
**Plastics — Standard table for
reference global solar spectral
irradiance at sea level — Horizontal,
relative air mass 1**

*Plastiques — Table de référence pour l'irradiance solaire spectrale
totale au niveau de la mer — Horizontale, masse d'air relative 1*

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Foreword

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The committee responsible for this document is ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

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Introduction

The effect of solar radiation on surface of the earth (global radiation) is the most important primary weathering factor. The photons absorbed by the molecules during radiation exposure are often sufficient to split chemical bonds, start photochemical reactions and cause an electron transfer^[1]. The spectral irradiance of the solar radiation is variable locally and in time. A reference spectrum is therefore required as a basis for the simulation of the spectral irradiance of solar radiation with artificial radiation sources/radiation systems. Data of the CIE (Commission Internationale de L'Éclairage) Publication (No. 85, 1989) have been used as a basis for years. Table 4 specifies the spectral irradiance of global radiation (direct and diffuse radiation) for a cloudless sky, zenith position of the sun by day and night comparisons at the equator at sea level. But in CIE 85, the data of the global solar irradiance only begins at 305 nm, the step width is very rough and the calculation code got unexplainably lost. Therefore, there have been efforts to revise CIE No. 85 for many years. The new [Table 1](#) gives modelled data (using the SMARTS model version 2.9.2) generated using an air mass zero (AM0) spectrum based on extraterrestrial spectrum of Gueymard^{[2][3]}.

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Plastics — Standard table for reference global solar spectral irradiance at sea level — Horizontal, relative air mass 1

1 Scope

This Technical Report provides a reference spectrum to the field of weathering degradation (see [Table 1](#)) in order to classify solar simulators in the UV, visible and infrared wavelength range.

The photochemical ageing which occurs in practice is simulated with time compression in laboratory weathering instruments by sequencing maximum stress climate episodes. To give a spectral irradiance target, the table specifies the spectral irradiance of global radiation (direct and diffuse radiation) with a cloudless sky, zenith position of the sun by day and night comparisons at the equator at sea level as defined in Table 4 of CIE No. 85. This is a realistic maximum exposure under representative clear sky conditions.

The data contained in [Table 1](#), [Figure 2](#), and [Figure 3](#) were generated using the SMARTS2 Version 2.9.2[2] [3] to recalculate the CIE No. 85, Table 4.

[Table 2](#) contains the original data from CIE No. 85, Table 4. The numbers are shown in [Figure 2](#) and [Figure 3](#) as well.

2 References

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CIE No. 85, Technical Report; *Solar Spectral Irradiance*; 1989

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

global solar irradiance

solar radiant flux, both direct and diffuse, received on a horizontal plane unit area from a solid angle of 2π steradians

Note 1 to entry: It is measured in watts per square metre ($\text{W}\cdot\text{m}^{-2}$).

3.2

spectral irradiance

E_λ

radiant flux per unit area per wavelength interval

Note 1 to entry: It is measured in watts per square metre per nanometre ($\text{W}\cdot\text{m}^{-2}\cdot\text{nm}^{-1}$).

**3.3
air mass**

relative optical path length of solar radiation through Earth's atmosphere for the purpose of this Technical Report

Note 1 to entry: As solar radiation passes through the atmosphere, it is attenuated by scattering and absorption. The more atmosphere through which it passes, the greater is the attenuation.

4 Reference global solar spectral irradiance at sea level

The reference global solar spectral irradiance for air mass 1.0 (illustration see [Figure 1](#)) is given in [Table 1](#) and [Figure 2](#) and [Figure 3](#). This is the global distribution (direct and diffuse) of the solar radiation corresponding to an integrated irradiance of 1 092 W m⁻² incident on a sun-facing horizontal plane considering the ground reflection of 0,2 under the following atmospheric conditions.

- The United States Standard Atmosphere Profile of 1976 (USSA76) except for the prescribed parameters below:
 - total hemispherical horizontal component;
 - total column water vapour 1,42 cm;
 - total column ozone 0,34 cm;
 - aerosol optical depth at 500 nm 0,1.
- The rural aerosol distribution of Shettle and Fenn was assumed.
- A carbon dioxide concentration of 370 ppm by volume was assumed.
- The direct beam included a circumsolar component, as if seen with a 5,6° field of view pyrheliometer.

[Annex A](#) contains the SMARTS2 input files used to generate the tabular data in [Table 1](#).

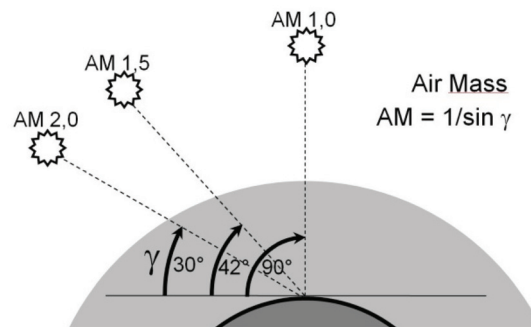


Figure 1 — Air mass coefficient defines the direct optical path length through the Earth's atmosphere

Table 1 — Reference global solar irradiance recalculated with SMART2 (input data from CIE No. 85, Table 4)

Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)
285,0	1,85E-11	305,5	0,0760	326,0	0,6710	346,5	0,7450	367,0	1,0310
285,5	6,67E-11	306,0	0,0740	326,5	0,7030	347,0	0,7560	367,5	1,0100
286,0	1,84E-10	306,5	0,0820	327,0	0,6900	347,5	0,7280	368,0	0,9490
286,5	8,17E-10	307,0	0,1010	327,5	0,6710	348,0	0,7240	368,5	0,9410
287,0	2,11E-09	307,5	0,1210	328,0	0,6270	348,5	0,7340	369,0	0,9830
287,5	6,13E-09	308,0	0,1270	328,5	0,6420	349,0	0,7060	369,5	1,0540
288,0	2,35E-08	308,5	0,1350	329,0	0,7130	349,5	0,7230	370,0	1,0670
288,5	5,24E-08	309,0	0,1290	329,5	0,7860	350,0	0,7970	370,5	0,9630
289,0	1,38E-07	309,5	0,1290	330,0	0,7920	350,5	0,8560	371,0	0,9770
289,5	3,99E-07	310,0	0,1470	330,5	0,7290	351,0	0,8310	371,5	1,0130
290,0	9,48E-07	310,5	0,1860	331,0	0,6880	351,5	0,7990	372,0	0,9470
290,5	1,84E-06	311,0	0,2290	331,5	0,7050	352,0	0,7780	372,5	0,9010
291,0	3,81E-06	311,5	0,2300	332,0	0,7220	352,5	0,7330	373,0	0,8670
291,5	9,09E-06	312,0	0,2420	332,5	0,7200	353,0	0,7780	373,5	0,7800
292,0	1,80E-05	312,5	0,2480	333,0	0,7050	353,5	0,8540	374,0	0,7770
292,5	2,53E-05	313,0	0,2640	333,5	0,6760	354,0	0,9010	374,5	0,7700
293,0	4,37E-05	313,5	0,2680	334,0	0,6880	354,5	0,9090	375,0	0,8210
293,5	9,18E-05	314,0	0,2870	334,5	0,7270	355,0	0,9080	375,5	0,9060
294,0	1,45E-04	314,5	0,2980	335,0	0,7510	355,5	0,8750	376,0	0,9370
294,5	2,04E-04	315,0	0,3080	335,5	0,7290	356,0	0,8190	376,5	0,9210
295,0	3,29E-04	315,5	0,2730	336,0	0,6670	356,5	0,7670	377,0	0,9870
295,5	6,18E-04	316,0	0,2740	336,5	0,6170	357,0	0,6730	377,5	1,0990
296,0	9,36E-04	316,5	0,3220	337,0	0,6050	357,5	0,6800	378,0	1,1830
296,5	1,23E-03	317,0	0,3670	337,5	0,6490	358,0	0,6320	378,5	1,1510
297,0	1,52E-03	317,5	0,3930	338,0	0,6940	358,5	0,5860	379,0	1,0260
297,5	2,53E-03	318,0	0,3700	338,5	0,7230	359,0	0,6880	379,5	0,9190
298,0	3,52E-03	318,5	0,3740	339,0	0,7340	359,5	0,8280	380,0	0,9640
298,5	3,99E-03	319,0	0,4030	339,5	0,7500	360,0	0,8740	380,5	1,0320
299,0	5,06E-03	319,5	0,3970	340,0	0,7960	360,5	0,8250	381,0	1,0480
299,5	7,77E-03	320,0	0,4170	340,5	0,7920	361,0	0,7580	381,5	0,9440
300,0	8,60E-03	320,5	0,4780	341,0	0,7410	361,5	0,7410	382,0	0,8030
300,5	1,00E-02	321,0	0,4700	341,5	0,7340	362,0	0,7750	382,5	0,6940
301,0	1,40E-02	321,5	0,4460	342,0	0,7640	362,5	0,8470	383,0	0,6210
301,5	1,80E-02	322,0	0,4300	342,5	0,7900	363,0	0,8690	383,5	0,6010
302,0	1,80E-02	322,5	0,4180	343,0	0,8010	363,5	0,8440	384,0	0,6940
302,5	2,50E-02	323,0	0,3980	343,5	0,7560	364,0	0,8730	384,5	0,8350
303,0	3,80E-02	323,5	0,4470	344,0	0,6530	364,5	0,8630	385,0	0,9150
303,5	4,60E-02	324,0	0,4910	344,5	0,6250	365,0	0,8950	385,5	0,8730
304,0	4,70E-02	324,5	0,5120	345,0	0,7090	365,5	0,9830	386,0	0,8410
304,5	0,056	325,0	0,517	345,5	0,753	366,0	1,052	386,5	0,874
305,0	0,071	325,5	0,588	346,0	0,733	366,5	1,052	387,0	0,880

Table 1 (continued)

Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)
387,5	0,867	416,0	1,606	457,0	1,903	498,0	1,790	539,0	1,727
388,0	0,857	417,0	1,564	458,0	1,861	499,0	1,788	540,0	1,667
388,5	0,850	418,0	1,494	459,0	1,844	500,0	1,781	541,0	1,603
389,0	0,922	419,0	1,552	460,0	1,830	501,0	1,726	542,0	1,745
389,5	1,021	420,0	1,420	461,0	1,892	502,0	1,725	543,0	1,713
390,0	1,070	421,0	1,610	462,0	1,907	503,0	1,805	544,0	1,774
390,5	1,078	422,0	1,586	463,0	1,912	504,0	1,686	545,0	1,732
391,0	1,140	423,0	1,533	464,0	1,851	505,0	1,801	546,0	1,717
391,5	1,155	424,0	1,522	465,0	1,825	506,0	1,872	547,0	1,737
392,0	1,062	425,0	1,566	466,0	1,861	507,0	1,790	548,0	1,687
392,5	0,884	426,0	1,519	467,0	1,777	508,0	1,742	549,0	1,738
393,0	0,640	427,0	1,465	468,0	1,853	509,0	1,823	550,0	1,723
393,5	0,508	428,0	1,478	469,0	1,859	510,0	1,773	551,0	1,720
394,0	0,659	429,0	1,366	470,0	1,786	511,0	1,804	552,0	1,754
394,5	0,909	430,0	1,088	471,0	1,814	512,0	1,850	553,0	1,704
395,0	1,072	431,0	0,986	472,0	1,906	513,0	1,736	554,0	1,736
395,5	1,141	432,0	1,638	473,0	1,831	514,0	1,698	555,0	1,745
396,0	1,002	433,0	1,522	474,0	1,851	515,0	1,746	556,0	1,715
396,5	0,728	434,0	1,404	475,0	1,911	516,0	1,761	557,0	1,673
397,0	0,563	435,0	1,539	476,0	1,846	517,0	1,433	558,0	1,709
397,5	0,831	436,0	1,684	477,0	1,856	518,0	1,638	559,0	1,617
398,0	1,124	437,0	1,716	478,0	1,914	519,0	1,587	560,0	1,645
398,5	1,327	438,0	1,504	479,0	1,875	520,0	1,731	561,0	1,740
399,0	1,407	439,0	1,446	480,0	1,903	521,0	1,743	562,0	1,656
399,5	1,449	440,0	1,655	481,0	1,900	522,0	1,781	563,0	1,719
400,0	1,463	441,0	1,629	482,0	1,904	523,0	1,678	564,0	1,685
401,0	1,521	442,0	1,742	483,0	1,878	524,0	1,804	565,0	1,696
402,0	1,577	443,0	1,765	484,0	1,841	525,0	1,790	566,0	1,603
403,0	1,515	444,0	1,718	485,0	1,833	526,0	1,739	567,0	1,709
404,0	1,537	445,0	1,781	486,0	1,484	527,0	1,521	568,0	1,695
405,0	1,496	446,0	1,594	487,0	1,660	528,0	1,741	569,0	1,658
406,0	1,456	447,0	1,810	488,0	1,795	529,0	1,821	570,0	1,658
407,0	1,427	448,0	1,830	489,0	1,690	530,0	1,750	571,0	1,601
408,0	1,488	449,0	1,823	490,0	1,886	531,0	1,844	572,0	1,694
409,0	1,586	450,0	1,887	491,0	1,811	532,0	1,810	573,0	1,700
410,0	1,350	451,0	1,955	492,0	1,725	533,0	1,615	574,0	1,691
411,0	1,508	452,0	1,869	493,0	1,843	534,0	1,729	575,0	1,654
412,0	1,599	453,0	1,724	494,0	1,798	535,0	1,753	576,0	1,639
413,0	1,532	454,0	1,846	495,0	1,907	536,0	1,827	577,0	1,679
414,0	1,512	455,0	1,831	496,0	1,812	537,0	1,689	578,0	1,625
415,0	1,563	456,0	1,889	497,0	1,841	538,0	1,772	579,0	1,646
580,0	1,669	621,0	1,600	662,0	1,467	703,0	1,326	744,0	1,269

Table 1 (continued)

Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)	Wave-length (nm)	Spectral irradiance (W·m ⁻² ·nm ⁻¹)
581,0	1,673	622,0	1,547	663,0	1,466	704,0	1,353	745,0	1,268
582,0	1,696	623,0	1,540	664,0	1,471	705,0	1,366	746,0	1,265
583,0	1,710	624,0	1,532	665,0	1,492	706,0	1,356	747,0	1,265
584,0	1,705	625,0	1,518	666,0	1,487	707,0	1,349	748,0	1,257
585,0	1,690	626,0	1,515	667,0	1,474	708,0	1,344	749,0	1,253
586,0	1,648	627,0	1,560	668,0	1,477	709,0	1,345	750,0	1,251
587,0	1,686	628,0	1,502	669,0	1,501	710,0	1,354	751,0	1,245
588,0	1,654	629,0	1,535	670,0	1,479	711,0	1,350	752,0	1,249
589,0	1,442	630,0	1,515	671,0	1,475	712,0	1,339	753,0	1,243
590,0	1,531	631,0	1,530	672,0	1,454	713,0	1,325	754,0	1,258
591,0	1,628	632,0	1,471	673,0	1,465	714,0	1,336	755,0	1,254
592,0	1,598	633,0	1,558	674,0	1,462	715,0	1,295	756,0	1,239
593,0	1,614	634,0	1,531	675,0	1,449	716,0	1,310	757,0	1,238
594,0	1,608	635,0	1,547	676,0	1,465	717,0	1,185	758,0	1,245
595,0	1,591	636,0	1,510	677,0	1,451	718,0	1,115	759,0	1,216
596,0	1,628	637,0	1,560	678,0	1,458	719,0	1,007	760,0	0,448
597,0	1,635	638,0	1,568	679,0	1,445	720,0	1,076	761,0	0,310
598,0	1,611	639,0	1,560	680,0	1,447	721,0	1,155	762,0	0,840
599,0	1,608	640,0	1,525	681,0	1,440	722,0	1,284	763,0	0,567
600,0	1,620	641,0	1,524	682,0	1,447	723,0	1,203	764,0	0,716
601,0	1,599	642,0	1,525	683,0	1,430	724,0	1,130	765,0	0,839
602,0	1,574	643,0	1,541	684,0	1,421	725,0	1,118	766,0	0,929
603,0	1,606	644,0	1,532	685,0	1,421	726,0	1,158	767,0	1,050
604,0	1,634	645,0	1,543	686,0	1,389	727,0	1,153	768,0	1,154
605,0	1,630	646,0	1,502	687,0	1,125	728,0	1,121	769,0	1,158
606,0	1,619	647,0	1,502	688,0	1,242	729,0	1,111	770,0	1,181
607,0	1,626	648,0	1,489	689,0	1,247	730,0	1,194	771,0	1,183
608,0	1,619	649,0	1,442	690,0	1,287	731,0	1,139	772,0	1,191
609,0	1,605	650,0	1,440	691,0	1,320	732,0	1,209	773,0	1,190
610,0	1,597	651,0	1,528	692,0	1,341	733,0	1,236	774,0	1,190
611,0	1,587	652,0	1,478	693,0	1,335	734,0	1,273	775,0	1,189
612,0	1,610	653,0	1,513	694,0	1,321	735,0	1,256	776,0	1,192
613,0	1,587	654,0	1,494	695,0	1,332	736,0	1,244	777,0	1,184
614,0	1,537	655,0	1,431	696,0	1,330	737,0	1,242	778,0	1,183
615,0	1,592	656,0	1,252	697,0	1,384	738,0	1,255	779,0	1,188
616,0	1,549	657,0	1,309	698,0	1,362	739,0	1,218	780,0	1,175
617,0	1,528	658,0	1,460	699,0	1,346	740,0	1,244	781,0	1,172
618,0	1,585	659,0	1,465	700,0	1,336	741,0	1,237	782,0	1,177
619,0	1,592	660,0	1,476	701,0	1,322	742,0	1,236	783,0	1,172
620,0	1,592	661,0	1,474	702,0	1,319	743,0	1,261	784,0	1,164
785,0	1,169	826,0	0,966	867,0	0,916	908,0	0,699	949,0	0,573
786,0	1,170	827,0	1,008	868,0	0,960	909,0	0,741	950,0	0,214