MORRISON HERSHFIELD

StoVentec Bracket Thermal Analysis

Presented to:

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1. INTRODUCTION

Morrison Hershfield (MH) was retained by Sto Corporation (Sto) to evaluate the thermal performance of the StoVentec Bracket system for a variety of insulation thicknesses, bracket spacing, and backup wall configurations. This report is a summary of the analysis.

The StoVentec Bracket system is composed of two brackets: the fixed point (FP) bracket which is 5-1/4 inch (135 mm) high, the movement (GP) bracket which is 3-3/4 inch (95.5 mm) high, and a T-rail. A 1/4 inch (6 mm) thick PVC thermal isolator can be added behind the brackets. The FP bracket supports the cladding dead load and wind load, and the GP brackets allow for movement and resist the cladding wind load only. The StoVentec brackets come in multiple sizes, which are used in combination with the exterior insulation thicknesses shown below in Table 1.1.

Table 1.1: StoVentec Bracket Sizes and Associated Exterior Insulation Thicknesses

Bracket Size	Exterior Insulation Thickness inches (mm)	Bracket Size	Exterior Insulation Thickness inches (mm)
40	1 (25)	200	7 (178)
60	1 (25)	220	8 (203)
80	2 (51)	240	8 (203)
100	3 (76)	260	9 (229)
120	4 (102)	280	10 (254)
140	4 (102)	300	11 (279)
160	5 (127)	320	12 (305)
180	6 (152)		

The StoVentec brackets are available in aluminum and stainless steel, in addition to the FP and GP configurations. At the direction of Sto, based on past reports, only the aluminum GP brackets were evaluated.

Table 1.2 below summarizes the evaluated wall configurations, and Figure 1.1 illustrates representative configurations for all backup wall types. The geometry of the GP brackets as well as T-Rail were based on the drawings provided by Sto, and are provided in Appendix A.

Table 1.2: Evaluated StoVentec Bracket Assemblies

Item	Evaluation Method	Sto Bracket System	Backup Wall	Bracket Size	Stud Spacing inches	Horizontal Bracket Spacing inches	Vertical Bracket Spacing inches
1	Simulated	Aluminum GP	6 inch Steel Stud, Uninsulated Cavity	80, 100, 120, 160 180, 200, 220	16	16, 32	24, 36, 48
2	Interpolated	Aluminum GP	6 inch Steel Stud, Uninsulated Cavity	80, 100, 120, 160, 180, 200, 220	16	16, 32	30, 42
3	Simulated	Aluminum GP	6 inch Steel Stud, Uninsulated Cavity	80, 100, 120, 160, 180, 200, 220	24	24	24, 36, 48
4	Interpolated	Aluminum GP	6 inch Steel Stud, Uninsulated Cavity	80, 100, 120, 160, 180, 200, 220	24	24	30, 42

Exterior Insulated Steel Stud Assembly

- 1/2 inch gypsum
- 6 inch x 1 5/8 inch steel studs with uninsulated cavity
- 1/2 inch gypsum sheathing
- StoVentec bracket system
- Exterior mineral wool insulation
- Vertical T-Rail

Figure 1.1: Schematics of Evaluated StoVentec Aluminum GP Assembly

The StoVentec brackets are used in conjunction with a T-Rail profile, adjusted such that the face of the T-Rail is against the face of the StoVentec bracket. With this configuration the rail penetrates the exterior insulation, as shown below in Figure 1.2.

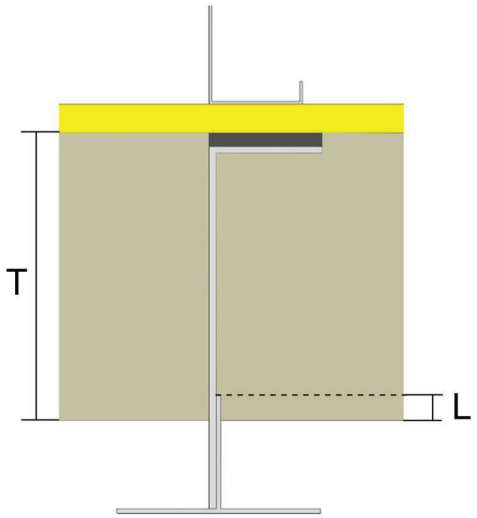

Figure1.2: T-Rail Penetration Depths for the StoVentec Bracket System with Thermal Isolator

Table 1.3: T-Rail Penetration Depth with Insulation Thickness and Bracket Size

StoVentec Bracket Size	Insulation Thickness T inches (mm)	With Thermal Isolator L inches (mm)
80	2 (51)	5/8 (15.8)
100	3 (76)	13/16 (21.2)
120	4 (102)	1(26.6)
160	5 (127)	1/2 (12)
180	6 (152)	11/16 (17.4)
200	7 (177.8)	7/8 (22.8)
220	8 (203)	1-1/8 (28.2)

2. MODELING PROCEDURES

The thermal performance of the different assembly scenarios was evaluated by 3D thermal modeling 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 modeling procedures utilized for this study were extensively calibrated and validated to within +/- 5% of hotbox testing 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], which are inline with guidelines set in CSA Z5010:21. The thermal analysis utilized steady-state conditions, published thermal properties of materials and information provided by Sto. Additional assumptions for the thermal analysis are listed in Appendix B. Further assembly information, including material properties, are given in Appendix C.

The U-value and effective R-value of the GP aluminum bracket assemblies were calculated with the thermal break. Further information as to this calculation is provided in Appendix B.4.

1 https://www.bchydro.com/thermalguide

3. THERMAL RESULTS

The U-values and effective R-values for all aluminum GP and FP bracket assembly configurations are shown below. Example temperature profiles for each configuration are provided in Appendix D.

Table 3.1: Thermal Performance of Exterior Insulated Steel-Frame Wall Assemblies with Studs at 16 inches o.c. and Aluminum GP Brackets at **16 inch Horizontal Bracket Spacing**

Vertical Bracket Spacing inches	Exterior Insulation Thickness inches	StoVenTec Bracket Size	Nominal Exterior Insulation R-value ft² hr °F/Btu (m²K/W)	Overall U-value Btu/h ft² °F (W/m² K)	Effective R-Value ft² hr °F/Btu (m²K/W)
24	2	80	R-8.4 (1.48 RSI)	0.099 (0.56)[1]	R-10.2 (1.79 RSI)[1]
	3	100	R-12.6 (2.22 RSI)	0.080 (0.45)[1]	R-12.5 (2.21 RSI)[1]
	4	120	R-16.8 (2.96 RSI)	0.068 (0.39)[1]	R-14.7 (2.60 RSI)[1]
	5	160	R-21.0 (3.70 RSI)	0.060 (0.34)[1]	R16.7 (2.94 RSI)[1]
	6	180	R-25.2 (4.44 RSI)	0.055 (0.31)[1]	R-18.3 (3.23 RSI)[1]
	7	200	R-29.4 (5.18 RSI)	0.051 (0.29)[1]	R-19.8 (3.49 RSI)[1]
	8	220	R-33.6 (5.92 RSI)	0.048 (0.27)[1]	R-20.9 (3.68 RSI)[1]
30	*2*	*80*	*R-8.4 (1.48 RSI)*	*0.097 (0.55)[2]*	*R-10.3 (1.81 RSI)[2]*
	3	*100*	*R-12.6 (2.22 RSI)*	*0.077 (0.44)[2]*	*R-13.0 (2.28 RSI)[2]*
	4	*120*	*R-16.8 (2.96 RSI)*	*0.065 (0.37)[2]*	*R-15.4 (2.72 RSI)[2]*
	5	*160*	*R-21.0 (3.70 RSI)*	*0.057 (0.32)[2]*	*R-17.6 (3.10 RSI)[2]*
	6	*180*	*R-25.2 (4.44 RSI)*	*0.051 (0.29)[2]*	*R-19.5 (3.44 RSI)[2]*
	7	*200*	*R-29.4 (5.18 RSI)*	*0.047 (0.27)[2]*	*R-21.2 (3.74 RSI)[2]*
	8	*220*	*R-33.6 (5.92 RSI)*	*0.044 (0.25)[2]*	*R-22.6 (3.98 RSI)[2]*
36	2	80	R-8.4 (1.48 RSI)	0.096 (0.55)[1]	R-10.4 (1.83 RSI)[1]
	3	100	R-12.6 (2.22 RSI)	0.075 (0.42)[1]	R-13.4 (2.36 RSI)[1]
	4	120	R-16.8 (2.96 RSI)	0.062 (0.35)[1]	R-16.0 (2.82 RSI)[1]
	5	160	R-21.0 (3.70 RSI)	0.054 (0.31)[1]	R-18.6 (3.28 RSI)[1]
	6	180	R-25.2 (4.44 RSI)	0.048 (0.27)[1]	R-20.7 (3.65 RSI)[1]
	7	200	R-29.4 (5.18 RSI)	0.044 (0.25)[1]	R-22.7 (3.99 RSI)[1]
	8	220	R-33.6 (5.92 RSI)	0.041 (0.23)[1]	R-24.3 (4.27 RSI)[1]
42	*2*	*80*	*R-8.4 (1.48 RSI)*	*0.095 (0.54)[2]*	*R-10.5 (1.85 RSI)[2]*
	3	*100*	*R-12.6 (2.22 RSI)*	*0.073 (0.42)[2]*	*R-13.6 (2.40 RSI)[2]*
	4	*120*	*R-16.8 (2.96 RSI)*	*0.061 (0.35)[2]*	*R-16.4 (2.89 RSI)[2]*
	5	*160*	*R-21.0 (3.70 RSI)*	*0.052 (0.30)[2]*	*R-19.1 (3.36 RSI)[2]*
	6	*180*	*R-25.2 (4.44 RSI)*	*0.047 (0.26)[2]*	*R-21.5 (3.78 RSI)[2]*
	7	*200*	*R-29.4 (5.18 RSI)*	*0.042 (0.24)[2]*	*R-23.6 (4.15 RSI)[2]*
	8	*220*	*R-33.6 (5.92 RSI)*	*0.039 (0.22)[2]*	*R-25.4 (4.47 RSI)[2]*
48	2	80	R-8.4 (1.48 RSI)	0.094 (0.53)1	R-10.6 (1.87 RSI)[1]
	3	100	R-12.6 (2.22 RSI)	0.072 (0.41)[1]	R-13.9 (2.44 RSI)[1]
	4	120	R-16.8 (2.96 RSI)	0.060 (0.32)[1]	R-16.8 (2.96 RSI)[1]
	5	160	R-21.0 (3.70 RSI)	0.051 (0.29)[1]	R-19.7 (3.47 RSI)[1]

	6	180	R-25.2 (4.44 RSI)	0.045 (0.26)[1]	R-22.2 (3.91 RSI)[1]
	7	200	R-29.4 (5.18 RSI)	0.041 (0.23)[1]	R-24.5 (4.31 RSI)[1]
	8	220	R-33.6 (5.92 RSI)	0.038 (0.21)[1]	R-26.4 (4.65 RSI)[1]

[1]Value was simulated (Item 1)
[2]Value was interpolated (Item 2)

Table 3.2: Thermal Performance of Exterior Insulated Steel-Frame Wall Assemblies with Studs at 16 inches o.c. and Aluminum GP Brackets at **32 inch Horizontal Bracket Spacing**

Vertical Bracket Spacing inches	Exterior Insulation Thickness inches	StoVenTec Bracket Size	Nominal Exterior Insulation R-value ft² hr °F/Btu (m²K/W)	Overall U-value Btu/h ft² °F (W/m² °K)	Effective R-value ft² hr °F/Btu (m² °K/W)
24	2	80	R-8.4 (1.48 RSI)	0.093 (0.53)[1]	R-10.7 (1.89 RSI)[1]
	3	100	R-12.6 (2.22 RSI)	0.072 (0.41)[1]	R-14.0 (2.46 RSI)[1]
	4	120	R-16.8 (2.96 RSI)	0.059 (0.34)[1]	R-16.9 (2.98 RSI)[1]
	5	160	R-21.0 (3.70 RSI)	0.051 (0.29)[1]	R-19.7 (3.48 RSI)[1]
	6	180	R-25.2 (4.44 RSI)	0.045 (0.26)[1]	R-22.3 (3.92 RSI)[1]
	7	200	R-29.4 (5.18 RSI)	0.041 (0.23)[1]	R-24.6 (4.33 RSI)[1]
	8	220	R-33.6 (5.92 RSI)	0.038 (0.21)[1]	R-26.6 (4.69 RSI)[1]
30	*2*	*80*	*R-8.4 (1.48 RSI)*	*0.092 (0.52)[2]*	*R-10.9 (1.91 RSI)[2]*
	3	*100*	*R-12.6 (2.22 RSI)*	*0.070 (0.40)[2]*	*R-14.2 (2.50 RSI)[2]*
	4	*120*	*R-16.8 (2.96 RSI)*	*0.057 (0.32)[2]*	*R-17.6 (3.09 RSI)[2]*
	5	*160*	*R-21.0 (3.70 RSI)*	*0.049 (0.28)[2]*	*R-20.4 (3.60 RSI)[2]*
	6	*180*	*R-25.2 (4.44 RSI)*	*0.043 (0.25)[2]*	*R-23.1 (4.07 RSI)[2]*
	7	*200*	*R-29.4 (5.18 RSI)*	*0.039 (0.22)[2]*	*R-25.6 (4.52 RSI)[2]*
	8	*220*	*R-33.6 (5.92 RSI)*	*0.035 (0.20)[2]*	*R-28.3 (4.99 RSI)[2]*
36	2	80	R-8.4 (1.48 RSI)	0.091 (0.51)[1]	R-11.0 (1.94 RSI)[1]
	3	100	R-12.6 (2.22 RSI)	0.069 (0.39)[1]	R-14.5 (2.55 RSI)[1]
	4	120	R-16.8 (2.96 RSI)	0.055 (0.31)[1]	R-18.1 (3.19 RSI)[1]
	5	160	R-21.0 (3.70 RSI)	0.047 (0.27)[1]	R-21.3 (3.75 RSI)[1]
	6	180	R-25.2 (4.44 RSI)	0.042 (0.24)[1]	R-23.9 (4.21 RSI)[1]
	7	200	R-29.4 (5.18 RSI)	0.037 (0.21)[1]	R-26.7 (4.70 RSI)[1]
	8	220	R-33.6 (5.92 RSI)	0.033 (0.19)[1]	R-30.1 (5.30 RSI)[1]
42	*2*	*80*	*R-8.4 (1.48 RSI)*	*0.090 (0.51)[2]*	*R-11.1 (1.95 RSI)[2]*
	3	*100*	*R-12.6 (2.22 RSI)*	*0.068 (0.39)[2]*	*R-14.6 (2.57 RSI)[2]*
	4	*120*	*R-16.8 (2.96 RSI)*	*0.054 (0.31)[2]*	*R-18.4 (3.23 RSI)[2]*
	5	*160*	*R-21.0 (3.70 RSI)*	*0.046 (0.26)[2]*	*R-21.5 (3.79 RSI)[2]*
	6	*180*	*R-25.2 (4.44 RSI)*	*0.041 (0.23)[2]*	*R-24.4 (4.30 RSI)[2]*
	7	*200*	*R-29.4 (5.18 RSI)*	*0.037 (0.21)[2]*	*R-27.3 (4.81 RSI)[2]*
	8	*220*	*R-33.6 (5.92 RSI)*	*0.032 (0.18)[2]*	*R-30.8 (5.42 RSI)[2]*
48	2	80	R-8.4 (1.48 RSI)	0.090 (0.51)[1]	R-11.2 (1.96 RSI)[1]
	3	100	R-12.6 (2.22 RSI)	0.068 (0.38)[1]	R-14.7 (2.60 RSI)[1]
	4	120	R-16.8 (2.96 RSI)	0.054 (0.31)[1]	R-18.5 (3.26 RSI)[1]
	5	160	R-21.0 (3.70 RSI)	0.046 (0.26)[1]	R-21.9 (3.86 RSI)[1]
	6	180	R-25.2 (4.44 RSI)	0.040 (0.23)[1]	R-24.9 (4.38 RSI)[1]
	7	200	R-29.4 (5.18 RSI)	0.036 (0.20)[1]	R-27.9 (4.92 RSI)[1]
	8	220	R-33.6 (5.92 RSI)	0.032 (0.18)[1]	R-31.5 (5.54 RSI)[1]

[1]Value was simulated (Item 1)
[2]Value was interpolated (Item 2)

Table 3.3: Thermal Performance of Exterior Insulated Steel-Frame Wall Assemblies with Studs at 24 inches o.c. and Aluminum GP Brackets at **24 inch Horizontal Bracket Spacing**

Vertical Bracket Spacing inches	Exterior Insulation Thickness inches	StoVenTec Bracket Size	Nominal Exterior Insulation R-value ft² hr °F/Btu (m²K/W)	Overall U-value Btu/h ft² °F (W/m² °K)	Effective R-value ft² hr °F/Btu (m² °K/W)
24	2	80	R-8.4 (1.48 RSI)	0.095 (0.54)[1]	R-10.5 (1.85 RSI)[1]
	3	100	R-12.6 (2.22 RSI)	0.074 (0.42)[1]	R-13.5 (2.38 RSI)[1]
	4	120	R-16.8 (2.96 RSI)	0.062 (0.35)[1]	R-16.2 (2.86 RSI)[1]
	5	160	R-21.0 (3.70 RSI)	0.053 (0.30)[1]	R-18.9 (3.32 RSI)[1]
	6	180	R-25.2 (4.44 RSI)	0.048 (0.27)[1]	R-20.9 (3.68 RSI)[1]
	7	200	R-29.4 (5.18 RSI)	0.044 (0.25)[1]	R-22.9 (4.03 RSI)[1]
	8	220	R-33.6 (5.92 RSI)	0.040 (0.23)[1]	R-24.7 (4.35 RSI)[1]
30	*2*	*80*	*R-8.4 (1.48 RSI)*	*0.094 (0.53)[2]*	*R-10.7 (1.88 RSI)[2]*
	3	*100*	*R-12.6 (2.22 RSI)*	*0.072 (0.41)[2]*	*R-13.8 (2.44 RSI)[2]*
	4	*120*	*R-16.8 (2.96 RSI)*	*0.06 (0.34)[2]*	*R-16.7 (2.95 RSI)[2]*
	5	*160*	*R-21.0 (3.70 RSI)*	*0.051 (0.29)[2]*	*R-19.5 (3.44 RSI)[2]*
	6	*180*	*R-25.2 (4.44 RSI)*	*0.046 (0.26)[2]*	*R-21.9 (3.85 RSI)[2]*
	7	*200*	*R-29.4 (5.18 RSI)*	*0.041 (0.24)[2]*	*R-24.1 (4.24 RSI)[2]*
	8	*220*	*R-33.6 (5.92 RSI)*	*0.038 (0.22)[2]*	*R-26.2 (4.61 RSI)[2]*
36	2	80	R-8.4 (1.48 RSI)	0.093 (0.53)[1]	R-10.8 (1.90 RSI)[1]
	3	100	R-12.6 (2.22 RSI)	0.071 (0.40)[1]	R-14.1 (2.49 RSI)[1]
	4	120	R-16.8 (2.96 RSI)	0.058 (0.33)[1]	R-17.2 (3.03 RSI)[1]
	5	160	R-21.0 (3.70 RSI)	0.049 (0.28)[1]	R-20.2 (3.56 RSI)[1]
	6	180	R-25.2 (4.44 RSI)	0.044 (0.25)[1]	R-22.9 (4.02 RSI)[1]
	7	200	R-29.4 (5.18 RSI)	0.040 (0.22)[1]	R-25.3 (4.46 RSI)[1]
	8	220	R-33.6 (5.92 RSI)	0.036 (0.21)[1]	R-27.6 (4.86 RSI)[1]
42	*2*	*80*	*R-8.4 (1.48 RSI)*	*0.092 (0.52)[2]*	*R-10.9 (1.92 RSI)[2]*
	3	*100*	*R-12.6 (2.22 RSI)*	*0.070 (0.40)[2]*	*R-14.3 (2.52 RSI)[2]*
	4	*120*	*R-16.8 (2.96 RSI)*	*0.057 (0.32)[2]*	*R-17.5 (3.08 RSI)[2]*
	5	*160*	*R-21.0 (3.70 RSI)*	*0.048 (0.28)[2]*	*R-20.6 (3.63 RSI)[2]*
	6	*180*	*R-25.2 (4.44 RSI)*	*0.043 (0.24)[2]*	*R-23.4 (4.13 RSI)[2]*
	7	*200*	*R-29.4 (5.18 RSI)*	*0.038 (0.22)[2]*	*R-26.0 (4.59 RSI)[2]*
	8	*220*	*R-33.6 (5.92 RSI)*	*0.035 (0.20)[2]*	*R-28.5 (5.02 RSI)[2]*
48	2	80	R-8.4 (1.48 RSI)	0.091 (0.52)[1]	R-11.0 (1.93 RSI)[1]
	3	100	R-12.6 (2.22 RSI)	0.069 (0.39)[1]	R-14.5 (2.55 RSI)[1]
	4	120	R-16.8 (2.96 RSI)	0.056 (0.32)[1]	R-17.8 (3.13 RSI)[1]
	5	160	R-21.0 (3.70 RSI)	0.047 (0.27)[1]	R-21.1 (3.71 RSI)[1]
	6	180	R-25.2 (4.44 RSI)	0.042 (0.24)[1]	R-24.0 (4.23 RSI)[1]
	7	200	R-29.4 (5.18 RSI)	0.037 (0.21)[1]	R-26.8 (4.71 RSI)[1]
	8	220	R-33.6 (5.92 RSI)	0.034 (0.19)[1]	R-29.4 (5.17 RSI)[1]

[1]Value was simulated (Item 3)
[2]Value was interpolated (Item 4)

We believe that this report meets your objectives for evaluating the thermal performance for the StoVentec bracket system assemblies. If you have any questions or comments related to the above, please do not hesitate to contact the undersigned.

Morrison Hershfield Limited

Garrett E. S. Therrien, E.I.T., M.A.Sc.
Building Science Consultant

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Principal, Building Science Consultant

APPENDIX B:
MODELING PARAMETERS AND ASSUMPTIONS

1. GENERAL MODELING APPROACH

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

- Material properties were taken from information provided by Sto Corporation and the ASHRAE Handbook – Fundamentals for common materials.
- Enclosed air spaces were modeled with an equivalent thermal conductivity of the air that includes the impacts of convection and radiation within the enclosure. Calculations for this equivalent conductivity were based on ISO 10077-2.
- 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 wind speed of 15 mph.
- In ASHRAE 1365-RP, for rain screen cavity systems, most lightweight claddings have an insignificant impact on the thermal performance other than shielding the insulation from direct wind exposure. The cladding and secondary structure outboard of the clip system were not explicitly modeled but were incorporated into the exterior film coefficient.
- From the calibration in 1365-RP, contact resistances between materials were modeled and varied between R-0.01 and R-0.2 depending on the materials and interfaces.
- Insulation and other components were considered tight to adjacent interfaces.
- The clear field transmittances included in this analysis include uniform thermal bridges such as studs, brackets, and rails.

2. 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.

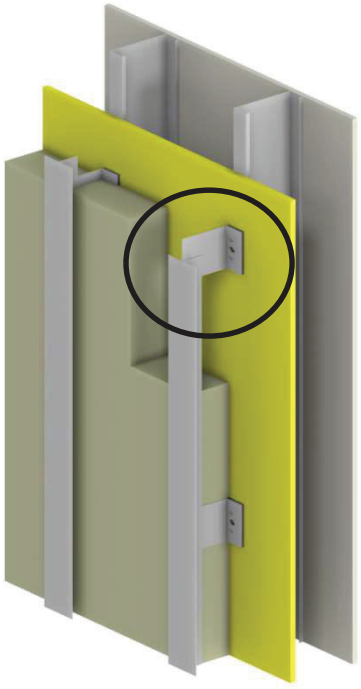
3. BOUNDARY CONDITIONS

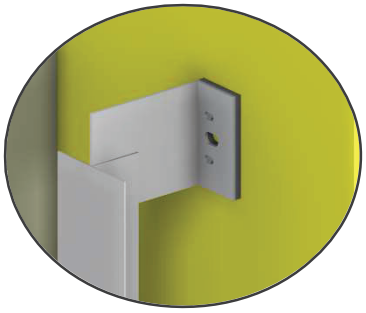
Table B3.1: Boundary Conditions

Boundary Location	Combined Convective and Radiation Heat Transfer Coefficient BTU/hft^2°F (W/m^{2}K)
Exterior Wall Surfaces with Generic Cladding	1.5 (8.3)
Interior Walls	1.5 (8.3)

APPENDIX C:
MATERIAL PROPERTIES

1. EXTERIOR INSULATED STEEL STUD ASSEMBLY





GP Bracket Detail

Component	Material	Thickness in (mm)	Thermal Conductivity Btu in / ft² hr °F (W/m K)	Nominal Resistance[1] ft² hr °F / Btu (m² K/W)
Interior Film	-	-	-	R-0.7 (0.12 RSI)
Gypsum	Gypsum	1/2 (13)	1.1 (0.16)	R-0.5 (0.08 RSI)
Stud Cavity	Air	6 (152)	6.7 (0.96)	R-0.9 (0.16 RSI)
Steel Stud	Galvanized Steel	18 ga.	430 (62)	-
Sheathing	Gypsum	1/2 (13)	1.1 (0.16)	R-0.5 (0.08 RSI)
Exterior Insulation	Mineral Wool	Varies	0.24 (0.034)	R-8.4 to R-33.6 (1.48 to 5.92 RSI)
Thermal Isolator	PVC	0.24 (6.0)	0.59 (0.085)	-
GP Bracket	Aluminum AW-6063		1457 (210)	-
Fasteners	Steel	0.26 (6.5) Θ	347 (50)	-
Vertical T-Rail	Aluminum	0.08 (2.0)	1110 (160)	-
Air Spaces[2]	Air	Varies	Varies	-
Exterior Film	-	-	-	R-0.7 (0.12 RSI)
Overall Wall Assembly 1D	-	-	-	R-11.6 to R-36.8 (2.04 to 6.48 RSI)

[1] Dash indicates not a continuous component
[2] The thermal conductivities of the air spaces were determined according to ISO 10077-2

APPENDIX D:
SIMULATED
TEMPERATURE PROFILES

As an example of the thermal profiles of the Sto Bracket system, the following figures illustrate a typical temperature distribution for the 16” studs with a 24” horizontal bracket spacing, variable vertical bracket spacing, and 6” exterior insulation.

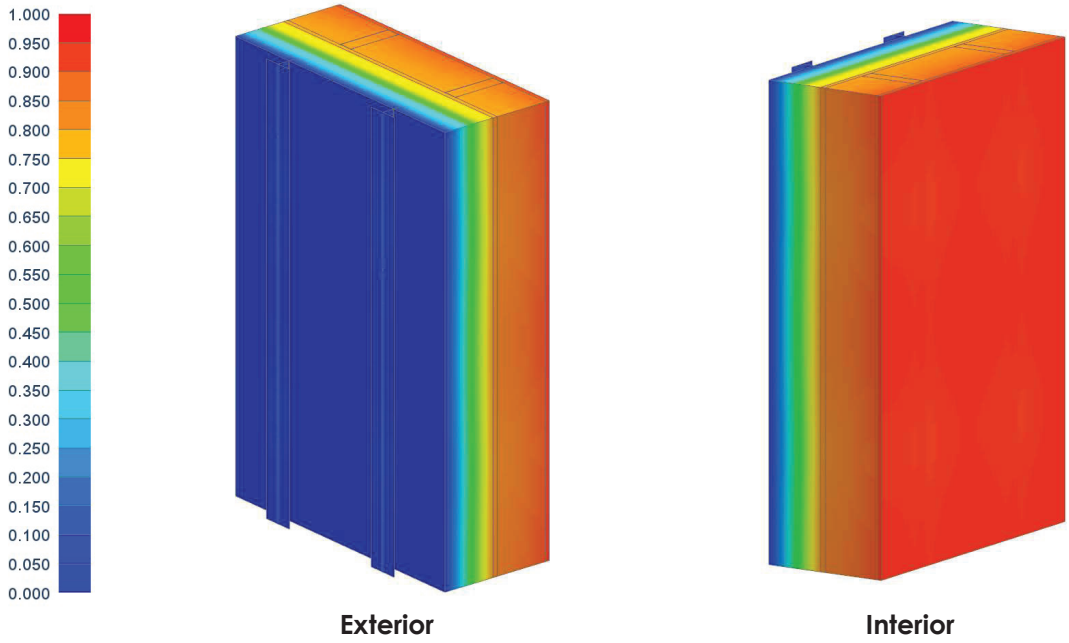


Figure D1: Temperature Profile 16” stud spacing, 16” horizontal bracket spacing, 24” vertical bracket spacing, and 6” exterior insulation

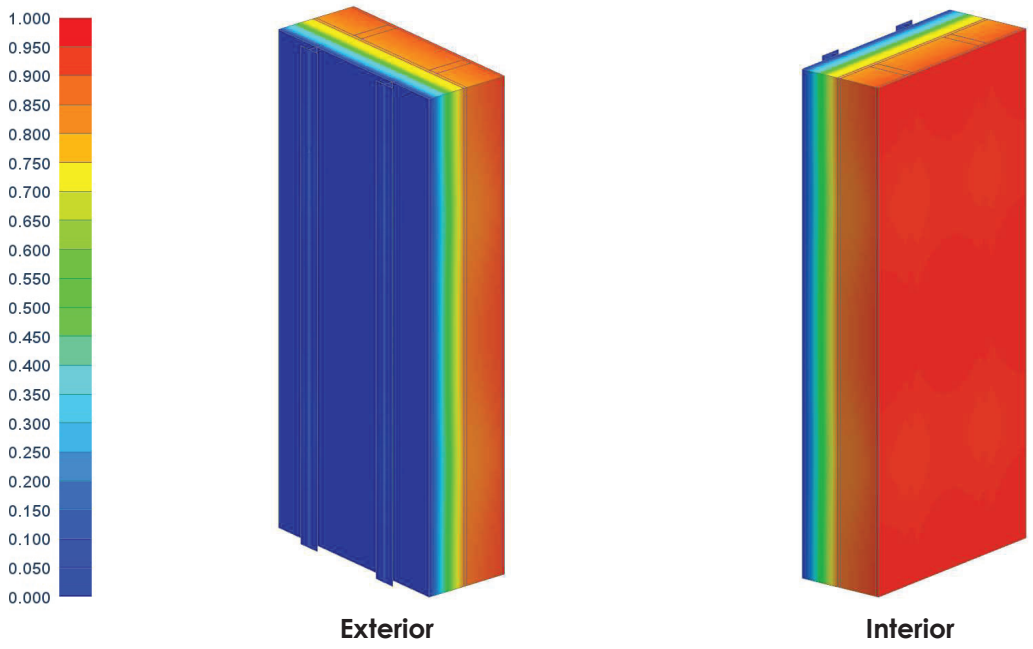


Figure D2: Temperature Profile of 16" stud spacing, 16" horizontal bracket spacing, 36" vertical bracket spacing, and 6" exterior insulation

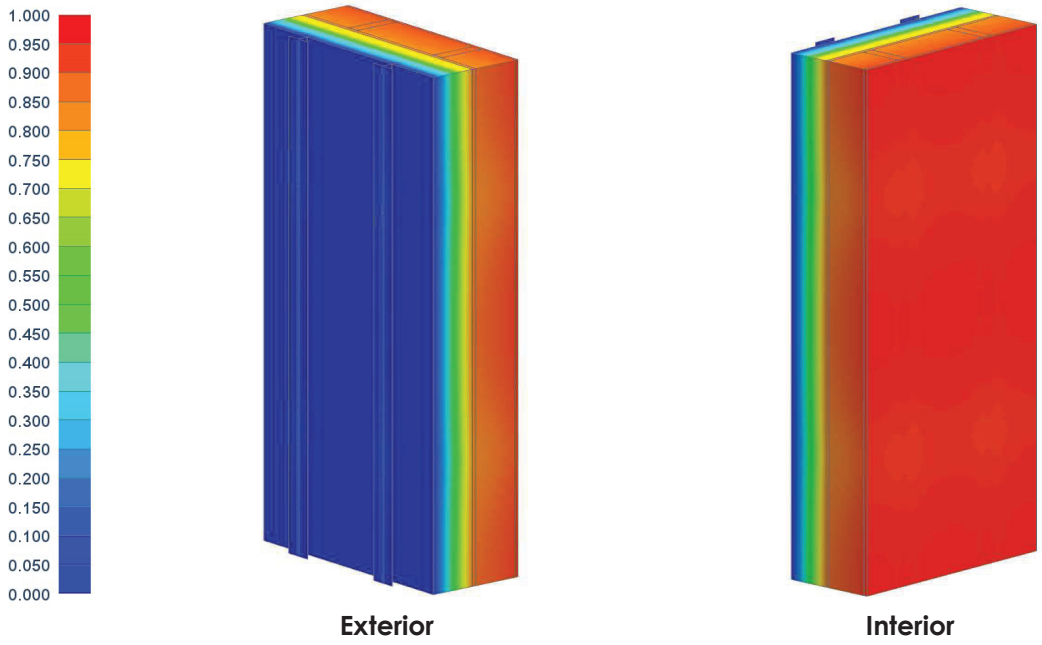


Figure D3: Temperature Profile of 16" stud spacing, 16" horizontal bracket spacing, 48" vertical bracket spacing, and 6" exterior insulation