Errata to
Principles of Heating, Ventilating, and Air-Conditioning,
6th Edition

January 28, 2013

Shaded items have been added since the previously published errata sheet dated August 9, 2012.

Page 67: In the left-hand column, near the bottom, "chapter 6 of the *2005 ASHRAE Handbook—Fundamentals*" should read "**chapter 1 of the *2009 ASHRAE Handbook—Fundamentals***" and the h_{w_2}, h_{w_1}, and $h_{condensate}$ values should be updated from $h_{w_2} = 1083.03$ Btu/lb, $h_{w_1} = 1102.55$ Btu/lb, and $h_{condensate} = 18.06$ Btu/lb to $h_{w_2} = \mathbf{1083.07}$ Btu/lb, $h_{w_1} = \mathbf{1102.57}$ Btu/lb, and $h_{condensate} = \mathbf{18.07}$ Btu/lb.

Page 69: In the left-hand column, in the paragraph under Equation 3-25, change the first sentence from "In Equations (3-24) and (3-25), respectively, 2500 kJ/kg (1076 Btu/lb) is the approximate energy content of the superheated water vapor at 23.8°C (75°F), less the energy content of water at 10°C (50°F)" to "In Equations (3-24) and (3-25), respectively, 2500 kJ/kg (1076 Btu/lb) is the approximate energy content of the superheated water vapor at 23.8°C (75°F) **(1093.95 Btu/lb)**, less the energy content of water at 10°C (50°F) **(18.07 Btu/lb)**" and add the following new explanatory text: "**This difference is rounded up to 1076 Btu/lb (2500 kJ/kg).**"

Page 69: In the right-hand column, under $m_w = q_l/1100 = 8800/1100 = 8$ lb/h, add the following new explanatory text: "**where 1100 Btu/lb approximates the enthalpy of the moisture added, causing the latent heat load. It is an approximation for 1076 But/lb in Equation 3-25.**"

Page 81: In the nomenclature under Equation 4-1, it states "*w* = mass of body, lb," but should read "***m*** = mass of body, lb."

Page 165: In Table 5-15, some of the data have been corrected. Please replace the original table with the attached corrected table. Updated values are in **bold**.

Page 260: In Table 29, some of the data have been corrected. Please replace the original table with the attached corrected table. Updated values are in **bold**.

Page 261: In Table 31, some of the data have been corrected. Please replace the original table with the attached corrected table. Updated values are in **bold**.

Page 501: Figures 18-36, 18-37, and 18-38 are missing. They are included on the following pages.

Table 5-1 Typical Thermal Properties of Common Building and Insulating Materials: Design Values[a]
(Table 4, Chapter 26, *2009 ASHRAE Handbook—Fundamentals*)

Description		Density, lb/ft^3	Conductivity[b] *k*, $Btu \cdot in/h \cdot ft^2 \cdot °F$	Resistance *R*, $h \cdot ft^2 \cdot °F/Btu$	Specific Heat, $Btu/lb \cdot °F$	Reference[n]
Building Board and Siding						
Board						
Asbestos/cement board		120	4	—	0.24	Nottage (1947)
Cement board		**71**	1.7	—	0.2	Kumaran (2002)
Fiber/cement board		88	1.7	—	0.2	Kumaran (2002)
		61	1.3	—	0.2	Kumaran (1996)
		26	0.5	—	0.45	Kumaran (1996)
		20	0.4	—	0.45	Kumaran (1996)
Gypsum or plaster board		40	1.1	—	0.27	Kumaran (2002)
Oriented strand board (OSB)	7/16 in.	41	—	0.62	0.45	Kumaran (2002)
	1/2 in.	41	—	0.68	0.45	Kumaran (2002)
Plywood (douglas fir)	1/2 in.	29	—	0.79	0.45	Kumaran (2002)
	5/8 in.	34	—	0.85	0.45	Kumaran (2002)
Plywood/wood panels	3/4 in.	28	—	1.08	0.45	Kumaran (2002)
Vegetable fiber board					—	
Sheathing, regular density[e]	1/2 in.	18	—	1.32	0.31	Lewis (1967)
intermediate density[e]	1/2 in.	22	—	1.09	0.31	Lewis (1967)
Nail-base sheathing[e]	1/2 in.	25	—	1.06	0.31	
Shingle backer	3/8 in.	18	—	0.94	0.3	
Sound-deadening board	**1/2 in.**	**15**	**—**	**1.35**	**0.3**	
Tile and lay-in panels, plain or acoustic		18	0.4	—	0.14	
Laminated paperboard		30	0.5	—	0.33	Lewis (1967)
Homogeneous board from repulped paper		30	0.5	—	0.28	
Hardboard[e]						
medium density		50	0.73	—	0.31	Lewis (1967)
high density, service-tempered grade and service grade		55	0.82	—	0.32	Lewis (1967)
high density, standard-tempered grade		63	1	—	0.32	Lewis (1967)
Particleboard[e]						
low density		37	0.71	—	0.31	Lewis (1967)
medium density		50	0.94	—	0.31	Lewis (1967)
high density		62	**1.18**	0.85	—	Lewis (1967)
underlayment	5/8 in.	40	—	0.82	0.29	Lewis (1967)
Waferboard		**44**	**0.73**	—	0.45	Kumaran (1996)
Shingles						
Asbestos/cement		120	—	**0.21**	—	
Wood, 16 in., 7 1/2 in. exposure		—	—	0.87	0.31	
Wood, double, 16 in., 12 in. exposure		—	—	1.19	0.28	
Wood, plus ins. backer board	5/16 in.	—	—	1.4	0.31	
Siding					—	
Asbestos/cement, lapped	1/4 in.	—	—	**0.21**	**0.24**	
Asphalt roll siding		—	—	**0.15**	**0.35**	
Siding						
Asphalt insulating siding (1/2 in. bed)		—	—	1.46	0.35	
Hardboard siding	7/16 in.	—	—	0.67	0.28	
Wood, drop, 8 in.	1 in.	—	—	0.79	0.28	
Wood, bevel						
8 in., lapped	1/2 in.	—	—	0.81	0.28	
10 in., lapped	3/4 in.	—	—	1.05	0.28	
Wood, plywood, 3/8 in., lapped		—	—	0.59	0.29	
Aluminum, steel, or vinyl,[j, k] over sheathing					—	
hollow-backed		—	—	0.62	0.29[k]	
insulating-board-backed					—	
	3/8 in.	—	—	1.82	0.32	
foil-backed	3/8 in.	—	—	2.96	—	
Architectural (soda-lime float) glass		158	6.9	—	**0.21**	
Building Membrane						
Vapor-permeable felt		—	—	0.06	—	
Vapor: seal, 2 layers of mopped 15 lb felt		—	—	0.12	—	
Vapor: seal, plastic film		—	—	Negligible	—	

Table 5-1 Typical Thermal Properties of Common Building and Insulating Materials: Design Values[a] (Continued)

(Table 4, Chapter 26, *2009 ASHRAE Handbook—Fundamentals*)

Description	Density, lb/ft³	Conductivity[b] *k*, Btu·in/h·ft²·°F	Resistance *R*, h·ft²·°F/Btu	Specific Heat, Btu/lb·°F	Reference[n]
Finish Flooring Materials					
Carpet and rebounded urethane pad .... 3/4 in.	7	—	2.38	—	NIST (2000)
Carpet and rubber pad (one-piece) .... 3/8 in.	20	—	0.68	—	NIST (2000)
Pile carpet with rubber pad...................... 3/8 to 1/2 in.	18	—	1.59	—	NIST (2000)
Linoleum/cork tile .... 1/4 in.	29	—	0.51	—	NIST (2000)
PVC/Rubber floor covering..	—	2.8	—	—	CIBSE (2006)
Rubber tile .... 1.0 in.	119	—	0.34	—	NIST (2000)
Terrazzo .... 1.0 in.	—	—	0.08	0.19	
Insulating Materials					
Blanket and batt[c,d]					
Glass-fiber batts...................................... 3 to 3 1/2 in.	0.6 to 0.9	**0.30**	—	0.2	Kumaran (2002)
.... 6 in.	0.5 to 0.8	**0.31 to 0.33**	—	0.2	Kumaran (2002)
Mineral fiber .... 5 1/2 in.	2	**0.25**	—	0.2	Kumaran (1996)
Mineral wool, felted	1 to 3	**0.28**	—	—	CIBSE (2006), NIST (2000)
....	**4 to 8**	**0.24**	—	—	NIST (2000)
Slag wool	**3 to 12**	**0.26**	—	—	Raznjevic (1976)
....	16	**0.28**	—	—	Raznjevic (1976)
....	19	**0.30**	—	—	Raznjevic (1976)
....	22	**0.33**	—	—	Raznjevic (1976)
....	25	**0.35**	—	—	Raznjevic (1976)
Board and slabs					
Cellular glass	**8**	0.33	—	0.18	(Manufacturer)
Cement fiber slabs, shredded wood with Portland cement binder...................................	**25 to 27**	0.50 to 0.53	—	—	
with magnesia oxysulfide binder............................	**22**	0.57	—	0.31	
Glass fiber board...	10	0.22 to 0.28	—	0.2	Kumaran (1996)
Expanded rubber (rigid)..	4	0.2	—	0.4	Nottage (1947)
Expanded polystyrene extruded (smooth skin)	**1.6 to 2.4**	0.15 to 0.21	—	0.35	Kumaran (1996)
Expanded polystyrene, molded beads	0.9 to 1.6	0.22 to 0.27	—	0.35	Kumaran (1996)
Mineral fiberboard, wet felted	10	**0.26**	—	0.2	Kumaran (1996)
core or roof insulation...	16 to 17	0.34	—	—	
acoustical tile[g]..	**18**	—	—	0.19	
....	**21**	0.37	—	—	
wet-molded, acoustical tile[g]	**23**	0.42	—	0.14	
Perlite board..	10	**0.36**	—	—	Kumaran (1996)
Polyisocyanurate, aged					
unfaced..	**1.6 to 2.3**	0.14 to 0.19	—	—	Kumaran (2002)
with facers...	4	**0.13**	—	0.35	Kumaran (1996)
Phenolic foam board with facers, aged.........................	4	**0.13**	—	—	Kumaran (1996)
Loose fill					
Cellulosic (milled paper or wood pulp)........................	**2 to 3.5**	**0.26 to 0.31**	—	**0.45**	NIST (2000), Kumaran (1996)
fiberized	**1.2 to 2.0**				
Perlite, expanded	**2 to 4**	0.27 to 0.31	—	0.26	(Manufacturer)
....	**4 to 7.5**	0.31 to 0.36	—	—	(Manufacturer)
....	**7.5 to 11**	0.36 to 0.42	—	—	(Manufacturer)
Mineral fiber (rock, slag, or glass)[d]..............................					
.... approx. 3 3/4 to 5 in.	0.6 to 2.0	—	11.0	0.17	
.... approx. 6 1/2 to 8 3/4 in.	0.6 to 2.0	—	19.0	—	
.... approx. 7 1/2 to 10 in.	0.6 to 2.0	—	22.0	—	
.... approx. 10 1/4 to 13 3/4 in.	0.6 to 2.0	—	30.0	—	
.... approx. 3 1/2 in. (closed sidewall application)	2.0 to 3.5	—	12.0 to 14.0	—	
Vermiculite, exfoliated..	7.0 to 8.2	0.47	—	0.32	Sabine et al. (1975)
....	**4.0 to 6.0**	0.44	—	—	(Manufacturer)
Spray-applied					
Cellulosic fiber	**3.5 to 6.0**	0.29 to 0.34	—	—	Yarbrough et al. (1987)
Glass fiber...	**3.5 to 4.5**	0.26 to 0.27	—	—	Yarbrough et al. (1987)
Polyurethane foam (low density)..................................	0.4 to 0.5	**0.29**	—	0.35	Kumaran (2002)
....	**2.4**	**0.18**	—	0.35	Kumaran (2002)
aged and dry.. 1 1/2 in.	**2.0**	—	9.09	0.35	Kumaran (1996)
.... 2 in.	**3.5**	—	10.9	0.35	Kumaran (1996)
.... 4 1/2 in.	**2.0**	—	20.95	—	Kumaran (1996)
Ureaformaldehyde foam, dry..	0.5 to 1.2	0.21 to 0.22	—	—	CIBSE (2006)
Metals					
(See Chapter 33, Table 3)					

Table 5-1 Typical Thermal Properties of Common Building and Insulating Materials: Design Values[a] (Continued)

(Table 4, Chapter 26, *2009 ASHRAE Handbook—Fundamentals*)

Description		Density, lb/ft³	Conductivity[b] *k*, Btu·in/h·ft²·°F	Resistance *R*, h·ft²·°F/Btu	Specific Heat, Btu/lb·°F	Reference[n]
Roofing						
Asbestos/cement shingles		120	—	0.21	0.24	
Asphalt (bitumen with inert fill)		100	**2.98**	—	—	CIBSE (2006)
		119	**4.0**	—	—	CIBSE (2006)
		144	**7.97**	—	—	CIBSE (2006)
Asphalt roll roofing		70	—	0.15	0.36	
Asphalt shingles		70	—	0.44	0.3	
Built-up roofing	3/8 in.	70	—	0.33	0.35	
Mastic asphalt (heavy, 20% grit)		59	**1.32**	—	—	CIBSE (2006)
Reed thatch		17	**0.62**	—	—	CIBSE (2006)
Roofing felt		141	**8.32**	—	—	CIBSE (2006)
Slate	1/2 in.	—	—	0.05	0.3	
Straw thatch		15	**0.49**	—	—	CIBSE (2006)
Wood shingles, plain and plastic-film-faced		—	—	0.94	0.31	
Plastering Materials						
Cement plaster, sand aggregate		116	5.0	—	0.2	
Sand aggregate						
	3/8 in.	—	—	0.08	0.2	
	3/4 in.	—	—	0.15	0.2	
Gypsum plaster		70	**2.63**	—	—	CIBSE (2006)
		80	**3.19**	—	—	CIBSE (2006)
Lightweight aggregate						
	1/2 in.	45	—	0.32	—	
	5/8 in.	45	—	0.39	—	
on metal lath	3/4 in.	—	—	0.47	—	
Perlite aggregate		45	1.5	—	0.32	
Sand aggregate		105	5.6	—	0.2	
on metal lath	3/4 in.	—	—	0.13	—	
Vermiculite aggregate		30	1	—	—	CIBSE (2006)
		40	**1.39**	—	—	CIBSE (2006)
		45	1.7	—	—	CIBSE (2006)
		50	1.8	—	—	CIBSE (2006)
		60	**2.08**	—	—	CIBSE (2006)
Perlite plaster		25	**0.55**	—	—	CIBSE (2006)
		38	**1.32**	—	—	CIBSE (2006)
Pulpboard or paper plaster		38	**0.48**	—	—	CIBSE (2006)
Sand/cement plaster, conditioned		98	4.4	—	—	CIBSE (2006)
Sand/cement/lime plaster, conditioned		90	3.33	—	—	CIBSE (2006)
Sand/gypsum (3:1) plaster, conditioned		97	4.5	—	—	CIBSE (2006)
Masonry Materials						
Masonry units						
Brick, fired clay		150	8.4 to 10.2	—	—	Valore (1988)
		140	7.4 to 9.0	—	—	Valore (1988)
		130	6.4 to 7.8	—	—	Valore (1988)
		120	5.6 to 6.8	—	0.19	Valore (1988)
		110	4.9 to 5.9	—	—	Valore (1988)
		100	4.2 to 5.1	—	—	Valore (1988)
		90	3.6 to 4.3	—	—	Valore (1988)
		80	3.0 to 3.7	—	—	Valore (1988)
		70	2.5 to 3.1	—	—	Valore (1988)
Clay tile, hollow						
1 cell deep	3 in.	—	—	0.80	0.21	Rowley (1937)
	4 in.	—	—	1.11	—	Rowley (1937)
2 cells deep	6 in.	—	—	1.52	—	Rowley (1937)
	8 in.	—	—	1.85	—	Rowley (1937)
	10 in.	—	—	2.22	—	Rowley (1937)
3 cells deep	12 in.	—	—	2.50	—	Rowley (1937)
Lightweight brick		50	**1.39**	—	—	Kumaran (1996)
		48	**1.51**	—	—	Kumaran (1996)
Concrete blocks[h, i]						
Limestone aggregate						
8 in., 36 lb, 138 lb/ft³ concrete, 2 cores		—	—	—	—	
with perlite-filled cores		—	—	2.1	—	Valore (1988)
12 in., 55 lb, 138 lb/ft³ concrete, 2 cores		—		—	—	
with perlite-filled cores		—	—	3.7	—	Valore (1988)

Table 5-1 Typical Thermal Properties of Common Building and Insulating Materials: Design Values[a] (Continued)
(Table 4, Chapter 26, *2009 ASHRAE Handbook—Fundamentals*)

Description	Density, lb/ft³	Conductivity[b] *k*, Btu·in/h·ft²·°F	Resistance *R*, h·ft²·°F/Btu	Specific Heat, Btu/lb·°F	Reference[n]
Normal-weight aggregate (sand and gravel)					
8 in., 33 to 36 lb, 126 to 136 lb/ft³ concrete, 2 or 3 cores	—	—	1.11 to 0.97	0.22	Van Geem (1985)
with perlite-filled cores	—	—	2.0	—	Van Geem (1985)
with vermiculite-filled cores	—	—	1.92 to 1.37	—	Valore (1988)
12 in., 50 lb, 125 lb/ft³ concrete, 2 cores	—	—	1.23	0.22	Valore (1988)
Medium-weight aggregate (combinations of normal and lightweight aggregate)					
8 in., 26 to 29 lb, 97 to 112 lb/ft³					
concrete, 2 or 3 cores	—	—	1.71 to 1.28	—	Van Geem (1985)
with perlite-filled cores	—	—	3.7 to 2.3	—	Van Geem (1985)
with vermiculite-filled cores	—	—	3.3	—	Van Geem (1985)
with molded-EPS-filled (beads) cores	—	—	3.2	—	Van Geem (1985)
with molded EPS inserts in cores	—	—	2.7	—	Van Geem (1985)
Lightweight aggregate (expanded shale, clay, slate or slag, pumice)					
6 in., 16 to 17 lb, 85 to 87 lb/ft³					
concrete, 2 or 3 cores	—	—	1.93 to 1.65	—	Van Geem (1985)
with perlite-filled cores	—	—	4.2	—	Van Geem (1985)
with vermiculite-filled cores	—	—	3.0	—	Van Geem (1985)
8 in., 19 to 22 lb, 72 to 86 lb/ft³ concrete	—	—	3.2 to 1.90	0.21	Van Geem (1985)
with perlite-filled cores	—	—	6.8 to 4.4	—	Van Geem (1985)
with vermiculite-filled cores	—	—	5.3 to 3.9	—	Shu et al. (1979)
with molded-EPS-filled (beads) cores	—	—	4.8	—	Shu et al. (1979)
with UF foam-filled cores	—	—	4.5	—	Shu et al. (1979)
with molded EPS inserts in cores	—	—	3.5	—	Shu et al. (1979)
12 in., 32 to 36 lb, 80 to 90 lb/ft³,					
concrete, 2 or 3 cores	—	—	2.6 to 2.3	—	Van Geem (1985)
with perlite-filled cores	—	—	9.2 to 6.3	—	Van Geem (1985)
with vermiculite-filled cores	—	—	5.8	—	Valore (1988)
Stone, lime, or sand	180	72	—	—	Valore (1988)
Quartzitic and sandstone	160	43	—	—	Valore (1988)
	140	24	—	—	Valore (1988)
	120	13	—	**0.19**	Valore (1988)
Calcitic, dolomitic, limestone, marble, and granite	180	30	—	—	Valore (1988)
	160	22	—	—	Valore (1988)
	140	16	—	—	Valore (1988)
	120	11	—	0.21	Valore (1988)
	100	8	—	—	Valore (1988)
Gypsum partition tile					
3 by 12 by 30 in., solid	—	—	1.26	0.19	Rowley (1937)
4 cells	—	—	1.35	—	Rowley (1937)
4 by 12 by 30 in., 3 cells	—	—	1.67	—	Rowley (1937)
Limestone	150	**3.95**	—	0.2	Kumaran (2002)
	163	**6.45**	—	0.2	Kumaran (2002)
Concretes[i]					
Sand and gravel or stone aggregate concretes (concretes with >50% quartz or quartzite sand have conductivities in higher end of range)	150	10.0 to 20.0	—	—	Valore (1988)
	140	9.0 to 18.0	—	0.19 to 0.24	Valore (1988)
	130	7.0 to 13.0	—	—	Valore (1988)
Lightweight aggregate or limestone concretes	120	6.4 to 9.1	—	—	Valore (1988)
Expanded shale, clay, or slate; expanded slags; cinders; pumice (with density up to 100 lb/ft³); scoria (sanded concretes have conductivities in higher end of range)	100	4.7 to 6.2	—	0.2	Valore (1988)
	80	3.3 to 4.1	—	0.2	Valore (1988)
	60	2.1 to 2.5	—	—	Valore (1988)
	40	1.3	—	—	Valore (1988)
Gypsum/fiber concrete (87.5% gypsum, 12.5% wood chips)	51	1.66	—	0.2	Rowley (1937)
Cement/lime, mortar, and stucco	120	9.7	—	—	Valore (1988)
	100	6.7	—	—	Valore (1988)
	80	4.5	—	—	Valore (1988)
Perlite, vermiculite, and polystyrene beads	50	1.8 to 1.9	—	—	Valore (1988)
	40	1.4 to 1.5	—	0.15 to 0.23	Valore (1988)
	30	1.1	—	—	Valore (1988)

Table 5-1 Typical Thermal Properties of Common Building and Insulating Materials: Design Values[a] (Continued)

(Table 4, Chapter 26, *2009 ASHRAE Handbook—Fundamentals*)

Description	Density, lb/ft^3	Conductivity[b] *k*, $Btu \cdot in/h \cdot ft^2 \cdot °F$	Resistance *R*, $h \cdot ft^2 \cdot °F/Btu$	Specific Heat, $Btu/lb \cdot °F$	Reference[n]
....	20	0.8	—	—	Valore (1988)
Foam concretes	120	5.4	—	—	Valore (1988)
....	100	4.1	—	—	Valore (1988)
....	80	3.0	—	—	Valore (1988)
....	70	2.5	—	—	Valore (1988)
Foam concretes and cellular concretes	60	2.1	—	—	Valore (1988)
....	40	1.4	—	—	Valore (1988)
....	20	0.8	—	—	Valore (1988)
Aerated concrete (oven-dried)	27 to 50	1.4	—	0.2	Kumaran (1996)
Polystyrene concrete (oven-dried)	16 to 50	**2.54**	—	0.2	Kumaran (1996)
Polymer concrete	122	11.4	—	—	Kumaran (1996)
....	138	**7.14**	—	—	Kumaran (1996)
Polymer cement	117	**5.39**	—	—	Kumaran (1996)
Slag concrete	60	1.5	—	—	Touloukian et al (1970)
....	80	**2.25**	—	—	Touloukian et al. (1970)
....	100	3	—	—	Touloukian et al. (1970)
....	125	**8.53**	—	—	Touloukian et al. (1970)
Woods (12% moisture content)[l]					
Hardwoods	—	—	—	0.39[m]	Wilkes (1979)
Oak	**41 to 47**	1.12 to 1.25	—	—	**Cardenas and Bible (1987)**
Birch	**43 to 45**	1.16 to 1.22	—	—	**Cardenas and Bible (1987)**
Maple	**40 to 44**	1.09 to 1.19	—	—	**Cardenas and Bible (1987)**
Ash	**38 to 42**	1.06 to 1.14	—	—	**Cardenas and Bible (1987)**
Softwoods	—	—	—	0.39[m]	Wilkes (1979)
Southern pine	**36 to 41**	1.00 to 1.12	—	—	Cardenas
Southern yellow pine	31	**1.06 to 1.16**	—	—	Kumaran (2002)
Eastern white pine	25	**0.85 to 0.94**	—	—	Kumaran (2002)
Douglas fir/larch	**34 to 36**	0.95 to 1.01	—	—	Cardenas and Bible (1987)
Southern cypress	**31 to 32**	0.90 to 0.92	—	—	Cardenas and Bible (1987)
Hem/fir, spruce/pine/fir	**24 to 31**	0.74 to 0.90	—	—	Cardenas and Bible (1987)
Spruce	25	**0.74 to 0.85**	—	—	Kumaran (2002)
Western red cedar	22	**0.83 to 0.86**	—	—	Kumaran (2002)
West coast woods, cedars	**22 to 31**	0.68 to 0.90	—	—	Cardenas and Bible (1987)
Eastern white cedar	22	**0.82 to 0.89**	—	—	Kumaran (2002)
California redwood	**24 to 28**	0.74 to 0.82	—	—	Cardenas and Bible (1987)
Pine (oven-dried)	23	0.64	—	0.45	Kumaran (1996)
Spruce (oven-dried)	25	0.69	—	0.45	Kumaran (1996)

Table 29 Window Component of Heat Gain (No Blinds or Overhang)

	Beam Solar Heat Gain						Diffuse Solar Heat Gain							Conduction		
Local Std. Hour	Beam Normal, Btu/h·ft^2	Surface Incident Angle	Surface Beam, Btu/h·ft^2	Beam SHGC	Adjusted Beam IAC	Beam Solar Heat Gain, Btu/h	Diffuse Horiz. E_d, Btu/h·ft^2	Ground Diffuse, Btu/h·ft^2	Y Ratio	Sky Diffuse, Btu/h·ft^2	Subtotal Diffuse, Btu/h·ft^2	Hemis. SHGC	Diff. Solar Heat Gain, Btu/h	Outside Temp., °F	Conduction Heat Gain, Btu/h	Total Window Heat Gain, Btu/h
1	0.0	117.4	0.0	0.000	1.000	0	0.0	0.0	0.4500	0.0	0.0	0.410	0	73.8	–54	–54
2	0.0	130.9	0.0	0.000	1.000	0	0.0	0.0	0.4500	0.0	0.0	0.410	0	73.0	–90	–90
3	0.0	144.5	0.0	0.000	1.000	0	0.0	0.0	0.4500	0.0	0.0	0.410	0	72.3	–121	–121
4	0.0	158.1	0.0	0.000	1.000	0	0.0	0.0	0.4500	0.0	0.0	0.410	0	71.7	–148	–148
5	0.0	171.3	0.0	0.000	1.000	0	0.0	0.0	0.4500	0.0	0.0	0.410	0	71.3	–166	–166
6	5.6	172.5	0.0	0.000	0.000	0	5.8	0.6	0.4500	2.6	3.2	0.410	**106**	71.7	–148	–42
7	92.4	159.5	0.0	0.000	0.000	0	27.4	5.0	0.4500	12.3	17.3	0.410	**569**	73.2	–81	488
8	155.4	145.9	0.0	0.000	0.000	0	42.9	11.2	0.4500	19.3	30.5	0.410	**1002**	76.7	76	1078
9	193.1	132.3	0.0	0.000	0.000	0	53.9	17.5	0.4500	24.3	41.8	0.410	**1371**	80.6	251	1622
10	216.1	118.8	0.0	0.000	0.000	0	61.6	23.1	0.4500	27.7	50.8	0.410	**1665**	84.1	408	2073
11	229.8	105.6	0.0	0.000	0.000	0	66.6	27.2	0.4553	30.3	57.5	0.410	**1887**	87.2	547	2434
12	236.7	92.6	0.0	0.000	0.000	0	69.3	29.6	0.5306	36.8	66.4	0.410	**2177**	89.3	641	2818
13	238.0	80.2	40.4	0.166	1.000	537	69.8	30.1	0.6332	44.2	74.3	0.410	**2436**	91.0	717	3690
14	233.8	68.7	85.1	0.321	1.000	2183	68.1	28.6	0.7505	51.1	79.7	0.410	**2614**	92.0	762	5559
15	223.5	58.4	117.0	0.398	1.000	3722	64.2	25.2	0.8644	55.5	80.7	0.410	**2648**	92.0	762	7132
16	205.3	50.4	130.8	0.438	1.000	4583	57.9	20.3	0.9555	55.3	75.6	0.410	**2479**	90.8	708	7770
17	175.5	45.8	122.4	0.448	1.000	4392	48.5	14.3	1.0073	48.9	63.2	0.410	**2072**	89.1	632	7096
18	126.2	45.5	88.4	0.449	1.000	3177	35.4	7.9	1.0100	35.7	43.6	0.410	**1429**	87.0	538	5143
19	44.7	49.7	28.9	0.441	1.000	1017	16.6	2.3	0.9631	16.0	18.3	0.410	**599**	83.9	399	2015
20	0.0	57.5	0.0	0.403	0.000	0	0.0	0.0	0.8755	0.0	0.0	0.410	0	81.7	300	300
21	0.0	67.5	0.0	0.330	0.000	0	0.0	0.0	0.7630	0.0	0.0	0.410	0	79.8	215	215
22	0.0	79.0	0.0	0.185	0.000	0	0.0	0.0	0.6452	0.0	0.0	0.410	0	77.9	130	130
23	0.0	91.3	0.0	0.000	1.000	0	0.0	0.0	0.5403	0.0	0.0	0.410	0	76.3	58	58
24	0.0	104.2	0.0	0.000	1.000	0	0.0	0.0	0.4618	0.0	0.0	0.410	0	75.0	0	0

Table 31 Window Component of Cooling Load (With Blinds, No Overhang)

	Unshaded Direct Beam Solar (if AC = 1)						Shaded Direct Beam (AC < 1.0) + Diffuse + Conduction									
Local Standard Hour	Beam Heat Gain, Btu/h	Convective 0%, Btu/h	Radiant 100%, Btu/h	Solar RTS, Zone Type 8, %	Radiant Btu/h	Cooling Load, Btu/h	Beam Heat Gain, Btu/h	Diffuse Heat Gain, Btu/h	Conduction Heat Gain, Btu/h	Total Heat Gain, Btu/h	Convective 54%, Btu/h	Radiant 46%, Btu/h	Nonsolar RTS, Zone Type 8	Radiant Btu/h	Cooling Load, Btu/h	Window Cooling Load, Btu/h
1	0	0	0	1	0	0	0	0	–54	–54	**–29**	**–25**	49%	211	186	186
2	0	0	0	0	0	0	0	0	–90	–90	**–48**	**–41**	17%	184	143	143
3	0	0	0	0	0	0	0	0	–121	–121	**–65**	**–56**	9%	165	109	109
4	0	0	0	0	0	0	0	0	–148	–148	**–80**	**–68**	5%	146	78	78
5	0	0	0	0	0	0	0	0	–166	–166	**–90**	**–76**	3%	127	51	51
6	0	0	0	0	0	0	0	84	–148	–64	**–35**	**–29**	2%	140	110	110
7	0	0	0	0	0	0	0	449	–81	368	**199**	**169**	2%	249	419	419
8	0	0	0	0	0	0	0	791	76	868	**469**	**399**	1%	411	810	810
9	0	0	0	0	0	0	0	1083	251	1334	**720**	**614**	1%	587	1200	1200
10	0	0	0	0	0	0	0	1315	408	1723	**930**	**793**	1%	746	1539	1539
11	0	0	0	0	0	0	0	1491	547	2037	**1100**	**937**	1%	880	1817	1817
12	0	0	0	0	0	0	0	1720	641	2361	**1275**	**1086**	1%	1008	2094	2094
13	0	0	0	0	0	0	349	1925	717	2990	**1615**	**1376**	1%	1219	2594	2594
14	0	0	0	0	0	0	1419	2065	762	4246	**2293**	**1953**	1%	1630	3583	3583
15	0	0	0	0	0	0	2430	2092	762	5284	**2853**	**2431**	1%	2070	4500	4500
16	0	0	0	0	0	0	3062	1958	708	5728	**3093**	**2635**	1%	2379	5014	5014
17	0	0	0	0	0	0	3003	1637	632	5271	**2847**	**2425**	1%	2409	4834	4834
18	0	0	0	0	0	0	2227	1129	538	3893	**2102**	**1791**	1%	2093	3883	3883
19	0	0	0	0	0	0	734	473	399	1606	**867**	**739**	1%	1400	2139	2139
20	0	0	0	0	0	0	0	0	300	300	**162**	**138**	1%	814	952	952
21	0	0	0	0	0	0	0	0	215	215	**116**	**99**	0%	555	654	654
22	0	0	0	0	0	0	0	0	130	130	**70**	**60**	0%	406	466	466
23	0	0	0	0	0	0	0	0	58	58	**31**	**27**	0%	314	341	341
24	0	0	0	0	0	0	0	0	0	0	**0**	**0**	0%	254	254	254

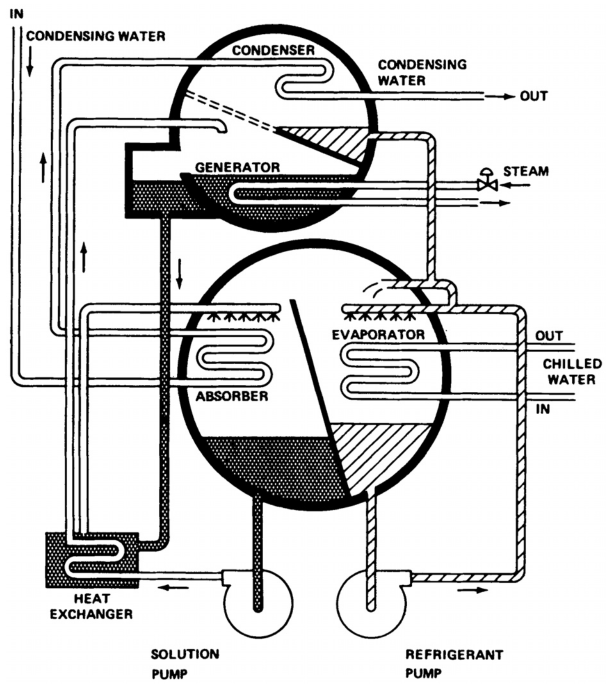

Fig. 18-36 Diagram of Two-Shell Lithium Bromide Cycle Water Chiller

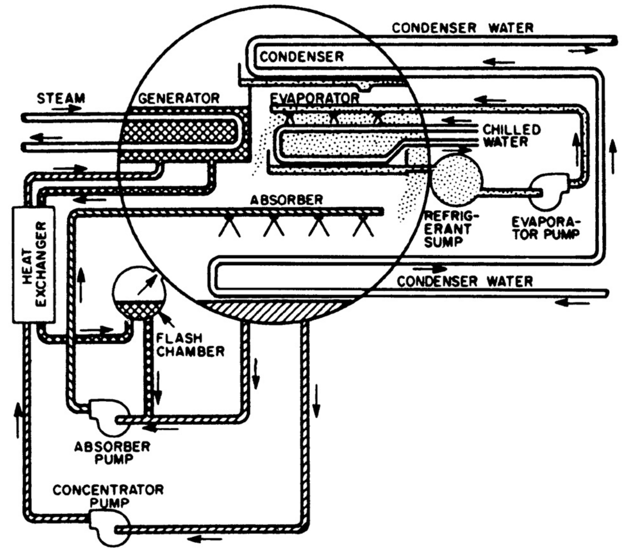

Fig. 18-37 Diagram of One-Shell Lithium Bromide Cycle Water Chiller

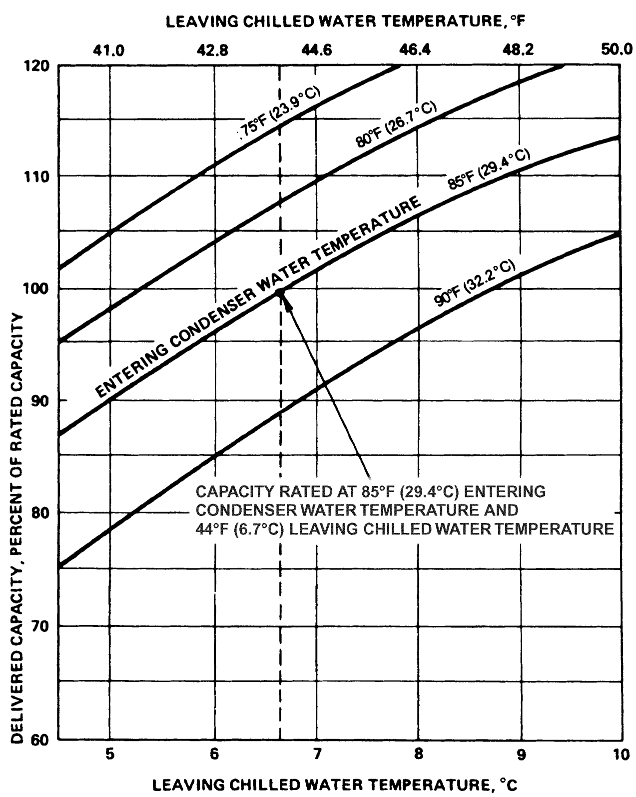

Fig. 18-38 Performance Characteristics of Lithium Bromide Cycle Water Chiller