TECHNICAL BULLETIN

METAL CONSTRUCTION ASSOCIATION

Energy Conservation for Exterior Wall Cladding Assemblies

Overview:

Whether designed to impress with vibrant colors and articulating designs, or just to act as a rainscreen system, metal cladding exteriors are nothing new to the construction industry. Metal claddings such as profiled metal, metal plate, insulated metal panels (IMP), and metal composite materials (MCM) are common throughout the construction world; however, with a larger focus on building energy efficiency and a push towards Net-zero ready construction, the method of attaching the cladding to the exterior wall has become a vital detail that cannot be overlooked in today's energy designs. Focusing on improvement of the exterior wall thermal performance not only helps meet more demanding building codes, but also reduces the operating costs of the building where it has been noted that roughly two-thirds of the total energy used by building occupants was wasted. This need to improve thermal performance has pushed for newer and more unique methods of attaching the exterior wall cladding with a specific focus on reducing the thermal bridging caused by conductive materials penetrating the insulation.

Discussion:

"Buildings contribute 40% of total emissions in the USA" in terms of total energy consumption. *(Center for Sustainable Systems, University of Michigan. 2021. "U.S. Renewable Energy Factsheet." Pub. No. CSS03-12)* In 2018, roughly two-thirds of the total energy used by building occupants was wasted and a significant portion of energy loss through the building envelope can be traced to the connection of the cladding, or any exterior components, to the building structure. With a push for Net-zero ready construction by 2030, buildings need to be designed, retrofitted, and built to conserve energy, with a focus on occupant thermal comfort. A significant component in the goal is performance improvement of the building envelope.

In North America, guidelines established in both the International Energy Conservation Code (IECC) and ASHRAE 90.1 have become the controlling factors in building design. In fact, only a handful of states have yet to adopt some form of ASHRAE 90.1 as a statewide energy code for commercial construction. Overall energy efficiency of the wall assembly, thermal bridging, and effectiveness of insulation are no longer suggested considerations; rather, they are requirements moving forward for new construction and, in certain cases, building retrofits.

Thermal Bridging Basics:

Increasing the thickness of insulation produces diminishing returns when comparing the nominal R value to the effective R value if thermal bridging is not taken into consideration during design and product choices. Thermal bridging occurs when a conductive material penetrates through the insulation. This bridge allows thermal transmission through the insulation, thereby reducing the effectiveness. These thermal bridges can have a huge impact on the building energy performance.

For example, a wall assembly with exterior insulation using a continuous vertical Z-girt to attach cladding to the structure provides a nominal R-Value of 18.2, but an effective R value of only

9.7. This equates to a loss of more than 50% in R value.
https://thermalenvelope.ca/pdf/thermal_data_sheet_5.1.5.pdf?version=v1.6.1

In simple steel stud construction, with no exterior insulation, the stud acts as a thermal bridge that has always been referenced as a "cold spot" in the wall. This effect is minimized with the use of exterior insulation; however, the cladding supports still act as a thermal bridge allowing heat transfer through the exterior insulation, resulting in thermal loss and a reduction in building energy performance.

As seen in Figure 1, heat flow through the exterior wall assembly is identified by the red zones. This thermal bridging can be significantly mitigated through the addition of continuous exterior insulation as shown by the image on the right where the area of red zones has been greatly diminished.

The cladding attachment system used can be a primary cause for thermal bridging if there is no consideration into building details or the products used to attach the cladding to the structure. Thermal bridging caused by these attachments can be mitigated by using thermally broken systems that are engineered and focused on reducing thermal transfer throughout the building envelope.

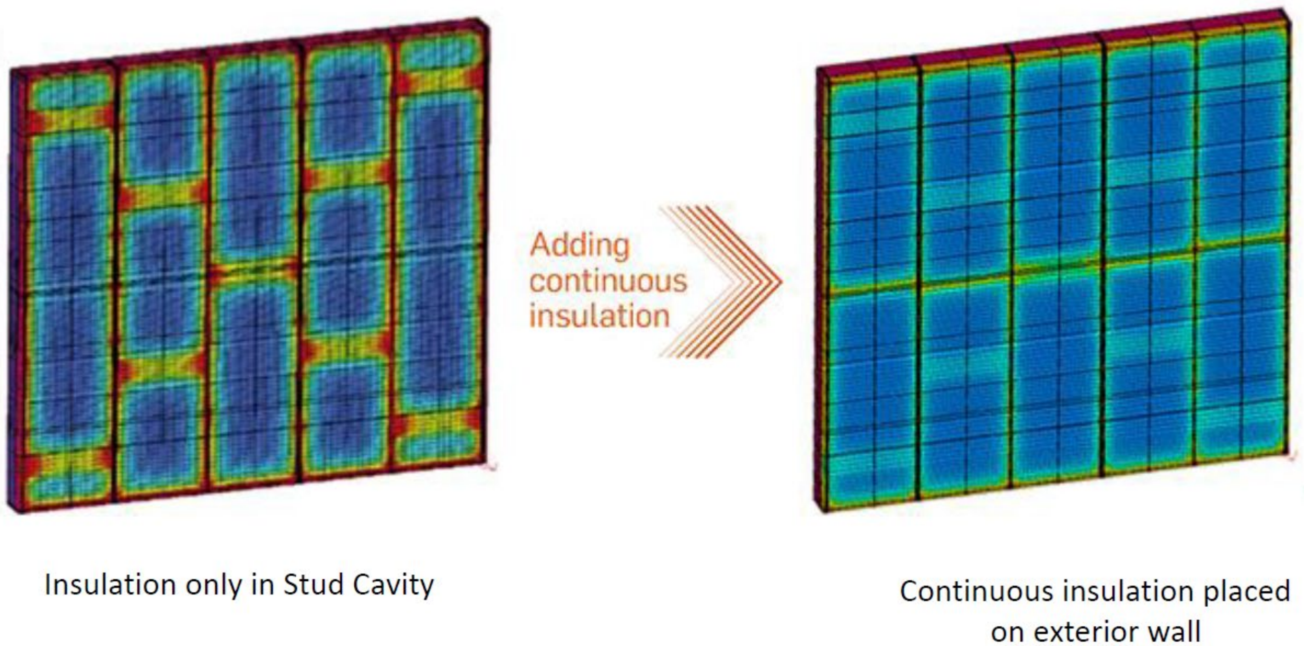

Figure 1: Thermography of Wall Assembly with and Without Continuous Exterior Insulation

Let's look at an example of the increase in effective R-value by introducing thermal clip attachments. There are many variables that go into this calculation based on the Parallel Path method as described in Chapter 27 of the ASHRAE Book of Fundamentals. Following is an example of a generic thermal clip and rail assembly on a steel stud structure with insulation in the stud cavity.

https://thermalenvelope.ca/catalogue/5.1.54/

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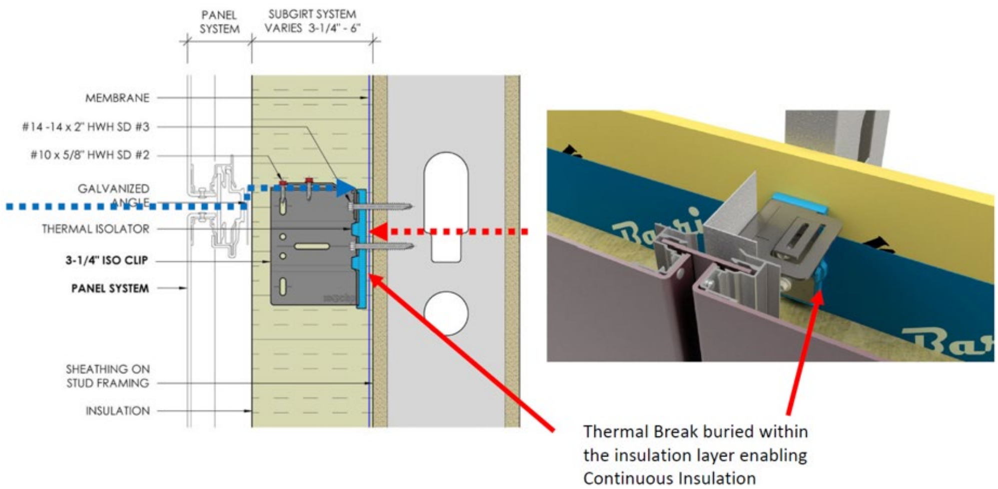


Figure 2: Thermally Broken Clip Example and Rendering Showing Path of Thermal Transfer and Thermal Break

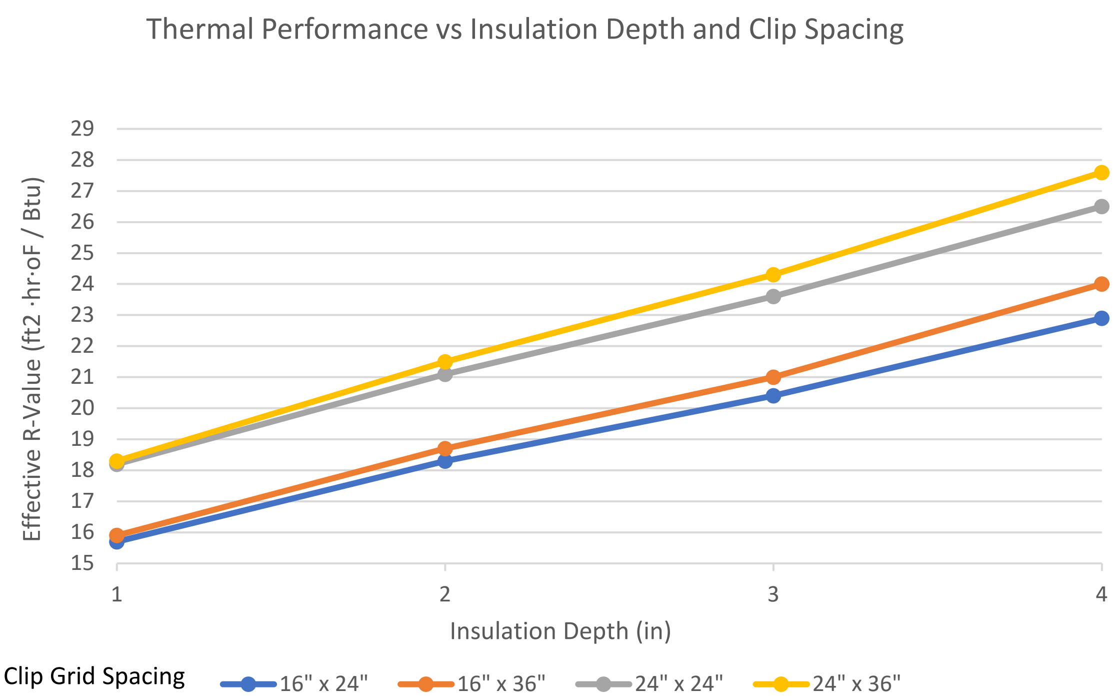


Figure 3: Thermal Performance vs Insulation Depth and Clip Spacing

Figure 2 shows one example of the use of thermal isolation clips and Figure 3 shows the effective R-value difference when increasing the insulation thickness, but also when changing the clip spacing. This figure depicts how the number of clips on the wall assembly has a direct impact on the effective R value of the wall. Each clip adds a penetration through the insulation allowing thermal transfer to occur and resulting in a loss in performance. The thermally broken system greatly reduces the impact of thermal bridging, but it does not eliminate it. Hence why it is important to not only consider the insulation depth and the installation system used, but also the clip spacing required to balance between thermal efficiency and structural limitations in the project design.

Figure 2 highlights how much of a difference clip spacing makes with a jump in the effective R value from R22.9 to R27.6 with all design elements being equal except for increasing the clip spacing from 16"x24" to 24"x36".

It should also be noted that clips come in a variety of materials, from aluminum to fiber glass and while some materials may be less conductive, the structural capacity of the clips, determined by wind load and cladding weight, must be considered in the overall design.

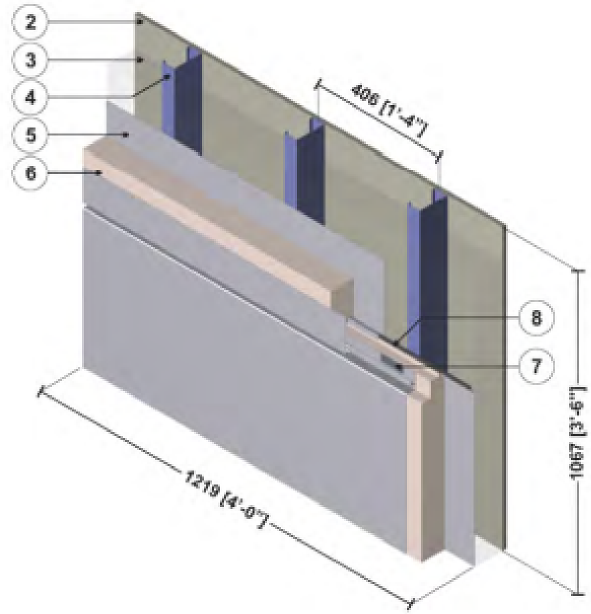
Many metal cladding systems are identified in the Morrison Hirschfield *Building Envelope Thermal Bridging Guide v1.6 (2021)* created as for BC Hydro and a number of project Co-Sponsors in British Columbia, Canada. Building Envelope Thermal Bridging Guide Version 1.6 (bchousing.org)

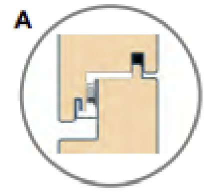
Following are several alternative metal system depictions. These are intended to be examples of how thermal isolation can be achieved. There are many variations of installation that can accomplish this goal. Contact the building envelope designer for specific solutions.

METAL CONSTRUCTION ASSOCIATION
8735 W. Higgins Road, Suite 300, Chicago, IL 60631
847.375.4718 I mca@metalconstruction.org I www.metalconstruction.org

Detail 6.1.3

Horizontal Insulated Metal Panel – Clear Wall with Horizontal Connection Joint and Steel Stud Backup Wall





Horizontal Joint

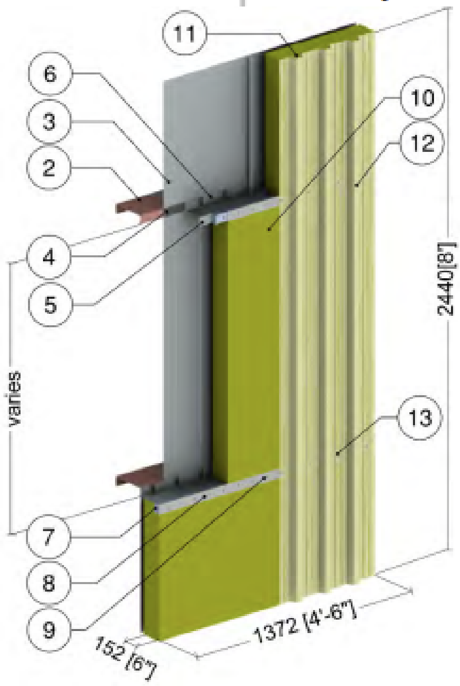
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film[1]	-	-	R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	Air in Stud Cavity	-	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
4	3 5/8" x 1 5/8" Steel Studs (16" o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Polyisocyanurate Insulation	3" (76)	0.143 (0.02)	R-21.0 (3.70)	1.8 (28)	0.29 (1220)
6	Steel Facer Skin	24 Gauge	430 (62)	-	489 (7830)	0.12 (500)
7	#14 Steel Fasteners	1/4" (6) Ø	314 (45)	-	489 (7830)	0.12 (500)
8	Sealant	Varies	2.4 (0.35)	-	-	-
9	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

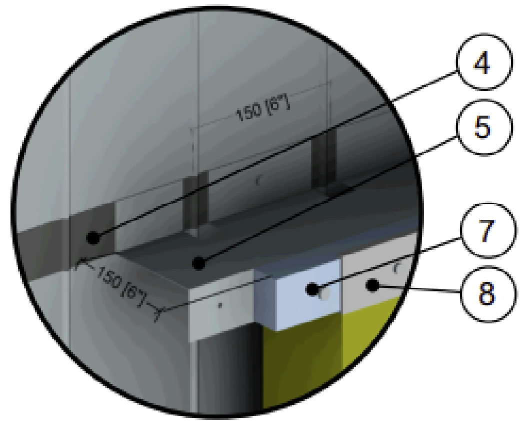
[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail pages are from the Building Envelope Thermal Bridging Guide

Detail 6.1.5

Structural Sheet Steel Wall with Cladding Supported by Notched Z-Bar for Baseline System – Clear Wall





Notched Z-Bar with Thermal Block and U-Bar

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films (left side)[1]	-	-	R-0.7 (0.12 RSI)	-	-
2	8 x 2 Steel Girts @ 48" o.c.	0.10" (2.6)	347 (50)	-	489 (7830)	0.12 (500)
3	Galvanized Steel Liner Panel	24 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Thermal Tape	1/8" (3.2)	0.097 (0.014)	-	-	-
5	Galvanized Steel Notched Z-Bar	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
6	#12 Galvanized Steel Fasteners	0.21" (5) Ø	430 (62)	-	489 (7830)	0.12 (500)
7	Thermal Block Insulation	2" (50)	0.200 (0.029)	R-10 (1.76 RSI)	9.4 (150)	0.23 (1000)
8	Galvanized Steel U-Bar	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
9	#12 Galvanized Steel Fasteners (7.5" o.c.)	0.21" (5) Ø	430 (62)	-	489 (7830)	0.12 (500)
10	Exterior Mineral Wool Insulation	6" (152)	0.238 (0.034)	R-25 (4.4 RSI)	1.8 (28)	0.29 (1090)
11	Air Gap[2]	-	Varies	-	0.075 (1.2)	0.24 (1000)
12	Galvanized Steel Cladding	24 Gauge	430 (62)	-	489 (7830)	0.12 (500)
13	#12 Galvanized Steel Fasteners	0.21" (5) Ø	430 (62)	-	489 (7830)	0.12 (500)
14	Exterior Film (right side)[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces was found using ISO 100077-2

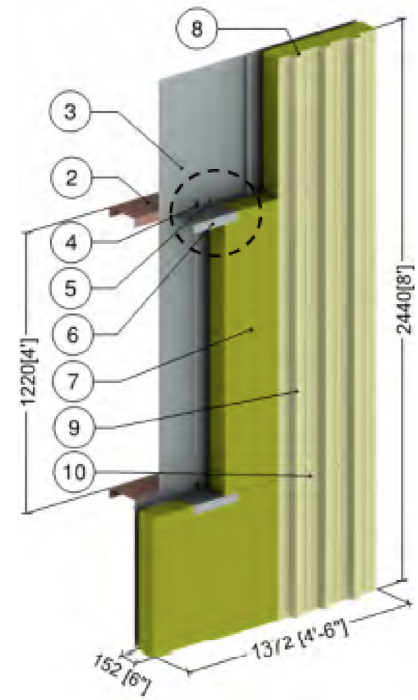
Detail pages are from the Building Envelope Thermal Bridging Guide

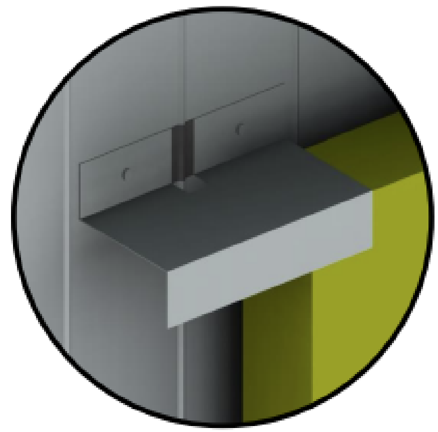
METAL CONSTRUCTION ASSOCIATION
8735 W. Higgins Road, Suite 300, Chicago, IL 60631
847.375.4718 | mca@metalconstruction.org | www.metalconstruction.org

BUILD LEGACIES METAL

Detail 6.1.6

Structural Sheet Steel Wall with Cladding Supported by Intermittent Notched Z-Bar – Clear Wall





Intermittent
Notched Z-Bar

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films (left side)[1]	-	-	R-0.7 (0.12 RSI)	-	-
2	8 x 2 Steel Girts @ 48" o.c.	0.10" (2.6)	347 (50)	-	489 (7830)	0.12 (500)
3	Galvanized Steel Liner Panel	24 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Thermal Tape	1/8" (3.2)	0.097 (0.014)	-	-	-
5	#12 Galvanized Steel Fasteners	0.21" (5) Ø	430 (62)	-	489 (7830)	0.12 (500)
6	Galvanized Steel Notched Z-Bar	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
7	Exterior Mineral Wool Insulation	6" (152)	0.238 (0.034)	R-25 (4.4 RSI)	1.8 (28)	0.29 (1090)
8	Air Gap[2]	-	Varies	-	0.075 (1.2)	0.24 (1000)
9	Galvanized Steel Cladding	24 Gauge	430 (62)	-	489 (7830)	0.12 (500)
10	#12 Galvanized Steel Fasteners (7.5" o.c.)	0.21" (5) Ø	430 (62)	-	489 (7830)	0.12 (500)
11	Exterior Film (right side)[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces was found using ISO 100077-2

Detail pages are from the Building Envelope Thermal Bridging Guide

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847.375.4718 I mca@metalconstruction.org I www.metalconstruction.org

SUMMARY

Designers attempting to improve the whole wall thermal performance to meet higher energy efficiency standards should consider minimizing the number of penetrations and connections through the outer thermal insulation layer. Thermally isolated cladding attachment systems mitigate temperature transfer and maximize the effectiveness of insulative materials outboard of structural components.

Recent trends across North America show project specifications beginning to include more provisions for thermal bridging effects. The forecast holds a greater focus on thermally improved systems, capable of achieving maximum energy savings.

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- Advocating for the interests of our industry
- Recognition of industry-achievement awards
- Monitoring of industry issues, such as codes and standards
- Research to develop improved metal construction products
- Promotional and marketing support for the metal construction industry
- Publications to promote use of metal wall and roof products in construction

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8735 W. Higgins Road, Suite 300, Chicago, IL 60631

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