

THERMAL ENHANCEMENTS FOR ALUMINUM-FRAMED CURTAINWALLS –

A Practical Perspective and Some Nonthermal Considerations

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Aluminum-framed curtainwall systems have many positive traits, though historically they have been underachievers with respect to thermal performance (at least when compared to opaque wall systems that include several inches of insulation). Increasing energy costs and a greater industry focus on thermal performance, sustainability, and related topics have encouraged manufacturers to develop strategies for improved thermal performance. Developments in recent years have enhanced the options and performance of products available on the market. This article will discuss various modifications that may be made to aluminum-framed curtainwall systems to improve their thermal performance. We will discuss enhancement options for both the glazing and framing systems, including potential impacts on thermal performance and other considerations, such as cost, durability, and weatherproofing.

TRADITIONAL CURTAINWALL PROVISIONS

The thermal performance of a curtainwall system relies upon the combined performance of the framing and glazing components. Mullion framing is normally formed from aluminum, which has a high conductivity. Captured curtainwall systems normally include interior aluminum tube mullions, combined with exterior aluminum pressure plates that are fastened to the tube mullions through an aluminum mullion stem. Approximately 0.25- to 0.375-in.-thick nonmetal (rubber or plastic) “thermal breaks” are often included between the

pressure plates and the mullion stems to help interrupt the thermal conductivity of the aluminum (*Figure 1*). Some curtainwall systems do not include pressure plates and instead include glazing that is bonded to the mullions with structural-grade sealant/

adhesive; these systems tend to perform better thermally than captured systems, though they are not the focus of this article.

Glass units included in curtainwall systems are often insulated glass (IG) units and include two panes of glass separated by an

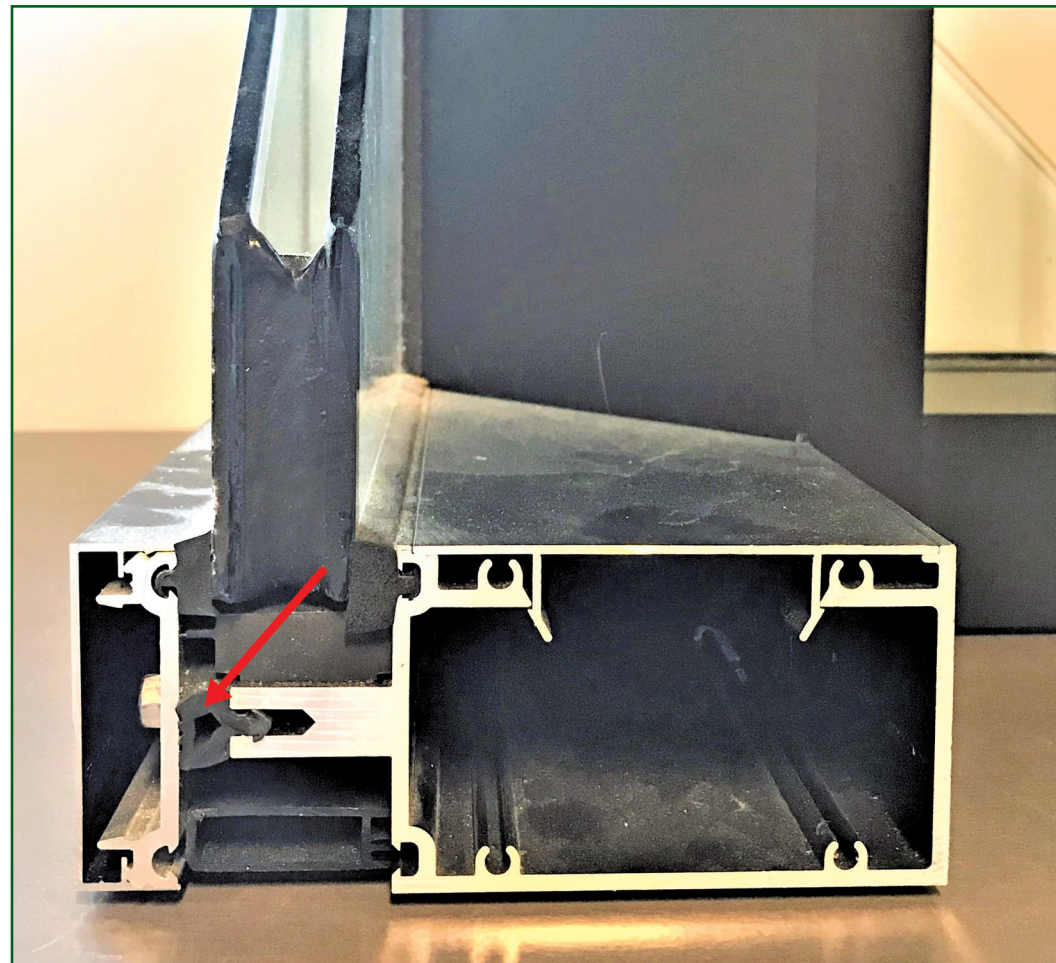


Figure 1 – Common curtainwall framing configuration. Red arrow points to approximately 0.25-in.-thick thermal break between aluminum pressure plate and mullion stem.



Figure 2 – Example of fiberglass pressure plates.

air space that is created by using a perimeter spacer bar. The spacer bar is normally bonded to each pane of glass with sealant/adhesive. The purpose of this seal is to retain the air (or gas) within the air space to achieve the insulating value and to prevent moisture from entering the air space. A secondary seal is often added around the spacer bar to help further secure and seal the glass unit together. IG units also often include a low-emissivity (low-E) coating on one of the concealed glass surfaces to help reflect radiant heat and improve the U-factor of the glazing.

Semi-rigid mineral wool insulation is often installed at spandrel areas and along columns and can help improve the thermal performance of these opaque areas substantially. These opaque areas are not the focus of this article.

The thermal performance of a curtainwall is evaluated via its U-factor, which describes the rate of heat transfer through an assembly. The lower the U-factor, the better the performance. Transparent vision areas of traditional curtainwalls (that is, those formed primarily from aluminum components and traditional 1-in., air-filled IG units) often achieve U-factors in the range of 0.45 to 0.6 Btu/ft²·°F·hr, depending upon the glazing used within the assembly and the mullion/framing configuration. (Note: prescriptive requirements in the 2015 International Energy Code require a

maximum U-factor of 0.38 for fixed fenestrations in Climate Zone 5.) Curtainwalls with high-performing glazing and thermal improvements to the framing can approach U-factors around 0.3 Btu/ft²·°F·hr (or potentially even better).

FRAMING UPGRADES

Curtainwall manufacturers have developed various creative strategies for improving the thermal performance of aluminum framing. As discussed below, strategies vary from completely new (nonmetal) framing materials, to minor adjustments, to detailing. Some of these materials and systems are relatively new to these applications. When evaluating materials and systems, it is always important to consider the track record of each in similar applications (to the extent feasible), as a track record in a specific application and climate is often the best indicator of future performance.

Alternative Framing Materials

Alternative framing materials, such as wood and fiberglass, have been widely used in the window market but are not as common in the curtainwall market. Some manufacturers offer timber-framed curtainwalls that utilize some aluminum extrusions (such as exterior pressure plates and caps) for corrosion/rot resistance and alignment but that contain interior timber mullions. Solid timber mullions can be costly, though

they are far less conductive than aluminum. We have not observed the use of fiberglass mullions, likely because hollow fiberglass members generally have reduced structural capacity (strength, stiffness) compared to aluminum mullions. We are generally tentative about the use of fiberglass mullions due to these reasons and to general concerns about long-term durability, fastener retention, and limited attachment options.

Nonmetal Pressure Plates and Accessories

Multiple different nonmetal material options are now available for pressure plates, including fiberglass and polyamide (historically, pressure plates have been solid aluminum; see Figure 2). Exterior snap covers typically remain aluminum. Use of such alternative materials essentially allows the nonmetal pressure plate to become part of the thermal break between exterior conditions and interior tube mullions, which is particularly helpful because the pressure plates are directly exposed to severe exterior conditions. Nonmetal pressure plates can have a moderate impact on the overall U-factor and may add significant cost to a project (Figure 3).

We have seen fiberglass pressure plates

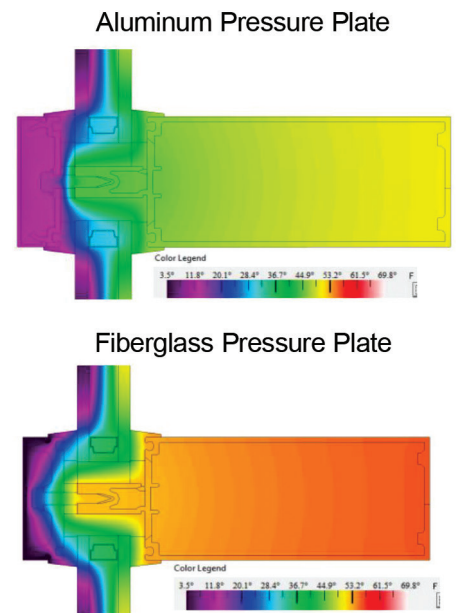


Figure 3 – Example thermal model output showing the temperature gradient across a curtainwall with aluminum pressure plate (top photo) and fiberglass pressure plate (bottom photo). Note that the orange coloring on the bottom figure indicates generally warmer temperatures than the yellow coloring on the top figure.

used successfully on various projects, though on some isolated projects, we have seen some initial problems (that were later resolved) related to the reduced stiffness of fiberglass versus aluminum. In one case, the fiberglass pressure plates deflected excessively between fasteners and therefore did not compress the exterior gaskets evenly, resulting in failed water testing of a mock-up (additional fasteners were later installed to resolve the problem). Some manufacturers offer fiberglass plates that include a different, thicker profile than their aluminum plates to help avoid stiffness and compression problems.

Installers/manufacturers should exercise care to ensure that appropriate sealant adhesion is attained at nonmetal pressure plates, as alternative silicone sealant materials and/or primers may be needed to achieve good adhesion. Project teams should also think carefully about the use of deep snap covers with some nonmetal pressure plates. Options for providing additional attachment for deep covers (occasional fasteners or clips, etc.) appear to be limited due to the reduced fastener holding power of fiberglass versus aluminum. We have limited project experience with polyamide pressure plates, though we expect that they offer some similar benefits and drawbacks as fiberglass plates.

Thermal Break Design

Alternative deeper and dual thermal break designs are now available that are far superior thermally to the traditional thin, flexible thermal breaks that have historically been used between pressure plates and mullion stems (*Figure 4*). These types of systems vary but generally provide notable improvement to thermal performance, though they may add significant cost. Approximately 1-in.-deep dual polyamide thermal

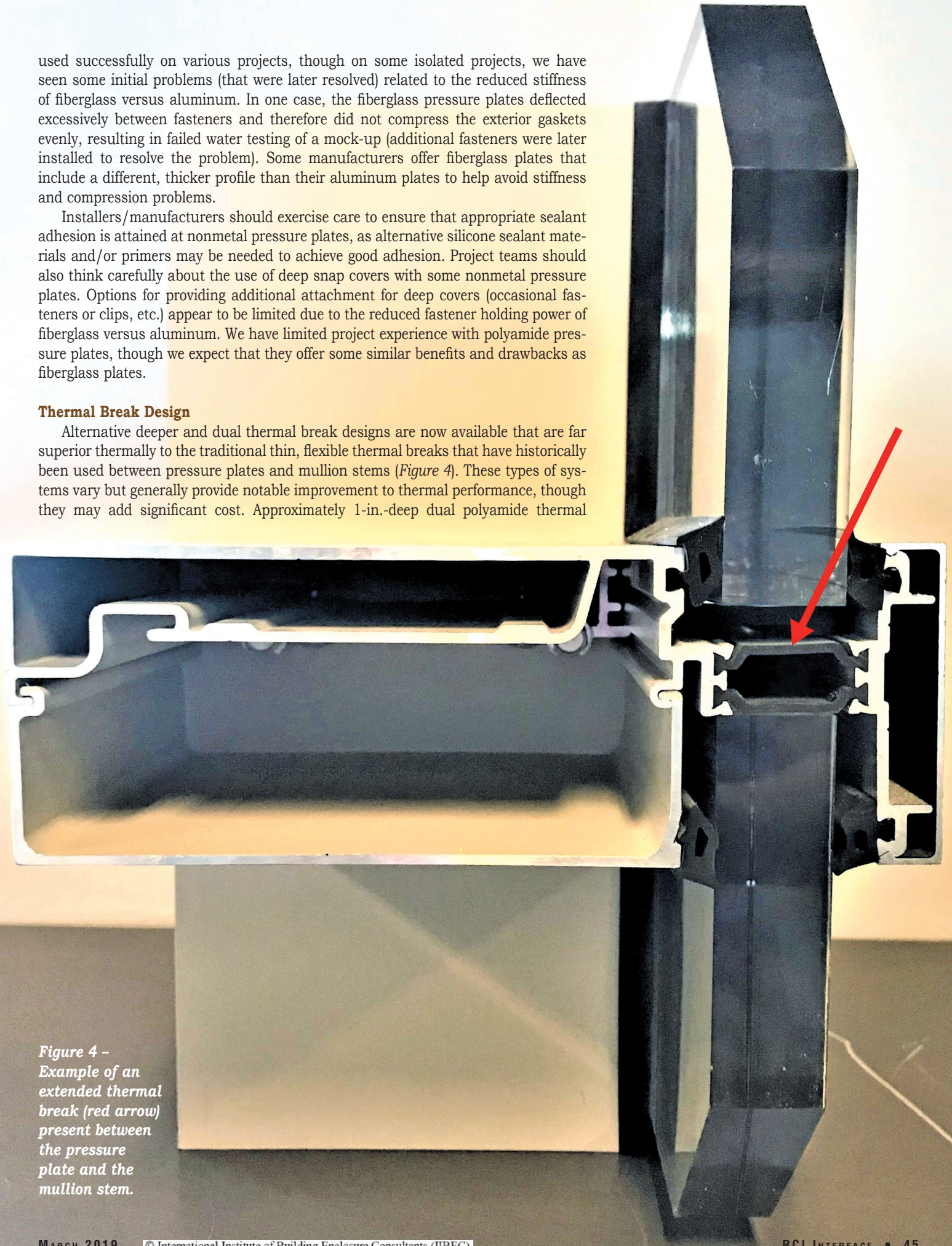


Figure 4 – Example of an extended thermal break (red arrow) present between the pressure plate and the mullion stem.

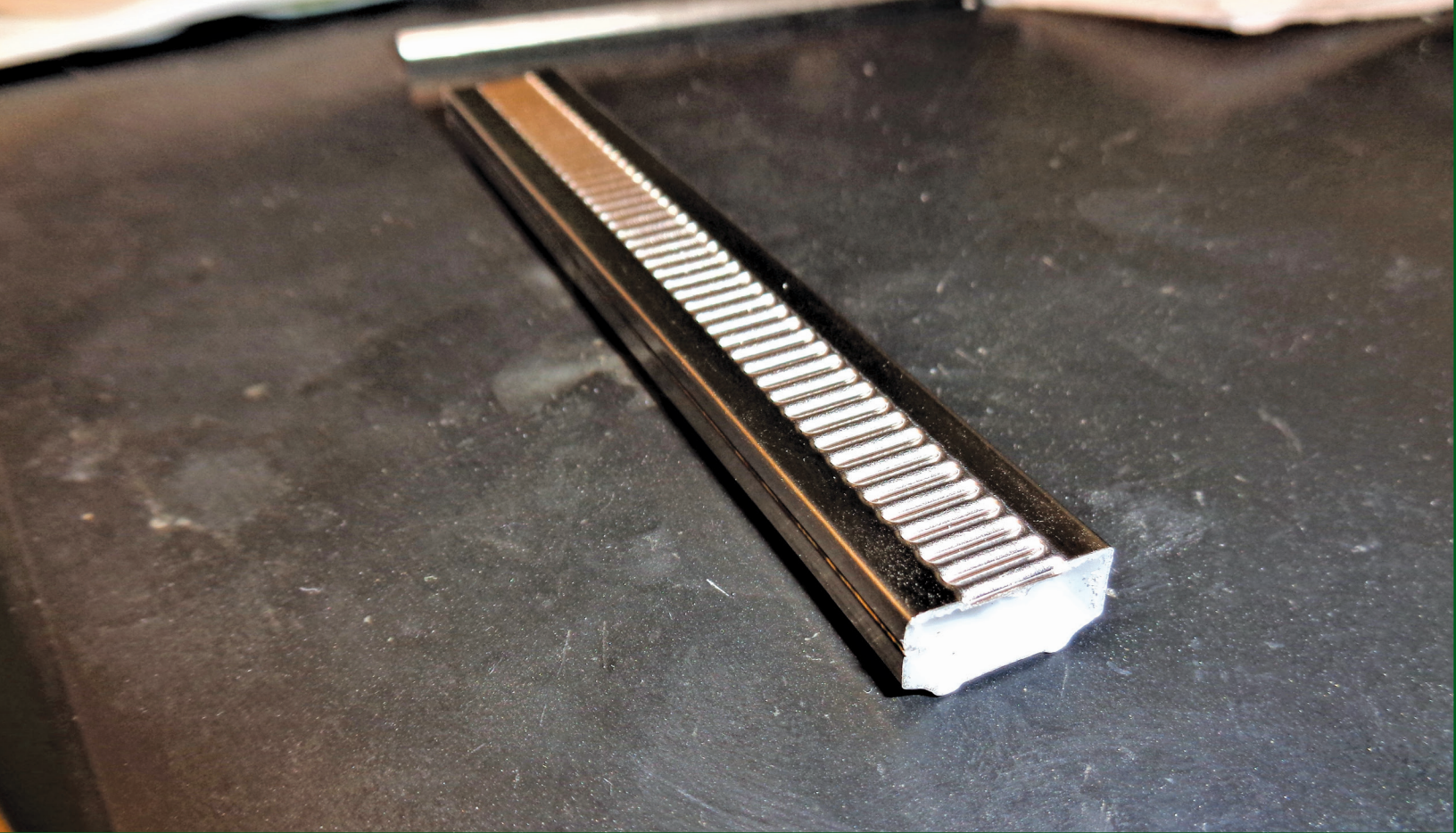


Figure 5 – Example of spacer formed from nonmetal material and encapsulated by a metal foil.

struts are available that span between a fixed pressure plate and the supporting mullion framing; thermal strut designs have been popular and effective in the aluminum window market for several years. Nonmetal polyamide “stems” are also available that essentially replace the aluminum at the stem area. Some manufacturers also offer dual thermal break systems, such as a combination of dual thermal struts and a traditional flexible thermal break along the pressure plate, or a deep polyamide break with a more flexible sealer gasket along its exterior face. One or more manufacturers now offer fiberglass inserts that are approximately 2 in. deep and essentially replace the entire stem and exterior face of the aluminum tube mullions with fiberglass.

Replacing the sturdy aluminum stems with nonmetal materials often affects the glass support method and, in some cases, may affect the long-term load-carrying capacity. Metal chairs are typically needed to support IG units (rather than supporting the glass directly with the stem), which may result in the need for a groove/slot in the exterior face of the tube mullion to receive the chairs. Such grooves/slots can make sealing mullion intersections more challenging.

We have witnessed occasional installation and performance problems with systems that include innovative thermal breaks, such as issues related to fastener size/depth and embedment, confusion of installers regarding fastener and attachment requirements, inadequate support of glazing, and issues with sealant adhesion to nonmetal materials. Using multiple thermal breaks and/or alternative thermal break materials can result in additional longitudinal joints in the glazing pocket (joints that intersect corner seals), which can naturally increase the risk of potential water migration downward between glazed openings.

Other Accessory Materials

Other minor adjustments can be made to the curtainwall framing system, such as replacing certain accessory materials at perimeter mullion conditions with nonmetal components. Pocket fillers, which fill the empty void present at the glazing pocket area at perimeter mullions, are typically aluminum, though they can sometimes be replaced with nonmetal fillers. Nonmetal pocket fillers normally add minimal cost and can help to limit the thermal bridging and thereby help reduce the risk for localized condensation at these potentially

sensitive areas, though that will generally have a limited effect on the overall thermal performance.

GLAZING UPGRADES

Air Space Modifications

Gasses such as argon or krypton can be used in IG unit “air spaces” (in lieu of air) to improve the thermal performance of the unit. These gasses have better insulating (thermal resistance) values and can, in some cases, improve glazing U-factors up to approximately 25%, depending upon the glazing configuration. Air space modifications are often convenient (or at least not overly cumbersome) for curtainwall fabricators and installers, as they enhance thermal performance without impacting the fabrication needs or weatherproofing performance of the curtainwall system (and generally have minor cost implications).

While the immediate thermal improvements are notable, the long-term performance of the gas-filled IG units is unclear. There are concerns by some over whether the gas will slowly diffuse out of the unit through the edge seal over time, though some studies have shown that the diffusion may be minimal if the edge seal is intact.



Figure 6 – Example of migration of flexible spacer at IG unit.

“Warm Edge” Spacers

A metal spacer at the perimeter of an IG unit can act as a thermal bridge across the air space. Using an alternative, less-conductive “warm edge” spacer material in lieu of a traditional aluminum bar is another popular method for enhancing thermal performance.

Various types of warm edge spacer bars are available today and may add minimal-to-moderate cost to a project. Some warm edge spacers utilize less-conductive solid metal materials (i.e., stainless steel), while others use other relatively rigid nonmetal materials (fiberglass, organics, etc.) that are often encapsulated by a thin metal foil/skin that helps provide vapor resistance (Figure 5). It is our experience that stainless steel spacers can improve traditional center-of-glass U-factor values by approximately 5%, while some rigid nonmetal materials can potentially improve values by approximately 10%. Some manufacturers use more-flexible materials (such as foam tapes, liquid-applied sealants, and combination plastic-sealant-foil spacers) that may be able to improve performance by nearly 15%.

We have observed that more-flexible spacer materials are more prone to movement/

migration over the medium-to-long term, as well as displacement of glass panes relative to one another. These issues, where present, can lead to seal failures, fogging, corrosion of low-E coatings, and other problems (Figure 6). There are also concerns by some about the long-term durability of a spacer bar made of organic material (such as plant-based material) rather than corrosion-resistant metal.

Triple-Glazed IG Units

As noted above, IG units are typically made up of two panes of glass, though triple-glazed IG units (with a third pane of glass with a second interstitial air/gas space and spacer) are also available. Review of various glass manufacturers’ data shows that the center-of-glass U-factor can be decreased by up to 40% or more by using triple-glazed IG units in lieu of dual-pane units, depending upon various factors.

Triple-glazed IG units are substantially heavier, thicker, and costlier than typical dual-pane IG units, and they can affect the design and cost of the supporting framing system due to the increased dimensions and loads. Not all curtainwall systems are capable of supporting triple-glazed units,

though many manufacturers offer systems that can accept both dual- and triple-glazed units.

Double Low-E Coatings

Low-E coatings are typically metallic coatings applied to glass that help to reflect solar energy and/or retain heat. It is our experience that in the north-east United States, low-E coatings are most often applied to the inner face of the exterior pane of glass (i.e., #2 surface) to reflect solar energy to the exterior during hot (cooling) seasons (though occasionally, coatings are applied to the #3 surface, which provides benefits during heating

seasons). Some glazing manufacturers now offer the option to provide a second, more durable (i.e., resistant to abrasion) pyrolytic “hard-coat” low-E coating on the innermost surface of the glass unit (inner surface of the inner pane; i.e., #4 surface). The combination of coatings provides benefits during both cooling and heating seasons.

Some dual-coating combinations can improve glazing U-factors similar to triple-glazed IG units at moderately expensive costs and without any substantial impacts on loads, dimensions, framing system design, or fabrication design, which can be attractive to designers and fabricators/installers. Double coatings may affect appearance options slightly, and the long-term durability of the interior coatings remains to be confirmed, particularly for areas at high risk for frequent contact and wear and tear.

SUMMARY AND SUGGESTIONS FOR FUTURE PROJECTS

While glazed wall systems will probably never compete well with opaque systems with respect to thermal performance, as noted above, today there are various innovative new curtainwall systems available

that can provide notable improvements in thermal performance. There are also various modifications and enhancements available for traditional systems.


Some of these modifications can provide substantial thermal improvements without having any significant impacts on the fabrication needs, constructability, weatherproofing, or long-term load-carrying capacity of the systems; and some modifications can impact cost only modestly. Some other approaches can have a larger impact on the constructability, cost, and, potentially, the long-term performance and durability of the system, while the expected service life of some systems and features is unclear due to lack of a track record.

As always, we recommend performing rigorous and thoughtful due diligence reviews of all newer products and technologies, and reviewing the track record of each system and feature to the extent possible.

We suggest considering the following when attempting to achieve good thermal performance of a curtainwall system:

- Balance thermal performance desires with other important con-

siderations such as constructability (including experience of local fabricators/installers), durability, and expected service life.

- Use curtainwall assemblies that have a track record of good performance in the project climate to the extent possible.
- Confirm that the curtainwall assembly has been put through performance testing with proposed framing changes and accessory products.
- Consider doing performance testing on the project-specific curtainwall assembly prior to widespread installation on the building.
- Require project-specific structural calculations that consider all related loads on all applicable materials, including accessory materials as applicable. Require project-specific thermal calculations of overall systems with project-specific components included (IG units, etc.). 



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