Notes for Table 8 .... Total Equivalent Temperature Differentials for Calculating Heat Gain Through Sunlit and Shaded Roofs (*Concluded*)

Light Colors. Credit should not be taken for light colored roofs except where the permanence of the light color is established by experience, as in rural areas or where there is little smoke. When the exterior surface of roof exposed to the sun is a light color, such as white or aluminum (which absorb approximately 50 percent and reflect 50 percent of the solar radiation) add to the temperature differential for roof in shade 55 percent of the difference between the roof in sun and roof in shade. When the roof exposed to the sun is a medium color such as light grey, blue or green, or bright red, add 80 percent of this difference.

For solar transmission in latitudes other than 40 deg north, and in other months. The table values of temperature differentials will be approximately correct for a roof in the following months:

North Latitude		South Latitude	
Latitude (deg)	Months	Latitude (deg)	Months
0	All months	0	All months
10	All months	10	All months
20	All months except Nov, Dec, Jan	20	All months except May, June, July
30	Mar, Apr, May, June, July, Aug, Sept	30	Sept, Oct, Nov, Dec, Jan, Feb, Mar
40	April, May, June, July, Aug	40	Oct, Nov, Dec, Jan, Feb
50	May, June, July	50	Nov, Dec, Jan

For other months, the total temperature differential (t_d) may be approximated by the use of the following formula:

$$t_e = t_s + \frac{I_s}{I_g}(t_o - t_s)$$

where

t_s = temperature differential for the same roof in shade for desired time of day; obtained from Table 8.

I_g = maximum solar transmission through glass, Btu per (hr) (sq ft) for flat skylight in Aug., 40 deg north latitude (*Note:* this is maximum value irrespective of time).

I_s = same as I_g except use the maximum value for flat skylight, for month, and latitude desired for t_o.

t_o = temperature differential for particular roof exposed to sun for the desired time of day from Table 8.

(*Note that this makes adjustment only for solar radiation and that there may be additional correction for outdoor temperature.*)

Basic Principles

A number of environmental factors affect the heat transfer through fenestration areas. These include: (1) solar radiation, (2) difference in indoor and outdoor temperatures, (3) low-temperature radiation from sky and surroundings, and (4) rate of air movement across the exterior and interior fenestration surfaces.

The solar radiation incident on any surface varies with the season, time of day, geographical location, and degree of sky contamination (clouds, dust, etc.). For design considerations the intensity of solar energy is taken as 294 Btu per (hr) (sq ft) on a horizontal surface when the sun is directly overhead. The intensity of diffuse solar energy (that portion reflected and refracted by water vapor and dust particles in the atmosphere) is taken as 29 Btu per (hr) (sq ft) on a vertical surface for the same conditions.

Heat transfer due to differences in indoor and outdoor temperatures depends not only upon the air temperatures but also upon the velocity of air movement across the surfaces and the thermal conductance of the fenestration. These latter two effects combine to produce the overall coefficient of heat transmission (U value).

The heat transfer due to low-temperature radiation from sky and surroundings (trees, buildings, etc.) is difficult to predict even for the rare case when the complete nature of the surroundings is known. For ease of predicting the instantaneous heat transfer it is assumed the surroundings are at the outdoor air temperature and the contribution to the heat transfer taken into account by an adjustment in the U value. Unless otherwise noted, U values include this adjustment.

The thermal interchanges between a glass or glass block fenestration and its surroundings are qualitatively identical for all types although interchanges within the fenestration may vary considerably. Fig. 2 shows the general instantaneous heat balance for glass or glass block. The heat balance relationship may be better understood when the following are considered:

1. Glass transmits, in varying degrees, radiation having wavelengths between 0.29 and 4.75 microns. The wavelength of the sun's radiation at the earth's surface ranges from approximately 0.30 microns to 2.50 microns. The visible portion lies between 0.40 and 0.70 microns with those wavelengths beyond 0.70 microns constituting the infra-red radiation and those below 0.40 microns the ultra-violet radiation. Approximately one-half of the sun's energy is in the visible range and one-half in the infra-red range with a negligibly small portion in the ultra-violet. The percentage of each wavelength transmitted by glass is dependent upon the chemical and physical characteristics of the glass, and upon the angle of incidence of the radiant energy. Of the energy not transmitted, part is absorbed and part reflected.
2. Glass is opaque to radiant energy emitted from sources below 450 F.
3. Because of the above principles, it is convenient to group radiant energy into two classifications, solar radiant energy and low temperature radiant energy.

The total instantaneous heat balance may be expressed in simple terms as follows:

$$\begin{bmatrix}\text{Total heat transfer}\\ \text{through the glass}\end{bmatrix} = \begin{bmatrix}\text{Transmitted}\\ \text{solar radiation}\end{bmatrix} + \begin{bmatrix}\text{Heat gain due to}\\ \text{absorbed solar}\\ \text{radiation}\end{bmatrix} + \begin{bmatrix}\text{Heat transfer due to}\\ \text{differences in outdoor and}\\ \text{indoor air temperatures}\end{bmatrix}$$

This may be further simplified to the following form:

$$\begin{bmatrix}\text{Total heat transfer}\\ \text{through the glass}\end{bmatrix} = \begin{bmatrix}\text{Total solar}\\ \text{heat gain}\end{bmatrix} + \begin{bmatrix}\text{Heat transfer due to}\\ \text{differences in outdoor}\\ \text{and indoor air temperatures}\end{bmatrix}$$

Symbolically this may be written as follows:

$$[q/A] = [F_D I_D + F_d I_d] + [U(t_o - t_i)] \qquad (2)$$

Table 9 .... Total Equivalent Temperature Differentials for Calculating Heat Gain Through Sunlit and Shaded Walls

North Latitude Wall Facing	Sun Time: A.M. 8		A.M. 10		A.M. 12		P.M. 2		P.M. 4		P.M. 6		P.M. 8		P.M. 10		P.M. 12		South Latitude Wall Facing
	Exterior color of wall—D = dark, L = light																		
	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	
	Frame																		
NE	22	10	24	12	14	10	12	10	14	14	14	14	10	10	6	4	2	2	SE
E	30	14	36	18	32	16	12	12	14	14	14	14	10	10	6	6	2	2	E
SE	13	6	26	16	28	18	24	16	16	14	14	14	10	10	6	4	2	2	NE
S	−4	−4	4	0	22	12	30	20	26	20	16	14	10	10	6	6	2	2	N
SW	−4	−4	0	−2	6	4	26	22	40	28	42	28	24	20	6	4	2	2	NW
W	−4	−4	0	0	6	6	20	12	40	28	48	34	22	22	8	8	2	2	W
NW	−4	−4	0	−2	6	4	12	10	24	20	40	26	34	24	6	4	2	2	SW
N (Shade)	−4	−4	−2	−2	4	4	10	10	14	14	12	12	8	8	4	4	0	0	S (Shade)
	4 In. Brick or Stone Veneer + Frame																		
NE	−2	−4	24	12	20	10	10	6	12	10	14	14	12	12	10	10	6	4	SE
E	2	0	30	14	31	17	14	14	12	12	14	14	12	12	10	8	6	6	E
SE	2	−2	20	10	28	16	26	16	18	14	14	14	12	12	10	8	6	6	NE
S	−4	−4	−2	−2	12	6	24	16	26	18	20	16	12	12	8	8	4	4	N
SW	0	−2	0	−2	2	2	12	8	32	22	36	26	34	24	10	8	6	6	NW
W	0	−2	0	0	4	2	10	8	26	18	40	28	42	28	16	14	6	6	W
NW	−4	−4	−2	−2	2	2	8	6	12	12	30	22	34	24	12	10	6	6	SW
N (Shade)	−4	−4	−2	−2	0	0	6	6	10	10	12	12	12	12	8	8	4	4	S (Shade)
	8 In. Hollow Tile or 8 In. Cinder Block																		
NE	0	0	0	0	20	10	16	10	10	6	12	10	14	12	12	10	8	8	SE
E	4	2	12	4	24	12	26	14	20	12	12	10	14	12	14	10	10	8	E
SE	2	0	2	0	16	8	20	12	20	14	14	12	14	12	12	10	8	6	NE
S	0	0	0	0	2	0	12	6	24	14	26	16	20	14	12	10	8	6	N
SW	2	0	2	0	2	0	6	4	12	10	26	18	30	20	26	18	8	6	NW
W	4	2	4	2	4	2	6	4	10	8	18	14	30	22	32	22	18	14	W
NW	0	0	0	0	2	0	4	2	8	6	12	10	22	18	30	22	10	8	SW
N (Shade)	−2	−2	−2	−2	−2	−2	0	0	6	6	10	10	10	10	10	10	6	6	S (Shade)
	8 In. Brick or 12 In. Hollow Tile or 12 In. Cinder Block																		
NE	2	2	2	2	10	2	16	8	14	8	10	6	10	8	10	10	10	8	SE
E	8	6	8	6	14	8	18	10	18	10	14	8	14	10	14	10	12	10	E
SE	8	4	6	4	6	4	14	10	18	12	16	12	12	10	12	10	12	10	NE
S	4	2	4	2	4	2	4	2	10	6	16	10	16	12	12	10	10	8	N
SW	8	4	6	4	6	4	8	4	10	6	12	8	20	12	24	16	20	14	NW
W	8	4	6	4	6	6	8	6	10	6	14	8	20	16	24	16	24	16	W
NW	2	2	2	2	2	2	4	2	6	4	8	6	10	8	16	14	18	14	SW
N (Shade)	0	0	0	0	0	0	0	0	2	2	6	6	8	8	8	8	6	6	S (Shade)
	12 In. Brick																		
NE	8	6	8	6	8	4	8	4	10	4	12	6	12	6	10	6	10	6	SE
E	12	8	12	8	12	8	10	6	12	8	14	10	14	10	14	8	14	8	E
SE	10	6	10	6	10	6	10	6	10	6	12	8	14	10	14	10	12	8	NE
S	8	6	8	6	6	4	6	4	6	4	8	4	10	6	12	8	12	8	N
SW	10	6	10	6	10	6	10	6	10	6	10	8	10	8	12	8	14	10	NW
W	12	8	12	8	12	8	10	6	10	6	10	6	10	6	12	8	16	10	W
NW	8	6	8	6	8	4	8	4	8	4	8	4	8	6	10	6	10	6	SW
N (Shade)	4	4	2	2	2	2	2	2	2	2	2	2	2	2	4	4	6	6	S (Shade)