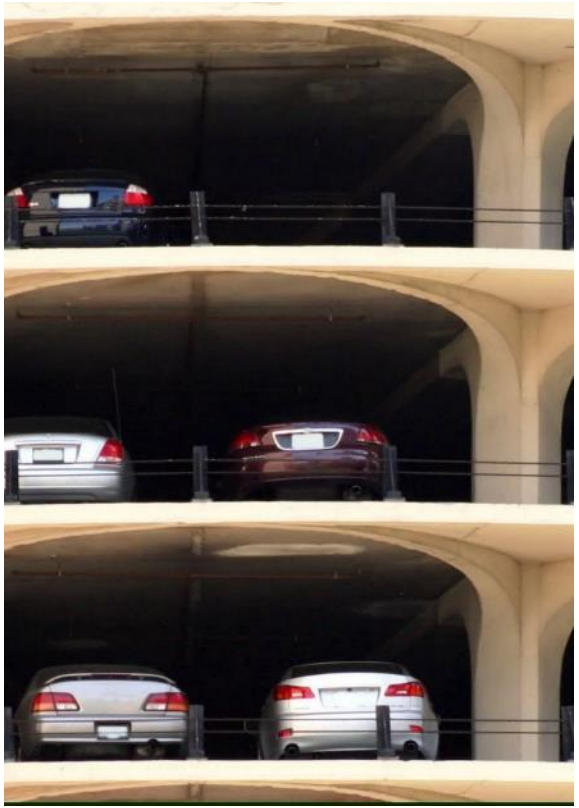
DOWSIL™ 758 Silicone Weather Barrier Sealant

- One-part neutral-cure sealant
- ±25% movement capability in properly designed joint
- Adheres to many polyethylene-film-based weather barriers, spun-bonded polyolefin and fibrous air barriers, flashing, and liquid elastomeric weather barriers
- Adheres to common fenestration substrates – anodized aluminum, vinyl, PVC and high-performance coatings
- Priming not required on most surfaces



DOWSIL™ Brand Parking Structure Sealants

- **DOWSIL™ NS Parking Structure Sealant** – nonsag sealant for horizontal and vertical control and expansion joints
- **DOWSIL™ SL Parking Structure Sealant** – self-leveling sealant for horizontal control and expansion joints
- **DOWSIL™ FC Parking Structure Sealant** – fast-curing, self-leveling two-component sealant for dynamic expansion joints



DOWSIL™ 123 Silicone Seal

- High movement (+200/-75%) for new and remedial construction
- Widths from 1" to 12"
- Available in standard and custom colors, EIFS textures and notched
- DOWSIL™ 123 Silicone Seal Custom Designs H.C. – Engineered extrusions and molded silicone pieces for new and remedial construction

DOWSIL™ ALLGUARD SILICONE ELASTOMERIC COATING

- Waterproof coating for above-grade exterior masonry substrates
- 2-coat water-based coating (10 mil DFT)
- SWR Institute validated
- 50% solids by volume
- 10-year warranty available + 10-year recoat warranty

DOWSIL™ Brand Structural glazing sealants

- **DOWSIL™ 795 Silicone Building Sealant** – one-component industry standard for on-site glazing
- **DOWSIL™ 995 Silicone Structural Sealant** – one-component, high-strength sealant for on-site and protective glazing
- **DOWSIL™ 983 Structural Glazing Sealant** – two-component, fast-cure, in-shop sealant for unitized curtainwall and protective glazing

Image courtesy of Senarq S A

DOWSIL™ 121 Structural Glazing Sealant

- Approved for structural and weatherseal applications
- Used for in-shop glazing or field repair/replacement
- Primerless adhesion to glass, alodine and anodized aluminum
- Adhesion to DOWSIL™ structural sealants for reglazing applications
- Adhesion and structural strength achieved in 24 to 48 hours
- Addresses ASTM C719 Class 25 (G, A, O)
- Addresses ASTM C1184 Structural Sealant Specification

DOW SERVICES

- 50+ year track record in construction
- Technical leadership (R&D, patents, ASTM)
- Authorized distributors
- Laboratory testing for adhesion, compatibility and staining
- Offering 20-year weatherseal, nonstaining and structural adhesion warranties
- Website: **dow.com/buildingscience**

AIA MASTER SPEC

- We will review your specification for you and offer recommendations at no charge; send specifications directly to our review department
- Specs are available on **dow.com/constructionsubmittal**

THANK YOU

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Shenzen Ping
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Ping
An Insurance Group

Façade of the ICE Krakow Kongress
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TSSA-Press Glass
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TSSA-Press Glass

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