"Polyisobutylene (PIB) Primary Sealant"

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Polyisobutylene (PIB) Primary Sealant

Scope

This document discusses the purpose of PIB primary sealants in the fabrication of insulating glass (IG) units, specifically looking at the performance attributes of Polyisobutylene (PIB).

Introduction

Many IG units produced today use a dual seal system made up of a spacer, a primary sealant and secondary sealant. The most important function of the primary sealant is to maintain gas tightness and minimize moisture ingress into the unit. It is applied as a seal between the spacer and the glass.

(Place diagram of IGU configuration)

PIB primary seal formulations are permanently thermoplastic and move (stretch and compress) with the pumping action induced by changes in the cavity pressure caused by changes in environmental conditions (temperature, barometric pressure, wind load). For example, in the summer, especially in insulating glass units with absorbing coatings or tinted glass, the gas in the cavity can become hotter than when fabricated, thus increasing the pressure within the cavity. The edge seals will expand (glass edges move apart) and the glass will deflect in order to equalize pressure with the exterior. When the cavity cools, the reverse happens. This creates a “pumping” action where the seals are stretching and compressing along with changes in atmospheric conditions.

Polyisobutylene primary sealants are not structural in nature and do not hold the lites of an IG unit together through these atmospheric “pumping cycles”. Chewing gum is made of (food grade) PIB, so the behavior of chewing gum when stretched is a good analogy for how PIB behaves when stretched. If stretched a little it will contract back to its initial dimension, but if stretched too far, holes will form and it will become stringy and discontinuous, and after the load is removed it may not return to its previous position/shape. The diffusion of moisture or gas through PIB is a function of the cross-sectional area (smaller area = lower diffusion) and path length (contact width on the spacer) of the sealant (longer the diffusion path = slower diffusion). When stretched, the PIB has higher cross-sectional area, and lower path length (think of extending chewing gum), and so it is important to control the extension of the PIB using the appropriate secondary seal (type, amount) for the application.

The IG unit design depends on the secondary seal for structural performance. The secondary sealant is a structural elastomeric material (such as silicone or Polysulphide) and is designed to control the extension of the typical edge seal atmospheric loads on an IGU. The amount of extension under a given load as determined by the material’s elastic properties and the contact width with the glass. It is the extension of the secondary seal that determines how much the primary seal is stretched in response to the atmospheric loads.

Excessive pressure on the IG edge through high atmospheric loads or inadequate edge seal design for the application may force the primary sealant into the sight line, and excessive opening of the space between the glass and the spacer can overstretch the
primary sealant and disrupt or deform the seal, leading to an increased rate of moisture ingress and/or gas leakage.

While PIB is a good barrier to moisture vapor, it is not impervious to liquid water. The secondary seal also affords protection to the PIB from liquid water which can degrade its properties and performance. It is recommended that users of this document reference the North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use, IGMA TM-3000-90(16) and the GANA Glazing Manual, Glass Association of North America, 50th Anniversary Edition pertaining to the glazing system to manage water ingress into the glazing pocket/ system.

Secondary sealant type (e.g. modulus) and quantity (contact width on the glass) must be chosen very carefully to meet the atmospheric load requirements of a particular application.

With the protection of the secondary seal to contain the extension/stretch of the PIB and protect it from liquid water, Polyisobutylene can provide a barrier, limiting the movement of moisture vapor into, and gas out of the unit. Without this protection, the IGU may fail prematurely.

Primary sealants (such as Polyisobutylene) are not structural but do have limited adhesion properties and may act as process aids in the manufacture of IG units to hold the spacer in position, provide shear and tensile strength for unit handling and, to fix the IG during the cure process of the secondary sealant. Manufacturers are cautioned to be cognizant of these limitations of the primary sealant.

1. **Terminology**

   1.1 Glazed Daylight Opening – The area within the perimeter of glazing infill where the sash or framing members end and the vision area starts. The area is defined by the glass stop, glazing bead, glazing gasket, and/or glazing sealants of the window or door.

   1.2 Glazed Daylight Opening Sightline Infringement – An extension into the glazed daylight opening by the sealant, the spacer, or the area of coating deletion.

   1.3 Insulating Glass Unit (IGU) Sightline – the imaginary line separating the IGU edge from the IGU vision area, running along the visible surface of the spacer.

   1.4 IGU Vision Area – the area bounded by the IGU sightline (the surface of the spacer facing the cavity) on all sides of the IGU.

   1.5 Modulus (Modulus of Elasticity) – The ratio of the increment of some specified form of stress to the increment of some specified form of strain, such as Young’s modulus, the bulk modulus, or the shear modulus.

   1.6 Primary Sealant – A sealant applied to the inner shoulders of a spacer with its principle purpose to minimize moisture, gas and solvent migration into the unit’s air space.

   1.7 Secondary Sealant – A sealant applied to the edge of the spacer and glass lites in an insulating glass unit to provide elastic, structural bonding of the assembly. As a single seal, this sealant also may have gas retention and moisture vapor transmission properties.
1.8 PIB Squeeze Out (also known as “creep”)—movement of the PIB past the spacer which results from pressure applied to the edges of the IG unit after or during installation.

Discussion—Primary sealant infringement within the as-fabricated insulating glass unit should not exceed 1/8 inch (3.0 mm) anywhere along the sightline except at corners, where the primary sealant squeeze out may exceed 1/8 inch (3.0 mm). The applied pressure at the edge of the IG can come from a variety of sources including, pressure from a drive-in gasket, a pressure plate framing system, daily pumping action of the IG unit with changes in temperature and barometric pressure, and elevation changes. A small amount of PIB movement (typically <3 mm) from applied pressure may occur over the life of an IGU. This typically has little or no effect on durability and stabilizes over time. PIB squeeze out may or may not result in shortened IG unit life. PIB squeeze out is also referred to as PIB “creep.”

![Figure 1.8.1, PIB Squeeze Out (Creep)](image)

1.9 PIB Migration—Progressive or continuous flow of PIB into the vision area of the glass that results from a change in rheology (decrease in viscosity) of the material, after installation.

Discussion—The change in rheology may be attributed to a variety of causes including, solvation or breakdown of the PIB by incompatible glazing components, or degradation of the PIB due to environmental exposure including temperature and UV. In addition to excessive movement into the vision area, it may also manifest as excessive pooling at the spacer. PIB migration may or may not result in shortened IG unit life.
1.10 Rheology: The study of the deformation and flow of matter, especially non-Newtonian flow of liquids and plastic flow of solids.

1.11 Solvation: The process of swelling, gelling, or dissolving of a material by a solvent; for resins, the solvent can be a plasticizer.

1.12 Viscosity: Energy dissipation and generation of stresses in a fluid by the distortion of fluid elements; quantitatively, when otherwise qualified, the absolute viscosity. Also known as flow resistance: internal friction.

2 General Information and Considerations

2.1 Composition: A formulation for a primary sealant typically includes Polyisobutylene (PIB), reinforcing fillers, specialty additives, and pigments. Polyisobutylene is chosen due to its excellent moisture and gas diffusion properties. The other components are included to enhance the performance properties of the sealant such as resistance to UV and high temperature, rheology and flow characteristics, shear strength, and adhesion to the components of the IG unit. The components in the primary sealant formulation all work together to form a gas and moisture tight seal that functions in the dynamic joint between the glass and spacer edge. PIB is available in two colors, gray and black.

2.2 Performance and Quality management is Critical: There are a number of key requirements in order for a primary sealant to perform well in an IG unit. The formulation ingredients must be carefully chosen and monitored for quality and the manufacturing process must also be controlled so that a consistent product is provided to the IG manufacturer. A reliable primary sealant manufacturer should be able to provide information about their products performance and reliability for a given application.
2.3 Edge Seal System Design Is Critical: There are multiple edge seal designs. Care must be taken to find the right combination of primary and secondary sealants and spacer for a given IG unit manufacturing process and expected downstream environmental exposures. All components should be evaluated as a system for suitability in the unit and for the application. In particular, the PIB contact width on the spacer (path length for diffusion), the elastic performance and the amount of secondary sealant (contact width on the glass) and spacer profile are key. For example, one might need to change the silicone contact width in an edge seal design for applications where higher atmospheric loads are expected (e.g. for small units, for high temperature applications, or for structural glazing applications). Properties related to edge pressure and stress must be taken into consideration when designing the edge seal system. This includes glass type and thickness, unit size and shape, glazing system, design pressure, anticipated heat and UV exposure etc.

2.4 Compatibility with other glazing system materials is critical: Selection of the right primary sealant by the IG manufacturer depends on many things including the construction of IG, the components used and the ultimate glazing conditions. Tests must be performed to ensure the compatibility of the primary sealant with the other components in the IG unit and the glazing system. This includes the secondary sealant, setting blocks, glazing sealants, spacer bar, heel beads, etc. Any component that may come in direct or indirect contact with the primary sealant should be evaluated. Particularly in silicone secondary seal based systems, even though the PIB may not in direct contact with a glazing material (such as setting blocks or sealants) used in the fenestration system, contamination problems can occur because volatile organic compounds which can off-gas from glazing materials can easily diffuse through the silicone material to the PIB and react with it. When some VOCs react with PIB it can cause the long polymer chains to break which reduces the viscosity of the material and causes it to flow. In the event that this happens, PIB may lose adhesion and flow out of the seal area or pool on sill spacer bars. As such it is essential to evaluate the physical properties of all components in the finished glazed system in combination.

2.5 Position and Quantity of the PIB: The primary sealant must be applied in the proper amount and position. Care must be taken to make a unit with consistent width and thickness and wet out of PIB. When the unit is glazed care must be taken so the edge pressure is within the design tolerance (reference North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use, IGMA TM-3000-90(16) and the GANA Glazing Manual, Glass Association of North America, 50th Anniversary Edition) and only compatible components are used (as in 2.4 above).

2.6 PIB Squeeze-Out vs. PIB Migration: IGMA TM-3100-09 - Voluntary Guidelines for the Identification of Visual Obstructions in the Air Space of Insulating Glass Units, and GANA ID 02-1011 - Guidelines for the Appearance of Insulating Glass Unit Edges in Commercial Applications both include a limit of 1/8 in. for the infringement of PIB squeeze-out into window sightlines. Since PIB migration is
differentiated from squeeze-out primarily due to a change in rheology of the PIB, such limits of infringement do not apply to PIB migration.

2.7 Caution should be given to determine if the visible condition of displaced PIB is due to PIB Migration or PIB Squeeze Out. Further analysis may be required to determine if there has been a change in rheology of the PIB, which can be determined by removing the IG unit and conducting tests on the PIB.

2.8 There are multiple factors that affect the performance of the primary sealant. Care must be taken during the entire process from the sealant manufacture and quality control, through to the glazier, in order to assure the primary sealant will perform as expected.

3 Field Conditions and Potential Root Causes

3.1 Exposed Spacer Bar: also known as spacer read though.

3.1.1 Potential root cause:

3.1.1.1 Poor application rate or positioning

Figure 3.1.1, Spacer Read through

Figure 3.1.2, Spacer Read Out
3.1.1.2 Excessive or unequal Edge Pressure on IGU

3.2 Excessive Primary Sealant in Sightline (add image)
3.2.1 Potential root cause:
   3.2.1.1 Poor application rate or positioning
   3.2.1.2 Excessive or unequal Edge Pressure on IGU

3.3 Scalloping of the Sealant
3.3.1 Potential root cause:
   3.3.1.1 Poor application rate or positioning
   3.3.1.2 Excessive or unequal Edge Pressure on IGU
   3.3.1.3 Movement of IGU due to external pressure differentials (pumping)

3.4 Bubbles in the Sealant
3.4.1 Potential root cause:
   3.4.1.1 Air in bulk material
   3.4.1.2 Introduced in pumping system
   3.4.1.3 Excessive pumping

Figure 3.3.1 Black PIB Scalloping
Figure 3.3.2 Gray PIB Scalloping
Figure 3.4.1, Bubbles in Sealant
Figure 3.4.2, Bubbles in Sealant

TB-1250-XX, Polysisobutylene and Primary Sealants, TG Ballot Version, September 19, 2017
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3.5 Discoloring of the Sealant

3.5.1 Potential root cause:

3.5.1.1 Chemical incompatibility
3.5.1.2 Contamination
3.5.1.3 Change over of PIB sealant from black to gray or vice versa

3.6 Shiner: Insufficient coverage of the spacer bar by the PIB primary sealant. This can occur at a corner or along the length.

3.6.1 Potential root cause:

3.6.1.1 Misalignment of the extrusion of the PIB
3.6.1.2 Can occur with insufficient press out
3.6.1.3 Insufficient amount of PIB extruded
4 References

GANA ID 02-1011 - Guidelines for the Appearance of Insulating Glass Unit Edges in Commercial Applications


Consult the publications page of the Insulating Glass Manufacturers Alliance (www.igmaonline.com) and the Tech Center section of the Glass Association of North America (GANA) website (www.glasswebsite.com) for additional Informational Bulletins and glass industry reference resources.