Morrison Hershfield
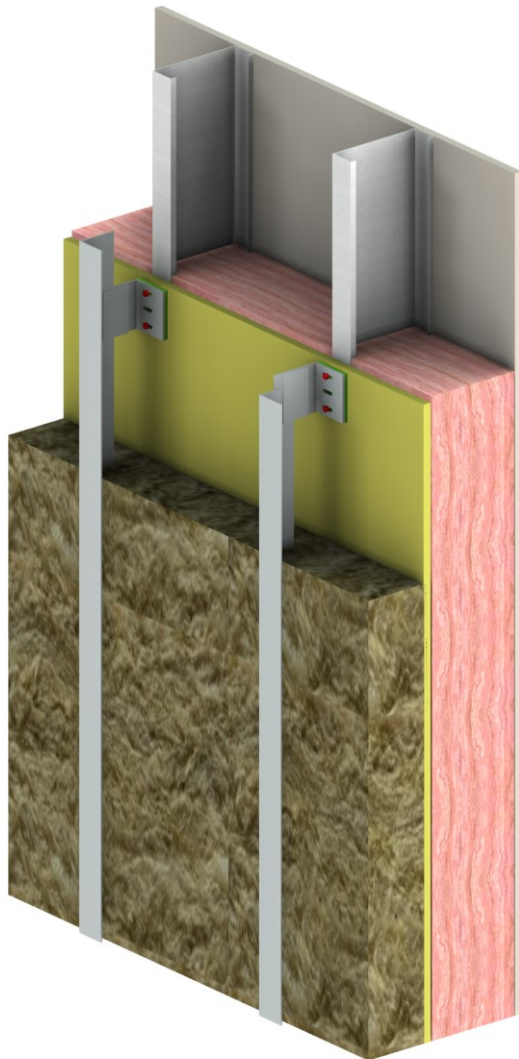
Thermal Performance of Nvelope System with R-19 Batt

Presented to:

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1. INTRODUCTION

The Nvelope Clip System is an aluminum clip system for attaching exterior cladding to various types of exterior insulated wall assemblies. Morrison Hershfield was contracted by SFS Group USA to evaluate the thermal performance of the clip system for several steel stud backup wall scenarios, including the use of the slottled steel stud R-Stud.

The Nvelope clip provides an intermittent structural attachment for claddings of exterior insulated wall assemblies. The clip is fabricated from extruded 6005A Aluminum alloy and includes a plastic isolator between the clip and the back-up wall. The vertical flange of the clip has a slot that allows sub-girts to be fastened to and adjusted to level the cladding, as seen in Figure 1. For steel stud assemblies, the clips are fastened through the exterior sheathing directly to the steel studs using self-drilling screws.
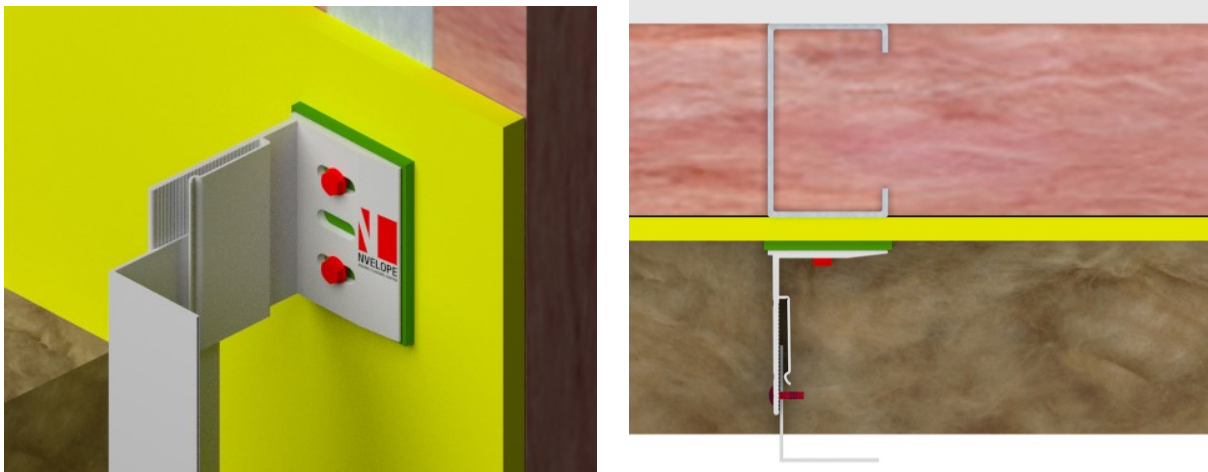
Figure 1: Nvelope System with Girt attachment for 4" insulation and steel stud back-up wall (isometric and section)

The R-Stud, shown in Figure 2, is a proprietary galvanized steel stud which has been slotted with a knockout, approximately 2"x10", in the centerline spaced 12"o.c., which reduces the volume of conductive steel that bypasses through the insulating layer in the cavity. This is in comparison to typical steel studs with minimal or no knockouts.

Figure 2: R-Stud slotted Stud with knockouts

Several construction scenarios for the Nvelope System, including varying insulation levels, backup wall assemblies, clip spacing, and types of insulation have been evaluated by MH in a past report. This report focuses on assemblies with R-19 batt insulation in the cavity of a steel stud backup wall, with and without the use of the R-stud.

2. MODELING OUTLINE

The thermal performance of the Nvelope Systems were evaluated by 3D thermal modelling using the Nx software package from Siemens, which is a general purpose computer aided design (CAD) and finite element analysis (FEA) package. The thermal solver and modelling procedures utilized for this study were extensively calibrated and validated for *ASHRAE Research Project 1365-RP Thermal Performance of Building Envelope Details for Mid- and High-Rise Construction* and for the *Building Envelope Thermal Bridging Guide*[1].

The clear field U-values (U) were determined using the methodology presented in these two documents. The thermal analysis utilized steady-state conditions, published thermal properties of materials, and information provided by SFS Group USA. Further modelling procedures and assumptions are summarized in Appendix A of this report. Components and material properties for the modelled assemblies are found in Appendix B.

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[1] http://www.bchydro.com/thermalguide

3. THERMAL ANALYSIS

The following presents the U-value results for the various scenarios analyzed. "Effective" R-values are presented in Appendix C. Example temperature profiles for the evaluated scenarios are given in Appendix D.

3.1 Case 1: Clear Field Thermal Performance of Split Insulated Steel Stud Assemblies with Nvelope Clip System with R-19 Batt
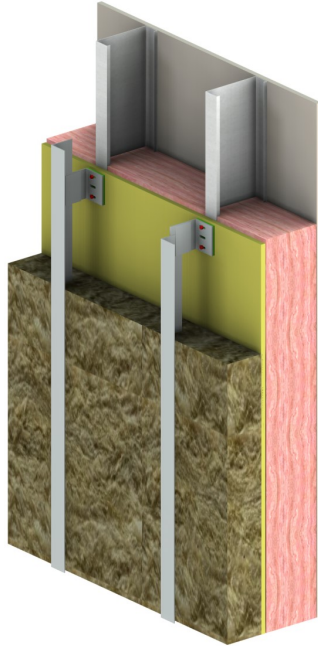
The thermal transmittance U-value results of the Nvelope System with a conventional steel stud backup wall with R-19 batt, as shown in Figure 3, are presented in Table 1.

The results include spacing of the clips ranging from 24" to 48" vertically and 16" o.c. horizontally to line up with the steel studs. Varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The results include all the components of the steel stud assembly, including 6" (152 mm) unslotted steel studs spaced at 16 o.c. and ½" exterior sheathing and interior drywall. The exterior cladding and cavity was not explicitly modelled, but the effects of the cladding and air space were simulated by adjusting the exterior air film coefficient accordingly. "Effective" R-values are given in Table C.1 in Appendix C.
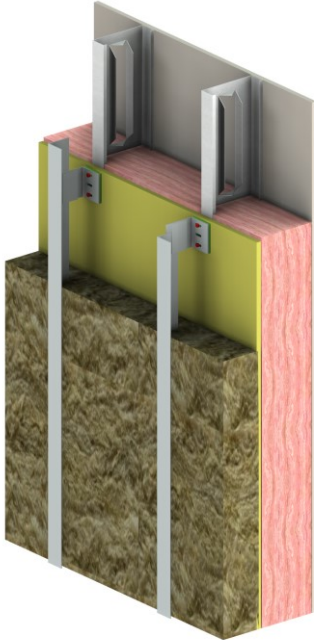
Figure 3: Case 1: Split Insulated Steel Stud Wall Assembly with Vertical Girts and R-19 batt insulation

Table 1: Thermal Transmittance U-values for Split Insulated Steel Stud Wall with Nvelope Clip System and R-19 Batt Insulation in Stud Cavity (Case 1)

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[2] hr·ft²·°F/BTU (m²K/W)	Interior Insulation Nominal R-Value hr·ft²·°F/BTU (m²K/W)	Effective Assembly U-Value BTU/hr·ft²·°F (W/m²K)		
			24" Vertical Clip Spacing	36" Vertical Clip Spacing	48" Vertical Clip Spacing
1.5	R-6.3 (1.11)	R-19 (3.35)	0.060 (0.339)	0.058 (0.331)	0.058 (0.328)
2	R-8.4 (1.48)	R-19 (3.35)	0.055 (0.312)	0.053 (0.302)	0.052 (0.297)
3	R-12.6 (2.22)	R-19 (3.35)	0.049 (0.277)	0.047 (0.265)	0.046 (0.259)
4	R-16.8 (2.96)	R-19 (3.35)	0.044 (0.249)	0.041 (0.235)	0.040 (0.227)

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[2]Indicates nominal R-value of the exterior insulation only. Air films, sheathings add an approximate nominal R-2.3 to the assembly. This additional thermal resistance is included when assessing the effectiveness of the system.

3.2 Case 2: Clear Field Thermal Performance of Split Insulated Steel Stud Assemblies with Nvelope System with R-19 Batt and R-studs

The thermal transmittance U-value results of the Nvelope System with the R-stud steel stud backup wall with R-19 batt, as shown in Figure 4, are presented in Table 2.

The results include the same conditions as Case 1 for direct comparison. This includes the spacing of the clips ranging from 24" to 48" vertically and 16" o.c. horizontally. The same varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The results include 6" (152 mm) R-stud steel studs spaced at 16 o.c. and ½" exterior sheathing and interior drywall. "Effective" R-values are given in Table C.2 in Appendix C.

Figure 4: Case 2: Split Insulated Steel Stud Wall Assembly with Vertical Girts and R-19 batt insulation with R-stud slotted steel studs

Table 2: Thermal Transmittance U-values for Split Insulated Steel Stud Wall with Nvelope System and R-19 Batt Insulation in Stud Cavity and R-studs (Case 2)

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[3] hr·ft²·°F/BTU (m²K/W)	Interior Insulation Nominal R-Value hr·ft²·°F/BTU (m²K/W)	Effective Assembly U-Value BTU/hr·ft²·°F (W/m²K)		
			24" Vertical Clip Spacing	36" Vertical Clip Spacing	48" Vertical Clip Spacing
1.5	R-6.3 (1.11)	R-19 (3.35)	0.051 (0.291)	0.050 (0.285)	0.050 (0.283)
2	R-8.4 (1.48)	R-19 (3.35)	0.048 (0.271)	0.046 (0.263)	0.046 (0.26)
3	R-12.6 (2.22)	R-19 (3.35)	0.043 (0.243)	0.041 (0.233)	0.040 (0.23)
4	R-16.8 (2.96)	R-19 (3.35)	0.039 (0.221)	0.037 (0.209)	0.036 (0.204)

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[3]Indicates nominal R-value of the exterior insulation only. Air films, sheathings add an approximate nominal R-2.3 to the assembly. This additional thermal resistance is included when assessing the effectiveness of the system.

4. CONCLUSIONS

We believe this satisfies the requirements for the evaluation of the thermal performance (U-values and effective R-Values) of the highlighted Nvelope System assemblies. The U-values provided by this report can be used for compliance calculations through the compliance paths set forth in relevant energy codes and standards such as ASHRAE 90.1, IECC, an/or NECB.

If there are any questions regarding this report, please feel free to contact the undersigned.
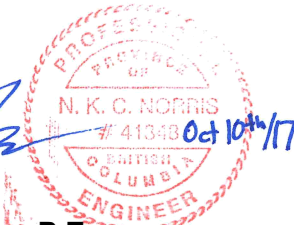

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Principal, Building Science Consultant

APPENDIX A –
MODELLING PARAMETERS AND ASSUMPTIONS

A.1 General Modeling Approach

For this report, a steady-state conduction model was used. The following parameters were also assumed:

- Cladding and vented rainscreen cavity airspaces were not explicitly modelled and their thermal resistance was included in the exterior air film

- Interior/exterior air films were taken from Table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation. The exterior air films were based on an exterior windspeed of 15mph.

- Material properties were taken from information provided by SFS Group USA, published material information and ASHRAE Handbook – Fundamentals for common materials.

- As per standard U-value evaluation, no solar heating impacts were included.

- This report contains only clear field values. The impacts of transition details, such as at slabs, parapets and glazing interfaces, were not included (see Appendix A.2).

- Placement of weather barriers and membranes were assumed not to impact the thermal conduction through the system and were not included in the analysis.

- From the calibration in 1365-RP, contact resistances between materials were modeled. This varied between R-0.01 and R-0.2 depending on the materials and interfaces.

- The temperature difference between interior and exterior was modeled as a dimensionless temperature index between 0 and 1 (see Appendix A.3). These values, along with other modeling parameters, are given in ASHRAE 1365-RP, Chapter 5.

A.2 Thermal Transmittance

The methodology presented in the Building Envelope Thermal Bridging Guide separates the thermal performance of assemblies and details in order to simplify heat loss calculations. For the assemblies, a characteristic area is modeled and the heat flow through that area is found. To find the effects of thermal bridges in transition details (such as slab edges, parapets etc), the assembly is modeled with and without the detail. The difference in heat loss between the two models is then prescribed to that detail. This allows the thermal transmittances to be divided into three categories: clear field, linear and point transmittances.

The **clear field transmittance** is the heat flow from the wall or roof assembly, including uniformly distributed thermal bridges that are not practical to account for on an individual basis, such as structural framing, brick ties and cladding supports. This is treated the same as in standard practice, defined as a clear field U-value, U_o (heat flow per area). For a specific area of opaque wall, this can be converted into an overall heat flow per temperature difference, Q_o.

The **linear transmittance** is the additional heat flow caused by transition details that can be defined by a characteristic length, L. This includes slab edges, corners, parapets, and

transitions between assemblies. The linear transmittance is a heat flow per length, and is represented by psi (Ψ).

The **point transmittance** is the heat flow caused by thermal bridges that occur only at single, infrequent locations. This includes building components such as pipe penetrations and intersections between linear details. The point transmittance is a single additive amount of heat, represented by chi (χ).

With these thermal quantities the overall heat flow through an assembly that includes transition details can be found simple by adding all the components together, as given in equation 1.

$$Q = \Sigma \, Q_{thermalbridge} + Q_o = \Sigma \, (\Psi \cdot L) + \Sigma \, (\chi) + Q_o \qquad \text{EQ 1}$$

Equation 1 gives the overall heat flow for a given assembly size. For energy modeling, or comparisons to standards and codes, often it is more useful to present equation 1 as a heat flow per area. Knowing that the opaque assembly area is A_{total}, and $U = Q/A_{total}$, equation 2 can be derived.

$$U = \frac{\Sigma \, (\Psi \cdot L) + \Sigma \, (\chi)}{A_{Total}} + U_o \qquad \text{EQ 2}$$

A.3   Temperature Index

The temperature index is the ratio of the surface temperature relative to the interior and exterior temperatures. The temperature index has a value between 0 and 1, where 0 is the exterior temperature and 1 is the interior temperature. If T_i is known, Equation 1 can be rearranged for $T_{surface}$. This arrangement allows the modelled surface temperatures to be applicable to any climate.

$$T_i = \frac{T_{surface} - T_{outside}}{T_{inside} - T_{outside}} \qquad \text{EQ 1}$$

Note, these indices shown in the temperature profiles for this analysis are for general information only and are **not** intended to predict in-service surface temperatures subject to transient conditions, variable heating systems, and/ or interior obstructions that restrict heating of the assembly. For full limitations of this modeling approach, see ASHRAE 1365-RP

Example temperature profiles for the assemblies and details modeled in this report are shown in Appendix D.
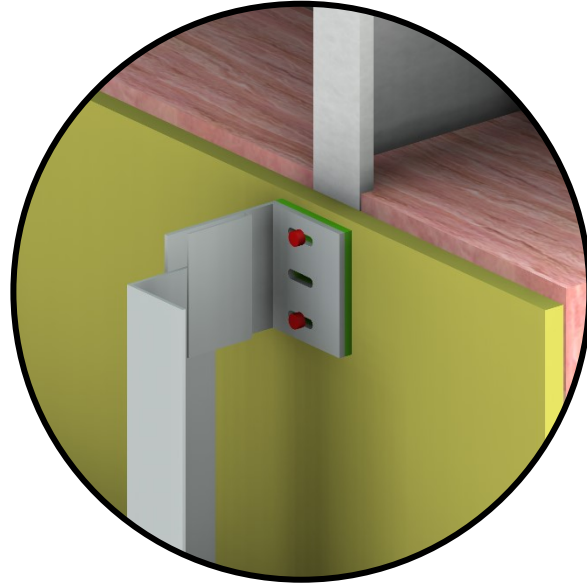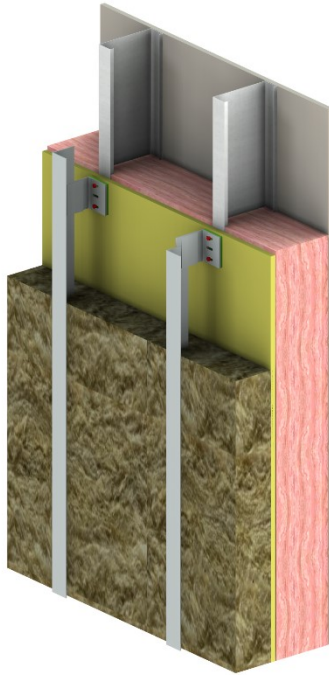
A.4   Boundary Conditions

Table B-1: Boundary Conditions

Boundary Location	Combined Convective and Radiation Heat Transfer Coefficient BTU/hft^{2}F (W/m^{2}K)
Exterior (15mph wind)	6.0 (34.0)
Interior Walls	1.5 (8.3)

APPENDIX B –
SYSTEM DETAILS AND MATERIAL PROPERTIES

Nvelope Clip System | Split Insulated Steel Stud Assembly with Vertical Sub-girts, R-19 Batt
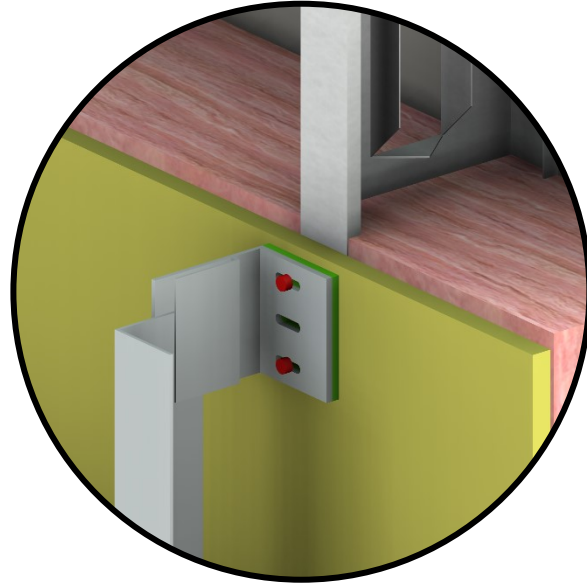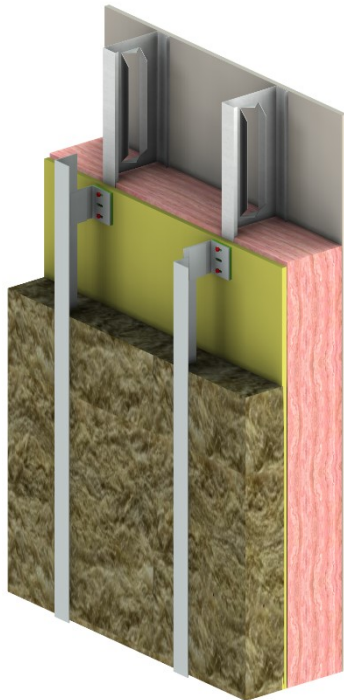

Clip Detail

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	-	-	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	Fiberglass Batt Insulation	6" (152)	0.31 (0.045)	R-19 (3.35 RSI)	0.9 (14)	0.17 (710)
4	6" x 1 5/8" Steel Studs	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Exterior Insulation (Mineral Wool)	1.5 to 4 (38 to 102)	0.24 (0.034)	R-6.3 to R-16.8 (1.11 RSI to 2.96 RSI)	4 (64)	0.20 (850)
7	Nvelope Clip Isolator	0.2" (5)	0.82 (0.117)	-	-	-
8	Nvelope Clip Extrusion – Aluminum 6005A alloy	varies	1340 (193)	-	-	-
9	Bolts – Stainless Steel	1/4" D (6D)	118 (17)	-	-	-
10	Vertical Sub-girt	0.09" (2.2)	1340 (193)	-	-	-
11	Generic Cladding with 1" (25mm) vented air space is incorporated into exterior heat transfer coefficient					
12	Exterior Film	-	-	R-0.7 (0.12 RSI)	-	-

* Nvelope clip @ 24" spacing vertically and 16" horizontally, with 4" exterior insulation and batt insulation as shown in images

Nvelope Clip System | Split Insulated Steel Stud Assembly with Vertical Sub-girts, R19 Batt and R-Studs

Clip Detail

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	-	-	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	Fiberglass Batt Insulation	6" (152)	0.31 (0.045)	R-19 (3.35 RSI)	0.9 (14)	0.17 (710)
4	6" x 1 5/8" Slotted Steel R-Studs	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Exterior Insulation (Mineral Wool)	1.5 to 4 (38 to 102)	0.24 (0.034)	R-6.3 to R-16.8 (1.11 RSI to 2.96 RSI)	4 (64)	0.20 (850)
7	Nvelope Clip Isolator	0.2" (5)	0.82 (0.117)	-	-	-
8	Nvelope Clip Extrusion – Aluminum 6005A alloy	varies	1340 (193)	-	-	-
9	Bolts – Stainless Steel	1/4" D (6D)	118 (17)	-	-	-
10	Vertical Sub-girt	0.09" (2.2)	1340 (193)	-	-	-
11	Generic Cladding with 1" (25mm) vented air space is incorporated into exterior heat transfer coefficient					
12	Exterior Film	-	-	R-0.7 (0.12 RSI)	-	-

* Nvelope clip @ 24" spacing vertically and 16" horizontally, with 4" exterior insulation and batt insulation as shown in images

APPENDIX C –
EFFECTIVE ASSEMBLY R-VALUES

C.1   Case 1: Thermal Performance of Split Insulated Steel Stud Assemblies with Nvelope Clip System with R-19 Batt

Table C.1: Thermal Resistance for Split Insulated Steel Stud Wall with Nvelope Clip System and R-19 Batt Insulation in Stud Cavity (Case 1). Clips spaced 16" horizontally

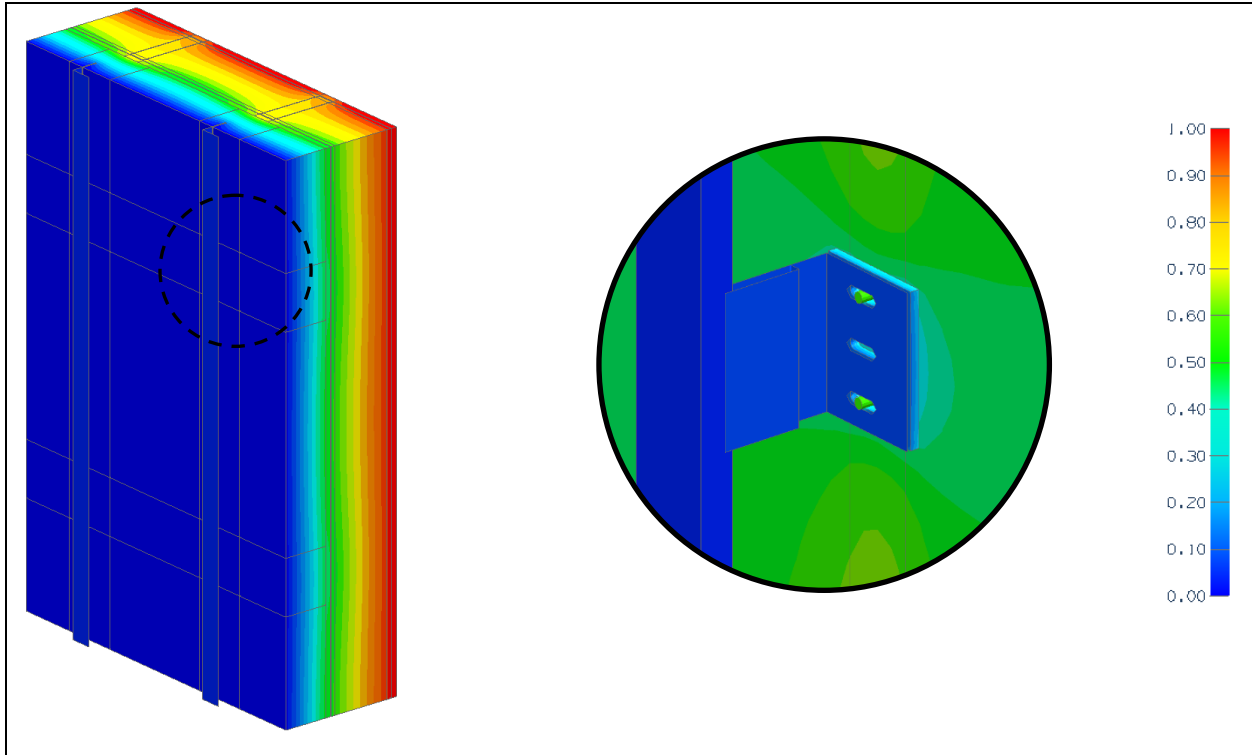| Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[1] hr·ft²·°F/BTU (m²K/W)	Interior Insulation Nominal R-Value hr·ft²·°F/BTU (m²K/W)	Assembly Effective R-Value hr·ft²·°F/BTU (m²K/W)		
			24" Vertical Spacing	36" Vertical Spacing	48" Vertical Spacing
1.5	R-6.3 (1.11)	R-19 (3.35)	R-16.8 (2.95)	R-17.2 (3.03)	R-17.3 (3.05)
2	R-8.4 (1.48)	R-19 (3.35)	R-18.2 (3.2)	R-18.8 (3.31)	R-19.1 (3.36)
3	R-12.6 (2.22)	R-19 (3.35)	R-20.5 (3.61)	R-21.5 (3.78)	R-21.9 (3.86)
4	R-16.8 (2.96)	R-19 (3.35)	R-22.8 (4.01)	R-24.2 (4.26)	R-25.0 (4.40)

C.2   Case 2: Thermal Performance of Split Insulated Steel Stud Assemblies with NV1 Clip System with R-19 Batt and R-studs

Table C.2: Thermal Resistance for Split Insulated Steel Stud Wall with Nvelope Clip System and R-19 Batt Insulation in Stud Cavity and R-studs (Case 2). Clips spaced 16" horizontally
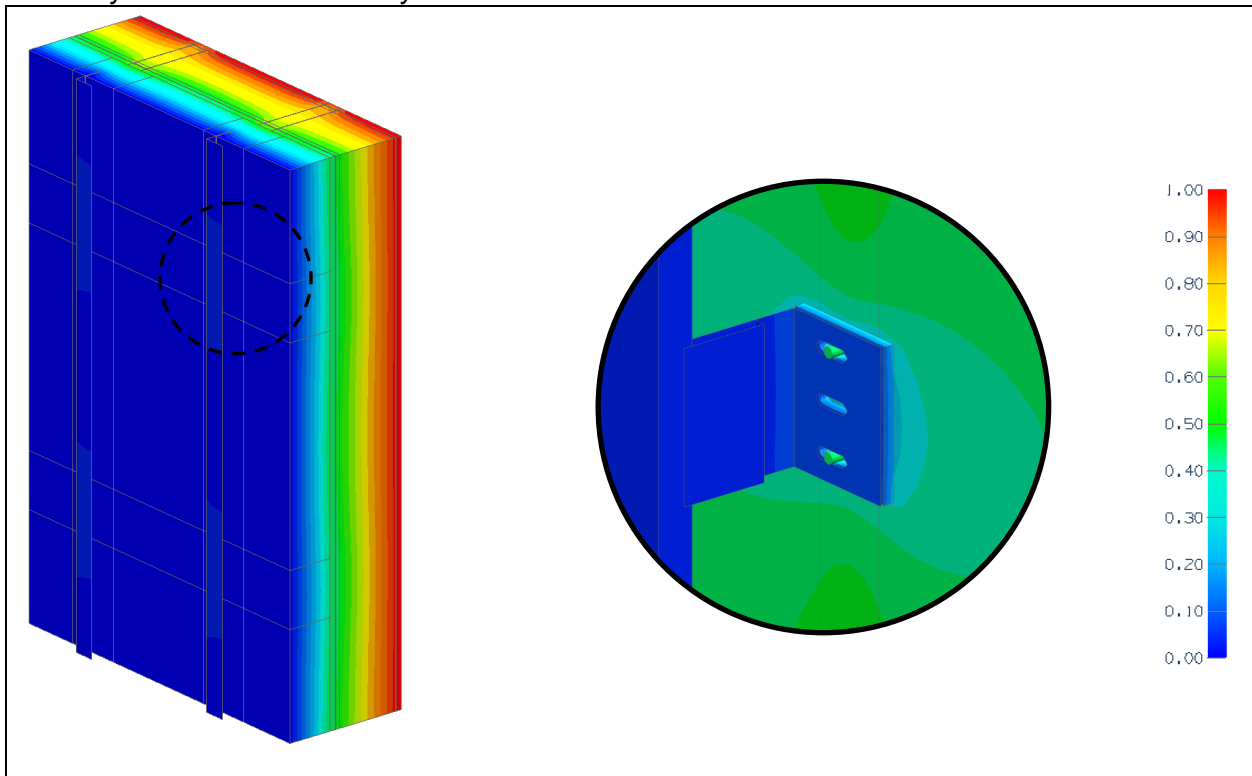
Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[1] hr·ft²·°F/BTU (m²K/W)	Interior Insulation Nominal R-Value hr·ft²·°F/BTU (m²K/W)	Assembly Effective R-Value hr·ft²·°F/BTU (m²K/W)		
			24" Vertical Spacing	36" Vertical Spacing	48" Vertical Spacing
1.5	R-6.3 (1.11)	R-19 (3.35)	R-19.5 (3.44)	R-19.9 (3.51)	R-20.1 (3.54)
2	R-8.4 (1.48)	R-19 (3.35)	R-21 (3.69)	R-21.6 (3.81)	R-21.8 (3.85)
3	R-12.6 (2.22)	R-19 (3.35)	R-23.3 (4.11)	R-24.3 (4.29)	R-24.7 (4.35)
4	R-16.8 (2.96)	R-19 (3.35)	R-25.6 (4.52)	R-27.2 (4.78)	R-27.8 (4.9)

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[1] Indicates nominal R-value of the exterior insulation only. Air films, sheathings add an approximate nominal R-2.3 to the assembly. This additional thermal resistance is included when assessing the effectiveness of the system.

APPENDIX D –
SIMULATED TEMPERATURE DISTRIBUTIONS

Figure D.1: *Temperature profile for Case 1 with 4" exterior insulation and clips spaced 24" o.c. vertically and 16" o.c. horizontally. Steel stud wall with R-19 interior insulation.*

Figure D.2: *Temperature profile for Case 2 with 4" exterior insulation and clips spaced 24" o.c. vertically and 16" o.c. horizontally. Steel stud wall with R-19 interior insulation and R-studs.*