Dow Performance Silicones

Insulating Glass Manual – Asia



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Introduction

Insulating glass is a key component of modern façade construction. Insulating glass brings many benefits to curtainwall performance. With today's high cost of energy, the thermal performance of a building façade has become very important. The use of insulating glass in façade construction allows the design profession to construct buildings with large vision areas that are aesthetically appealing as well as thermally efficient.

Insulating glass (IG) units consist of two or more glass panes which are separated along the perimeter by a spacer and sealant system. The cavity between the panes of glass may be filled with dry air or an inert gas. Many types of glass can be used including laminated glass, coated glass or spandrel glass. These components are selected to meet the specific color, reflectivity, light transmission and sound transmission requirements of the IG unit.

Insulating glass is also used in silicone structural glazing, which is a method utilizing silicone adhesive to attach glass to the structure of a building. The performance of insulating glass in structural glazing applications is critical due to the loads, stresses and extreme environmental factors impacting the façade. For these requirements to be fulfilled, both the construction of IG units and the manufacturing of the individual components must meet very high standards of quality. From the glass production and coating application, the manufacturing of spacer bars and sealants, to the final assembly of insulating glass products, quality must be consistently maintained through the implementation of special application and quality control procedures.

The selection of the proper materials is a key element of successful IG performance. Dow provides high performance silicone sealants which are specifically designed for the production of insulating glass.

The *DOWSIL™ Insulating Glass Manual* is intended to provide guidelines and considerations for IG manufacturers, not only for the use of DOWSIL™ insulating glass sealants, but also as a source of additional information about IG production. No claim is made as to its completeness or accuracy of the statements made in this manual. It was prepared by Dow based on the company's best current knowledge and experience in sealant manufacturing and IG production. Dow makes no claim as to the performance of IG units based on information provided in this document.

DOWSIL™ Product Offering

Dow offers a full line of high performance silicone sealants. Each sealant is developed and tested for a specific application and should only be used as intended unless specifically approved by Dow. Specific product information is available at consumer.dow.com/construction.

Insulating Glass Silicone Sealants

The DOWSIL™ Silicone Sealants offered for insulating glass applications are described below. These products are intended for IG production only and are not approved for use as structural glazing sealants. A typical structural glazing application would be the attachment of glass to a metallic frame.

DOWSIL™ 982 Silicone Insulating Glass Sealant

DOWSIL™ 982 Silicone Insulating Glass Sealant is a two component, neutral cure, fast curing silicone sealant intended for use as a secondary seal in dual sealed IG units. DOWSIL™ 982 Silicone Insulating Glass Sealant is appropriate for use in IG units used in structural glazing applications. DOWSIL™ 982 Silicone Insulating Glass Sealant meets ASTM C 1369. For more information, please refer to the product data sheet.

DOWSIL™ 3362N Insulating Glass Sealant

DOWSIL™ 3362N Insulating Glass Sealant is a two component, neutral curing silicone sealant intended for use as a secondary seal in dual sealed IG units. DOWSIL 3362N Insulating Glass Sealant is appropriate for use in IG units used in structural glazing applications. DOWSIL 3362N Sealant meets GB16776-2005 and GB24266-2009, the China standards for insulating glass sealants and EN1279-4.

DOWSIL™ 3362 HD Insulating Glass Sealant

DOWSIL™ 3362 HD Insulating Glass Sealant is a special higher modulus grade of sealant specifically designed for IG units. The higher modulus properties of the sealant limit the deflection of the primary seal of the IG unit, increasing the probability for the IG system to pass gas loss tests (e.g. EN 1279/3).

DOWSIL™ 3-0117 Silicone Insulating Glass Sealant

DOWSIL™ 3-0117 Silicone Insulating Glass Sealant is a high modulus, one component, neutral curing silicone sealant intended for use as a secondary seal in dual sealed IG units. DOWSIL™ 3-0117 Silicone Insulating Glass Sealant is appropriate for use in IG units used in structural glazing applications.

Dow Customer Support

Dow offers a broad range of products and services to assist manufacturers in the production of insulating glass. Dow can assist the IG manufacturer in the design of the secondary seal joint dimensioning. Dow technical service engineers can assist in the design, evaluation and component selection of the insulating glass system, considering the special requirements related to gas permeability. Dow routinely assists the IG manufacturer in the development of a comprehensive quality control program that can help to ensure proper sealant application and quality control. A further description of these customer support services is provided in the following sections of the DOWSIL™ Insulating Glass Manual.

Dow Project Support

Every structural glazing project using DOWSIL™ Structural Glazing Sealants must be reviewed and glazing substrates tested by Dow. Please refer to the Asia Structural Sealant Glazing Manual for a description of the guidelines that must be followed. In support of our structural glazing products, Dow can also review insulating glass joint dimensioning to help ensure compliance with Dow and relevant industry standards. Dow will provide a recommendation letter supporting the use of DOWSIL™ Insulating Glass Sealants for a specific project. Approval is based on production in compliance with the guidelines provided by Dow in this manual.

Since the silicone secondary sealant of the IG unit is only one component of the final product, it alone cannot determine the successful performance of the IG units. Many components including the spacer type, butyl primary seal type and application, glass type, material performance, product application and workmanship will affect the overall performance of the IG unit. It is the responsibility of the IG producer to select the appropriate materials and to manufacture their IG units. The IG producer is ultimately responsible for the overall performance of the IG units produced.

Design Review for Structural Glazing Project

All structural glazing projects must be reviewed and the joint design approved by Dow on project by project basis. Guidelines for the appropriate design of structural glazing are described in the *Asia Structural Sealant Glazing Manual.* For structural glazing projects that use insulating glass, the silicone secondary seal on the IG unit must be an approved silicone sealant. Dow offers to review IG joint dimensions to help ensure compliance with Dow and relevant industry selected. Please submit project information or the “Project Checklist” by the procedures described in the *Asia Structural Sealant Glazing Manual*. Please include information such as glass dimensions, sealant joint dimensions, total dynamic loads and a cross-section detail of the IG unit edge design.

Testing for Structural Glazing Project

For all structural glazing projects, the materials which contact the DOWSIL™ Structural Silicone Sealant must be tested for adhesion and compatibility by Dow. Guidelines for material selection and testing are described in the DOWSIL™ Structural Glazing Manual. When DOWSIL™ Insulating Glass Sealants are used, Dow recommends that any material which has not been previously tested and approved by Dow for adhesion and compatibility should be tested by Dow prior to use. If a material needs to be tested, please refer to the *Asia Structural Sealant Glazing Manual* for information on the procedure for submitting samples to Dow for testing.

IG Production Support

Dow professionals offer their experience and expertise to any insulating glass manufacturer who selects DOWSIL™ Insulating Glass Sealants for their IG production. Dow Technical Service Engineers are available to review the IG production process steps including material selection, production procedures, workmanship, quality control procedures and documentation. Dow can assist in particular with achieving compliance according to gas filled IG Sealant standard EN-1279 part 3. Many Dow customers have successfully passed EN-1279-3 gas loss requirements using DOWSIL™ Insulating Glass Sealant. We can help you achieve similar results. These issues are discussed further in subsequent sections of the *DOWSIL™ Insulating Glass Manual*.

Compatibility Considerations

An important consideration when choosing sealants for insulating glass units, structural glazing and weatherseals is compatibility between the sealants. By choosing all sealants from Dow you can be sure that decision is simplified. All DOWSIL™ insulating glass sealants and structural glazing sealants are compatible with each other. For most weatherseal joints DOWSIL™ 791 Silicone Weatherproofing Sealant is recommended, but for more information or assistance choosing sealants please contact your Dow Technical Service Engineer.

Sealant Choices

The secondary sealant and structural sealant suppliers must approve the proposed structural sealant choice for the structural sealant glazing applications. (See Product Offering, page 4, for silicone IG sealants suitable for structural applications.) Under certain conditions, the corrosive vapors liberating from acetoxy cure silicone sealants can cause degradation of two-part silicone secondary sealants, potentially leading to premature failure of the insulating glass unit. Dow does not approve the use of neutral-cure IG silicone sealants in the presence of acetoxy silicone sealants. Dow also does not approve the use of acetoxy silicone sealants as structural secondary IG sealants.

Compatibility

Check with the secondary sealant and structural sealant suppliers to confirm and approve the compatibility of the sealants and any accessory materials they may contact, such as setting blocks, gaskets, spacers, and weatherseals. Most silicone sealant suppliers perform the 22-day ASTM C 1087 compatibility test upon request. The sealant is applied in direct contact with the accessory material in question. The test specimen is placed in a chamber with high-intensity ultraviolet radiation. After the test period, samples are inspected for compatibility in the form of sealant discoloration and adhesion. Please note that non-silicone setting and edge blocks have the ability to cause discoloration of IG secondary seals and field-applied silicone weatherseals.

Exposure to Solvents

Silicone insulating glass sealants are susceptible to swelling when in contact with solvents such as isopropanol, volatile siloxane fluids, methylethylketone, and terpenes. These solvents will not decompose the silicone, but will permeate the silicone and attack the PIB primary seal. Solvent-based water repellents that are post-applied to a masonry building and allowed to enter the glazing weep system have been documented to cause PIB flow within a sealed IG unit. Setting blocks and edge blocks that are saturated with solvent have been documented to cause PIB flow within a unit. Solvent-extended sealants and solvent-based sealants contacting the secondary seals of an IG unit can have similar effects. PIB flow within a unit is very unsightly and may result in premature fogging.

Design and Material Considerations

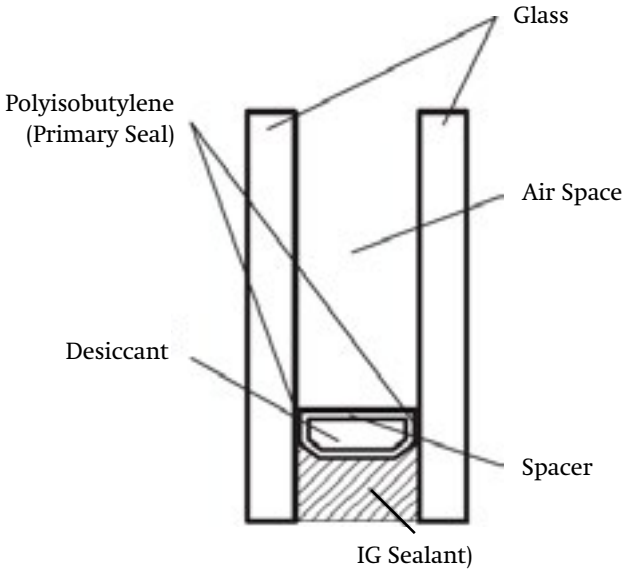
Many factors will contribute to determine the successful performance of an IG unit. In this section, we will discuss types of insulating glass, IG joint dimensioning and components of an IG unit.

Insulating Glass Components

An IG unit, whether used in a structural glazing system or in a mechanically captured frame is intended to offer the building occupant an aesthetically pleasing, thermally efficient façade element that requires minimal maintenance during the expected life of the unit. Typical IG units are comprised of two (or occasionally three) panes of glass with a cavity between the panes. The panes of glass are sealed around the perimeter with a spacer and sealant system that ensures that the units are hermetically sealed and sufficiently stable to withstand thermal and windload stresses on the unit. For a typical dual-sealed IG unit, a polyisobutylene (PIB) or butyl primary seal between the metal spacer and glass provides low vapor permeability and a silicone secondary seal provides structural integrity for the panes of glass.

For insulating performance, the space between the panes of glass is filled with dry air or an inert gas that provides enhanced thermal insulating performance. To maintain the long-term insulating performance of the unit, the glazed perimeter of the IG unit must have low vapor permeability to resist the ingress of moisture that can cause fogging of the IG unit. To absorb incidental moisture that may enter the void, a desiccant is used inside the spacer. All of these components must work synergistically to provide the expected performance of an IG unit. Below is a diagram showing the components of a typical IG unit.

Typical Dual Sealed Insulating Glass Unit



Types of Insulating Glass

The types of insulating glass are described in the following section.

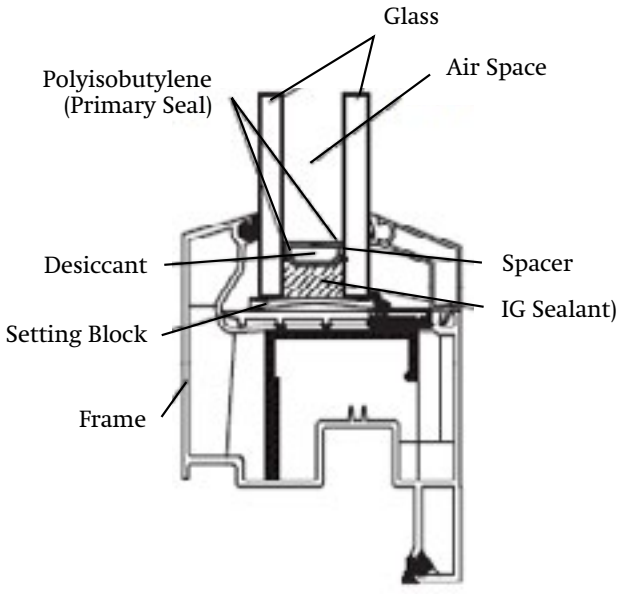
Frame Mounted Insulating Glass

Frame mounted insulating glass is secured on all four sides by a frame that completely covers the edge seal. The insulating glass may be placed inside a fixed frame or the insulating glass could be set on the frame then secured continuously by a pressure bar. Typical applications include curtainwall facades or windows constructed of wood, plastic or aluminum. In these designs, there is no restriction on the type of spacer bar system or sealant type used. Silicone insulating glass sealants which are recommended for non-structural and structural applications can be used effectively in these designs.

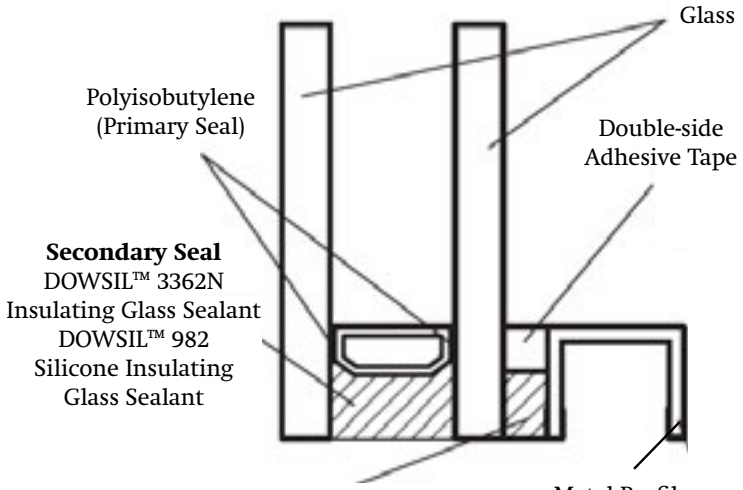
Structurally Glazed Insulating Glass (Uncovered Edge Seal)

For insulating glass with an uncovered edge seal, there are additional demands on the primary and secondary seals of the IG unit. Ultra-violet (UV) rays from the sun travel readily through glass and can damage the edge seal of the IG unit. Only silicone sealants are stable after long-term exposure to UV light. Organic sealant such as polysulphide and polyurethane do not provide long-term resistance to UV light and hence are not suitable for this application.

Frame Mounted Insulating Glass Unit



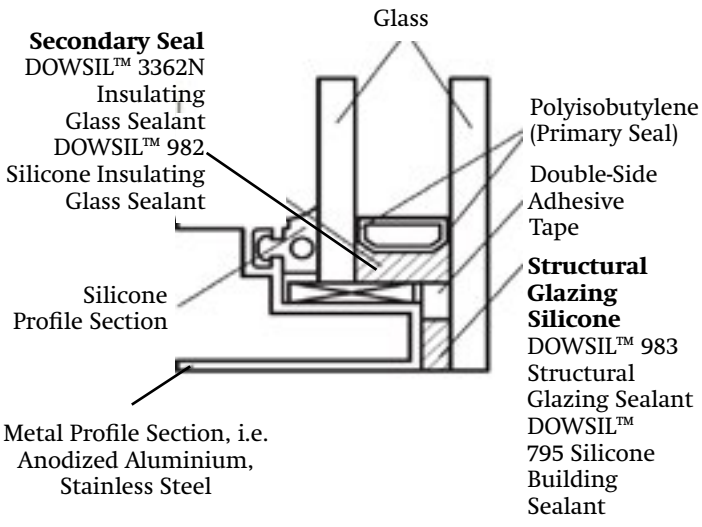
Structurally Glazed Insulating Glass Unit



Typical examples of insulating glass with uncovered edge seal include:

1. Silicone structural glazing where the IG unit is structurally glazed on the inner pane of glass. In these designs, the IG secondary seal is structurally attaching the outer pane of glass. A design is considered "structurally glazed" if 1, 2, 3 or 4 edges of the glass are supported by structural silicone sealant and there is no mechanical attachment of the glass along the edge. A silicone insulating glass sealant approved for structural glazing projects must be used.
2. Silicone structural glazing where the insulating glass is produced as "stepped glass" and the structural silicone is applied to the inner surface of the outer pane of glass. In this design, the secondary seal of the IG unit is typically not acting structurally. Nevertheless, due to the high UV exposure of the edge seal of the IG unit, only UV-stable silicone insulating glass sealants are recommended for this application. Please see the figure below.
3. Structural glass systems which are point supported or bolted to the structure. Structural glass systems often have the appearance of a structurally glazed façade. These systems are not structural glazing unless the glass fixation is done only on the interior pane of glass. The insulating glass edge is typically uncovered in these designs.

Structural Glazing Detail for Stepped Insulating Glass Unit



Insulating Glass with Mechanically Retained Edge Seal

Proprietary systems have been introduced where the inner pane of an IG unit is mechanically retained to the structure. These designs commonly use a metallic U-profile channel applied into the silicone secondary seal of the IG units. The IG unit is attached to the structure of the building by mechanical retention along the cavity of the U-profile channel.
Some designs have a continuous U-profile channel and some are positioned periodically along the perimeter of the glass. Some designs use a combination spacer and U-profile in one extrusion. These designs are considered as structural glazing since the outer pane of glass is structurally attached to the profile and not the inner pane of glass.

Since these designs are proprietary to the system designer, Dow reviews and approves these designs on a system by system basis. All mechanically retained IG systems must be reviewed and approved by Dow Technical Service Engineers.

Insulating Glass Joint Dimensioning

Proper dimensioning of the secondary seal of an IG unit is critical to the ultimate performance of the unit. Many factors affect the performance of the IG unit including wind, climatic and impact loads. Dow offers to review the joint dimensioning of an IG secondary seal and will make recommendations based on the following guidelines. Ultimately the IG manufacturer is responsible for the joint dimensioning and performance of their IG units.

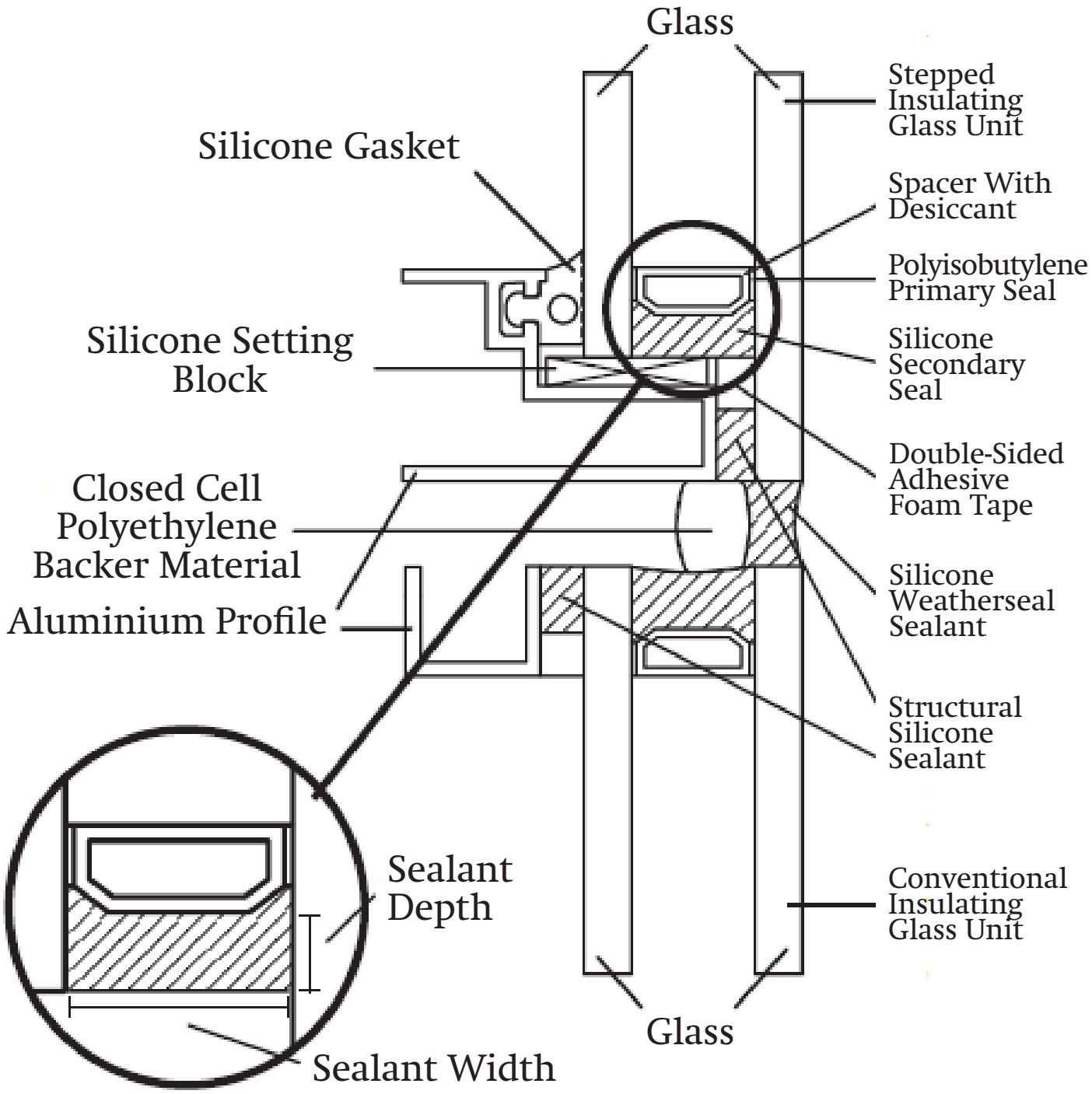
Insulating Glass Joint Dimensioning Guidelines

Following are guidelines that apply for the use of DOWSIL™ Insulating Glass Sealant.

- A minimum joint depth of 6 mm is required if the edge seal of the IG unit provides any structural function such as for structural glazing.
- When used for structural function, the IG secondary sealant depth shall be determined by the Calculation for Total Dynamic Load (Wind Load, Climatic Load, Impact Load)
- When used for structural function and the IG unit is subjected to permanent shear or tension load, the IG secondary seal shall be as determined by the IG Sealant Depth Calculation for Deadload or any Continuous Load.

The above guidelines are minimum requirements and exclude any application tolerances.

Structurally Glazed Insulating Glass Units



Insulating Glass Terminology

Sealant Depth

The sealant depth is the minimum dimension from the spacer to the outer edge of the silicone secondary seal. This dimension may also be referred to as the insulating glass sealant bite.

Sealant Width

The sealant width is the dimension between the panes of glass. The sealant width may also be referred to as the “cavity” or “air space” of the IG unit.

IG Sealant Depth Calculation for Total Dynamic Load (Wind Load, Climatic Load, Impact Load)

The sealant depth requirement is based on the total dynamic loads applied to the IG unit. The loads may be from the wind, climate or impact. Higher wind loads and larger dimensions of the glass require greater sealant depth. Climatic loads are determined by the change in temperature and pressure on the IG unit. Climatic loads on the secondary seal are greater for smaller glass dimensions in most situations. Dow considers the effect of climatic loads during the joint dimensioning of an IG unit. Additional loads such as impact loads or point loads can also be considered in the determination of total dynamic load.



IG Sealant Depth Calculation for Total Dynamic Load

$$\text{Minimum Sealant Depth} = \frac{\text{Glass Short Span (mm)} \times \text{Total Dynamic Load (kPa)} \times 0.5}{140 \text{ kPa}}$$

- Glass Short Span is the shorter of the two dimensions of the rectangular glass panel. For example, on a 1500 mm by 250 mm glass panel, 1500 mm is the short span.
- The maximum wind load in kPa is based on a return period of 10 years or according to local regulations. This value is provided by the design professional to Dow.
- 140 kPa (0.14 MPa) is the Maximum Allowable Design Stress for both DOWSIL™ 982 Silicone Insulating Glass Sealant and DOWSIL™ 3362N Insulating Glass Sealant.
- Total Dynamic Load is the difference between the pressure in the cavity of the IG unit and the sum of wind load and atmospheric pressure. The pressure in the cavity is affected by temperature, elevation and atmospheric pressure during production of the IG unit. The stiffness of the glass panes will affect the total dynamic load. An insulating glass unit pressurized by wind loading deflects very similarly to the assumed trapezoidal load distribution rule. In IG units where the thickness of the inboard glass is equal to or greater than the outboard glass, the IG industry generally accepts that the insulating glass secondary seal bite carries 50 percent of the maximum windload (50/50 load-sharing principle). Thus, the secondary seal bite is calculated as one half that of the structural silicone sealant bite.
- The 50:50 load-sharing principle concludes that if the insulating glass unit is made of two symmetrical, well-sealed glass panes, where the inboard glass pane is equal to or greater than the outboard panes, then the insulating glass unit secondary sealant absorbs approximately 50 percent of the maximum windload forces placed on the unit in the field, while the silicone structural glazing sealant that attaches the insulating glass unit to the curtainwall mullion carries 100 percent of the maximum windload. The 50:50 load-sharing principle is well documented and is generally accepted throughout insulating glass industry. Therefore, as a minimum, insulating glass units are designed with a secondary seal depth sufficient to withstand at least 50 percent of the maximum windload specifications for a specific structural silicone glazed building. In cases where the thickness of the outboard glass is greater than that of the inboard glass, the 50/50 load sharing (or 50 percent of structural bite) no longer is valid and the load-sharing must be determined.

IG Sealant Depth Calculation for Continuous Load (Deadload)

The IG secondary seal is subject to continuous load if the outer pane of glass is not supported by horizontal framing members or setting blocks, or is being used in roof glazing or positive sloped glazing. The deadload weight of the glass must be considered in the joint dimensioning of the IG unit. Thicker glass panes will require greater sealant depth of the IG joint.



IG Sealant Depth Calculation for Continuous Load (Deadload)

- The glass weight is determined only for the outer pane of insulating glass unit
- The Allowable Design Stress for Continuous Load for DOWSIL™ 982 Silicone Insulating Glass Sealant and DOWSIL™ 3362N Insulating Glass Sealant is 7 kPa or 700 kg/m².

$$\text{Minimum Sealant Depth (mm)} = \frac{\text{Weight of glass (kg)}}{\text{glass perimeter (m) x sealant deadload design strength (700 kg/m}^2\text{)}}$$

Material Component Considerations for Insulating Glass Production

For the successful performance of IG units, it is important that the proper materials are selected. There are many different types of glass, glass coatings, spacer materials, desiccants, primary seals, etc. to choose from. These products must be tested and found to be compatible with each other. There are special considerations when using specific components of an IG unit. The following discussion is intended to help the manufacturer of IG units to properly select and handle the components of an IG unit. It is ultimately the decision of the IG producer to select the materials for his or her own IG units.

Glass Coatings

Due to the continual advancement in glass-coating technology, a wide range of possibilities are available to the glass processor. All glass coatings should exhibit sufficient resistance to chemicals, maintain adhesion to glass and remain integral.

In addition, the DOWSIL™ Insulating Glass Sealant should be tested for long-term adhesion to the specific glass coating. Coatings which do not meet these requirements should be removed from the glass surfaces to be bonded.

Coating Types

Glass Enamel or Ceramic Frit

Glass enamel is a ceramic glass coating that is applied by various means, i.e. spray, roller, screen print, transfer print or dip coating. The inorganic coating is fused to the glass surface by firing the glass at a high temperature (>550°C). For successful performance, the enamel must demonstrate scratch resistance, chemical resistance, smooth surface roughness and a thermal coefficient of expansion similar to glass. In most cases, DOWSIL™ Insulating Glass Sealants demonstrate excellent adhesion to ceramic frit coatings but sometimes a primer is required.

Metal and Metal Oxide Coating

Metal or metal oxide coatings are either pyrolytically or magnetronically applied to the glass surface. In the pyrolytic method, molten metal or metal oxide is applied at high temperature to the glass by either dipping or spraying. Magnetronic sputtering allows various metal and metal oxide coatings to be applied in thin layers on the glass substrate. This permits a broad range of light reflection, light transmission, infrared reflection and color of the glass surface. Magnetronic sputtering also allows for a combination of heat and sun protective coatings to be applied one on top of the other. Hard coatings are usually composed of nickel and chrome elements which are especially suited as sun protective coatings. Sun protective coatings can be applied either pyrolytically or magnetronically.

Soft coatings usually contain silver which has high reflective properties and is especially effective in protection against heat radiation. As a rule, coatings that provide heat reflective properties are magnetronically applied, so that the silver coating which is soft and susceptible to corrosion may be embedded between metal oxide layers such as tin or bismuth oxide.

Depending on the coating type, the coating may have to be removed from the surface area to be sealed. Each individual coating type should be tested by Dow. Normally, insulating glass sealants can be applied over all pyrolytic coatings and most hard magnetronic coatings, while heat reflective coatings that contain a soft silver layer must be completely removed.

Polymer Coatings

Various polymer coatings are available for use as spandrel glass coatings. Polymer coatings which are based on organic polymers such as polyurethane, acrylic, polyester or epoxy are not generally acceptable for structural glazing applications. Inorganic silicone-based polymer spandrel coatings are available and may be suitable for structural glazing applications. The coating manufacturer must verify that the polymer coating is durable and has long-term adhesion to glass. Specific polymer coatings must be tested for compatibility and long-term adhesion with the DOWSIL™ Insulating Glass Sealant.

Glass Coating Removal

DOWSIL™ Insulating Glass Sealants should only be applied to coatings which exhibit sufficient resistance to chemicals, long-term adhesion to glass, durability and integral performance. If a glass coating does not demonstrate these features or is incompatible with the insulating glass sealant, the glass coating must be removed. Also if the DOWSIL™ Insulating Glass Sealant does not adequately adhere to the glass coating, the coating must be completely removed from the glass surfaces to be bonded. Should coating residue remain on the glass surface, appropriate tests should be performed to ensure that the residue does not adversely affect adhesion of the DOWSIL™ Insulating Glass Sealant.

Mechanical Stripping is the most common method to remove a glass coating. Special grinding tools are used to remove glass coating only on the surfaces to be bonded. Grinding may be done manually or integrated into the production line. The quality of the coating removal is dependent upon the nature of the coating, the quality and condition of the grinding machine, as well as the production variables such as feed rate, grinder speed and grinding pressure. Wet grinding may also be effective to remove a glass coating. For some coating types, it is not possible to achieve a completely residue-free coating removal by means of mechanical stripping. Accordingly, testing of sealant adhesion to glass surfaces treated by this method is especially important to ensure proper adhesion.

Spacer System Components

For successful performance of an IG unit, the spacer system components serve several functions. The spacer profile maintains the cavity dimension and encloses the cavity of the IG unit. The spacer also contains the desiccant, which keeps the cavity free of moisture. A primary seal provides a vapor barrier for the cavity of the IG unit. A wide range of spacer system components are available for IG production. There are advantages and disadvantages to all of these materials. Following is a discussion of the different spacer system components available.

Spacer Profile Types

Aluminum Profiles

Aluminum profiles may be either mill finished or anodized in a variety of colors. Aluminum spacers are very common due to their low cost, ease of handling and bending.

Zinc or Galvanized Steel Profiles

Zinc or galvanized steel profiles are low cost and easy to handle. Steel has a lower coefficient of thermal expansion and heat transmission than aluminum which often improves the durability and performance of an IG unit.

Stainless Steel Profiles

Stainless steel profiles are generally higher in cost and more difficult to handle. Handling depends on the dimension of the profile. Stainless steel is very durable and has a lower heat transmission coefficient than aluminum to provide a durable, high performance IG unit. Stainless steel profiles are available in silver or black.

Organic Spacer Profile

This spacer type is a composite of organic polymer and a metallic foil to provide a vapor barrier. Some organic spacer profiles use glass fiber impregnation in the organic polymer to provide stiffening.

Warm Edge Spacer System

This spacer type is composed of a silicone foam core with a two-sided adhesive, a metallic foil and pre-applied butyl seal to provide a vapor barrier. This profile provides good thermal insulating properties.

Thermoplastic Spacer

Thermoplastic spacer is applied directly on the glass surface on the automated production line. This material is a one-component hot melt sealant that acts as a spacer, vapor barrier and desiccant in one. This material provides very good thermal insulating properties.

Desiccant

The desiccant is a molecular sieve that is filled into the spacer profile during IG production. This molecular sieve acts to absorb incidental moisture in the cavity of the IG unit. Proper storage and handling of the desiccant is critical for the performance of the IG unit. Different grades of desiccant need to be used for dry air and gas filled IG units.

Primary Seal

The primary seal in an IG unit provides the vapor and gas barrier between the metallic or organic spacer profile and glass. Polyisobutylene (or PIB) is the common material used as a primary seal in an IG unit. The PIB must be continuous during application and be fully compatible with the adjacent materials including the secondary seal of the IG unit. For successful performance, the PIB must be stable and durable in the environment in which the IG unit will be exposed.

Gas Filled Insulating Glass Units

The global requirements to lower carbon dioxide (CO_2) emissions is accelerating the trend toward using more thermally efficient window and façade systems. Poorly designed windows are one of the primary sources of thermal loss in buildings, but the development of low emissivity (low-E) coated glass, gas filled IG units and warm-edge technologies allow the production of windows that are thermally efficient. This means that large areas of glazing that add natural light and aesthetic appeal to a building can be used without forfeiting thermal performance.

Thermal transfer by conduction and convection in an IG unit can be decreased by substituting air with a gas having lower thermal conductivity (argon, krypton or xenon). Transfer by radiation can be decreased using low emissivity (low-E) glass and the thermal conductivity at the edge can be reduced through warm edge technology. The table on the next page reports the thermal transmittance of a single glass pane and IG units (Ug) with and without low-E coating and gas-filling.

Silicone Sealant Use in Gas Filled Insulating Glass Units

While the key performance advantage of organic based sealants (polysulphide, polyurethane) for high thermal efficient IG units is their low gas permeability, (which allows them higher workmanship tolerance) their relatively weaker adhesion to glass after exposure to sunlight prohibits their use in structural glazing, roof glazing or any other application that requires high durability, UV exposure and/or extreme weathering resistance.

Silicone sealants, on the other hand, excel in their adhesion durability to glass after sunlight exposure, making them the material of choice for structural and commercial glazing as well as demanding roof glazing applications. With over 25 years of global experience with silicone insulating glass sealants, the excellent performance and service-life of silicone dual-sealed IG units have been demonstrated.

It has been demonstrated that argon-filled, silicone dual-sealed IG units can be manufactured, which reliably pass EN 1279-3 requirements.

Number of Panes	Type	U_g-Value (EN 52619) W/(m²K)
Single pane	Monolithic float glass, 6 mm	5.2
Double Pane	Float glass (2×6 mm glass, 12 mm spacer, air filled)	2.7
Double Pane	Float glass (2 × 6 mm glass, 12 mm spacer, low-E coat (1×), air filled)	1.75
Double Pane	Float glass (2 × 6 mm glass, 12 mm spacer, low-E coat (1×), argon filled)	1.49
Double Pane	Float glass (2 × 6 mm glass, 1 × 12 mm inter-pane space), low-E coat (1×), Krypton-filled	1.42

Numerous commercial systems using gas and silicone have been successfully introduced to the market. Consequently, silicone dual-sealed IG units can today be produced that not only excel in their durability and longevity, but also reliably meet the stringent requirements for gas retention, and therefore provide optimum service-life and insulation value.

Due to the high gas permeability of silicone sealants, special considerations must be taken in the design and manufacture of silicone sealed IG units. The key point is to focus on the gas leakage through the IG unit as a whole, not necessarily through individual components. Indeed, a properly applied polyisobutylene primary seal is so impermeable to inert gases that it alone acts as the main barrier to gas leakage while the secondary seal acts to secure the two glass panes and protect the primary seal from harsh environmental conditions and premature degradation.

Design Considerations

Design is a primary factor affecting whether an IG unit will pass gas loss requirements. The loss of gas can be reduced by increasing the resistance to gas leakage. Gas leakage can be slowed by decreasing the area available for gas transmission and increasing the path length required for gas transmission.

Bent spacer-frame corners, gas-filling techniques integrated into the IG assembling process (rather than filling via holes drilled into the spacer), improved semi-automatic PIB application equipment and in-line (heated) PIB primary seal presses have all substantially contributed to the reduction of gas loss and helped to improve the quality and service-life of IG units.

It has been demonstrated that IG edge-seal systems which have the ability to accommodate some movement within the spacer itself, place less stress on the primary seal and thus ensure low gas loss rates under accelerated and actual service-life conditions. Examples of such spacers include thermoplastic spacers or rubber profile spacers (warm edge spacers).

Insulating glass edge-seal systems that minimize differential thermal movement or minimize primary seal movement, especially within the sensitive corner region, tend to perform significantly better in terms of gas loss rates than systems with high thermal movement. For example, IG units of different designs, but based on stainless steel spacers, have better gas loss rates than IG units using aluminum spacers.

In the case of rigid spacers, the degree to which the primary seal is strained during periods of positive pressure differential and the time during which extension in the primary seal occurs are determined by the modulus and elastic recovery of the secondary seal. A secondary seal which has high modulus and high elastic recovery will reduce the strain on the primary seal. In practice, positive pressure differentials occur at low atmospheric pressures or at high temperature, whereby temperature is responsible for most pressure differentials. Therefore, the tensile stress behavior (Young's modulus) of secondary sealants at elevated temperatures must be considered as well as elastic recovery properties of the sealant.

DOWSIL™ 3362 HD Insulating Glass Sealant has been developed specifically to provide the high modulus and elastic recovery requirements of this application.

Workmanship Considerations

Workmanship plays an important role in determining the success of gas filling, much as it does in ensuring success of manufacturing a standard air-filled IG unit. Following are some practices which will assist in the qualification and production of IG units which pass gas-filling requirements:

- Glass panes and spacers must be properly cleaned to ensure that the primary and secondary sealants achieve satisfactory adhesion.
- Spacers must be properly aligned. Failure to do so will result in less than desired secondary seal depths. PIB primary seal stressing and failure can occur if insufficient secondary seal is present to maintain structural integrity of the IG unit. Bent corners are recommended to maintain a solid, uniform spacer function.
- Corner keys and any probe holes located in the spacer should be injected with PIB to eliminate voids or openings of any kind through which gas could migrate. Any voids or openings will act as a channel through which the gas will migrate with minimal resistance.
- The PIB primary seal must not contain voids or skips. Any voids or skips will act as an open door for gas migration. The PIB primary seal must be applied in a uniform and continuous depth and thickness along the entire perimeter of the IG unit. The PIB must be homogeneous and fully wet both the glass and spacer during IG production.
- The secondary seal must also be free of voids or skips. Any inconsistencies may allow undue stressing or failure of the PIB seal, the primary barrier to gas leakage. Two-part sealants must be properly mixed and used at the proper mix ratio. Please refer to the Product Quality section of this manual for proper guidelines.

Dow can assist the IG manufacturer to optimize their design and production processes to meet current European gas loss testing requirements. For more information, please contact your Dow Technical Service Engineer.

Product Quality

Dow performs extensive quality assurance testing in our manufacturing facilities in accordance with ISO 9001 standards. This section of the manual is intended to provide the sealant user with procedures and recommendations for the proper storage, handling, use and quality control of DOWSIL™ Insulating Glass Silicone Sealants. As a sealant user, you must read, understand and closely follow the procedures and recommendations set forth in this section of the manual. Factory production control procedures for insulating glass production are also described in various industry standards such as EN 1279, Part 6 and ASTMC1249. If you have questions regarding any of the following procedures or recommendations, please contact your local Dow Construction Office or your Dow Technical Service Engineer prior to using the DOWSIL™ sealant.

General Considerations

Material Storage and Handling

DOWSIL™ sealants must be stored in a cool dry environment, below the recommended temperature. Excessive temperatures or moisture may cause a reduction in the sealant shelf life. Sealant cure, adhesion and physical properties could be harmed if the sealant is not handled and stored properly. The sealant user must understand and follow recommendations on the proper use of dispensing equipment for two-component silicone sealants.

Shelf Life

DOWSIL™ sealants must be used within their stated shelf life. Sealant that is used beyond its stated shelf life may not cure properly to its full physical properties and should not be used.

Joint Preparation and Sealant Application

Specific procedures and recommendations on joint preparation and sealant application are made later in this section. These procedures and recommendations will help to ensure proper sealant adhesion, cure and joint fill. Ignoring or skipping a step in the process could have an adverse effect on the performance of the insulating glass sealant. These procedures should be understood and completely followed by the sealant user.

Quality Control

DOWSIL™ provides procedures and recommendations that must be completely understood and followed by the sealant user. These procedures are proven to be effective and reliable. In the Documentation section of this manual, Dow provides quality control logs which can be used by the sealant user. Dow will assist you in the development of a comprehensive quality control program. Dow will also audit a production facility and make recommendations for improvement if necessary.

One-Component Sealants

Storage Temperature and Conditions

DOWSIL™ Insulating Glass Silicone Sealants must be stored at a temperature below 27°C. An expiry date is clearly marked on the product packaging. Sealant should only be used if it is within the expiry date shown on the package. The sealant should be kept in its original unopened package until the sealant is to be used. Sealant should be stored indoors in a dry environment.

Skin-over time/Elastomeric Test

A skin-over time and elastomeric test should be performed once per week and on each new lot of sealant to be used. The purpose of this test is to ensure that the sealant cures fully and has typical elastomeric properties. Any variation such as excessively long skin-over time may indicate that the sealant is out of shelf life or has been stored at an excessively high temperature. Skin-over time will vary with temperature and humidity. Higher temperature and higher humidity will cause the sealant to skin-over and cure faster.

The following procedure must be performed before any new lot of sealant is used in production. Production quality control procedures, such as adhesion tests on production materials, are described later in this section.

1. Spread a 2 mm thick layer of sealant on a polyethylene sheet.
2. Every few minutes, touch the sealant film lightly with your finger.
3. When the sealant no longer adheres to your finger, the skin-over time has been reached. If the skin-over time is greater than 2 hours, do not use this material and contact your Dow Construction Office.
4. Allow the sealant to cure for 48 hours. After 48 hours, peel the cured sealant slab from the polyethylene sheet. Stretch the sealant slowly to determine whether it has cured to normal elastomeric properties. A control sample of “good sealant” can be used for comparison. If the sealant has not cured properly, do not use the material and contact your Dow Construction Office.
5. Record results in your Quality Control log. A sample Quality Control log is available in the Documentation section of this manual. The completed log should be retained and be available for review by Dow upon request.

Two-Component Sealants

Storage Temperature and Conditions

DOWSIL™ Insulating Glass Silicone Sealants must be stored at temperatures below 30°C. An expiry date is clearly marked on the product packaging for the curing agent and base. Sealant should only be used if it is within the expiry date shown on the package. The sealant should be kept in its original unopened package until the sealant is to be used. Sealant should be stored indoors in a dry environment. Containers of curing agent and base are not lot-matched. For practical purposes it is best to use the oldest container of material first.

Two-Component Dispensing Equipment Guidelines

DOWSIL™ 982 Silicone Insulating Glass Sealant and DOWSIL™ 3362N Insulating Glass Sealant are high performance materials that are approved for use as insulating glass sealants in structural glazing applications.Properly applied, DOWSIL™ 982 Silicone Insulating Glass Sealant and DOWSIL™ 3362N Insulating Glass Sealant provide the excellent long-term adhesion and durability that is necessary for IG applications. DOWSIL™ Silicone Insulating Glass Sealants require correct pumping and mixing by the sealant user to achieve intended performance. State-of-the-art technology for the application of two-component sealants uses a sophisticated pumping, metering and mixing machine. There are several different suppliers for such equipment. The dispensing machines available in the market are all different in design; therefore Dow strongly recommends that the sealant user follow the guidelines provided by the equipment supplier regarding the proper use and maintenance of the dispensing equipment. In addition to the guidelines from the equipment supplier, Dow recommends that the sealant user understands and complies with the following best practices.

Maintain Proper Production Facility Temperature

Ambient temperature in the production facility must be between 10°C and 40°C. For best performance, maintain a temperature of between 18°C to 30°C. At colder temperatures, between 10°C and 18°C, cure rate and adhesion development will be slower. In higher temperatures, between 30°C and 40°C, working time will be shorter.

Provide Proper Sealant Storage Conditions

Sealant containers must be stored below the sealant's recommended storage temperature of 30°C for the base and 27°C for the curing agent. Sealant can be used at temperatures of up to 40°C. Containers should be stored in their original unopened containers. At higher temperature and relative humidity, the sealant will cure faster and have a shorter working time. To minimize the damage of moisture on the individual sealant components, pails and drums must be kept airtight during storage and after being placed on the dispensing equipment.

Curing Agent Must Be Homogeneous

Prior to placing material on the dispensing equipment, the curing agent should be visually inspected and stirred in the pail to ensure homogeneity. Do not incorporate excessive air during mixing of the curing agent. Mixing with a flat paddle using a figure-of-8 pattern will minimize air entrapment.

Properly Maintain Sealant Dispensing Equipment

It is essential that the sealant user establish a quality program that will ensure that the sealant dispensing equipment is functioning properly. Because there are many different manufacturers of dispensing equipment, maintenance requirements will differ. Requirements common to all equipment manufacturers include:

- DOWSIL™ Insulating Glass Sealants must be processed in a closed system free from exposure to air. Air introduced during the change of sealant containers must be completely purged from the system prior to use to ensure proper product performance.
- Regularly inspect and maintain dispensing equipment. Air can be incorporated into the sealant if the pump is defective or gaskets have hardened or are damaged, allowing air ingress into the system. When using high pressure pumping equipment with a follower plate system, regularly check the follower plate to ensure that it is moving smoothly and will not be blocked by a damaged drum or pail or by a damaged or brittle gasket. Proper maintenance and cleaning of the mixer helps to ensure properly mixed sealant. Filters should be regularly inspected and replaced as necessary.
- Sealant must not be contaminated by contact with machinery oils from the equipment. Pumps must be checked for tightness, and oil should not be used on the follower plates.

When using a solvent such as DOWSIL™ 3522 Cleaning Solvent for cleaning of the mixing line, the sealant lines must be completely closed against the solvent lines to avoid contamination of the sealant with solvent. All gaskets must be compatible with the cleaning solvent.

Some gaskets, especially those in direct contact to the sealant components, could become brittle or show a volume increase after prolonged exposure. Deteriorated gaskets must be immediately replaced. Please request silicone compatible gaskets and other components from your equipment supplier. The equipment supplier should also provide a schedule for regular replacement of gaskets. Please contact your Dow Technical Service Engineer if you need specific recommendations.

Surface Preparation and Sealant Application

Insulating glass production requires a diligent and thorough procedure to ensure that glass and accessory materials are properly cleaned prior to sealant application. The following procedures should be followed for IG production.

1. **Inspect** glass, spacer profiles, U-profile inserts, etc., prior to use. The materials used in production must be representative of the materials that were tested and approved by Dow. The substrates should be in good condition and not damaged by outdoor weathering.
2. **Clean** glass and accessory substrates including spacers, U-profile extrusions, etc. During automated IG production, glass is cleaned through an automated washing process. The IG manufacturer must ensure that joint surfaces are clean, dry, dust free and frost free. Moisture or contaminants on the surface may have an adverse effect on sealant adhesion to a substrate.
3. **Prime** joint surfaces to receive sealant if required by Dow.
4. **Place** the spacer system and glass. Care must be taken to not contaminate cleaned surface during any phase of production. If contamination occurs, surfaces must be re-cleaned.
5. **Apply** sealant into the IG joint cavity. If applied through an automated process, ensure that the joint is completely filled with sealant. If applied manually, push the bead of sealant into the joint in a continuous manner to avoid air entrapment.
6. **Tool** the sealant joint surface with a tooling device such as a spatula. Many insulating glass dispensing guns use self-tooling nozzles. Ensure that the tooling device provides a completely filled joint without air entrapment.
7. **Inspect** the finished insulating glass units. Determine whether the entire joints have been properly filled and tooled. The sealant must be continuous and free of voids or gaps. Inspect whether the sealant is curing properly. Ensure that all of the recommended quality control tests are being performed.

Substrate Cleaning Procedure

The key to acceptable sealant adhesion is a clean surface. For most IG production, glass is cleaned through an automated washing process. If glass or accessory materials are to be cleaned manually, please use the following recommended procedures:

Non-Porous Substrates

Non-porous substrates such as glass and metallic profiles must be cleaned with a solvent prior to application of sealant. Dow recommends the "two-cloth cleaning method" be used to clean non-porous materials. The "two-cloth cleaning method" is described later in this section. Isopropanol is recommended for solvent cleaning of non-porous substrates. Alternate solvents or cleaning agents will be considered. Please contact your Dow Technical Service Engineer for more information.

Solvent Consideration

The solvents named in this section are recommended based upon our experience with these products. You should always check with the supplier of the substrate to ensure that the cleaning procedures and solvents are compatible with each substrate.

Two-Cloth Cleaning Method

The "two-cloth cleaning method" is a proven technique to clean non-porous surfaces. The use of one cloth to clean a substrate is not a recommended procedure and is not as effective as two cloths. Clean, soft, absorbent, lint-free cloths must be used. This method consists of cleaning the substrate with a solvent-saturated cloth followed by a drying wipe with a separate clean cloth. Following is the procedure described in greater detail:

1. Thoroughly clean all surfaces of loose debris.
2. Pour a small quantity of cleaning solvent into a working container. A clear plastic, solvent-resistant squeeze bottle works best for this purpose. Do not apply solvent directly from the original container.
3 Wipe the joint surfaces with sufficient force to remove dirt and contaminants.
4. Immediately dry the solvent wet surface of the substrate with a separate clean, dry cloth. The second cloth must wipe the substrate before the solvent has evaporated.
5. Visually inspect the second cloth to determine if the contaminants were effectively removed. If the second cloth remains dirty, repeat the "two-cloth cleaning method" until the second cloth remains clean. For each subsequent cleaning, rotate each cloth to a clean portion of the cloth. Do not clean with the dirty portion of the cloth. Replace used and dirty cloths frequently.

Substrate Priming Procedure

For most IG production, priming is not required. In some instances, special coated glass types or spacer profiles may require priming. In these non-standard applications, please use the following procedure for primer application:

Before using, verify that the DOWSIL™ 1200 OS Primer is within its stated shelf life. The primer should be stored below 25°C in its original unopened container. The primer should be clear and water-like in appearance. If the primer is milky white in appearance, do not use the primer.

1. Joint surface must first be clean and dry. The step of priming should begin within four (4) hours after the cleaning step. If there is a greater time delay, joint surfaces must be re-cleaned prior to priming.
2. Pour a small amount of primer into a clean, dry container. Do not pour more than a 10 minute supply of primer into the working container. Replace and tighten the cap on the container immediately after dispensing the primer. Excessive exposure of the primer to atmospheric moisture will cause it to deteriorate and turn milky white in the container.
3. Pour a small amount of primer from the working container onto a clean, dry, lint-free cloth and gently wipe a thin film on all joint surfaces requiring primer. Apply only enough primer to wet the surface. Over-priming can potentially cause adhesion loss between the sealant and the substrate. If too much primer is applied, a powdery white film will form on the substrate. The excess primer should be removed using a clean dry cloth before sealant application.
4. Allow the primer to dry until all of the solvent evaporates. This typically takes from 5 to 30 minutes depending on temperature and humidity.
5. Inspect the surface for dryness and for the appearance of over-priming. A primed non-porous surface will have a slight haze. If red colored primer is used, the primed surfaces will appear red in color. Primed surfaces must be sealed within the next four (4) hours. Any surfaces primed and not sealed within four hours must be re-cleaned and re-primed before applying sealant

Masking

If aesthetics are important, surface adjacent to the IG joint can be protected by masking. Prior to sealant installation, a masking tape can be applied to the surface adjacent to the joint. Test the tape prior to use to ensure that it can be easily removed and does not damage the substrate. During application of the tape, do not apply the tape to joint surfaces since residual adhesive from tape may harm sealant adhesion. Immediately after the sealant has been applied and tooled, remove the tape.

Sealant Application and Quality Control Procedures

Sealant Application Procedure

Sealant must only be applied to surfaces that have been cleaned and primed according to the recommended procedures. Sealant must be applied to clean, dry surfaces. Sealant adhesion may be adversely affected by poor surface preparation. Sealant must also completely fill the IG joint as the performance of the IG unit is dependent on having sufficient sealant depth or bite. An underfilled secondary seal in an IG unit may reduce the performance of the IG unit.

The following steps describe the correct procedure to apply sealant:

1. Apply sealant in a continuous operation using an application gun or dispensing equipment. A positive pressure, adequate to fill the entire joint, should be used. By "pushing the bead" of sealant into the joint in a continuous manner, air entrapment can be avoided. If applied through an automated process, ensure that the IG joint is completely and continuously filled.
2. Tool the sealant with light pressure before a skin forms on the sealant. This is typically within 5 to 15 minutes. Most automated operations use a self-tooling nozzle. Ensure that this tooling nozzle provides adequate pressure to completely fill the IG joint.
3. Avoid the use of wet tooling aids such as soaps or solvents during tooling. Dry tooling is recommended. Do not scoop sealant since this does not effectively push sealant into the joint causing the sealant to fully wet out the sides of the joint.
4. If the surface adjacent to the IG joint has been masked, remove the masking at this time.

Sealant Cure Requirements

Silicone sealants require exposure to atmospheric moisture to cure. In a closed container or concealed joint that is not exposed to atmospheric moisture, sealant cure will be slow to nonexistent. Sealant adhesion will only occur if the sealant is allowed to cure to its full physical properties. Please ensure that the tooled sealant joint is fully exposed to the environment.

Factory Glazing Cure Requirements

Dow only supports the production of insulating glass with DOWSIL™ Silicone Insulating Glass Sealants in a factory environment. Production of insulating glass at the construction site is not supported by Dow.

DOWSIL™ one-component insulating glass sealants typically require 7 to 21 days to cure in a production facility environment. Cure rate depends on the sealant used, sealant joint depth, temperature and humidity. IG units which use one-component insulating glass sealants should not be shipped to the job site until the sealant has fully cured and it can be demonstrated through quality control testing that the sealant has achieved full adhesion (100 percent cohesive failure).

DOWSIL™ two-component insulating glass sealants cure in deep section within 3 to 4 hours depending on temperature and humidity. The sealant generally achieves full adhesion (100 percent cohesive failure) in 1 to 3 days depending on the glass type. IG units should not be shipped to the job site until the sealant has fully cured and it can be demonstrated through quality control tests that the sealant has achieved full adhesion (100 percent cohesive failure). Verification of sealant cure and adhesion is done through the use of "peel adhesion" and/or "H-piece" testing. These procedures are described in greater detail later in the next section.

Quality Control Test Procedures

General Considerations

Quality Control is an important element of successful IG production. This section of the manual should be fully understood and continually reviewed by the sealant user. The procedures and recommendations made in this section are the foundation of a comprehensive quality control program. In the Documentation section of this manual, Dow provides quality control logs which you can use for the development of a comprehensive quality control program by the sealant user. Dow can assist you in the development of a comprehensive quality control program specifically for your organization. Dow can also audit a production facility and make recommendations for improvement if necessary.

Sealant Production Quality Control

During production, periodic quality control should be performed on DOWSIL™ Silicone Insulating Glass Sealants produced through two-component dispensing equipment. These test procedures help to ensure the sealant is being properly mixed at the correct ratio. The test methods and frequency of testing are detailed in the following pages.

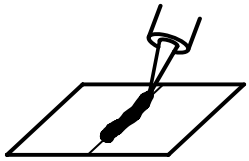
Butterfly Test

The Butterfly Test is a procedure used to evaluate the mix quality of DOWSIL™ Silicone Insulating Glass Sealants. This test is performed at each pump start-up and after either the curing agent or base containers are changed. The purpose of this test is to determine whether the two-component dispensing equipment is adequately mixing the sealant base and curing agent. For black DOWSIL™ Silicone Insulating Glass Sealants, the sealant base is white and the curing agent is black. When properly mixed, the finished sealant is a uniform black colour, with no gray or white streaks. Improper mix can be the result of a damaged check valve, a clogged hose, a clogged mixer, etc. Regular equipment maintenance will help to ensure proper sealant mixing. Please consult with your dispensing equipment manufacturer for maintenance guidelines.

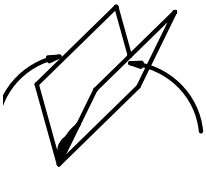
If gray DOWSIL™ Silicone Insulating Glass Sealants is being used, the sealant base is white and the curing agent is dark gray or black depending on product.

Following is the procedure for performing a Butterfly Test:

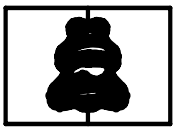
1. Fold a sheet of stiff, white A4 paper in half.
2. Apply a bead of sealant to the fold in the paper.
3. Press the sheet of paper together compressing the sealant into a thin film.
4. Pull the paper apart and visually inspect the sealant for indications of poor mix



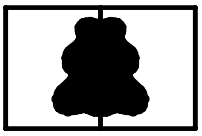
Apply Sealant to Folded Paper



Press Together



Insufficient Mixing



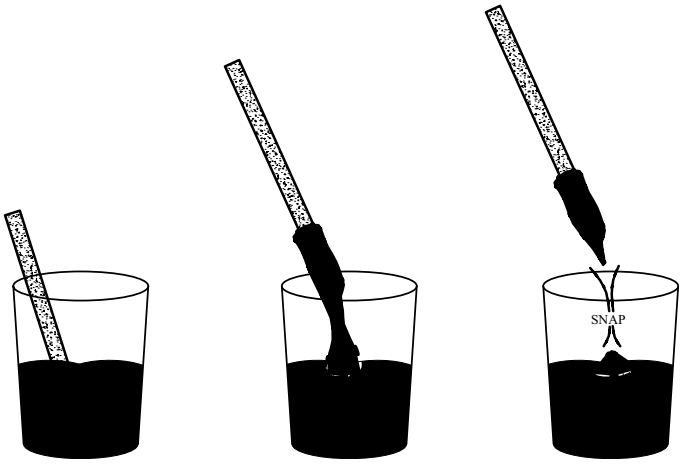
Proper Mixing

Snap Time Test

Once proper mixing of the sealant is established by the Butterfly Test, a Snap Time Test must be performed. This test is performed each time a pump starts up and after either the curing agent or base containers are changed. The snap time test helps to determine if the mix ratio is correct and whether the sealant is curing properly. Mixed sealant will handle like a one-component sealant until the chemical reaction between the base material and curing agent begins to occur. The sealant will in a matter of minutes begin to "snap" and begin to show elastomeric or rubber properties.

Following is a procedure for the Snap Time Test:

1. Fill a small container with mixed DOWSIL™ Silicone Insulating Glass Sealant.
2. Place a small stick or spatula into the sealant. Record the time.
3. Every few minutes, pull the stick out of the sealant. Do not stir or agitate the sealant. As the sealant becomes more cured, the sealant will become stringy. Once the sealant tears cohesively and snaps back once it is pulled, this is the "snap time". Record this time.



Stick Inserted in Cup | Before Snap Time | Snap Time

The Snap Time Test will vary depending on temperature and humidity. Higher temperatures and higher humidity will cause the sealant to snap faster. Colder temperatures and lower humidity conditions will result in a longer snap time. Snap time will also vary from tester to tester depending on how the results are interpreted. Also, there will be variation from lot to lot of material and as the sealant ages. Highly unusual snap time values could be an indication of a problem with the pump. The most important determination from snap time is that the sealant does cure. If the sealant does not cure, then further investigation is required.

Mixing Ratio Test

The Mixing Ratio Test is not a test that is required by Dow as a daily test. This test is useful to determine whether the sealant is mixed at the recommended ratio. Most two-component silicone dispensing machines provide a set of valves which allow the mixing ratio to be checked. Following is a procedure to perform the Mixing Ratio Test:

1. Hold a disposable cup underneath each valve outlet on the pump. Open the valve for 10 seconds or at least 3 strokes of both the base and curing agent pumps. Pressure valves need to be adjusted in such a way that they equalize the pressure on both components.
2. Weigh the two cups, minus the weight of the cup itself. The weight ratio between the two components should be within the recommended mix ratio for the sealant being tested. Check the actual mix ratio range on the data sheet.

The Mixing Ratio Test is a useful test if there are concerns with the mix of the sealant or the snap time. This test method is a very good diagnostic test and along with the butterfly test and the snap test should be useful in the investigation of equipment problems. Dow Technical Service Engineers are available to assist you if there is concern with mixing or cure of DOWSIL™ Silicone Insulating Glass Sealants.

Adhesion and Cure Quality Control Tests

The following adhesion and cure quality tests should be used to provide consistent and reliable sealant quality during IG production. Each test is valuable in its own way and must be considered as part of your comprehensive quality control program. Peel adhesion testing is recommended as the daily test to verify sealant adhesion. H-piece testing is recommended as a test to verify properly cured sealant properties. Butterfly adhesion test is an alternate adhesion test of an actual IG production unit.

Peel Adhesion Test

The peel adhesion test is the most effective daily test to verify sealant adhesion to a substrate. This simple screening test should be used as the daily test to verify adhesion of sealant to each substrate.

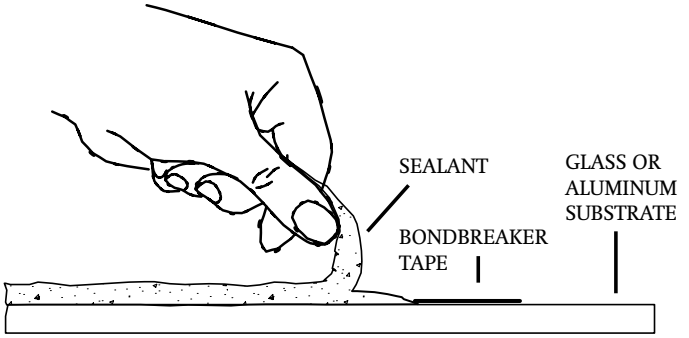
Following is a description of the peel adhesion test:

1. Clean and prime the substrate as recommended by Dow.
2. Place a piece of polyethylene sheet or bond breaker tape across the flat surface.
3. Apply a bead of sealant and tool it to form a strip approximately 20 cm long, 1.5 cm wide and 6 mm thick, including 4 cm of the sealant over the polyethylene sheet or bond breaker.
4. After sealant cure, grasp the 4 cm tab of sealant which overlays the polyethylene sheet. Pull the sealant at a 180° angle. Peel back only 2 to 3 cm of sealant leaving the remainder in place for additional testing.
5. If the sealant tears within itself and remains fully bonded to the substrate, this is called “cohesive failure”. 100 percent cohesive failure is desirable since this indicates that the strength of adhesion is greater than the strength of cohesion.
6. If the sealant totally releases from the substrate, this is 100 percent adhesive failure (or 0 percent cohesive failure). Since sealant adhesion develops over time, repeat the test after an additional 24 hours of cure. Continue until 100 percent cohesive failure is achieved. If adhesion does not develop as expected, contact your local Dow Construction Office.

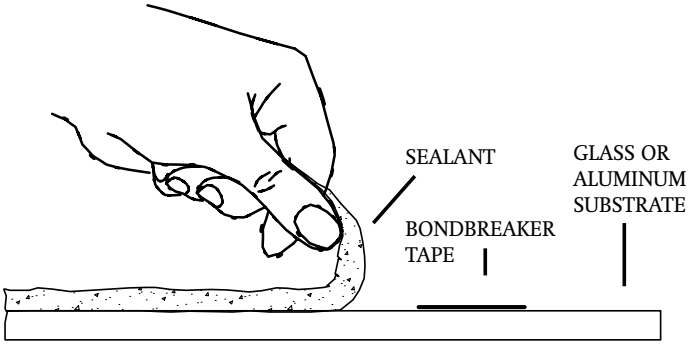
Following are some additional recommendations for peel adhesion testing:

- Peel adhesion tests must be run on production samples from the exact same lot of substrate or profile.
- The substrate should be cleaned exactly the way the production units are cleaned.
- The peel adhesion samples must be cured at the same temperature and humidity as the production units are stored during cure.
- Samples should be tested periodically, for example 1, 2, 3 days of cure for DOWSIL™ Silicone Insulating Glass Sealants. Testing can conclude once the peel adhesion test shows full adhesion or 100 percent cohesive failure. For DOWSIL™ one-component Insulating Glass Sealants, peel adhesion tests should be performed at 7 day intervals.
- Once samples achieve full adhesion, samples can be immersed in room-temperature water for 1 day to 7 days and tested again for cohesive failure.

Important: Insulating Glass Units should only be shipped to the job site once full adhesion has been verified by successful peel adhesion tests (100 percent cohesive failure).



Peel Adhesion Test: Cohesive Failure



Peel Adhesion Test: Adhesive Failure

Butterfly Adhesion Test

The Butterfly Adhesion Test is an alternate procedure to evaluate adhesion of the sealant to glass. This test may be performed on a test mock-up sample or directly on an actual IG production unit.

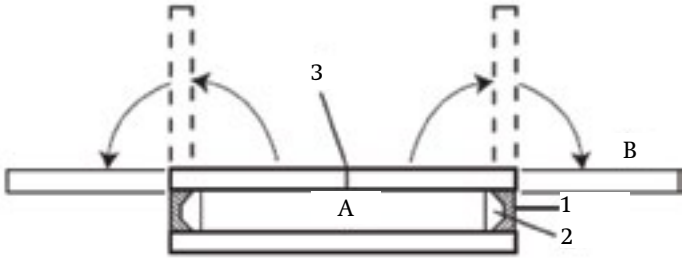
To perform this test, score then break the glass at the midpoint of the pane. Bend the two halves outward at a 180° angle. Inspect the adhesion of the secondary seal. There should be no greater than 5 percent adhesive failure on the glass surfaces.

1. DOWSIL™ Insulating Glass Silicone Sealants

2. Spacer system

3. Float glass scored then broken at midpoint

If an actual production unit is used in this test, note the quality of the sealant application. Note whether the sealant fill is complete and free of voids or bubbles. Observe the quality and continuity of the PIB application. This procedure provides an opportunity to evaluate the overall quality of the IG unit application.



Documentation

The sealant user is responsible for developing proper quality control documentation for their project. In the following pages Dow provides sample quality control logs that can be used on their own or as a model for a customized quality control manual.

A comprehensive quality control manual for production of IG units for a structural glazing project should include the following:

- Insulating glass joint dimension details that may be reviewed and approved by Dow in an approval letter(s)
- Project substrate and materials descriptions and specifications
- Dow adhesion and compatibility approval letter(s) may be included
- In-house IG production and quality control procedures
- Completed sealant production quality control logs with Butterfly Test, Snap Time Test and Mix Ratio Test results as required
- Completed sealant adhesion and cure quality control logs with Peel Adhesion Test and Butterfly Adhesion Test results if performed

Traceability documentation which allows each IG unit to be precisely correlated to a specific date, time and location of production. All production units must be numbered so that they can be specifically linked to the quality control logs. The position of each IG unit on the building should be marked on the elevation drawing so that it can be easily identified if required. This traceability documentation is critical in the event that a problem needs to be investigated on a project.

Dow will assist you in the development of a comprehensive quality control program. During a Production and Quality Control Audit, your comprehensive quality control program will be evaluated.

Production and Quality Control Audit

Dow can audit the IG production and quality control operations of any user of DOWSIL™ Insulating Glass Sealants. During this audit, the sealant user's production operations, quality control procedures and documentation will be evaluated. Below are some of the important elements that Dow will be evaluating during an audit:

Production Facility Operations and Safety

- Clean production facility
- Production facility temperature and humidity
- Proper sealant storage and handling
- Properly operating and well-maintained sealant dispensing equipment
- Proper substrate handling
- Compliance with Dow recommended sealant application procedures: two-cloth cleaning method, priming, sealant application, tooling, etc.
- Storage and handling of production units
- Compliance with reasonable safety procedures including safe handling of flammable materials and use of personal protective equipment

Quality Control

- Compliance with Dow sealant production quality control procedures: Butterfly Test, Snap Time Test, Mix Ratio Test
- Properly completed sealant production quality control log
- Compliance with Dow adhesion and cure quality control procedures: peel adhesion test, butterfly adhesion test
- Properly completed adhesion and cure quality control log
- Traceability documentation in accordance with Dow recommendations
- Commitment by management to train personnel and implement a comprehensive quality control program

Sealant Production Quality Control Log

Company Name & Location:

Project Name & Location:

Dispensing Pump Type & Location:

Date	Time	Temp. & Humidity	C/A Lot Number	Base Lot Number	Snap Time Test	Tester	Comments

Sealant Adhesion Quality Control Log (Peel Adhesion Test)

Company Name & Location:

Project Name & Location:

Dispensing Pump Type & Location:

Cleaning Solvent: **Primer**

Substrates: **Primer Lot Number:**

Date	Time	Temp. & Humidity	C/A Lot Number	Base Lot Number	Peel Adhesion Test (% Cohesive Failure)			Tester
					Day 1	Day 2	Day 3	

How to Contact Us

Dow has sales offices, manufacturing sites, and science and technology laboratories around the globe. To learn how Dow can help your business, contact your nearest Customer Service Specialist – find out how at **consumer.dow.com/construction.**

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