

PROCEEDINGS

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## GLAZING FAILURES AND WAYS TO PREVENT THEM

**BRIAN HUBBS, PENG, AND JAMES HIGGINS**

*RDH BUILDING ENGINEERING LTD.*

224 West 8th Avenue, Vancouver, BC, Canada V5Y 1N5

Phone: 604-873-1181 • Fax: 604-873-0933 • E-mail: [brian@rdh.com](mailto:brian@rdh.com)



## **ABSTRACT**

Over the past few decades, the use of glass and glazing on our high-rise buildings has increased dramatically. More recently, as a result of increased industry recognition of the importance of energy efficiency, the trend is towards more energy-efficient glazing systems. However, there are instances of implementation of new technology that have resulted in premature and costly failures.

Several case studies will be used to show and explain the variety of problems that can occur with glass and glazing after installation and will offer designers risk-reduction recommendations to avoid the most common causes of failures.

## **SPEAKER**

*BRIAN HUBBS, PENG — RDH BUILDING ENGINEERING LTD.*

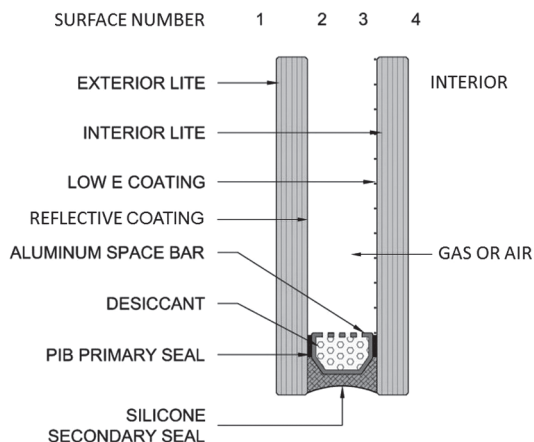
BRIAN HUBBS has over 20 years' experience as a consultant practicing exclusively in the field of building science. Recognized by his peers as being a practical building science engineer and researcher who consistently delivers innovative solutions, Brian has a unique blend of theoretical and hands-on knowledge gained from completing hundreds of building enclosure investigations and rehabilitation projects, as well as from design consulting and construction review of building enclosures for new buildings.

# GLAZING FAILURES AND WAYS TO PREVENT THEM

## ABSTRACT

Over the past few decades, the use of glass and glazing on high-rise buildings has increased dramatically. More recently, as a result of increased industry recognition of the importance of energy efficiency, the trend is towards more energy-efficient glazing systems. Common methods of improving thermal performance of insulated glass units (IGUs) includes the application of high-performance coatings, use of triple glazing or warm-edge-spacer technology, and installation of solar-selective films on or inside the units. While these solutions have all been effective at improving thermal performance, there have been cases where the implementation of this new technology has resulted in premature and costly failures. In this paper, case studies are used to show and explain the variety of problems that can occur with glass and glazing after installation. The case studies examine each type of IGU failure and help to explain how different investigation techniques were used to find the failure mechanisms.

The common symptoms indicating IGU failure are found to be condensation within the sealed unit, corrosion of the low-emissivity (low-e) surface films, deflection of the edge spacer, and volatile fogging. Each symptom shows where the IGU design or manufacturing issues introduced failure mechanisms. In most cases, a failed IGU will require extensive costly work to remove and replace.



**Figure 1 – Conventional dual-sealed IGU.**

The paper is intended to show how IGUs work and how to optimize the IGU design for longevity, as well as offer risk-reduction recommendations to avoid the most common causes of IGU failures. It will present a checklist of items to include in specifications to address the key aspects of high-performance glazing and glass.

## INTRODUCTION

The design and manufacturing of IGUs in modern glazing systems in North America is increasingly driven by the need for more thermally efficient assemblies. Current building codes continually increase the required thermal performance of building enclosures and building energy efficiency. As glazing manufacturers aim to meet these standards, new designs, materials, and manufacturing methods are being used in IGU assembly.

An IGU is made of two to three layers of glass, with reflective metallic and low-e coatings on various surfaces. The glass is held in place and sealed together with edge spacers and sealant, and the cavities between the glass lites are filled with various gasses such as argon (see *Figure 1*). The edge spacer is filled with desiccant in order to keep the airspace within the sealed unit free of moisture.

A good-quality, conventional, double-glazed IGU using a conventional spacer bar with a primary and secondary seal has a long track record of success, but common long-term failure mechanisms

leading to fogging, deterioration, and permanent damage are well known. In recent times, new products and technologies have been incorporated into IGU design, and the long-term implications of these new features are often unknown. Conventional IGUs incorporating a single hollow aluminum extrusion are likely to be the least energy-efficient compared to new designs, due to the thermal conductivity of the spacer material. With each new design or component in the IGU, new risks for failure are added. Failure mechanisms can range in complexity from the use of nondurable components leading to premature failure at the edge seal, to manufacturing conditions leading to deformation and warping once the IGU is in the field. In some cases, the IGU problems are not directly linked to designs or components aiming to increase energy efficiency, but are the result of manufacturing methods and IGU assemblies oriented towards decreasing the cost of the IGU and glass, while remaining energy-efficient.

The following sections introduce and discuss several common failure mechanisms encountered by the authors.

## GLASS AND IGU ISSUES

### Innovative Vision-Wall IGU Spacer Design

The need to improve thermal performance can lead to IGU design changes away from conventional components, towards more thermally efficient materials. This change can introduce other performance issues and failure risks. On a high-rise residential tower in Vancouver, BC, the IGUs using a proprietary edge spacer design encountered these issues.

The 48-story building is a hotel and multiunit residential tower with a hotel on the first 31 floors and condominiums on the upper 17 floors. The building is completely clad with structural silicone-glazed (SSG) unitized curtain wall. The residential floors used a silver low-e coating on surface #2, while the lower hotel floors utilized a stainless steel coating, giving the building a two-tone color (*Figure 2*).



**Figure 2 – Building elevation showing two-tone curtain wall.**



**Figure 3 – Significant IGU condensation visible from the interior.**

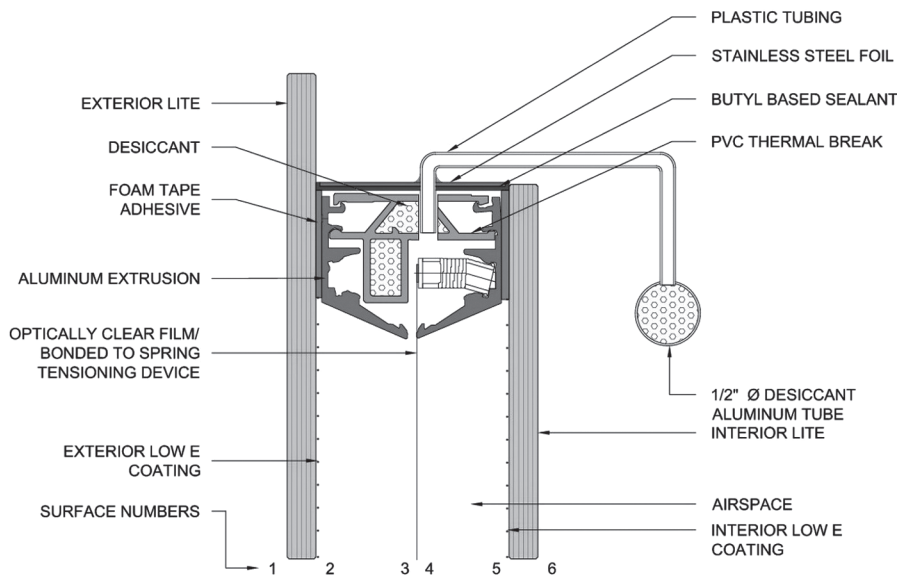
Since completion in 2001, the building experienced issues related to the IGU performance, including window condensation and corrosion of the low-e-coating within the glazing units (*Figure 3*). The issues continued for years despite ongoing attempted repairs by the original curtain wall manufacturer.

The authors completed an extensive investigation to understand the failure mechanism. Initial review of the proprietary IGU edge spacer design (*Figure 4*) showed where the innovative design may be prone to premature failure.

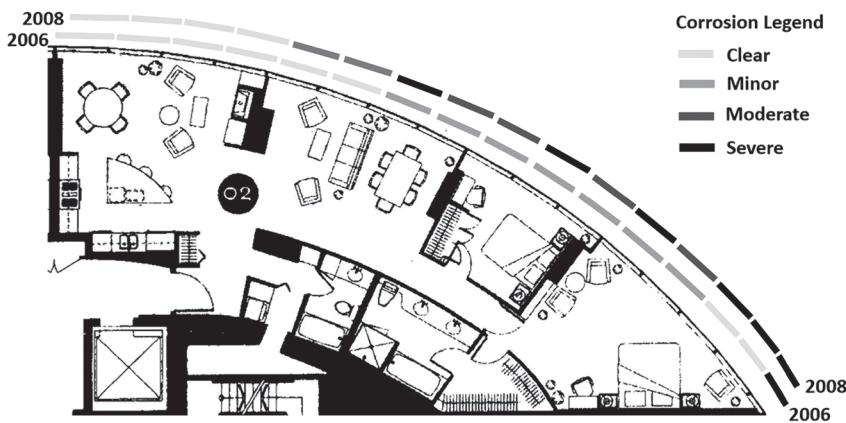
The installed IGUs have two unique design features that set them apart from conventional IGUs. First, they contain an optically clear polyethylene terephthalate (PET) film that is suspended between the outer and inner lites of glass to increase the thermal insulating performance. The optically clear film is suspended on springs that are attached to the spacer bar. The spacer bar consists of a large, desiccant-filled PVC thermal break mechanically attached between two aluminum extrusions. The glass is fastened to the aluminum spacer bar extrusions with two-sided foam tape. The hermetic seal around the

perimeter of the IGU consists of a stainless steel foil band set into a thin layer of a butyl-based thermoplastic sealant.

The second significant departure from conventional IGUs is that the IGUs are allowed to vent and equalize to the interior of the building. The venting is done through a small breather tube that is attached to a spigot that penetrates through the stainless steel edge band to the interior of the IGU. The breather tube is attached to a large aluminum tube filled with desiccant in the interior of the building. When temperature variation, wind pressure, and atmospheric pressure change the volume of air inside the IGU, these small volumes of air will flow in and out of the unit through the desiccant tube. The theory is that the desiccant tube will allow air movement while absorbing moisture from the interior air entering the system, thus ensuring that no moisture is able to enter the IGU assembly through the breather tube. If small amounts of moisture are able to enter the IGU, it will be



**Figure 4 – Schematic drawing of the proprietary IGU edge spacer design.**



Feb 13/2006 Visual Condition	Aug 7/2008 Visual Condition	2006 Dewpoint	2008 Dewpoint
Clear	Clear		-12
Clear	Clear		1
Clear	Clear	-55	-4
Clear	Clear		-1
Clear	Minor		2
Clear	Minor		2
Minor	Moderate		3
Minor	Moderate		4
Minor	Moderate		
Minor	Severe		
Minor	Moderate		
Minor	Severe		2
Minor	Moderate		2
Clear	Severe		8
Clear	Severe	-10	4
Severe	Severe	-5	6

**Figure 5 – Results showing the correlation of visual condition and dew point as well as an indication of the rate of deterioration.**

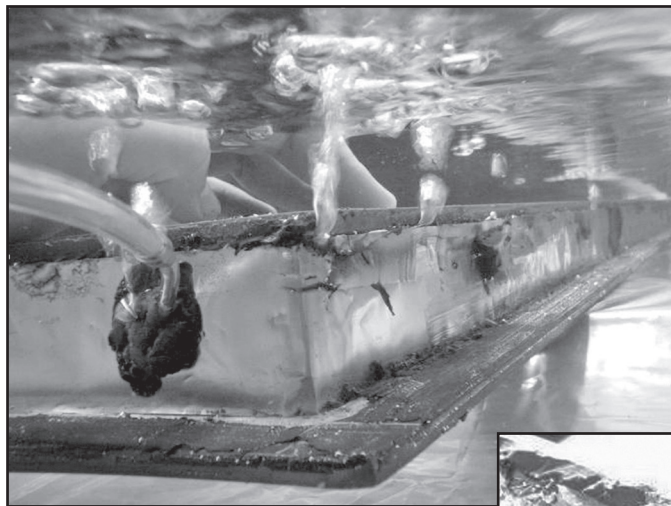


absorbed by the large amount of desiccant located inside the PVC spacer bar extrusion.

It was found that the visual clarity of the IGUs on the building was worsening and had deteriorated to unacceptable levels on many units. The deterioration of the visual quality of the IGUs is a result of condensation and the related low-e coating corrosion inside the IGU, which correlated well with the dew point measured inside the IGU (see Figure 5).

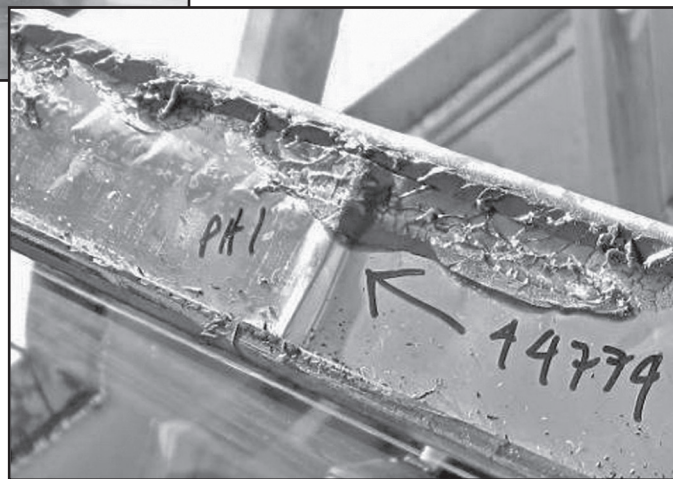
The condensation was found to be caused by a buildup of moisture inside the IGU as a result of temperature changes, pressure differences across the enclosure, and fluctuations in barometric pressure forcing moist exterior or interior air through discontinuities in the perimeter seal (shown in Figure 6 and Figure 7). Three air leakage mechanisms were found to contribute to this moisture buildup:

1. When wind blows against the building, the glazing system is under an inward-acting pressure. This inward-acting pressure forces moist air through the discontinuities in the perimeter edge seal; through the spacer bar, where it is dehumidified by the desiccant; through the airspace of the IGU; into the vent tube; and through the desiccant tube to the interior of the building. The source of moisture for this leakage mechanism is from the exterior.
2. Stack effect and wind-induced suction pressures create an outward-acting pressure on the glazing system. An outward-acting pressure forces moist air to flow into the desiccant tube, where it is dehumidified by the desiccant, into the vent tube, through the IGU spacer bar, and through discontinuities in the perimeter edge seal to the exterior. The source of moisture for this leakage mechanism is from the interior.
3. Temperature changes, fluctuations in barometric pressure, and dynamic wind loads all act to cyclically change the pressure inside the IGU



**Figure 6 – Typical ridges in metal banding caused by repetitive thermal expansion and contraction of metal film over thermoplastic sealant.**

**Figure 7 – Submerged IGU showing air leakage (bubbles) at ridges and discontinuities in the edge seal.**



with respect to the exterior and interior of the building. As the pressure inside the IGU equalizes with ambient conditions, airflow moves in and out of the IGU through the desiccant tube and any discontinuities in the perimeter seal, causing the desiccant to absorb moisture. The source of moisture for this leakage mechanism is both interior and exterior. The ratio of exterior to interior air leakage is related to the relative size of the air leakage paths. For example, if the leakage paths through the exterior perimeter are larger than the area of the desiccant tubing, then the percentage of the moisture entering the IGU from the exterior is proportionately larger from the exterior than the interior.

Replacement of the desiccant tubes was suggested by the manufacturer as a possible method to prevent clear and moderate IGUs from getting worse over time. Unfortunately, only air leakage path 2 is affected by a desiccant tube-replacement program. Air leakage path 1 transports moisture into the IGU desiccant before the air ever gets to the desiccant tube. With respect to leakage path 3, air testing performed in the laboratory suggests that discontinuities in the edge seal are an order of magnitude larger than the desiccant tubing.

Therefore, even a very large desiccant tube attached to the existing tubing would not have any appreciable effect on reducing the moisture inside the IGU. It was determined through the course of the IGU failure investigation that the only reliable repair strategy to address the fogging and corroding surfaces in the IGUs was to replace the IGUs.

The four-sided structurally glazed curtain wall system posed several reglazing challenges to the design and construction team. The original IGUs relied on a single bead of silicone between the exterior lite and the curtain wall frame to fasten the entire unit to the building. This sealant bead was installed in an environmentally controlled plant, on an accessible horizontal surface from the edge of the glass once the IGU was placed in the framing. In addition, stringent in-plant quality control procedures were in place. On site, there is no direct access to the edge of the IGU to allow the application of structural sealant after the unit is installed. The work also needed to be performed off swing stages exposed to Vancouver weather. As a result, a hybrid structurally glazed and mechanically attached system was used to reglaze the building, and a continuous stage was



**Figure 8 – High-rise tower showing a portion of the completed IGU replacement and the custom suspended scaffolding ring.**

designed to wrap the entire building to increase the wind resistance of the work platform and reduce the amount of tieback required (see *Figure 8*).

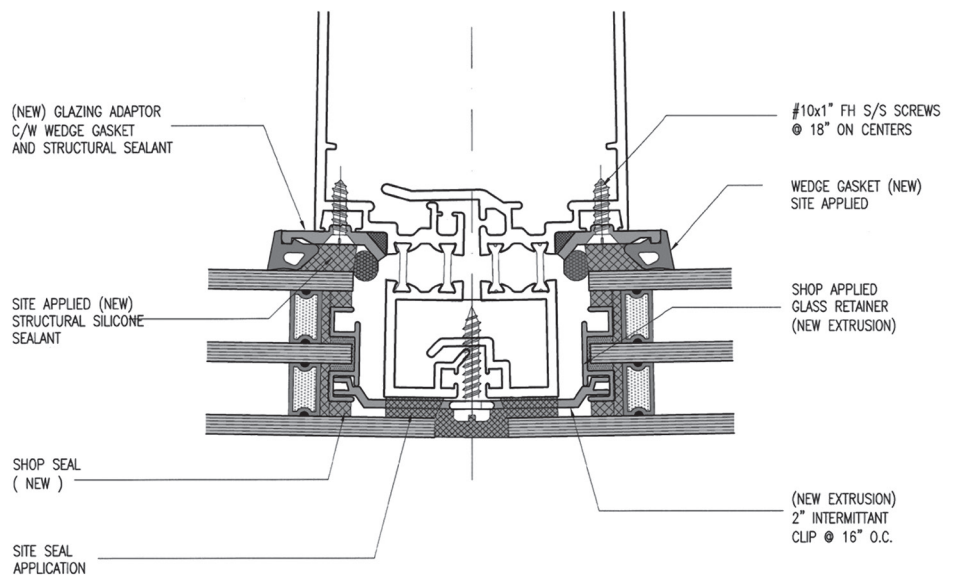
The concept for the mechanically attached four-sided structural glazing is shown in *Figure 9* with a conventional triple-glazed IGU.

This case study provides the following important lessons when specifying a new super-energy-efficient system:

- Durability of the glazing seals is the most important aspect of a glazing unit.
- Design of desiccated venting tubes must consider the local environment and the structural design of the IGU to size the desiccant tube.
- Moisture that enters the units will cause corrosion of susceptible coatings on the glass.
- In-situ repairs of IGUs are rarely practical.
- Glazing replacements are costly.
- A high level of due diligence is required before using new systems without a long track record of performance.

### Spontaneous Glass Breakage

As glass units become larger, the tendency to use tempered glass to meet structural and safety requirements increases. When glass is heated in the tempering process, nickel sulphide (NiS) inclusions (shown in *Figure 11*) shift from a low-temperature state to a high-temperature



**Figure 9 – Hybrid glazing system utilizing factory-applied mechanical fasteners and field-applied structural glazing.**

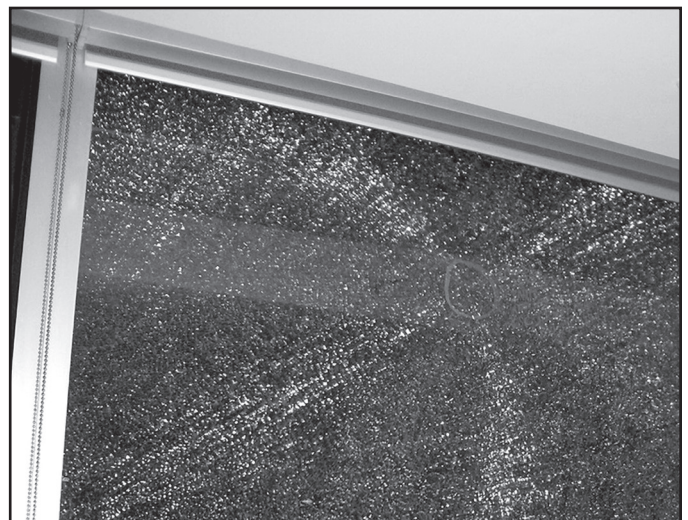
state, and they shrink. As the glass ages on the building, these NiS inclusions return to their low-temperature state and expand; this often takes five to ten years to occur. When the NiS inclusion expands inside the tempered glass, the stresses can cause spontaneous breakage (see *Figure 10*). If the glass is on the exterior of the building (i.e., the exterior lite of an IGU), it can fall out, causing a safety hazard. To reduce the risk of spontaneous glass breakage, the use of heat-strengthened glass is recommended on the exterior of buildings, as it does not have the risk of spontaneous glass breakage from NiS inclusions. If tempered glass is used on the exterior of buildings, it can be treated by heat-soaking to reduce the risk of spontaneous glass breakage in-situ.

### Thermal Stress Breakage

Conventional annealed glass, the standard glass product used in the manufacturing of IGUs, can be at risk of breaking due to induced thermal stresses. A common example of thermal stress breakage occurs when hot water is poured into a cold glass cup, causing it to break. The risk of thermal stress breakage increases considerably if the edge of the glass

is rough or has been damaged. In a typical building, thermal stress breakage is relatively rare because the sun generally heats both the glass surface and edges uniformly. On buildings with exterior solar shading, the lower portion of the glass can be directly exposed to the sun while the upper portion remains shaded. Partial shading induced by the solar shades creates a temperature differential between the top and the bottom of the glass panel, which significantly increases the risk of thermal stress breakage in non-heat-treated glass. The addition of solar-selective coatings and high-aspect-ratio glazing shapes can also increase the risk of thermal stress breakage.

On buildings that have high risk factors for thermal stress breakage, heat-treated glass can be used. Both tempered and



**Figure 10 – Typical spontaneous glass breakage.**



**Figure 11 – Typical butterfly pattern at the epicenter of the break with magnified NiS inclusion inset (right).**



made in a chamber that is flooded with pure argon in a highly automated, modern glazing line; or the IGU is manufactured in a conventional manner, and the airspace between the glass layers is purged with Argon by drilling holes through the edge spacer and injecting gas prior to final sealing.

heat-strengthened glass virtually eliminate the risk of thermal stress breakage under normal service conditions.

On a six-month-old building in Vancouver, BC, the owners reported a number of broken windows without an apparent physical cause. The building had exterior solar shades, and IGUs consisted of annealed glass with a solar-selective, low-e coating on surface #2. All cracks were found to intersect with edges at 90 degrees (Figure 12). When the units were replaced, the installation was reviewed and the edges were found to be undamaged and units properly glazed. It was determined that the breakage was caused by thermal stress fractures. The owner was informed that more thermal stress breaks should be expected and that all replacement units should be heat-strengthened to prevent thermal stress fractures in the future.

### Gas Fill

Filling the airspace of an IGU with an inert gas is very commonly specified and used to increase the thermal performance of an IGU. The most common gas is argon, as it is 30% less conductive than air and reduces convection loops within an IGU, improving the center-of-glass U-value for a double-glazing unit with low-e glass by up to 25%. It has a relatively low cost and generally provides for good payback in terms of energy savings.

Argon is installed into the IGU using one of two basic methods: The unit is either

The most important factors with respect to how effective argon-filled IGUs will perform over the life of the building is how much argon is installed, the design of the edge seal, and the quality control during the manufacturing process. The design of the edge seal is important because argon is a very small molecule and will diffuse through many common edge-seal materials unless an effective argon barrier is used in the design. In addition, argon (like all gasses) will move through small discontinuities in the edge seals under pressures generated inside the IGU by temperature, wind, and barometric pressure. This is why it's important to design units with an effective edge seal and to manufacture units without discontinuities in either the primary or secondary sealants.

Argon gas is colorless and odorless, and it is impossible to determine how much argon has been installed into the IGU without specialized equipment. Most manufacturers have monitoring equipment to measure the concentration of gas inside the units during filling operations. However, once constructed, it is difficult to accurately measure

argon gas concentrations for quality assurance and control (QA/QC) purposes in the field. One nondestructive method of checking that the argon levels are within specified levels is to use a device called a Sparklike GasGlass Tester. This device ignites a spark within the IGU (similar to neon or a fluorescent lightbulb) and utilizes a spectrometer to calculate the concentration of argon fill.

As part of the QA/QC program, argon gas concentrations were measured in-situ on two recent projects in Vancouver. The glazing units had been manufactured conventionally, and argon had been injected after assembly and primary sealant installation. The results were as follows:

- Argon was specified, and according to the IGU tracking sticker, it had argon fill.
- One hundred units were randomly tested in the field.
- IGUs were between one and four months old.
- The argon concentration varied:
  - 3% of units had concentrations above 90% argon.
  - 25% had concentrations between 75-90%.
  - 11% had concentrations between 50-75%.
  - 61% had no measurable concentration or below 50% (out of spec for unit).
  - There were largely batch-related consistencies; certain dates had argon, and others did not.
  - There was no apparent loss with age.



**Figure 12 – Typical thermal stress break caused by solar shades partially shading annealed glass. Note that the break pattern starts and stops at 90 degrees to the edge.**



**Figure 13 – Displacement of spacer bar and seal into vision area after 10 years in service.**

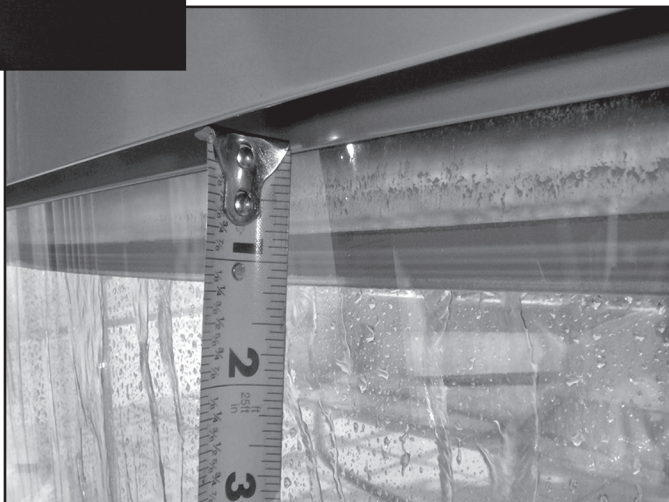
In this case, the design and installation of the edge seals were appropriate and effective, and the gas fill QA/QC in the factory was the only factor impacting the concentration of argon and the long-term performance of the system. The poor argon concentration found in the majority of the units was determined to be the result of inadequate QA/QC when the IGU was manufactured. This illustrates the importance of verifying the argon concentration in the factory.

#### **Edge Spacer Deflection**

When IGUs are designed and manufactured, it is important to consider where they will be installed. If IGUs are manufactured and sealed at one elevation above sea level and then shipped to another elevation, the pressure inside the unit can end up differing considerably after installation. This can create positive pressures that bow the glass outwards or negative pressures that create suction forces on the spacer bar.

It is important to note that the pressures created are larger on smaller units, due to the increased stiffness of the glass. Aside from the obvious aesthetic concerns created by reflections when the glass sheets are not parallel, more serious issues are also possible if units are not designed to withstand the pressure in combination with thermal cycling.

On one building in Vancouver, BC (elevation 200 feet), the windows and IGUs were manufactured and sealed in Edmonton, AB (elevation 2,191 feet), creating a suction pressure inside the unit once installed. The IGUs were double-glazed, utilizing an aluminum spacer bar and a single thermoplastic sealant. Thermoplastic sealants



**Figure 14 – Large deflections up to 1.25 in. occurred on the long edge of the smaller IGUs due to the increased pressures created.**

such as hot-melt butyl behave elastically at some temperatures and can flow at high temperatures. After 10 years in service, the spacer bars had all displaced into the vision area (see Figure 13) as a result of the constant negative pressure in combination with very slow creep of the edge sealant during warm temperature cycles. The amount of displacement was correlated to the size of the units, with the highest displacement occurring on the smaller units with high aspect ratios, as shown in Figure 14.

To reduce the risk of spacer bar deflection, a dual seal can be utilized in the construction of the IGU. A conventional

dual-sealed system would include a thermoplastic primary seal of polyisobutylene to provide a vapor and moisture barrier, as well as a secondary thermosetting seal, such as silicone, to hold the glass and spacer in position and provide a secondary weather barrier. In addition, capillary and vent tubes can be installed at the time of manufacturing, which need to be removed and/or sealed once the glazing units have arrived on site and have equalized in pressure. While effective, this method intro-

duces some additional risk—especially if windows are unitized and delivered to site fully assembled for installation.

On a five-year-old building in Portland, OR, owners complained of dust and fingerprints on their windows that could not be removed by cleaning. When these observations were reviewed in the field, it was found that the dust and fingerprints reported were actually corrosion of the low e-coating on surface 2 of the IGU. As a result of this finding, a sample of units

was tested to determine the dew point temperature (see Figure 15). It was found that all units exhibiting corrosion of the low-e coating had dew points greater than  $-5^{\circ}\text{C}$



**Figure 15 – Complaints of dirt build-up and fingerings on the inside of IGUs prompted dew point testing, which revealed high levels of moisture inside the units.**





**Figure 16 – The culprit was unsealed capillary tubes concealed within the window assembly.**

(23°F). In Portland, this dew point level means that condensation will likely occur when exterior temperatures fall below that level in the winter months. When condensation occurs, it can cause the low-e coating to corrode. Several glazing units were removed to investigate the cause of the high dew points.

As shown in *Figure 16*, unsealed capillary tubes were found on all units with high dew points. To reduce the risk of IGU failure, always ensure that capillary and vent tubes are properly sealed when installed into the glazing system or once the product arrives on site.

### Volatile Fogging

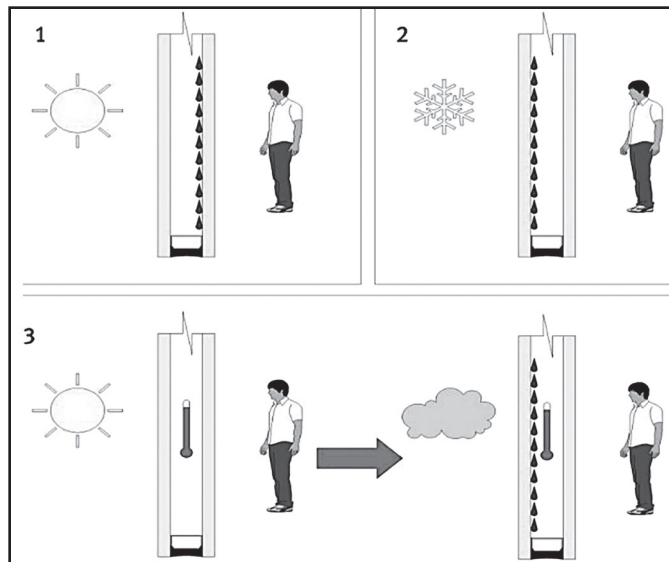
Volatile fogging is another process that can cause premature failure of IGUs. Volatile fogging is similar to moisture fogging and condensation, except that it typically occurs during or immediately after periods of high temperatures. If volatile compounds are present inside the IGU, they will often be absorbed by the desiccant. If the desiccant is not specifically designed to hold volatile organic compounds (VOCs), they can escape the desiccant when exposed to high temperatures and then condense on the cooler interior glass surfaces (see *Figures 17 and 18*). Volatile fogging can damage and corrode glass coatings inside the IGU, as shown in *Figure 19*, as well as soften some glazing sealants and reduce their effectiveness. The VOCs can enter the glazing unit during manufacturing, where they are used as cleaners and primers; they



**Figure 17 – Volatile fogging during a period of warm weather on a one-year-old IGU.**

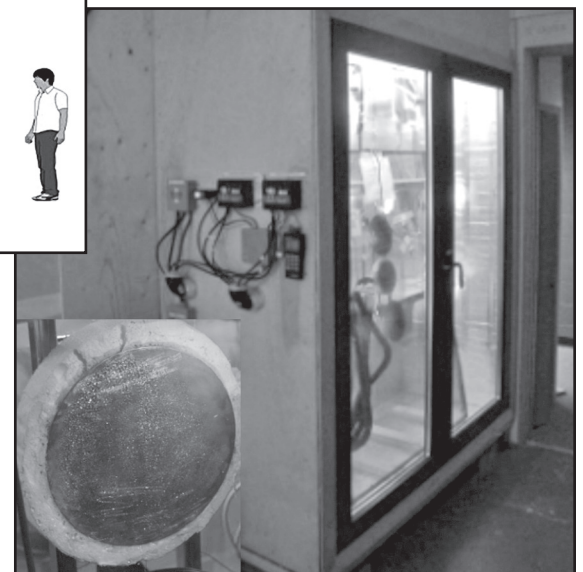


**Figure 18 – One of the authors examining damage to low-e coatings caused by volatile fogging and condensation fogging. Same location under magnification shows corrosion pattern (inset).**

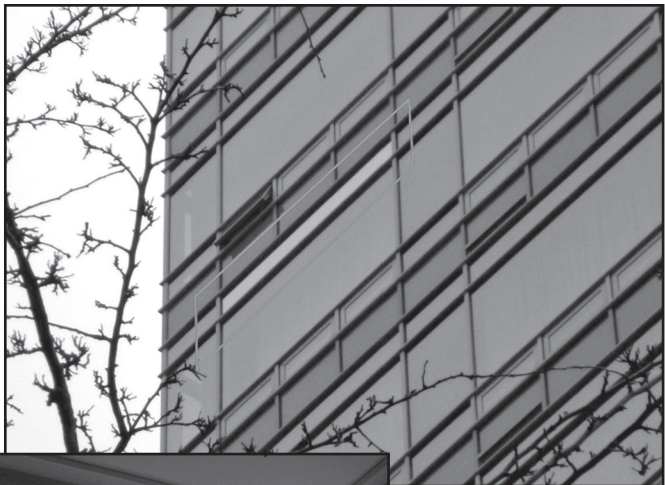


**Figure 19 – Volatile fogging (1), moisture condensation fogging (2), volatile fogging and/or moisture condensation (3).**

**Figure 20 – Suspect units being tested for volatile fogging in laboratory.**



**Figure 21 – A 20-year-old building in Vancouver, BC, with copper reflective glass that cannot be matched by the replacement IGU manufactured in 2012.**



**Figure 22 – Glazing in Figure 21 viewed from the interior.**



can also off-gas from sealants or organics in the spacer bar as they cure or decompose when exposed to sunlight.

Testing for volatile fogging is performed by heating the unit to 50°C (122°F) while cooling a specific portion of the glass to 20°C (68°F) and looking for condensation (see Figure 20). The risk of volatile fogging can be reduced by using glazing components, such as spacer bars and sealants,

that are resistant to off-gassing when curing (and when exposed to UV); by using desiccants that can permanently absorb volatiles; and by ensuring that IGUs have been tested in accordance with ASTM 2190 or CAN/CGSB 12.8.

When designing iconic buildings with unique glass colors, it is important to consider future glass replacement. As the building ages, the IGUs will need to be replaced, and trendy glass colors may not be manufactured 10 to 20 years from now. From a reglazing perspective, it's preferable to select glass that has similar optical properties to several manufacturers' products. This will ensure that the initial pricing will be more

competitive; in addition, it will be more likely that matching replacement glass will be found in the future. Figures 21 and 22 show an example of a building where the original glass tinting and color could not be matched by a replacement IGU.

### Edge Deletion

Insulated glass units are manufactured from two or more layers of glass that are separated by a spacer bar and hermetically sealed with various sealants. In order for the sealants to adhere to the glass, moisture-sensitive coatings need to be fully removed or edge-deleted where the sealant is in contact with the glass so that the sealants can bond directly to the glass (see Figure 23). Many low-e coatings contain layers of reactive metals (such as silver) that can affect the bond over time if exposed to moisture or chemicals in the adjacent sealants or setting blocks. Signs of incomplete edge deletion are easy to spot as a reflective residue along the sealant bond line, as shown in Figure 24.

### Edge Seal Types

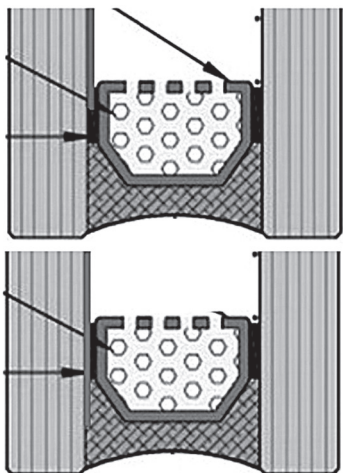
There are various edge seal designs on the market today. It's important to select an edge seal system that is appropriate for the unit's size, location, and installation method. In the author's experience, the more durable edge seal systems have incorporated a design with a good vapor barrier and an effective weather barrier that also structurally bonds the glass together for the life of the unit. Dual-sealed systems incorporating a primary seal and secondary seal leverage the strengths of different sealants and provide a level of redundancy

### Replacement Issues

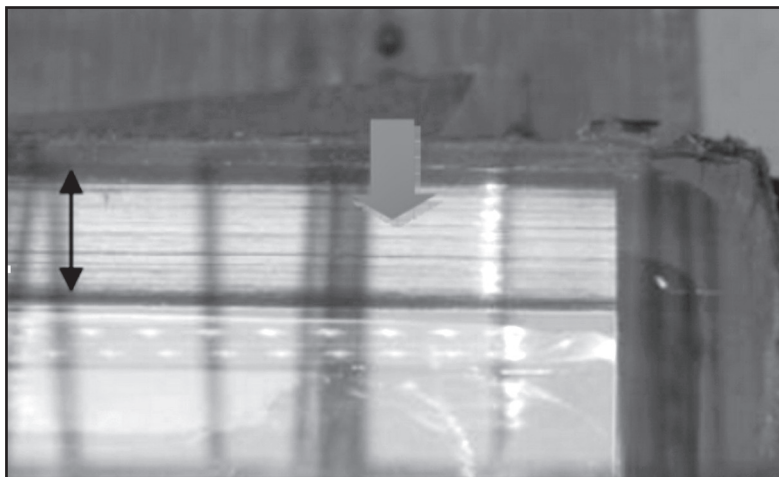
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Typical full edge deletion (red line)

Incomplete edge deletion (red line)



**Figure 23 – Typical versus incomplete edge deletion.**



**Figure 24 – Incomplete edge deletion on a new IGU made apparent by the reflective residue.**



in the event of small manufacturing defects. For larger units in high-rise construction, dual-sealed systems leveraging the vapor resistance and watertightness of polyisobutylene for the primary seal and the water resistance, durability, and structural strength of silicone are some of the best-performing systems, provided both seals are continuous (see Figure 27).

## TESTING AND CERTIFICATION

Building codes require that glazing units must conform to CAN/CGSB 12.8 or ASTM 2190 in order to be used in construction in North America. It is the responsibility of the manufacturer to perform this testing and keep it current. This can be difficult and confusing with the large combination of coatings, gasses, spacer bars, and sealants on the market today.

One way to reduce the amount of due diligence required on the part of the specifier is to require Insulating Glass Manufacturers Alliance (IGMA) certification for the units that are being produced for the

project. This certification provides a third-party review of the testing results and manufacturing, and increases the likelihood that the product conforms to the required standards.

However, it is not sufficient to simply check if the manufacturer is IGMA-certified. For example, a manufacturer may be certified for double-glazing with a dual seal on an aluminum spacer bar, but may not be certified to produce gas-filled, triple-glazed IGUs on a thermally broken spacer bar. It's good practice to obtain proof of IGMA certification for the system specified when using new or non-standard IGUs.

## INSTALLATION

The installation of IGUs can also have a large impact on their durability. Good glazing practices are outlined in IGMA TM-3000 and TM 1500, with key points summarized as follows:

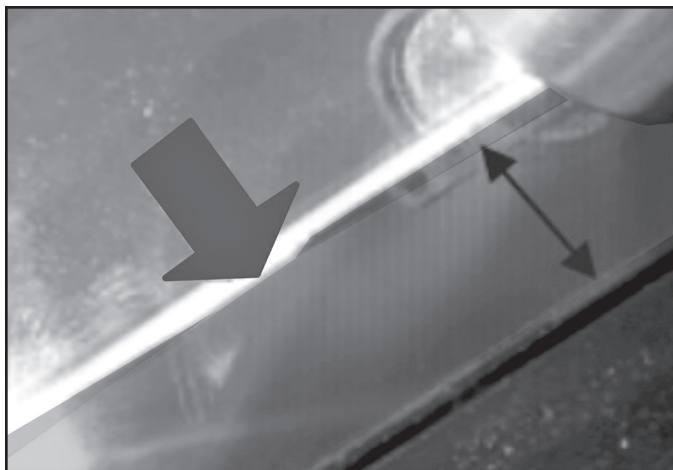
- Maintain enough space between the glass and framing system to avoid contact with the frame under in-service conditions, and allow venti-



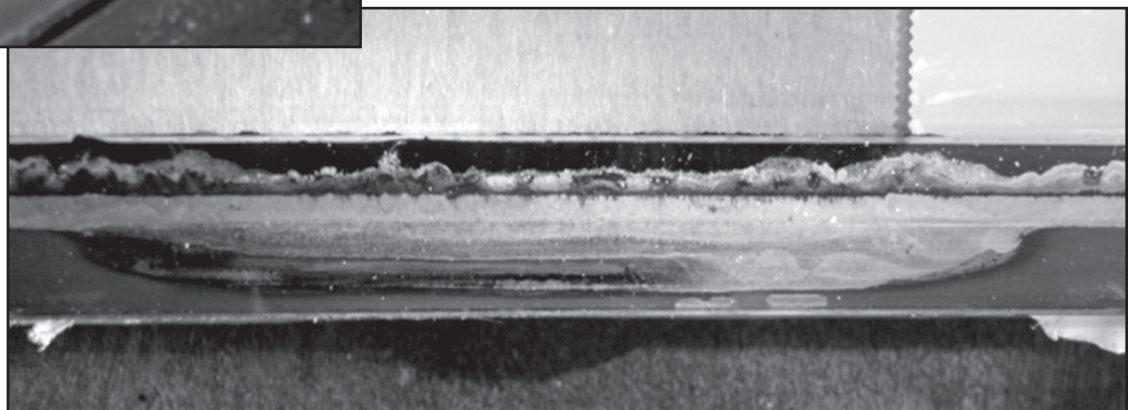
**Figure 25 – Corrosion of partially edge-deleted low-e coating.**



**Figure 26 – Low-e corrosion residue left on IGU sealant after pull test showing loss of adhesion.**



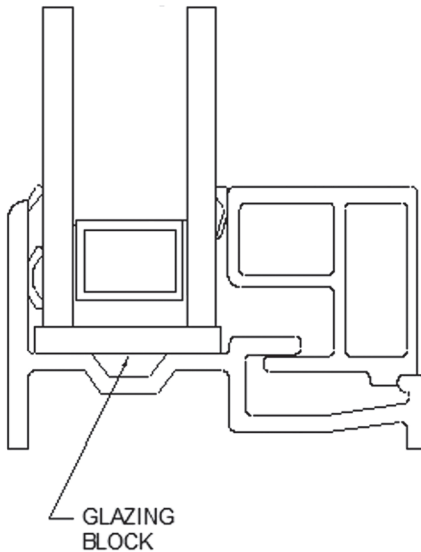
**Figure 27 – Visual review of a completed edge seal revealing a gap in the primary seal (lower arrow) and a continuous secondary seal (upper arrow).**



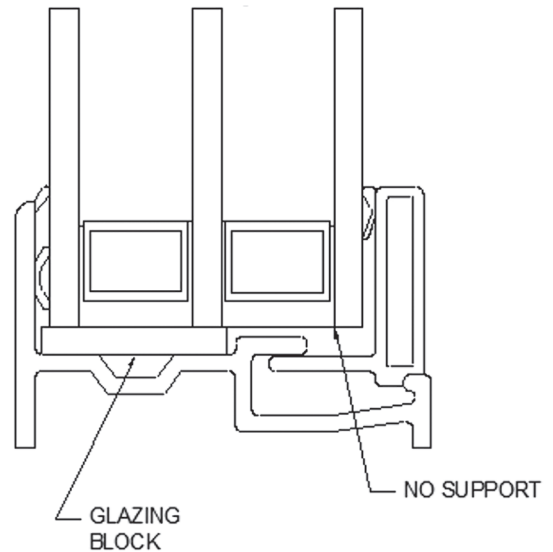
**Figure 28 – View of the bottom of the IGU showing damage to a silicone IGU edge seal caused by setting block incompatibility.**

lation and drainage of moisture out of the glazing cavity.

- Set IGU on setting blocks so that it never sits in water.
- Ensure that the setting blocks are made of a material that is compatible with the edge sealants and coatings (see Figure 28).
- Support all lites evenly to avoid shear stress on the edge seals.



**Figure 29 – Typical legacy window system designed for double-glazing from IGMA TM1500.**



**Figure 30 – Typical legacy window system modified to utilize triple glazing without consideration of good glazing practices. From IGMA TM1500.**

With the more frequent specification of triple glazing, even support of glazing lites can often be difficult with legacy framing systems that have been designed around thinner double glazing (Figures 29 and 30). It is important to check to ensure specified glazing streams can support the use of triple glazing installed in accordance with IGMA TM1500 before selecting a glazing manufacturer.

## RECOMMENDATIONS

The following are recommendations to reduce the risks associated with IGUs:

- For tempered glass on the exterior of buildings, specify heat-soaking to reduce the risk of spontaneous glass breakage, or switch to heat-strengthened glass. For guardrails, use laminated glass.
- On buildings with solar shades, large projections, or high-aspect ratio glass, use heat-strengthened

glass to reduce the risk of thermal stress breakage.

- Use a dual-sealed edge seal for larger glazing units on exposed buildings.
- Primary seal: Use a thermoplastic-like polyisobutylene or hot melt butyl with good vapor resistance.
- Secondary seal: Use a thermosetting sealant to act as the weather barrier and structural adhesive, (e.g., silicone, polysulphide).
- Make sure primary and secondary seals are continuous.
- Ensure all moisture- and chemically sensitive coatings are edge-deleted prior to manufacturing.
- Use a durable spacer bar such as stainless steel, aluminum, or silicone foam. Avoid plastics, rubbers, and organics unless they have a long track record of performance.

- Stick with conventional hermetically sealed systems if possible. Be cautious of suspended films and other new technologies until they have a good track record of performance.
- If practical, use durable glass coatings.
- Select coatings and colors that will be around for the life of the building.
- Specify that IGU manufacturers be IGMA-certified to produce the units specified, and that they provide written confirmation of this in their submittals.
- Specify that IGUs be installed according to good glazing practice outlined in IGMA TM-3000/TM 1500, and check to make sure it can be achieved with the glazing systems selected. 