approaching or exceeding those for a clear atmosphere are often encountered during Cleveland summers, but with dew-point and maximum dry-bulb temperatures 10 to 15 deg lower. Considerable judgment, therefore, is required in selecting solar intensity values for design purposes.

Data regarding the irradiation of vertical and horizontal surfaces by diffuse or sky radiation are few. Suggested design values for a 40-deg

TABLE 5. VALUES OF K, THE COSINE OF THE INCIDENT ANGLE, FOR VARIOUSLY ORIENTED WALLS AND A HORIZONTAL SURFACE

Computed for 18 Deg Declination, North (August 1)

Latitude	Sun Time	Cosine K of the Incident Angle						
	AM → ↓	N	NE	E	SE	S	SW	Horiz.
30 Deg North	6 a.m. 6 p.m.	0.267	0.862	0.953	0.484			0.156
	7 5	0.144	0.752	0.919	0.548			0.367
	8 4	0.030	0.694	0.824	0.561			0.566
	9 3		0.427	0.672	0.524	0.068		0.737
	10 2		0.234	0.476	0.438	0.144		0.866
	11 1		0.039	0.248	0.310	0.192		0.951
	12			0.000	0.147	0.208	0.147	0.978
40 Deg North	5 a.m. 7 p.m.	0.406	0.934	0.914	0.358			0.009
	6 6	0.237	0.840	0.951	0.505			0.199
	7 5	0.079	0.705	0.919	0.594			0.391
	8 4		0.533	0.824	0.631	0.069		0.566
	9 3		0.337	0.673	0.614	0.196		0.713
	10 2		0.129	0.475	0.542	0.292		0.829
	11 1			0.246	0.424	0.354	0.076	0.903
	12			0.000	0.265	0.375	0.265	0.927
50 Deg North	5 a.m. 7 p.m.	0.385	0.922	0.920	0.378			0.078
	6 6	0.199	0.813	0.951	0.532			0.233
	7 5	0.010	0.656	0.918	0.643			0.399
	8 4		0.465	0.824	0.700	0.166		0.545
	9 3		0.252	0.673	0.699	0.316		0.669
	10 2		0.030	0.475	0.642	0.433		0.786
	11 1			0.247	0.532	0.505	0.183	0.829
	12			0.000	0.375	0.530	0.375	0.848
	↑ PM →	N	NW	W	SW	S	SE	Horiz.

latitude on August 1 (18 deg declination, north) are given in Table 4 for the two types of atmospheres. These are based upon observations made on cloudless days in Cleveland over a period of several summers. Since more less extensive data were available for industrial atmospheres, there is more uncertainty regarding these values. In both instances, the values include an unknown amount of ground reflection, which may be expected to vary with location. It should be noted that clouds which do not obscure the sun tend to *increase* diffuse radiation values. Nearby buildings may *reduce* diffuse irradiation by partial shading.

Calculation Tables

The irradiation of a surface by the sun is the product of I_{Dn}, the direct normal radiation (see Table 4), and the cosine K of the incident angle, θ. For horizontal surfaces, the cosine K equals the sine of the solar altitude. For vertical walls, K is a function of the solar altitude β and the wall solar azimuth γ, thus

$$K = \cos\theta = \cos\beta \cos\gamma \quad (1)$$

These three angles are defined in Fig. 1. Values of K are given in Table 5 and values of β and γ are given in Table 6 for 18 deg north declination (August 1).

To compute K values for orientations other than those given in Table 5, third angle ϕ, the solar azimuth, is required. In this discussion, ϕ will be measured east from south in the morning, and west from south in the afternoon. Hence, ϕ values are equal to 90 deg minus the γ values for an east or west facing wall, except when Table 6 shows the south walls to be in the shade. In this case ϕ equals $90 + \gamma$, that is, ϕ is greater than 90 deg.

TABLE 6. VALUES OF THE WALL SOLAR AZIMUTH, γ, FOR VARIOUSLY ORIENTED WALLS AND SOLAR ALTITUDE

Computed for 18 Deg Declination, North (August 1)

Latitude	Sun Time	Solar Altitude β Degrees	Azimuth Angle γ, Degrees					
	AM→ ↓		N	NE	E	SE	S	SW
30 Deg North	6 a.m. 6 p.m.	9.0	74	29	16	61		
	7 5	21.5	81	36	9	54		
	8 4	34.5	88	43	2	47	shade	
	9 3	47.5	shade	51	6	39	84	
	10 2	60.0		62	17	28	73	
	11 1	72.0		83	38	7	52	shade
	12	78.0		shade	90	45	0	45
40 Deg North	5 a.m. 7 p.m.	0.5	66	21	24	69		
	6 6	11.5	76	31	14	59		
	7 5	23.0	85	40	5	50	shade	
	8 4	34.5	shade	50	5	40	85	
	9 3	45.5		61	16	29	74	
	10 2	56.0		76	31	14	59	shade
	11 1	64.5		shade	55	10	35	80
	12	68.0			90	45	0	45
50 Deg North	5 a.m. 7 p.m.	4.5	67	22	23	68		
	6 6	13.5	78	33	12	57		
	7 5	23.5	90	45	0	45	90	
	8 4	33.0	shade	57	12	33	78	
	9 3	42.0		70	25	20	65	
	10 2	50.0		87	42	3	48	shade
	11 1	56.0		shade	64	19	26	71
	12	58.0			90	45	0	45
	↑ PM →		N	NW	W	SW	S	SE

The wall azimuth ψ is the angle, measured east from south to the perpendicular to the wall for walls which have an easterly component, and west from south for those having a westerly component. For example, ψ for a wall facing northeast is 135 deg.

The wall solar azimuth γ may be found according to the following schedule:

For walls facing east of south:	For walls facing west of south:
$\gamma = \phi - \psi$ a.m.	$\gamma = \phi + \psi$ a.m.
$\gamma = \phi + \psi$ p.m.	$\gamma = \phi - \psi$ p.m.

Treat negative values of γ as if they were positive. If γ is greater than 90 deg, the wall is in the shade.

Values of K for other seasons and latitudes may be found in the literature,[7] or may be computed from data given in *Hydrographic Office Bulletin* No. 214, Tables of Computed Altitude and Azimuth[8] and the Ephemeris