

γ is 16 deg. From Equation 10, the fraction of the total window area that is receiving direct solar radiation is:

$$G_t = 1 - \frac{0.1 \tan 45.5}{\cos 16} - 0.167 \tan 16 + \frac{0.0167 \tan 45.5 \tan 16}{\cos 16}$$

$$= 1 - 0.106 - 0.048 + 0.005 = 0.851$$

In this instance the convection and radiation heat gain is due principally to temperature difference, so that shading has but a small effect on that portion of the absorbed radiation. Hence, the factor 0.851 is applied only to the Table 16 value. Note also a small error results from the fact

TABLE 25. EFFECT OF SHADING UPON INSTANTANEOUS SOLAR HEAT GAIN THROUGH SINGLE THICKNESS OF COMMON WINDOW GLASS

TYPE OF SHADING	FINISH ON SIDE EXPOSED TO SUN	FRACTION OF GAIN THROUGH UNSHADED WINDOW
Canvas Awning	Dark	0.25-0.35
Inside Roller Shade, Fully Drawn ^a	White	0.45
Inside Roller Shade, Fully Drawn ^a	Medium color	0.53
Inside Roller Shade, Fully Drawn ^a	Dark color	0.80
Inside Roller Shade, Half Drawn ^a	White	0.73
Inside Roller Shade, Half Drawn ^a	Medium color	0.81
Inside Roller Shade, Half Drawn ^a	Dark color	0.90
Inside Venetian Blind, Slats set at 45 deg ^b	White	0.62
Inside Venetian Blind, Slats set at 45 deg ^b	Medium	0.74
Inside Venetian Blind, Slats set at 45 deg ^b	Aluminum	0.70
Inside Venetian Blind, Slats set at 45 deg ^b	Dark color	0.85
Outside Venetian Blind, Slats set at 45 deg ^b	Cream	0.20
Outside Venetian Blind, Slats set at 45 deg, extended as an awning ^c	Any color	0.40
Outside Shading Screen ^d , solar altitude 0-20 deg	Dark color	0.75-0.43
Outside Shading Screen ^d , solar altitude 20-40 deg	Dark color	0.43-0.22
Outside Shading Screen ^d , solar altitude, above 40 deg	Dark color	0.22

^a Roller shades are assumed to be opaque. Some white shades may transmit considerable solar radiation. For white translucent shades fully drawn use 0.53, and for half drawn use 0.77.

^b Venetian blinds are fully drawn and cover window. It is assumed that the occupant will adjust slats to prevent direct rays from passing between slats.

^c Commercial shade with wide slats.

^d Metal slats 0.05 in. wide, spaced 0.063 in. apart, and set at 17 deg angle with horizontal. At solar altitudes below 38 deg some direct solar rays are allowed to pass between slats, and this amount becomes progressively greater at low solar altitudes.

that the diffuse radiation is not shaded to the same extent as the direct radiation. The total instantaneous heat gain therefore is:

$$q = 3 \times 5 (0.851 \times 180 + 26) = 2690 \text{ Btu per (hr)(sq ft)}$$

A window such as the one used in Example 16 would customarily be provided with an additional shading means for use particularly when directly sunlit. Conventional shading devices include awnings, shades, and screens of various types.

Experimental work conducted at the A.S.H.V.E. Research Laboratory,^{20, 21} and other research²² to determine the effectiveness of various types of window shades, have been used as the basis for the recommended ratios in column 3 of Table 25. A study of absorptivity of the shade to solar radiation and heat transfer from the shade to the outdoors and indoors, was used to determine these ratios.

There are a number of variables affecting these ratios such as color, fit, solar altitude, and angle of incidence of the solar radiation. These values, therefore, must be considered as approximate, only, and will have to be used with considerable judgment. An inside shade is effective to the ex-

tent of its reflectivity, since the portion of the solar radiation directly transmitted by the glass that is absorbed by the shade is transferred by convection to the room air, and by radiation to the solid room surfaces.

INSTANTANEOUS HEAT GAINS VS. INSTANTANEOUS COOLING LOADS

The difference between instantaneous heat gain and instantaneous cooling load has been mentioned previously; its practical importance is sufficient to warrant further consideration.

Fig. 5 offers a simplified schematic illustration showing how the radiative part of the instantaneous heat gain is first absorbed by solid objects, and is not encountered by the conditioning equipment as a cooling load until some later time, when it finally appears in the air stream entering the equipment. While it is true that some lag also is inherent in convective heat transfer and the time required to change the air in the conditioned space, this is usually of the order of a few minutes to perhaps half an hour. Heat storage in the interior furnishings and structure increases according to the proportion of the instantaneous heat gain which is in the form of radiation, and also as the thermal capacitance of the objects and materials involved is increased.

Constituents of the total instantaneous heat gain which have appreciable radiation components include those due to glass areas, exposed walls and roofs, lighting, appliances, and people.

No comprehensive data are presently available for use in design load estimates to evaluate the interior load-lag effect, but several investigators^{13, 14, 23, 24} have made a study of the problem and have presented much useful data. Tables 12, 13, 16, 17, 20, and 21 are all based on instantaneous rates of heat transfer. Hence, practical judgment and experience offer the only basis of procedure. Until the needed data become available, it is recommended that the non-continuous load be averaged over two or three hours during the time of maximum load, when determining the total instantaneous cooling load where a large portion of the heat gain is radiant. This suggestion applies only to conditions near the time of maximum heat gain, as the heat stored within the structure would necessarily appear in the cooling load eventually; but if it appears at a time when the gain from outside is relatively low, the equipment will be able to maintain satisfactory conditions within the range of maximum capacity.

LOAD FROM INTERIOR PARTITIONS, CEILINGS, AND FLOORS

Whenever a conditioned space is adjacent to another space in which a different temperature prevails, the transfer of heat through the separating structural section must be considered. Calculations are made according to the relation:

$$q = U_1 A_1 (t_b - t_i) \text{ Btu per hour.} \quad (11)$$

where U_1 = coefficient of overall heat transfer between the adjacent and the conditioned space, Btu per (hour) (square foot) (Fahrenheit degree).

A_1 = area of separating section concerned, square feet.

t_b = air temperature in adjacent space, Fahrenheit degrees.

t_i = air temperature in conditioned space, Fahrenheit degrees.

Magnitudes of U_1 may be obtained from Chapter 9. The temperature