Chapter -14
Appendix

Room Heating Load Calculation Forms

Room Heating Load Calculations

P. _____ of _____ PP.

Project _____ Location _____ Indoor DB _____ F

Engrs. _____ Calc. by _____ Chk. by _____ Outdoor DB _____ F

Room																
Plan Size																
Heat Transfer	*U* ×	*A* ×	TD =	BTU/hr	*U* ×	*A* ×	TD =	BTU/hr	*U* ×	*A* ×	TD =	BTU/hr				
Walls																
Windows																
Doors																
Roof/ceiling																
Floor																
Partition																
Heat Transfer Loss																
Infiltration	1.1 ×	(CFM) *A*	× *B*	× TC =	1.1 ×	(CFM) *A*	× *B*	× TC =	1.1 ×	(CFM) *A*	× *B*	× TC =				
Window	1.1				1.1				1.1							
Door	1.1				1.1				1.1							
Infiltration Heat Loss																
Room Heating Load																

Room																
Plan Size																
Heat Transfer	*U* ×	*A* ×	TD =	BTU/hr	*U* ×	*A* ×	TD =	BTU/hr	*U* ×	*A* ×	TD =	BTU/hr				
Walls																
Windows																
Doors																
Roof/ceiling																
Floor																
Partition																
Heat Transfer Loss																
Infiltration	1.1 ×	(CFM) *A*	× *B*	× TC =	1.1 ×	(CFM) *A*	× *B*	× TC =	1.1 ×	(CFM) *A*	× *B*	× TC =				
Window	1.1				1.1				1.1							
Door	1.1				1.1				1.1							
Infiltration Heat Loss																
Room Heating Load																

Infiltration CFM	Column A	Column B
Windows	CFM per ft	Crack length, ft
Doors	CFM per ft^2	Area, ft^2

Figure A.1
Room heating load calculations form.

Building Heating Load Calculations Form

Building Heating Load Calculations

Project _____

Location _____ Calc. by _____

Engineers _____ Chk. by _____

	DB, F	W', gr/lb
Indoor		
Outdoor		
Diff.		

Heat Transfer	Q =	U	×	A	×	TD	=	BTU/hr
Roof								
Walls								
Windows								
Doors								
Floor								

Heat Transfer Subtotal	
Infiltration $Q_s = 1.1 \times$ _____ CFM × _____ TC =	
Building Net Load	
Ventilation $Q_s = 1.1 \times$ _____ CFM × _____ TC =	
$Q_L = 0.68 \times$ _____ CFM × _____ gr/lb =	
Duct Heat Loss _____ %	
Duct Heat Leakage _____ %	
Piping and Pickup Allowance _____ %	
Service HW Load	
Boiler or Furnace Gross Load	

Figure A.2
Building heating load calculations form.

Commercial Cooling Load Calculations Form

COMMERCIAL COOLING LOAD CALCULATIONS

Project _____ Bldg./Room _____
Location _____ Engrs. _____ Calc. by _____ Chk. by _____

		DB F	WB F	RH %	W′ gr/lb
Design Conditions	Outdoor				
	Room				

Daily Range _____ F Ave. _____ F
Day _____ Time _____
Lat. _____

Conduction		Dir.	Color	U	A, ft² Gross	A, ft² Net	CLTD, F Table	CLTD, F Corr.	SCL BTU/hr
Glass									
Wall	Group								
Roof/ceiling									
Floor									
Partition									
Door									

Solar	Dir.	Sh.	SHGF	A	SC	CLF	
Glass							

$RSHR = \frac{RSCL}{RTCL} = \frac{RSCL}{1.1 \times (t_r - t_{sa})} = CFM_{sa}$

Lights _____ W × 3.41 × _____ BF × _____ CLF
Lights _____ W × 3.41 × _____ BF × _____ CLF
People _____ SHG × _____ n × _____ CLF
_____ LHG × _____ n
Equipment _____ _____
Equipment _____ _____
Infiltration 1.1 × _____ CFM × _____ TC
0.68 × _____ CFM × _____ gr/lb

Subtotal

SA duct gain _____
SA duct leakage _____
_____
SA fan gain (draw through) _____

Room/Building Cooling Load

SA fan gain (blow through) _____
Ventilation 1.1 × _____ CFM × _____ TC
0.68 × _____ CFM × _____ gr/lb
RA duct gain _____
RA fan gain _____

Cooling Coil Load

Pump gain _____

Refrigeration Load

LCL BTU/hr

Total CL BTU/hr

Figure A.3
Commercial cooling load calculations form.

Residential Cooling Load Calculations Form

RESIDENTIAL COOLING LOAD CALCULATIONS Project _____ Location _____ Out. DB _____ F Out. WB _____ F In. DB _____ F In. RH _____ % D.R. _____ F ACH _____

Room Name																				
Plan Size																				
Wall	D.	U	A	CLTD	BTU/hr	D.	U	A	CLTD	BTU/hr	D.	U	A	CLTD	BTU/hr	D.	U	A	CLTD	BTU/hr
Roof/ceiling																				
Floor																				
Partition																				
Door																				
Windows	D.			CLF		D.			CLF		D.			CLF		D.			CLF	
Infiltration																				
People																				
Appliances																				
RSCL																				

Room Name																				
Plan Size																				
Wall	D.	U	A	CLTD	BTU/hr	D.	U	A	CLTD	BTU/hr	D.	U	A	CLTD	BTU/hr	D.	U	A	CLTD	BTU/hr
Roof/ceiling																				
Floor																				
Partition																				
Door																				
Windows	D.			CLF		D.			CLF		D.			CLF		D.			CLF	
Infiltration																				
People																				
Appliances																				
RSCL																				

Building Total

Sum RSCL = _____

Duct gain _____ % = _____

Duct leak _____ % = _____

BSCL = _____

BTCL = _____ × BSCL = _____

Unit size = _____

NOTES:

Figure A.4
Residential cooling load calculations form.

Table A.2 Unit Equivalents (Conversion Factors)

TABLE A.2 UNIT EQUIVALENTS (CONVERSION FACTORS)

To change from one set of units to another, multiply known quantity and unit by the ratio of unit equivalents that results in the desired units.

LENGTH

U.S.: 12 in. = 1 ft = 0.333 yd
metric: 1 m = 100 cm
= 1000 mm = 10^{-3}
km = 10^6 microns
U.S.—metric: 1 ft = 0.30 m
SI unit is the m

AREA

U.S.: 144 in.^{2} = 1 ft^2
U.S.—metric: 1 ft^2 = 0.093 m^2
SI unit is the m^2

VOLUME

U.S.: 1728 in.^{3} = 1 ft^3 = 7.48 gal
U.S.—metric: 1 ft^3 = 0.0283 m^3
SI unit is the m^3

MASS

U.S.: 1 lb = 16 oz = 7000 gr
metric: 1 kg = 1000 g
U.S.—metric: 2.2 lb = 1 kg
SI unit is the kg

FORCE

U.S.—metric: 1 lb = 4.45 N
SI unit is the N

VELOCITY

U.S.: 1 ft/sec = 0.68 mi/hr
SI unit is the m/sec

DENSITY

U.S.—metric: 1 lb/ft^3 = 16.0 kg/m^3
SI unit is the kg/m^3

PRESSURE

U.S.: 1 psi = 2.3 ft w. = 2.04 in. Hg
metric: 1 atm = 101,300 N/m^3
1 mm Hg = 133.3 Pa
U.S.—metric: 14.7 psi = 1 atm
SI unit is the N/m^2 (Pa)

TEMPERATURE

U.S.: F = R − 460
metric: C = K − 273
U.S.—metric: F = (9 / 5) C + 32
C = 5 / 9(F − 32)
SI unit is the K

ENERGY

U.S.: 1 BTU = 778 ft-lb
metric: 1 J = 1 W-sec = 0.239 cal
U.S.—metric: 1 BTU = 1055 J = 252 cal
SI unit is the J

POWER (RATE OF ENERGY)

2545 BTU/hr = 1 hp = 0.746 KW
= 33,000 ft-lb/min
3410 BTU/hr =1 KW
1 ton of refrigeration = 12,000 BTU/hr
= 4.72 HP = 3.52 KW
SI unit is the W

SPECIFIC HEAT

U.S.—metric: 1 BTU/lb-F = 1 cal/gm C
= 4.2 kJ/kg C

HEAT TRANSFER COEFFICIENT U

U.S.—metric: 1 BTU/hr-ft^2-F = 5.68 W/m^2 C

VOLUME FLOW RATE

U.S.—metric: 1 CFM = 1.70 m^3/hr

APPROXIMATE EQUIVALENTS FOR WATER ONLY (AT 60°F)

Density: 8.33 lb = 1 gal
62.4 lb = 1 ft^3
Flow rate: 1 GPM = 500 lb/hr

Table A.3 Properties of Saturated Steam and Saturated Water

TABLE A.3 PROPERTIES OF SATURATED STEAM AND SATURATED WATER

		Temperature Table Specific vol, cu ft/lb		Enthalpy, BTU/lb					Pressure Table Specific vol, cu ft/lb		Enthalpy, BTU/lb		
Temp F	Abs press, psi	Sat liquid v_f	Sat vapor v_g	Sat liquid h_f	Evap h_{fg}	Sat vapor h_g	Abs press, psi	Temp, F	Sat liquid v_f	Sat vapor v_g	Sat liquid h_f	Evap h_{fg}	Sat vapor h_g
32	0.08854	0.01602	3306	0.00	1075.8	1075.8	0.50	79.58	0.01608	641.4	47.6	1048.8	1096.4
35	0.09995	0.01602	2947	3.02	1074.1	1077.1	1.0	101.74	0.01614	333.6	69.7	1036.3	1106.0
40	0.12170	0.01602	2444	8.05	1071.3	1079.3	2.0	126.08	0.01623	173.73	94.0	1022.2	1116.2
45	0.14752	0.01602	2036.4	13.06	1068.4	1081.5	3.0	141.48	0.01630	118.71	109.4	1013.2	1122.6
50	0.17811	0.01603	1703.2	18.07	1065.6	1083.7	4.0	152.97	0.01636	90.63	120.9	1006.4	1127.3
55	0.2141	0.01603	1430.7	23.07	1062.7	1085.8	5.0	162.24	0.01640	73.52	130.1	1001.0	1131.1
60	0.2563	0.01604	1206.7	28.06	1059.9	1088.0	6.0	170.06	0.01645	61.98	138.0	996.2	1134.2
65	0.3056	0.01605	1021.4	33.05	1057.1	1090.2	7.0	176.85	0.01649	53.64	144.8	992.1	1136.9
70	0.3631	0.01606	867.9	38.04	1054.3	1092.3	8.0	182.86	0.01653	47.34	150.8	988.5	1139.3
75	0.4298	0.01607	740.0	43.03	1051.5	1094.5	9.0	188.28	0.01656	42.40	156.2	985.2	1141.4
80	0.5069	0.01608	633.1	48.02	1048.6	1096.6	10	193.21	0.01659	38.42	161.2	982.1	1143.3
85	0.5959	0.01609	543.5	53.00	1045.8	1098.8	14.7	212.00	0.01672	26.80	180.0	970.4	1150.4
90	0.6982	0.01610	468.0	57.99	1042.9	1100.9	20	227.96	0.01683	20.089	196.2	960.1	1156.3
95	0.8153	0.01612	404.3	62.98	1040.1	1103.1	25	240.07	0.01692	16.303	208.5	952.1	1160.6
100	0.9492	0.01613	350.4	67.97	1037.2	1105.2	30	250.33	0.01701	13.746	218.8	945.3	1164.1
105	1.1016	0.01615	304.5	72.95	1034.3	1107.3	40	267.25	0.01715	10.498	236.0	933.7	1169.7
110	1.2748	0.01617	265.4	77.94	1031.6	1109.5	50	281.01	0.01727	8.515	250.1	924.0	1174.1
115	1.4709	0.01618	231.9	82.93	1028.7	1111.6	60	292.71	0.01738	7.175	262.1	915.5	1177.6
120	1.6924	0.01620	203.27	87.92	1025.8	1113.7	70	302.92	0.01748	6.206	272.6	907.9	1180.6
125	1.9420	0.01622	178.61	92.91	1022.9	1115.8	80	312.03	0.01757	5.472	282.0	901.1	1183.1
130	2.2225	0.01625	157.34	97.90	1020.0	1117.9	90	320.27	0.01766	4.896	290.6	894.7	1185.3
135	2.5370	0.01627	138.95	102.9	1017.0	1119.9	100	327.81	0.01774	4.432	298.4	888.8	1187.2
140	2.8886	0.01629	123.01	107.9	1014.1	1122.0	110	334.77	0.01782	4.049	305.7	883.2	1188.9
145	3.281	0.01632	109.15	112.9	1011.2	1124.1	120	341.25	0.01789	3.728	312.4	877.9	1190.4
150	3.718	0.01634	97.07	117.9	1008.2	1126.1	130	347.32	0.01796	3.455	318.8	872.9	1191.7
155	4.203	0.01637	86.52	122.9	1005.2	1128.1	140	353.02	0.01802	3.220	324.8	868.2	1193.0
160	4.741	0.01639	77.29	127.9	1002.3	1130.2	150	358.42	0.01809	3.015	330.5	863.6	1194.1
165	5.335	0.01642	69.19	132.9	999.3	1132.2	160	363.53	0.01815	2.834	335.9	859.2	1195.1
170	5.992	0.01645	62.06	137.9	996.3	1134.2	170	368.41	0.01822	2.675	341.1	854.9	1196.0
175	6.715	0.01648	55.78	142.9	993.3	1136.2	180	373.06	0.01827	2.532	346.1	850.8	1196.9
180	7.510	0.01651	50.23	147.9	990.2	1138.1	190	377.51	0.01833	2.404	350.8	846.8	1197.6
185	8.383	0.01654	45.31	152.9	987.2	1140.1	200	381.79	0.01839	2.288	355.4	843.0	1198.4
190	9.339	0.01657	40.96	157.9	984.1	1142.0	250	400.95	0.01865	1.8438	376.0	825.1	1201.1
200	11.526	0.01663	33.64	168.0	977.9	1145.9	300	417.33	0.01890	1.5433	393.8	809.0	1202.8
212	14.696	0.01672	26.80	180.0	970.4	1150.4	350	431.72	0.01913	1.3260	409.7	794.2	1203.9
220	17.186	0.01677	23.15	188.1	965.2	1153.4	400	444.59	0.0193	1.1613	424.0	780.5	1204.5
240	24.969	0.01692	16.323	208.3	952.2	1160.5	450	456.28	0.0195	1.0320	437.2	767.4	1204.6
260	35.429	0.01709	11.763	228.6	938.7	1167.3	500	467.01	0.0197	0.9278	449.4	755.0	1204.4
280	49.203	0.01726	8.645	249.1	924.7	1173.8	600	486.21	0.0201	0.7698	471.6	731.6	1203.2
300	67.013	0.01745	6.466	269.6	910.1	1179.7	700	503.10	0.0205	0.6554	491.5	709.7	1201.2
350	134.63	0.01799	3.342	321.6	870.7	1192.3	800	518.23	0.0209	0.5687	509.7	688.9	1198.6
400	247.31	0.01864	1.8633	375.0	826.0	1201.0	900	531.98	0.0212	0.5006	526.6	668.8	1195.4
450	422.6	0.0194	1.0993	430.1	774.5	1204.6	1000	544.61	0.0216	0.4456	542.4	649.4	1191.8
500	680.8	0.0204	0.6749	487.8	713.9	1201.7	1200	567.22	0.0223	0.3619	571.7	611.7	1183.4
550	1045.2	0.0218	0.4240	549.3	640.8	1190.0	1500	596.23	0.0235	0.2760	611.6	556.3	1167.9

Table A.4 Thermal Resistance R of Building and Insulating Materials

TABLE A.4 THERMAL RESISTANCE *R* OF BUILDING AND INSULATING MATERIALS (hr · ft^2-F/BTU)

Description		Density lb/ft^3	Resistance (*R*) Per Inch	Resistance (*R*) 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	--	0.03
Asbestos-cement board	0.25 in.	120	--	0.06
Gypsum or plaster board	0.375 in.	50	--	0.32
Gypsum or plaster board	0.5 in.	50	--	0.45
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.		--	0.94
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
INSULATING MATERIALS				
Blanket and Batt				
Mineral fiber, fibrous form processed				
from rock, slag, or glass				
approx. 2–2.75 in.		0.3–2.0	--	7
approx. 3–3.5 in.		0.3–2.0	--	11
approx. 3.50–6.5 in.		0.3–2.0	--	19
approx. 6–7 in.		0.3–2.0		22
approx. 8.5 in.		0.3–2.0		30

TABLE A.4 (Continued)

Description	Density lb/ft³	Resistance (*R*) Per Inch	Resistance (*R*) Per Listed Thickness
Board and Slabs			
Cellular glass	8.5	2.63	--
Glass fiber, organic bonded	4–9	4.00	--
Expanded rubber (rigid)	4.5	4.55	--
Expanded polystyrene extruded			
Cut cell surface	1.8	4.00	--
Expanded polystyrene extruded			
Smooth skin surface	2.2	5.00	--
Expanded polystyrene extruded			
Smooth skin surface	3.5	5.26	--
Expanded polystyrene, molded beads	1.0	3.57	--
Expanded polyurethane (*R*-11 exp.)	1.5	6.25	--
(Thickness 1 in. or greater)	2.5		
Mineral fiber with resin binder	15	3.45	--
Mineral fiberboard, wet felted			
Core or roof insulation	16–17	2.94	--
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	--
Wood shredded (cemented in preformed slabs)	22	1.67	--
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	5.0–8.0	2.70	--
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
Vermiculite, exfoliated	7.0–8.2	2.13	--
	4.0–6.0	2.27	--
Roof Insulation			
Preformed, for use above deck			1.39
Different roof insulations are available in different thicknesses to provide the design C values listed. Consult individual manufacturers for actual thickness of their material			to 8.33
MASONRY MATERIALS			
Concretes			
Cement mortar	116	0.20	--
Gypsum-fiber concrete 87.5% gypsum, 12.5% wood chips	51	0.60	--
Lightweight aggregates including expanded	120	0.19	--
shale, clay, or slate; expanded slags;	100	0.28	--
cirders; 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	

TABLE A.4 (Continued)

Description		Density lb/ft³	Resistance (*R*) Per Inch	Resistance (*R*) Per Listed Thickness
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 × 12 × 30 in. solid		--	--	1.26
3 × 12 × 30 in. 4-cell		--	--	1.35
4 × 12 × 30 in. 3-cell		--	--	1.67
PLASTERING MATERIALS				
Cement plaster, sand aggregate		116	0.20	--
Sand aggregate	0.375 in.	--	--	0.08
Sand aggregate	0.75 in.	--	--	0.15
Gypsum plaster:				
Lightweight aggregate	0.5 in.	45	--	0.32
Lightweight aggregate	0.625 in.	45	--	0.39
Lightweight aggregate on metal lath	0.75 in.	--	--	0.47
Perlite aggregate		45	0.67	--
Sand aggregate		105	0.18	--
Sand aggregate	0.5 in.	105	--	0.09
Sand aggregate	0.625 in.	105	--	0.11
Sand aggregate on metal lath	0.75 in.	--	--	0.13
Vermiculite aggregate		45	0.59	--
ROOFING				
Asbestos-cement shingles		120	--	0.21
Asphalt roll roofing		70	--	0.15
Asphalt shingles		70	--	0.44
Built-up roofing	0.375 in.	70	--	0.33
Slate	0.5 in.	--	--	0.05
Wood shingles, plain and plastic film faced		--	--	0.94

TABLE A.4 (Continued)

Description	Density lb/ft³	Resistance (*R*) Per Inch	Resistance (*R*) Per Listed Thickness
SIDING MATERIALS (on flat surface)			
Shingles			
Asbestos-cement	120	--	0.21
Wood, 16 in., 7.5 exposure	--	--	0.87
Wood, double, 16 in., 12 in. exposure	--	--	1.19
Wood, plus insul. backer board, 0.3125 in	--	--	1.40
Siding			
Asbestos-cement, 0.25 in., lapped	--	--	0.21
Asphalt roll siding	--	--	0.15
Asphalt insulting siding (0.5 in. bed.)	--	--	1.46
Wood drop, 1 x 8 in	--	--	0.79
Wood, bevel, 0.5 x 8 in., lapped	--	--	0.81
Wood, bevel, 0.75 x 10 in., lapped	--	--	1.05
Wood, plywood, 0.375 in., lapped	--	--	0.59
Wood, medium density siding, 0.4375 in	40	0.67	
Aluminum or steel, over sheathing			
Hollow-backed	--	--	0.61
Insulating-board backed nominal 0.375 in	--	--	1.82
Insulating-board backed nominal 0.375 in., foil backed			2.96
Architectural glass	--	--	0.10
WOODS			
Maple, oak, and similar hardwoods	45	0.91	--
Fir, pine, and similar softwoods	32	1.25	--
Fir, pine, and similar softwoods 0.75 in.	32	--	0.94
1.5 in.		--	1.89
2.5 in.		--	3.12
3.5 in.		--	4.35

TABLE A.5 THERMAL RESISTANCE *R* OF SURFACE AIR FILMS AND AIR SPACES (hr · ft²-F/BTU)

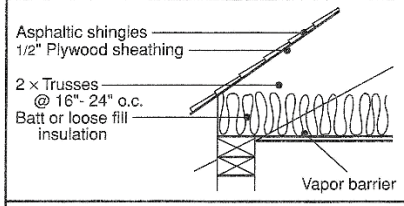
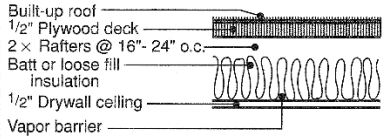
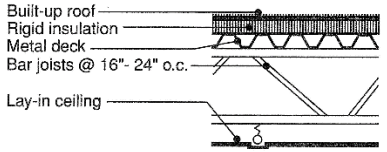
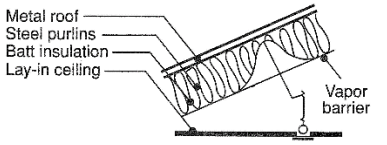
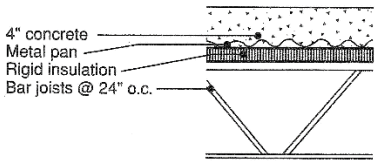
SURFACE AIR FILMS

	Direction of Heat Flow	*R*-Value
STILL AIR (interior surfaces)		
Horizontal	Upward	0.61
Sloping–45 degree	Upward	0.62
Vertical	Horizontal	0.68
Sloping–45 degree	Downward	0.76
Horizontal	Downward	0.92
MOVING AIR (exterior surfaces)		
15 mph Wind (Winter)	Any	0.17
7.5 mph Wind (Summer)	Any	0.25

AIR SPACES

Position of Air Space	Direction of Heat Flow	Thickness of Air Space ½"	¾"	1½"	3½"
		R-Value			
Horizontal	Up	0.84	0.87	0.89	0.93
45° Slope	Up	0.90	0.94	0.91	0.96
Vertical	Horizontal	0.91	1.01	1.02	1.01
Horizontal	Down	0.92	1.02	1.14	1.21
45° Slope	Down	0.92	1.02	1.09	1.05

TABLE A.6 TYPICAL BUILDING ROOF AND WALL CONSTRUCTION CROSS-SECTIONS AND OVERALL HEAT TRANSFER COEFFICIENTS, BTU/HR-FT²-F

ROOF SECTIONS	R_i	U_w
	11 19 22 30	0.08 0.05 0.04 0.03
	11 19 22 30	0.07 0.05 0.04 0.03
	No ceiling 5.5 8 11 15 Ceiling 5.5 8 11 15	 0.14 0.11 0.08 0.06 0.10 0.08 0.06 0.05
	No ceiling 3.5 8 11 19 Ceiling 3.5 8 11 19	 0.23 0.11 0.08 0.05 0.13 0.08 0.07 0.04
	No insulation 3 5.5 8 11	0.31 0.15 0.11 0.09 0.07

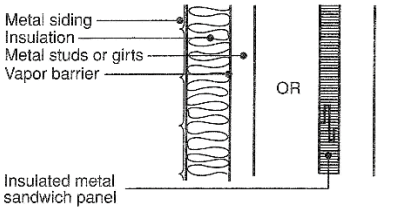
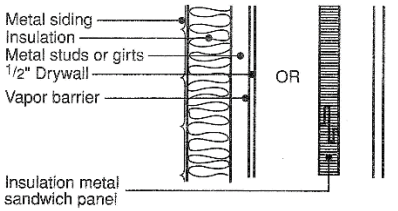
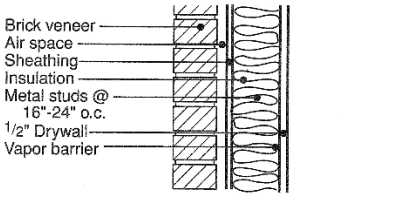
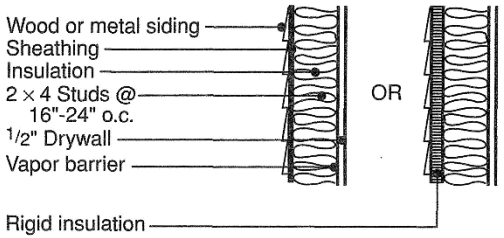
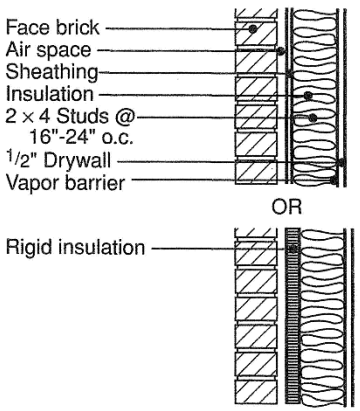
WALL SECTIONS	R_i	U_w
	3.5 8 11 19	0.23 0.11 0.08 0.05
	3.5 8 11 19	0.17 0.10 0.07 0.05
	8 11 19	0.09 0.07 0.05

TABLE A.6 (Continued)

WALL SECTIONS	R_i	U_w
	8 11 14	0.09 0.08 0.07
2 × 6 studs, same construction as above	8 11 19	0.09 0.07 0.05
	8 11 19	0.09 0.07 0.06
2 × 6 studs, same construction as above	8 11 19	0.08 0.07 0.05

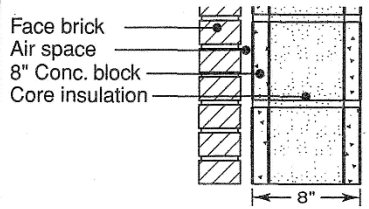
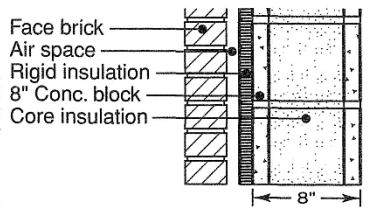
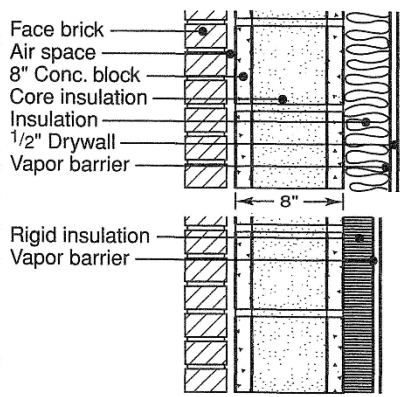
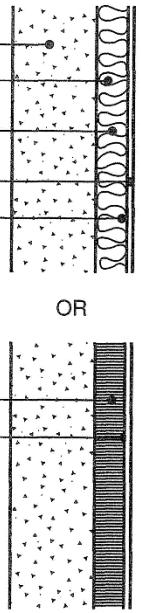
WALL SECTIONS	DENSITY	R_i	U_w
	Conc. Block 80#/cu ft	no insulation core insulation	0.23 0.12
	Conc. Block 120#/cu ft	no insulation core insulation	0.27 0.16
	Conc. Block 80#/cu ft	Core insulation and R_i 3 5.5 8 11	 0.09 0.07 0.06 0.05
	Conc. Block 120#/cu ft	Core insulation and R_i 3 5.5 8 11	 0.11 0.09 0.07 0.06
	Conc. Block 80#/cu ft	Core insulation and R_i 3.5 (1 × 2 @ 16" o.c.) 5.5 8 (2 × 3 @ 16" o.c.)	 0.08 0.07 0.06
	Conc. Block 120#/cu ft	Core insulation and R_i 3.5 (1 × 2 @ 16" o.c.) 5.5 8 (2 × 3 @ 16" o.c.)	 0.10 0.08 0.07

TABLE A.6 (Continued)

WALL SECTIONS	DENSITY	*W*	R_i	U_w
Concrete 	80#/cu ft	6"	—	0.31
		8"	—	0.25
		12"	—	0.18
	120#/cu ft	6"	—	0.50
		8"	—	0.42
		12"	—	0.32
Concrete Insulation Metal furring/studs @ 16" to 24" o.c. 1/2" Drywall Vapor barrier OR Rigid insulation Vapor barrier 	80#/cu ft	6"	3	0.15
			5.5	0.11
			8	0.09
			11	0.07
		8"	3	0.13
			5.5	0.10
			8	0.08
			11	0.06
		12"	3	0.11
			5.5	0.09
			8	0.07
			11	0.06
	120#/cu ft	6"	3	0.18
			5.5	0.13
			8	0.10
			11	0.07
		8"	3	0.17
			5.5	0.12
			8	0.09
			11	0.07
		12"	3	0.15
			5.5	0.11
			8	0.09
			11	0.07

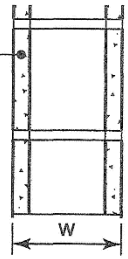
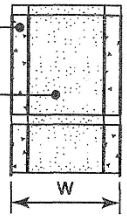
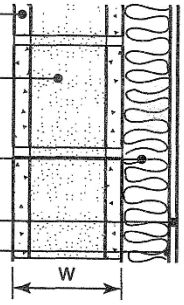
WALL SECTIONS	DENSITY	*W*	R_i	U_w
Concrete block 	Conc. Block 80#/cu ft	6"	—	.37
		8"	—	.34
		12"	—	.29
	Conc. Block 120#/cu ft	6"	—	.47
		8"	—	.43
		12"	—	.38
Concrete block Core insulation 	Conc. Block 80#/cu ft	6"	—	.18
		8"	—	.14
		12"	—	.10
	Conc. Block 120#/cu ft	6"	—	.26
		8"	—	.22
		12"	—	.17
Concrete block Core insulation Batt or rigid insulation 1/2" Drywall Vapor barrier 	Conc. Block 80#/cu ft	6"	3.5	.11
			5.5	.09
			8	.07
		8"	3.5	.09
			5.5	.08
			8	.05
		12"	3.5	.07
			5.5	.06
			8	.05
	Conc. Block 120#/cu ft	6"	3.5	.13
			5.5	.10
			8	.08
		8"	3.5	.12
			5.5	.09
			8	.06
		12"	3.5	.10
			5.5	.08
			8	.06

TABLE A.7 OVERALL HEAT TRANSFER COEFFICIENT *U* FOR BUILDING CONSTRUCTION COMPONENTS, BTU/HR-FT^2-F

Construction	*U*-Value in BTU/hr-ft^2-F	
	Summer	Winter
WALLS		
Frame with wood siding, sheathing, and inside finish:		
No insulation	.22	.23
R-7 insulation (2 in.–2½ in.)	.09	.09
R-11 insulation (3 in.–3½ in.)	.07	.07
Frame with 4 in. brick or stone veneer, sheathing, and inside finish:		
No insulation	.24	.24
R-7 insulation	.09	.09
R-11 insulation	.07	.07
Frame with 1 in. stucco, sheathing, and inside finish:		
No insulation	.29	.29
R-7 insulation	.10	.10
R-11 insulation	.07	.07
Masonry:		
8 in. concrete block, no finish	.49	.51
12 in. concrete block, no finish	.45	.47
Masonry (8 in. concrete block):		
Inside finish:		
furred gypsum wallboard (½ in.); no insulation	.29	.30
furred, foil-backed gypsum wallboard (½ in.); no insulation	.29	.30
1 in. polystyrene insulation board (*R*-5), and ½ in. gypsum wallboard	.13	.13
Masonry (8 in. cinder block or hollow clay tile):		
Inside finish:		
furred gypsum wallboard (½ in.); no insulation	.25	.25
furred, foil-backed gypsum wallboard (½ in.); no insulation	.17	.17
1 in. polystyrene insulation board (*R*-5), and ½ in. gypsum wallboard	.12	.12
Masonry (4 in. face brick and 8 in. cinder block or 8 in. hollow clay tile):		
Inside finish:		
furred gypsum wallboard (½ in.); no insulation	.22	.22
furred, foil-backed gypsum wallboard (½ in.); no insulation	.15	.16
1 in. polystyrene insulation board (*R*-5), and ½ in. gypsum wallboard	.12	.12
Masonry (12 in. hollow clay tile or 12 in. cinder block):		
Inside finish:		
furred gypsum wallboard (½ in.); no insulation	.24	.24
furred, foil-backed gypsum wallboard (½ in.); no insulation	.16	.17
1 in. polystyrene insulation board (*R*-5), and ½ in. gypsum wallboard	.12	.12
Masonry (4 in. face brick, 4 in. common brick):		
Inside finish:		
furred gypsum wallboard (½ in.); no insulation	.28	.28
furred, foil-backed gypsum wallboard (½ in.); no insulation	.18	.19
1 in. polystyrene insulation board (*R*-5), and ½ in. gypsum wallboard	.13	.13
Masonry (8 in. concrete or 8 in. stone):		
Inside finish:		
furred gypsum wallboard (½ in.); no insulation	.33	.34
furred, foil-backed gypsum wallboard (½ in.); no insulation	.21	.21
1 in. polystyrene insulation board (*R*-5), and ½ in. gypsum wallboard	.14	.14
Metal with vinyl inside finish, *R*-7 (3 in. glass fiber batt)	.14	.14
PARTITIONS		
Frame (½ in. gypsum wallboard one side only): No insulation	.55	.55
Frame (½ in. gypsum wallboard each side):		
No insulation	.31	.31
R-11 insulation	.08	.08
Masonry (4 in. cinder block):		
No insulation, no finish	.40	.40
No insulation, one side furred gypsum wallboard (½ in.)	.26	.26
No insulation, both sides furred gypsum wallboard (½ in.)	.19	.19
One side 1 in. polystyrene insulation board (*R*-5), and ½ in. gypsum wallboard	.13	.13

TABLE A.7 (Continued)

Construction	*U*-Value in BTU/hr-ft²-F	
	Summer	Winter
CEILING–FLOOR		
Frame (asphalt tile floor, ⅝ in. plywood, 25/32 in. wood subfloor, finished ceiling):		
Heat flow up	.23	.23
Heat flow down	.20	.19
Concrete (asphalt tile floor, 4 in. concrete deck, air space, finished ceiling):		
Heat flow up	.34	.33
Heat flow down	.26	.25
ROOF (flat roof, no finished ceiling)		
Steel deck:		
No insulation	.64	.86
1 in. insulation (*R*-2.78)	.23	.25
2 in. insulation (*R*-5.56)	.15	.16
1 in. Wood deck:		
No insulation	.40	.48
1 in. insulation (*R*-2.78)	.19	.21
2 in. insulation (*R*-5.56)	.12	.13
2.5 in. Wood deck:		
No insulation	.25	.26
1 in. insulation (*R*-2.78)	.15	.16
2 in. insulation (*R*-5.56)	.10	.11
4 in. Wood deck:		
No insulation	.17	.18
1 in. insulation (*R*-2.78)	.12	.12
2 in. insulation (*R*-5.56)	.09	.09
ROOF–CEILING (flat roof, finished ceiling)		
Steel deck:		
No insulation	.33	.40
1 in. insulation (*R*-2.78)	.17	.19
2 in. insulation (*R*-5.56)	.12	.13
1 in. Wood deck:		
No insulation	.26	.29
1 in. insulation (*R*-2.78)	.15	.16
2 in. insulation (*R*-5.56)	.11	.11
2.5 in. Wood deck:		
No insulation	.18	.20
1 in. insulation (*R*-2.78)	.12	.13
2 in. insulation (*R*-5.56)	.09	.10
4 in. Wood deck:		
No insulation	.14	.15
1 in. insulation (*R*-2.78)	.10	.10
2 in. insulation (*R*-5.56)	.08	.08
4 in. Lightweight concrete deck:		
No insulation	.14	.15
6 in. Lightweight concrete deck:		
No insulation	.10	.11
8 in. Lightweight concrete deck:		
No insulation	.08	.09
2 in. Heavyweight concrete deck:		
No insulation	.32	.38
1 in. insulation (*R*-2.78)	.17	.19
2 in. insulation (*R*-5.56)	.11	.12
4 in. Heavyweight concrete deck:		
No insulation	.30	.36
1 in. insulation (*R*-2.78)	.16	.18
2 in. insulation (*R*-5.56)	.11	.12
6 in. Heavyweight concrete deck:		
No insulation	.28	.33
1 in. insulation (*R*-2.78)	.16	.17
2 in. insulation (*R*-5.56)	.11	.12

TABLE A.7 (Continued)

Construction	*U*-Value in BTU/hr-ft^2-F	
	Summer	Winter
ROOF–CEILING (wood frame pitched roof, finished ceiling on rafters)		
No insulation	.28	.29
R-19 insulation (5½ in.–6½ in.)	.05	.05
ROOF–ATTIC–CEILING (attic with natural ventilation)		
No insulation	.15	.29
R-19 insulation (5½ in.–6½ in.)	.04	.05
FLOORS		
Floor over unconditioned space, no ceiling:		
Wood frame:		
No insulation	.33	.27
R-7 insulation (2 in.–2½ in.)	.09	.08
Concrete deck:		
No insulation	.59	.43
R-7 insulation	.10	.09
DOORS		
Solid wood:		
1 in. thick	.61	.64
1½ in. thick	.47	.49
2 in. thick	.42.	.43
Steel:		
1½ in. thick, mineral fiber core	.58	.59
1½ in. thick, polystyrene core	.46	.47
1½ in. thick, urethane foam core	.39	.40

TABLE A.8 OVERALL HEAT TRANSFER COEFFICIENT *U* FOR GLASS (BTU/HR-FT^2-F) (For glass installed vertically)

Type of Glazing	Type of Frame (Sash)			
	Aluminum (with thermal break)		Wood or Vinyl	
	Winter	Summer	Winter	Summer
Single glass	1.10	1.01	0.98	0.90
Double glass				
⅜ in. air space	0.60	0.56	0.51	0.47
⅜ in. air space E-film	0.48	0.45	0.39	0.37
Triple Glass				
⅜ in. air space	0.46	0.43	0.38	0.36
⅜ in. argon space	0.34	0.33	0.25	0.24

Note: E-film is a reflective coating (E = 0.15).
Abridged with permission from the *1993 ASHRAE Handbook—Fundamentals.*

TABLE A.9 OUTDOOR DESIGN CONDITIONS HEATING AND COOLING—UNITED STATES

		Heating		Cooling				
Location	LAT	Degree Days	DB	DB	MWB	WB	MDB	DR
ALABAMA								
Birmingham	34	2551	18	94	75	77	88	19
Mobile	31	1560	26	94	77	79	89	17
Montgomery	32	2291	24	95	76	79	91	19
ALASKA								
Anchorage	61	10864	-14	71	59	60	69	13
Fairbanks	65	14279	-47	81	61	63	77	19
Juneau	58	9075	4	74	60	61	71	14
ARIZONA								
Flagstaff	35	7152	1	85	56	61	74	28
Phoenix	34	1765	34	110	70	76	97	23
Tucson	32	1800	31	104	65	72	88	29
ARKANSAS								
Fort Smith	35	3292	13	99	76	79	92	22
Little Rock	35	3219	16	97	77	80	92	20
CALIFORNIA								
Bakersfield	35	2122	32	104	70	73	98	27
Los Angeles	34	2061	43	85	64	70	78	11
Sacramento	39	2502	31	100	69	72	96	33
San Diego	33	1458	44	85	67	73	79	9
San Francisco	38	3015	37	83	63	64	69	17
San Jose	37		35	93	67	70	88	22
DISTRICT OF COLUMBIA								
Washington, DC	39	4224	15	95	76	79	89	17
COLORADO								
Denver	40	5524	-3	93	60	65	81	27
CONNECTICUT								
Bridgeport	41	5617	8	86	73	76	83	14
Hartford	42	6235	2	91	73	76	87	21
DELAWARE								
Wilmington	40	4930	10	91	75	78	87	17
FLORIDA								
Jacksonville	31	1239	29	94	77	80	90	18
Miami	26	214	46	91	77	80	87	11
Orlando	28	766	37	94	76	79	88	17
Tampa	28	683	36	92	77	80	88	15
GEORGIA								
Atlanta	34	2961	18	93	75	77	88	17
Savannah	32	1819	26	95	77	79	90	18
HAWAII								
Honolulu	21	0	61	89	73	76	84	12
IDAHO								
Boise	44	5809	2	96	63	66	90	30
ILLINOIS								
Chicago	42	6639	-6	91	74	77	88	20
Springfield	40	5429	-4	93	76	79	89	19

TABLE A.9 (Continued)

Location	LAT	Heating Degree Days	Heating DB	Cooling DB	Cooling MWB	Cooling WB	Cooling MDB	Cooling DR
INDIA								
Bombay	19N		64	93	74	81	88	9
Calcutta	23N		56	97	79	84	92	18
New Delhi	29N		46	105	72	82	91	22
INDIANA								
Fort Wayne	41	6205	-4	90	74	77	86	20
Indianapolis	40	5699	-3	91	75	78	88	19
Lafayette	40	6010	-5	93	75	79	89	21
South Bend	42	6439	-2	90	73	77	86	19
IOWA								
Des Moines	42	6588	-9	93	76	78	89	19
Sioux City	42	6951	-11	94	75	78	89	20
KANSAS								
Topeka	39	5182	-2	96	75	79	90	20
Wichita	38	4620	2	100	73	77	91	22
KENTUCKY								
Lexington	38	4683	4	91	74	77	87	18
Louisville	38	4660	6	93	76	78	90	18
LOUISIANA								
Baton Rouge	31	1560	27	94	78	80	89	17
New Orleans	30	1254	30	93	79	81	90	16
MAINE								
Bangor	45		-7	87	71	73	83	21
Portland	44	7511	-3	86	71	74	83	19
MARYLAND								
Baltimore	39	4654	11	93	75	78	88	19
MASSACHUSETTS								
Boston	42	5634	7	91	73	75	87	15
Worcester	42	6969	0	85	71	74	82	17
MICHIGAN								
Detroit	42	6232	0	90	73	76	86	20
Flint	44	7377	-2	88	73	75	84	21
Lansing	43	6909	-3	89	73	76	85	22
MINNESOTA								
Duluth	47		-21	84	69	72	81	20
Minneapolis	45	8382	-16	91	73	76	88	19
MISSISSIPPI								
Jackson	32	2239	21	95	77	80	90	19
MISSOURI								
Kansas City	39	4711	-1	96	75	78	90	19
St. Louis	39	4484	2	85	76	79	90	18
MONTANA								
Billings	46	7049	-13	93	63	65	86	26
Great Falls	47	7750	-19	92	61	64	84	27
NEBRASKA								
Lincoln	41	5864	-7	97	74	78	90	22
Omaha	41	6612	-7	95	75	78	90	20

TABLE A.9 (Continued)

Location	LAT	Heating Degree Days	Heating DB	Cooling DB	Cooling MWB	Cooling WB	Cooling MDB	Cooling DR
NEVADA								
Las Vegas	36	2709	27	108	66	71	95	25
Reno	40	6332	8	95	61	63	87	37
NEW HAMPSHIRE								
Concord	43	7383	-8	90	71	74	85	24
NEW JERSEY								
Newark	41	4589	10	93	74	77	88	16
Trenton	40	4980	11	93	75	78	89	19
NEW MEXICO								
Albuquerque	35	4348	13	96	60	65	83	25
NEW YORK								
Albany	43	6875	-7	90	71	74	85	24
Buffalo	43	7062	2	86	70	74	82	18
NYC	41	4871	11	91	74	76	86	14
NORTH CAROLINA								
Charlotte	35	3191	18	94	74	77	88	18
Raleigh	36	3393	16	93	76	78	88	19
NORTH DAKOTA								
Bismarck	47	8851	-21	93	68	72	86	27
Fargo	47	9226	-22	91	71	75	86	22
OHIO								
Cincinnati	39	4410	5	93	74	77	89	20
Cleveland	41	6351	1	89	73	76	85	19
Columbus	40	5211	1	90	74	77	87	19
OKLAHOMA								
Oklahoma City	35	3725	9	99	74	77	91	21
Tulsa	36	3860	9	100	76	79	92	20
OREGON								
Eugene	44	4726	21	91	67	69	87	28
Portland	46	4635	22	90	67	69	87	22
PENNSYLVANIA								
Philadelphia	40	4486	10	93	75	78	89	19
Pittsburgh	40	5053	4	90	72	75	89	18
PUERTO RICO								
San Juan	18	0	69	92	77	81	88	12
RHODE ISLAND								
Providence	42	5954	5	89	73	76	85	17
SOUTH CAROLINA								
Charleston	33	1794	25	94	78	80	90	16
Columbia	34	2484	21	96	76	78	90	20
SOUTH DAKOTA								
Sioux Falls	44	7839	-16	94	73	76	89	22
TENNESSEE								
Memphis	35	3015	16	96	78	77	80	17
Nashville	36	3578	10	94	76	74	78	19

TABLE A.9 (Continued)

Location	LAT	Heating		Cooling				
		Degree Days	DB	DB	MWB	WB	MDB	DR
TEXAS								
Dallas	33	2363	17	100	74	78	92	20
Houston	30	1278	27	96	77	80	99	18
San Antonio	30	1546	26	98	73	78	87	19
UTAH								
Salt Lake City	37	6052	6	96	62	66	85	28
VERMONT								
Burlington	45	8269	-11	87	71	74	83	20
VIRGINIA								
Norfolk	37	3421	20	93	77	79	89	15
Richmond	38	3865	14	94	76	79	90	19
WASHINGTON								
Seattle	47	4424	1	85	65	66	83	18
Spokane	48	6655	3	92	62	65	86	26
WEST VIRGINIA								
Charleston	38	4476	6	91	73	76	86	19
WISCONSIN								
La Crosse	44	7589	-13	91	74	77	87	20
Milwaukee	43	7635	-7	89	74	76	86	17
WYOMING								
Cheyenne	41	7381	-7	87	58	62	77	26

Lat. = latitude
DB = dry bulb temperature, F
MWB = mean coincident wet bulb temperature, F
MDB = mean coincident dry bulb temperature, F
DR = mean daily range of DB temperature, F
Abridged with permission from the *1997 ASHRAE Handbook—Fundamentals.*

TABLE A.9 OUTDOOR HEATING AND COOLING DESIGN CONDITIONS—CANADA

		Heating		Cooling				
Location, USA	LAT	Degree Days	DB	DB	MWB	WB	MDB	DR
ALBERTA								
Calgary	51	9703	-22	83	60	62	78	22
Edmonton	53	10268	-28	82	63	66	77	22
BRITISH COLUMBIA								
Vancouver	49	5515	18	76	65	66	75	14
Victoria	49	5579	23	79	63	64	77	18
MANITOBA								
Winnipeg	50	10679	-27	87	68	72	82	21
NEW BRUNSWICK								
Fredricton	46	8671	-12	86	69	72	82	21
NOVA SCOTIA								
Halifax	45	7361	-2	80	68	70	77	17
ONTARIO								
Ottawa	45	8735	-13	86	70	73	82	19
Toronto	44	6827	-4	87	71	74	83	20
QUEBEC								
Montreal	46	7899	-16	84	71	73	81	20
Quebec City	47	8937	-16	84	70	73	80	19
SASKATCHEWAN								
Regina	50	10806	-29	89	64	68	82	24

Lat. = latitude
DB = dry bulb temperature, F
MWB = mean coincident wet bulb temperature, F
MDB = mean coincident dry bulb temperature, F
DR = mean daily range of DB temperature, F
Abridged with permission from the *1997 ASHRAE Handbook—Fundamentals.*

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Lat: **16.77N** Long: **96.17E** Elev: **108** StdP: **14.64** Time Zone: **6.5 (MYR)** Period: **90-10** WBAN: **99999**

Annual Heating and Humidification Design Conditions

	Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB		
				99.6%			99%			0.4%		1%				
		99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	
(1)	**1**	**63.1**	**65.3**	**53.4**	**60.9**	**85.0**	**55.9**	**66.9**	**81.7**	**12.2**	**83.0**	**11.1**	**81.1**	**3.0**	**0**	(1)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

	Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB		
			0.4%		1%		2%		0.4%		1%		2%				
			DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(2)	**4**	**20.8**	**100.6**	**78.6**	**98.7**	**77.8**	**96.8**	**77.1**	**83.3**	**92.0**	**82.4**	**90.4**	**81.5**	**88.7**	**6.6**	**270**	(2)

Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Hours 8 to 4 & 55/69	
0.4%			1%			2%			0.4%		1%		2%			
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB		
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(3) **81.0**	**161.7**	**86.2**	**80.8**	**160.4**	**85.5**	**80.4**	**158.3**	**84.7**	**47.3**	**92.3**	**46.4**	**89.1**	**45.4**	**88.7**	**43**	(3)

Extreme Annual Design Conditions

Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB								
				Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years		
1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(4) **12.2**	**11.4**	**10.1**	**92.8**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	(4)

Monthly Climatic Design Conditions

				Annual (d)	Jan (e)	Feb (f)	Mar (g)	Apr (h)	May (i)	Jun (j)	Jul (k)	Aug (l)	Sep (m)	Oct (n)	Nov (o)	Dec (p)	
(5)	Temperatures, Degree-Days and Degree-Hours	Tavg		**82.1**	**78.1**	**81.3**	**85.0**	**88.3**	**84.2**	**81.2**	**81.0**	**80.7**	**81.6**	**83.2**	**82.1**	**79.0**	(5)
(6)		Sd			**2.76**	**2.58**	**2.02**	**2.36**	**3.87**	**2.07**	**2.27**	**2.15**	**2.21**	**1.98**	**2.56**	**2.78**	(6)
(7)		HDD50		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	(7)
(8)		HDD65		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	(8)
(9)		CDD50		**11732**	**872**	**876**	**1085**	**1149**	**1062**	**937**	**960**	**952**	**948**	**1029**	**962**	**900**	(9)
(10)		CDD65		**6257**	**407**	**456**	**620**	**699**	**597**	**487**	**495**	**487**	**498**	**564**	**512**	**435**	(10)
(11)		CDH74		**65446**	**3828**	**4857**	**7362**	**9330**	**6647**	**4492**	**4462**	**4252**	**4755**	**6078**	**5330**	**4053**	(11)
(12)		CDH80		**26909**	**1733**	**2529**	**3937**	**5279**	**2865**	**1128**	**1054**	**929**	**1315**	**2229**	**2226**	**1685**	(12)
(13)	Precipitation	PrecAvg		**94.2**	**0.1**	**0.1**	**2.0**	**2.0**	**13.7**	**18.8**	**17.8**	**20.2**	**10.8**	**6.1**	**1.7**	**0.9**	(13)
(14)		PrecMax		**130.9**	**3.7**	**2.7**	**4.1**	**3.3**	**21.9**	**36.4**	**34.8**	**33.2**	**25.3**	**15.8**	**12.5**	**1.9**	(14)
(15)		PrecMin		**89.3**	**0.0**	**0.0**	**0.0**	**0.0**	**2.2**	**13.5**	**16.1**	**14.7**	**6.1**	**3.3**	**0.1**	**0.0**	(15)
(16)		PrecSD		**11.0**	**0.6**	**0.4**	**0.7**	**0.7**	**4.3**	**4.9**	**4.5**	**4.5**	**4.0**	**2.9**	**3.1**	**0.4**	(16)
(17)	Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	0.4%	DB		**94.6**	**98.3**	**100.5**	**103.9**	**102.5**	**91.4**	**91.6**	**91.0**	**91.7**	**93.3**	**94.9**	**93.4**	(17)
(18)			MCWB		**72.6**	**74.1**	**77.2**	**78.1**	**80.5**	**81.4**	**80.3**	**80.5**	**80.5**	**79.9**	**78.8**	**76.4**	(18)
(19)		2%	DB		**92.4**	**96.2**	**98.5**	**101.8**	**99.2**	**89.6**	**89.4**	**88.7**	**89.7**	**91.6**	**93.0**	**91.6**	(19)
(20)			MCWB		**72.1**	**73.6**	**75.4**	**77.8**	**80.6**	**81.0**	**80.6**	**80.7**	**80.6**	**79.5**	**78.0**	**75.2**	(20)
(21)		5%	DB		**91.0**	**94.6**	**96.8**	**100.1**	**96.4**	**87.8**	**87.6**	**86.4**	**88.0**	**90.5**	**91.4**	**89.8**	(21)
(22)			MCWB		**71.8**	**73.3**	**75.6**	**78.3**	**80.5**	**80.5**	**80.4**	**79.6**	**80.4**	**79.7**	**77.2**	**74.1**	(22)
(23)		10%	DB		**89.3**	**92.3**	**95.1**	**98.2**	**91.6**	**86.0**	**85.8**	**84.6**	**86.3**	**89.3**	**89.8**	**88.1**	(23)
(24)			MCWB		**71.5**	**72.6**	**75.9**	**78.2**	**80.5**	**79.5**	**79.3**	**79.3**	**79.5**	**80.0**	**77.3**	**73.2**	(24)
(25)	Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures	0.4%	WB		**78.8**	**81.0**	**83.8**	**84.3**	**84.6**	**83.0**	**82.6**	**82.6**	**82.8**	**83.5**	**82.1**	**80.3**	(25)
(26)			MCDB		**87.5**	**93.1**	**94.7**	**96.5**	**94.4**	**88.5**	**88.2**	**87.5**	**88.4**	**89.8**	**90.3**	**87.4**	(26)
(27)		2%	WB		**76.0**	**78.2**	**80.7**	**82.4**	**83.0**	**81.8**	**81.1**	**81.2**	**81.5**	**82.0**	**80.1**	**78.4**	(27)
(28)			MCDB		**86.9**	**89.3**	**93.2**	**95.1**	**92.1**	**87.0**	**85.8**	**85.6**	**86.9**	**88.6**	**88.2**	**87.5**	(28)
(29)		5%	WB		**74.4**	**76.4**	**79.4**	**81.0**	**81.9**	**80.8**	**80.4**	**80.4**	**80.5**	**80.9**	**79.4**	**76.7**	(29)
(30)			MCDB		**85.9**	**87.7**	**90.4**	**92.8**	**90.4**	**85.1**	**84.7**	**84.2**	**85.5**	**87.1**	**87.2**	**85.6**	(30)
(31)		10%	WB		**73.0**	**74.9**	**78.3**	**80.1**	**80.8**	**80.0**	**79.8**	**79.8**	**79.9**	**80.0**	**78.8**	**75.5**	(31)
(32)			MCDB		**84.7**	**86.3**	**88.4**	**91.1**	**88.5**	**83.9**	**83.7**	**83.1**	**84.3**	**85.8**	**86.2**	**83.8**	(32)
(33)	Mean Daily Temperature Range		MDBR		**23.9**	**25.0**	**22.7**	**20.8**	**13.8**	**9.6**	**9.3**	**8.9**	**9.8**	**12.2**	**16.6**	**20.6**	(33)
(34)		5% DB	MCDBR		**25.7**	**26.5**	**24.6**	**23.4**	**20.4**	**12.5**	**12.1**	**11.6**	**12.3**	**14.4**	**18.5**	**21.5**	(34)
(35)			MCWBR		**9.3**	**8.9**	**8.2**	**6.7**	**6.6**	**5.9**	**5.2**	**5.3**	**5.3**	**5.9**	**7.0**	**8.3**	(35)
(36)		5% WB	MCDBR		**22.7**	**24.4**	**21.9**	**20.6**	**15.9**	**10.8**	**10.2**	**10.1**	**10.9**	**13.2**	**16.1**	**19.6**	(36)
(37)			MCWBR		**10.2**	**10.0**	**9.0**	**6.8**	**7.3**	**5.7**	**5.3**	**5.2**	**5.2**	**5.9**	**7.1**	**9.9**	(37)
(38)	Clear Sky Solar Irradiance	taub			**0.438**	**0.466**	**0.515**	**0.566**	**0.577**	**0.522**	**0.509**	**0.516**	**0.495**	**0.492**	**0.438**	**0.427**	(38)
(39)		taud			**2.354**	**2.230**	**2.041**	**1.899**	**1.881**	**2.025**	**2.069**	**2.079**	**2.207**	**2.253**	**2.434**	**2.428**	(39)
(40)		Ebn,noon			**269**	**267**	**257**	**243**	**237**	**248**	**252**	**253**	**258**	**256**	**267**	**269**	(40)
(41)		Edh,noon			**38**	**45**	**55**	**64**	**64**	**55**	**53**	**53**	**46**	**43**	**35**	**34**	(41)

Nomenclature: See separate page

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Lat: **16.77N** Long: **96.17E** Elev: **33** StdP: **100.93** Time Zone: **6.50 (MYR)** Period: **90-10** WBAN: **99999**

Annual Heating and Humidification Design Conditions

	Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB		
				99.6%			99%			0.4%		1%				
		99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	
(1)	1	17.3	18.5	11.9	8.7	29.4	13.3	9.6	27.6	5.4	28.3	5.0	27.3	1.3	0	(1)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

	Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB		
			0.4%		1%		2%		0.4%		1%		2%				
			DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(2)	4	11.5	38.1	25.9	37.1	25.4	36.0	25.0	28.5	33.3	28.0	32.4	27.5	31.5	2.9	270	(2)

	Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Hours 8 to 4 & 12.8/20.6	
	0.4%			1%			2%			0.4%		1%		2%			
	DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB		
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(3)	27.2	23.1	30.1	27.1	22.9	29.7	26.9	22.6	29.3	92.1	33.5	89.9	31.7	87.7	31.5	43	(3)

Extreme Annual Design Conditions

	Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB								
					Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years		
	1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(4)	5.5	5.1	4.5	33.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	(4)

Monthly Climatic Design Conditions

				Annual (d)	Jan (e)	Feb (f)	Mar (g)	Apr (h)	May (i)	Jun (j)	Jul (k)	Aug (l)	Sep (m)	Oct (n)	Nov (o)	Dec (p)	
(5)	Temperatures, Degree-Days and Degree-Hours	Tavg		27.9	25.6	27.4	29.4	31.3	29.0	27.4	27.2	27.1	27.6	28.4	27.8	26.1	(5)
(6)		Sd			1.53	1.44	1.12	1.31	2.15	1.15	1.26	1.20	1.23	1.10	1.42	1.54	(6)
(7)		HDD10.0		0	0	0	0	0	0	0	0	0	0	0	0	0	(7)
(8)		HDD18.3		0	0	0	0	0	0	0	0	0	0	0	0	0	(8)
(9)		CDD10.0		6518	484	487	603	638	590	521	533	529	527	572	534	500	(9)
(10)		CDD18.3		3476	226	253	344	388	332	271	275	271	277	313	284	242	(10)
(11)		CDH23.3		36359	2127	2698	4090	5183	3693	2496	2479	2362	2642	3377	2961	2252	(11)
(12)		CDH26.7		14949	963	1405	2187	2933	1592	627	586	516	731	1238	1237	936	(12)
(13)	Precipitation	PrecAvg		2392	2	2	51	51	347	478	453	513	274	156	43	22	(13)
(14)		PrecMax		3324	93	69	103	84	556	924	884	842	643	400	318	48	(14)
(15)		PrecMin		2268	0	0	0	0	56	342	408	372	154	83	2	0	(15)
(16)		PrecSD		278.7	15.1	11.0	17.8	18.3	109.9	123.3	115.3	113.4	100.8	74.7	77.6	11.2	(16)
(17)	Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	0.4%	DB		34.8	36.8	38.1	39.9	39.2	33.0	33.1	32.8	33.2	34.1	34.9	34.1	(17)
(18)			MCWB		22.6	23.4	25.1	25.6	26.9	27.5	26.9	27.0	26.9	26.6	26.0	24.7	(18)
(19)		2%	DB		33.5	35.7	37.0	38.8	37.3	32.0	31.9	31.5	32.0	33.1	33.9	33.1	(19)
(20)			MCWB		22.3	23.1	24.1	25.4	27.0	27.2	27.0	27.0	27.0	26.4	25.5	24.0	(20)
(21)		5%	DB		32.8	34.8	36.0	37.8	35.8	31.0	30.9	30.2	31.1	32.5	33.0	32.1	(21)
(22)			MCWB		22.1	22.9	24.2	25.7	26.9	26.9	26.9	26.4	26.9	26.5	25.1	23.4	(22)
(23)		10%	DB		31.8	33.5	35.1	36.8	33.1	30.0	29.9	29.2	30.2	31.8	32.1	31.2	(23)
(24)			MCWB		22.0	22.6	24.4	25.7	26.9	26.4	26.3	26.3	26.4	26.7	25.2	22.9	(24)
(25)	Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures	0.4%	WB		26.0	27.2	28.8	29.0	29.2	28.4	28.1	28.1	28.2	28.6	27.8	26.8	(25)
(26)			MCDB		30.9	33.9	34.8	35.8	34.7	31.4	31.2	30.8	31.3	32.1	32.4	30.8	(26)
(27)		2%	WB		24.4	25.6	27.0	28.0	28.3	27.7	27.3	27.3	27.5	27.8	26.7	25.8	(27)
(28)			MCDB		30.5	31.9	34.0	35.0	33.4	30.5	29.9	29.8	30.5	31.4	31.2	30.8	(28)
(29)		5%	WB		23.5	24.7	26.3	27.2	27.7	27.1	26.9	26.9	26.9	27.1	26.4	24.8	(29)
(30)			MCDB		29.9	30.9	32.4	33.8	32.4	29.5	29.3	29.0	29.7	30.6	30.7	29.8	(30)
(31)		10%	WB		22.8	23.8	25.7	26.7	27.1	26.7	26.6	26.5	26.6	26.7	26.0	24.2	(31)
(32)			MCDB		29.3	30.2	31.3	32.9	31.4	28.8	28.7	28.4	29.1	29.9	30.1	28.8	(32)
(33)	Mean Daily Temperature Range		MDBR		13.3	13.9	12.6	11.5	7.7	5.4	5.2	4.9	5.4	6.8	9.2	11.4	(33)
(34)		5% DB	MCDBR		14.3	14.7	13.7	13.0	11.4	6.9	6.7	6.4	6.9	8.0	10.3	11.9	(34)
(35)			MCWBR		5.2	4.9	4.5	3.7	3.7	3.3	2.9	2.9	3.0	3.3	3.9	4.6	(35)
(36)		5% WB	MCDBR		12.6	13.6	12.2	11.5	8.8	6.0	5.7	5.6	6.1	7.3	9.0	10.9	(36)
(37)			MCWBR		5.7	5.6	5.0	3.8	4.1	3.2	2.9	2.9	2.9	3.3	4.0	5.5	(37)
(38)	Clear Sky Solar Irradiance	taub			0.438	0.466	0.515	0.566	0.577	0.522	0.509	0.516	0.495	0.492	0.438	0.427	(38)
(39)		taud			2.354	2.230	2.041	1.899	1.881	2.025	2.069	2.079	2.207	2.253	2.434	2.428	(39)
(40)		Ebn,noon			848	841	809	767	748	783	796	796	815	806	843	848	(40)
(41)		Edh,noon			119	141	175	202	203	174	167	167	146	136	110	109	(41)

Nomenclature: See separate page

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