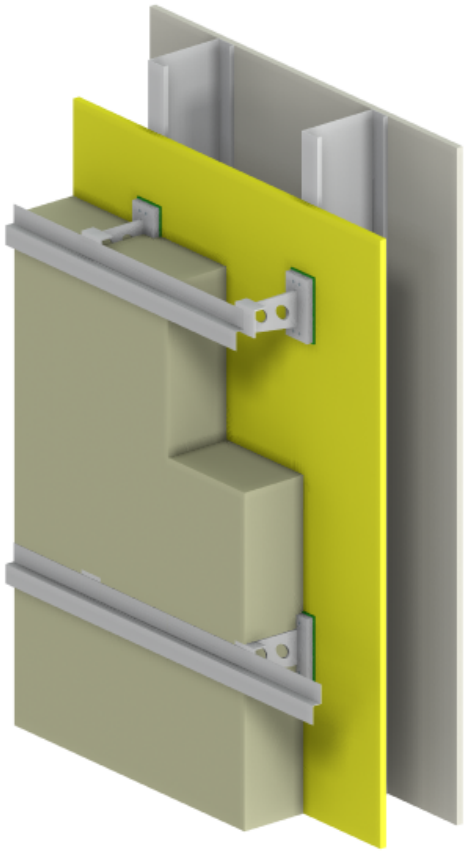
MORRISON HERSHFIELD

Thermal Performance of TAC Aluminum Clip System



Presented to:

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1. INTRODUCTION

Morrison Hershfield (MH) was retained by Exterior Technologies Group (ETG) to evaluate the thermal performance of the TAC Aluminum Clip system for a variety of clip spacings and insulation thicknesses. This report is a summary of the analysis.

The TAC Aluminum Clip is made of aluminum with a polypropylene thermal isolator, fastened with stainless steel fasteners. The clip is available in four sizes ranging from 3 inches to 5 inches and was evaluated with the corresponding exterior insulation thicknesses such that the horizontal z-girt is outboard of the exterior insulation, resulting in no girt penetration of the exterior insulation.

The TAC Aluminum Clips were evaluated to determine the clear field U-values and effective R-values for a variety of clip spacings. A sensitivity analysis was performed to determine the thermal impact of alternate exterior insulation types for the 16 inch o.c. horizontal and 24 inch o.c. vertical clip spacing and exterior insulated steel stud assemblies. A second sensitivity analysis was performed to determine the thermal impact of the number of stainless steel fasteners for the 5 inch TAC Aluminum Clip spaced at 16 inches o.c. horizontally and 24 inches o.c. vertically.

Table 1.1 below summarizes the evaluated wall configurations, and Figure 1.1 illustrates representative configurations for the two steel stud assembly backup walls. The geometry of the TAC Aluminum Clips and polypropylene thermal isolator were based on the drawings provided by ETG and are provided in Appendix A.

Table 1.1: Evaluated TAC Aluminum Clip Assemblies

Backup Wall	Number of Clip Screws	Exterior Insulation Thickness (inches)	Exterior Insulation R-value per inch	Horizontal Clip Spacing (inches)	Vertical Clip Spacing (inches)
6” Steel Stud, 16” o.c., Uninsulated Cavity	4	3, 4, 5, 6	R-4.2/in	16, 32	24, 32, 48
6” Steel Stud, 16” o.c., R-19 Batt Insulation in Cavity	4	3, 4, 5, 6	R-4.2/in	16, 32	24, 32, 48
6” Steel Stud, 16” o.c., Uninsulated Cavity	4	3, 4, 5, 6	R-5/in, R-6/in	16	24
6” Steel Stud, 16” o.c., Uninsulated Cavity	2	5	R-4.2/in	16	24

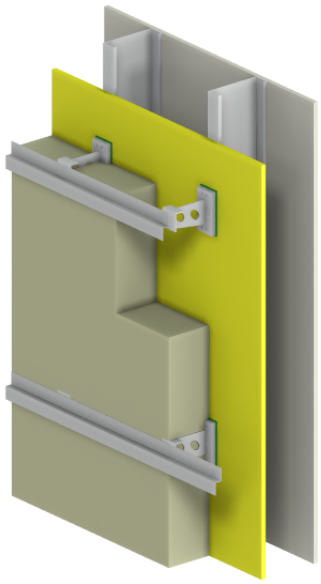
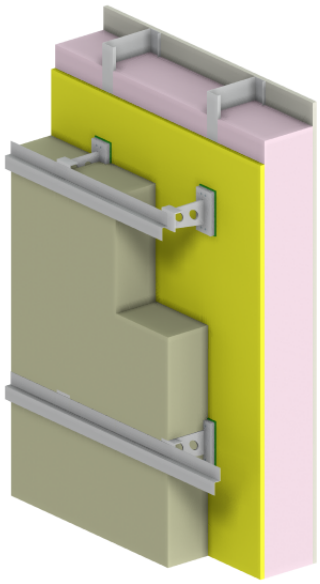
	
Exterior Insulated Steel Stud Assembly	**Split Insulated Steel Stud Assembly**
• 1/2 inch gypsum • 6 inch x 1 5/8 inch steel studs at 16" o.c., uninsulated cavity • 1/2 inch gypsum sheathing • TAC Aluminum Clip System • Exterior insulation • Horizontal 18ga. galvanized steel Z-girt	• 1/2 inch gypsum • 6 inch x 1 5/8 inch steel studs at 16" o.c., R-19 batt insulation cavity • 1/2 inch gypsum sheathing • TAC Aluminum Clip System • Exterior insulation • Horizontal 18ga. galvanized steel Z-girt

Figure 1.1: Schematics of Evaluated TAC Aluminum Clip Assemblies

2. MODELLING PROCEDURES

The thermal performance of the different assembly scenarios was 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 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]. The thermal analysis utilized steady-state conditions, published thermal properties of materials and information provided by ETG. Additional assumptions for the thermal analysis are listed in Appendix B. Further assembly information, including material properties, are given in Appendix C.

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

3. THERMAL RESULTS

The U-values and effective R-values for all TAC Aluminum Clip configurations are shown below. Example temperature profiles for each configuration are provided in Appendix D.

3.1 Exterior Insulated Steel Stud Assembly

Table 3.1.1: U-Values and Effective R-Values for the TAC Aluminum Clip spaced 16" o.c. Horizontally, Mineral Wool Exterior Insulation (R-4.2/in); Exterior Insulated Steel Stud Assembly

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[2] ft2 · hr ·°F/Btu (m2 ·°K/W)	24" Vertical Clip Spacing		32" Vertical Clip Spacing		48" Vertical Clip Spacing	
		U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)
3	R-12.6 (2.22 RSI)	0.086 (0.49)	R-11.7 (2.06)	0.080 (0.46)	R-12.5 (2.20)	0.075 (0.42)	R-13.4 (2.36)
4	R-16.8 (2.96 RSI)	0.074 (0.42)	R-13.6 (2.40)	0.068 (0.39)	R-14.7 (2.60)	0.062 (0.35)	R-16.1 (2.84)
5	R-21.0 (3.70 RSI)	0.064 (0.36)	R-15.6 (2.75)	0.059 (0.33)	R-17.1 (3.01)	0.053 (0.30)	R-18.9 (3.33)
6	R-25.2 (4.44 RSI)	0.058 (0.33)	R-17.2 (3.02)	0.053 (0.30)	R-19.0 (3.35)	0.047 (0.27)	R-21.3 (3.76)

Table 3.1.2: U-Values and Effective R-Values for the TAC Aluminum Clip spaced 32" o.c. Horizontally, Mineral Wool Exterior Insulation (R-4.2/in); Exterior Insulated Steel Stud Assembly

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[2] h ft² °F/Btu (m²K/W)	24" Vertical Clip Spacing		32" Vertical Clip Spacing		48" Vertical Clip Spacing	
		U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)
3	R-12.6 (2.22 RSI)	0.075 (0.42)	R-13.4 (2.36)	0.072 (0.41)	R-13.9 (2.45)	0.069 (0.39)	R-14.5 (2.55)
4	R-16.8 (2.96 RSI)	0.062 (0.35)	R-16.1 (2.84)	0.059 (0.34)	R-16.9 (2.98)	0.056 (0.32)	R-17.8 (3.14)
5	R-21.0 (3.70 RSI)	0.053 (0.30)	R-18.9 (3.33)	0.050 (0.28)	R-20.0 (3.52)	0.047 (0.27)	R-21.2 (3.73)
6	R-25.2 (4.44 RSI)	0.047 (0.27)	R-21.3 (3.75)	0.044 (0.25)	R-22.7 (4.00)	0.041 (0.23)	R-24.3 (4.28)

3.2 Split Insulated Steel Stud Assembly

Table 3.2.1: U-Values and Effective R-Values for the TAC Aluminum Clip spaced 16" o.c. Horizontally, Mineral Wool Exterior Insulation (R-4.2/in); Split Insulated Steel Stud Assembly

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[3] h ft² °F/Btu (m²K/W)	24" Vertical Clip Spacing		32" Vertical Clip Spacing		48" Vertical Clip Spacing	
		U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)
3	R-12.6 (2.22 RSI)	0.057 (0.32)	R-17.5 (3.09)	0.054 (0.31)	R-18.6 (3.27)	0.051 (0.29)	R-19.8 (3.48)
4	R-16.8 (2.96 RSI)	0.052 (0.29)	R-19.4 (3.42)	0.048 (0.27)	R-20.8 (3.66)	0.044 (0.25)	R-22.5 (3.96)
5	R-21.0 (3.70 RSI)	0.047 (0.27)	R-21.4 (3.76)	0.043 (0.25)	R-23.1 (4.07)	0.040 (0.22)	R-25.3 (4.45)
6	R-25.2 (4.44 RSI)	0.044 (0.25)	R-22.9 (4.04)	0.040 (0.23)	R-25.0 (4.41)	0.036 (0.20)	R-27.7 (4.88)

[2] This value is the nominal R-value of the exterior insulation ONLY. Additional components, such as the interior drywall, stud cavity, sheathing, and air films all contribute an additional R-3.2 towards the nominal R-value of the entire assembly.

[3] This value is the nominal R-value of the exterior insulation ONLY. Additional components, such as the interior drywall, batt insulation, sheathing, and air films all contribute an additional R-21.3 towards the nominal R-value of the entire assembly.

Table 3.2.2: U-Values and Effective R-Values for the TAC Aluminum Clip spaced 32" o.c. Horizontally, Mineral Wool Exterior Insulation (R-4.2/in); Split Insulated Steel Stud Assembly

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[4] h ft² °F/Btu (m²K/W)	24" Vertical Clip Spacing		32" Vertical Clip Spacing		48" Vertical Clip Spacing	
		U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)
3	R-12.6 (2.22 RSI)	0.051 (0.29)	R-19.8 (3.49)	0.049 (0.28)	R-20.4 (3.60)	0.047 (0.27)	R-21.2 (3.73)
4	R-16.8 (2.96 RSI)	0.044 (0.25)	R-22.5 (3.97)	0.043 (0.24)	R-23.5 (4.13)	0.041 (0.23)	R-24.5 (4.32)
5	R-21.0 (3.70 RSI)	0.039 (0.22)	R-25.3 (4.46)	0.038 (0.21)	R-26.5 (4.67)	0.036 (0.20)	R-27.9 (4.91)
6	R-25.2 (4.44 RSI)	0.036 (0.20)	R-27.8 (4.89)	0.034 (0.19)	R-29.3 (5.16)	0.032 (0.18)	R-31.0 (5.47)

3.3 Sensitivity Analysis: Alternate Exterior Insulation

Table 3.3.1: U-Values and Effective R-Values for the TAC Aluminum Clip spaced 16" o.c. Horizontally and 24" o.c. Vertically, Rigid Foam Board Exterior Insulation(R-5/in); Exterior Insulated Steel Stud Assembly

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[5] h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)
3	R-15.0 (2.64 RSI)	0.078 (0.44)	R-12.8 (2.26)
4	R-20.0 (3.52 RSI)	0.067 (0.38)	R-14.9 (2.62)
5	R-25.0 (4.40 RSI)	0.059 (0.33)	R-17.0 (3.00)
6	R-30.0 (5.28 RSI)	0.054 (0.30)	R-18.7 (3.29)

Table 3.3.2: U-Values and Effective R-Values for the TAC Aluminum Clip spaced 16" o.c. Horizontally and 24" o.c. Vertically, Sprayfoam Exterior Insulation (R-6/in); Exterior Insulated Steel Stud Assembly

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[5] h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)
3	R-18.0 (3.17 RSI)	0.071 (0.40)	R-14.1 (2.48)
4	R-24.0 (4.23 RSI)	0.061 (0.35)	R-16.3 (2.86)
5	R-30.0 (5.28 RSI)	0.054 (0.31)	R-18.6 (3.27)
6	R-36.0 (6.34 RSI)	0.049 (0.28)	R-20.3 (3.58)

To illustrate the difference in thermal performance of the three different exterior insulation types, the nominal vs. effective R-values for the three exterior insulation types are shown below in Figure 3.3.1.

[4] This value is the nominal R-value of the exterior insulation ONLY. Additional components, such as the interior drywall, batt insulation, sheathing, and air films all contribute an additional R-21.3 towards the nominal R-value of the entire assembly.

[5] This value is the nominal R-value of the exterior insulation ONLY. Additional components, such as the interior drywall, stud cavity, sheathing, and air films all contribute an additional R-3.2 towards the nominal R-value of the entire assembly.

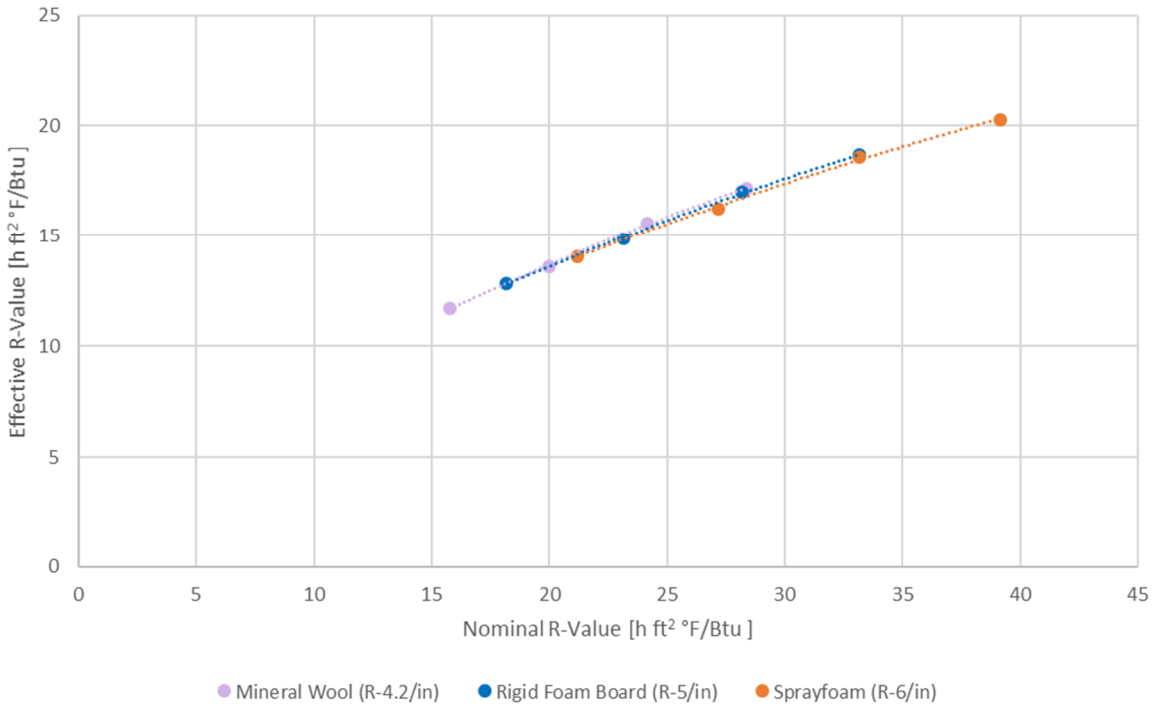


Figure 3.3.1: Nominal R-Value vs. Effective R-Value for the TAC Aluminum Clip Spaced 16" o.c. Horizontally and 24" o.c. Vertically, with Three Exterior Insulation Types; Exterior Insulated Steel Stud

3.4 Sensitivity Analysis: Two Screw Clip Attachment

Table 3.4.1 below illustrates the thermal impact of two screw clip attachment. For comparison, the thermal results of the baseline four screw clip attachment for the 5 inch exterior insulation assembly is also shown.

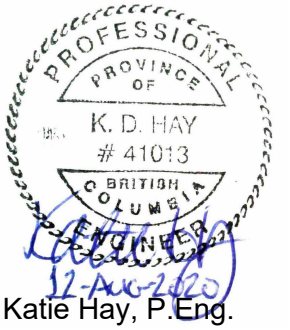
Table 3.4.1: U-Values and Effective R-Value for the TAC Aluminum Clip spaced 16" o.c. Horizontally and 24" o.c. Vertically with Two Screw Attachment, Mineral Wool Exterior Insulation (R-4.2/in); Exterior Insulated Steel Stud Assembly

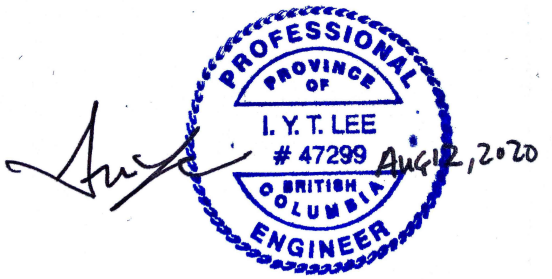
Number of Clip Screws	Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[6] h ft² °F/Btu (m²K/W)	U-Value Btu/h ft² °F (W/m²K)	Effective R-Value h ft² °F/Btu (m²K/W)
4	5	R-21.0 (3.70 RSI)	0.064 (0.36)	R-15.6 (2.75)
2	5	R-21.0 (3.70 RSI)	0.062 (0.35)	R-16.1 (2.83)

[6] This value is the nominal R-value of the exterior insulation ONLY. Additional components, such as the interior drywall, stud cavity, sheathing, and air films all contribute an additional R-3.2 towards the nominal R-value of the entire assembly.

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

Morrison Hershfield Limited

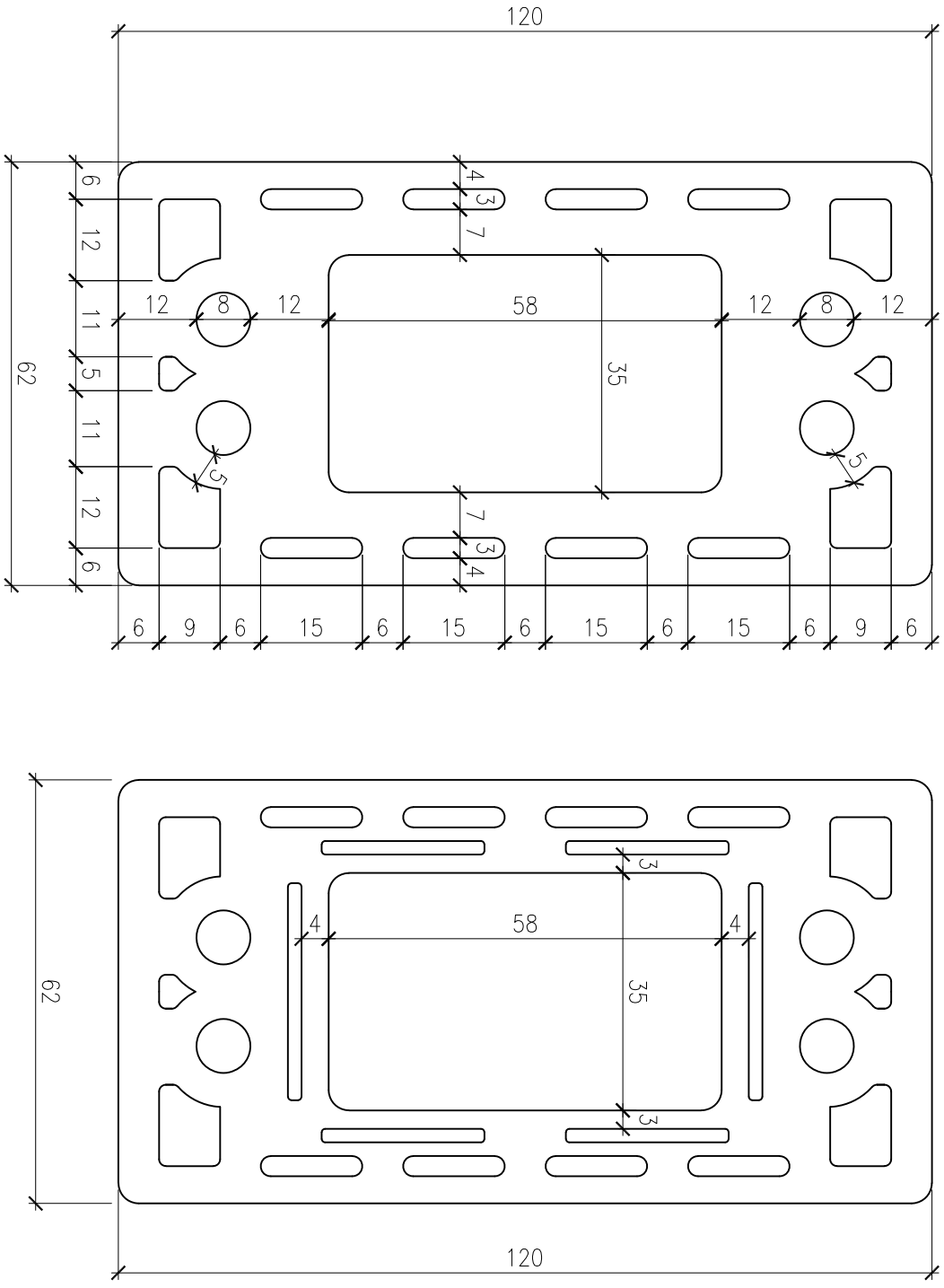




Katie Hay, P.Eng.
Building Science Consultant

Ivan Lee, P.Eng.
Building Science Consultant

APPENDIX A:
DETAIL DRAWINGS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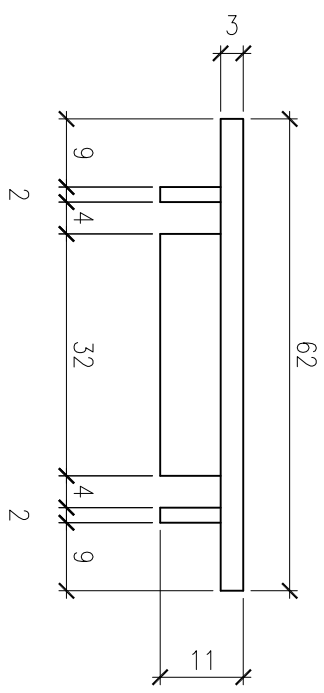
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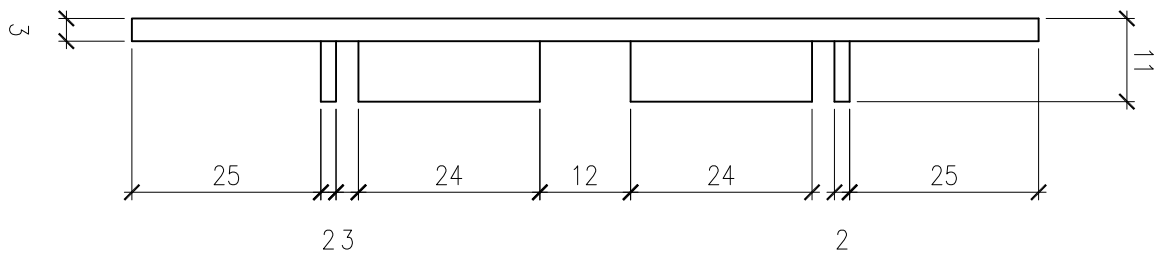
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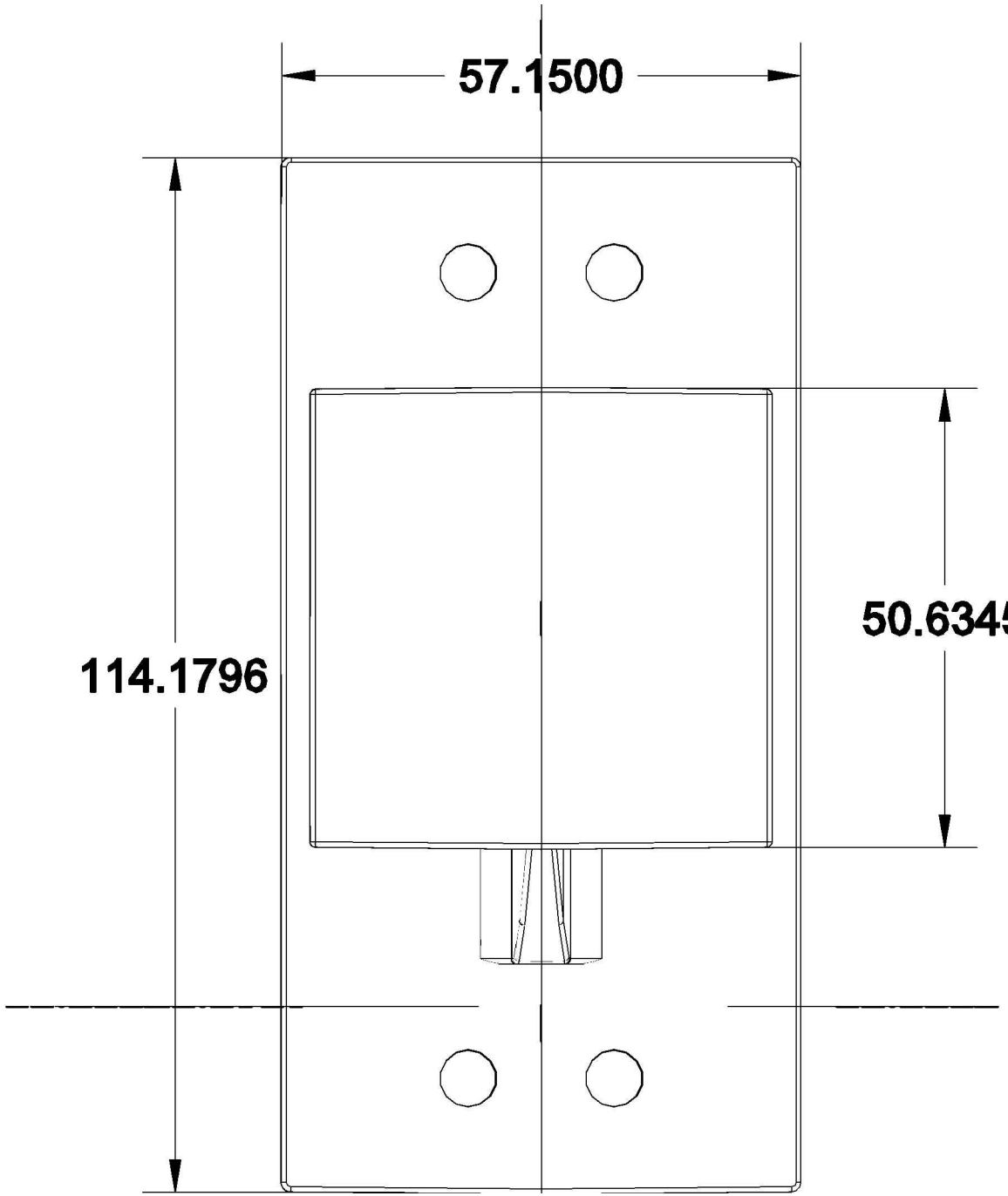
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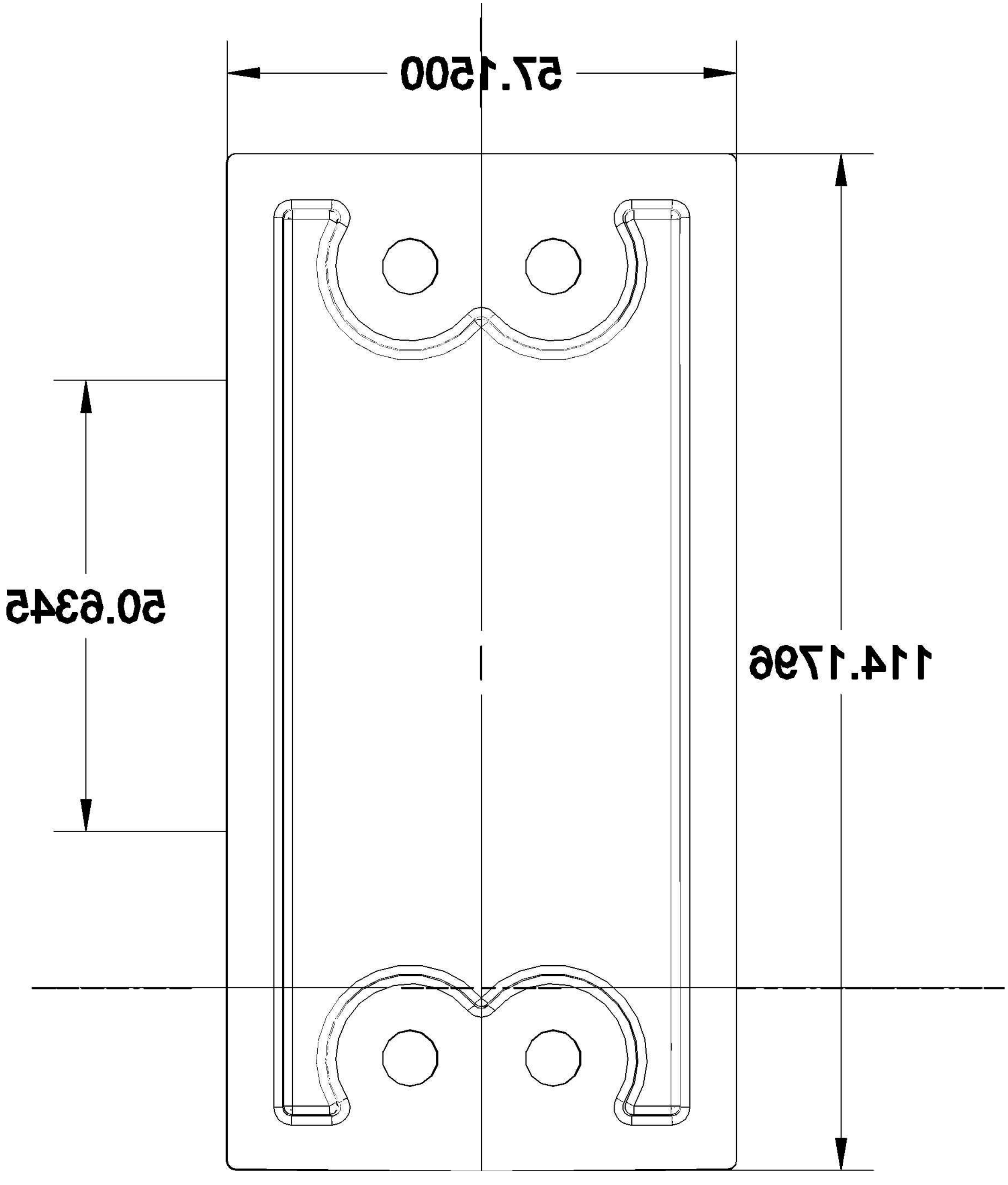
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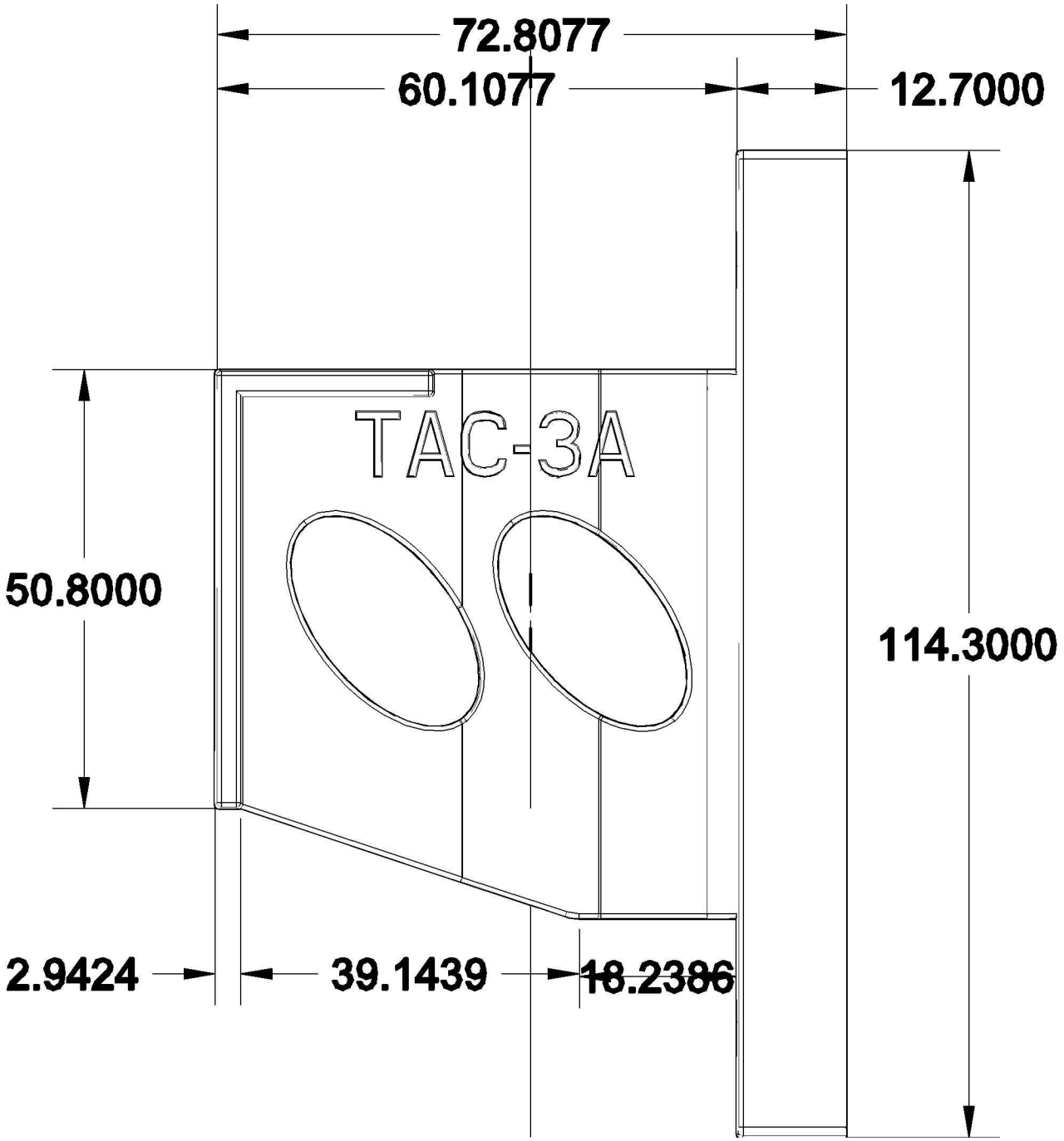
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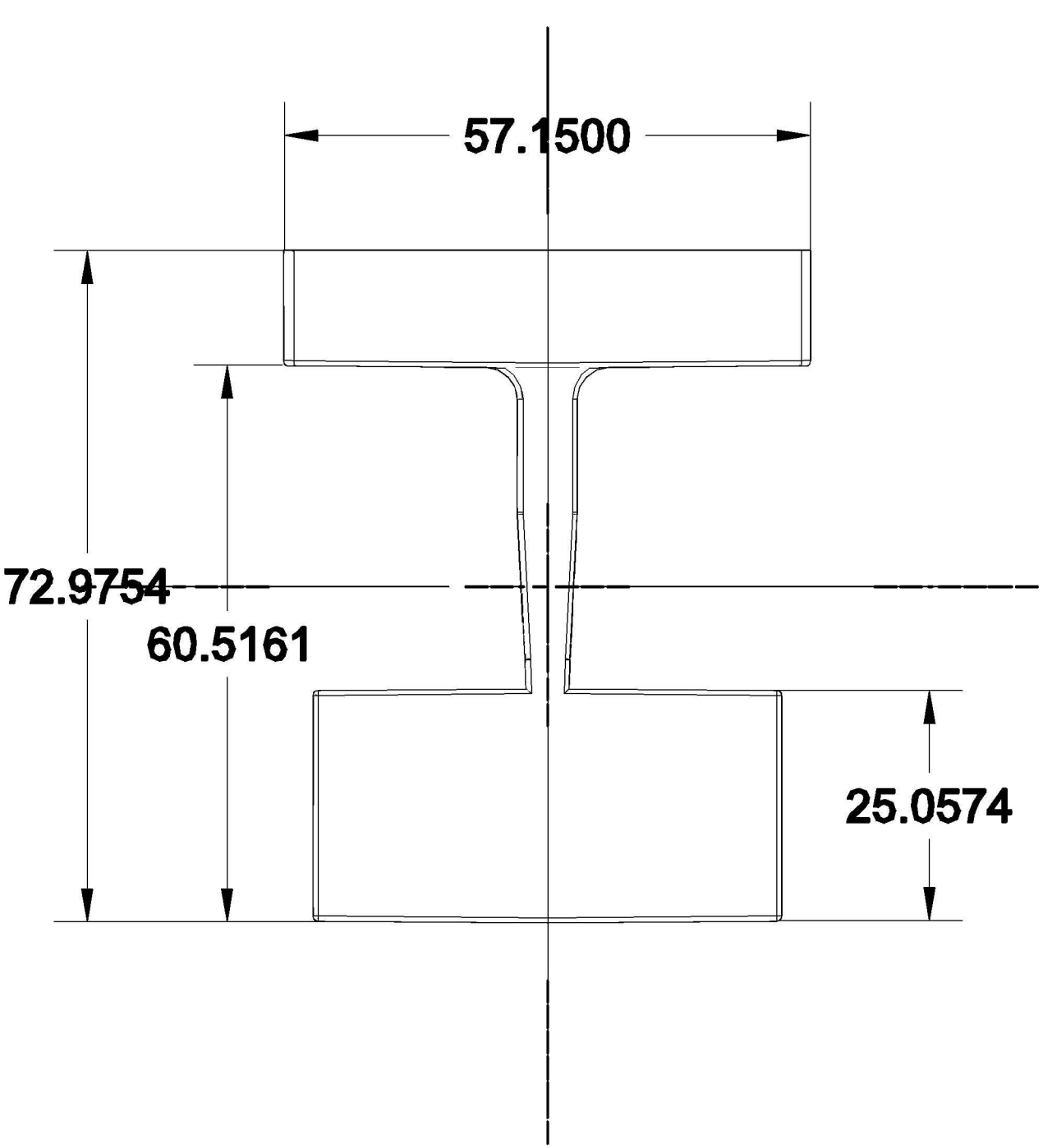
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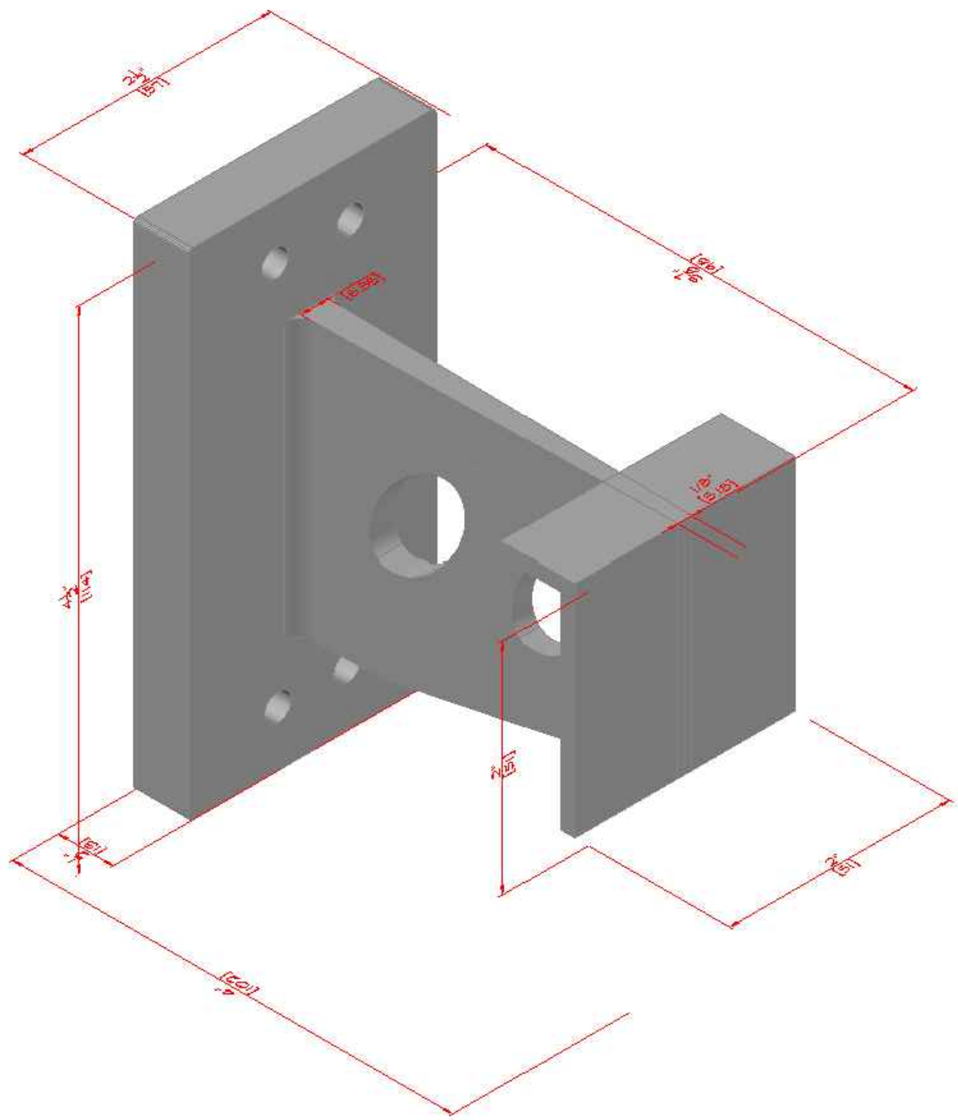

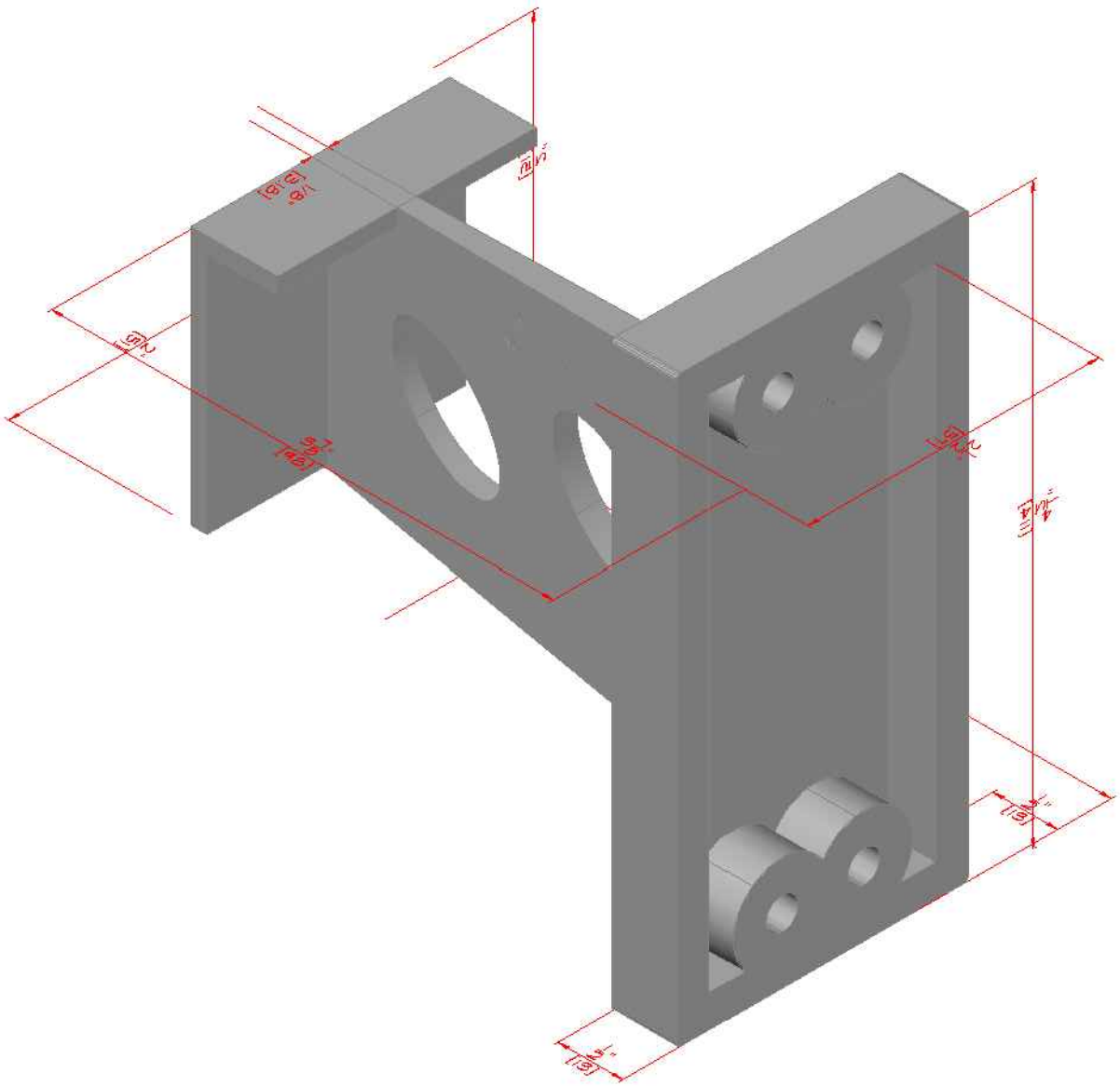

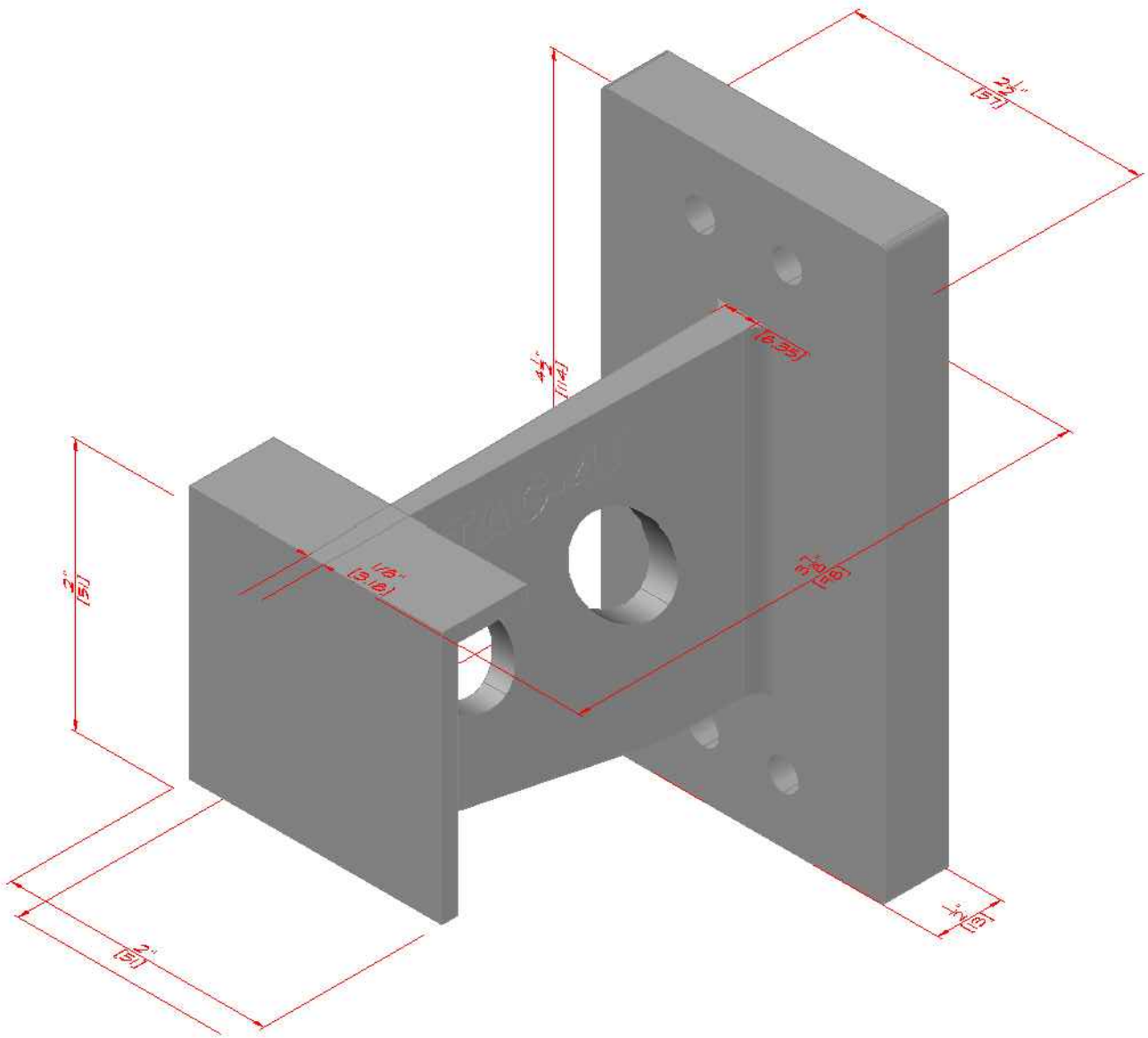
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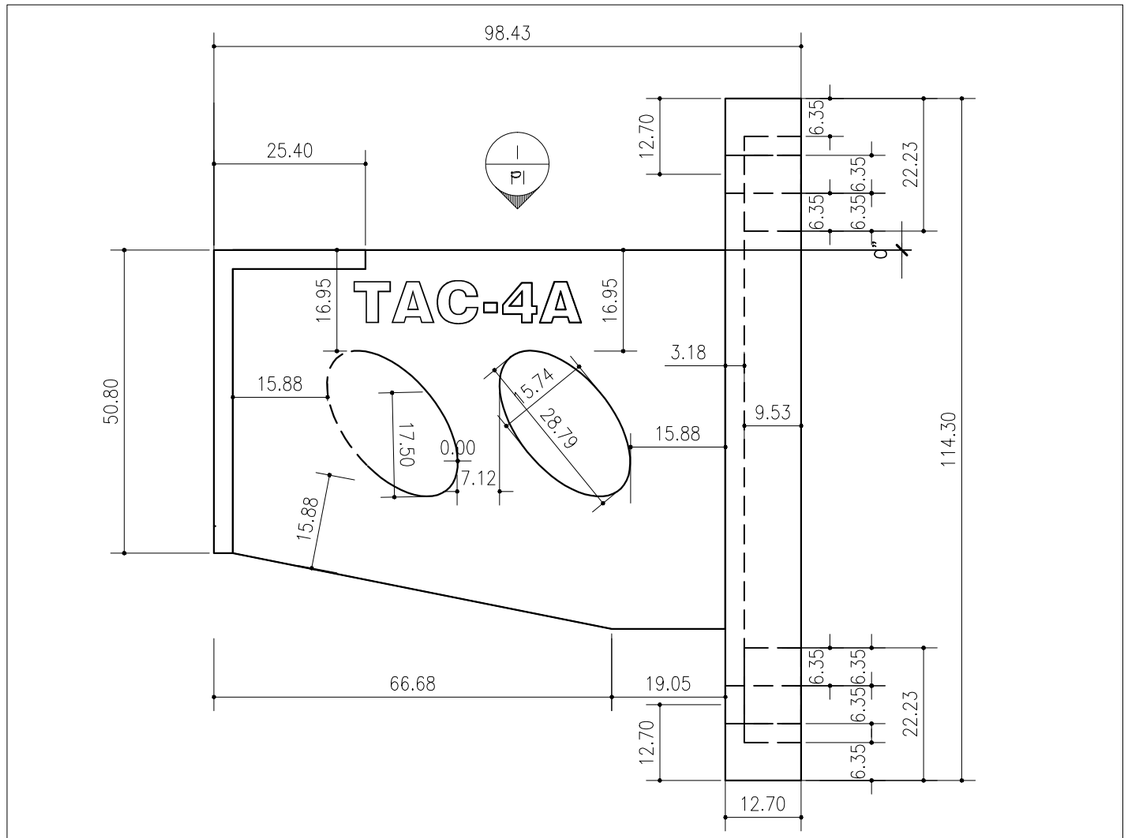

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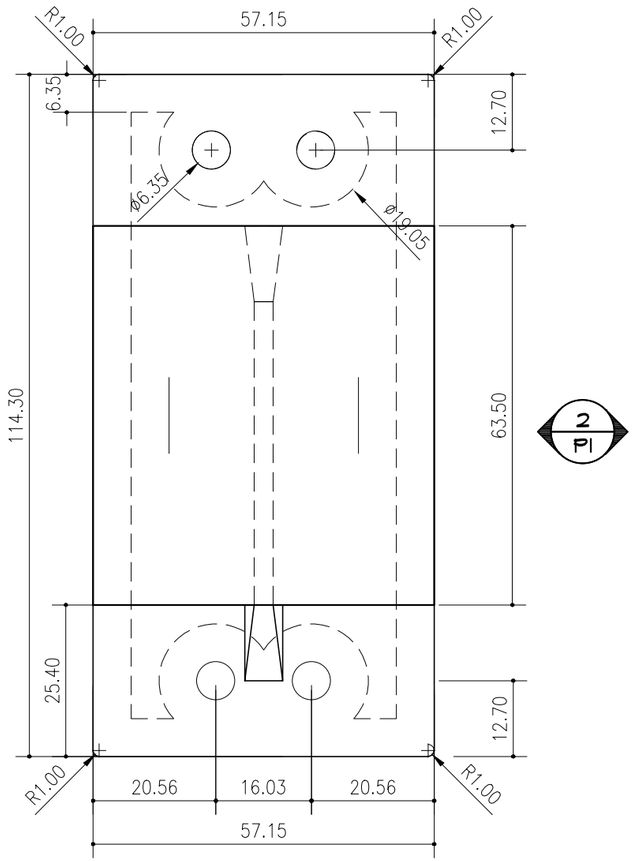

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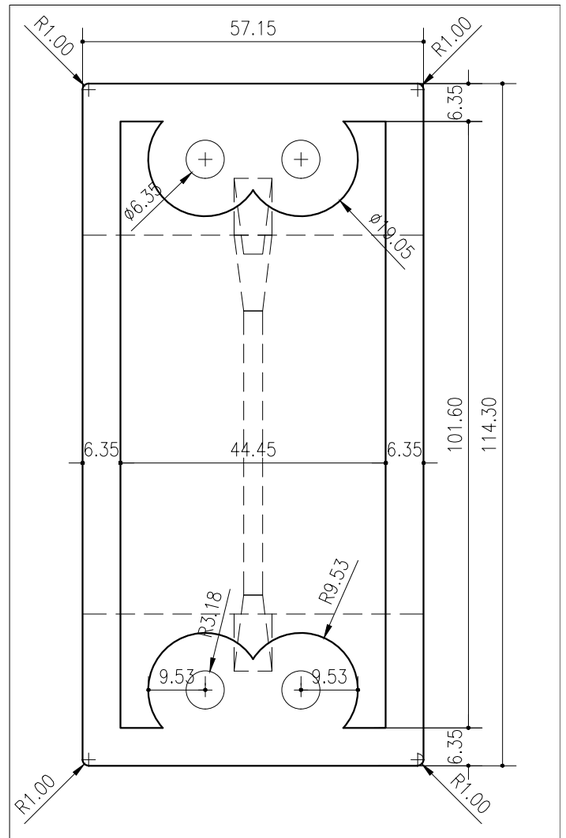

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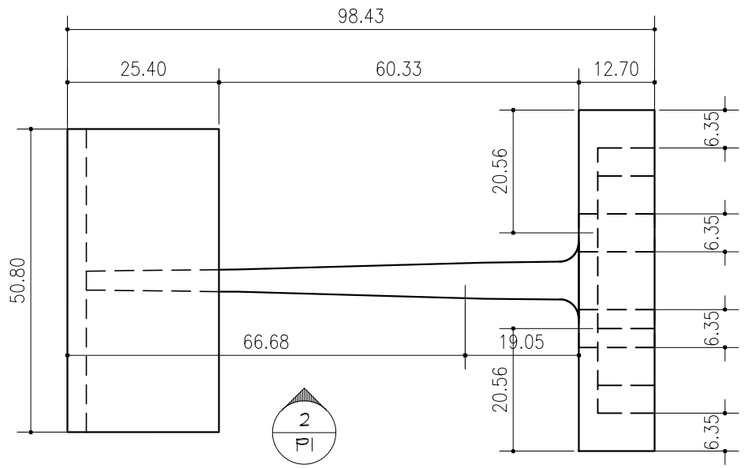

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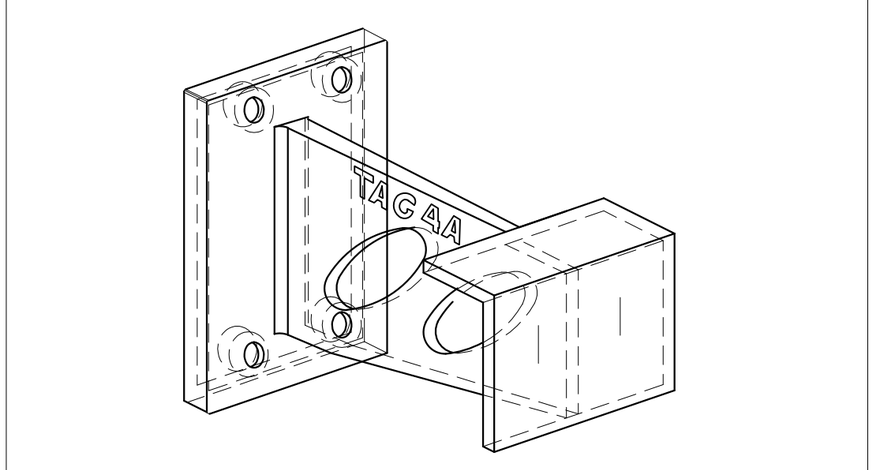

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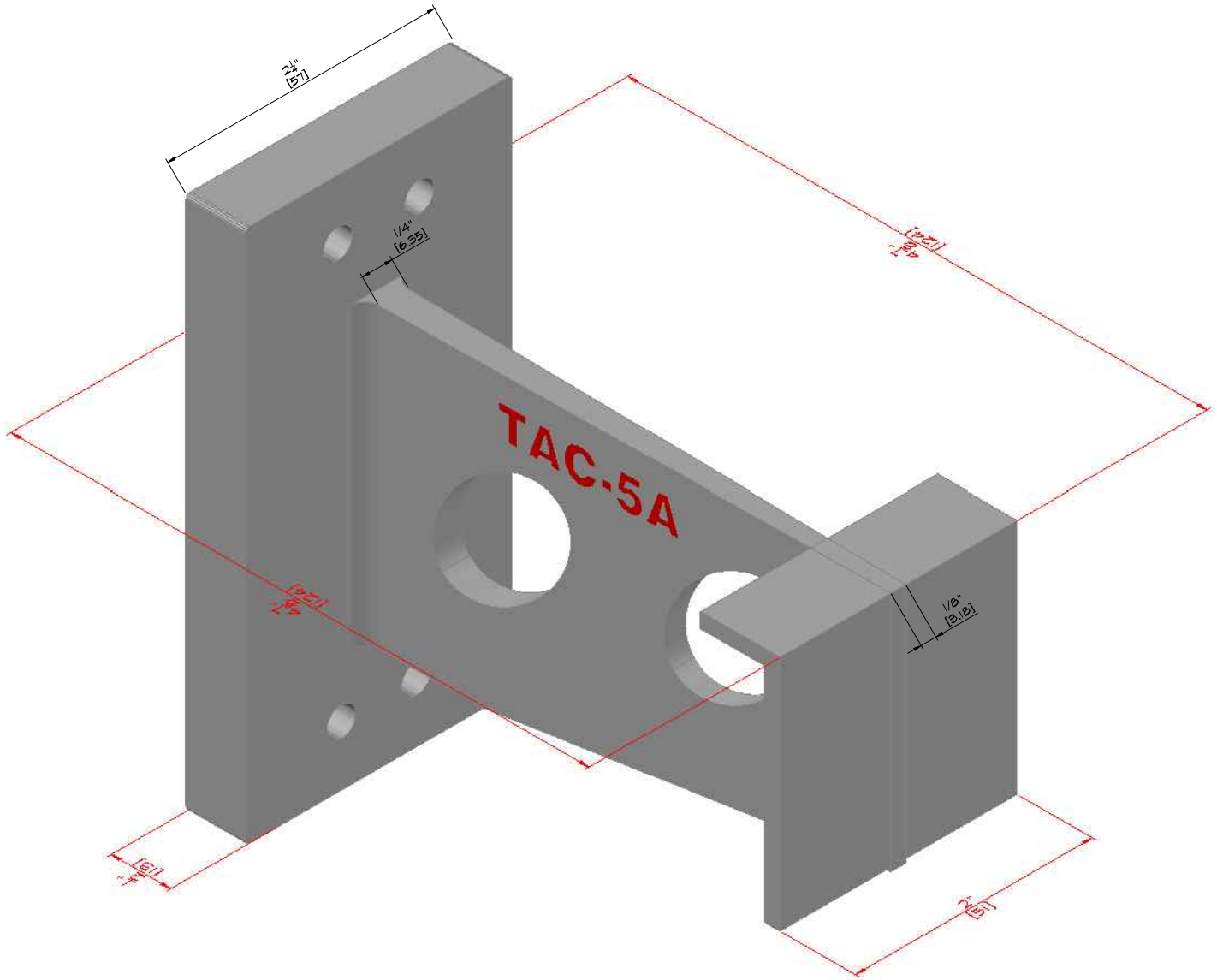
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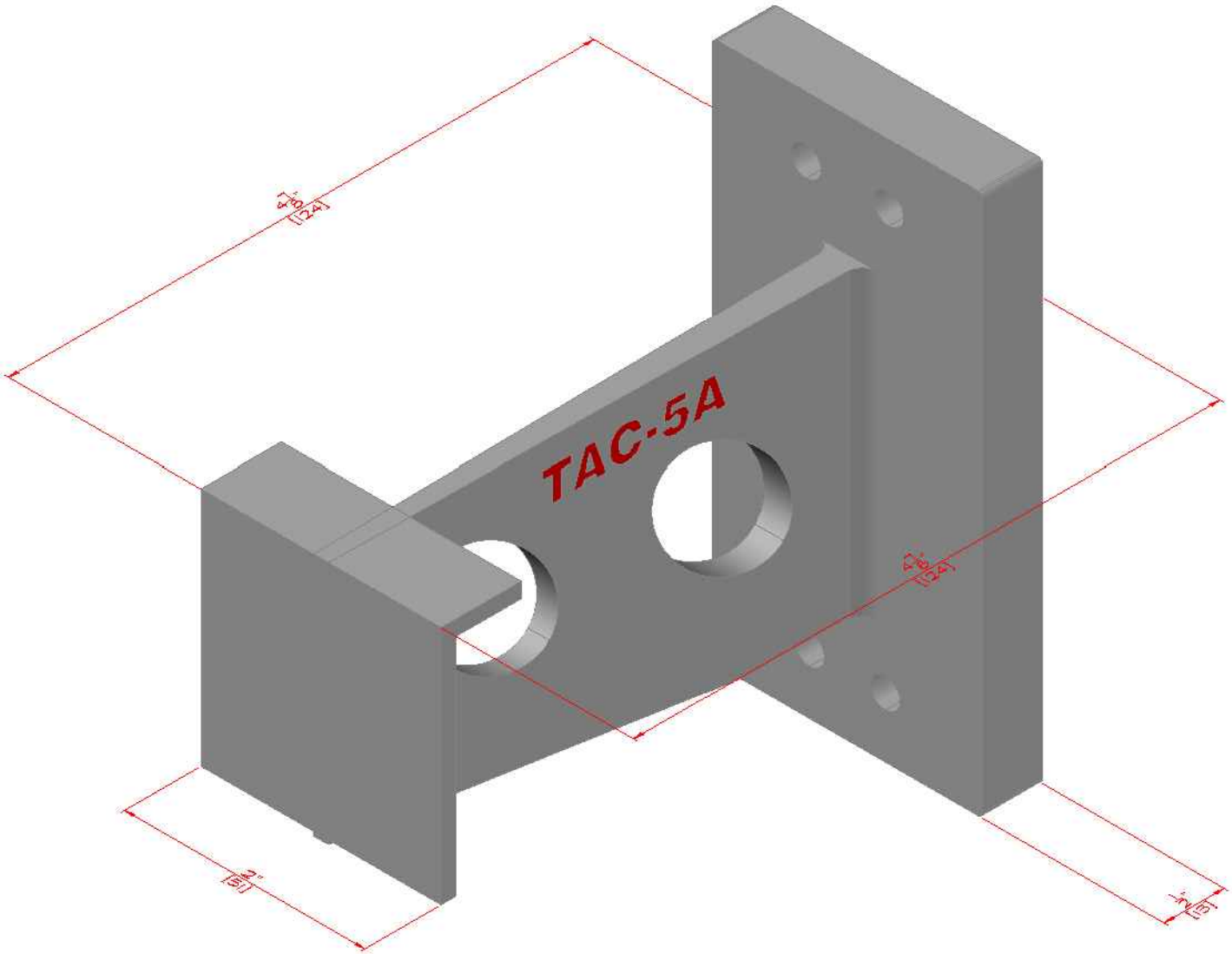
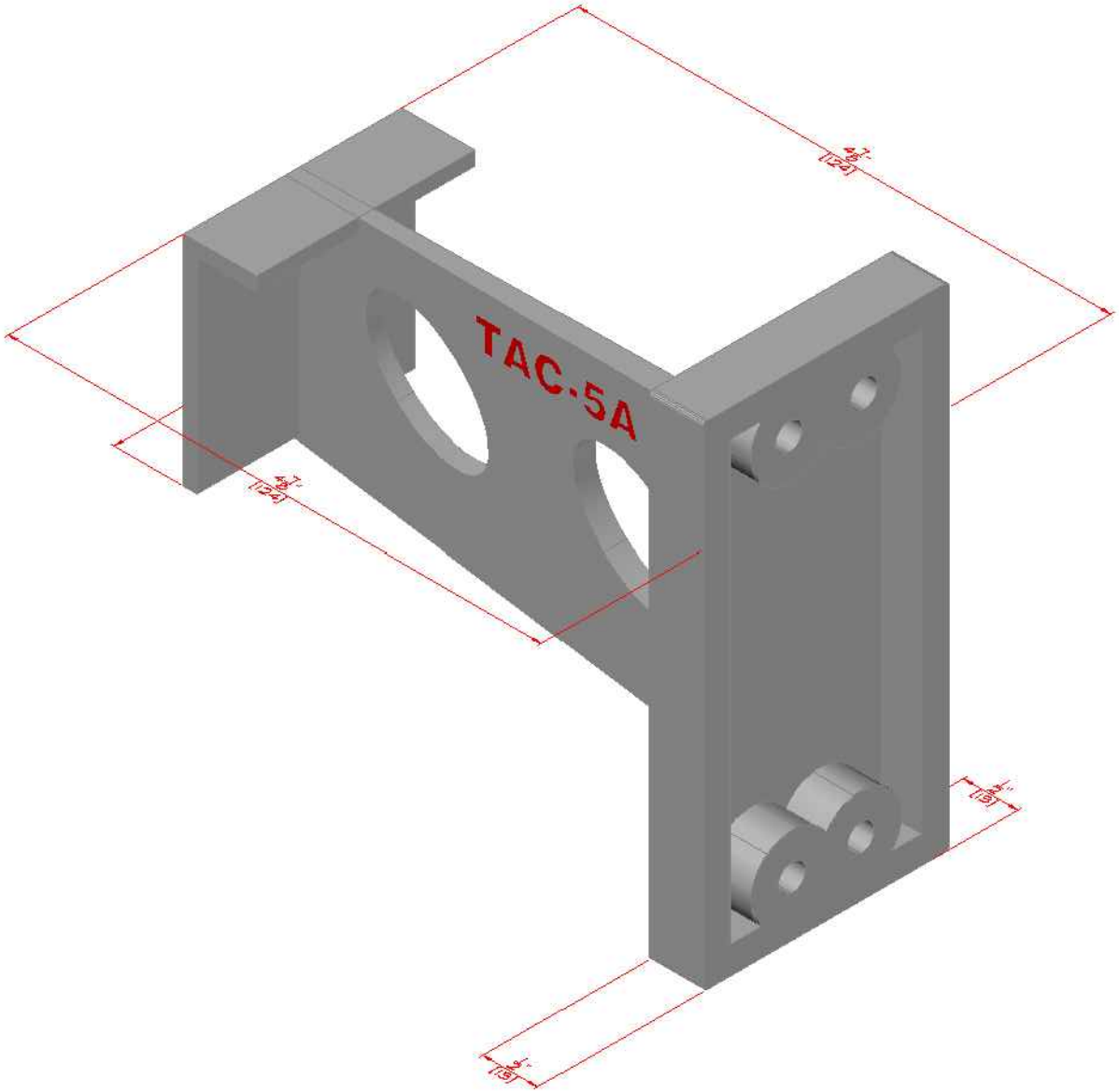
2 7/8"
1/8"
[3.18]
[61]
2 3/8"
[60]
TAC-5A


TAC-5A
4.90
[124]
4.90
[124]
2"
[51]
.24"
[6]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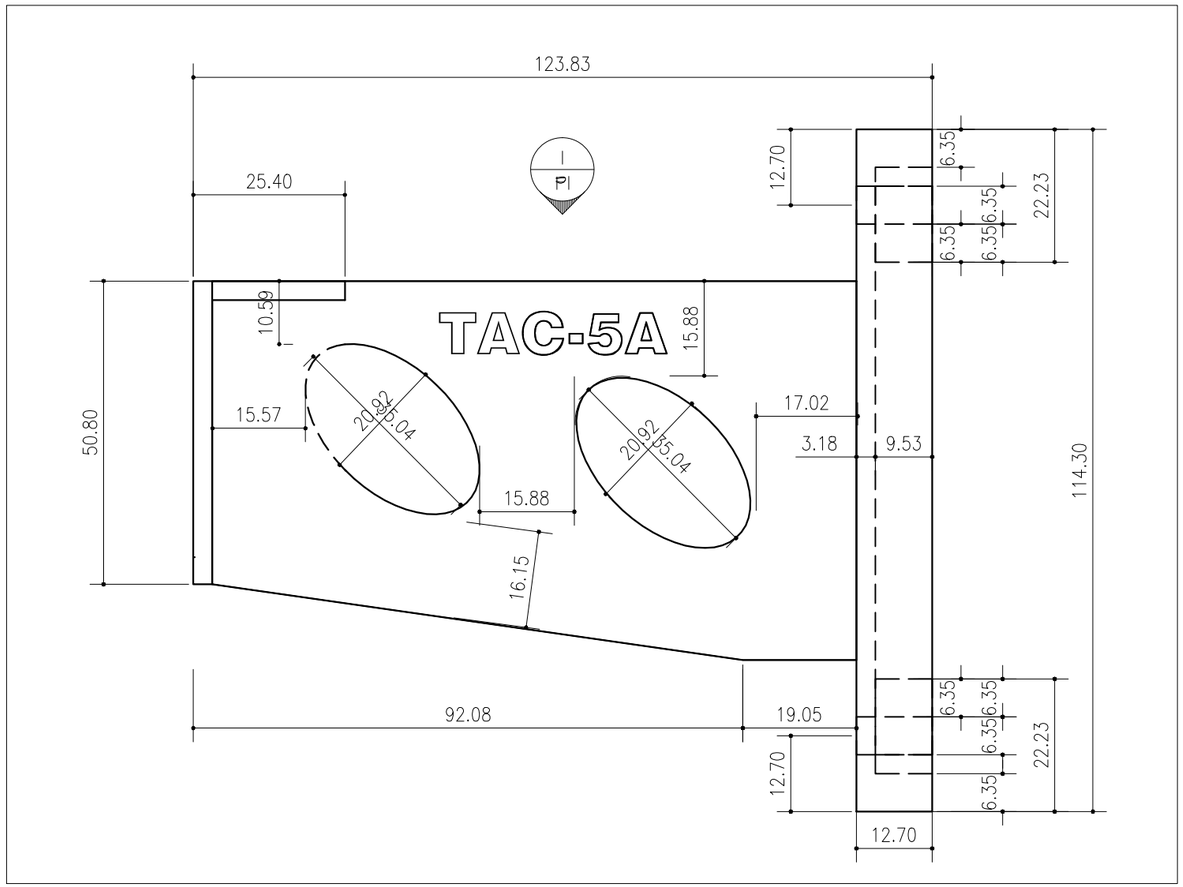
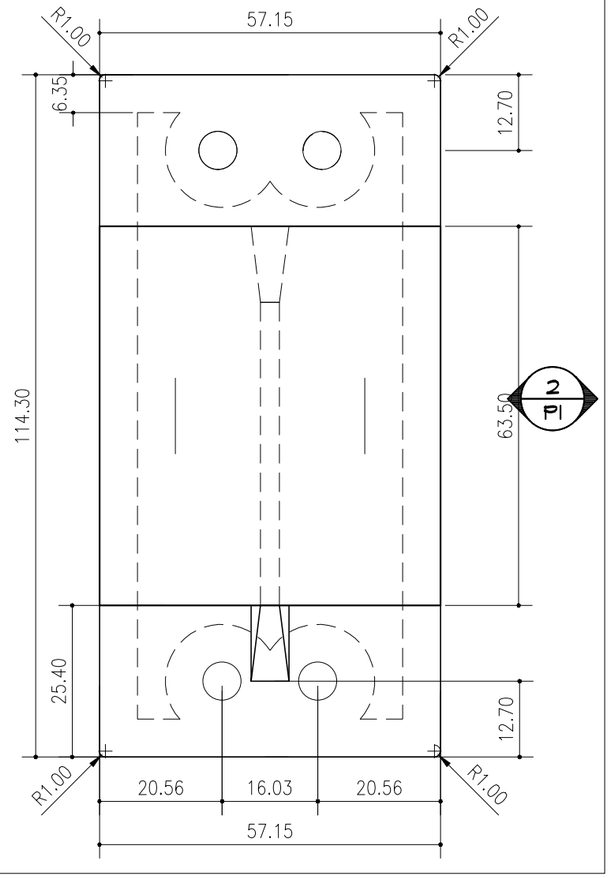
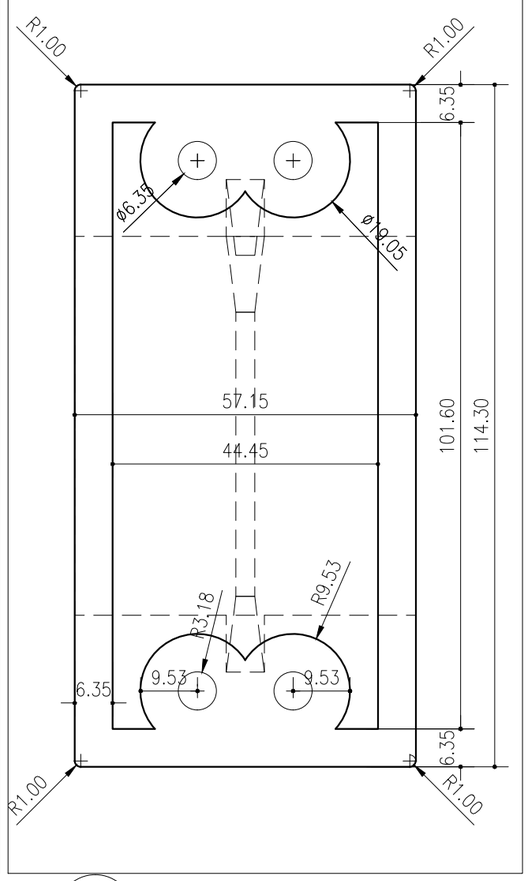


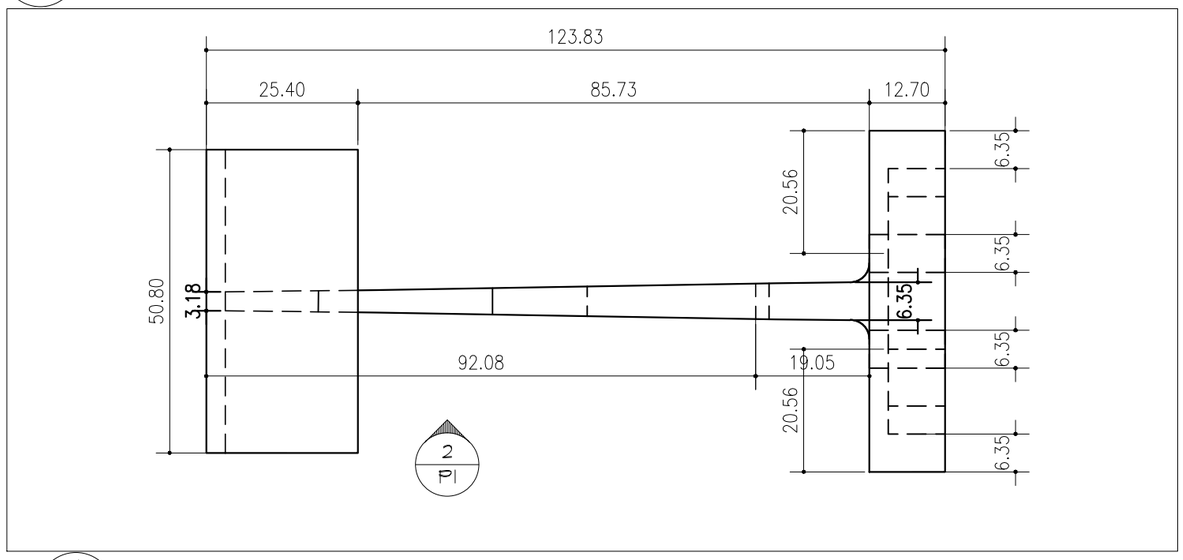
2 P1 SIDE VIEW
SCALE: 1:1



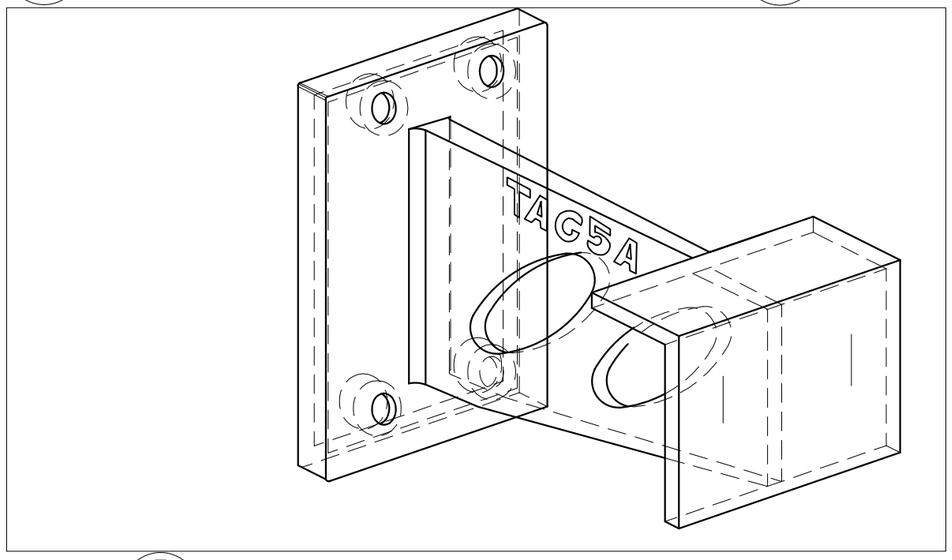
3 P1 FRONT VIEW
SCALE: 1:1



4 P1 REAR VIEW
SCALE: 1:1



1 P1 TOP VIEW
SCALE: 1:1

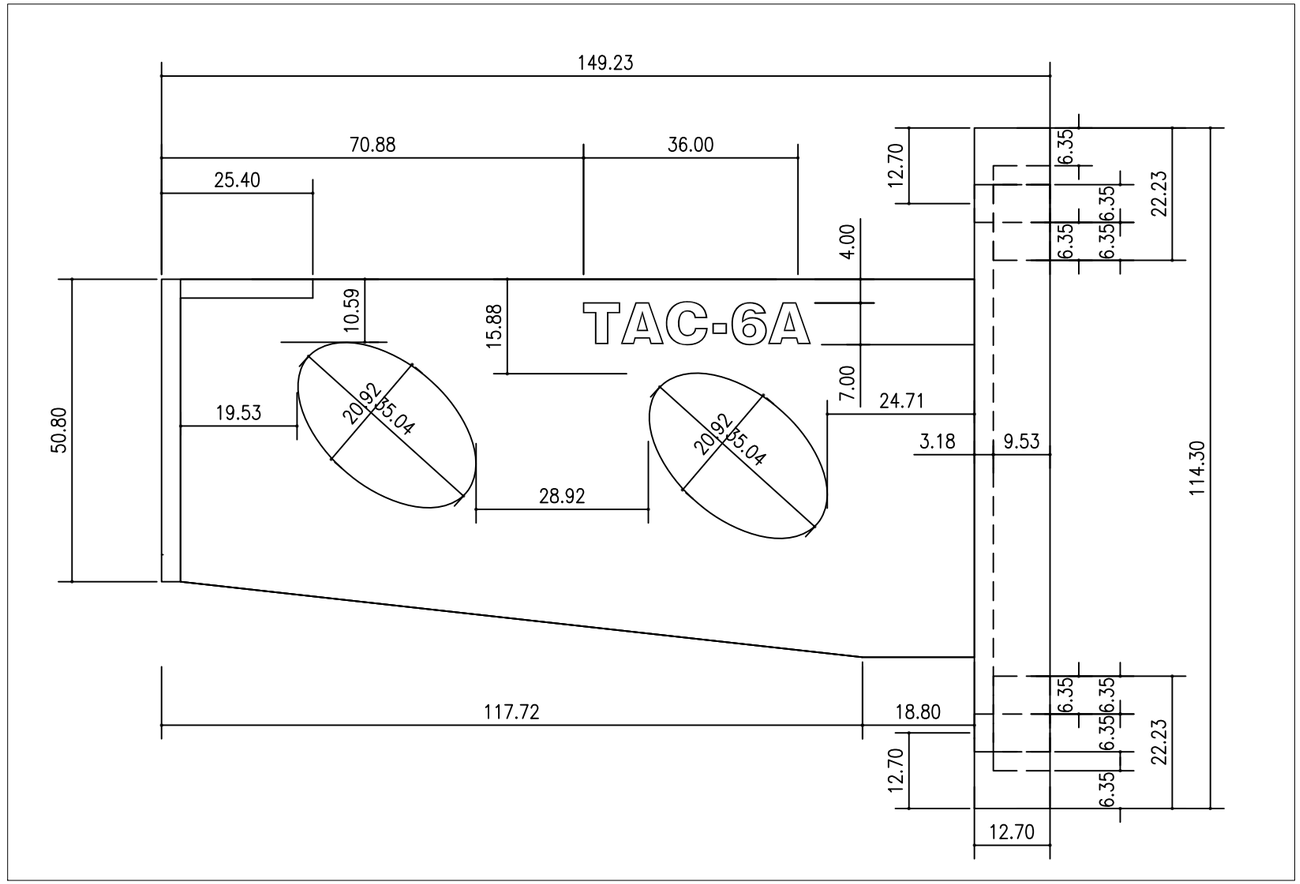


5 P1 ISOMETRIC VIEW
N.T.S

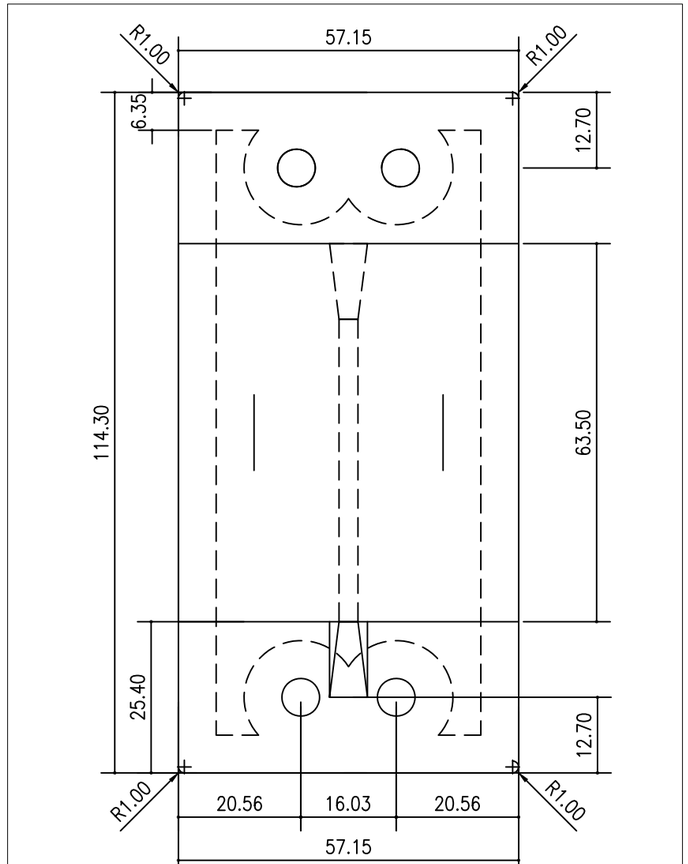
TAC-5A

P1 OF 1

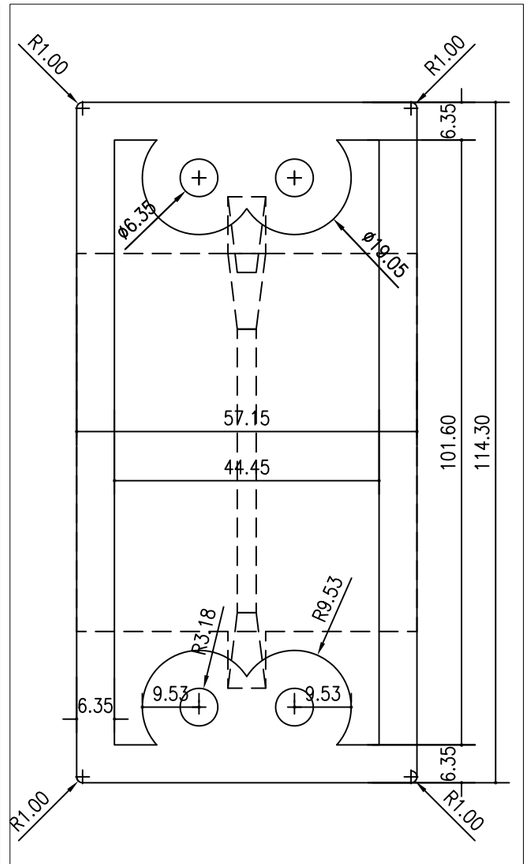
DTD. 05-17-2016



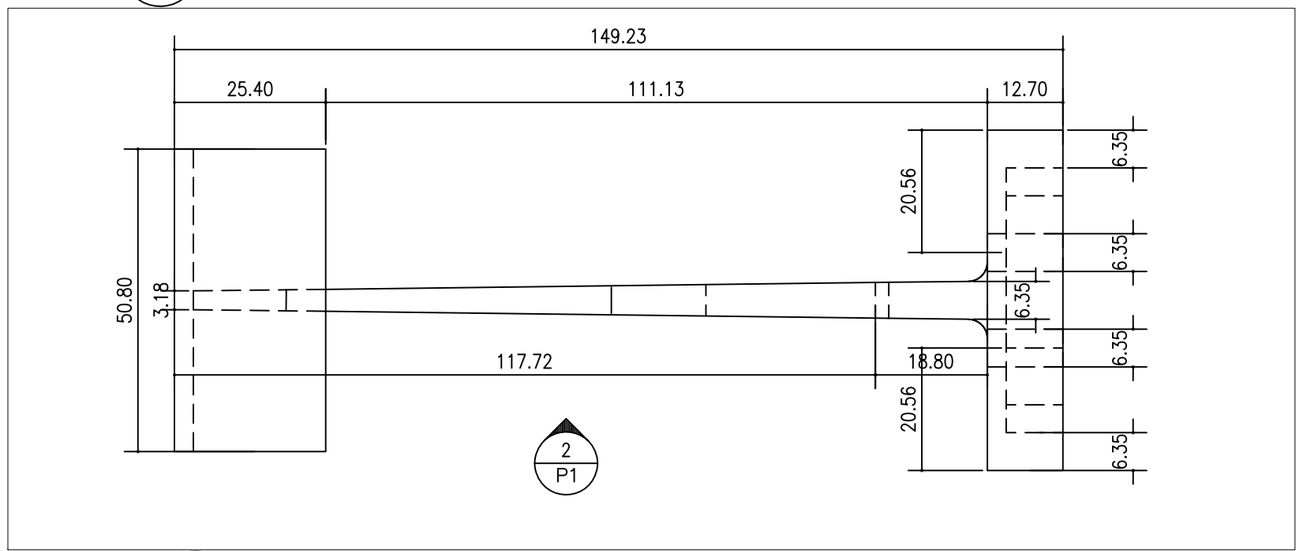
2 P1 SIDE VIEW
SCALE: 1:1



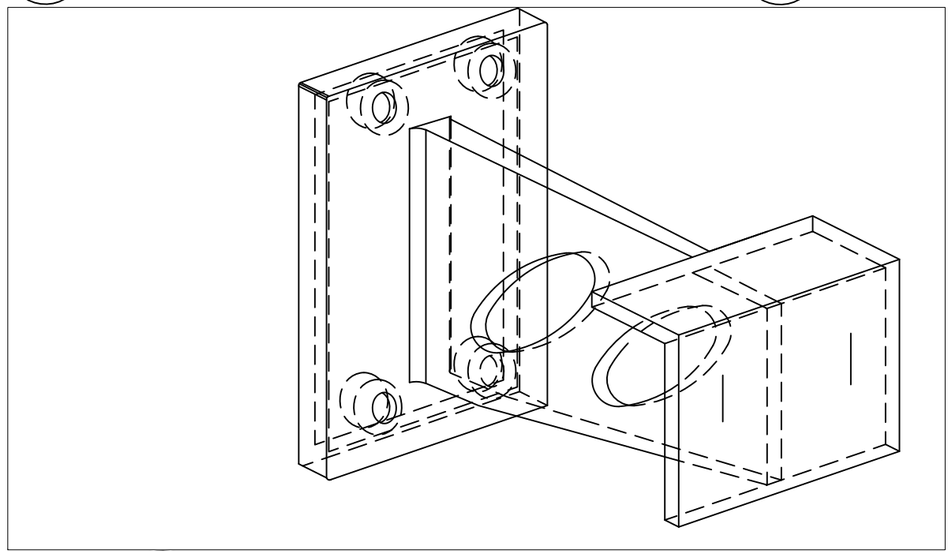
3 P1 FRONT VIEW
SCALE: 1:1



4 P1 REAR VIEW
SCALE: 1:1



1 P1 TOP VIEW
SCALE: 1:1



5 P1 ISOMETRIC VIEW
N.T.S

TAC-6A

P1 OF 1

DTD. 07-28-2020

APPENDIX B:
MODELLING PARAMETERS AND ASSUMPTIONS

1. GENERAL MODELLING 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 Exterior Technologies Group and the ASHRAE Handbook – Fundamentals for common materials.
- Enclosed air spaces were modelled 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 10, p. 26.21 of 2017 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 modelled but were incorporated into the exterior film coefficient.
- From the calibration in 1365-RP, contact resistances between materials were modelled 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, clips, and girts.

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 modelling approach, see ASHRAE 1365-RP.

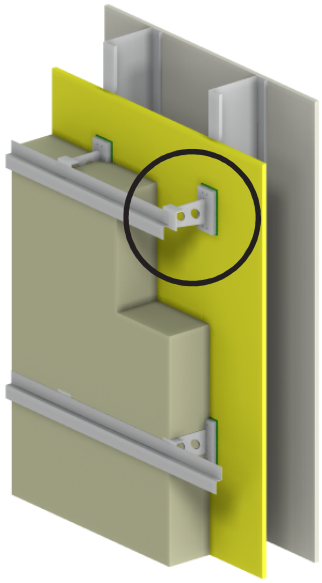
3. BOUNDARY CONDITIONS

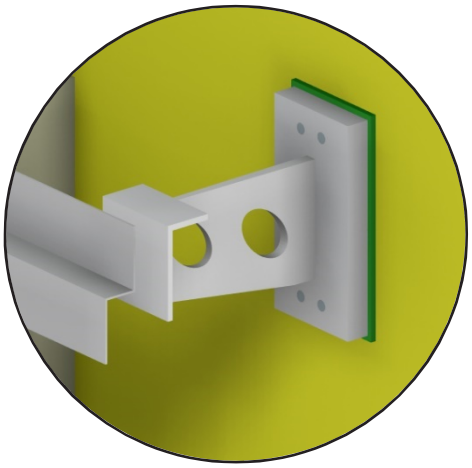
Table B3.1: Boundary Conditions

Boundary Location	**Combined Convective and Radiation Heat Transfer Coefficient** Btu/h ft^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



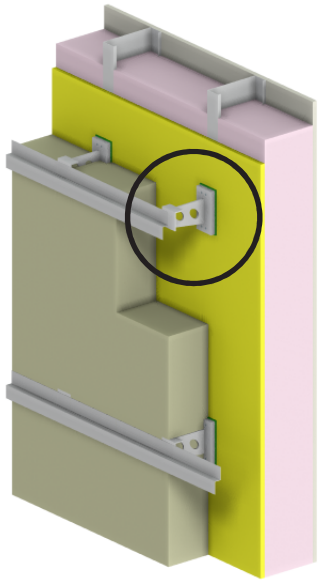


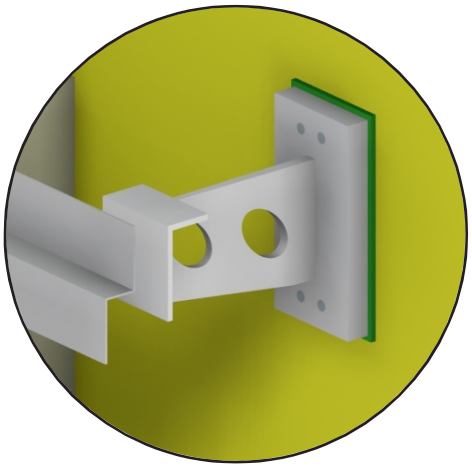
TAC Aluminum Clip Detail

Component	Material	Thickness in (mm)	Thermal Conductivity Btu in / ft² h °F (W/m K)	Nominal Resistance ft² h °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)	-	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 (R4.2/in)	Varies	0.24 (0.034)	R-12.6 to R-25.2 (2.22 to 4.44 RSI)
TAC Aluminum Clip	Aluminum	-	1110 (160)	-
Fasteners	Stainless Steel	1/4 (6.4) Φ	118 (17)	-
Thermal Isolator	Polypropylene	0.12 (3)	1.53 (0.22)	-
Girt	Galvanized Steel	18 ga.	430 (62)	-
Air Spaces[1]	Air	Varies	Varies	-
Exterior Film	-	-	-	R-0.7 (0.12 RSI)
Overall Wall Assembly 1D	-	-	-	R-15.8 to R-28.4 (2.78 to 5.00 RSI)

[1] The thermal conductivities of the air spaces were determined according to ISO 10077-2

2. SPLIT INSULATED STEEL STUD ASSEMBLY





TAC Aluminum Clip Detail

Component	Material	Thickness in (mm)	Thermal Conductivity Btu in / ft² h °F (W/m K)	Nominal Resistance ft² h °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	R-19 Batt Insulation	6 (152)	0.32 (0.046)	R-19.0 (3.35 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 (R4.2/in)	Varies	0.24 (0.034)	R-12.6 to R-25.2 (2.22 to 4.44 RSI)
TAC Aluminum Clip	Aluminum	-	1110 (160)	-
Fasteners	Stainless Steel	1/4 (6.4) Φ	118 (17)	-
Thermal Isolator	Polypropylene	0.12 (3)	1.53 (0.22)	-
Girt	Galvanized Steel	18 ga.	430 (62)	-
Air Spaces[1]	Air	Varies	Varies	-
Exterior Film	-	-	-	R-0.7 (0.12 RSI)
Overall Wall Assembly 1D	-	-	-	R-33.9 to R-46.5 (5.97 to 8.18 RSI)

[1] The thermal conductivities of the air spaces were determined according to ISO 10077-2

3. SENSITIVITY ANALYSIS: ALTERNATE EXTERIOR INSULATION

Table C3.1: Material Properties for the TAC Aluminum Clip Spaced 16" o.c. x 24" o.c. with Rigid Foam Board Exterior Insulation (R-5/in), Exterior Insulated Steel Stud Assembly

Component	**Material**	**Thickness** in (mm)	**Thermal Conductivity** Btu in / ft² h °F (W/m K)	**Nominal Resistance** ft² h °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)	-	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	Rigid Foam Board (R5/in)	Varies	0.20 (0.029)	R-15.0 to R-30.0 (2.64 to 5.28 RSI)
TAC Aluminum Clip	Aluminum	-	1110 (160)	-
Fasteners	Stainless Steel	1/4 (6.4) Φ	118 (17)	-
Thermal Isolator	Polypropylene	0.12 (3)	1.53 (0.22)	-
Girt	Galvanized Steel	18 ga.	430 (62)	-
Air Spaces[1]	Air	Varies	Varies	-
Exterior Film	-	-	-	R-0.7 (0.12 RSI)
Overall Wall Assembly 1D	-	-	-	R-18.2 to R-33.2 (3.20 to 5.84 RSI)

[1] The thermal conductivities of the air spaces were determined according to ISO 10077-2

Table C3.2: Material Properties for the TAC Aluminum Clip Spaced 16" o.c. x 24" o.c. with Sprayfoam Exterior Insulation (R-6/in) Exterior Insulated Steel Stud Assembly

Component	Material	Thickness in (mm)	Thermal Conductivity Btu in / ft² h °F (W/m K)	Nominal Resistance ft² h °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)	-	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	Sprayfoam (R6/in)	Varies	0.17 (0.024)	R-18.0 to R-36.0 (3.17 to 6.34 RSI)
TAC Aluminum Clip	Aluminum	-	1110 (160)	-
Fasteners	Stainless Steel	1/4 (6.4) Φ	118 (17)	-
Thermal Isolator	Polypropylene	0.12 (3)	1.53 (0.22)	-
Girt	Galvanized Steel	18 ga.	430 (62)	-
Air Spaces[1]	Air	Varies	Varies	-
Exterior Film	-	-	-	R-0.7 (0.12 RSI)
Overall Wall Assembly 1D	-	-	-	R-21.2 to R-39.2 (3.73 to 6.90 RSI)

[1] The thermal conductivities of the air spaces were determined according to ISO 10077-2

4. SENSITIVITY ANALYSIS: TWO SCREW CLIP ATTACHMENT

Component	**Material**	**Thickness** in (mm)	**Thermal Conductivity** Btu in / ft² h °F (W/m K)	**Nominal Resistance** ft² h °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)	-	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 (R4.2/in)	5 (127)	0.24 (0.034)	R-21 (3.70 RSI)
TAC Aluminum Clip	Aluminum	-	1110 (160)	-
Fasteners	Stainless Steel	1/4 (6.4) Φ	118 (17)	-
Thermal Isolator	Polypropylene	0.12 (3)	1.53 (0.22)	-
Girt	Galvanized Steel	18 ga.	430 (62)	-
Air Spaces[1]	Air	Varies	Varies	-
Exterior Film	-	-	-	R-0.7 (0.12 RSI)
Overall Wall Assembly 1D	-	-	-	R-24.2 (4.26 RSI)

[1] 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 TAC Aluminum Clip system, the following figures illustrate a typical temperature distribution for the 5 inch TAC Clip with 5 inches of exterior insulation and a clip spacing of 16 inches o.c. horizontal and 24 inches o.c. vertical. The profiles are presented as a temperature index (between 0 and 1). See Appendix B.2 for more information.

1. EXTERIOR INSULATED STEEL STUD ASSEMBLY

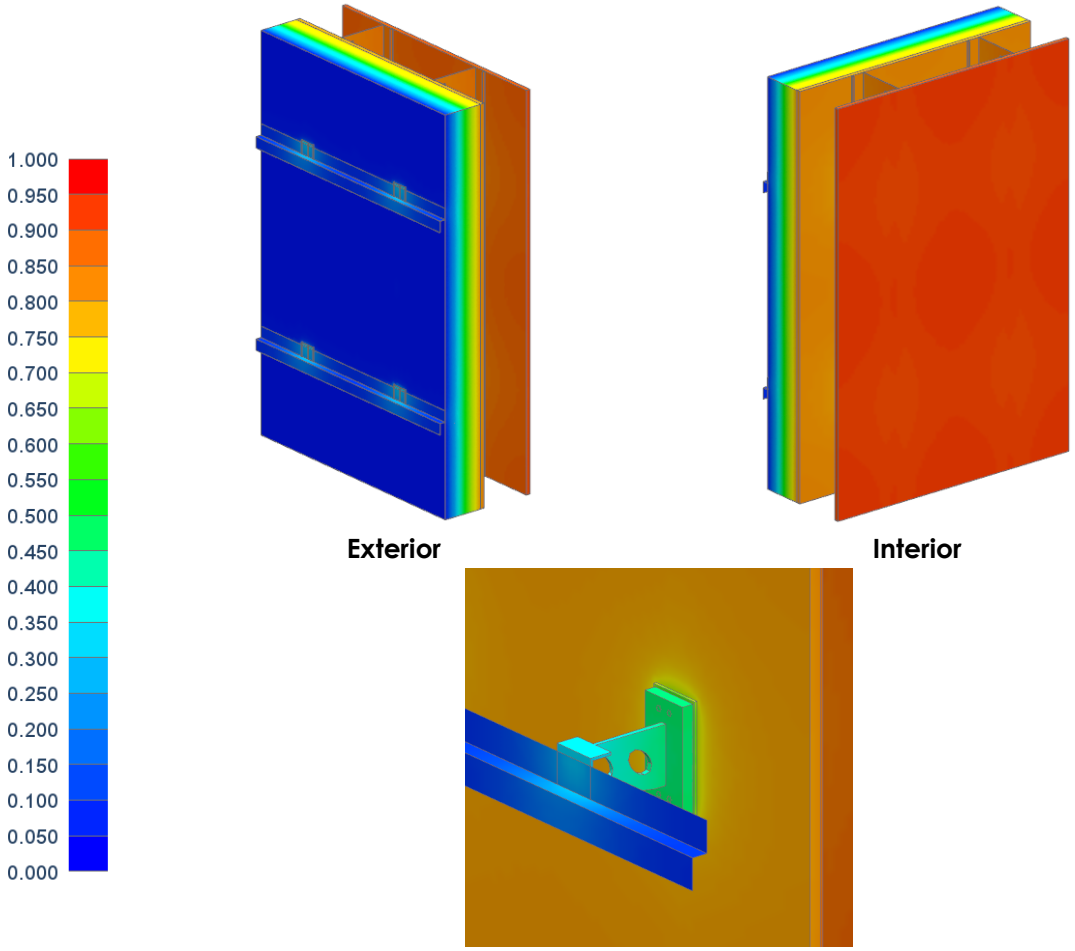


Figure D1.1: Temperature Profile of the 5 inch TAC Aluminum Clip Spaced 16" o.c. x 24" o.c. with Mineral Wool (R-4.2/in) Exterior Insulation (R-21), Exterior Insulated Steel Stud Assembly

2. SPLIT INSULATED STEEL STUD ASSEMBLY

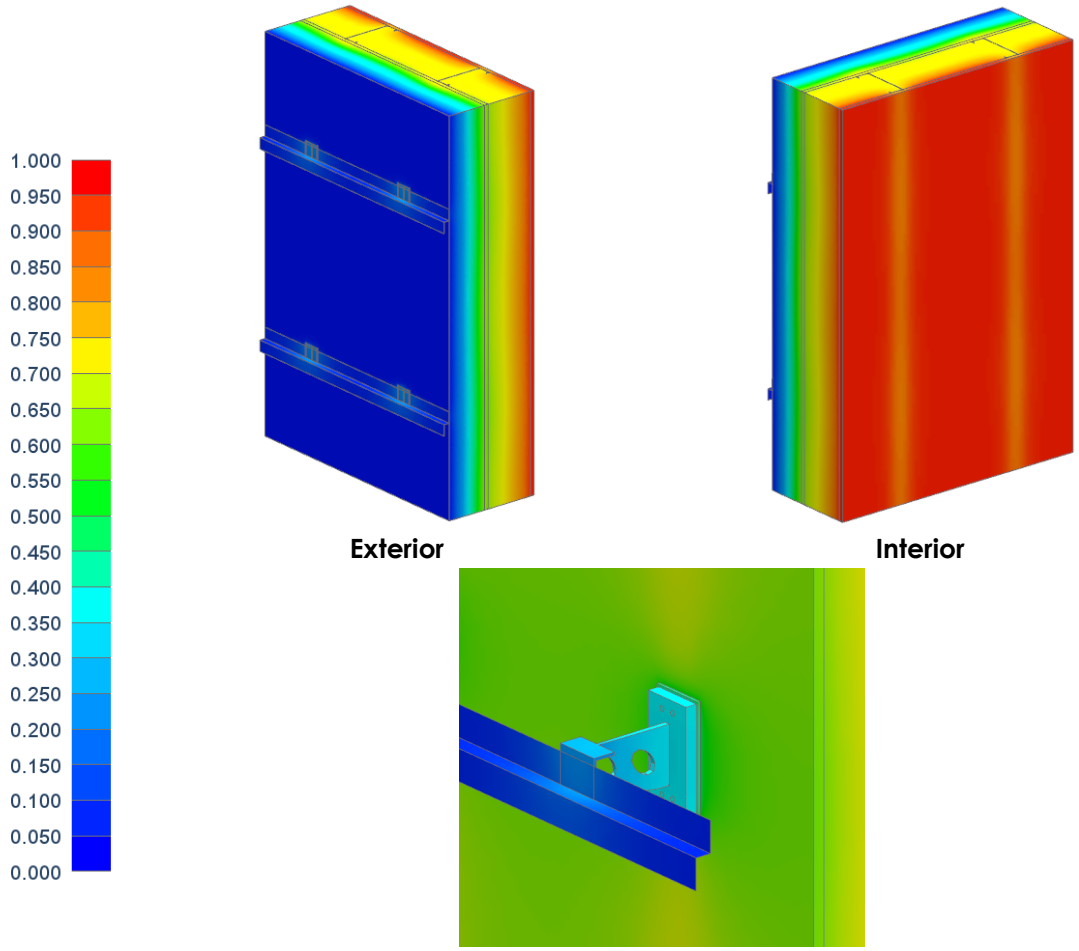


Figure D2.1: Temperature Profile of the 5 inch TAC Aluminum Clip Spaced 16" o.c. x 24" o.c. with Mineral Wool (R-4.2/in) Exterior Insulation (R-21), Split Insulated Steel Stud Assembly

3. SENSITIVITY ANALYSIS: ALTERNATE EXTERIOR INSULATION

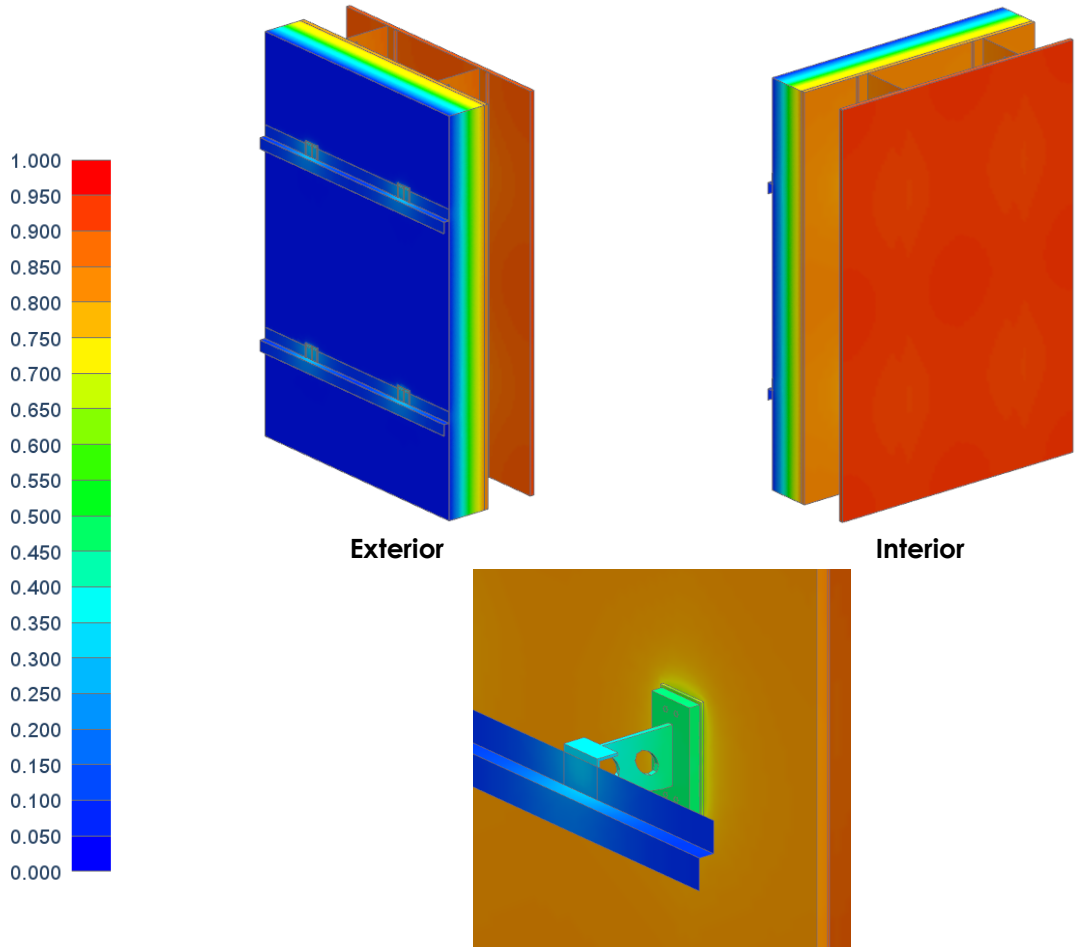


Figure D3.1: Temperature Profile of the 5 inch TAC Aluminum Clip Spaced 16" o.c. x 24" o.c. with Rigid Foam Board (R-5/in) Exterior Insulation (R-25), Exterior Insulated Steel Stud Assembly

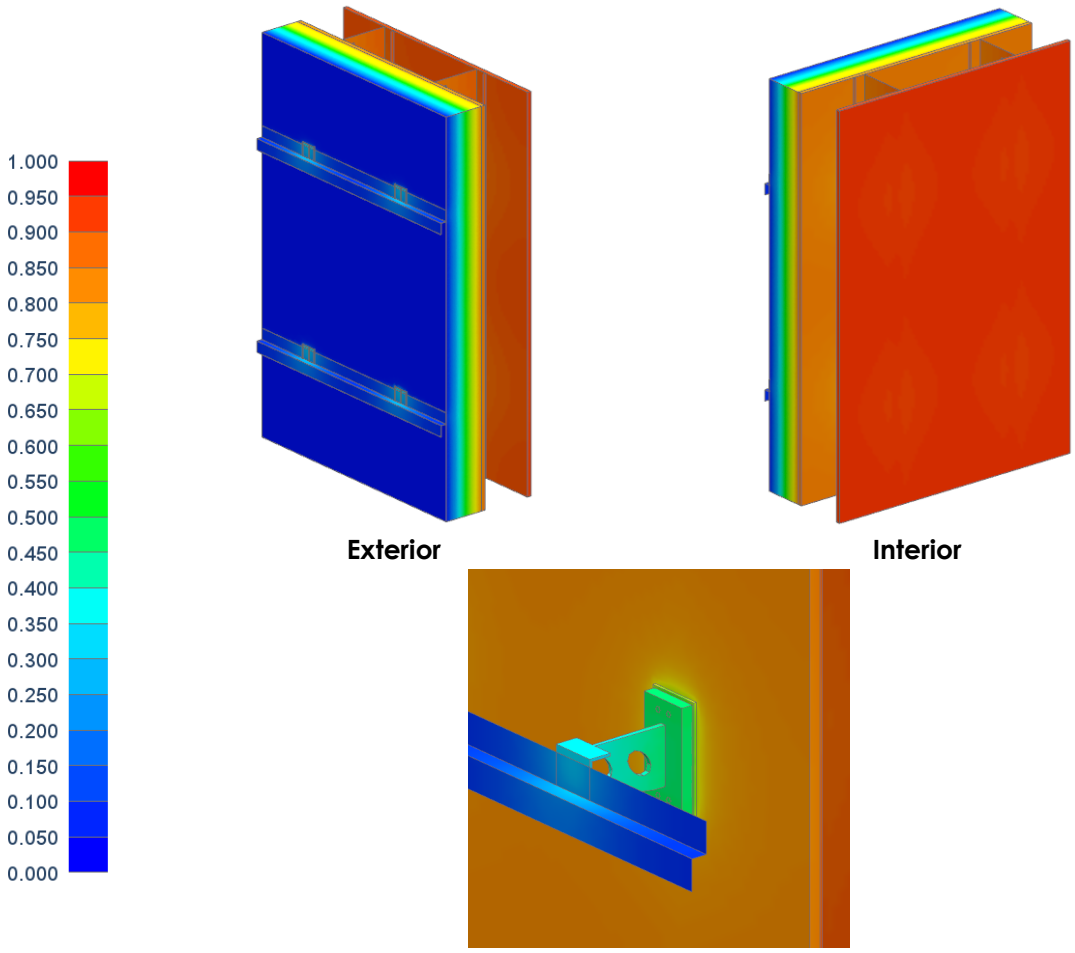


Figure D3.2: Temperature Profile of the 5 inch TAC Aluminum Clip Spaced 16" o.c. x 24" o.c. with Sprayfoam (R-6/in) Exterior Insulation (R-30), Exterior Insulated Steel Stud Assembly

4. SENSIVITY ANALYSIS: TWO SCREW CLIP ATTACHMENT

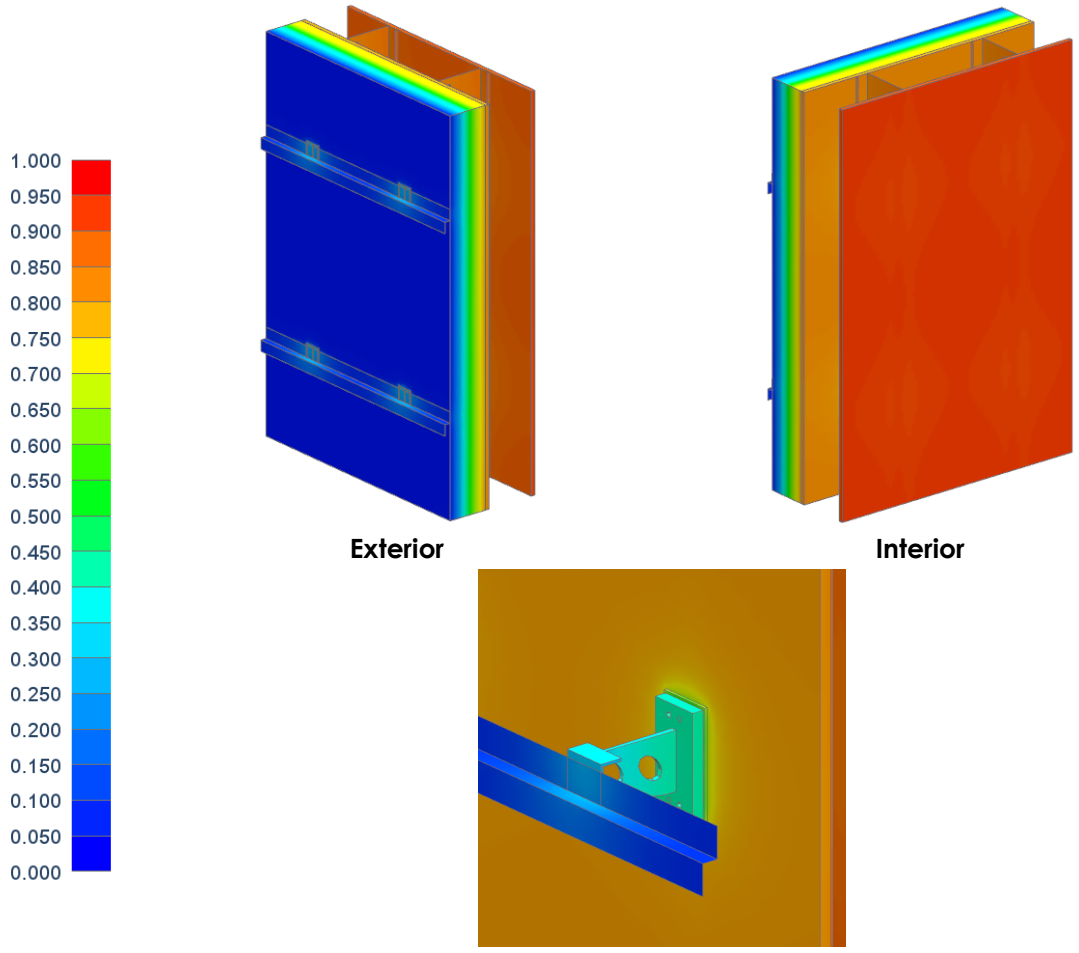


Figure D4.1: Temperature Profile of the 5 inch TAC Aluminum Clip Spaced 16" o.c. x 24" o.c. with Two Screw Clip Attachment, Exterior Insulated Steel Stud Assembly