

R-VALUES

DATA PACKET

TABLE 2.4*
Thermal Properties of Typical Building and Insulating Materials
 Design Btu/(Hr·ft²·°F)

DESCRIPTION	DENSITY LB/FT ³	RESISTANCE (R)	
		PER INCH	PER LISTED THICKNESS
BUILDING BOARD			
Boards, Panels, Subflooring, Sheathing Woodboard Panel Products			
Asbestos-cement board.....	120	0.25	--
Asbestos-cement board.....0.125 in.	120	--	0.01
Asbestos-cement board.....0.25 in.	120	--	0.06
Gypsum or plaster board.....0.375 in.	50	--	0.12
Gypsum or plaster board.....0.5 in.	50	--	0.15
Gypsum or plaster board.....0.625 in.	50	--	0.56
Plywood (Douglas Fir).....	34	1.25	--
Plywood (Douglas Fir).....0.25 in.	34	--	0.31
Plywood (Douglas Fir).....0.375 in.	34	--	0.47
Plywood (Douglas Fir).....0.5 in.	34	--	0.62
Plywood (Douglas Fir).....0.625 in.	34	--	0.77
Plywood or wood panels.....0.75 in.	34	--	0.93
Vegetable Fiber Board			
Sheathing, regular density.....0.5 in.	18	--	1.32
.....0.78125 in.	18	--	2.06
Sheathing, intermediate density.....0.5 in.	22	--	1.22
Nail-base sheathing.....0.5 in.	25	--	1.14
Shingle backer.....0.375 in.	18	--	0.94
Shingle backer.....0.3125 in.	18	--	0.78
Sound deadening board.....0.5 in.	15	--	1.35
Tile and lay-in panels, plain or acoustic.....	18	2.50	--
.....0.5 in.	18	--	1.25
.....0.75 in.	18	--	1.89
Laminated paperboard.....	30	2.00	--
Homogeneous board from repulped paper.....	30	2.00	--
Hardboard			
Medium density.....	50	1.37	--
High density, service temp. service underlay.....	55	1.22	--
High density, std. tempered.....	63	1.00	--
Particleboard			
Low density.....	37	1.85	--
Medium density.....	50	1.06	--
High density.....	62.5	0.85	--
Underlayment.....0.625 in.	40	--	0.82
Wood subfloor.....0.75 in.	--	--	0.91
BUILDING MEMBRANE			
Vapor - permeable felt.....	--	--	0.06
Vapor - seal, 2 layers of mopped 15-lb. felt.....	--	--	0.12
Vapor - seal, plastic film.....	--	--	Negl.
FINISH FLOORING MATERIALS			
Carpet and fibrous pad.....	--	--	2.08
Carpet and rubber pad.....	--	--	1.23
Cork tile.....0.125 in.	--	--	0.28
Terrazzo.....1 in.	--	--	0.08
Tile asphalt, linoleum, vinyl, rubber.....	--	--	0.05
vinyl asbestos.....	--	--	--
ceramic.....	--	--	--
Wood, hardwood finish.....0.75 in.	--	--	0.68

* Excerpted from the ASHRAE Handbook of Fundamentals 1985

DESCRIPTION	DENSITY L/FT ³	RESISTANCE (R)	
		PER INCH	PER LISTED THICKNESS
INSULATING MATERIALS			
Blanket and Batt			
Mineral Fiber, fibrous form processed from rock, slag or glass			
approx. 3-1 in.....	0.3-2.0	--	11
approx. 3.5 in.....	0.3-2.0	--	13
approx. 5.5-6.5 in.....	0.3-2.0	--	19
approx. 6-7.5 in.....	0.3-2.0	--	22
approx. 9-10 in.....	0.3-2.0	--	30
approx. 12-13 in.....	0.3-2.0	--	38
Board and Slabs			
Cellular glass.....	8.5	2.86	--
Glass fiber, organic bonded.....	4.9	4.00	--
Expanded perlite, organic bonded.....	1.0	2.78	--
Expanded rubber (rigid).....	4.5	4.55	--
Expanded polystyrene extruded			
Cut cell surface.....	1.8	4.00	--
Smooth skin surface.....	1.8-3.5	5.00	--
Expanded polystyrene, molded beads			
.....	1.0	3.85	--
.....	1.25	4.00	--
.....	1.5	4.17	--
.....	1.75	4.17	--
.....	2.0	4.35	--
Cellular polyurethane (R-11 exp.) (unfaced).....	1.5	6.25	--
Cellular polyisocyanurate (R-11 exp.) (foil faced, glass fiber-reinforced core)			
Nominal 0.5 in.....	2.0	7.20	--
Nominal 1.0 in.....	--	--	3.6
Nominal 2.0 in.....	--	--	7.2
Nominal 2.0 in.....	--	--	14.4
Mineral fiber with resin binder.....	15	3.45	--
Mineral fiberboard, wet felted			
Core or roof insulation.....	16-17	2.91	--
Acoustical tile.....	18	2.86	--
Acoustical tile.....	21	2.70	--
Mineral fiberboard, wet molded			
Acoustical tile.....	23	2.38	--
Wood or cane fiberboard			
Acoustical tile..... 0.5 in.	--	--	1.25
Acoustical tile..... 0.75 in.	--	--	1.89
Interior finish (plank, tile).....	15	2.86	--
Cement fiber slabs (shredded wood with Portland cement binder)			
.....	25-27.0	2.0-1.89	--
Cement fiber slabs (shredded wood with magnesium oxysulfid binder)			
.....	22.0	1.75	--
LOOSE FILL			
Cellulosic insulation (milled paper or wood pulp).....			
.....	2.3-3.2	3.13-3.70	--
Sawdust or shavings.....	8.0-15.0	2.22	--
Wood fiber, softwoods.....	2.0-3.5	3.33	--
Perlite, expanded.....	2.0-1.1	3.7-3.3	--
.....	4.1-7.4	3.3-2.8	--
.....	7.4-11.0	2.8-2.4	--
Mineral fiber (rock, slag or glass)			
approx. 3.75-5 in.....	0.6-2.0	--	11
approx. 6.5-8.75 in.....	0.6-2.0	--	19
approx. 7.5-10 in.....	0.6-2.0	--	22
approx. 10.25-13.75 in.....	0.6-2.0	--	30
Mineral fiber (rock, slag or glass)			
approx. 3.5 in. (closed sidewall application).....	2.0-3.5	--	12.0-11.6
Vermiculite, exfoliated.....	7.0-8.2	2.13	--

DESCRIPTION	DENSITY LB/FT ³	RESISTANCE (R)	
		PER INCH	PER LISTED THICKNESS
FIELD APPLIED			
Polyurethane foam	1.5-2.5	6.25-5.26	--
Ureaformaldehyde foam	0.7-1.6	3.57-4.55	--
Spray cellulosic fiber base	2.0-6.0	3.33-4.17	--
MASONRY MATERIALS			
Concretes			
Cement mortar	116	0.20	--
Gypsum fiber concrete 87.5% gypsum, 12.5% wood chips	51	0.60	--
Lightweight aggregates included expanded	120	0.19	--
shale, clay or slate; expanded slags;	100	0.28	--
cinders, pumice, vermiculite; also	80	0.40	--
cellular concretes	60	0.59	--
.....	40	0.86	--
.....	30	1.11	--
.....	20	1.43	--
Perlite, expanded	40	1.08	--
.....	30	1.41	--
.....	20	2.00	--
Sand and gravel or stone aggregate (oven dried)	140	0.11	--
Sand and gravel or stone aggregate (not dried)	140	0.08	--
Stucco	116	0.20	--
MASONRY UNITS			
Brick, common	120	0.20	--
Brick, face	130	0.11	--
Clay tile, hollow:			
1 cell deep	3 in.	--	0.80
1 cell deep	4 in.	--	1.11
2 cells deep	6 in.	--	1.52
2 cells deep	8 in.	--	1.85
2 cells deep	10 in.	--	2.22
3 cells deep	12 in.	--	2.50
Concrete blocks, three oval core:			
Sand and gravel aggregate	4 in.	--	0.71
.....	8 in.	--	1.11
.....	12 in.	--	1.28
Cinder aggregate	3 in.	--	0.86
.....	4 in.	--	1.11
.....	8 in.	--	1.72
.....	12 in.	--	1.89
Lightweight aggregate	3 in.	--	1.27
(expanded shale, clay, slate	4 in.	--	1.50
or slag; pumice)	8 in.	--	2.00
.....	12 in.	--	2.27
Concrete blocks, rectangular core			
Sand and gravel aggregate			
2 core, 8 in. 36 lb.	--	--	1.04
Same with filled cores	--	--	1.93
Lightweight aggregate (expanded shale, clay, slate or slag, pumice):			
3 core, 6 in. 19 lb.	--	--	1.65
Same with filled cores	--	--	2.99
2 core, 8 in. 24 lb.	--	--	2.18
Same with filled cores	--	--	5.03
3 core, 12 in. 38 lb.	--	--	2.48
Same with filled cores	--	--	5.82
Stone, lime or sand	--	0.08	--
Gypsum partition tile:			
3 x 12 x 30 in. solid	--	--	1.26
12 x 30 in. 4-cell	--	--	1.35
4 x 12 x 30 in. 3-cell	--	--	1.67

CORRUGATED CARDBOARD ($\frac{1}{8}$ ") = .184

TABLE B — Continued
THERMAL RESISTANCES OF BUILDING MATERIALS

Description of Material	Per inch of Thickness	For Thickness Listed
ROOFING		
Asbestos-cement shingles .....	....	.21
Asphalt shingles .....	....	.44
Wood shingles .....	....	.94
Asphalt roll roofing .....	....	.15
Built-up roofing, ½" .....	....	.33
Slate, ½" .....	....	.05
Sheet metal	Negligible	....
Vapor barrier	Negligible	....

MASONRY MATERIALS

	Thickness			
	1"	4"	8"	12"
Concrete, Sand and Gravel or stone aggregate, or Stone .....	.08			
Cement Mortar and stucco .....	.20			
Brick:				
Common brick, assumed 4" thick .....		.80		
Face Brick, assumed 4" thick .....		.44		
Concrete Block:				
Three oval core, Sand and Gravel Aggregate .....		.71	1.11	1.28
Three oval core, cinder aggregate		1.11	1.72	1.89
Three oval core, light weight aggregate		1.50	2.00	2.27
Light weight aggregate with insulation in cores			5.03	5.82

INSULATING MATERIALS

	Thickness							
	1"	3½"	5½"	8"	10"	12"	14"	16"
Blanket and Bat Type								
Glass Fiber	3.1	11	19	26	32	38	44	50
Rockwool	3.7	13	20	29	37	44	51	58
Loose fill type								
Cellulose (Macerated paper or pulp products)	3.70	13	20	29	37	44	51	58
Wood fiber, redwood hemlock or fir	3.33	12	19	27	33	40	46	52
Mineral wool (glass, slag or rock)	2.2	8	12	18	22	26	32	37
Vermiculite (expanded)	2.3	8	12	18	23	27	33	38
Perlite (expanded)	2.7	9	15	22	27	32	37	42
Board Type								
Glass fiber	4.0							
Polystyrene (styrofoam)	4.5							
Polyurethane	6.25							
Urea-Formaldehyde	5.0							

The Resistance (R) factors shown in the columns above will vary slightly for the various manufacturers.

TABLE B
THERMAL RESISTANCES OF BUILDING MATERIALS

Description of Material	Per inch of Thickness	For Thickness Listed
AIR SPACES		
Bounded by ordinary materials — Vertical, ¼" or more in width .....	....	.97
Bounded by reflective materials — Vertical, ¼" or more in width .....	....	2.0
SURFACES		
Still air, ordinary non-reflective materials, vertical .....	....	.68
15 M.P.H. wind velocity, ordinary non-reflective materials, vertical .....	....	.17
EXTERIOR FINISHES (Frame Walls)		
Brick Veneer, 4" thick (nominal) .....	....	.44
Shingles, on flat surface, including building paper:		
Wood, 16" with 7½" exposure .....	....	.93
Wood, double, 16", 12" exposure .....	....	1.25
Asbestos-cement .....	....	.27
Siding, on flat surface, including building paper:		
Drop, 1 x 8 inches .....	....	.85
Bevel, ½ x 8 inches, lapped .....	....	.87
Bevel, ¾ x 10 inches, lapped .....	....	1.11
Plywood, ¾", lapped .....	....	.65
Asbestos-cement, ¼", lapped .....	....	.27
Metal Siding	Negligible	....
WOODS		
Maple, oak, and similar hardwoods .....	.91	....
Fir, pine, and similar softwoods	1.25	....
Plywood	1.25	....
SHEATHING		
Insulating board, ¾" (wood or cane fiber) .....	....	2.06
Plywood, ¾ inch .....	....	.78
Fir or pine, 1 inch (actual ¾") .....	....	.98
Styrofoam Board, 1 inch .....	....	4.00
Styrofoam Board, 2 inch .....	....	8.00
INTERIOR FINISHES		
Gypsum plaster:		
Sand aggregate .....	.18	....
Vermiculite aggregate .....	.59	....
Perlite aggregate .....	.67	....
Cement plaster, sand aggregate .....	.20	....
Gypsum Board, ½", plain or decorated (drywall or sheet rock) .....	....	.32
Gypsum Board, ½", plain or decorated (dry wall or sheet rock) .....	....	.45
Gypsum Board and plaster, ½" board, ½" plaster (sand aggregate) .....	....	.41
Insulating Board, ½", plain or decorated .....	....	1.43
Insulating Board and plaster, ½" board, ½" plaster (sand aggregate) .....	....	1.52
Plywood, ¼ inch, plain or decorated .....	....	.31
Lath and plaster (gypsum, sand aggregate), ¾ inch plaster .....	....	.13
Carpet with Fibrous Pad .....	....	2.08
Carpet with Rubber Pad .....	....	1.23

CLASSROOM ACTIVITY **H**

Thermal Insulation

Introduction The need for energy conservation is clear, since fossil fuel resources are finite and are being rapidly depleted. Blanket-type fiberglass and mineral wool insulation are commonly used to reduce heat losses in the home, and they not only make economic sense as the cost of fuel increases, but constitute good environmental stewardship as well. This activity shows quantitatively just how much energy is saved by various thicknesses of insulation used. By obtaining the current costs of the insulation from your hardware store or building supplier, you could also determine the total cost of insulation that is appropriate for your own home.

The R value printed on the package of insulating material measures the resistance of a material to heat transmission. Thus, the greater the R value, the better the insulating effect of the material. The reciprocal of R is called thermal conductance C , and this value is the rate of heat loss in BTU/hr·ft²·F° for the thickness of insulation in the package.

Table H-1 R VALUES FOR VARIOUS THICKNESSES OF BLANKET-TYPE FIBERGLASS INSULATION

Thickness (inches)	R Value
1	5.70
2	7.40
3	11.10
4	14.80
5	18.50
6	22.20
7	25.90
8	29.60
9	33.30
10	37.00
11	40.70
12	44.40

Procedure Table H-1 shows the R values for various thicknesses of blanket-type insulation. From this information compute the C value for each thickness

APPENDIX E

Thermal Resistances of Building Materials

		R for thickness listed
Air Spaces	Air bounded by ordinary materials, vertical and $\frac{3}{4}$ " or wider	0.97
Surfaces	Still air, vertical, inside	0.68
	15-mph wind speed, outside	0.17
	Still air, horizontal, inside	0.61
	Still air, 45° slope, inside	0.62
Exterior Finishes	Brick veneer, 4" thick (nominal)	0.44
	Wood shingles, 16" with 7½" exposure	0.93
	Asbestos-cement shingles	0.27
	Wood siding, bevel ½" x 8", lapped	0.81
	Aluminum, hollow-backed over sheathing	0.61*
	Building paper, permeable felt	0.06
	*This is the resistance of the air film only. Aluminum has negligible resistance.	
Masonry Materials	Brick, common, 4" thick	0.80
	Concrete block, 8-oval core, sand and gravel aggregate, 8"	1.11
	Concrete, sand, and gravel or stone aggregate, per inch of thickness	0.08
	Stone, per inch of thickness	0.08
Wood	Hardwoods, per inch of thickness	0.91
	Softwoods and plywood, per inch of thickness	1.25
Windows	(Treat doors, with or without glass, the same as windows.)	
	Single (no storm sash)	0.89
	With storm sash	1.89
	Double glazed with ¼" air space	1.64
Building Board and Paper	Gypsum or plasterboard, ¾" thick	0.32
	Gypsum or plasterboard, ½" thick	0.45
	Vapor-permeable felt paper	0.06

Appendix, E

To adjust the U value for wall area occupied by studs, compute U for wall at studs. Find 15% of U for stud area and 85% of U for wall area. Add these values for net U for the wall.

Construction of 45° pitched roof (heat flow up)	Resistance R
1. Outside surface (15-mph wind)	0.17
2. Wood shingles	0.94
3. Roof boards, nominal 1" fir × 6" with 3" space between	0.70(approx.)
4. Fiberglass insulation, 6" bats	22.20
5. Gypsum wallboard, 1/2"	0.45
6. Inside surface (still air)	0.62
Total R	25.08

$$U = \frac{1}{R} = \frac{1}{25.08} = 0.04 \text{ BTU}/(\text{hr})(\text{ft}^2)(^\circ\text{F}).$$

Adjust U for roof area occupied by rafters in a manner similar to that for wall studs.

Note: For more complete treatment of heat transfer situation involving buildings, refer to:

1. *ASHRAE Handbook of Fundamentals*, 1972.
2. *Heat Loss Calculation Guide H-21*, Institute of Boiler and Radiator Manufacturers.

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