

TABLE 12. PERIODIC HEAT FLOW DATA FOR HOMOGENEOUS WALLS OR ROOFS

MATERIAL	THICKNESS, IN.	OVER-ALL COEFFICIENT, BTU PER (HR) (SQ FT) (°F) U^a	THERMAL RESISTANCE OF SOLID MATERIAL, (HR) (SQ FT) (°F)/BTU $\frac{L}{k}$	TIME LAG, HR	FACTOR, λ , IN EQUATION 5			
					Horizontal and North	East	South	West
Stone	8	0.67	0.64	5.5	0.51	0.36	0.48	0.42
	12	0.55	0.96	8.0	0.28	0.19	0.26	0.22
	16	0.47	1.28	10.5	0.17	0.10	0.15	0.13
	24	0.36	1.92	15.5	0.06	0.03	0.05	0.04
Solid Concrete	2	0.98	0.17	1.1	0.93	0.87	0.92	0.89
	4	0.84	0.33	2.5	0.79	0.68	0.76	0.72
	6	0.74	0.50	3.8	0.61	0.48	0.58	0.51
	8	0.66	0.67	5.1	0.49	0.33	0.46	0.39
	12	0.54	1.00	7.8	0.29	0.17	0.26	0.22
Common Brick	16	0.46	1.33	10.2	0.17	0.09	0.15	0.12
	4	0.60	0.80	2.3	0.83	0.75	0.81	0.78
	8	0.41	1.60	5.5	0.51	0.39	0.49	0.44
	12	0.31	2.40	8.5	0.26	0.17	0.25	0.21
Face Brick	16	0.25	3.20	12.0	0.13	0.08	0.12	0.10
	4	0.77	0.44	2.4	0.81	0.70	0.78	0.74
Wood	1/4	0.68	0.62	0.17	1.0	1.0	1.0	1.0
	1	0.48	1.25	0.45	1.0	0.99	0.99	0.99
Insulating Board	2	0.30	2.50	1.3	0.98	0.91	0.96	0.94
	1/4	0.42	1.51	0.08	1.0	1.0	1.0	1.0
	1	0.26	3.03	0.23	1.0	1.0	1.0	1.0
	2	0.14	6.05	0.77	1.0	1.0	1.0	1.0
	4	0.08	12.1	2.7	0.83	0.74	0.81	0.76
	6	0.05	18.2	5.0	0.64	0.49	0.61	0.55

^aBased upon an outdoor combined film coefficient of 4.0 and an indoor combined film coefficient of heat transfer of 1.65 Btu per (hour) (square foot) (Fahrenheit degree).

partially completed. The method reported by Mackey and Wright ⁷ will be adopted as the basis for the design procedure recommended here.

Homogeneous Walls or Roofs, Constant Indoor Temperature

For walls or roofs of a single, homogeneous material, the *instantaneous* rate of heat gain within an enclosure where the indoor air temperature is held constant is, approximately,

$$\frac{q}{A} = U(t_m - t_i) + \lambda U(t_e^* - t_m) \text{ Btu per (hour) (square foot)} \quad (7)$$

where t_m = 24-hr average sol-air temperature for the particular value of $\frac{b}{f_o}$, Fahrenheit degrees.

λ = Amplitude decrement factor, a variable that depends upon the thickness, material, and orientation of the wall or roof; see Table 12 for values.

t_e^* = Sol-air temperature at a time earlier than the time for which the heat gain is being found by an amount that is equal to the time lag of the wall or roof, Fahrenheit degrees; see Table 12 for values of time lag.

U = Over-all coefficient of heat transfer of the wall or roof, Btu per (hour) (square foot) (Fahrenheit degree),

$$\frac{1}{f_i} + \frac{1}{f_o} + \frac{L}{k} = \frac{1}{1.65} + \frac{1}{4} + \frac{L}{k} = \frac{1}{0.856 + \frac{L}{k}}$$

L = Thickness of building material, feet.

k = Thermal conductivity of building material, Btu per (hour) (square foot) (Fahrenheit degree per foot).

f_i = Film coefficient of heat transfer of indoor air Btu per (hour) (square foot) (Fahrenheit degree).

TABLE 13. APPROXIMATE TIME OF MAXIMUM RATE OF HEAT ENTRY INTO WEATHER SIDE OF WALLS OR ROOFS IN NEW YORK, N. Y., AND IN LINCOLN, NEBR. ^{a,b}

SURFACE	Horizontal roof	North wall	East wall	South wall	West wall
SUN TIME	12 noon to 1:00 p.m.	6:00 p.m.	9:00 a.m.	1:00 p.m.	4:00 p.m.

^aMid-summer; solar absorptivities of weather surface of 0.4 or greater.

^bFor a completely shaded surface, the time of maximum rate of heat entry into the weather side is the time of maximum temperature of the outdoor air, which is at approximately 3:00 p. m., sun time, in both localities.

The time at which the maximum occurs in the rate of heat entry into the *outside* surface of walls or roofs is taken as the time at which the peak point occurs in the sol-air temperature cycle (mean *sun time* is used in the sol-air cycles). Table 13 gives these time data. Adding the time lag to the time from Table 13 will give the time of the maximum rate of heat entry into the conditioned space. The corresponding maximum rate of heat entry follows from Equation 7 with t_e^* being the maximum temperature of the sol-air cycle.

An example in the use of Tables 10, 11, and 12 follows:

Example 3. Find the instantaneous design rate of heat gain through an 8-in. west wall of common brick ($b = 0.7$, $f_o = 4$) located in New York, N. Y., at 9:30 p. m. sun time, when the temperature of the indoor air is constant at 80 F.

From Table 12, $U = 0.41$, the time lag is 5.5 hr, and $\lambda = 0.44$.

By linear interpolation on the basis of the value of b/f_o in Table 10,

$$t_m = 84.8 + \frac{0.175}{0.25} (96.5 - 84.8) = 93 \text{ F.}$$

The design sol-air temperature at a time earlier than 9:30 p. m. by the time lag (at 4:00 p. m.) for a west wall in New York, N. Y., is, from Table 10,

$$t_e^* = 94 + \frac{0.175}{0.25} (145 - 94) = 129.7 \text{ F.}$$

From Equation 7, the instantaneous design rate of heat gain is

$$\frac{q}{A} = 0.41 [(93 - 80) + 0.44 (129.7 - 93)]$$

$$= 11.9 \text{ Btu per hour for each square foot of sunlit surface.}$$

From Table 12, the time lag is 5.5 hr. From Table 13, the time of maximum rate of heat entry for a west wall is 4:00 p. m. The time of maximum instantaneous rate of heat gain by the enclosure, as far as the west wall is concerned, is then 4:00 p. m. plus 5.5 hr or 9:30 p. m. (This is *sun time*.) The computed rate is therefore the maximum.

Composite Walls or Roofs, Constant Indoor Temperature

A composite wall or roof is made up of two or more layers of different materials. Since the analytical solution for this type of construction has not been reduced to simple and practical terms, it is necessary at present to utilize approximate procedures. In accord with the results of comparative calculations, the following procedures are suggested ⁷.

To find the time lag for a composite construction:

a. Find the time lag for each layer from Table 12.

b. Add the individual time lags, recognizing that this sum will always be *less* than the true time lag for the actual composite wall.

c. To the sum from (b), add an *arbitrary* additional lag of $\frac{1}{2}$ to 1 hr to obtain the estimated lag for the actual construction. For two-layer and light construction walls,