

Table 12 .... Instantaneous Rates of Heat Gain Due to Transmitted Direct and Diffuse or Sky Solar Radiation by a Single Sheet of Unshaded Common Window Glass

For Clear Atmosphere and 18 Deg Declination, North (August 1)

Note: For total instantaneous heat gain, add these values to the Table 13 values

| Latitude     | Sun Time  |        | Instantaneous Heat Gain in Btu per (hr) (sq ft) |     |     |     |     |    |    |     |        |
|--------------|-----------|--------|-------------------------------------------------|-----|-----|-----|-----|----|----|-----|--------|
|              | AM →      |        | N                                               | NE  | E   | SE  | S   | SW | W  | NW  | Horiz. |
|              | ↓         |        |                                                 |     |     |     |     |    |    |     |        |
| 30 Deg north | 6 a.m.    | 6 p.m. | 25                                              | 98  | 108 | 52  | 5   | 5  | 5  | 5   | 17     |
|              | 7         | 5      | 22                                              | 155 | 190 | 110 | 10  | 10 | 10 | 10  | 71     |
|              | 8         | 4      | 18                                              | 149 | 205 | 136 | 14  | 13 | 13 | 13  | 137    |
|              | 9         | 3      | 16*                                             | 106 | 180 | 138 | 21  | 16 | 16 | 16  | 195    |
|              | 10        | 2      | 17                                              | 54  | 128 | 116 | 34  | 17 | 16 | 16  | 241    |
|              | 11        | 1      | 18                                              | 20  | 59  | 78  | 45  | 19 | 18 | 18  | 267    |
|              | 12        | 18     | 19                                              | 19  | 35  | 49  | 35  | 19 | 19 | 276 |        |
| 40 Deg north | 5 a.m.    | 7 p.m. | 3                                               | 7   | 6   | 2   | 0   | 0  | 0  | 0   | 1      |
|              | 6         | 6      | 26                                              | 116 | 131 | 67  | 7   | 6  | 6  | 6   | 25     |
|              | 7         | 5      | 16                                              | 149 | 195 | 124 | 11  | 10 | 10 | 10  | 77     |
|              | 8         | 4      | 14                                              | 129 | 205 | 156 | 18  | 12 | 12 | 12  | 137    |
|              | 9         | 3      | 15                                              | 79  | 180 | 162 | 42  | 14 | 14 | 14  | 188    |
|              | 10        | 2      | 18                                              | 31  | 127 | 148 | 69  | 16 | 16 | 16  | 229    |
|              | 11        | 17     | 18                                              | 58  | 113 | 90  | 23  | 17 | 17 | 252 |        |
|              | 12        | 17     | 17                                              | 19  | 64  | 98  | 64  | 19 | 17 | 259 |        |
| 50 Deg north | 5 a.m.    | 7 p.m. | 20                                              | 54  | 54  | 20  | 3   | 3  | 3  | 3   | 6      |
|              | 6         | 6      | 25                                              | 128 | 149 | 81  | 8   | 7  | 7  | 7   | 34     |
|              | 7         | 5      | 18                                              | 139 | 197 | 136 | 12  | 10 | 10 | 10  | 80     |
|              | 8         | 4      | 15                                              | 107 | 202 | 171 | 32  | 18 | 18 | 18  | 129    |
|              | 9         | 3      | 14                                              | 54  | 176 | 183 | 72  | 14 | 14 | 14  | 173    |
|              | 10        | 2      | 16                                              | 18  | 124 | 174 | 110 | 16 | 16 | 16  | 206    |
|              | 11        | 16     | 18                                              | 57  | 143 | 136 | 42  | 16 | 16 | 227 |        |
|              | 12        | 16     | 16                                              | 16  | 96  | 144 | 96  | 16 | 16 | 234 |        |
|              | ↑<br>PM → |        | N                                               | NW  | W   | SW  | S   | SE | E  | NE  | Horiz. |

\* Italics indicate shaded glass.

Table 13 .... Instantaneous Rates of Heat Gain by Convection and Radiation from a Single Sheet of Unshaded Common Window Glass

For Clear Atmosphere and 18 Deg Declination, North (August 1)

For 30, 40, 50 Deg North Latitude

For 80 F Indoor Temperature

Note: For total instantaneous heat gain, add these values to the Table 12 values

| Instantaneous Heat Gain in Btu per (hr) (sq ft) |                |    |    |    |    |    |    |    |    |        |  |
|-------------------------------------------------|----------------|----|----|----|----|----|----|----|----|--------|--|
| Sun Time                                        | Dry-Bulb F Deg | N  | NE | E  | SE | S  | SW | W  | NW | Horiz. |  |
| 5 a.m.                                          | 74             | -6 | -6 | -6 | -6 | -6 | -6 | -6 | -6 | -6     |  |
| 6                                               | 74             | -5 | -4 | -4 | -5 | -5 | -6 | -6 | -6 | -5     |  |
| 7                                               | 75             | -5 | -2 | -2 | -3 | -5 | -5 | -5 | -5 | -3     |  |
| 8                                               | 77             | -3 | 0  | 1  | 0  | -2 | -3 | -3 | -3 | 0      |  |
| 9                                               | 80             | 0  | 2  | 4  | 3  | 1  | 0  | 0  | 0  | 3      |  |
| 10                                              | 83             | 3  | 4  | 6  | 6  | 5  | 3  | 3  | 3  | 8      |  |
| 11                                              | 87             | 8  | 8  | 10 | 11 | 10 | 9  | 8  | 8  | 13     |  |
| 12                                              | 90             | 12 | 12 | 12 | 13 | 14 | 13 | 12 | 12 | 16     |  |
| 1 p.m.                                          | 93             | 15 | 15 | 15 | 16 | 17 | 17 | 17 | 15 | 20     |  |
| 2                                               | 94             | 16 | 16 | 16 | 16 | 18 | 19 | 19 | 17 | 21     |  |
| 3                                               | 95             | 17 | 17 | 17 | 17 | 19 | 21 | 21 | 19 | 21     |  |
| 4                                               | 94             | 16 | 16 | 16 | 16 | 17 | 20 | 20 | 19 | 19     |  |
| 5                                               | 93             | 15 | 15 | 15 | 15 | 15 | 18 | 19 | 18 | 17     |  |
| 6                                               | 91             | 13 | 13 | 13 | 13 | 13 | 14 | 15 | 15 | 13     |  |
| 7                                               | 87             | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8      |  |
| 8                                               | 85             | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6      |  |
| 9                                               | 83             | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3      |  |

## Cooling Load

Table 14 .... Application Factors to Apply to Tables 12, 13 and 15 to Obtain Instantaneous Rates of Heat Gain for Various Types of Single Flat Glass and Combinations of Two Sheets of Flat Glass Spaced at 1/4 in.

| Glass*                        | Normal Incidence Transmittance | Factor to Apply to Table 12 | Factor to Apply to Table 13  |
|-------------------------------|--------------------------------|-----------------------------|------------------------------|
| Single common window          | 0.87                           | 1.00                        | 1.0(X) + 0.0(Y) <sup>a</sup> |
| Single regular plate          | 0.77                           | 0.87                        | 1.0(X) + 0.25(Y)             |
| Single heat absorbing plate   | 0.41                           | 0.46 <sup>b</sup>           | 1.0(X) + 1.00(Y)             |
| Double common window          | 0.76                           | 0.85                        | 0.6(X) + 0.10(Y)             |
| Double regular plate:         | 0.60                           | 0.66 <sup>b</sup>           | 0.6(X) + 0.55(Y)             |
| Heat absorbing plate outdoors | 0.35                           | 0.37 <sup>b</sup>           | 0.6(X) + 0.75(Y)             |
| Regular plate indoors         |                                |                             |                              |

\* Common window glass 1/4 in. thick. Plate glass 1/4 in. thick.

<sup>b</sup> For better precision, increase factors 10 percent when glass is in the shade.

<sup>a</sup> X values are Table 13 values.

<sup>b</sup> Y values are Table 13 values.

side surface conductance for convection  $f_{cs}$  as given by Equation 3, and an equivalent surface conductance for radiation  $f_{rs}$  as given by Equation 4. Inside surfaces seen by the glass are assumed to radiate as a black body at room air temperature.

$$f_{cs} = 0.27 (t_{si} - t_i)^{0.25} \quad (3)$$

$$f_{rs} = 0.162 \left[ \left( \frac{t_{si} + 460}{100} \right)^4 - \left( \frac{t_i + 460}{100} \right)^4 \right] / (t_{si} - t_i) \quad (4)$$

where

$t_{si}$  = temperature of inside surface of glass, Fahrenheit.

$t_i$  = temperature of indoor air, Fahrenheit.

A more complete treatment of the problem is given in an ASHRAE research paper.<sup>23</sup>

## Design Tables for Flat Glass

Tables 12 and 13 give design values of instantaneous rates of heat gain for single unshaded common window glass for a solar declination of 18 deg. This corresponds to a nominal August 1 day. The tables are based upon the solar intensity values for a clear atmosphere as given in Table 4. Table 12 values represent the first bracketed term of Equation 2a; therefore, the values are dependent only upon values of  $I$  and  $\tau$ . Table 13 values represent the second term of Equation 2a, and are based upon a 80 F indoor temperature and a dry-bulb temperature cycle, with a 95 F maximum as tabulated. The total heat gain is the sum of the Table 12 and Table 13 values. In preparing Table 13, convection and radiation heat exchange were combined, and a combined surface conductance of 4.0 used. Corrections to be applied for other design temperatures are given in Table 24 in a later section Effect of Deviation from Design Conditions.

Tables 12 and 13 may be used for other types of glass with good accuracy, by using the factors given in Table 14. Table 12 values are multiplied by the appropriate factor given in Table 14 to obtain heat gain due to transmitted solar radiation. For glasses having a transmittance for normally incident radiation differing from the table values, factors may be found by linear interpolation. To obtain instantaneous rates of heat gain by convection and radiation, two steps are required. First, Table 13 values are multiplied by the appropriate coefficient of  $X$  listed in Table 14. Second, Table 15 values are multiplied by the appropriate coefficient of  $Y$  listed in Table 14, and added to the first value. All convection and radiation gain values for double glass were computed for a 1/4-in. air space. No great error is involved in cooling load estimates if these are used for double glass with other air spaces.

Example 8: Find the total instantaneous heat gain through a single sheet of regular plate glass in a southwest wall at 2 p.m. sun time and 40-deg north latitude on August 1. The maximum dry-bulb temperature for design is 95 F; the atmosphere is clear. The indoor temperature is 80 F.

Solution: From Table 12 the heat gain due to transmitted radiation is 148 Btu per (hr) (sq ft) for common window glass; from Table 14, the factor for regular plate glass is 0.87. The coefficient of  $X$  in Table 14 is 1.0, while  $X$  is found from Table 13 for common window glass for the same hour, orientation and latitude. The coefficient of  $Y$  in Table 14 is 0.25, while the  $Y$  value is found from Table 15 for a southwest wall at 2:00 p.m. and 40-deg north latitude. The correction for design dry-bulb temperature is found from Table 24 to be 1.0 Btu per (hr) (sq ft) per degree difference from 95 F design temperature. The total instantaneous heat gain is, from Equation 2a,

$$q = 0.87 \times 148 + 1.0 \times 19 + 0.25 \times 27 + 1.0 (98 - 95) = 157.5 \text{ Btu per (hr) (sq ft)}$$

## Design Tables for Rolled Figured Glass

Tables 16 and 17 give design values of instantaneous rates of heat gain for a number of common patterns of single vertical sheets of rolled figured glass. The tables are for a solar declination of 18 deg, which corresponds to a nominal August 1 day, and are based upon the solar intensity values for a clear atmosphere as given in Table 4. The values are given in terms of corrections to apply to Tables 12 and 13. The heat gain due to transmitted solar radiation is found by multiplying the Table 12 values by the approximate percentages given in Table 17. To obtain instantaneous rates of heat gain by convection and radiation, Table 15 values are multiplied by the appropriate value of  $Y$  from Table 16 and then added to the corresponding Table 13 values. The total instantaneous heat gain is the sum of the gain due to transmitted solar radiation and the gain by convection and radiation.

The values given in Tables 16 and 17 are based upon an ASHRAE research paper<sup>24</sup> to which the reader is directed for additional data. The values in Tables 16 and 17 may be used with fair precision for other patterns of similar transmittance and surface characteristics. For example, the data for hammered glass may be used for glass having shallow, closely spaced ribs or for glass having small, closely spaced circular indentations. Because some patterns have distinct orientation properties, no attempt has been made to give values for nonvertical glass.

## Design Tables for Glass Block Walls

Table 18 describes the glass block patterns discussed in following text. Table 19 gives design values for instantaneous heat gain due to transmitted direct and diffuse solar radiation