Archtoolbox

R-values of Insulation and Other Building Materials

There is a table of building material R-Values further down in this article, but first we should quickly cover some basics about R-Values, U-Factors, and calculating thermal resistance.

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What are R-values?

In construction, the R-value is the measurement of a material's capacity to **resist heat flow** from one side to the other. In simple terms, R-values measure the effectiveness of insulation and a higher number represents more effective insulation.

R-values are additive. For instance if you have a material with an R-value of 12 attached to another material with an R-value of 3, then both materials combined have an R-value of 15.

R-value Units

As we said before, the R-value measures the thermal resistance of a material. This can also be expressed as the temperature difference that will cause one unit of heat to pass through one unit of area over a period of time.

$$R = \frac{F^{o} \times ft^{2} \times hr}{BTU}$$

Imperial Units

R-value Equation (Imperial units)

$$R = \frac{m^2 \times K}{W}$$

Metric Units

R-value Equation (SI units)

The two equations above are used to calculate the R-value of a material. Keep in mind that, due to the units, the Imperial R-value will be quite a bit smaller than the SI R-value so it is important to determine the units used when working internationally. The charts below use Imperial Units since our website is focused on the North American market.

What are U-factors?

Many energy modeling programs and code calculations require U-factors (sometimes called U-values) of assemblies. The U-factor is the heat transfer coefficient, which simply means that is is a measure of an assembly's capacity to **transfer** thermal energy across its thickness. The U-factor of an assembly is the reciprocal of the total R-value of the assembly. The equation is shown below.

$$U = \frac{1}{R_1 + R_2 + R_3 + \ldots}$$

U Factor Equation

Tables of Building Material R-values

The R-values for specific assemblies like doors and glazing in the table below are generalizations because they can vary significantly based on special materials that the manufacturer uses. For instance, using argon gas in a double pane insulating glass unit will dramatically improve the R-value. Consult manufacturer literature for values specific to your project.

MATERIAL	THICKNESS	R-VALUE (F° · SQ.FT. · HR/BTU)
Air Films		
Exterior		0.17
Interior Wall		0.68
Interior Ceiling		0.61

MATERIAL	THICKNESS	R-VALUE (F° · SQ.FT. · HR/BTU)
Air Space		
Minimum 1/2" up to 4"		1.00
Building Board		
Gypsum Wall Board	1/2"	0.45
Gypsum Wall Board	5/8"	0.5625
Plywood	1/2"	0.62
Plywood	1"	1.25
Fiber board sheathing	1/2"	1.32
Medium Density Particle Board	1/2"	0.53
Insulating Materials		
R-11 Mineral Fiber with 2x4 metal studs @ 16" OC		5.50
R-11 Mineral Fiber with 2x4 wood studs @ 16" OC		12.44
R-11 Mineral Fiber with 2x4 metal studs @ 24" OC		6.60
R-19 Mineral Fiber with 2x6 metal studs @ 16" OC		7.10
R-19 Mineral Fiber with 2x6 metal studs @ 24" OC		8.55
R-19 Mineral Fiber with 2x6 wood studs @ 24" OC		19.11

MATERIAL	THICKNESS	R-VALUE (F° · SQ.FT. · HR/BTU)
Expanded Polystyrene (Extruded)	1"	5.00
Polyurethane Foam (Foamed on site)	1"	6.25
Polyisocyanurate (Foil Faced)	1"	7.20
Masonry and Concrete		
Common Brick	4"	0.80
Face Brick	4"	0.44
Concrete Masonry Unit (CMU)	4"	0.80
Concrete Masonry Unit (CMU)	8"	1.11
Concrete Masonry Unit (CMU)	12"	1.28
Concrete 60 pounds per cubic foot	1"	0.52
Concrete 70 pounds per cubic foot	1"	0.42
Concrete 80 pounds per cubic foot	1"	0.33
Concrete 90 pounds per cubic foot	1"	0.26
Concrete 100 pounds per cubic foot	1"	0.21
Concrete 120 pounds per cubic foot	1"	0.13
Concrete 150 pounds per cubic foot	1"	0.07
Granite	1"	0.05

MATERIAL	THICKNESS	R-VALUE (F° · SQ.FT. · HR/BTU)
Sandstone / Limestone	1"	0.08
Siding		
Aluminum / Vinyl (not insulated)		0.61
Aluminum / Vinyl (1/2" insulation)		1.80
Flooring		
Hardwood	3/4"	0.68
Tile		0.05
Carpet with fiber pad		2.08
Carpet with rubber pad		1.23
Roofing		
Asphalt Shingles		0.44
Wood Shingles		0.97
Glazing		
Single Pane	1/4"	0.91

MATERIAL	THICKNESS	R-VALUE (F° · SQ.FT. · HR/BTU)
Double Pane with 1/4" air space		1.69
Double Pane with 1/2" air space		2.04
Double Pane with 3/4" air space		2.38
Triple Pane with 1/4" air spaces		2.56
Triple Pane with 1/2" air spaces		3.23
Doors		
Wood, solid core	1 3/4"	2.17
Solid insulated metal door, polystyrene insulation ASTM C518 Calculated	1.5" - 2"	6.00 - 7.00
Solid insulated metal door, polystyrene insulation ASTM C1363 Operable	1.5" - 2"	2.20 - 2.80
Solid insulated metal door, polyurethane insulation ASTM C518 Calculated	1.5" - 2"	10.00 - 11.00
Solid insulated metal door, polyurethane insulation ASTM C1363 Operable	1.5" - 2"	2.50 - 3.50

The values in the table above were taken from a number of sources including: the *ASHRAE Handbook of Fundamentals*, ColoradoENERGY.org, and *Building Construction Illustrated* by Francis D.K. Ching. Other minor sources were also used. Archtoolbox does not test materials or assemblies.

Doors and Assemblies

In the chart above, you will notice that there are two vastly different R-values provided for insulated metal doors with polyurethane insulation. Based on ASTM C518 (Calculation Method) the door has an R-value of up to 11, but using ASTM C1363 (Tested/Operable) the same door only have an R-value of up to 3.5. This is a huge difference and essentially comes down to ASTM C518 being a theoretical maximum based on a steady-state thermal test of only a portion of the door panel. However, we all know that the frame, gasketing, and, hardware will significantly affect the thermal transmittance. So a new standard test has been implemented, ASTM C1363, which tests the entire door assembly including the frame and hardware.

The results of ASTM C1363 are much lower, but are much more accurate to the actual installed conditions. In fact, the doors are performing the same as before – it is just that the R-values are much more in line with how the door really performs. Many architects are now specifying doors with the ASTM C1363 test as the standard for thermal transmittance. It is expected that other products will follow suit.

For more information, check out the Steel Door Institute's article *Why Have Thermal Performance Ratings Changed?*

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