Triple-Pane Guidelines

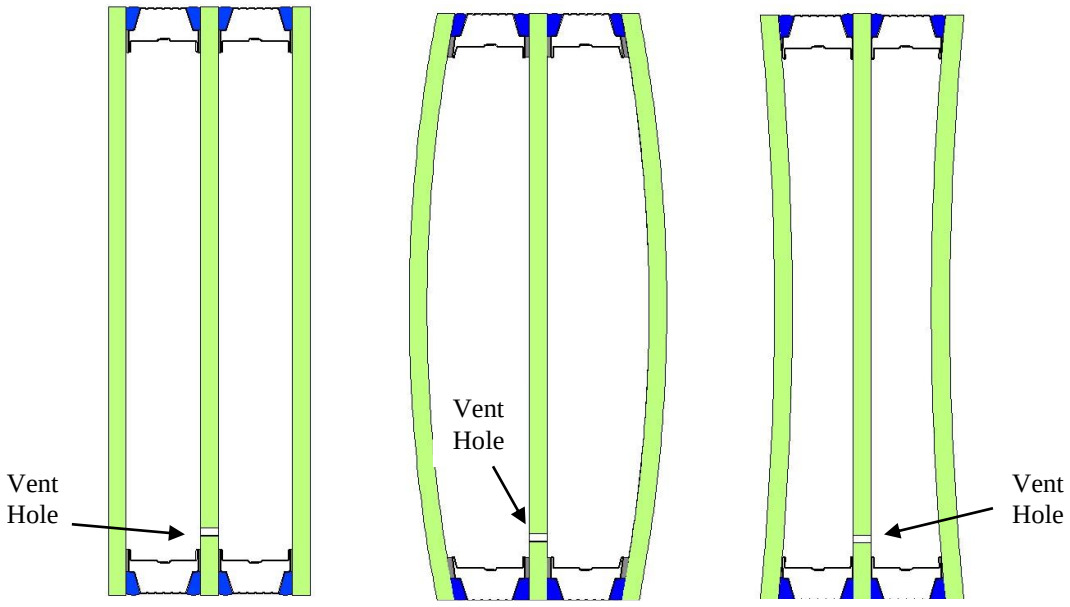
The continued progression towards energy-efficient windows will increase the need for triple-pane insulating glass. The triple-pane unit is more complex than the standard double-pane unit because of the reaction that occurs with two sealed airspaces. There is also the complexity of analyzing the risk for thermal stress breakage with three glass panes. The interaction of triple-panes with two airspaces and potentially three LoĒ coatings becomes a complex equation. Triple glazing has some challenging issues compared to double glazing when selecting the glass construction. The following factors need to be considered.

Airspace Dimension/Overall IG Thickness

The change in airspace pressure from temperature and/or altitude changes will cause the outdoor and indoor glass lites in triple-panes to deflect. The two major concerns with insulating glass units and in particular triple-panes are the stress on the insulating glass sealants and on the glass lites. The stresses that occur from temperature and altitude changes can be larger than those that occur in a standard double-pane unit. The effects of temperature and/or altitude changes on the edge seal and glass stress of a triple-pane unit with two 13.0mm airspaces will be similar to a double-pane unit with a 26.0mm airspace (airspaces are additive).

Equalization Hole in Center Lite

In some triple-pane units, Cardinal utilizes a small hole in the corner of the center pane to allow equalization of the pressure of the two airspaces. With a hole in the center lite, there will be minimal deflection on the center lite. The use of the vent hole will also be beneficial in high altitude applications because only one capillary tube will be required which will increase the longevity of the triple-pane.



No Deflection

Positive deflection occurring from increase in altitude and/or temperature.

Negative deflection occurring from decrease in altitude and/or temperature.

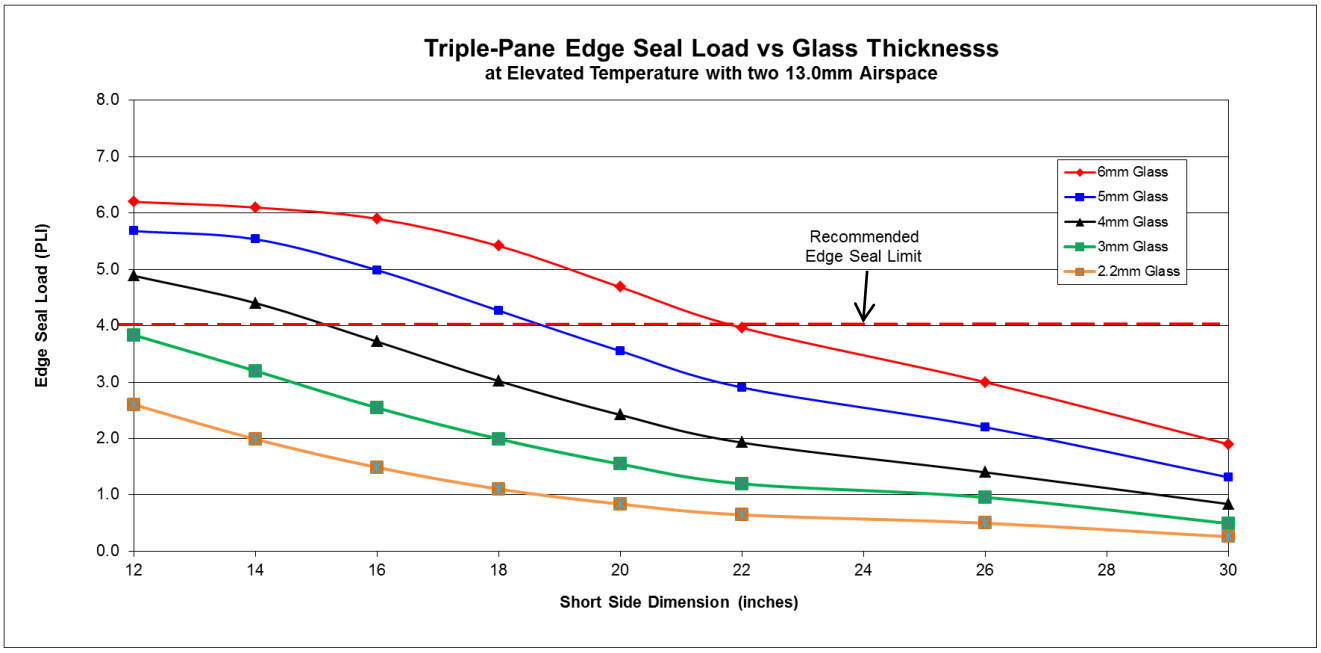
Edge Load

Factors that determine the amount of load applied to the glass lites and the insulating glass edge seal include:

- Glass thickness
- Size of the insulating glass unit
- Airspace dimension
- Temperature
- Altitude
- Windload

The graph below shows the resulting edge seal load on a triple-pane unit constructed with two 13.0mm airspaces at an elevated airspace temperature, with various glass thicknesses.

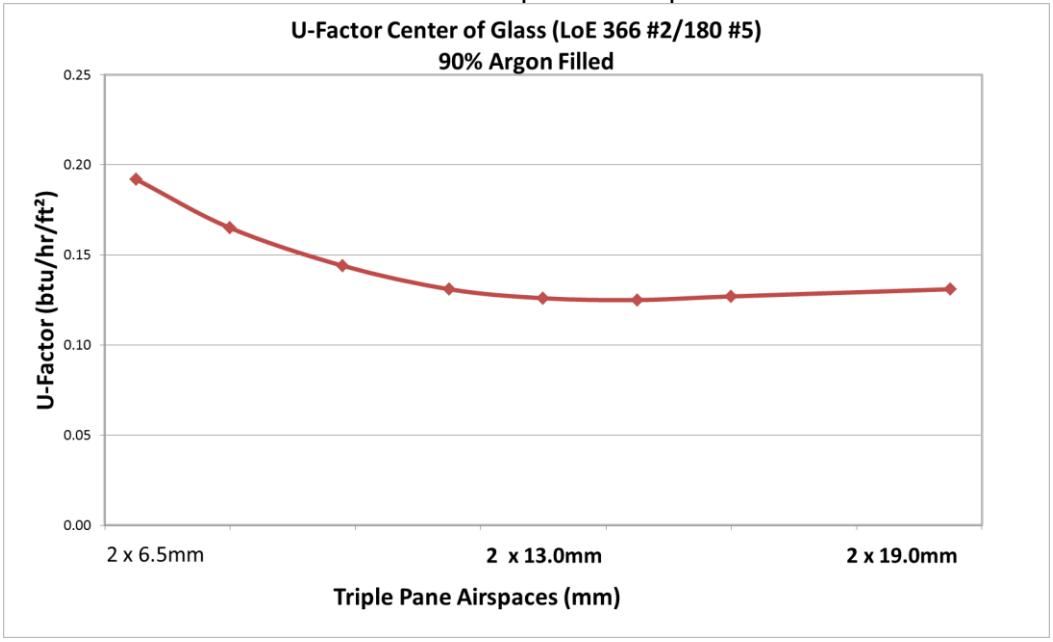
As illustrated in the graph, the edge seal load increases as the glass thickness increases. The load on the IG edge seals becomes significant on triple-pane units, especially when the short side dimension is less than 20 inches. A triple-pane unit constructed with three lites of 6mm glass will have edge seal loads more than three times higher than a triple-pane constructed with 2.2mm glass. For this reason Cardinal does not recommend the use of wide airspaces for triple-pane units, especially triple-panes utilizing thick glass.



Performance

As shown in the graph below, the optimum U-Factor occurs in airspaces between 9.8mm and 13.0mm. Using airspaces greater than 13.0mm increases the edge seal loads and does not improve the performance of the IG unit.

U-Factor versus Airspace for Triple-Panes



Triple-Pane Airspace Limitations

Triple-Pane Construction Guidelines

Glass Thickness (mm) all three panes	Recommended Airspace
2.2mm	6.5mm to 13.0mm
3.0mm	6.5mm to 13.0mm
4.0mm	6.5mm to 11.5mm
5.0mm	6.5mm to 9.8mm
6.0mm	6.5mm to 8.0mm

To minimize the edge seal loads and glass stress of a triple-pane IG unit, Cardinal recommends the above IG constructions for the respective glass thickness.

These recommendations do not include effects from altitude changes. Recommendations are based on Cardinal's XL Edge® and Endur IG™ spacer systems.

Triple-Pane LoĒ Coating Placement

The use of two or three LoĒ® coatings in a triple-pane will provide the optimum U-Factor performance. To achieve the optimum U-Factor, one LoĒ coating is required in each airspace of the triple-pane. To reduce the risk for thermal stress breakage, Cardinal recommends the coatings be positioned on the #2 and #5 surfaces versus #2 and #4 or #3 and #5.

In triple-pane constructions where LoĒ - i89™ (#6) is used, LoĒ-180® is recommend for the center pane; see Cardinal's TSB IG #7 Heat Treatment recommendations.

The location of the coatings in a triple-pane has minimal effect on performance.

- The U-Factor is the same for a triple-pane with the LoĒ coating on #2 and #5, #2 and #4; or #3 and #5.
- Visible light transmittance, UV transmittance, and winter indoor glass temperatures are not affected by LoĒ coating placement.
- The Solar Heat Gain Coefficient (SHGC) will be slightly higher for a triple-pane with the coatings on #2 & #5, versus #2 and #4. The typical change in SHGC from surfaces #2 and #5 versus #2 and #4 result in only a .01 to .02 increase.

Triple-Glazing Recommended Square Foot Limits

	Annealed Glass		Heat Strengthened or Tempered Glass			Weight (lbs/ft²) Triple Pane
Glass Thickness All three panes	Maximum Square Feet	Maximum Length	Maximum Square Feet	Squareness Factor Max Short Dimension (inches)	Maximum Length	
2.2mm	10	70 inches	15	36	70 inches	3.6
3.0mm	15	80 inches	20	36	80 inches	4.8
3.9mm	24	90 inches	30	48	90 inches	6.3
4.7mm	33	100 inches	50	60	100 inches	7.5
5.7mm	40	120 inches	40	80	144 inches	9.8

Notes:
1. The Squareness Factor/oil canning factor for Heat Treated Glass is based on reducing the potential of bi-stable glass (oil canning & soft center).
2. All factors must be met for fabrication allowance. For example: an IG unit constructed with 3mm tempered glass that has a dimension of 37"x74" has a square footage of 19 square feet, and its maximum length is 74 inches. Both of these criteria are under the specified limits for 3mm tempered glass, however, the minimum short dimension is greater than 36 inches, therefore, it does not meet the Squareness Factor.
3. The limits shown are based on Cardinal manufacturing and handling parameters. The limits do not take into account windload requirements.

Windload

The additional lite in a triple-pane will increase the windload resistance compared to a double-pane insulating glass unit. Per ASTM E1300, triple-pane units utilizing the same glass thickness as a double-pane unit will increase its windload resistance by 35%.

Safety Glass

To meet ANSI and CPSC requirements, all three lites of the triple-glazing are required to have safety glass, including the middle lite of the triple-glazing.

Altitude Limits

The allowable limits for shipping and installation for triple-panes without capillary tubes will in most cases be less than that of a double-pane. See Cardinal's Altitude tables for ship through and installation limits.

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