

Breaking Up Is(n't) Hard to Do

BY GEOFF WEISENBERGER

Multiple makers of structural thermal break products share their thoughts on thermal bridging and how to address it in steel buildings.

THERMAL BRIDGING has been around forever, though it hasn't always been known by that name and has only somewhat recently become a consideration in the U.S.

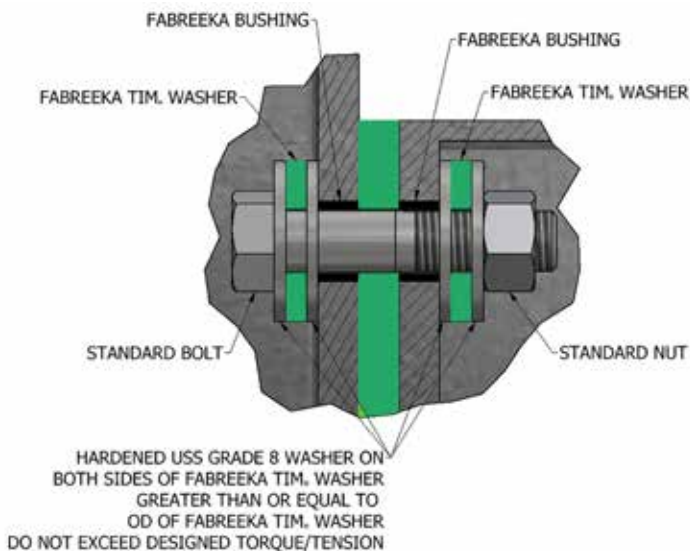
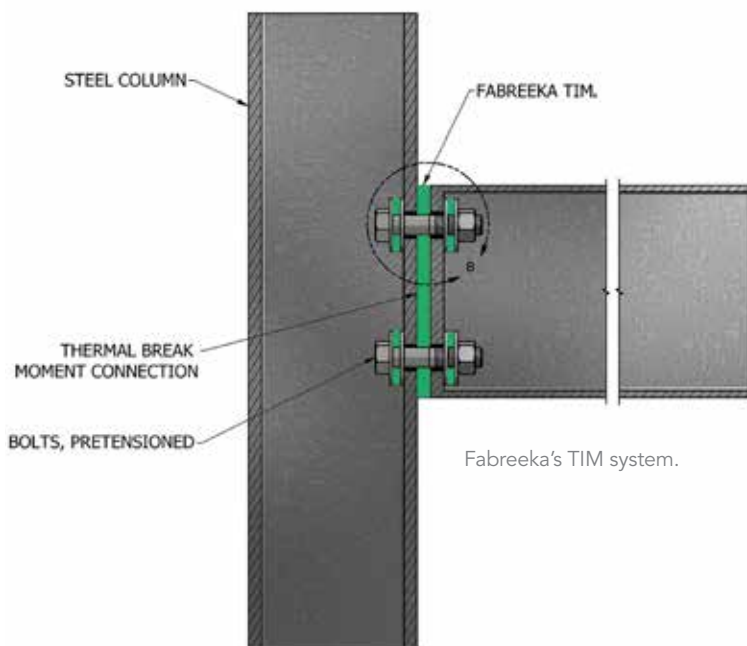
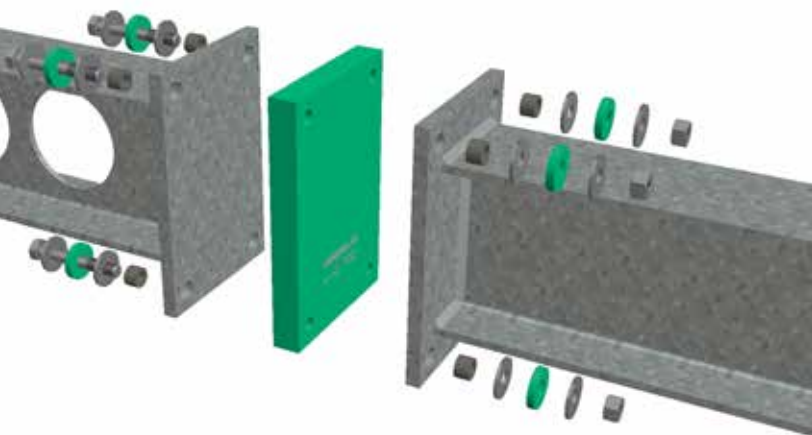
Simply put, thermal bridging is the transfer of extreme heat or cold through a building envelope via a "bridge," typically a metal element. While all materials transfer heat or cold to a certain degree, metals do so with much more efficiency. Problems can occur when this transmission produces undesirable hot or cold spots in a building, increasing HVAC demands or creating condensation issues.

While building designs themselves can minimize the effects of thermal bridging, there are often situations where structural steel must penetrate the building envelope. Luckily, multiple manufacturers now offer structural thermal break products to address the issue in steel buildings.

There are some structural issues that must be considered before using any of these materials. The *AISC Specification for Structural Steel Buildings* (ANSI/AISC 360) references the *RCSC Specification for Structural Joints Using High-Strength Bolts*. Section 3.1 of the *RCSC Specification* states, "Compressible material shall not be placed within the grip of the bolt." Also note that the commentary to Section 1.1 of the *RCSC Specification* states, "These provisions do not apply when material other than steel is included in the grip..." The designer of a joint utilizing a thermal break material should ensure that the connection including the fasteners will perform as expected with the thermal break in place in the grip.



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“Structural thermal breaks are relatively new in construction terms, and inevitably it takes time for the both the design realm and supply chain to get up to speed with addressing the issue of energy loss and condensation risk associated with linear and point thermal bridging,” says Stephen Blundell, Technical Director of Structural Thermal Break Connections with thermal break manufacturer Farrat. “The introduction of structural thermal breaks has been driven by regulation, and for designers it is relatively straightforward to identify and address thermal bridging.”

“Thermal bridging causes three main problems in buildings,” says Brent Chancellor, PE, PhD, New York City/Mid-Atlantic regional sales manager with Schöck North America, another maker of thermal break products. “A condensation/mold problem, thermal energy loss and a thermal comfort problem. Thermal energy loss is the root cause of the other two problems. When a steel canopy beam, for example, penetrates the building envelope, the surface temperature on the beam inside the building can dip below the dew point and, given moderate air moisture, condensation can form on the beam. Eliminating this condensation possibility by stopping thermal bridging through the building envelope is one of the most important reasons to use a structural thermal break.”

There are many opportunities for thermal bridging to take place in a building in terms of elements and assemblies. “The list of thermal bridging elements is large and goes beyond the well-understood balcony scenario,” notes Blundell. “We have supplied structural thermal breaks for the following building elements across the world: balconies, façade system connections to the primary frame, shading and entrance canopies, roof plant room columns, external balustrading, connections of external to internal primary building elements, isolation of substructure and basement structure elements, external staircases, fall-protection systems, window-cleaning gantry rail systems, connections to existing structures and external signage.”

“No matter what type of building element/penetration you’re dealing with, it is important that the structural thermal break is installed within the insulated envelope, or failing that it is on the warm side of the insulation and the insulation is extended from the insulated envelope around the connection,” Blundell continues. “From a constructability point of view, it is important on occasions to create a stub that would otherwise not be required in steel construction to allow the floor, façade or roof construction to progress ahead of the final connection to the external element.”

So why has it finally become a big deal? Chancellor explains: “Energy has been very cheap in the U.S. for a long time. Often, developers are focused on first cost and not necessarily what will create a high-performance building. Since energy is much more expensive in Europe, many European countries have been addressing thermal bridging problems by specifying structural thermal breaks for decades. However, U.S. energy codes are changing. If your project follows the prescriptive path of the *International Energy Conservation Code (IECC) 2015/ASHRAE 90.1-13*, then you are now required to address thermal bridging and achieve continuous insulation on the building envelope.”

And thermal bridging is an area where structural engineers can absolutely play a role. “As structural engineers, we often think that insulating the building envelope is the architect’s or mechanical engineer’s domain,” says Chancellor. “However, structural engineers can have a significant impact on the energy efficiency and sustainability of the building by working with architects to prevent thermal bridging from structural members—shelf angles, canopy beams, balcony beams, rooftop dunnage, etc.—that penetrate the building insulation layer. By providing and specifying structural thermal breaks, structural engineers can significantly reduce energy loss and condensation problems in the building.”

According to Chancellor, structural thermal breaks should be placed so that they are in line with the insulation on the rest of the building envelope. This placement location means that the definition of continuous insulation in IECC 2015/ASHRAE 90.1-13 will be met. To incorporate a structural thermal break in a canopy beam, for example, the beam will be cut at the building envelope and end plates will be shop welded to form a butt end plate moment connection, and a structural thermal break will be installed between the two end plates.

“Talk with your architect about the thermal performance requirements of the structural thermal break,” he suggests. “Typically, to be thermally effective, the structural thermal break will need be 2 in. to 3 in. thick. In fact, if the thermal break is not thick enough, the thermal bridging problem can be made worse due to the increased area of the end plate relative to the beam area.”

How and where a break product is used also matters. “Engineers must consider the loads applied on the pad, says, Luis De Jesus, engineering manager of another thermal break manufacturer, Fabreeka. “Some of our thermal break materials are only intended for low loads and no moments while our standard TIM product is intended for high loads and moment connections, which may be overkill on light-duty applications.”

“The thickness of the thermal break must be determined by considering the entire envelope of the building,” De Jesus continues. “There is a thickness where a thermal break cost can be offset by the energy savings, but that can only be done by considering the entire envelope of the building and running a thermal analysis. Typically the thickness will need to be ½ in. or greater for the main plate, and all washers are ¼ in. thick.”

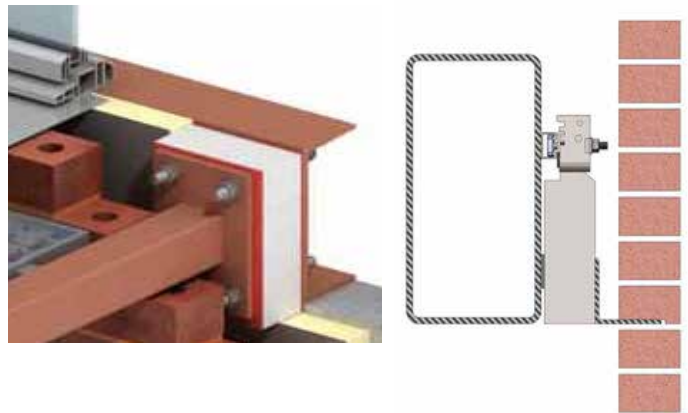
“In our experience, design teams are very familiar with the performance requirements of the building envelope—planar elements like façades, windows, roofs and such—but not linear or point thermal bridges,” says Blundell. “Point thermal bridging requires 3D thermal modelling analysis and the model must include all the building fabric around it. We find that this analysis is often overlooked and considered too expensive to undertake, and often any decision is left until late and invariably with the supply chain to resolve. Where it is undertaken, it is often driven by regulatory or client requirements, where the detail poses significant condensation risk or where there are many identical details, which will have a significant impact on the building energy model.”

How bad is the problem? The effects can be rather significant. It has been demonstrated that heat flow through building details can be underestimated by almost 70%, according to Rob Haley of Armatherm, which makes thermal break products.

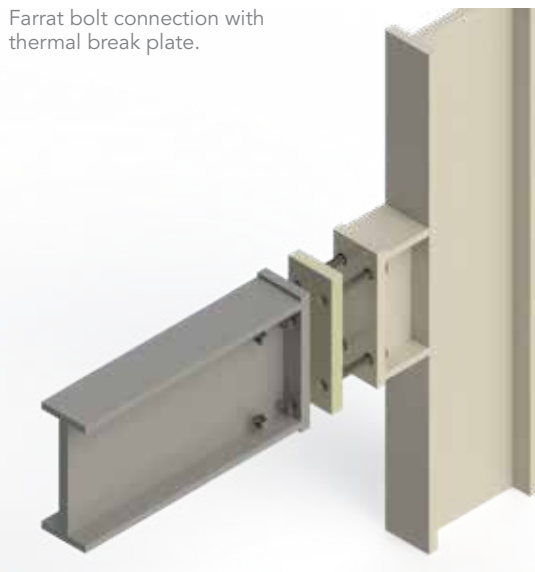
Schöck’s Isokorb thermal break pad between two steel members.



Halfen’s HIT steel-to-steel thermal connection (left) and a detail of its FK4 masonry façade support system as attached to HSS framing (right).

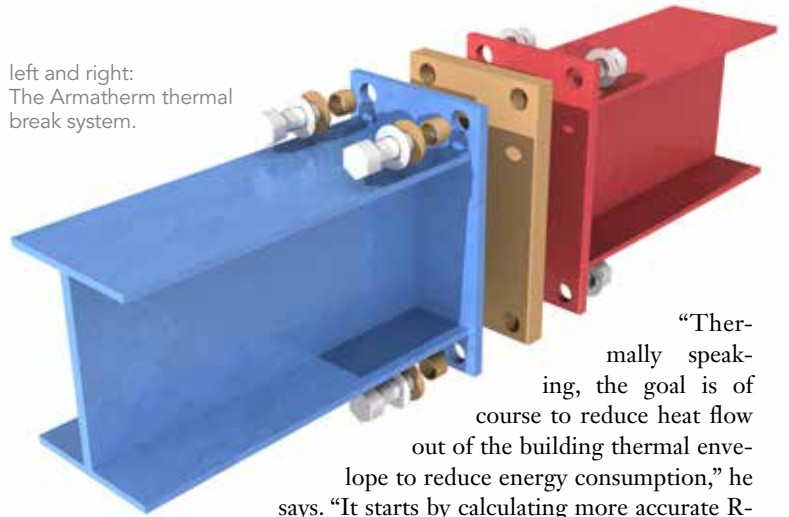


Farrat bolt connection with thermal break plate.





left and right:
The Armatherm thermal
break system.



“Thermally speaking, the goal is of course to reduce heat flow out of the building thermal envelope to reduce energy consumption,” he says. “It starts by calculating more accurate R- and U-values of building walls, roofs and foundations. As the energy codes change to include higher R-values, more accurate design must be done to determine what the actual, effective R-values of wall and roof assemblies really are. In the past, thermal bridges have been ignored or overlooked because the thought process was ‘It’s only a small area, how much energy could possibly be lost?’ However, heat does not flow as a function of area in parallel paths but rather in multiple directions, so the total heat loss coming out of a wall due to thermal bridging is much higher than previously thought. So it starts with better analysis and whole-building energy modeling to determine the overall heat loss of a building, which includes the effects of thermal bridging.”

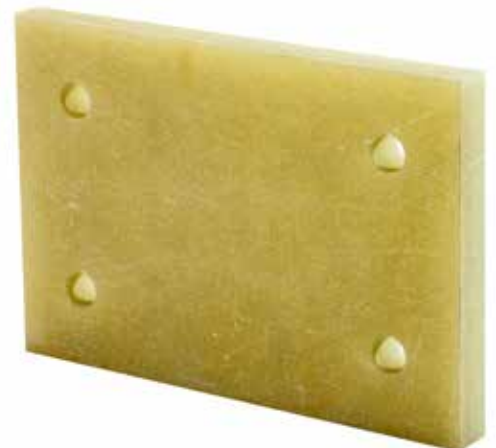
“In addition to preventing heat loss in connections, structural thermal breaks also help to push the dew point outside of the building envelope. This is important in buildings where the relative humidity is higher than normal and the dew point is easy to achieve when internal material surfaces cool to temperatures below the dew point, creating condensation.”

While 70% is an extreme case, notes De Jesus, there are buildings where this is possible. “A building with many balconies and canopies is a good example of a large thermal bridging problem,” he says. “In order to determine payback on the thermal break a thermal analysis of the building envelope must be done. Remember: Every building is substantially different.”

So what makes a good thermal break product? Structural speaking, says Haley, thermal break materials must have low thermal conductivity *as well as* high strength. Materials that deflect and creep considerably should not be used in steel framing connections or wall attachments even if they have a low conductivity value—and of course, there must be no compromise in the structural integrity of the connections. He also notes that all of Armatherm’s thermal break materials have been evaluated



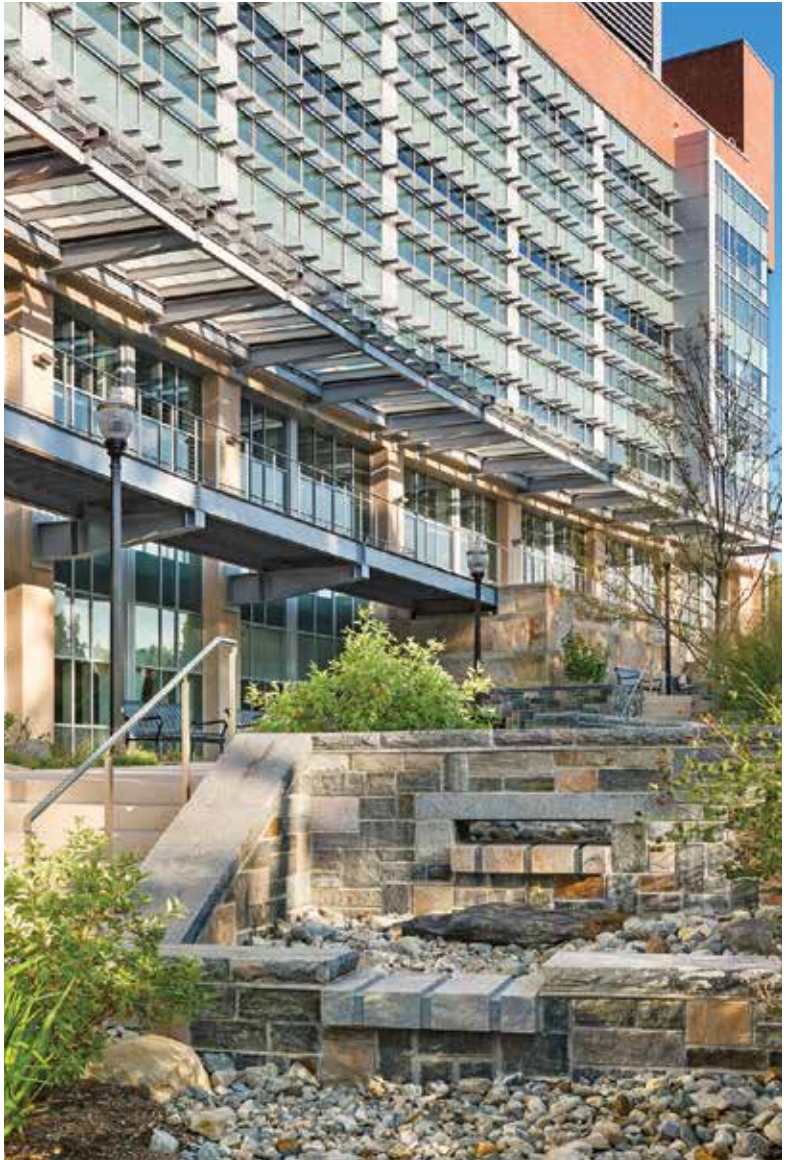
left: Farrat structural
thermal break
(FSTB) plate.
right: A steel-to-steel
connection using an
FSTB plate.



and tested in shear and moment connections to prove that the materials do not compromise connections. In addition, bolt force and rotation have been evaluated within these connections to satisfy RCSC design requirements for “filler” plates.

Another consideration is how thermal breaks affect the rest of a structural system. “If the structural thermal break is a shelf angle or canopy beam, there is little to no impact on the rest of the structure when you use a structural thermal break,” notes Chancellor. “However, there are other situations where using a structural thermal break will need to be accounted for in the design of the structure. For example, if structural thermal breaks are used in beams that are part of the lateral force-resisting system, then the change in beam stiffness and the capacity of the beam connection need to be considered in the structure’s design.”

Of course, all of this would be moot without factoring in payback. Haley points to research showing heating energy versus effective wall R-values, which include the effects of thermal bridging in several U.S. cities, noting that it is obvious that as the R-value decreases, the energy consumption increases. “The key is to run this type of analysis with and without thermal breaks to determine the energy cost of operating a building, then subtracting the thermal break costs and calculating payback,” he says. “This has been done in several papers using concrete construction, where currently the breaks are quite expensive and the payback



The Life Science Laboratories building at the University of Massachusetts, Amherst (UMass)—fabricated by AISC member and certified fabricator Capco Steel Erection Company—incorporates Schöck’s Type 22 structural thermal break where steel cantilevers penetrate the insulated building envelope, reducing heat loss by approximately 50% at each penetration.



Tnemecc offers a non-structural thermal break product that can be sprayed directly onto steel in a shop environment.



is quite long. In steel construction however, the cost for a typical break is negligible compared to the energy savings, especially in cladding connections where steel Z girts are replaced with our girts, improving the efficiency of a steel stud wall by over 50%.

Modeling is a necessity, notes Nick Cekine, PE, manager of field engineering services with Halfen, another maker of thermal break products. “The energy calcs for a building are typically handled by the architect,” he says. “We supply the necessary energy calculation coefficients needed by the architect to develop the building energy model. The thermal coefficients are obtained by specific testing done by third-party companies that are experts in the requirements. The architect uses this information to develop the LEED required life-cycle cost analyses to determine whether their total building design will receive a LEED Platinum, Gold, Silver, etc. certification.”

Now that it’s been noticed, the issue isn’t going anywhere and will continue to play a factor in steel building design.

“The market for structural thermal breaks has grown every year,” says Cekine. “With the IECC incorporating newer and more stringent energy-conservation requirements for buildings, the market is expected to continue to grow. It should continue to provide increasing opportunities for steel fabricators to design, market and implement their solutions.” ■

For more information on the topic of thermal bridging, visit www.aisc.org/sustainability to view the document Thermal Bridging Solutions: Minimizing Structural Steel’s Impact on Building Envelope Energy Transfer.

Here are brief descriptions of the structural thermal break offerings from the companies mentioned in this article—as well as one non-structural product.

Armatherm

Armatherm designs and manufactures low-thermal-conductivity/high-compressive-strength structural thermal break materials. These materials have been used in more than 7,000 structural steel framing connections, transferring load in moment and shear conditions. Armatherm FRR material is made of a reinforced thermoset resin, which is fire-resistant and has very limited creep under load, making it the ideal material for use in structural and facade thermal break connections. It can be used anywhere a penetration or transition creates a thermal bridge in the building envelope. Improvements in the effective U-value of wall assemblies can be realized by as much as 60% to 70%.

www.armatherm.com

Farrat

Farrat structural thermal break (FSTB) plates are high-performance thermal insulators used between horizontal and vertical connections of internal and external elements to prevent thermal or cold bridging. They provide a simple, economical and effective solution to meeting regulations by reducing heat loss and the risk of condensation. FSTBs are available in a number of grades, combining both low-thermal-conductivity and high-compression-strength characteristics. Farrat TBK and Farrat TBL Plates are available in a variety of thicknesses and are precision-CNC-cut (2D and 3D) to suit bespoke connection details. In comparison to mechanical structural thermal break systems (modular), the Farrat solution provides the ability to create bespoke connections, which take up less space within the construction.

www.farrat.com

Schöck

Schöck’s Isokorb modular-type structural thermal break uses a pair of stainless steel bolts that pass through a pair of stainless steel plates. A small stainless steel hollow structural section (HSS) is welded between the two steel plates to ensure a rigid connection with no creep concerns. Stainless steel has about 70% less thermal conductivity than carbon steel. Multiple modules are used to carry the tension and compression of the bending moment force couple, as well as the shear in the connection. A minimum of two modules is typically used per connection, and the number of modules increases as the loads at the connection increase. The area between the modules is filled in with rigid insulation to complete the insulated structural thermal break.

www.schock-na.com

Fabreeka

Fabreeka-TIM is a load-bearing thermal break used between flanged steel connections. The primary benefit is that it maintains structural integrity while reducing energy loss. Made from a fiberglass-reinforced laminate composite, it is available in several thicknesses: ¼ in., ½ in., ¾ in., 1 in. and 2 in. Fabreeka uses a water jet machine for precise cutting to any configuration. The product can be supplied with Fabreeka-TIM washers and Fabreeka bushings that, when used together in a structural connection, greatly reduce the energy loss rate through conduction.

www.fabreeka.com

Halfen

Halfen’s STS (steel-to-steel) connection, part of the HIT insulated connection system, provides a thermal break for continuous balcony elements, transferring bending moments and positive and negative shear forces while reducing heat loss by 50% compared to direct steel connections. The company’s FK4 system uses a steel bracket and relieving angle to support a masonry façade while permitting continuous insulation behind the angle. The system is able to accommodate thicker wall cavities using a thinner and lighter material than that of a traditional shelf angle.

www.halfen.com

Tnemec

Tnemec’s Aerolon offers a non-structural spray-applied thermal insulation option that combines high-performance coating technology with an insulating solid: aerogel. Aerolon is the first fluid-applied coating to act as an effective non-structural thermal break, helping to regulate heat transfer and control condensation within and in-board of the building envelope. With a low thermal conductivity of 35 mW/mK, Aerolon helps keep surface temperatures above the dew point, reducing condensation and inhibiting moisture inside walls. When applied to common thermal bridging areas—such as pass-through I-beams, fins, canopies, roof davits or window frames—the insulating coating reduces the thermal conductivity of the substrate, limiting the transfer of exterior temperatures through building penetrations.

Visit www.tnemec.com/thermalbreak for more information. You can also read more about the product in the December 2016 article “A Fluid Solution,” available at www.modernsteel.com.