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ASTM E891-87

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Standard Tables for
Terrestrial Direct Normal Solar Spectral Irradiance for Air Mass 1.5[1]

This standard is issued under the fixed designation E 891; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

These tables utilize the recently revised (1)[2] extraterrestrial spectrum of Neckel and Labs (2) and replace the previous standard based on Standard E 490. In addition, refinements were made to absorption and scattering calculations in the computer code (3, 4) used to calculate the spectrum. These refinements consist of a change in the depolarization factor in the Rayleigh scattering calculations, a more accurate sampling technique for calculating scattered irradiance, and a better choice of wavelengths to perform the calculations. Comparisons with the previous standard based on Standard E 490 have shown that approximately a 5 % difference can exist in narrow band widths of the specimen, but for the integrated total little difference is apparent.

1. Scope

1.1 These tables define an air mass 1.5 solar spectral irradiance distribution for use in all solar applications where a standard terrestrial spectral irradiance is required for the direct normal radiation. A similar standard for global irradiance on a 37° tilted surface is given in Standard E 892.

1.2 These tables are modeled data that were generated using a zero air mass solar spectrum based on the revised extraterrestrial spectrum of Neckel and Labs (1), the BRITE (3, 4) Monte Carlo radiative transfer code, and the 1962 U.S. Standard Atmosphere (5) with a rural aerosol (6, 7, 8). Further details are presented in Appendix X1.

1.3 The air mass zero (AM0) spectrum that was used to generate the terrestrial spectrum was provided by C. Fröhlich and C. Wehrli (1) and is a revised and extended Neckel and Labs (2) spectrum. Neckel and Labs revised their spectrum by employing newer limb-darkening data to convert from radiance to irradiance, as reported by Fröhlich (9), citing the study by Hardrop (10). Comparisons by Fröhlich with calibrated sun-photometer data from Mauna Loa, Hawaii, indicate that this new extraterrestrial spectrum is the best currently available.

1.4 The development of the terrestrial solar spectrum data is based on work reported by Bird, Hulstrom, and Lewis (11). In computing the terrestrial values using the BRITE Monte Carlo radiation transfer code, the authors cited took the iterations to 2.4500 µm only. We have extended the spectrum to 4.045 µm using sixteen $E\lambda_i$ values from the original Standard E 891 – 82.

Irradiance values in Standard E 891 – 82 were computed from the extraterrestrial spectrum represented by Standard E 490. The additional data points were added to account for the solar irradiance in this region that account for approximately 1.5 % of the total irradiance between 0.305 and 4.045 µm. The errors propagated by doing so are insignificant.

1.5 An air mass of 1.5 and a turbidity of 0.27 were chosen for this standard because they are representative of average conditions in the 48 contiguous states of the United States.

2. Referenced Documents

2.1 *ASTM Standards:*
E 490 Solar Constant and Air Mass Zero Solar Spectral Irradiance Tables[3]
E 772 Terminology Relating to Solar Energy Conversion[4]
E 892 Tables for Terrestrial Solar Spectral Irradiance at Air Mass 1.5 for a 37° Tilted Surface[5]

3. Terminology

3.1 *Definitions (from Terminology E 772):*
3.1.1 *air mass* (AM)— ratio of the mass of atmosphere in the actual observer-sun path to the mass that would exist if the observer were at sea level, at standard barometric pressure, and the sun were directly overhead.

NOTE 1—(Sometimes called air mass ratio.) Air mass varies with the zenith angle of the sun and the local barometric pressure, that changes with altitude. For sun zenith angle, Z, of 62° or less, and local atmospheric pressure, P, where P_o is standard atmospheric pressure, AM $\simeq$ sec Z (P/P_o).

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[1] This standard is under the jurisdiction of ASTM Committee G-3 on Durability of Nonmetallic Materials and is the direct responsibility of Subcommittee G03.09.
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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] *Annual Book of ASTM Standards*, Vol 15.03.
[4] *Annual Book of ASTM Standards*, Vol 12.02.
[5] *Annual Book of ASTM Standards*, Vol 06.01.

3.1.2 *solar irradiance, direct (E_s)*—solar flux coming from the solid angle of the sun's disk on a surface perpendicular to the axis of that solid angle.

3.1.2.1 *Discussion*—In conventional instruments the acceptance cone includes a plane angle of about 6°.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air mass zero* (AM0)—describing solar radiation quantities outside the Earth's atmosphere at the mean earth-sun distance.

3.2.2 *meteorological range*—distance V at which the threshold contrast, ϵ, between a black and white target is 0.02.

$$V = \frac{1}{\sigma} ln \frac{1}{\epsilon} \qquad (1)$$

Therefore, V is a function only of the atmospheric extinction coefficient σ.

3.2.3 *solar irradiance, spectral* (Eλ)—solar irradiance per unit wavelength interval at a given wavelength λ. (Units $W \cdot m^{-2} \cdot \mu m^{-1}$.)

$$E\lambda = dE/d\lambda \qquad (2)$$

4. Significance and Use

4.1 Absorptance, reflectance, and transmittance of terrestrial solar energy are important factors in solar thermal system performance, photovoltaic system performance, materials studies, biomass studies, and solar simulation activities. For each of the optical properties, the initial measurements are normally a function of wavelength, which requires that the spectral distribution of the solar flux be known before the solar weighted property can be calculated. In order to compare the performance of competitive products, a single standard solar spectral irradiance distribution is desirable.

4.2 These tables provide an appropriate standard spectral irradiance distribution to be used in determining relative performance of solar thermal, photovoltaic, and other systems, components, and materials where the direct irradiance component is desired.

5. Solar Spectral Irradiance (Air Mass 1.5)

5.1 Table 1 presents the direct normal spectral irradiance in tabular form from 0.305 to 4.045 μm that is falling on a surface. The sun is at AM 1.5. The first column gives the wavelength (λ) in micrometres; the second gives the $\Delta\lambda$ integrating interval in micrometres; the third gives the direct irradiance in $W \cdot m^{-2} \cdot \mu m^{-1}$; the fourth gives the integrated solar irradiance in the wavelength range from 0.3 μm to λ_i in $W \cdot m^{-2}$; and the fifth gives the fraction of the direct normal solar irradiance in the wavelength range 0 to λ_i. There is an insignificant amount of radiation reaching the earth's surface below 0.3 μm. A plot of the results is shown in the Appendix.

6. Application

6.1 The output per unit area, O_s, of a device or system exposed to solar irradiance is the integral over wavelength of the product of the appropriate spectral response, $R(\lambda)$ (photovoltaic, photochemical, optical absorptance, reflectance, transmittance, etc.), and the solar spectral irradiance, $E\lambda$ as follows:

$$O_s = \int_0^\infty R(\lambda)E\lambda d\lambda \qquad (3)$$

6.2 The solar response R_s of a device or system is the weighted average spectral response with the solar spectral irradiance as the weighting function as follows:

$$R_s = \frac{\int_0^\infty R(\lambda)E\lambda d\lambda}{\int_0^\infty E\lambda d\lambda} \qquad (4)$$

6.3 Since the spectral response or property and the spectral irradiance are not known as algebraic expressions in general, the integration must be performed as summations so that eqs 1 and 2 become, respectively,

$$O_s = \sum_{i=1}^N R(\lambda_i)E\lambda_i \Delta\lambda_i, \text{ and} \qquad (5)$$

$$R_s = \sum_{i=1}^N R(\lambda_i)E\lambda_i \Delta\lambda_i / \sum_{i=1}^N E\lambda_i \Delta\lambda_i \qquad (6)$$

where:
λ_i = wavelength of the ith point out of N for which the spectral data is known.

6.4 *Weighted Ordinate Method*—The summations are performed as indicated in Eq 5 and Eq 6 by using the values of λ_i, $\Delta\lambda_i$, and $E\lambda_i$ given in Table 1. Interpolation between nearby values of the spectral response, $R(\lambda)$, is often required since the wavelengths of the digitally recorded response curves may differ from those given in the table.

6.5 *Selected Ordinate Method:*

6.5.1 In the selected ordinate method the solar spectral irradiance is divided into m wavelength intervals, each containing $1/m$ of the total solar irradiance, $E_{0-\infty}$ and having a centroid wavelength λ_j. This makes all the products $E\lambda_j\Delta\lambda_j$ equal to $E_{0-\infty}/m$, allowing them to be factored from the summation. Eq 5 and Eq 5 respectively reduce to the following:

$$O_s = \frac{E_{0-\infty}}{m} \sum_{j=1}^m R(\lambda_j), \text{ and} \qquad (7)$$

$$R_s = 1/m \sum_{j=1}^m R(\lambda_j) \qquad (8)$$

6.5.2 Appropriate values for the centroid wavelengths for 100 and 50 selected ordinates are provided in Table 2 and Table 3. For devices with spectral responses that are relatively smooth, the 50-point selected ordinates are adequate. For devices with spectral responses that contain complex structure the 100-point selected ordinate or weighted ordinate method should be used.

7. Bias

7.1 In the spectral region of interest to most solar users (0.3 to 4.045 μm), the BRITE Monte Carlo computer code has not been adequately verified with experimental data. A comparison of the direct normal irradiance resulting from this code has been compared with other rigorous codes. The comparison indicates that the various models agree within ±5 % in spectral regions where there is significant radiation present. Almost all of the differences in the results of these rigorous codes can be traced to differences in the molecular absorption coefficients used as input to the codes.

7.2 The direct normal irradiance presented is the same as

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TABLE 1 Direct Normal Irradiance—Standard Curve

NOTE 1—λ_i = wavelength, μm.

$E\lambda_i$ = direct normal spectral irradiance at wavelength λ_i (centered at λ_i and calculated using absorption data with a resolution of 20 cm^{-1}), $W \cdot m^{-2} \cdot \mu m^{-1}$.

$E_0 - \lambda_i$ = integrated direct normal irradiance in the wavelength range 0 to λ_i, $W \cdot m^{-2}$.

$E_0 - \lambda_n$ = integrated solar irradiance over all wavelengths included in Table 1, $W \cdot m^{-2}$.

λ_i	$E\lambda_i$	$E_0 - \lambda_i$	$F\lambda_i$	λ_i	$E\lambda_i$	$E_0 - \lambda_i$	$F\lambda_i$
0.3050	3.4	0.02	0.0000	0.9800	549.7	518.10	0.6743
0.3100	15.6	0.07	0.0001	0.9935	630.1	526.06	0.6847
0.3150	41.1	0.21	0.0003	1.0400	582.9	554.26	0.7214
0.3200	71.2	0.49	0.0006	1.0700	539.7	571.10	0.7433
0.3250	100.2	0.92	0.0012	1.1000	366.2	584.69	0.7610
0.3300	152.4	1.55	0.0020	1.1200	98.1	589.33	0.7670
0.3350	155.6	2.32	0.0030	1.1300	169.5	590.67	0.7688
0.3400	179.4	3.16	0.0041	1.1370	118.7	591.68	0.7701
0.3450	186.7	4.08	0.0053	1.1610	301.9	596.73	0.7767
0.3500	212.0	5.07	0.0066	1.1800	406.8	603.46	0.7854
0.3600	240.5	7.34	0.0095	1.2000	375.2	611.28	0.7956
0.3700	324.0	10.16	0.0132	1.2350	423.6	625.26	0.8138
0.3800	362.4	13.59	0.0177	1.2900	365.7	646.96	0.8421
0.3900	381.7	17.31	0.0225	1.3200	223.4	655.80	0.8536
0.4000	556.0	22.00	0.0286	1.3500	30.1	659.60	0.8585
0.4100	656.3	28.06	0.0365	1.3950	1.4	660.31	0.8594
0.4200	690.8	34.80	0.0453	1.4425	51.6	661.57	0.8611
0.4300	641.9	41.46	0.0540	1.4625	97.0	663.06	0.8630
0.4400	798.5	48.66	0.0633	1.4770	97.3	664.46	0.8648
0.4500	956.6	57.44	0.0748	1.4970	167.1	667.11	0.8683
0.4600	990.0	67.17	0.0874	1.5200	239.3	671.78	0.8744
0.4700	998.0	77.12	0.1004	1.5390	248.8	676.42	0.8804
0.4800	1046.1	87.34	0.1137	1.5588	249.3	681.15	0.8866
0.4900	1005.1	97.59	0.1270	1.5780	222.3	685.87	0.8927
0.5000	1026.7	107.75	0.1402	1.5920	227.3	689.01	0.8968
0.5100	1066.7	118.22	0.1539	1.6100	210.5	692.95	0.9019
0.5200	1011.5	128.61	0.1674	1.6300	224.7	697.31	0.9076
0.5300	1084.9	139.89	0.1810	1.6460	215.9	700.83	0.9122
0.5400	1082.4	149.93	0.1951	1.6780	202.8	707.53	0.9209
0.5500	1102.2	160.85	0.2094	1.7400	158.2	718.72	0.9355
0.5700	1087.4	182.75	0.2379	1.8000	28.6	724.33	0.9428
0.5900	1024.3	203.87	0.2653	1.8600	1.8	725.24	0.9439
0.6100	1088.8	225.00	0.2928	1.9200	1.1	725.32	0.9441
0.6300	1062.1	246.51	0.3208	1.9608	19.7	725.74	0.9446
0.6500	1061.7	267.74	0.3485	1.9850	84.9	727.05	0.9463
0.6700	1046.2	288.82	0.3759	2.0050	25.0	728.15	0.9477
0.6900	859.2	387.88	0.4007	2.0358	92.5	729.91	0.9500
0.7100	1002.4	326.49	0.4249	2.0650	56.3	732.14	0.9529
0.7180	816.9	333.77	0.4344	2.1000	82.7	734.57	0.9561
0.7244	842.8	339.08	0.4413	2.1480	76.2	738.39	0.9611
0.7400	971.0	353.23	0.4597	2.1980	66.4	741.95	0.9657
0.7525	956.3	365.27	0.4754	2.2700	65.0	746.68	0.9719
0.7575	942.2	378.82	0.4816	2.3600	57.6	752.20	0.9790
0.7625	524.8	373.69	0.4864	2.4500	19.8	755.68	0.9836
0.7675	830.7	377.08	0.4908	2.4940	17.0	756.49	0.9846
0.7800	908.9	387.95	0.5049	2.5370	3.0	756.92	0.9852
0.8000	873.4	405.77	0.5281	2.9418	4.0	758.34	0.9870
0.8160	712.0	418.46	0.5446	2.9730	7.0	758.51	0.9872
0.8237	660.2	423.74	0.5515	3.0050	6.0	758.72	0.9875
0.8315	765.5	429.30	0.5580	3.0560	3.0	758.95	0.9878
0.8400	799.8	435.95	0.5674	3.1320	5.0	759.25	0.9882
0.8600	815.2	452.10	0.5884	3.1560	18.0	759.53	0.9886
0.8800	778.3	468.04	0.6092	3.2040	1.2	759.99	0.9892
0.9050	630.4	485.65	0.6321	3.2450	3.0	760.08	0.9893
0.9150	565.2	491.62	0.6399	3.3170	12.0	760.62	0.9900
0.9250	586.4	497.38	0.6474	3.3440	3.0	760.82	0.9902
0.9300	348.1	499.72	0.6504	3.4500	12.2	761.62	0.9913
0.9370	224.2	501.72	0.6530	3.5730	11.0	763.05	0.9932
0.9480	271.4	504.45	0.6566	3.7650	9.0	764.97	0.9957
0.9650	451.2	510.59	0.6646	4.0450	6.9	767.20	0.9986
				>4.0450		768.31	1.0000

that measured with a 5.8 field-of-view normal incidence pyrheliometer that allows a small amount of circumsolar (diffuse) radiation to be detected. For the type of atmospheric conditions modeled, this circumsolar radiation adds approximately 1 % to the measured direct irradiance.

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TABLE 2 100 Selected Ordinates for Direct Normal Irradiance[A]

F_k	$E_0 - \lambda_k$	λ_k	F_k	$E_0 - \lambda_k$	λ_k
0.005	3.8416	0.3437	0.505	387.9965	0.7801
0.015	11.5247	0.3740	0.515	395.6796	0.7887
0.025	19.2078	0.3940	0.525	403.3627	0.7973
0.035	26.8909	0.4081	0.535	411.0458	0.8067
0.045	34.5740	0.4197	0.545	418.7289	0.8164
0.055	42.2571	0.4311	0.555	426.4120	0.8274
0.065	49.9402	0.4415	0.565	434.0951	0.8376
0.075	57.6233	0.4502	0.575	441.7782	0.8472
0.085	65.3063	0.4581	0.585	449.4613	0.8567
0.095	72.9895	0.4658	0.595	457.1444	0.8663
0.105	80.6725	0.4735	0.605	464.8275	0.8760
0.115	88.3556	0.4810	0.615	472.5106	0.8863
0.125	96.0387	0.4885	0.625	480.1937	0.8973
0.135	103.7219	0.4960	0.635	487.8768	0.9087
0.145	111.4050	0.5035	0.645	495.5599	0.9218
0.155	119.0881	0.5108	0.655	503.2430	0.9431
0.165	126.7712	0.5182	0.665	510.9261	0.9657
0.175	134.4543	0.5256	0.675	518.6092	0.9809
0.185	142.1374	0.5328	0.685	526.2923	0.9939
0.195	149.8205	0.5399	0.695	533.9754	1.0066
0.205	157.5036	0.5469	0.705	541.6585	1.0192
0.215	165.1867	0.5540	0.715	549.3416	1.0319
0.225	172.8698	0.5610	0.725	557.0247	1.0449
0.235	180.5529	0.5680	0.735	564.7078	1.0586
0.245	188.2360	0.5752	0.745	572.3909	1.0728
0.255	195.9191	0.5825	0.755	580.0740	1.0898
0.265	203.6022	0.5897	0.765	587.7571	1.1132
0.275	211.2853	0.5970	0.775	595.4402	1.1549
0.285	218.9684	0.6043	0.785	603.1233	1.1790
0.295	226.6515	0.6115	0.795	610.8064	1.1988
0.305	234.3346	0.6187	0.805	618.4895	1.2180
0.315	242.0177	0.6258	0.815	626.1726	1.2373
0.325	249.7008	0.6330	0.825	633.8557	1.2568
0.335	257.3839	0.6402	0.835	641.5388	1.2763
0.345	265.0670	0.6475	0.845	649.2219	1.2977
0.355	272.7501	0.6548	0.855	656.9050	1.3287
0.365	280.4332	0.6620	0.865	664.5881	1.4780
0.375	288.1163	0.6693	0.875	672.2712	1.5220
0.385	295.7994	0.6773	0.885	679.9543	1.5532
0.395	303.4825	0.6854	0.895	687.6374	1.5859
0.405	311.1656	0.6935	0.905	695.3205	1.6209
0.415	318.8487	0.7018	0.915	703.0036	1.6564
0.425	326.5318	0.7100	0.925	710.6867	1.6955
0.435	334.2149	0.7185	0.935	718.3698	1.7381
0.445	341.8980	0.7275	0.945	726.0529	1.9660
0.455	349.5811	0.7360	0.955	733.7360	2.0880
0.465	357.2642	0.7442	0.965	741.4191	2.1905
0.475	364.9473	0.7522	0.975	749.1022	2.3095
0.485	372.6304	0.7611	0.985	756.7853	2.5235
0.495	380.3135	0.7712	0.995	764.4684	3.7148

[A] Data given at the wavelength midpoints of the equal energy intervals.

APPENDIXES

(Nonmandatory Information)

X1. ATMOSPHERIC PARAMETERS OF THE MODEL ATMOSPHERE

X1.1 The 1962 U.S. standard atmosphere model **(4)** with a rural aerosol was used to produce the data for this standard. This atmospheric model exhibits the following parameters for a vertical path from sea-level to the top of the atmosphere:

Precipitable water vapor	=	14.2 mm
Total ozone	=	3.4 mm
Turbidity (base e, λ = 0.5 µm)	=	0.27

X1.2 Atmospheric parameters, such as: temperature, pressure, aerosol density, air density, and the density of nine molecular species are defined at 33 levels within the atmosphere. Atmospheric parameters vary exponentially between the 33 levels. The precipitable water vapor and total ozone was derived by integrating water vapor and ozone concentrations throughout the exponentially varying 33 levels. The absorption and scattering properties of the aerosol were calculated with Mie theory. A bi-model, log-normal aerosol size distribution with a complex index of refraction that varies with wavelength was used to define the aerosol. The turbidity used corresponds

TABLE 3 50 Selected Ordinates for Direct Normal Irradiance[A]

F_k	$E_0 - \lambda_k$	λ_k
0.010	7.6831	0.3612
0.030	23.0493	0.4017
0.050	38.4155	0.4254
0.070	53.7817	0.4458
0.090	69.1479	0.4620
0.110	84.5141	0.4772
0.130	99.8803	0.4923
0.150	115.2465	0.5072
0.170	130.6127	0.5219
0.190	145.9789	0.5364
0.210	161.3451	0.5505
0.230	176.7113	0.5645
0.250	192.0775	0.5788
0.270	207.4437	0.5934
0.290	222.8099	0.6079
0.310	238.1761	0.6223
0.330	253.5423	0.6366
0.350	268.9085	0.6511
0.370	284.2747	0.6657
0.390	299.6409	0.6814
0.410	315.0071	0.6977
0.430	330.3733	0.7143
0.450	345.7395	0.7317
0.470	361.1057	0.7482
0.490	376.4719	0.7666
0.510	391.8381	0.7844
0.530	407.2043	0.8018
0.550	422.5705	0.8220
0.570	437.9367	0.8425
0.590	453.3029	0.8615
0.610	468.6691	0.8809
0.630	484.0353	0.9027
0.650	499.4015	0.9293
0.670	514.7677	0.9733
0.690	530.1339	1.0002
0.710	545.5001	1.0256
0.730	560.8663	1.0518
0.750	576.2325	1.0813
0.770	591.5987	1.1364
0.790	606.9649	1.1890
0.810	622.3311	1.2277
0.830	637.6973	1.2685
0.850	653.0635	1.3107
0.870	668.4297	1.5035
0.890	683.7959	1.5692
0.910	699.1621	1.6384
0.930	714.5283	1.7168
0.950	729.8945	2.0342
0.970	745.2607	2.2484
0.990	760.6269	3.3179

[A] Data given at the wavelength midpoints of the equal energy intervals.

to a sea-level meteorological range of 23 km.

X1.3 The standard data presented here was generated for a solar zenith angle of 48.19° (AM 1.5) and computed for an atmosphere with a composition that is estimated to be a reasonable average for the 48 contiguous states of the United States over a period of a year.

X2. COMPUTATIONAL TECHNIQUE FOR TABULATED VALUES DERIVED FROM THE SPECTRAL IRRADIANCE

X2.1 Integrated Irradiance

X2.1.1 The integrated irradiance values $E_{0-\lambda i}$ presented in column 4 and used in column 5 of Table 1 were computed using a modified trapezoidal integration technique. More specifically

$$E_{0\to\lambda i} = E_{0\to\lambda 1} + \sum_{j=1}^{i-1}\left(\frac{E_{\lambda j+1} + E_{\lambda j}}{2}\right)\Delta\lambda_j \qquad \text{(X2.1)}$$

where:

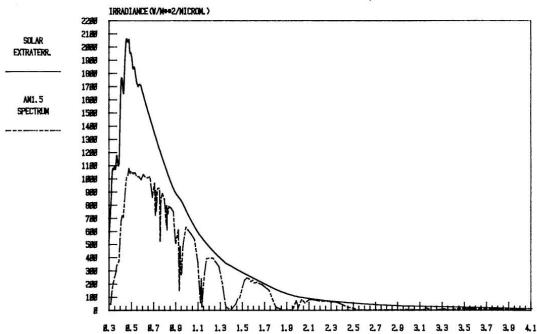$$\Delta\lambda_j = \lambda_{j+1} - \lambda_j \qquad \text{(X2.2)}$$

and $E_0 - \lambda_1$ is the contribution prior to the first tabulated wavelength. This is estimated as half of the first trapezoidal area interval as:

$$E_{0-\lambda 1} = 1/2\left(\frac{E\lambda_2 + E_{\lambda 1}}{2}\right)(\lambda_2 - \lambda_1). \qquad \text{(X2.3)}$$

Similarly, $E_{\lambda\lambda N\to\infty}$, the total irradiance beyond the last tabulated wavelength λ_N is estimated as

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FIG. X2.1 Plot of Direct Normal Irradiance-USSTD Atmosphere

$$E_{\lambda N \to \infty} = 1/2 \left(\frac{E_{\lambda N} + E_{\lambda N-1}}{2} \right)(\lambda_N - \lambda_{N-1}). \qquad \text{(X2.4)}$$

Leading to an expression for the solar irradiance,

$$E_{0 \to \infty} = E_{0 \to \lambda N} + E_{\lambda N - \infty}. \qquad \text{(X2.5)}$$

X2.2 Selected Ordinates

X2.2.1 Wavelength values were derived for the selected ordinates by an area interpolation procedure. The k_{th} selected ordinate wavelength was derived from:

$$F_k = F_{i+1} - \frac{\Delta F}{\Delta \lambda i} \Delta \lambda_k \qquad \text{(X2.6)}$$

where:
$F_i = E_{0 \to \lambda i}/E_{0 \to \infty}$
$\Delta \lambda_k = \lambda_{i+1} - \lambda_k$, and
$F_i < F_k < F_{i+1}$.

Compute λ_k (the wavelength at midpoint of the equal energy interval) from the following equation:

$$\lambda_k = \lambda_i + \left[\frac{E_{0-\lambda k} - E_{0-\lambda i}}{E_{0-\lambda_{i+1}} - E_{0-\lambda i}} \right] \cdot (\lambda_{i+1} - \lambda_i) \qquad \text{(X2.7)}$$

where:

$$\lambda_i < \lambda_k < \lambda_{i+1}, \text{ and } E_{0-\lambda k} = F_k E_{0-\infty}. \qquad \text{(X2.8)}$$

The value of F_k appropriate for the k_{th} selected ordinate is given by $F_k = (2K - 1)/2m$.

where:

m = number of elected ordinate points desired (50, or 100).

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