

Technical Hotline

Achieving Passivhaus Requirements with Exterior Wall Insulation

Passivhaus design for residential and commercial buildings is gaining momentum as architects and owners strive to be more energy conscious. Passivhaus design requires significantly lower thermal conductivity for exterior walls than the IECC (International Energy Conservation Code), the energy code adopted by most states and cities in the US.

For example, the range of requirements in climate zones 4, 5, and 6 of the 2021 IECC and a “stretch code” version of the 2018 IECC (as adopted by the State of New York in 2020), compared to typical Passivhaus design requirements are listed in Table 1.

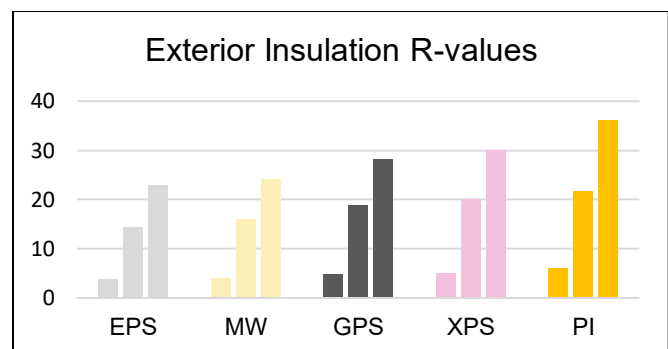
Table 1. Thermal conductivity (U-factor) requirements for metal framed wall assemblies

Thermal Conductivity (Btu/h•ft ² •°F)	2021 IECC	2020 NYS “Stretch”	Passivhaus Design
	0.064 - 0.049	0.061 - 0.044	0.02 – 0.01

The thermal insulation needed to achieve low thermal conductivity values such as those required for Passivhaus design is typically not possible without thick sections of continuous high R-value exterior insulation. Continuous exterior insulation is generally the most efficient and practical way to insulate a building by minimizing the loss of energy caused by thermal bridging and maximizing the amount of uninterrupted wall area to insulate.

Commonly available exterior insulating materials and their R-values for given thicknesses are shown in the adjacent graph. Among the exterior wall systems offered by Sto Corp., StoTherm ci GPS (or StoPanel GPS ci) is often the best cost/R-value option with full building code compliance and the ability to achieve Passivhaus requirements.

Sample calculations are shown on the next page for a typical steel frame wall assembly that achieves greater than R-40 (U-factor 0.025).



Thickness	Type of Insulation and R-value				
	EPS	MW	GPS	XPS	PI
1-inch	3.8	4.0	4.7	5.0	6.0
4-inch	14.4	16.0	18.8	20.0	21.7
6-inch	22.8	24.0	28.2	30.0	36.0

EPS = Expanded Polystyrene, MW = Mineral Wool, GPS = Graphite Polystyrene, XPS = Extruded Polystyrene, PI = Polyisocyanurate

Examples: Achieving R-40 (U-0.025) Exterior Wall Insulation for Passivhaus Design over Steel Frame

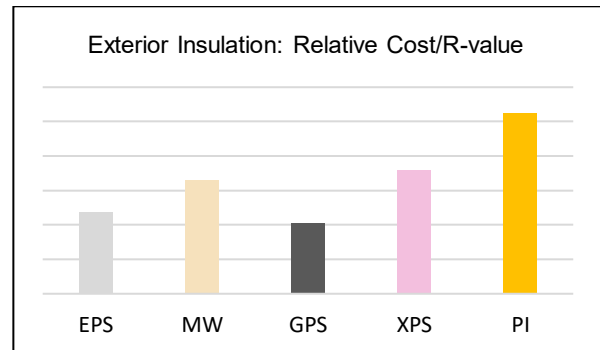
Assembly No. 1 with 16" oc studs and 7" exterior insulation		
#	Component	R-value
1	Interior Air Film	0.68
2	5/8" Int Gypsum Wallboard	0.56
3	6-in, 16" oc Stud Spacing w R-19 Batt	7.10
4	5/8" Glass Mat Gypsum Sheathing	0.56
5	Sto Gold Coat or StoPanel AWRB	0.77
6	7" Sto GPS Board	32.90
7	StoTherm ci GPS Base+Finish	0.57
8	Exterior Air Film	0.17
R _{Assembly}		43.31
Assembly U-factor = 1 / $\sum R_1, R_2, \dots R_8$		0.023

Assembly No. 2 with 24" oc studs and 6" exterior insulation		
#	Component	R-value
1	Interior Air Film	0.68
2	5/8" Int Gypsum Wallboard	0.56
3	6-in, 16" oc Stud Spacing w R-19 Batt	8.60
4	5/8" Glass Mat Gypsum Sheathing	0.56
5	Sto Gold Coat or StoPanel AWRB	0.77
6	6" Sto GPS Board	28.20
7	StoTherm ci GPS Base+Finish	0.57
8	Exterior Air Film	0.17
R _{Assembly}		40.11
Assembly U-factor = 1 / $\sum R_1, R_2, \dots R_8$		0.025

The examples show the significance of thermal bridging by steel framing in relation to overall R-value of the assemblies. Despite R-19 insulation in the stud cavity, the R-value of the insulated steel frame is reduced by more than half in each case for "effective" R-values of 7.10 and 8.60, respectively, for the 16 and 24-inch steel frame assemblies.

While any of the commonly available exterior insulating materials can be used to compensate for the loss in R-value due to thermal bridging of steel framing, other considerations will factor into the final choice of material, such as overall compliance with the applicable building code, how much added wall thickness is acceptable, and cost. The graph below shows relative cost per R-value of each exterior insulation material.

Based on this information, meeting Passivhaus thermal conductivity design requirements is achievable and can be most cost effective with StoTherm ci GPS (or StoPanel GPS ci).



Note: relative cost based on "EIFS grade" exterior insulation materials

References

- 2017 ASHRAE Handbook Fundamentals, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, Georgia
- ASHRAE 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, Georgia
- [Passivhaus u-values](#)
- https://up.codes/viewer/connecticut/iecc-2021/chapter/CE_4/ce-commercial-energy-efficiency#CE_4
- https://up.codes/viewer/new_york/iecc-2018

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