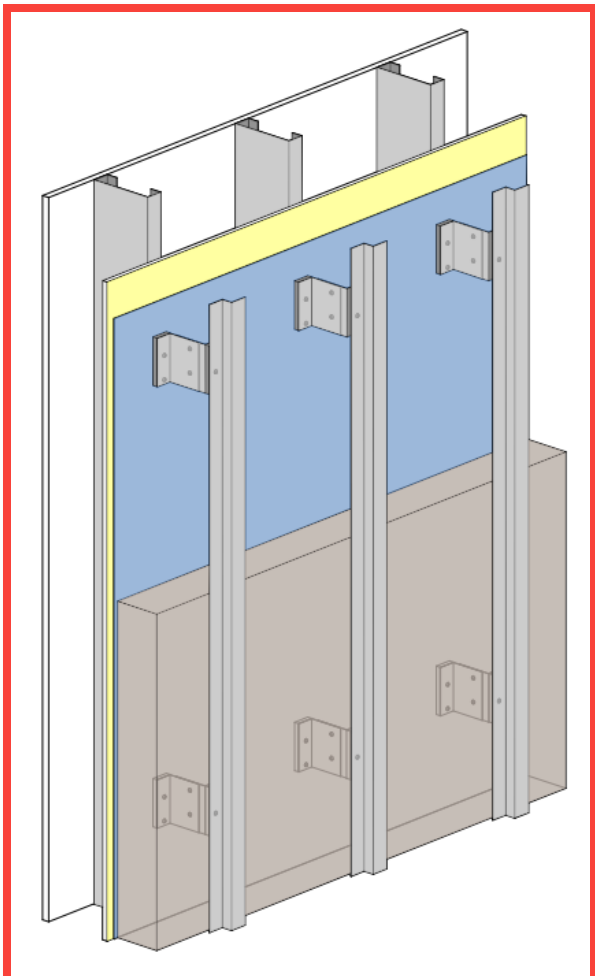
Comparative Thermal Performance

Intermittent Cladding Supports

September 27, 2018



INTRODUCTION

This document has been compiled to provide a direct comparison between various cladding attachment clips currently available in the market. Thermal modelling provides an estimate of the overall thermal performance of a wall assembly, taking into account the effects of thermal bridges. Extensive comparison has validated the accuracy of both 2-D and 3-D thermal modelling, compared to physical assembly testing (hot-box tests). See the section entitled “Validity of Results” for more discussion on these studies.

However, there are many different ways to create thermal models, each of which can be considered valid depending on the assumptions made. This makes comparing thermal modelling results for different products, completed by different organizations, using different software, nearly impossible. Unless a set of products are all reviewed using the same parameters, direct comparison of the modelling outputs is unreliable. Some parameters that may cause variations in results include, but are not limited to:

- Whether or not exterior cladding and support members outboard of the clips are included.
- Assumptions related to the amount and nature of air movement in the cavity behind the cladding.
- Exterior and interior boundary conditions.
- Spacing/layout of components.
- The method used to calculate/determine the thermal performance of various components which are composed of multiple materials.
- Various options for individual components within the assembly, and their associated thermal resistances (e.g., 12.7mm vs 15.9mm sheathing, paper-faced gypsum board vs fiberglass-faced gypsum board).

The purpose of this document is to provide a direct comparison between seven different commercially available cladding attachment clip systems. Depending on the specific assembly and materials used the project-specific effective thermal performance achieved by a given product may vary from what is shown here. For project-specific assemblies, project-specific parameters should be reviewed and incorporated into project specific modelling or hot-box testing.

IMPORTANCE OF CONSISTENT AND ACCURATE THERMAL PERFORMANCE REPORTING

As part of the effort to reduce building energy use, many building codes in North America have, or are incorporating, mandatory requirements for the thermal performance of building envelopes. There are various compliance paths available within the energy codes but they all require that the overall thermal performance of the envelope be established. Inaccurate envelope thermal resistance values can result in:

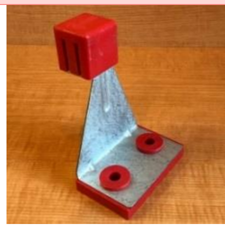
- Higher than predicted energy use, resulting in:
  - Negative environmental impact.
  - Additional operating cost for the building owner.
- Reduced thermal comfort for building users.
- Potential for interstitial condensation, leading to deterioration of building components.
- A building that is not code-compliant.

Although computer simulations have been shown to be accurate, within an accepted margin of error, when compared to hot-box testing, we must be aware that computer simulations are susceptible to human/input error. Methods and approaches for establishing thermal resistance of building walls requires further regulation in order to standardized the industry and reduce the risks associated with inaccurate estimations. Some methods the industry may consider include:

- Mandatory calibration of models, validating the results of a base model with physical testing prior to completing additional variations of the model.
- Certification and regulation of individuals and organizations completing simulations.
- Independent verification of modelling outputs, mandatory peer review by an independent organization.

CLIP DESCRIPTIONS

Table 1 – Clip Descriptions

Product	Clip Image	Clip	Thermal Break	Other Notes
Clip ‘A’		Stainless Steel	10mm Aerogel – Inside face	
Clip ‘B’		Zinc-Aluminum-Magnesium Coated Steel	Polyoxymethylene Plastic – Inside and outside face	
Clip ‘C’		Fiberglass	N/A – Fiberglass clip	Galvanized steel through fasteners are included with this clip. Two #14 screws per clip.
Clip ‘D’		Galvanized Steel	Polymer Isolator – Inside face	
Clip ‘E’		Aluminum	10mm Aerogel – Inside face Cork-Neoprene Pad – Outside face	Aerogel is not continuous, at top and bottom of clip aluminum is in contact with the substrate. Also, despite the cork there is a small area of contact between the clip and the exterior girt.
Clip ‘F’		Aluminum	Polymer Isolator – Inside face	
Clip ‘G’		Aluminum	Polymer Isolator – Inside face	

RESULTS

Results of the thermal modelling undertaken are summarized in the tables and chart below. Results are presented in h·ft²·°F/Btu (W/m²·K). The relative thermal performance chart is based on the average of all results presented below, for each type of clip.

Table 2 - Clips spaced at 16" (400mm) o.c. horizontally and 24" (600mm) o.c. vertically

Clip Name	Empty Stud Space		R20 Batt in Stud Space	
	100mm Exterior Mineral Wool	150mm Exterior Mineral Wool	100mm Exterior Mineral Wool	150mm Exterior Mineral Wool
Clip 'A'	R-17.0 (U-0.33)	R-23.9 (U-0.24)	R-24.2 (U-0.23)	R-31.2 (U-0.18)
Clip 'B'	R-14.7 (U-0.39)	R-18.9 (U-0.30)	R-21.2 (U-0.27)	R-25.5 (U-0.22)
Clip 'C'	R-13.4 (U-0.42)	R-18.4 (U-0.31)	R-19.3 (U-0.29)	R-24.0 (U-0.24)
Clip 'D'	R-12.8 (U-0.44)	R-16.7 (U-0.34)	R-18.9 (U-0.30)	R-22.8 (U-0.25)
Clip 'E'	R-11.3 (U-0.50)	R-12.0 (U-0.47)	R-19.6 (U-0.29)	R-20.8 (U-0.27)
Clip 'F'	R-10.0 (U-0.57)	R-11.4 (U-0.50)	R-15.2 (U-0.37)	R-16.9 (U-0.34)
Clip 'G'	R-8.5 (U-0.67)	R-10.0 (U-0.57)	R-14.0 (U-0.41)	R-15.4 (U-0.37)

Table 3 - Clips spaced at 16" (400mm) o.c. horizontally and 48" (1200mm) o.c. vertically

Clip Name	Empty Stud Space		R20 Batt in Stud Space	
	100mm Exterior Mineral Wool	150mm Exterior Mineral Wool	100mm Exterior Mineral Wool	150mm Exterior Mineral Wool
Clip 'A'	R-18.0 (U-0.32)	R-25.7 (U-0.22)	R-25.7 (U-0.22)	R-33.4 (U-0.17)
Clip 'B'	R-16.4 (U-0.35)	R-22.1 (U-0.26)	R-23.4 (U-0.24)	R-29.1 (U-0.20)
Clip 'C'	R-15.6 (U-0.36)	R-21.8 (U-0.26)	R-22.1 (U-0.26)	R-28.1 (U-0.20)
Clip 'D'	R-14.3 (U-0.40)	R-19.6 (U-0.29)	R-20.9 (U-0.27)	R-26.1 (U-0.22)
Clip 'E'	R-14.6 (U-0.39)	R-16.9 (U-0.34)	R-22.9 (U-0.25)	R-26.4 (U-0.22)
Clip 'F'	R-11.7 (U-0.49)	R-13.9 (U-0.41)	R-16.2 (U-0.35)	R-19.8 (U-0.29)
Clip 'G'	R-9.6 (U-0.59)	R-11.6 (U-0.49)	R-15.3 (U-0.37)	R-17.1 (U-0.33)

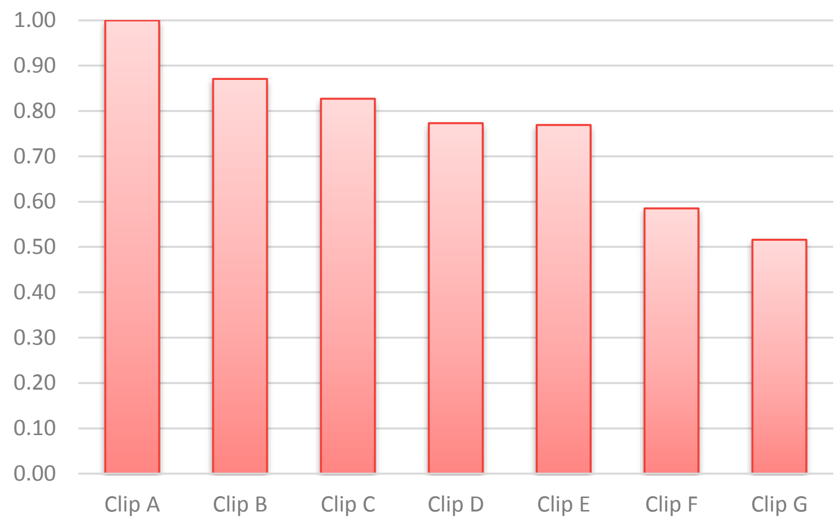


Figure 1 – Relative Thermal Performance

ASSUMPTIONS

- Assembly Materials:
  - Ext Insulation –Semi-Rigid Mineral Wool– R-4.2h·ft²·°F/Btu/in (RSI-0.74K·m²/W/25mm)
  - Stud Space Insulation – 152mm Fiberglass Batt – R-20 h·ft²·°F/Btu (RSI-3.52 K·m²/W)
  - Sheathing – 12.7mm Glass Faced Gypsum – R-0.56 h·ft²·°F/Btu (RSI-0.099 K·m²/W)
  - Interior Sheathing – 12.7mm Gypsum Board – R-0.45 h·ft²·°F/Btu (RSI-0.079 K·m²/W)
  - 152mm Steel Studs at 16" (400mm) o.c.
  - Exterior Cladding has not been modelled, addition of exterior cladding may increase the effective thermal performance of the wall assemblies
- Air Film Coefficients:
  - Exterior air film coefficient of 5.3 BTU/ h·ft²·°F (30 W/m²·K)
  - Interior air film coefficient of 1.46 BTU/ h·ft²·°F (8.3 W/m²·K)
- Thermal Conductivity of Various Clip Components/Materials:
  - Stainless Steel – 99.1 BTU·in/ h·ft²·°F (14.3 W/m·K)
  - Galvanized Steel – 430.5 BTU·in/ h·ft²·°F (62.1 W/m·K)
  - Aerogel Insulation – 0.097 BTU·in/ h·ft²·°F (0.014 W/m·K)
  - Thermal Spacers – 1.23 BTU·in/ h·ft²·°F (0.177 W/m·K)
  - Cork – 0.40 BTU·in/ h·ft²·°F (0.058 W/m·K)
  - Fiberglass – 2.08 BTU·in/ h·ft²·°F (0.3 W/m·K)
  - Aluminum Alloy – 1109.3 BTU·in/ h·ft²·°F (160 W/m·K)

VALIDITY OF RESULTS

The software used forms the basis of the NFRC 100 and CSA A440.2 National Standards for evaluating the thermal performance of windows, which are more complex than wall assemblies. In using these standards, the method has been compared against hot-box tests thousands of times and must be within a tight percentage of the test for the process to be accepted. Thus, it is fair to say that this method has been validated against physical testing many thousands of times. *In addition, WSP has had our modelling results for assemblies like those included in this document validated against physical hot-box testing, the modelling results were conservative and within 5.6% of hot-box testing.*

This method has also been used extensively in research. Some examples include:

- ASHRAE Research Project 785-RP compared physical hot-box testing against models for assemblies similar to those used in this guide, and found the model to be within 4% of the test results for steel-stud wall assemblies with and without stud-cavity and exterior insulation.
- In ASHRAE 877-RP, the method was used to evaluate curtain-walls, sloped glazing, and hip-ridge and barrel-vault skylights (Figures A and B). The model was found to be within 8% of hot-box test results for these extremely complex and three-dimensional specimens.
- ASHRAE Research Project 1236-RP compared models to hot-box testing for garage doors, fire-exit doors, revolving doors (Figure C), and aircraft hangar doors (Figure D): the models were within 7% of tests, which is within the error margin of the test facility.
- ASHRAE Research Project 1365-RP compared 2-D and 3-D models of steel stud framed walls and determined that the variation between the two approaches is less than 3%. The 2-D modelling always provided a slightly lower thermal performance than 3-D modelling, confirming that 2-D modelling results are conservative. See Table 4 for examples.

Therefore, this method has consistently provided accurate results compared to physical tests, and has been shown to be reliable for more than three decades.

Table 4 - Comparison of Thermal Resistance for Steel Stud Assemblies using Different Software (Table 3.2 from ASHRAE 1365-RP)

ID	**Measured Thermal Resistance**	**Simulated Thermal Resistance**		**% Difference from Measured Results**	
		Using Frame (2D)	Using TMG (3D)	Using Frame (2D)	Using TMG (3D)
SS.16	R-7.81 (1.38 RSI)	R-7.68 (1.35 RSI)	R-7.7 (1.36 RSI)	-2.2%	-1.8%
SS.17	R-12.52 (2.21 RSI)	R-12.18 (2.15 RSI)	R-12.5 (2.20 RSI)	-2.8%	-0.7%
SS.18	R-13.85 (2.44 RSI)	R-13.87 (2.44 RSI)	R-14.1 (2.49 RSI)	0%	1.9%

Figure A - Typical commercial hip-ridge skylight

Figure B - Typical commercial barrel-vault skylight

Figure C - Typical commercial revolving door

Figure D - Sliding hangar-door mock up in a test chamber

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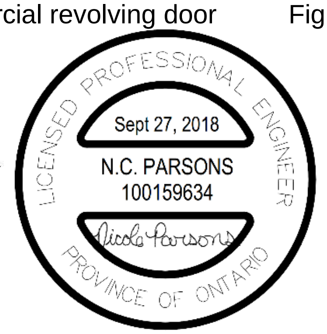

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