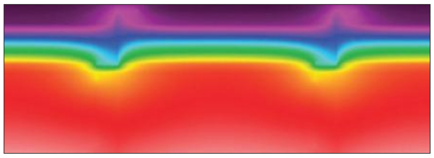
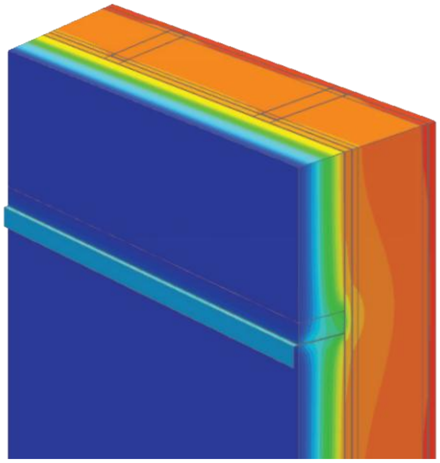
PANEL ATTACHMENT & THE ENERGY CODE:
HOW TO MEET & EXCEED THE ENGERY CODE WITH EXTERIOR MINERAL FIBER INSULATION

One specific and important part of the energy codes currently being implemented calls for an increased performance requirement on exterior wall assemblies, especially with steel-framed walls. ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 90.1, which is the basis of nearly all energy codes, has several paths to thermal compliance. However, it must be noted that the overall goal is to increase the wall assemblies' performance by making it more effective at doing its job – resisting the transfer of thermal energy so the conditioned space requires less work by the HVAC system to maintain desirable conditions.



Z-GIRT THERMAL BRIDGING



The emphasis on increased thermal performance for building envelopes has not only led to increased insulation thickness but, more importantly, how the insulation is effectively installed to maximize the investment. Design and construction professionals have struggled with how to achieve the requirements of the energy codes and have settled upon the use of 'Z' furring strips (aka "girts") for a number of years. Now the industry's designs, means and methods are changing, and where the once-beloved simple 'Z-girt' was acceptable, it is now no longer a viable option.

This white paper explains why Z-girts and other traditional means of exterior wall construction no longer conform to code. The root cause along with some solutions and benefits will be presented.

THE BASICS: THERMAL BRIDGING

¤ Heat energy transfers from warm environments to cold environments, *e.g. interior of a building to the exterior of a building and vice-versa in warm climate zones.*

¤ Conduction heat transfer is the underlying cause of thermal bridging. The heat energy transfers through connected materials where one part of the connected materials, or assemblies, are in a warm environment and the other end of the connected materials, or assemblies, are in a cold environment – *e.g. exterior wall assemblies where one side of the wall is a conditioned space and the other side is an unconditioned space, or outside.*

¤ The rate at which the heat energy transfers is directly related to the property of thermal conductivity of the materials connecting, or bridging, the two environments – *e.g. metal is highly conductive of heat, which is why it is used for activities where conductive heat transfer is important such as cooking food on a stovetop, radiators, etc.*

¤ The goal is to keep the overall thermal conductivity of the materials bridging the two environments together as low as possible, therefore increasing the assembly's ability to resist heat transfer – *e.g. adding insulation into an exterior wall assembly is primarily to help increase the resistance to heat transfer through the entire assembly (inwards or outwards).*

¤ Bridged materials with a low resistance to heat transfer (therefore are very conductive like metal) which pass through highly resistant materials create a path for heat to follow and "go around", also known as following the path of least resistance – *e.g. metal framing members, such as steel studs, penetrating the insulation added to the assembly create a bridge and allow heat to transfer right through the insulation at 16" on center (stud spacing).*

"NOW THE INDUSTRY'S DESIGNS, MEANS AND METHODS ARE CHANGING, AND WHERE THE ONCE-BELOVED SIMPLE 'Z-GIRT' WAS ACCEPTABLE, IT IS NOW NO LONGER A VIABLE OPTION."

WHY DOES THIS MATTER?

Penetrations are pathways for heat to transfer and are known as thermal bridges. The greater the pathway, the greater the amount of heat energy lost creating higher operating costs amongst other risks.

To help reduce this, the assembly design must reduce the amount of conductive material bypassing the insulation, use greater thermally resistant materials within the assembly and finally break the bridge, or connection, of materials transferring heat energy.

When a wall assemblies R-value is considered, it is important to realize the assemblies R-value is not the rated R-value of the insulation. This is proven with batt-insulated steel stud wall assemblies by the ASHRAE Standard 90.1, where it states R-19 batt insulation in a steel framing application only has an effective, or real, R-value of 7.1 (less than 40% of its rated value). This is primarily due to the steel studs penetrating the insulation, creating a bridge for heat to transfer. The insulation on its own is R-19 – that is true, however once it's made part of an assembly, the installation method will begin to affect it – creating an effective R-value. Effective R-value is the inverse of the U-value for the entire wall assembly (which is commonly referenced within the code).

WHAT ABOUT EXTERIOR INSULATION?

The same challenge of deteriorating insulating values can be seen on exterior insulated wall assemblies as well, where only a fraction of the insulations stated R-value is actually delivered. Using a typical continuous furring channel for cladding attachment, such as a vertical Z-girt, will only allow the insulation to perform at ± 40% of its rated R-value. Rotate the cladding attachment Z-girt 90° to the horizontal and you will only increase the effectiveness of the insulation to ± 50% of its rated R-value. Therefore the building owner, or occupant, is only receiving half of what they have actually paid for.

WHAT AFFECTS THE THERMAL BRIDGING WITH EXTERIOR INSULATION?

There are several characteristics of the cladding attachment methodology and configuration effecting overall thermal performance. In an effort to understand how to maximize the insulations thermal performance, it is important to review just a few of the culprits affecting the exterior insulations clear wall performance. These include the amount of material penetrating the insulation, the actual conductivity of the material penetrating the insulation and lastly what amount of contact area between all bridged/connected parts.

Opaque (clear) Wall Effective R-Value Comparison for Exterior Insulated Steel Stud Assemblies (NO Batt Insulation in Stud Cavity)

Insulation Thickness	Nominal Exterior Insulation R-Value	Nominal Entire Assembly R-Value	Continuous Vertical Girts @ 16" O.C.			Continuous Horizontal Girts @ 24" O.C.			Intermittent Brackets (non-thermally isolated) @ 24" O.C.			Knight Wall MFI-System™ (brackets @ 24" O.C.)		
(inches)	(ft²·°F·hr/BTU)	(ft²·°F·hr/BTU)	Eff. R-Value	U-Value	% Efficient	Eff. R-Value	U-Value	% Efficient	Eff. R-Value	U-Value	% Efficient	Eff. R-Value	U-Value	% Efficient
2.0	8.4	11.9	7.8	(0.128)	51%	8.7	(0.115)	62%	9.7	(0.103)	74%	**10.8**	**(0.093)**	**87%**
3.0	12.6	16.1	9.2	(0.109)	45%	10.6	(0.095)	56%	12.3	(0.081)	70%	**14.1**	**(0.071)**	**84%**
3.5	14.7	18.2	9.7	(0.103)	42%	11.4	(0.088)	54%	13.5	(0.074)	68%	**15.7**	**(0.064)**	**83%**
4.0	16.8	20.3	10.3	(0.097)	40%	12.2	(0.082)	52%	13.9	(0.072)	62%	**17.2**	**(0.058)**	**82%**
5.0	21.0	24.5	11.3	(0.089)	37%	13.5	(0.074)	48%	15.6	(0.064)	58%	**20.1**	**(0.050)**	**79%**
6.0	25.2	28.7	12.0	(0.083)	34%	14.7	(0.068)	44%	17.1	(0.059)	54%	**22.7**	**(0.044)**	**76%**

* The base wall (air films, sheathings) equal R-3.5. The overall nominal resistance of the assembly is R-3.5 + the nominal resistance of the insulation.

* % efficient accounts for insulation R-value only since the base wall R-value is constant amongst all assemblies & not added - Eff. R-value minus base wall R-value divided by nominal insulation R-value

"ONCE INSULATION IS MADE PART OF AN ASSEMBLY, THE INSTALLATION METHOD WILL BEGIN TO AFFECT IT - CREATING AN EFFECTIVE R-VALUE."

With a greater cross sectional area of material penetrating the insulation, the greater the amount of heat energy can be moved. The best way to think of this is an eight lane interstate versus a two-lane road with the cars analogous of the heat energy. Which one can move more cars (heat energy) from point A to point B per hour?

With material penetrating the insulation, the actual thermal conductivity of the material used for the attachment system will allow for more heat energy to be transferred. It is important to note that every material in the world has the property of thermal conductivity, but some materials are very low in conductivity whereas others are very high. Aluminum has a far greater thermal conductivity versus steel. Therefore, more heat energy will be able to flow through a cross section of aluminum versus steel, decreasing overall performance even further. Looking at the road and car analogy, aluminum is a 75 MPH interstate whereas steel is a 35 MPH street. Which way moves cars (heat energy) from point A to point B fastest?

How the material contacts the substrate and different pieces within the cladding attachment assembly also has an effect on how heat energy transfers. The greater the contact area between conductive materials, the more heat energy can transfer and move from point A to point B. If we limit contact area, we can "bottleneck" and limit the heat energy transfer. So looking at the road and car analogy one last time, reduction in contact area is like a traffic jam on a busy interstate. The cars (heat energy) are still moving from one point to another, but at a much slower rate.

THERMALLY ISOLATED INTERMITTENT BRACKET WITH 57% REDUCTION IN CONTACT AREA
- BY KNIGHT WALL SYSTEMS

THE BOTTOM LINE IMPACT OF INCREASED THERMALLY EFFICIENT WALL ASSEMBLIES

It is overwhelmingly obvious that the simplest, most excepted and versatile way to increase a wall assembly's thermal performance is by use of insulation applied to the exterior of the wall. Exterior insulation is typically marketed as "continuous insulation". Though more than likely it will not be installed within the assembly without thermal bridges as specified by ASHRAE Standard 90.1 (definitions: ci). More than likely it will have some kind of girt, bracket or clip penetrating it, creating a thermal bridge. Now the real questions are: how big of a thermal bridge is it, what does it do to the wall and what does it mean for the owner?

Of course, allowing only screw fasteners to penetrate the insulation is the most preferred methodology to reduce and nearly eliminate thermal bridging, but not all projects, design loads, goals or insulations will effectively allow this to occur.

Aside from only allowing screw fasteners to penetrate the insulation, as per ASHRAE, there are a few other approaches to reduce the thermal bridging:

¤ Using intermittent brackets in lieu of a continuous rail or girt will cut down on the amount of material penetrating the insulation.

¤ Specify the use of a lower conductivity material while strength and durability are not sacrificed. Steel's thermal conductivity is much lower than aluminum and provides exceptional strength and durability.

¤ Pieces of the metal attachment system should not directly contact each other. This will reduce the thermal transfer from one piece of the system to another (known as a thermal break or thermal isolation). Cutting down on the contact area with the base wall will also reduce the amount of heat transfer occurring out-of or into the conditioned space.

By reducing the thermal bridging, the overall performance of the wall is dramatically increased. Moreover, the amount of insulation (thickness) required to meet code can be reduced – including mineral fiber insulation. *As a matter of fact – it is impossible to be at or below a maximum U-factor of 0.064 with steel stud assemblies and continuous vertical or horizontal Z-girts with 6" of mineral fiber insulation or less.*

The operation cost of a facility can also be reduced with less thermal bridges. With the average cost of a kWh of electricity in 2011 at nearly 12 cents (eia.gov), reducing heating and cooling HVAC workloads can translate to substantial cost savings over the life of a building. When an R-19 batt insulated steel framed wall, 4" deep vertical and horizontal Z-girt assemblies and a 4" deep thermally isolated intermittent bracket system are compared for kWh/SF used, the bracket system wins hands down. The intermittent bracket system uses ± 55% less kWh compared to batt and ± 38% and ± 28% less compared to vertical and horizontal Z-girts respectively.

Being that a thermally isolated intermittent bracket system has less thermal bridging and performs much better than continuous furring strips, the overall thickness of insulation required for code compliance is reduced. As stated earlier, furring strips require more than 6" of exterior mineral fiber insulation whereas some intermittent bracket systems can require as little as 3.5". This not only reduces the cost per square foot per R-value of insulation required, but with a reduction in overall wall thickness, the overall useable or leasable floor area for the owner can be increased.

3D F.E.A. THERMAL MODELING

Since heat transfers through an assembly in three dimensions: outward (or inward) through the wall, up the wall and laterally across the wall all at the same time, the best and most accurate way to calculate the overall thermal resistance of a wall assembly is by use of 3D thermal modeling software.

For the 3D thermal analysis, many manufactures have used the expert services provided by Morrison-Hershfield. The CAD/FEA analysis software NX, from Siemens, was used. Using this software, MH had previously conducted a research project for ASHRAE in which a 3D thermal model was developed and calibrated to within 5% of measurements from over 30 different hotbox tests. Most all of the thermal data contained within this white paper come from either the ASHRAE research project 1365 or privately commissioned reports all using the same proven software.

+ Window area not considered. Calculations based on average heating and cooling degree-day data published by NOAA and average kWh cost published by the US EIA. The calculations are based on opaque wall area with conductive heat loss only.

KNIGHT WALL SYSTEMS MINERAL FIBER SOLUTIONS

Knight Wall Systems offers one of the building construction industry's most efficient and versatile cladding attachment systems, called the MFI-System™.

The MFI-System™ outperforms the competition by only requiring the use of 3.5" of exterior mineral fiber insulation to meet the prescriptive path requirements of ASHRAE 90.1-2007/2010 in all climate zones (U-value of 0.064).

The system can be installed in a vertical or horizontal orientation, with no effect on thermal performance, is fully warranted, highly durable and one of the most budget conscious pre-engineered attachment systems on the market today.

ABOUT KNIGHT WALL SYSTEMS

Knight Wall Systems is one of several subsidiaries of Knight Construction and Supply Inc., in business since 1968 and primarily serving industrial customers throughout the US. The firm is family owned and has more than 115 employees at its eastern Washington headquarters and manufacturing facility.

REFERENCES

www.ashrae.org (Std. 90.1 & RP-1365)
www.eia.gov
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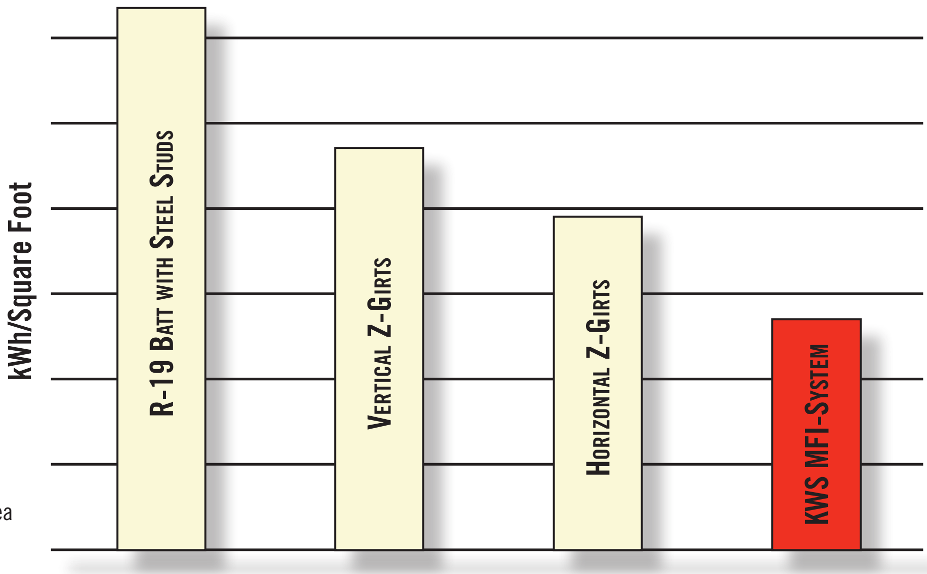
Morrison-Hershfield (report # 38123128.00 & 18123069.00)

COMPARISON OF ENERGY USAGE PER SQUARE FOOT



ALL KNIGHT WALL SYSTEMS COMPONENTS ARE MANUFACTURED IN THE USA. (PATENT PENDING)

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