TABLE 10. SUMMER DESIGN SOL-AIR TEMPERATURES FOR NEW YORK, N. Y. (NORTH LATITUDE 40°46'; ELEVATION 180 FT)

| MEAN SUN TIME | SOL-AIR TEMPERATURE, $t_e$, FAHRENHEIT DEGREES | | | | | |
|---|---|---|---|---|---|---|
| | Any Surface[b] | Horizontal | North | East | South | West |
| Ratio[a]: $\frac{b}{f_o}$ | 0 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| 12 midnight | 79 | 79 | 79 | 79 | 79 | 79 |
| 1 a.m. | 78 | 78 | 78 | 78 | 78 | 78 |
| 2 | 77 | 77 | 77 | 77 | 77 | 77 |
| 3 | 77 | 77 | 77 | 77 | 77 | 77 |
| 4 | 76 | 76 | 76 | 76 | 76 | 76 |
| 5 | 76 | 76 | 76 | 76 | 76 | 76 |
| 6 | 76 | 81 | 80 | 89 | 77 | 77 |
| 7 | 80 | 96 | 85 | 106 | 82 | 82 |
| 8 | 82 | 110 | 85 | 114 | 86 | 85 |
| 9 | 86 | 127 | 90 | 120 | 97 | 90 |
| 10 | 88 | 137 | 92 | 114 | 104 | 92 |
| 11 | 90 | 148 | 94 | 106 | 111 | 94 |
| 12 noon | 92 | 155 | 97 | 97 | 115 | 98 |
| 1 p.m. | 93 | 154 | 98 | 98 | 117 | 108 |
| 2 | 94 | 152 | 99 | 99 | 112 | 126 |
| 3 | 94 | 144 | 99 | 99 | 102 | 136 |
| 4 | 94 | 136 | 99 | 99 | 99 | 145 |
| 5 | 93 | 121 | 103 | 97 | 97 | 140 |
| 6 | 90 | 106 | 106 | 93 | 93 | 134 |
| 7 | 88 | 93 | 102 | 90 | 90 | 115 |
| 8 | 85 | 85 | 85 | 85 | 85 | 85 |
| 9 | 83 | 83 | 83 | 83 | 83 | 83 |
| 10 | 82 | 82 | 82 | 82 | 82 | 82 |
| 11 | 81 | 81 | 81 | 81 | 81 | 81 |
| 24-hr avg. $t_m$ | 84.8 | 106.4 | 88.5 | 92.3 | 90.7 | 96.5 |

[a] $b$ = surface absorptivity, dimensionless.
$f_o$ = unit convective conductance, Btu per (hr) (sq ft) (F deg).
[b] Values in this column are magnitudes of $t_o$, the outdoor air temperature.

TABLE 11. SUMMER DESIGN SOL-AIR TEMPERATURES FOR LINCOLN, NEBR. (NORTH LATITUDE 40°50'; ELEVATION 1225 FT)

| MEAN SUN TIME | SOL-AIR TEMPERATURE, $t_e$, FAHRENHEIT DEGREES | | | | | |
|---|---|---|---|---|---|---|
| | Any Surface[b] | Horizontal | North | East | South | West |
| Ratio[a]: $\frac{b}{f_o}$ | 0 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| 12 midnight | 89 | 89 | 89 | 89 | 89 | 89 |
| 1 a.m. | 88 | 88 | 88 | 88 | 88 | 88 |
| 2 | 86 | 86 | 86 | 86 | 86 | 86 |
| 3 | 84 | 84 | 84 | 84 | 84 | 84 |
| 4 | 84 | 84 | 84 | 84 | 84 | 84 |
| 5 | 82 | 82 | 82 | 82 | 82 | 82 |
| 6 | 81 | 87 | 88 | 100 | 82 | 82 |
| 7 | 82 | 103 | 93 | 125 | 85 | 85 |
| 8 | 88 | 124 | 94 | 137 | 92 | 92 |
| 9 | 93 | 143 | 98 | 142 | 104 | 98 |
| 10 | 96 | 160 | 102 | 138 | 115 | 102 |
| 11 | 100 | 172 | 106 | 129 | 125 | 106 |
| 12 noon | 102 | 178 | 108 | 115 | 130 | 108 |
| 1 p.m. | 104 | 180 | 110 | 110 | 132 | 119 |
| 2 | 106 | 178 | 112 | 112 | 131 | 137 |
| 3 | 107 | 170 | 113 | 113 | 126 | 150 |
| 4 | 107 | 158 | 112 | 112 | 117 | 158 |
| 5 | 106 | 142 | 113 | 110 | 110 | 157 |
| 6 | 105 | 126 | 117 | 108 | 108 | 149 |
| 7 | 102 | 109 | 113 | 104 | 104 | 128 |
| 8 | 98 | 99 | 98 | 98 | 98 | 98 |
| 9 | 94 | 94 | 94 | 94 | 94 | 94 |
| 10 | 92 | 92 | 92 | 92 | 92 | 92 |
| 11 | 90 | 90 | 90 | 90 | 90 | 90 |
| 24-hr avg. $t_m$ | 94.4 | 121.6 | 98.6 | 105.9 | 102.1 | 106.6 |

[a] $b$ = surface absorptivity, dimensionless.
$f_o$ = unit convective conductance, Btu per (hr) (sq ft) (F deg).



2. To adjust the data in Tables 10 and 11 for variations in $t_o$:
a. Establish the magnitude of $t'_o$ at the locality in question.
b. Determine the difference $(t'_o - t_o)$.
c. Add (algebraically) the difference $(t'_o - t_o)$ to the data tabulated.

3. To adjust the data in Tables 10 and 11 to other magnitudes of $b/f_o$ than 0.25:
a. For New York or Lincoln, merely interpolate or extrapolate the tabulated data by direct proportion, using the column for $b/f_o = 0$.
b. For other localities, first determine $t'_o = t'_o + b/f_o\, I'_t$ for $b/f_o = 0$ and $b/f_o = 0.25$. Then interpolate or extrapolate by direct proportion as before.

Sol-air data for a particular locality may be adjusted for different azimuths of the vertical surface in question in a similar manner, although, all things considered, a simple interpolation between the four points of the compass should serve for all but the most accurate calculations.

An example of the use of the tables in determining sol-air temperature is given.

*Example 2.* Find the summer design sol-air temperature in New York, N. Y. or a west wall which has a solar absorptivity of 0.7, at a sun time of 3:00 p. m.

$$\text{Use } f_o = 4\text{; then } \frac{b}{f_o} \text{ for this wall is } \frac{0.7}{4.0} \text{ or } 0.175.$$

From Table 10: for $\frac{b}{f_o} = 0$, $t_e = 94$ F; for $\frac{b}{f_o} = 0.25$, $t_e = 136$ F; and by linear interpolation for this wall:

$$t_e = 94 + \frac{0.175}{0.25}(136 - 94) = 94 + 29 = 123 \text{ F}.$$

Sol-air temperatures are especially helpful in the calculation of periodic heat transfer, as will be illustrated in the material which follows.

## PRINCIPLES OF PERIODIC HEAT FLOW

Calculation principles for periodic heat flow are dealt with briefly in this section; in the section which follows, *practical tables are given to facilitate rapid design estimates.* In addition to the rate of heat entry into the outside building surface these tables take into account the following factors:

1. The thermal conductivity of material.
2. The density, specific heat and character of material.
3. Thickness of material.
4. Room air temperature.
5. Unit convective conductance between the inside surface and room air; and radiant heat transfer between the inside surfaces and other surfaces in the room.

### Time Lag

The fundamental analysis of periodic heat flow is complicated when compared with steady-state calculations on account of the time-variable storage of heat from point to point through a wall or roof. The cyclic variation of outdoor conditions produces a related cyclic variation of temperature and heat flow throughout each structural section exposed to the weather. The cyclic variations undergo a progressive *shift in phase* and