TABLE 15. INSTANTANEOUS RATES OF HEAT GAIN DUE TO SOLAR AND SKY RADIATION FOR SINGLE SHEETS OF UNSHADED COMMON WINDOW GLASS [a, b] (CONCLUDED)

| SUN TIME | SOLAR ALTITUDE β DEG | INSTANTANEOUS RATE OF HEAT GAIN, BTU PER HOUR FOR EACH SQUARE FOOT OF UNSHADED GLASS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | N | NE | E | SE | S | SW | W | NW | Horizontal |
| *45 Deg North Latitude* | | | | | | | | | | |
| 5 a.m. | 2.0 | 9 | 23 | 23 | 8 | 1 | 1 | 1 | 1 | 2 |
| 6 | 12.5 | 22 | 111 | 129 | 68 | 6 | 6 | 6 | 6 | 28 |
| 7 | 23.0 | 13 | 135 | 182 | 121 | 11 | 11 | 11 | 11 | 82 |
| 8 | 33.5 | 14 | 116 | 192 | 153 | 24 | 14 | 14 | 14 | 141 |
| 9 | 44.0 | 15 | 63 | 168 | 166 | 55 | 15 | 15 | 15 | 189 |
| 10 | 53.0 | 16 | 22 | 123 | 154 | 88 | 16 | 16 | 16 | 225 |
| 11 | 60.0 | 16 | 16 | 56 | 127 | 113 | 30 | 16 | 16 | 249 |
| 12 | 63.0 | 16 | 16 | 16 | 76 | 119 | 76 | 16 | 16 | 256 |
| 1 p.m. | 60.0 | 16 | 16 | 16 | 30 | 113 | 127 | 56 | 16 | 249 |
| 2 | 53.0 | 16 | 16 | 16 | 16 | 88 | 154 | 123 | 22 | 225 |
| 3 | 44.0 | 15 | 15 | 15 | 15 | 55 | 166 | 168 | 63 | 189 |
| 4 | 33.5 | 14 | 14 | 14 | 14 | 24 | 153 | 192 | 116 | 141 |
| 5 | 23.0 | 13 | 11 | 11 | 11 | 11 | 121 | 182 | 135 | 82 |
| 6 | 12.5 | 22 | 6 | 6 | 6 | 6 | 68 | 129 | 111 | 28 |
| 7 | 2.0 | 9 | 1 | 1 | 1 | 1 | 8 | 23 | 23 | 2 |
| *50 Deg North Latitude* | | | | | | | | | | |
| 5 a.m. | 4.5 | 18 | 48 | 48 | 17 | 2 | 2 | 2 | 2 | 5 |
| 6 | 13.5 | 22 | 119 | 139 | 75 | 6 | 6 | 6 | 6 | 32 |
| 7 | 23.5 | 11 | 131 | 183 | 127 | 11 | 11 | 11 | 11 | 84 |
| 8 | 33.0 | 13 | 103 | 190 | 161 | 30 | 13 | 13 | 13 | 138 |
| 9 | 42.0 | 14 | 51 | 165 | 173 | 69 | 14 | 14 | 14 | 179 |
| 10 | 50.0 | 16 | 19 | 122 | 166 | 109 | 16 | 16 | 16 | 214 |
| 11 | 56.0 | 16 | 16 | 55 | 138 | 133 | 41 | 16 | 16 | 235 |
| 12 | 58.0 | 16 | 16 | 16 | 92 | 140 | 92 | 16 | 16 | 242 |
| 1 p.m. | 56.0 | 16 | 16 | 16 | 41 | 133 | 138 | 55 | 16 | 235 |
| 2 | 50.0 | 16 | 16 | 16 | 16 | 109 | 166 | 122 | 19 | 214 |
| 3 | 42.0 | 14 | 14 | 14 | 14 | 69 | 173 | 165 | 51 | 179 |
| 4 | 33.0 | 13 | 13 | 13 | 13 | 30 | 161 | 190 | 103 | 138 |
| 5 | 23.5 | 11 | 11 | 11 | 11 | 11 | 127 | 183 | 131 | 84 |
| 6 | 13.5 | 22 | 6 | 6 | 6 | 6 | 75 | 139 | 119 | 32 |
| 7 | 4.5 | 18 | 2 | 2 | 2 | 2 | 17 | 48 | 48 | 5 |

[a] Table compiled from solar radiation transmission data developed by A.S.H.V.E. Research Laboratory[2] and direct intensity values developed by Moon[1], recently enlarged and revised by the A.S.H.V.E. Research Laboratory.

[b] For relatively clear atmosphere at sea level. For hazy atmosphere values may be reduced 10 per cent. Above sea level add one per cent per 1000 ft elevation.

inclusive, and for all exposures from 10:00 a.m. to 2:00 p.m. inclusive. For Southern exposures at 8:00 a.m. or at 4:00 p.m. the error may be ±15 per cent. At noon this method gives accurate results; the error becomes progressively larger as the time differs from noon.

In regard to *glass blocks*, data on the over-all unit conductances for heat transfer by convection and conduction are given in Table 18, Chapter 6; these will serve also for cooling load calculations for shaded or north-exposure walls. (Steady-state calculations as suggested there take no account of the time lag present with periodic cycles of air temperature.)

The results of experimental observations [12] on heat gains through glass-block sections are given in Table 18. Tabulated heat-gain rates are based upon a constant indoor-air temperature of 78 F and a maximum outdoor-air temperature of 95 F for the design day chosen. The values given are approximate, and intended for estimates only; they are *averages* for *four* representative glass block designs, two with smooth exterior faces and two with ribbed exterior faces.



TABLE 16. RATIO OF INSTANTANEOUS RATE OF HEAT GAIN THROUGH SINGLE THICKNESS OF HEAT ABSORBING SUNLIT GLASS TO HEAT GAIN FOR COMMON GLASS AS GIVEN IN TABLE 15

| TRANSMISSIVITY[a] | APPROXIMATE RATIO | TRANSMISSIVITY[a] | APPROXIMATE RATIO | TRANSMISSIVITY[a] | APPROXIMATE RATIO |
|---|---|---|---|---|---|
| 0.90 | 1.02 | 0.70 | 0.85 | 0.40 | 0.60 |
| 0.87 | 1.0 | 0.60 | 0.76 | 0.30 | 0.52 |
| 0.80 | 0.93 | 0.50 | 0.68 | 0.20 | 0.45 |

[a] For direct solar radiation at normal incidence.

TABLE 17. APPROXIMATE SOLAR DECLINATIONS IN DEGREES

| DATE | DECLINATION | DATE | DECLINATION | DATE | DECLINATION |
|---|---|---|---|---|---|
| April 1 | 4.5 | June 1 | 22.0 | Aug. 1 | 18.0 |
| April 15 | 10.0 | June 15 | 23.5 | Aug. 15 | 14.0 |
| May 1 | 15.0 | July 1 | 23.0 | Sept. 1 | 8.5 |
| May 15 | 19.0 | July 15 | 21.5 | Sept. 15 | 3.0 |

TABLE 18. TOTAL INSTANTANEOUS RATES OF HEAT GAIN FOR GLASS BLOCKS [12] ON DESIGN DAY OF AUGUST 1

*(Values tabulated include solar and sky radiation, convection, and conduction averaged for four types of blocks)*

| MEAN SUN TIME | TOTAL INSTANTANEOUS RATE OF HEAT GAIN, BTU PER HOUR FOR EACH SQUARE FOOT OF SUNLIT GLASS BLOCK | | | | | |
|---|---|---|---|---|---|---|
| | Vertical Surface Facing | | | | | |
| | East | West | South | | | |
| North Latitude, Deg | 30 to 45 | 30 to 45 | 30 | 35 | 40 | 45 |
| 7 a.m. | 61 | ----- | −4.5 | −2.0 | −0.5 | 1.0 |
| 8 | 78 | ----- | 0.0 | 2.0 | 4.0 | 5.0 |
| 9 | 74 | 5.0 | 5.0 | 7.0 | 10 | 12 |
| 10 | 58 | 6.5 | 11 | 15 | 18 | 21 |
| 11 | 45 | 7.5 | 17 | 22 | 26 | 32 |
| 12 noon | 37 | 11 | 22 | 28 | 34 | 41 |
| 1 p.m. | 30 | 22 | 25 | 32 | 39 | 46 |
| 2 | 24 | 35 | 26 | 32 | 39 | 47 |
| 3 | 20 | 55 | 24 | 30 | 37 | 45 |
| 4 | 16 | 77 | 20 | 26 | 32 | 41 |
| 5 | 13 | 86 | 15 | 20 | 25 | 34 |
| 6 | 11 | 55 | 9.5 | 14 | 18 | 26 |
| 7 | 8 | 19 | 3.5 | 7.0 | 11 | 18 |

## Shading of Glass Areas—Design Tables

The effects and possibilities of shading should be carefully investigated whenever the heat gain from glass is a large portion of the cooling load.

Vertical glass which is not mounted in the plane of the building surface is partially shaded by the *setback*. If a vertical window of height $l$ and width $w$ be set back from the plane of the building a distance $s$, the fraction of the total area of the window which receives *direct* solar radiation is:

$$G_f = 1 - r_1 \tan \beta - r_2 \tan \gamma + r_1 r_2 \tan \beta \tan \gamma \qquad (13)$$

*where*

$r_1 = s/l$, $r_2 = s/w$, $\beta$ = solar altitude, and $\gamma$ is the difference between the azimuth angles of the wall in question and of the horizontal projection of the sun's rays. ($\gamma$ is always equal to or less than 90 deg.)