

# Appendix: Thermal Modeling

Thermal modeling for this guide was undertaken using HEAT3.1.<sup>1</sup> HEAT3 is a three-dimensional finite-element thermal analysis software tool commonly used by the building industry to analyze building enclosure assemblies in three dimensions, which two-dimensional analysis tools (such as THERM) cannot accurately analyze. It allows for a more detailed analysis of building enclosure assemblies, including the impact of fasteners, masonry ties and discrete clips, and other construction realities. Modeling can determine effective R-values/U-factors from the heat flow measured through the building enclosure assembly.

The boundary conditions used for this guide's modeling are industry standard ASHRAE winter exterior and interior boundary conditions with temperatures of 0°F and 70°F and surface films 0.17 ft<sup>2</sup>·°F·hr/Btu and 0.68 ft<sup>2</sup>·°F·hr/Btu respectively. The material conductivities used for the modeling are provided in Table A-1.

Table A-1 Material conductivities used for thermal modeling

Material	Thermal Conductivity Btu·in/hr·ft <sup>2</sup> ·°F (W/m·K)
Masonry veneer	5.5 (0.79)
Mortar	5.0 (0.72)
Cement Board	1.73 (0.25)
¾-inch grout with metal lathe	32.6 (4.7)
Air cavities at varying thicknesses	Varies*
Polypropylene (in ½-inch drain mat)	1.53 (0.22)
High density polyethylene	3.5 (0.5)
EPDM	1.73 (0.25)
Galvanized sheet steel (studs, girts, ties)	430 (62)
Stainless steel (clips, ties, fasteners)	118 (17)
Mild steel (fasteners/angles)	314 (45.3)
Brass (masonry tie bolt sleeve)	832 (120)
Fiberglass frame (clip)	2.1 (0.3)
Exterior mineral wool insulation (R-4.2/in)	0.24 (0.0343)
Closed cell spray foam (R-6/in)	0.17 (0.0240)
½-inch Exterior gypsum	0.90 (0.13)
½-inch Plywood – Douglas Fir	0.65 (0.093)
Wood 2x SPF	0.83 (0.12)
Fiberglass batts 5.5-inch R-21	0.26 (0.0379)
Fiberglass batts 7.2-inch R-30	0.24 (0.0348)
Fiberglass batts 3.625-inch R-15	0.24 (0.0348)
Fiberglass batts 6-inch R-21	0.29 (0.0411)
½-inch Interior gypsum	1.1 (0.16)
Concrete (including reinforcing)	13.9 (2)
8-inch concrete masonry unit empty, including grout	8.0 (1.153)

\* All air spaces assigned R-values based on values given for plane air spaces in the ASHRAE Handbook – Fundamentals.