IGMA INSULATING GLASS MANUFACTURERS ALLIANCE

NGA NATIONAL GLASS ASSOCIATION with GANA

"Polyisobutylene (PIB) Primary Sealant" **TB-1250-XX**

TECHNICAL BULLETIN

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Scope

This document discusses the function of PIB primary sealants in insulating glass units (IGU), specifically looking at the performance and aesthetic attributes of Polyisobutylene (PIB).

Introduction

Many insulating glass units (IGU) 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. PIB is applied as a seal between the spacer and the glass.

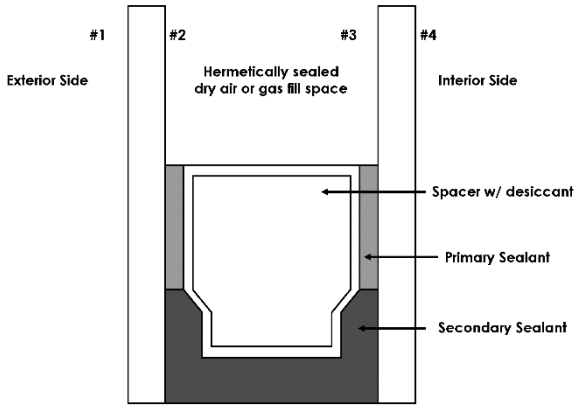


Figure 1.1, Typical Insulating Glass Unit

(figure not to scale)

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". The IG unit design depends on the secondary seal for structural performance. The secondary sealant is a structural elastomeric material (such as silicone, polyurethane 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 conditions.

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. Excessive pressure on the IGU 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 ingression and/or gas leakage.

While PIB is a good barrier to moisture vapor, edge seal systems with PIB are not impervious to liquid water. 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.

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 IGU 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 Atmospheric Load - Loading that may include conditions that are encountered due to barometric pressure, elevation changes, and items related to pressure changes that occur in an insulating glass unit.

1.2 Environmental Exposure - Loading that is related to exposures to weather conditions from temperature changes, solar exposure, weather and environmental events that influence the performance of materials used in insulating glass units.

1.3 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.

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

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

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

1.7 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.

1.8 Primary Sealant - A sealant applied to the inner shoulders of a spacer with its principle purpose to minimize moisture migration into the unit's cavity and maximize gas retention in the unit's cavity.

1.9 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.

1.10 PIB Squeeze Out (also known as "creep") - Movement of the PIB past the spacer which results from pressure applied to the edges of the IGU after or during installation.

Figure 1.8.1, PIB Squeeze Out (Creep)

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).

Applied pressure at the edge of the IGU 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. Applied pressure will result in PIB movement over the life of an IGU. PIB movement can be an aesthetic issue but no data exists to indicate how this may impact the durability of an IG unit.

1.11 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.

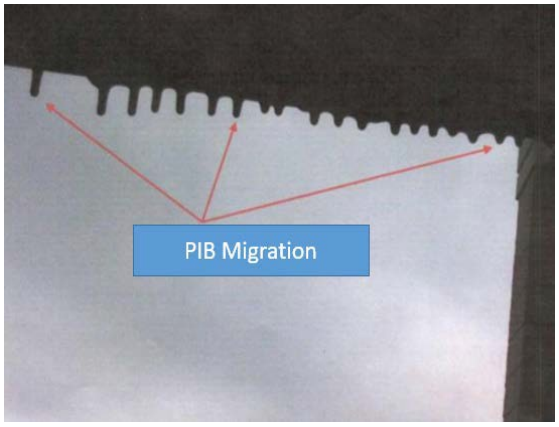


Figure 1.9.1, PIB Migration

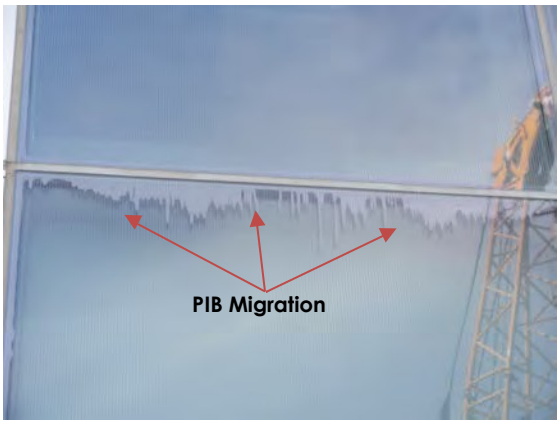


Figure 1.9.2, PIB Migration

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.

1.12 Rheology - The study of the deformation and flow of matter, especially non-Newtonian flow of liquids and plastic flow of solids.

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

1.14 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 IGU 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 glazing system materials is critical: Tests must be performed to ensure the compatibility of glazing components (setting blocks, glazing sealants, spacer bar, heel beads, etc.) with all components of the IGU including the PIB and secondary sealant. Any component that may come in direct or indirect contact with the primary sealant should be evaluated. Plasticizers and solvents can migrate from glazing materials and may diffuse through the secondary sealant material resulting in solvation of the PIB. This may lead to reduced viscosity and PIB movement. Contaminated PIB may lose adhesion and flow out of the seal area or pool on sill spacer bars.

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, 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.

PIB migration beyond a limit of ½" into the daylight opening may indicate a change in rheology in the PIB and is unacceptable.

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 Definitions

The descriptions and definitions below are for illustrative purposes. All will be present, to some extent, within normal production variation without affecting the durability of the IG unit. Contact your IG supplier for specifications regarding acceptable limits.

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

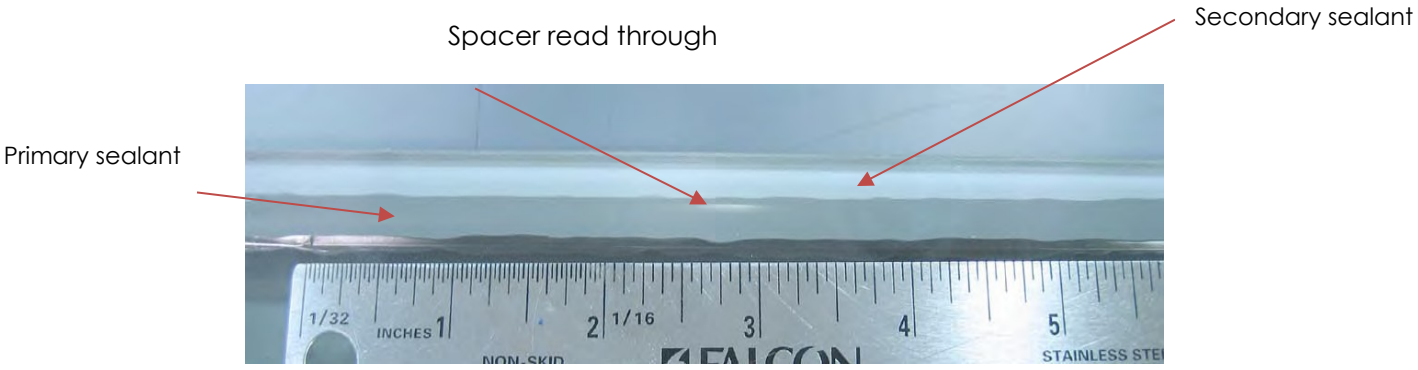


Figure 3.1.1, Spacer Read through

3.1.1 Potential root cause:

3.1.1.1 Normal Variation

3.1.1.2 Poor application or positioning

3.1.1.3 Excessive or unequal Edge Pressure on IGU, from glazing or IGU production

3.1.1.4 PIB movement capability and adhesion characteristics

3.2 Primary Sealant in Sightline

Figure 3.2.1, Primary Sealant in Sightline

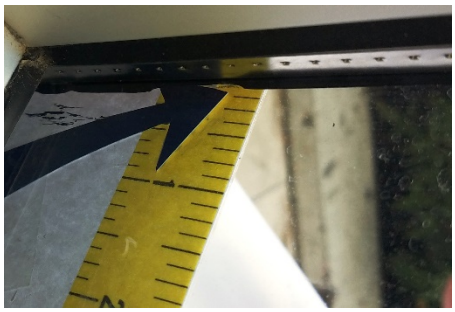


Figure 3.2.2, Primary Sealant in Sightline

3.2.1 Potential root cause:

3.2.1.1 Normal variation

3.2.1.2 Poor application or positioning

3.2.1.3 Excessive or unequal Edge Pressure on IGU, from glazing or IGU production

3.2.1.4 PIB rheological characteristics

3.2.1.5 Chemical incompatibility with glazing materials

3.3 Scalloping of the Sealant

Figure 3.3.1 Black PIB Scalloping

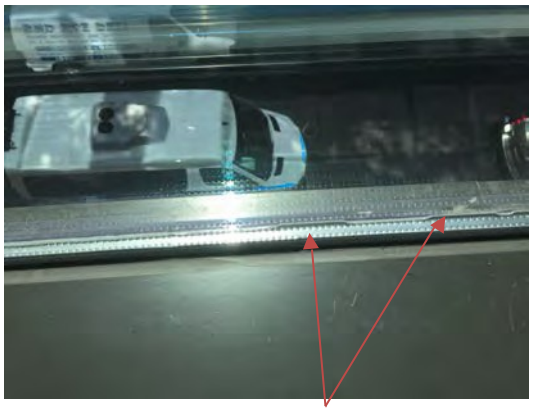


Figure 3.3.2 Gray PIB Scalloping

3.3.1 Potential root cause:

3.3.1.1 Poor application or positioning

3.3.1.2 Excessive or unequal Edge Pressure on IGU, from glazing or IGU production

3.3.1.3 Movement of IGU due to external pressure differentials (pumping)

3.3.1.4 PIB rheological characteristics

3.3.1.5 Chemical incompatibility with glazing materials

3.4 Bubbles in the Sealant

3.4.1 Potential root cause:

3.4.1.1 Normal application variation

3.4.1.2 Air in bulk material

3.4.1.3 Introduced in pumping system

3.4.1.4 Excessive pumping

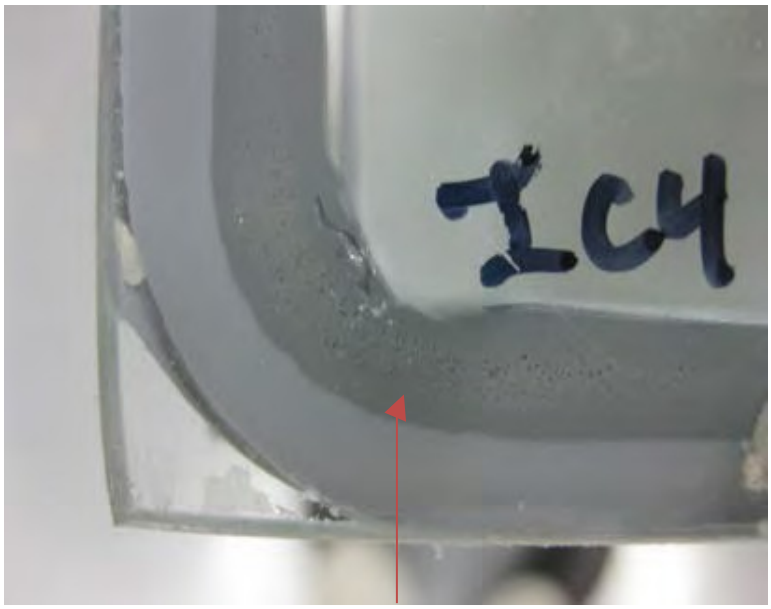
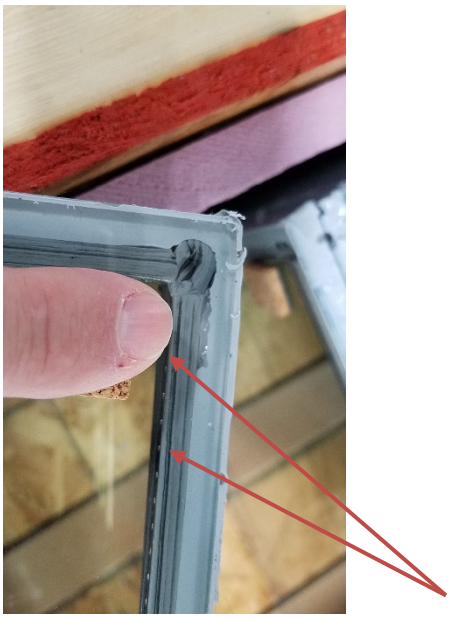


Figure 3.4.2, Bubbles in Sealant

3.5 Discoloring of the Sealant



Streaks of black PIB in gray PIB due to incomplete purging of the extruder when color is changed. (Refer to 3.5.1.4)

3.5.1 Potential root cause:

- 3.5.1.1 Normal Variation
- 3.5.1.2 Chemical incompatibility with glazing materials
- 3.5.1.3 Contamination
- 3.5.1.4 Changeover of PIB sealant from black to gray or vice versa

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

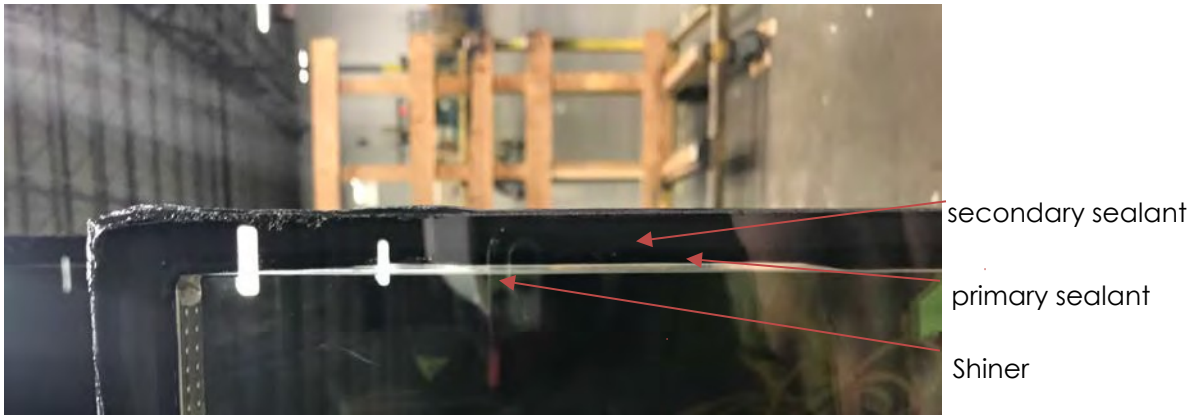


Figure 3.6.1, Shiner

3.6.1 Potential root cause:

3.6.1.1 Normal variation

3.6.1.2 Placement of the extrusion of the PIB

3.6.1.3 Insufficient press out

3.6.1.4 Insufficient amount of PIB extruded

4 References

NGA FB27-11(2015) (formerly GANA ID 02-0315) - Guidelines for the Appearance of Insulating Glass Unit Edges in Commercial Applications

IGMA TM-3100-09, Voluntary Guidelines for the Identification of Visual Obstructions in the Insulating Glass Unit Cavity.

Consult the publications page of the Insulating Glass Manufacturers Alliance (www.igmaonline.org) and the publications section of the National Glass Association (www.glass.org) for additional informational bulletins and glass industry reference resources.