

Table 7.... Summer Design Sol-Air Temperatures Used for Tables 8 and 9

Mean Sun Time	Sol-Air Temperature t_a , Fahrenheit Degrees								
	Any Surface*		North	East		South		West	
	Ratio $\frac{A_s}{A_m}$	0	0.225	0	0.225	0.125	0.225	0.125	0.225
12 Midnight		77	77	77	77	77	77	77	77
1 AM		76	76	76	76	76	76	76	76
2		76	76	76	76	76	76	76	76
3		75	75	75	75	75	75	75	75
4		74	74	74	74	74	74	74	74
5		74	74	74	74	74	74	74	74
6		74	76	74	110	93	74	74	74
7		75	91	75	123	100	75	75	75
8		77	106	77	126	103	78	77	77
9		80	119	80	125	104	80	80	80
10		83	129	83	125	104	83	83	83
11		87	137	87	108	96	89	87	87
12 Noon		90	142	90	92	92	114	104	92
1 PM		93	144	93	93	93	115	105	102
2		94	140	94	94	94	111	104	111
3		95	132	95	95	95	104	100	119
4		94	120	94	94	94	99	96	120
5		93	107	93	93	93	95	94	118
6		91	96	91	91	91	91	91	111
7		87	80	87	87	87	88	87	103
8		85	85	85	85	85	85	85	85
9		83	83	83	83	83	83	83	83
10		81	81	81	81	81	81	81	81
11		79	79	79	79	79	79	79	79
24 Hr Avg. t_a		83.1	100.5	83.1	93.0	88.4	89.0	86.2	93.0

* A_s = surface absorptivity, dimensionless, roof = 0.9; dark walls = 0.9, and light walls = 0.5. f_{ac} = unit convective conductance = 4.0 Btu per (hr) (F deg).
 * Values in this column are magnitudes of t_a , the outdoor air temperature.

Examples of Use of Equivalent Temperature Tables

Example 5: Given: A roof is constructed of 2 in. gypsum slab on $\frac{1}{2}$ in. gypsum board with 1 in. insulation covered with built-up roofing, $\frac{1}{2}$ in. thick, and exposed to the sun. The location is the central part of the United States. Find the rate of heat flow into the building at 2:00 p.m. during July for an outdoor temperature 95 F, and an indoor temperature 80 F.

Solution: From Table 8 in 2:00 p.m. column for 2 in. gypsum plus 1 in. insulation, find the total equivalent temperature differential 52 deg. The overall heat transmission coefficient for summer is taken from Table 10 and is found to be 0.17. The heat flow rate equals $52 \times 0.17 = 8.84$ Btu per (hr) (sq ft).

Example 6: For the conditions of Example 5, find the rate of heat flow into building at 2:00 p.m. during July for design temperatures of 105 F (outdoor) and 78 F (indoor). Daily range of temperature 30 deg., i.e., outdoor temperature minimum of 75 F which occurs at 4:00 or 5:00 a.m.; this being 30 deg less than the maximum.

Solution: Make correction in equivalent temperature differential in accordance with Note 5 in Table 8 as follows:

The correction for 27-deg design temperature difference is $(27 - 15) = +12$.

The correction for 30-deg daily range is $\left(-\frac{30 - 20}{2} \right) = -5$.

Net total correction is $+12 - 5 = +7$.
 The heat-flow rate at 2:00 p.m. is $(52 + 7) \times 0.17 = 10.03$ Btu per (hr) (sq ft).

A method of determining heat-flow rates, when structure is not given in Tables 8 or 9, is illustrated in Example 7.

Example 7: A 4-in. stone concrete roof covered with an average depth of 4 in. of cinder concrete ($k = 4.0$), on which is placed a $\frac{1}{2}$ -in. thick felt roof with $\frac{1}{2}$ -in. pitch and slag surface, is exposed to the sun. The location is the central part of the United States. Design temperatures are: outdoor 95 F; daily range 20 deg; indoor temperature 80 F. Find the heat-flow rate at 2:00 p.m. for a day in July.

Solution: For the purpose of selecting the equivalent temperature differential, this construction is assumed to be equal approximately to an uninsulated 6-in. concrete roof, for which the equivalent temperature is found to be 38 deg in the 2:00 p.m. column of Table 8. Calculate the overall heat transmission coefficient U (see Equation 3 of Chapter 24) of the roof as follows:

$$U = \frac{1}{\frac{1}{1.2} + \frac{4}{12} + \frac{4}{4.9} + \frac{0.375}{1.33} + \frac{0.50}{1.00} + \frac{1}{4.0}} = 0.33$$

The heat-flow rate is then 38×0.33 equals 12.5 Btu per (hr) (sq ft).

TABLES FOR PREDICTING TOTAL HEAT TRANSFER THROUGH FENESTRATION AREAS

A fenestration is any light-transmitting opening in an exterior building wall. It may be in the form of plate or sheet glass, insulating glass, glass block, pattern glass or plastic panels. Any of these may be in combination with some type of interior or exterior sun control. Some have integral sun control.

Table 8.... Total Equivalent Temperature Differentials for Calculating Heat Gain Through Sunlit and Shaded Roofs

Description of Roof Construction*	Sun Time								
	A.M.			P.M.					
	8	10	12	2	4	6	8	10	12
Light Construction Roofs—Exposed to Sun									
1" Wood ^b or 1" Wood ^b + 1" or 2" insulation	12	38	54	62	50	26	10	4	0
Medium Construction Roofs—Exposed to Sun									
2" Concrete or 2" Concrete + 1" or 2" insulation or 2" Wood ^b	6	30	48	58	50	32	14	6	2
2" Gypsum or 2" Gypsum + 1" insulation 1" Wood ^b or 2" Wood ^b or 2" Concrete or in furred ceiling 2" Gypsum	0	20	40	52	54	42	20	10	6
4" Concrete or 4" Concrete with 2" insulation	0	20	38	50	52	40	22	12	6
Heavy Construction Roofs—Exposed to Sun									
6" Concrete or 6" Concrete + 2" insulation	4	6	24	38	46	44	32	18	12
Roofs Covered with Water—Exposed to Sun									
Light construction roof with 1" water	0	4	16	22	18	14	10	2	0
Heavy construction roof with 1" water	-2	-2	4	10	14	16	14	10	6
Any roof with 6" water	-2	0	0	6	10	10	8	4	0
Roofs with Roof Sprays—Exposed to Sun									
Light construction	0	4	12	18	16	14	10	2	0
Heavy construction	-2	-2	2	8	12	14	12	10	6
Roofs in Shade									
Light construction	-4	0	6	12	14	12	8	2	0
Medium construction	-4	-2	2	8	12	12	10	6	2
Heavy construction	-2	-2	0	4	8	10	10	8	4

* Includes $\frac{1}{2}$ in. felt roofing with or without slag. May also be used for shingle roof.

^b Nominal thickness of the wood.

Notes for Table 8

$$\text{Explanation: } \left(\frac{\text{Total heat transmission from solar radiation and temperature difference between outdoor and room air, Btu per (hr) (sq ft) of roof area}}{\text{Equivalent temperature differential from above table}} \right) \times \left(\frac{\text{Heat transmission coefficient for summer, Btu per (hr) (sq ft) (F deg)}}{\text{Heat transmission coefficient for summer, Btu per (hr) (sq ft) (F deg)}} \right)$$

1. Source: Calculated by Mackey and Wright method (see reference list) and adjusted after studying ASHRAE original test data. Estimated for about August 1 in 40 deg north latitude. (For sol-air temperatures used in calculations see Table 7.) For typical design day where the maximum outdoor temperature is 95 F and minimum temperature at night is approximately 75 F (daily range of temperature, 20 F) mean 24 hr temperature 84 F for a room temperature of 80 F. All roofs have been assumed a dark color which absorbs 90 percent of solar radiation, and reflects only 10 percent.

2. Application: These values may be used for all normal air conditioning estimates; usually without correction, in latitude 0 deg to 90 deg north or south when the load is calculated for the hottest weather. Note 5 explains how to adjust the temperature differential for other room and outdoor temperatures.

3. Partial Roofs: If the roof is peaked and the heat gain is primarily due to solar radiation, use for the area of the roof, the area projected on a horizontal plane.

4. Attics: If the ceiling is insulated and if a fan is used in the attic for positive ventilation, the total temperature differential for a roof exposed to the sun may be decreased 15 percent.

5. Corrections: For temperature difference when outdoor maximum design temperature means room is different from 15 deg. If the outdoor design temperature minus room temperature is different from the base of 15 deg, correct as follows: When the difference is greater (or less) than 15 deg add the excess to (or subtract the deficiency from) the above differential.

For Outdoor Daily Range of Temperature other than 20 deg, correct Equivalent Temperature Difference as follows:

Outdoor Daily Range	Medium Construction	Heavy Construction
For each 1 deg difference less than 20 deg	Add 1 deg	Add 1 deg
For each 1 deg difference greater than 20 deg	Subtract 1 deg	Subtract 1 deg
Maximum Correction	5 deg	5 deg

For Light Construction, apply no correction.