

# Expert Series: Insulating Glass - The History, Evolution and Mechanics of the IGU



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### What is an Insulating Glass Unit?

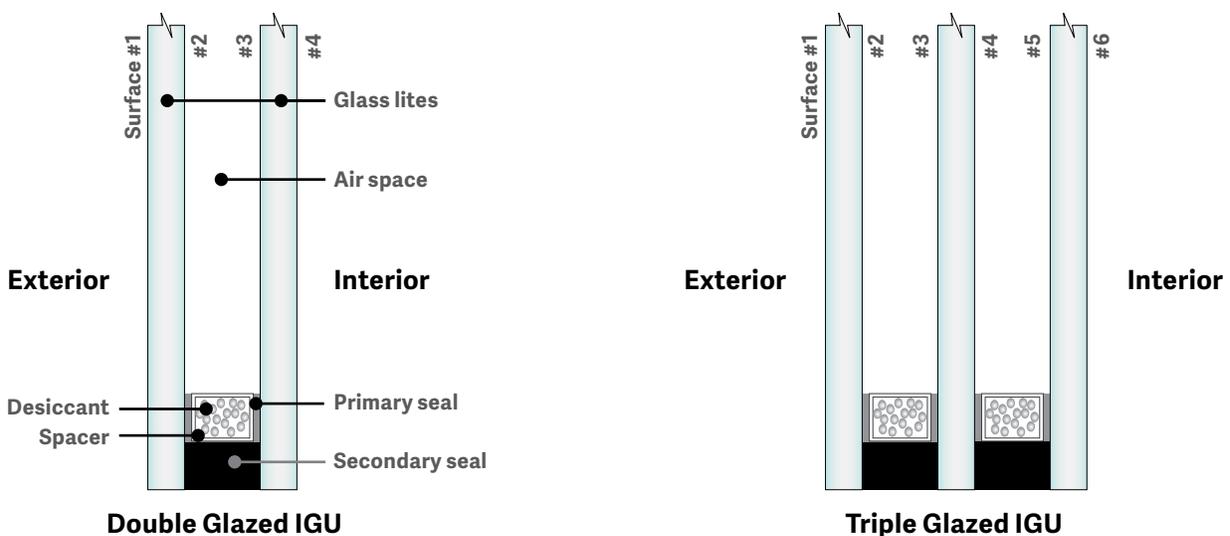
An insulating glass unit (IGU) is a glazing assembly comprised of two or more lites of glass separated by one or more hermetically sealed cavities, filled with either air or inert gas. The configuration delivers superior insulating performance compared to monolithic (single pane) glazing, by reducing air-to-air heat transfer in the building envelope. When used in conjunction with low-emissivity (low-E) glass coatings, IGUs become an efficient mechanism in reducing heat-transfer, conserving energy and enhancing occupant comfort while also providing the benefits of natural light.

### The Origin of IGUs

In the 19th century, window glazing consisted of a single pane of glass. Though effective in protecting occupants from the elements and transmitting natural light, this type of glazing is thermally inefficient and limited practical glass usage. In 1865, engineer and inventor Thomas D. Stetson patented an "insulation pane" that consisted of two lites of glass that were sealed at the edge which took advantage of the insulating effect of dry air. The lites of glass were separated by either rope or wood and sealed with tar. The first commercially viable IGUs were developed by LOF in the 1930's and improved on into the 1940's, with the 1941 patent of the "Thermopane". However, it wasn't until 30 years later during the oil embargo/shortages of 1970's that the use of IGUs become more widespread. It was at this time that glass manufacturers began to develop low-emissivity (low-E) coatings to improve energy conservation and thermal efficiency, almost doubling the insulating performance of an IGU. These coatings are nearly invisible and work by reflecting heat (both solar and ambient) to keep a structure cooler in the summer and reduce heat from escaping the interior to outside in the winter.

### Measuring Insulating Performance

The unit of measure for how well an IGU insulates is U-value. U-value measures how much heat will transfer through an IGU. The lower the U-value, the better the IGU insulates by reducing heat flow. The U-value of a 1" overall width IGU with argon fill and a low-E coating is 0.25 (Btu/h-ft<sup>2</sup>-F) which can be compared to the U-value of monolithic 6mm glass which is 1.0 (Btu/h-ft<sup>2</sup>-F).



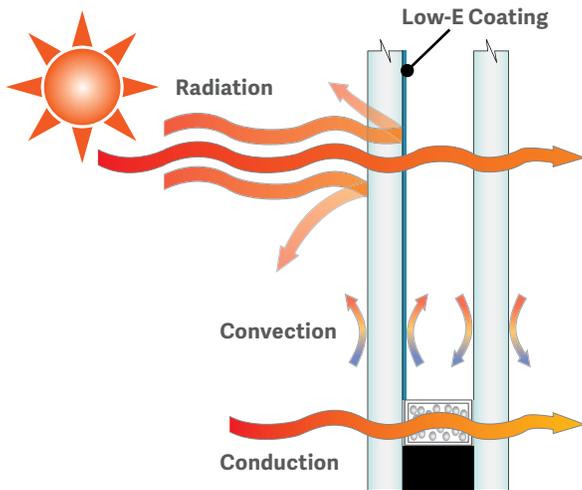
IGU glass surface numbers are identified by counting from exterior (surface #1) to interior. In the above diagram of a triple glaze IGU, the interior facing side of the innermost lite is #6.

### What is the makeup of an IGU?

Component	Description	Performance Attributes	Properties / Key Notes
<b>Glass</b>	<ul style="list-style-type: none"> <li>The primary material component of the IGU.</li> <li>Can include two or more lites.</li> <li>May be annealed, heat-treated, laminated, coated, etc.</li> </ul>	Provides light transmission and views. The presence of a low-E coating can simultaneously enhance solar control (reduce solar radiation) and improve insulating performance.	Different types and thicknesses may be selected based upon aesthetics, energy performance, thermal breakage resistance, codes, deflection control, etc.
<b>Air Space</b>	Hermetically sealed cavity bound by separated glass and spacer.	Provides a conduction thermal break and slows convection, enhancing insulating performance.	It is natural for these gases to diffuse through the IGU edge seal over time. An accepted diffusion rate is 1% per year. Even at this rate, the remaining gas continues to provide insulating benefits.
<b>Spacer</b>	A metal or non-metal component that separates two lites of glass at the edge of the IGU.	<ul style="list-style-type: none"> <li>Reduces heat flow.</li> <li>Can be warm-edge type to further reduce u-factor.</li> <li>Contains the desiccant (drying agent).</li> <li>Contributes to structural integrity of the IGU.</li> </ul>	<b>Profiles:</b> <ul style="list-style-type: none"> <li>Rigid Box, U-shaped.</li> <li>Rectangularly extruded.</li> </ul> <b>Conductivity:</b> <ul style="list-style-type: none"> <li>Spacers composed of low conductance materials such as Stainless Steel or nonmetal materials, are considered "warm edge" spacers versus highly conductive materials such as aluminum spacer.</li> </ul>
<b>Desiccant</b>	<p>Desiccant (drying agent) is contained within the spacer system at the perimeter of the IGU.</p> <p>It is either a beaded form or impregnated into an extruded spacer material such as a butyl or silicone spacer.</p>	Keeps the cavity dry by adsorbing moisture and or solvent vapors that may be present at the time of fabrication or penetrate the seal over the IGU lifecycle.	Molecular sieve desiccants primarily focus on moisture adsorption while Silica gel desiccants adsorb both moisture and volatiles outgassed from touchup paint or sealants.
<b>Primary Seal</b>	<ul style="list-style-type: none"> <li>Material applied along the spacer shoulder.</li> <li>Typically, a non-curing component that remains pliable over the lifecycle of the IGU.</li> </ul>	<p>Allows for proper positioning of the spacer during IGU fabrication.</p> <p>Provides a barrier to gas and water vapor transfer.</p>	<ul style="list-style-type: none"> <li>Polyisobutylene (PIB) (most common).</li> </ul>
<b>Secondary Seal</b>	Provides an elastic structural bond between the glass and spacer while protecting the primary seal and spacer edge from the elements.	<ul style="list-style-type: none"> <li>Maintains structural integrity of the IGU.</li> <li>Protects primary seal from deformation by controlling edge movement.</li> </ul>	<ul style="list-style-type: none"> <li>Silicone (structural, UV stable)</li> <li>Polyurethane, Polysulfide (structural, low vapor transmission)</li> <li>Hot Melt Butyl (low vapor transmission)</li> </ul>

### How IGUs Work

Heat flows naturally from warm to cool. This flow occurs in three methods of heat transfer: radiation, convection and conduction. There are several IGU design considerations that can help minimize each type of heat transfer:



**Radiation** is the transfer of heat in the form of electromagnetic waves which are absorbed and then re-radiated. The sun is a major source of radiant energy. Radiant energy is also emitted from a person's body if the person is sitting close to a cool surface, such as a window. Low-E coatings on glass are designed to slow radiant heat transfer. During warm months, the coatings reflect solar near-infrared radiation away from the structure, while the coatings reflect longwave radiation (heat) back into the structure during cooler periods.

**Convection** refers to heat transfer involving the movement of gas. Air currents in the IGU cavity carry heat to the top of the IGU. The air cools as it travels along the surface of the glass. Gravity causes the cooler dense air to fall, creating a convective loop. Design considerations to slow convective heat transfer include modifying the size of the cavity and the introduction of inert gases into the air space. For example, argon, which is heavier than air, slows the convective loop.

**Conduction** is the transfer of heat between solid materials that are in direct contact with one another. Along the edge of the IGU, conductive heat moves from glass to spacer and back to glass. This transfer can be slowed by using a warm edge spacer.

### What Happens Over the Lifecycle of an IGU?

The most common insulating glass unit configurations are 1/4" glass, 1/2" air space, 1/4" glass for architectural (commercial) use and 1/8" glass, 1/2" air space, 1/8" glass for residential. From the time of fabrication until IGU failure, moisture will slowly penetrate the seal. Desiccant adsorbs this moisture until it reaches saturation. At this point moisture will begin to accumulate in the IGU and fogging between the panes may occur. This is what is referred to as a "seal failure".

American Society for Testing and Materials (ASTM International) has established standards and testing protocols for the performance and evaluation of insulating Glass. These include ASTM E 2190, ASTM E 2188 and ASTM E 2189. Certification programs administered by organizations such as the Insulating Glass Certification council (IGCC) verify compliance to these standards.

### Learn More About IGU's

If you need more information, Guardian's Technical Services group is available to assist with the evaluation of insulating glass units. Please contact Guardian at <https://www.guardianglass.com/us/en/contact> or call 855-58-GLASS (45277).

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