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R-VALUES FOR SINGLE WYTHE CONCRETE MASONRY WALLS

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INTRODUCTION

Concrete masonry walls are often constructed of hollow units with cores filled with loose fill material and/or grout. This construction method provides the minimum wall thickness, while allowing insulation and reinforcement to be included to increase thermal and structural performance, respectively.

Determining the thermal insulation values of these walls, however, can be time consuming, especially when the wall is composed of several materials. This TEK facilitates the determination of thermal resistance (R) and thermal transmittance (U) of these single wythe concrete masonry walls.

R-VALUE TABLES

Tables of calculated R-values for hollow block of 6, 8, 10 and 12 in. (152, 203, 254, and 305 mm) thicknesses, for concrete densities of 85 to 135 lb/ft³ (1362 to 2163 kg/m³) are included. In addition, Table 1 shows the approximate percentage of grouted and ungrouted wall area for different vertical and horizontal grout spacings, which can be used to determine R-values of partially grouted walls. Thermal properties used in compiling the tables are listed in Table 6.

In addition to the core insulations listed in Tables 2 through 5, polystyrene inserts are available which fit in the cores of concrete masonry units. Inserts are available in many shapes and sizes to provide a range of insulating values and accommodate various construction conditions. Specially designed concrete masonry units may incorporate reduced-height webs to accommodate inserts. Such webs also reduce thermal bridging through masonry, since the reduced web area provides a smaller cross-sectional area for heat flow through the wall. To further reduce thermal bridging, some manufacturers have developed units with two cross webs rather than three. In addition, some inserts have building code approval to be left in the grouted cores, thus improving the thermal performance of fully or partially grouted masonry walls.

The ASHRAE series-parallel method (also called isothermal planes) (ref. 1) was used to calculate the base case values (i.e., the row *Exposed block, both sides*) in Tables 2 through 5. This method accounts for the thermal bridging through the webs

Table 1—Percent Ungrouted Area/Percent Grouted Area For Partially Grouted Walls

Horizontal grout spacing, in. (mm)	Vertical grout spacing, in. (mm)					
	no vert. grout	48 (1219)	40 (1016)	32 (813)	24 (610)	16 (406)
no horiz. grout	100 / 0	83 / 17	80 / 20	75 / 25	67 / 33	50 / 50
48 (1219)	83 / 17	69 / 31	67 / 33	63 / 37	56 / 44	42 / 58
40 (1016)	80 / 20	67 / 33	64 / 36	60 / 40	53 / 47	40 / 60
32 (813)	75 / 25	63 / 37	60 / 40	56 / 44	50 / 50	37 / 63
24 (610)	67 / 33	56 / 44	53 / 47	50 / 50	44 / 56	33 / 67
16 (406)	50 / 50	42 / 58	40 / 60	37 / 63	33 / 67	25 / 75

of concrete masonry units. R-values of the various finish systems are added to these base values. To determine R-values for walls with 2 in. (51 mm) of rigid insulation (expanded polystyrene, extruded polystyrene, or polyisocyanurate) rather than the 1 in. (25 mm) shown in the tables, simply add the appropriate insulation thermal resistivity value from Table 6 to the R-values in Tables 2 through 5.

R-values of concrete masonry walls are correlated to concrete density, since thermal conductivity of concrete increases with increasing density. Tables 2 through 5 list a range of R-values for each density, as well as a single value, which represents a calculated middle of the range. The U-factor is determined by simply inverting the R-value (i.e., $U = 1/R$).

A range of thermal values is appropriate for concrete products because the thermal conductivity of concrete cannot always be accurately estimated from density alone. The thermal conductivity of concrete varies with aggregate type(s) used in the concrete mix, the mix design, moisture content, etc.

These published values reflect a compendium of historical data on thermal conductivity of concrete (refs. 1,3). Locally available products and local conditions may result in thermal values which fall outside of this range. The middle-of-the-range values are presented for use in cases where more accurate values are not available from local manufacturers.

(continued on back page)

Construction	Density of concrete, pcf	Cores empty		Loose-fill insulation				Polyurethane foamed insulation		Solid grouted	
				Perlite		Vermiculite					
		range	mid	range	mid	range	mid	range	mid	range	mid
Exposed block, both sides	85	2.2-2.5	2.4	4.8-6.1	5.3	4.5-5.6	5.0	5.2-7.0	5.9	1.6-1.8	1.7
	95	2.1-2.4	2.2	4.1-5.4	4.6	3.9-5.0	4.3	4.4-6.1	5.0	1.5-1.7	1.6
	105	2.0-2.2	2.1	3.5-4.8	4.0	3.3-4.5	3.8	3.7-5.2	4.3	1.4-1.6	1.5
	115	1.8-2.1	2.0	3.0-4.2	3.4	2.9-4.0	3.3	3.1-4.5	3.6	1.4-1.5	1.4
	125	1.7-2.0	1.8	2.5-3.7	3.0	2.5-3.5	2.9	2.6-3.9	3.1	1.3-1.5	1.4
	135	1.6-1.9	1.7	2.2-3.2	2.6	2.2-3.1	2.5	2.2-3.4	2.7	1.3-1.4	1.3
¹/₂ in. (13 mm) gypsum board on furring	85	3.6-3.9	3.8	6.2-7.5	6.7	5.9-7.0	6.3	6.6-8.4	7.3	3.0-3.2	3.1
	95	3.5-3.8	3.6	5.5-6.8	6.0	5.3-6.4	5.7	5.8-7.5	6.4	2.9-3.1	3.0
	105	3.4-3.6	3.5	4.9-6.2	5.4	4.7-5.9	5.2	5.1-6.6	5.7	2.8-3.0	2.9
	115	3.2-3.5	3.4	4.4-5.6	4.8	4.3-5.4	4.7	4.5-5.9	5.0	2.8-2.9	2.8
	125	3.1-3.4	3.2	3.9-5.1	4.4	3.9-4.9	4.3	4.0-5.3	4.5	2.7-2.9	2.8
	135	3.0-3.3	3.1	3.6-4.6	4.0	3.6-4.5	3.9	3.6-4.8	4.1	2.7-2.8	2.7
1 in. (25 mm) expanded polystyrene[c]	85	7.6-7.9	7.8	10.2-11.5	10.7	9.9-11.0	10.3	10.6-12.4	11.3	7.0-7.2	7.1
	95	7.5-7.8	7.6	9.5-10.8	10.0	9.3-10.4	9.7	9.8-11.5	10.4	6.9-7.1	7.0
	105	7.4-7.6	7.5	8.9-10.2	9.4	8.7-9.9	9.2	9.1-10.6	9.7	6.8-7.0	6.9
	115	7.2-7.5	7.4	8.4-9.6	8.8	8.3-9.4	8.7	8.5-9.9	9.0	6.8-6.9	6.8
	125	7.1-7.4	7.2	7.9-9.1	8.4	7.9-8.9	8.3	8.0-9.3	8.5	6.7-6.9	6.8
	135	7.0-7.3	7.1	7.6-8.6	8.0	7.6-8.5	7.9	7.6-8.8	8.1	6.7-6.8	6.7
1 in. (25 mm) extruded polystyrene[c]	85	8.6-8.9	8.8	11.2-12.5	11.7	10.9-12.0	11.3	11.6-13.4	12.3	8.0-8.2	8.1
	95	8.5-8.8	8.6	10.5-11.8	11.0	10.3-11.4	10.7	10.8-12.5	11.4	7.9-8.1	8.0
	105	8.4-8.6	8.5	9.9-11.2	10.4	9.7-10.9	10.2	10.1-11.6	10.7	7.8-8.0	7.9
	115	8.2-8.5	8.4	9.4-10.6	9.8	9.3-10.4	9.7	9.5-10.9	10.0	7.8-7.9	7.8
	125	8.1-8.4	8.2	8.9-10.1	9.4	8.9-9.9	9.3	9.0-10.3	9.5	7.7-7.9	7.8
	135	8.0-8.3	8.1	8.6-9.6	9.0	8.6-9.5	8.9	8.6-9.8	9.1	7.7-7.8	7.7
1 in. (25 mm) polyiso-cyanurate[d]	85	12.1-12.4	12.2	14.6-16.0	15.2	14.3-15.5	14.8	15.1-16.9	15.8	11.5-11.7	11.6
	95	12.0-12.2	12.1	13.9-15.3	14.5	13.7-14.9	14.2	14.2-15.9	14.9	11.4-11.6	11.5
	105	11.8-12.1	12.0	13.3-14.6	13.8	13.2-14.3	13.7	13.5-15.1	14.1	11.3-11.5	11.4
	115	11.7-12.0	11.8	12.8-14.1	13.3	12.7-13.8	13.2	12.9-14.4	13.5	11.2-11.4	11.3
	125	11.6-11.9	11.7	12.4-13.5	12.8	12.3-13.4	12.7	12.5-13.8	13.0	11.2-11.3	11.2
	135	11.5-11.8	11.6	12.1-13.1	12.4	12.0-13.0	12.4	12.0-13.2	12.5	11.1-11.3	11.2
2 x 4 furring with R13 batt & ¹/₂ in. (13 mm) gypsum board on furring	85	13.0-13.3	13.2	15.6-16.9	16.1	15.3-16.4	15.7	16.0-17.8	16.7	12.4-12.6	12.5
	95	12.9-13.2	13.0	14.9-16.2	15.4	14.7-15.8	15.1	15.2-16.9	15.8	12.3-12.5	12.4
	105	12.8-13.0	12.9	14.3-15.6	14.8	14.1-15.3	14.6	14.5-16.0	15.1	12.2-12.4	12.3
	115	12.6-12.9	12.8	13.8-15.0	14.2	13.7-14.8	14.1	13.9-15.3	14.4	12.2-12.3	12.2
	125	12.5-12.8	12.6	13.3-14.5	13.8	13.3-14.3	13.7	13.4-14.7	13.9	12.1-12.3	12.2
	135	12.4-12.7	12.5	13.0-14.0	13.4	13.0-13.9	13.3	13.0-14.2	13.5	12.1-12.2	12.1

Table 2—R-Values For 6 in. (152 mm) Concrete Masonry Walls, hr·ft²·°F/Btu[a]

[a] Notes: (hr·ft²·°F/Btu) (0.176) = m²·K/W. Mortar joints are ³/₈ in. (10 mm) thick, with face shell mortar bedding assumed. Unit dimensions based on *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C 90 (ref. 2). Surface air films are included.

[b] Values apply when all masonry cores are filled completely. Grout density is 140 pcf (2243 kg/m³). Lightweight grouts, which will provide higher R-values, are also available in some areas.

[c] Installed over wood furring. Includes ¹/₂ in. (13 mm) gypsum board and nonreflective air space.

[d] Installed over wood furring. Includes ¹/₂ in. (13 mm) gypsum board and reflective air space.

		Cores empty		Cores filled with[b]:							
				Loose-fill insulation				Polyurethane foamed insulation		Solid grouted	
				Perlite		Vermiculite					
Construction	Density of concrete, pcf	range	mid	range	mid	range	mid	range	mid	range	mid
Exposed block, both sides	85	2.4-2.7	2.5	6.3-8.2	7.1	5.9-7.5	6.6	6.9-9.4	8.0	1.9-2.1	2.0
	95	2.3-2.6	2.4	5.3-7.2	6.1	5.0-6.7	5.7	5.8-8.1	6.7	1.7-2.0	1.8
	105	2.1-2.4	2.2	4.5-6.3	5.2	4.3-5.9	4.9	4.8-7.0	5.6	1.6-1.9	1.7
	115	2.0-2.3	2.1	3.8-5.5	4.4	3.7-5.2	4.3	4.0-6.0	4.7	1.5-1.8	1.6
	125	1.9-2.2	2.0	3.2-4.8	3.8	3.1-4.6	3.7	3.3-5.1	4.0	1.5-1.7	1.5
	135	1.7-2.1	1.9	2.7-4.2	3.3	2.7-4.0	3.2	2.8-4.4	3.4	1.4-1.6	1.5
¹/₂ in. (13 mm) gypsum board on furring	85	3.8-4.1	3.9	7.7-9.6	8.5	7.3-8.9	8.0	8.3-10.8	9.4	3.3-3.5	3.4
	95	3.7-4.0	3.8	6.7-8.6	7.5	6.4-8.1	7.1	7.2-9.5	8.1	3.1-3.4	3.2
	105	3.5-3.8	3.6	5.9-7.7	6.6	5.7-7.3	6.3	6.2-8.4	7.0	3.0-3.3	3.1
	115	3.4-3.7	3.5	5.2-6.9	5.8	5.1-6.6	5.7	5.4-7.4	6.1	2.9-3.2	3.0
	125	3.3-3.6	3.4	4.6-6.2	5.2	4.5-6.0	5.1	4.7-6.5	5.4	2.9-3.1	2.9
	135	3.1-3.5	3.3	4.1-5.6	4.7	4.1-5.4	4.6	4.2-5.8	4.8	2.8-3.0	2.9
1 in. (25 mm) expanded polystyrene[c]	85	7.8-8.1	7.9	11.7-13.6	12.5	11.3-12.9	12.0	12.3-14.8	13.4	7.3-7.5	7.4
	95	7.7-8.0	7.8	10.7-12.6	11.5	10.4-12.1	11.1	11.2-13.5	12.1	7.1-7.4	7.2
	105	7.5-7.8	7.6	9.9-11.7	10.6	9.7-11.3	10.3	10.2-12.4	11.0	7.0-7.3	7.1
	115	7.4-7.7	7.5	9.2-10.9	9.8	9.1-10.6	9.7	9.4-11.4	10.1	6.9-7.2	7.0
	125	7.3-7.6	7.4	8.6-10.2	9.2	8.5-10.0	9.1	8.7-10.5	9.4	6.9-7.1	6.9
	135	7.1-7.5	7.3	8.1-9.6	8.7	8.1-9.4	8.6	8.2-9.8	8.8	6.8-7.0	6.9
1 in. (25 mm) extruded polystyrene[c]	85	8.8-9.1	8.9	12.7-14.6	13.5	12.3-13.9	13.0	13.4-15.8	14.4	8.3-8.5	8.4
	95	8.7-9.0	8.8	11.7-13.6	12.5	11.4-13.1	12.1	12.2-14.5	13.1	8.1-8.4	8.2
	105	8.5-8.8	8.6	10.9-12.7	11.6	10.7-12.3	11.3	11.2-13.4	12.0	8.0-8.3	8.1
	115	8.4-8.7	8.5	10.2-11.9	10.8	10.1-11.6	10.7	10.4-12.4	11.1	7.9-8.2	8.0
	125	8.3-8.6	8.4	9.6-11.2	10.2	9.5-11.0	10.1	9.7-11.5	10.4	7.9-8.1	7.9
	135	8.1-8.5	8.3	9.1-10.6	9.7	9.1-10.4	9.6	9.2-10.8	9.8	7.8-8.0	7.9
1 in. (25 mm) polyiso-cyanurate[d]	85	12.3-12.6	12.4	16.2-18.1	17.0	15.7-17.3	16.4	16.8-19.3	17.8	11.7-12.0	11.8
	95	12.1-12.4	12.3	15.2-17.1	16.0	14.9-16.5	15.6	15.6-18.0	16.6	11.6-11.9	11.7
	105	12.0-12.3	12.1	14.4-16.2	15.1	14.2-15.8	14.8	14.6-16.8	15.5	11.5-11.7	11.6
	115	11.9-12.2	12.0	13.7-15.4	14.3	13.5-15.1	14.1	13.8-15.8	14.6	11.4-11.6	11.5
	125	11.7-12.0	11.9	13.1-14.7	13.7	13.0-14.4	13.5	13.2-15.0	13.9	11.3-11.5	11.4
	135	11.6-11.9	11.7	12.6-14.0	13.1	12.5-13.9	13.0	12.7-14.3	13.2	11.3-11.5	11.4
2 x 4 furring with R13 batt & ¹/₂ in. (13 mm) gypsum board on furring	85	13.2-13.5	13.3	17.1-19.0	17.9	16.7-18.3	17.4	17.7-20.2	18.8	12.7-12.9	12.8
	95	13.1-13.4	13.2	16.1-18.0	16.9	15.8-17.5	16.5	16.6-18.9	17.5	12.5-12.8	12.6
	105	12.9-13.2	13.0	15.3-17.1	16.0	15.1-16.7	15.7	15.6-17.8	16.4	12.4-12.7	12.5
	115	12.8-13.1	12.9	14.6-16.3	15.2	14.5-16.0	15.1	14.8-16.8	15.5	12.3-12.6	12.4
	125	12.7-13.0	12.8	14.0-15.6	14.6	13.9-15.4	14.5	14.1-15.9	14.8	12.3-12.5	12.3
	135	12.5-12.9	12.7	13.5-15.0	14.1	13.5-14.8	14.0	13.6-15.2	14.2	12.2-12.4	12.3

Table 3—R-Values For 8 in. (203 mm) Concrete Masonry Walls, hr·ft²·°F/Btu[a]

[a] Notes: (hr·ft²·°F/Btu) (0.176) = m²·K/W. Mortar joints are ³/₈ in. (10 mm) thick, with face shell mortar bedding assumed. Unit dimensions based on *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C 90 (ref. 2). Surface air films are included.

[b] Values apply when all masonry cores are filled completely. Grout density is 140 pcf (2243 kg/m³). Lightweight grouts, which will provide higher R-values, are also available in some areas.

[c] Installed over wood furring. Includes ¹/₂ in. (13 mm) gypsum board and nonreflective air space.

[d] Installed over wood furring. Includes ¹/₂ in. (13 mm) gypsum board and reflective air space.

Construction	Density of concrete, pcf	Cores Empty range	mid	Perlite range	mid	Vermiculite range	mid	Polyurethane foamed insulation range	mid	Solid grouted range	mid

Table 4—R-Values For 10 in. (254 mm) Concrete Masonry Walls, hr·ft²·°F/Btu[a]

Construction	Density of concrete, pcf	Cores Empty		Cores filled with[b]: Loose-fill insulation Perlite		Vermiculite		Polyurethane foamed insulation		Solid grouted	
		range	mid	range	mid	range	mid	range	mid	range	mid
Exposed block, both sides	85	2.5-2.9	2.7	7.5-9.9	8.5	7.0-9.1	7.9	8.2-11.3	9.5	2.1-2.4	2.2
	95	2.4-2.7	2.5	6.3-8.7	7.2	6.0-8.0	6.8	6.7-9.7	7.9	1.9-2.2	2.0
	105	2.2-2.5	2.3	5.2-7.5	6.1	5.0-7.0	5.8	5.5-8.2	6.6	1.8-2.1	1.9
	115	2.1-2.4	2.2	4.4-6.5	5.2	4.2-6.2	5.0	4.6-7.0	5.5	1.7-2.0	1.8
	125	1.9-2.3	2.1	3.7-5.6	4.4	3.6-5.4	4.3	3.8-6.0	4.6	1.6-1.9	1.7
	135	1.8-2.1	2.0	3.1-4.9	3.7	3.0-4.7	3.6	3.2-5.1	3.9	1.5-1.8	1.6
½ in. (13 mm) gypsum board on furring	85	3.9-4.3	4.1	8.9-11.3	9.9	8.4-10.5	9.3	9.6-12.7	10.9	3.5-3.8	3.6
	95	3.8-4.1	3.9	7.7-10.1	8.6	7.4-9.4	8.2	8.1-11.1	9.3	3.3-3.6	3.4
	105	3.6-3.9	3.7	6.6-8.9	7.5	6.4-8.4	7.2	6.9-9.6	8.0	3.2-3.5	3.3
	115	3.5-3.8	3.6	5.8-7.9	6.6	5.6-7.6	6.4	6.0-8.4	6.9	3.1-3.4	3.2
	125	3.3-3.7	3.5	5.1-7.0	5.8	5.0-6.8	5.7	5.2-7.4	6.0	3.0-3.3	3.1
	135	3.2-3.5	3.4	4.5-6.3	5.1	4.4-6.1	5.0	4.6-6.5	5.3	2.9-3.2	3.0
1 in. (25 mm) expanded polystyrene[c]	85	7.9-8.3	8.1	12.9-15.3	13.9	12.4-14.5	13.3	13.6-16.7	14.9	7.5-7.8	7.6
	95	7.8-8.1	7.9	11.7-14.1	12.6	11.4-13.4	12.2	12.1-15.1	13.3	7.3-7.6	7.4
	105	7.6-7.9	7.7	10.6-12.9	11.5	10.4-12.4	11.2	10.9-13.6	12.0	7.2-7.5	7.3
	115	7.5-7.8	7.6	9.8-11.9	10.6	9.6-11.6	10.4	10.0-12.4	10.9	7.1-7.4	7.2
	125	7.3-7.7	7.5	9.1-11.0	9.8	9.0-10.8	9.7	9.2-11.4	10.0	7.0-7.3	7.1
	135	7.2-7.5	7.4	8.5-10.3	9.1	8.4-10.1	9.0	8.6-10.5	9.3	6.9-7.2	7.0
1 in. (25 mm) extruded polystyrene[c]	85	8.9-9.3	9.1	13.9-16.3	14.9	13.4-15.5	14.3	14.6-17.7	15.9	8.5-8.8	8.6
	95	8.8-9.1	8.9	12.7-15.1	13.6	12.4-14.4	13.2	13.1-16.1	14.3	8.3-8.6	8.4
	105	8.6-8.9	8.7	11.6-13.9	12.5	11.4-13.4	12.2	11.9-14.6	13.0	8.2-8.5	8.3
	115	8.5-8.8	8.6	10.8-12.9	11.6	10.6-12.6	11.4	11.0-13.4	11.9	8.1-8.4	8.2
	125	8.3-8.7	8.5	10.1-12.0	10.8	10.0-11.8	10.7	10.2-12.4	11.0	8.0-8.3	8.1
	135	8.2-8.5	8.4	9.5-11.3	10.1	9.4-11.1	10.0	9.6-11.5	10.3	7.9-8.2	8.0
1 in. (25 mm) polyiso-cyanurate[d]	85	12.4-12.7	12.5	17.4-19.8	18.4	16.9-18.9	17.8	18.0-21.1	19.3	11.9-12.2	12.1
	95	12.2-12.6	12.4	16.1-18.5	17.1	15.8-17.9	16.7	16.6-19.5	17.8	11.8-12.1	11.9
	105	12.1-12.4	12.2	15.1-17.4	16.0	14.9-16.9	15.7	15.4-18.1	16.5	11.7-11.9	11.8
	115	11.9-12.3	12.1	14.3-16.4	15.1	14.1-16.0	14.9	14.4-16.9	15.4	11.6-11.8	11.7
	125	11.8-12.1	11.9	13.5-15.5	14.3	13.5-15.2	14.1	13.7-15.9	14.5	11.5-11.7	11.6
	135	11.7-12.0	11.8	13.0-14.7	13.6	12.9-14.6	13.5	13.0-14.9	13.7	11.4-11.6	11.5
2 x 4 furring with R13 batt & ½ in. (13 mm) gypsum board on furring	85	13.3-13.7	13.5	18.3-20.7	19.3	17.8-19.9	18.7	19.0-22.1	20.3	12.9-13.2	13.0
	95	13.2-13.5	13.3	17.1-19.5	18.0	16.8-18.8	17.6	17.5-20.5	18.7	12.7-13.0	12.8
	105	13.0-13.3	13.1	16.0-18.3	16.9	15.8-17.8	16.6	16.3-19.0	17.4	12.6-12.9	12.7
	115	12.9-13.2	13.0	15.2-17.3	16.0	15.0-17.0	15.8	15.4-17.8	16.3	12.5-12.8	12.6
	125	12.7-13.1	12.9	14.5-16.4	15.2	14.4-16.2	15.1	14.6-16.8	15.4	12.4-12.7	12.5
	135	12.6-12.9	12.8	13.9-15.7	14.5	13.8-15.5	14.4	14.0-15.9	14.7	12.3-12.6	12.4

[a] Notes: (hr·ft²·°F/Btu) (0.176) = m²·K/W. Mortar joints are ⅜ in. (10 mm) thick, with face shell mortar bedding assumed. Unit dimensions based on *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C 90 (ref. 2). Surface air films are included.

[b] Values apply when all masonry cores are filled completely. Grout density is 140 pcf (2243 kg/m³). Lightweight grouts, which will provide higher R-values, are also available in some areas.

[c] Installed over wood furring. Includes ½ in. (13 mm) gypsum board and nonreflective air space.

[d] Installed over wood furring. Includes ½ in. (13 mm) gypsum board and reflective air space.

		Cores Empty		Cores filled with[b]:							
				Loose-fill insulation				Polyurethane foamed insulation		Solid grouted	
				Perlite		Vermiculite					
Construction	Density of concrete, pcf	range	mid	range	mid	range	mid	range	mid	range	mid
Exposed block, both sides	85	2.6-3.0	2.8	9.1-12.1	10.3	8.5-11.0	9.6	10.0-13.8	11.5	2.3-2.6	2.4
	95	2.4-2.8	2.6	7.6-10.5	8.8	7.2-9.7	8.2	8.2-11.8	9.6	2.1-2.4	2.3
	105	2.3-2.6	2.4	6.3-9.1	7.4	6.0-8.5	7.0	6.7-10.0	8.0	2.0-2.3	2.1
	115	2.1-2.5	2.3	5.2-7.9	6.2	5.1-7.4	6.0	5.5-8.5	6.6	1.9-2.2	2.0
	125	2.0-2.3	2.2	4.4-6.8	5.3	4.2-6.5	5.1	4.5-7.2	5.5	1.8-2.0	1.9
	135	1.9-2.2	2.0	3.6-5.8	4.4	3.6-5.6	4.3	3.7-6.1	4.6	1.7-1.9	1.8
1/2 in. (13 mm) gypsum board on furring	85	4.0-4.4	4.2	10.5-13.5	11.7	9.9-12.4	11.0	11.4-15.2	12.9	3.7-4.0	3.8
	95	3.8-4.2	4.0	9.0-11.9	10.2	8.6-11.1	9.6	9.6-13.2	11.0	3.5-3.8	3.7
	105	3.7-4.0	3.8	7.7-10.5	8.8	7.4-9.9	8.4	8.1-11.4	9.4	3.4-3.7	3.5
	115	3.5-3.9	3.7	6.6-9.3	7.6	6.5-8.8	7.4	6.9-9.9	8.0	3.3-3.6	3.4
	125	3.4-3.7	3.6	5.8-8.2	6.7	5.6-7.9	6.5	5.9-8.6	6.9	3.2-3.4	3.3
	135	3.3-3.6	3.4	5.0-7.2	5.8	5.0-7.0	5.7	5.1-7.5	6.0	3.1-3.3	3.2
1 in. (25 mm) expanded polystyrene[c]	85	8.0-8.4	8.2	14.5-17.5	15.7	13.9-16.4	15.0	15.4-19.2	16.9	7.7-8.0	7.8
	95	7.8-8.2	8.0	13.0-15.9	14.2	12.6-15.1	13.6	13.6-17.2	15.0	7.5-7.8	7.7
	105	7.7-8.0	7.8	11.7-14.5	12.8	11.4-13.9	12.4	12.1-15.4	13.4	7.4-7.7	7.5
	115	7.5-7.9	7.7	10.6-13.3	11.6	10.5-12.8	11.4	10.9-13.9	12.0	7.3-7.6	7.4
	125	7.4-7.7	7.6	9.8-12.2	10.7	9.6-11.9	10.5	9.9-12.6	10.9	7.2-7.4	7.3
	135	7.3-7.6	7.4	9.0-11.2	9.8	9.0-11.0	9.7	9.1-11.5	10.0	7.1-7.3	7.2
1 in. (25 mm) extruded polystyrene[c]	85	9.0-9.4	9.2	15.5-18.5	16.7	14.9-17.4	16.0	16.4-20.2	17.9	8.7-9.0	8.8
	95	8.8-9.2	9.0	14.0-16.9	15.2	13.6-16.1	14.6	14.6-18.2	16.0	8.5-8.8	8.7
	105	8.7-9.0	8.8	12.7-15.5	13.8	12.4-14.9	13.4	13.1-16.4	14.4	8.4-8.7	8.5
	115	8.5-8.9	8.7	11.6-14.3	12.6	11.5-13.8	12.4	11.9-14.9	13.0	8.3-8.6	8.4
	125	8.4-8.7	8.6	10.8-13.2	11.7	10.6-12.9	11.5	10.9-13.6	11.9	8.2-8.4	8.3
	135	8.3-8.6	8.4	10.0-12.2	10.8	10.0-12.0	10.7	10.1-12.5	11.0	8.1-8.4	8.2
1 in. (25 mm) polyiso-cyanurate[d]	85	12.5-12.8	12.6	19.0-22.0	20.2	18.4-20.9	19.4	19.8-23.7	21.4	12.2-12.5	12.3
	95	12.3-12.6	12.4	17.4-20.4	18.6	17.0-19.6	18.1	18.0-21.6	19.5	12.0-12.3	12.1
	105	12.2-12.5	12.3	16.2-19.0	17.3	15.9-18.4	16.9	16.5-19.9	17.8	11.9-12.2	12.0
	115	12.0-12.3	12.1	15.1-17.7	16.1	14.9-17.3	15.8	15.3-18.4	16.5	11.8-12.0	11.9
	125	11.9-12.2	12.0	14.2-16.6	15.1	14.1-16.3	14.9	14.4-17.1	15.4	11.7-11.9	11.8
	135	11.8-12.1	11.9	13.5-15.7	14.3	13.4-15.5	14.2	13.6-16.0	14.5	11.6-11.8	11.7
2 x 4 furring with R13 batt & 1/2 in. (13 mm) gypsum board on furring	85	13.4-13.8	13.6	19.9-22.9	21.1	19.3-21.8	20.4	20.8-24.6	22.3	13.1-13.4	13.2
	95	13.2-13.6	13.4	18.4-21.3	19.6	18.0-20.5	19.0	19.0-22.6	20.4	12.9-13.2	13.1
	105	13.1-13.4	13.2	17.1-19.9	18.2	16.8-19.3	17.8	17.5-20.8	18.8	12.8-13.1	12.9
	115	12.9-13.3	13.1	16.0-18.7	17.0	15.9-18.2	16.8	16.3-19.3	17.4	12.7-13.0	12.8
	125	12.8-13.1	13.0	15.2-17.6	16.1	15.0-17.3	15.9	15.3-18.0	16.3	12.6-12.8	12.7
	135	12.7-13.0	12.8	14.4-16.6	15.2	14.4-16.4	15.1	14.5-16.9	15.4	12.5-12.7	12.6

Table 5—R-Values For 12 in. (305 mm) Concrete Masonry Walls, hr·ft²·ºF/Btu[a]

[a] Notes: (hr·ft²·ºF/Btu) (0.176) = m²·K/W. Mortar joints are 3/8 in. (10 mm) thick, with face shell mortar bedding assumed. Unit dimensions based on *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C 90 (ref. 2). Surface air films are included.

[b] Values apply when all masonry cores are filled completely. Grout density is 140 pcf (2243 kg/m³). Lightweight grouts, which will provide higher R-values, are also available in some areas.

[c] Installed over wood furring. Includes 1/2 in. (13 mm) gypsum board and nonreflective air space.

[d] Installed over wood furring. Includes 1/2 in. (13 mm) gypsum board and reflective air space.

The values for insulated and grouted cores in Tables 1 through 5 are based on the assumption that all masonry cores are either insulated or grouted. That is, for walls which are either not grouted or are fully grouted, the values in Tables 2 through 5 can be used directly.

R-VALUES FOR PARTIALLY GROUTED MASONRY

For partially grouted walls, the values in Tables 2 through 5 must be modified. The first step is to determine how much of the wall area is grouted, from Table 1. The U-factor of the wall is calculated from the area-weighted average of the U-factor of the grouted area and the U-factor of the ungrouted area as follows:

$$U = (a_{gr} \times U_{gr}) + (a_{ungr} \times U_{ungr}) \text{ and } \qquad R = 1/U$$

where:
a_{gr} = fractional grouted area of wall
a_{ungr} = fractional ungrouted area of wall
R = total thermal resistance of wall, $hr \cdot ft^2 \cdot {}^oF/Btu$ ($m^2 \cdot K/W$)
U = total thermal conductance of wall, $Btu/hr \cdot ft^2 \cdot {}^oF$ ($W/m^2 \cdot K$)
U_{gr} = conductance of fully grouted wall, $Btu/hr \cdot ft^2 \cdot {}^oF$ ($W/m^2 \cdot K$)
U_{ungr} = conductance of ungrouted wall, $Btu/hr \cdot ft^2 \cdot {}^oF$ ($W/m^2 K$)

For example, consider an 8 in. (203 mm) wall composed of hollow 105 lb/ft^3 (1682 kg/m^3) concrete masonry, and grouted at 48 in. (1219 mm) o.c. both vertically and horizontally. The ungrouted cores contain perlite loose fill insulation.

From Table 1, 31% of the wall is grouted and 69% contains insulation. From Table 3, the R-value for a solidly grouted concrete masonry wall is 1.7 $hr \cdot ft^2 \cdot {}^oF/Btu$ (0.30 $m^2 \cdot K/W$). The corresponding U-factor is 1/1.7 or 0.588 Btu/$hr \cdot ft^2 \cdot {}^oF$ (3.3 $W/m^2 \cdot K$). Again from Table 3, a wall containing perlite loose fill insulation has an R-value of 5.2, with a corresponding U-factor of 0.192. The U-factor and R-value of the wall are calculated as follows:

$U = a_{gr} \times U_{gr} + a_{ungr} \times U_{ungr}$
  = (0.31 x 0.588) + (0.69 x 0.192)
  = 0.315 Btu/hr·ft^2·^oF (1.79 W/m^2·K)
$R = 1/U$ = 1/0.315 = 3.2 hr·ft^2·^oF/Btu (0.56 m^2·K/W)

Table 6—Thermal Data Used to Develop Tables	
Material:	Thermal resistivity (R-value per inch), $hr \cdot ft^2 \cdot {}^oF/Btu \cdot in$ (m·K/W)
Vermiculite	2.27 (15.7)
Perlite	3.13 (21.7)
Expanded polystyrene	4.00 (27.7)
Extruded polystyrene	5.00 (34.7)
Cellular polyisocyanurate, gas-impermeable facer	7.04 (48.8)
Polyurethane foamed-in-place insulation	5.91 (41.0)
Wood	1.00 (6.9)
Concrete:	
85 pcf	0.23-0.34 (1.6-2.4)
95 pcf	0.18-0.28 (1.2-1.9)
105 pcf	0.14-0.23 (0.97-1.6)
115 pcf	0.11-0.19 (0.76-1.3)
125 pcf	0.08-0.15 (0.55-1.0)
135 pcf	0.07-0.12 (0.49-0.83)
140 pcf	0.06-0.11 (0.40-0.78)
Mortar	0.20 (1.4)
Material	R-value, $hr \cdot ft^2 \cdot {}^oF/Btu$ (m^2·K/W)
½ in. (13 mm) gypsum wallboard	0.45 (0.08)
Inside surface air film	0.68 (0.12)
Outside surface air film	0.17 (0.03)
Nonreflective air space	0.97 (0.17)
Reflective air space	2.38 (0.42)

REFERENCES
1. *ASHRAE Fundamentals Handbook*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2001.
2. *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C 90-03. ASTM International, 2003.
3. Valore, Rudolph C. *The Thermophysical Properties of Masonry and Its Constituents, Parts I and II*. Washington, DC: International Masonry Institute, 1988.