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Colorimetry —

Part 2: CIE standard illuminants

Colorimétrie —

Partie 2: Illuminants CIE normalisés

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by the International Commission on Illumination (CIE) in cooperation with Technical Committee ISO/TC 274, *Light and lighting*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 139, *Paints and varnishes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition cancels and replaces ISO 11664-2:2007/CIE S 014-2:2006, which has been technically revised.

The main changes are as follows:

— CIE illuminant D50 has been included as CIE standard illuminant because of its extensive use in the fields of graphic, arts and photography.

A list of all parts in the ISO/CIE 11664 series can be found on the CIE and ISO websites.

Any feedback or questions on this document should be directed to the CIE Central Bureau or the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

The illuminants defined in this document are as follows:

a) CIE standard illuminant A

CIE standard illuminant A is intended to represent typical tungsten-filament lighting. Its relative spectral power distribution is that of a Planckian radiator at a temperature of approximately 2 855,5 K. CIE standard illuminant A should be used in all applications of colorimetry involving the use of incandescent lighting, unless there are specific reasons for using a different illuminant. CIE standard illuminant A is used in photometry as primary reference spectrum for the calibration of photometric devices.

b) CIE standard illuminant D65

CIE standard illuminant D65 is intended to represent average daylight having a correlated colour temperature of approximately 6 500 K. CIE standard illuminant D65 should be used in all colorimetric calculations requiring representative outdoor daylight, unless there are specific reasons for using a different spectral power distribution. Variations in the relative spectral power distribution of daylight are known to occur, particularly in the ultraviolet spectral region, as a function of season, time of day and geographic location. However, CIE standard illuminant D65 is used pending the availability of additional information on these variations.

c) CIE standard illuminant D50

CIE standard illuminant D50 is intended to represent daylight with a correlated colour temperature of approximately 5 000 K. CIE standard illuminant D50 should be used in colorimetric calculations where the use of such a correlated colour temperature is intended.

Values for the relative spectral power distribution of CIE standard illuminants A, D65 and D50 are given in this document at 1-nm intervals from 300 nm to 830 nm.

The term "illuminant" refers to a defined spectral power distribution, not necessarily realizable or provided by an artificial source. Illuminants are used in colorimetry to compute the tristimulus values of reflected or transmitted object colours under specified conditions of illumination. The CIE has also defined other illuminants, such as illuminant C, other daylight illuminants, and illuminants for LED and other electric light sources. These illuminants are described in CIE 015, but they do not have the status of CIE standard illuminants. It is recommended that one of the three CIE standard illuminants defined in this document be used wherever possible. This will greatly facilitate the comparison of published results.

In most practical applications of colorimetry, it is sufficient to use the values of CIE standard illuminants A, D65 and D50 at less frequent wavelength intervals or in a narrower spectral region than specified in this document. Data and guidelines that facilitate such practice are provided in CIE 015, together with other recommended procedures for practical colorimetry.

The term "source" refers to a physical emitter of light, such as a lamp or the sun. In certain cases, the CIE recommends laboratory sources that approximate the spectral power distributions of CIE illuminants. In all cases, however, the definition of a CIE-recommended source is secondary to the definition of the corresponding CIE illuminant, because of the possibility that, from time to time, new developments will lead to improved sources that represent a particular illuminant more accurately or are more suitable for laboratory use.

CIE standard source A, the practical realization of CIE standard illuminant A, is described in this document. At present, there are no CIE-recommended sources representing CIE standard illuminants D65 and D50.

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Colorimetry —

Part 2:
CIE standard illuminants

1 Scope

This document defines three CIE standard illuminants for use in colorimetry: CIE standard illuminant A for the representation of typical tungsten-filament lighting, CIE standard illuminant D65 for the representation of average daylight having a correlated colour temperature of approximately 6 500 K and CIE standard illuminant D50 for the representation of daylight with a correlated colour temperature of approximately 5 000 K. Values of the relative spectral power distribution of the three illuminants are included in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CIE S 017, *ILV: International Lighting Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CIE S 017 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

CIE maintains a terminology database for use in standardization at the following address:

— CIE e-ILV: available at http://cie.co.at/e-ilv

3.1
illuminant
radiation with a relative spectral power distribution defined over the wavelength range that influences object colour perception

[SOURCE: CIE S 017:2020, Entry 17-23-018, modified — Notes to entry omitted.]

3.2
CIE standard illuminant
illuminant standardized by the CIE for the purpose of harmonization

[SOURCE: CIE S 017:2020, Entry 17-23-021, modified — Notes to entry omitted.]

3.3
CIE standard source
artificial source specified by the CIE whose radiation approximates a CIE standard illuminant

[SOURCE: CIE S 017:2020, Entry 17-23-022, modified — Notes to entry omitted.]

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3.4
daylight illuminant
D illuminant
illuminant having the same or nearly the same relative spectral power distribution of the radiant flux as a phase of daylight

[SOURCE: CIE S 017:2020, Entry 17-23-020, modified — Notes to entry omitted.]

3.5
standard air
dry air at 15 °C and 101 325 Pa, containing 0,045 % by volume of carbon dioxide

[SOURCE: CIE 018:2019, Clause 3]

4 CIE standard illuminant A

4.1 Definition

The relative spectral power distribution of CIE standard illuminant A, $S_A(\lambda)$, is defined by Formula (1) over the wavelength range 300 nm to 830 nm.

$$S_A(\lambda) = 100\left(\frac{560}{\lambda}\right)^5 \times \frac{\exp\frac{1{,}435\times10^7}{2\,848\times560} - 1}{\exp\frac{1{,}435\times10^7}{2\,848\;\lambda} - 1} \quad (1)$$

where λ is the wavelength in nanometres and the numerical values in the two exponential terms are definitive constants originating from the first definition of illuminant A in 1931 (see also Annex C). This spectral power distribution is normalized to the value 100 (exactly) at the wavelength 560 nm (exactly).

NOTE Table A.1 in Annex A provides the relative spectral power distribution of CIE standard illuminant A to six significant digits, at 1-nm intervals. For practical purposes it suffices to use these tabulated values instead of the values calculated from Formula (1).

Despite the fact that Formula (1) is based on Planck's equation for vacuum, the wavelengths are to be taken as being in standard air (see 3.5). This makes CIE standard illuminant A compatible with other CIE colorimetric and photometric data.

4.2 Theoretical basis

Formula (1) is equivalent to and can be derived from Formula (2):

$$S_\lambda(\lambda) = 100\frac{M_{e,\lambda}(\lambda,T)}{M_{e,\lambda}(560,T)} \quad (2)$$

where

$$M_{e,\lambda}(\lambda,T) = c_1\,\lambda^{-5}\left[\exp\left(\frac{c_2}{\lambda T}\right) - 1\right]^{-1};$$

λ is the wavelength (in nm);

the quotient c_2/T is given by 14 350 μm·K/2 848 K = (1,435 × 10^7/2 848) nm.

Since the numerical value of c_1 cancels out Formula (2), this definition of CIE standard illuminant A involves no assumptions about the numerical values of c_1, c_2 and T other than the quotient c_2/T.

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The constant c_2 is calculated from $h \cdot c/k$ and its value is 14 387,768 55 ... µm·K, using the values of the Planck constant, h, the speed of light in vacuum, c, and the Boltzmann constant, k, as specified in *The International System of Units*[1]. Using this value for c_2, the assigned temperature for CIE standard illuminant A is 2 855,496 ... K, thus approximately 2 855,5 K.

NOTE More information regarding the historical changes to the temperature used to define CIE standard illuminant A can be found in Annex C.

5 CIE standard illuminant D65

5.1 Definition

CIE standard illuminant D65 shall be as defined in Annex B by the relative spectral power distribution values provided in Column 2 of Table B.1. The values are presented at 1-nm intervals over the wavelength range from 300 nm to 830 nm; the wavelength values given apply in standard air. If required, other intermediate values shall be derived by linear interpolation from the published values.

5.2 Experimental basis

The relative spectral power distribution of CIE standard illuminant D65 is based on experimental measurements of daylight in the wavelength range 330 nm to 700 nm, with extrapolations to 300 nm and 830 nm, as reported by Judd et al.[2] The extrapolated values are believed to be sufficiently accurate for conventional colorimetric purposes, but are not recommended for non-colorimetric use.

5.3 Correlated colour temperature

CIE standard illuminant D65 has a nominal correlated colour temperature of 6 500 K.

NOTE Using the value of c_2 = 14 388 µm·K specified in the *International Temperature Scale* of 1990,[3] the definition of correlated colour temperature (CIE S 017, 17–23–068) and the relative spectral power distribution data of Table B.1, the correlated colour temperature of CIE standard illuminant D65 is found to be 6 502,712 K. Using the value of c_2 = 14 387,768 775 ... µm·K, as shown in 4.2, the definition of correlated colour temperature (CIE S 017, 17–23–068) and the relative spectral power distribution data of Table B.1, the correlated colour temperature of CIE standard illuminant D65 is found to be 6 502,608 K. The difference from the nominal correlated colour temperature of 6 500 K of CIE standard illuminant D65 is judged to be insignificantly small.

6 CIE standard illuminant D50

6.1 Definition

CIE standard illuminant D50 shall be as defined in Annex B by the relative spectral power distribution values provided in Column 3 of Table B.1. The values are presented at 1-nm intervals over the wavelength range from 300 nm to 830 nm; the wavelength values given apply in standard air. If required, other intermediate values shall be derived by linear interpolation from the published values.

6.2 Correlated colour temperature

CIE standard illuminant D50 has a nominal correlated colour temperature of 5 000 K.

NOTE Using the value of c_2 = 14 388 µm·K specified in the *International Temperature Scale* of 1990,[3] the definition of correlated colour temperature (CIE S 017, 17–23–068) and the relative spectral power distribution data of Table B.1, the correlated colour temperature of CIE standard illuminant D50 is found to be 5 001,319 K. Using the value of c_2 = 14 387,768 775 ... µm·K, as shown in 4.2, the definition of correlated colour temperature (CIE S 017, 17–23–068) and the relative spectral power distribution data of Table B.1, the correlated colour temperature of CIE standard illuminant D50 is found to be 5 001,239 K. The difference from the nominal correlated colour temperature of 5 000 K of CIE standard illuminant D50 is judged to be insignificantly small.

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The actual correlated colour temperature of CIE standard illuminant D50 is slightly different from 5 000 K; however, this is judged to be visually insignificant.

7 Sources for realizing CIE standard illuminants

7.1 Source for CIE standard illuminant A

CIE standard illuminant A can be realized by CIE standard source A, defined as a gas-filled, tungsten-filament lamp operating at an assigned temperature T = (2 848 K/14 350 µm·K) · c_2, where c_2 is expressed in µm·K. A lamp with a fused-quartz envelope or window is recommended if the spectral power distribution of the ultraviolet radiation of CIE standard illuminant A is to be realized more accurately.

The assigned temperature, T, is currently approximated to 2 855,5 K as shown in 4.2.

7.2 Sources for CIE standard illuminants D65 and D50

At present, there are no CIE-recommended standard sources for realizing CIE standard illuminants D65 and D50. The quality of sources intended for laboratory realization of CIE standard illuminant D65 or D50 can be assessed by a method described in ISO 23603/CIE S 012.[4]

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Annex A
(informative)

Table of relative spectral power distribution of CIE standard illuminant A

CIE standard illuminant A is defined by Formula (1) in 4.1. Table A.1 is provided for practical use only.

Table A.1 — Relative spectral power distribution of CIE standard illuminant A (wavelengths in standard air)

λ/nm	$S_A(\lambda)$
300	0,930 483
301	0,967 643
302	1,005 97
303	1,045 49
304	1,086 23
305	1,128 21
306	1,171 47
307	1,216 02
308	1,261 88
309	1,309 10
310	1,357 69
311	1,407 68
312	1,459 10
313	1,511 98
314	1,566 33
315	1,622 19
316	1,679 59
317	1,738 55
318	1,799 10
319	1,861 27
320	1,925 08
321	1,990 57
322	2,057 76
323	2,126 67
324	2,197 34
325	2,269 80
326	2,344 06
327	2,420 17
328	2,498 14
329	2,578 01
330	2,659 81
331	2,743 55
332	2,829 28

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
333	2,917 01
334	3,006 78
335	3,098 61
336	3,192 53
337	3,288 57
338	3,386 76
339	3,487 12
340	3,589 68
341	3,694 47
342	3,801 52
343	3,910 85
344	4,022 50
345	4,136 48
346	4,252 82
347	4,371 56
348	4,492 72
349	4,616 31
350	4,742 38
351	4,870 95
352	5,002 04
353	5,135 68
354	5,271 89
355	5,410 70
356	5,552 13
357	5,696 22
358	5,842 98
359	5,992 44
360	6,144 62
361	6,299 55
362	6,457 24
363	6,617 74
364	6,781 05
365	6,947 20
366	7,116 21
367	7,288 11
368	7,462 92
369	7,640 66
370	7,821 35
371	8,005 01
372	8,191 67
373	8,381 34
374	8,574 04
375	8,769 80
376	8,968 64

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
377	9,170 56
378	9,375 61
379	9,583 78
380	9,795 10
381	10,009 6
382	10,227 3
383	10,448 1
384	10,672 2
385	10,899 6
386	11,130 2
387	11,364 0
388	11,601 2
389	11,841 6
390	12,085 3
391	12,332 4
392	12,582 8
393	12,836 6
394	13,093 8
395	13,354 3
396	13,618 2
397	13,885 5
398	14,156 3
399	14,430 4
400	14,708 0
401	14,989 1
402	15,273 6
403	15,561 6
404	15,853 0
405	16,148 0
406	16,446 4
407	16,748 4
408	17,053 8
409	17,362 8
410	17,675 3
411	17,991 3
412	18,310 8
413	18,633 9
414	18,960 5
415	19,290 7
416	19,624 4
417	19,961 7
418	20,302 6
419	20,647 0
420	20,995 0

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
421	21,346 5
422	21,701 6
423	22,060 3
424	22,422 5
425	22,788 3
426	23,157 7
427	23,530 7
428	23,907 2
429	24,287 3
430	24,670 9
431	25,058 1
432	25,448 9
433	25,843 2
434	26,241 1
435	26,642 5
436	27,047 5
437	27,456 0
438	27,868 1
439	28,283 6
440	28,702 7
441	29,125 3
442	29,551 5
443	29,981 1
444	30,414 2
445	30,850 8
446	31,290 9
447	31,734 5
448	32,181 5
449	32,632 0
450	33,085 9
451	33,543 2
452	34,004 0
453	34,468 2
454	34,935 8
455	35,406 8
456	35,881 1
457	36,358 8
458	36,839 9
459	37,324 3
460	37,812 1
461	38,303 1
462	38,797 5
463	39,295 1
464	39,796 0

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
465	40,300 2
466	40,807 6
467	41,318 2
468	41,832 0
469	42,349 1
470	42,869 3
471	43,392 6
472	43,919 2
473	44,448 8
474	44,981 6
475	45,517 4
476	46,056 3
477	46,598 3
478	47,143 3
479	47,691 3
480	48,242 3
481	48,796 3
482	49,353 3
483	49,913 2
484	50,476 0
485	51,041 8
486	51,610 4
487	52,181 8
488	52,756 1
489	53,333 2
490	53,913 2
491	54,495 8
492	55,081 3
493	55,669 4
494	56,260 3
495	56,853 9
496	57,450 1
497	58,048 9
498	58,650 4
499	59,254 5
500	59,861 1
501	60,470 3
502	61,082 0
503	61,696 2
504	62,312 8
505	62,932 0
506	63,553 5
507	64,177 5
508	64,803 8

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
509	65,432 5
510	66,063 5
511	66,696 8
512	67,332 4
513	67,970 2
514	68,610 2
515	69,252 5
516	69,896 9
517	70,543 5
518	71,192 2
519	71,843 0
520	72,495 9
521	73,150 8
522	73,807 7
523	74,466 6
524	75,127 5
525	75,790 3
526	76,455 1
527	77,121 7
528	77,790 2
529	78,460 5
530	79,132 6
531	79,806 5
532	80,482 1
533	81,159 5
534	81,838 6
535	82,519 3
536	83,201 7
537	83,885 6
538	84,571 2
539	85,258 4
540	85,947 0
541	86,637 2
542	87,328 8
543	88,021 9
544	88,716 5
545	89,412 4
546	90,109 7
547	90,808 3
548	91,508 2
549	92,209 5
550	92,912 0
551	93,615 7
552	94,320 6

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
553	95,026 7
554	95,733 9
555	96,442 3
556	97,151 8
557	97,862 3
558	98,573 9
559	99,286 4
560	100,000
561	100,715
562	101,430
563	102,146
564	102,864
565	103,582
566	104,301
567	105,020
568	105,741
569	106,462
570	107,184
571	107,906
572	108,630
573	109,354
574	110,078
575	110,803
576	111,529
577	112,255
578	112,982
579	113,709
580	114,436
581	115,164
582	115,893
583	116,622
584	117,351
585	118,080
586	118,810
587	119,540
588	120,270
589	121,001
590	121,731
591	122,462
592	123,193
593	123,924
594	124,655
595	125,386
596	126,118

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
597	126,849
598	127,58
599	128,312
600	129,043
601	129,774
602	130,505
603	131,236
604	131,966
605	132,697
606	133,427
607	134,157
608	134,887
609	135,617
610	136,346
611	137,075
612	137,804
613	138,532
614	139,260
615	139,988
616	140,715
617	141,441
618	142,167
619	142,893
620	143,618
621	144,343
622	145,067
623	145,790
624	146,513
625	147,235
626	147,957
627	148,678
628	149,398
629	150,117
630	150,836
631	151,554
632	152,271
633	152,988
634	153,704
635	154,418
636	155,132
637	155,845
638	156,558
639	157,269
640	157,979

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
641	158,689
642	159,397
643	160,104
644	160,811
645	161,516
646	162,221
647	162,924
648	163,626
649	164,327
650	165,028
651	165,726
652	166,424
653	167,121
654	167,816
655	168,510
656	169,203
657	169,895
658	170,586
659	171,275
660	171,963
661	172,650
662	173,335
663	174,019
664	174,702
665	175,383
666	176,063
667	176,741
668	177,419
669	178,094
670	178,769
671	179,441
672	180,113
673	180,783
674	181,451
675	182,118
676	182,783
677	183,447
678	184,109
679	184,770
680	185,429
681	186,087
682	186,743
683	187,397
684	188,050

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
685	188,701
686	189,350
687	189,998
688	190,644
689	191,288
690	191,931
691	192,572
692	193,211
693	193,849
694	194,484
695	195,118
696	195,750
697	196,381
698	197,009
699	197,636
700	198,261
701	198,884
702	199,506
703	200,125
704	200,743
705	201,359
706	201,972
707	202,584
708	203,195
709	203,803
710	204,409
711	205,013
712	205,616
713	206,216
714	206,815
715	207,411
716	208,006
717	208,599
718	209,189
719	209,778
720	210,365
721	210,949
722	211,532
723	212,112
724	212,691
725	213,268
726	213,842
727	214,415
728	214,985

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
729	215,553
730	216,120
731	216,684
732	217,246
733	217,806
734	218,364
735	218,920
736	219,473
737	220,025
738	220,574
739	221,122
740	221,667
741	222,210
742	222,751
743	223,290
744	223,826
745	224,361
746	224,893
747	225,423
748	225,951
749	226,477
750	227,000
751	227,522
752	228,041
753	228,558
754	229,073
755	229,585
756	230,096
757	230,604
758	231,110
759	231,614
760	232,115
761	232,615
762	233,112
763	233,606
764	234,099
765	234,589
766	235,078
767	235,564
768	236,047
769	236,529
770	237,008
771	237,485
772	237,959

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
773	238,432
774	238,902
775	239,370
776	239,836
777	240,299
778	240,760
779	241,219
780	241,675
781	242,130
782	242,582
783	243,031
784	243,479
785	243,924
786	244,367
787	244,808
788	245,246
789	245,682
790	246,116
791	246,548
792	246,977
793	247,404
794	247,829
795	248,251
796	248,671
797	249,089
798	249,505
799	249,918
800	250,329
801	250,738
802	251,144
803	251,548
804	251,950
805	252,350
806	252,747
807	253,142
808	253,535
809	253,925
810	254,314
811	254,700
812	255,083
813	255,465
814	255,844
815	256,221
816	256,595

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Table A.1 *(continued)*

λ/nm	$S_A(\lambda)$
817	256,968
818	257,338
819	257,706
820	258,071
821	258,434
822	258,795
823	259,154
824	259,511
825	259,865
826	260,217
827	260,567
828	260,914
829	261,259
830	261,602

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Annex B
(normative)

Table of relative spectral power distributions of CIE standard illuminants D65 and D50

CIE standard illuminants D65 and D50 are defined by the relative spectral power distribution values provided in Table B.1.

Table B.1 — Relative spectral power distributions of CIE standard illuminants D65 and D50 (wavelengths in standard air)

λ/nm	$S_{D65}(\lambda)$	$S_{D50}(\lambda)$
300	0,034 100 0	0,019 220 0
301	0,360 140	0,222 348
302	0,686 180	0,425 476
303	1,012 22	0,628 604
304	1,338 26	0,831 732
305	1,664 30	1,034 86
306	1,990 34	1,237 99
307	2,316 38	1,441 12
308	2,642 42	1,644 24
309	2,968 46	1,847 37
310	3,294 50	2,050 50
311	4,988 65	2,623 29
312	6,682 80	3,196 08
313	8,376 95	3,768 87
314	10,071 1	4,341 66
315	11,765 2	4,914 45
316	13,459 4	5,487 24
317	15,153 5	6,060 03
318	16,847 7	6,632 82
319	18,541 8	7,205 61
320	20,236 0	7,778 40
321	21,917 7	8,475 31
322	23,599 5	9,172 22
323	25,281 2	9,869 13
324	26,963 0	10,566 0
325	28,644 7	11,263 0
326	30,326 5	11,959 9
327	32,008 2	12,656 8
328	33,690 0	13,353 7
329	35,371 7	14,050 6
330	37,053 5	14,747 5
331	37,343 0	15,067 6

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Table B.1 *(continued)*

λ/nm	$S_{D65}(\lambda)$	$S_{D50}(\lambda)$
332	37,632 6	15,387 6
333	37,922 1	15,707 6
334	38,211 6	16,027 7
335	38,501 1	16,347 8
336	38,790 7	16,667 8
337	39,080 2	16,987 8
338	39,369 7	17,307 9
339	39,659 3	17,628 0
340	39,948 8	17,948 0
341	40,445 1	18,254 2
342	40,941 4	18,560 3
343	41,437 7	18,866 5
344	41,934 0	19,172 7
345	42,430 2	19,478 8
346	42,926 5	19,785 0
347	43,422 8	20,091 2
348	43,919 1	20,397 4
349	44,415 4	20,703 5
350	44,911 7	21,009 7
351	45,084 4	21,302 9
352	45,257 0	21,596 1
353	45,429 7	21,889 4
354	45,602 3	22,182 6
355	45,775 0	22,475 8
356	45,947 7	22,769 0
357	46,120 3	23,062 2
358	46,293 0	23,355 5
359	46,465 6	23,648 7
360	46,638 3	23,941 9
361	47,183 4	24,243 8
362	47,728 5	24,545 7
363	48,273 5	24,847 5
364	48,818 6	25,149 4
365	49,363 7	25,451 3
366	49,908 8	25,753 2
367	50,453 9	26,055 1
368	50,998 9	26,356 9
369	51,544 0	26,658 8
370	52,089 1	26,960 7
371	51,877 7	26,713 4
372	51,666 4	26,466 1
373	51,455 0	26,218 7
374	51,243 7	25,971 4
375	51,032 3	25,724 1

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Table B.1 *(continued)*

λ/nm	$S_{D65}(\lambda)$	$S_{D50}(\lambda)$
376	50,820 9	25,476 8
377	50,609 6	25,229 5
378	50,398 2	24,982 1
379	50,186 9	24,734 8
380	49,975 5	24,487 5
381	50,442 8	25,025 8
382	50,910 0	25,564 1
383	51,377 3	26,102 4
384	51,844 6	26,640 7
385	52,311 8	27,179 0
386	52,779 1	27,717 4
387	53,246 4	28,255 7
388	53,713 7	28,794 0
389	54,180 9	29,332 3
390	54,648 2	29,870 6
391	57,458 9	31,814 4
392	60,269 5	33,758 1
393	63,080 2	35,701 8
394	65,890 9	37,645 6
395	68,701 5	39,589 4
396	71,512 2	41,533 1
397	74,322 9	43,476 8
398	77,133 6	45,420 6
399	79,944 2	47,364 4
400	82,754 9	49,308 1
401	83,628 0	50,028 6
402	84,501 1	50,749 0
403	85,374 2	51,469 5
404	86,247 3	52,190 0
405	87,120 4	52,910 4
406	87,993 6	53,630 9
407	88,866 7	54,351 4
408	89,739 8	55,071 9
409	90,612 9	55,792 3
410	91,486 0	56,512 8
411	91,680 6	56,864 9
412	91,875 2	57,217 0
413	92,069 7	57,569 1
414	92,264 3	57,921 2
415	92,458 9	58,273 3
416	92,653 5	58,625 4
417	92,848 1	58,977 5
418	93,042 6	59,329 6
419	93,237 2	59,681 7

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Table B.1 *(continued)*

λ/nm	$S_{D65}(\lambda)$	$S_{D50}(\lambda)$
420	93,431 8	60,033 8
421	92,756 8	59,812 2
422	92,081 9	59,590 5
423	91,406 9	59,368 9
424	90,732 0	59,147 3
425	90,057 0	58,925 6
426	89,382 1	58,704 0
427	88,707 1	58,482 4
428	88,032 2	58,260 8
429	87,357 2	58,039 1
430	86,682 3	57,817 5
431	88,500 6	59,518 2
432	90,318 8	61,219 0
433	92,137 1	62,919 7
434	93,955 4	64,620 5
435	95,773 6	66,321 2
436	97,591 9	68,021 9
437	99,410 2	69,722 7
438	101,228	71,423 4
439	103,047	73,124 2
440	104,865	74,824 9
441	106,079	76,067 1
442	107,294	77,309 4
443	108,508	78,551 6
444	109,722	79,793 8
445	110,936	81,036 0
446	112,151	82,278 3
447	113,365	83,520 5
448	114,579	84,762 7
449	115,794	86,005 0
450	117,008	87,247 2
451	117,088	87,583 7
452	117,169	87,920 2
453	117,249	88,256 7
454	117,330	88,593 2
455	117,410	88,929 7
456	117,490	89,266 2
457	117,571	89,602 7
458	117,651	89,939 2
459	117,732	90,275 7
460	117,812	90,612 2
461	117,517	90,687 8
462	117,222	90,763 4
463	116,927	90,839 0

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Table B.1 *(continued)*

λ/nm	$S_{D65}(\lambda)$	$S_{D50}(\lambda)$
464	116,632	90,914 6
465	116,336	90,990 2
466	116,041	91,065 7
467	115,746	91,141 3
468	115,451	91,216 9
469	115,156	91,292 5
470	114,861	91,368 1
471	114,967	91,742 1
472	115,073	92,116 2
473	115,180	92,490 2
474	115,286	92,864 3
475	115,392	93,238 3
476	115,498	93,612 3
477	115,604	93,986 4
478	115,711	94,360 4
479	115,817	94,734 5
480	115,923	95,108 5
481	115,212	94,793 9
482	114,501	94,479 3
483	113,789	94,164 8
484	113,078	93,850 2
485	112,367	93,535 6
486	111,656	93,221 0
487	110,945	92,906 4
488	110,233	92,591 9
489	109,522	92,277 3
490	108,811	91,962 7
491	108,865	92,338 8
492	108,920	92,714 9
493	108,974	93,091 0
494	109,028	93,467 1
495	109,082	93,843 2
496	109,137	94,219 3
497	109,191	94,595 4
498	109,245	94,971 5
499	109,300	95,347 6
500	109,354	95,723 7
501	109,199	95,812 7
502	109,044	95,901 6
503	108,888	95,990 6
504	108,733	96,079 5
505	108,578	96,168 5
506	108,423	96,257 5
507	108,268	96,346 4

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Table B.1 *(continued)*

λ/nm	$S_{D65}(\lambda)$	$S_{D50}(\lambda)$
508	108,112	96,435 4
509	107,957	96,524 3
510	107,802	96,613 3
511	107,501	96,664 9
512	107,200	96,716 4
513	106,898	96,768 0
514	106,597	96,819 6
515	106,296	96,871 2
516	105,995	96,922 7
517	105,694	96,974 3
518	105,392	97,025 9
519	105,091	97,077 4
520	104,790	97,129 0
521	105,080	97,626 0
522	105,370	98,123 0
523	105,660	98,620 0
524	105,950	99,117 0
525	106,239	99,614 0
526	106,529	100,111
527	106,819	100,608
528	107,109	101,105
529	107,399	101,602
530	107,689	102,099
531	107,361	101,965
532	107,032	101,830
533	106,704	101,696
534	106,375	101,561
535	106,047	101,427
536	105,719	101,292
537	105,390	101,158
538	105,062	101,024
539	104,733	100,889
540	104,405	100,755
541	104,369	100,911
542	104,333	101,067
543	104,297	101,223
544	104,261	101,380
545	104,225	101,536
546	104,190	101,692
547	104,154	101,848
548	104,118	102,005
549	104,082	102,161
550	104,046	102,317
551	103,641	102,085

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Table B.1 *(continued)*

λ/nm	$S_{D65}(\lambda)$	$S_{D50}(\lambda)$
552	103,237	101,854
553	102,832	101,622
554	102,428	101,390
555	102,023	101,158
556	101,618	100,927
557	101,214	100,695
558	100,809	100,463
559	100,405	100,232
560	100,000	100,000
561	99,633 4	99,773 5
562	99,266 8	99,547 0
563	98,900 3	99,320 5
564	98,533 7	99,094 0
565	98,167 1	98,867 5
566	97,800 5	98,641 0
567	97,433 9	98,414 5
568	97,067 4	98,188 0
569	96,700 8	97,961 5
570	96,334 2	97,735 0
571	96,279 6	97,853 3
572	96,225 0	97,971 6
573	96,170 3	98,089 9
574	96,115 7	98,208 2
575	96,061 1	98,326 5
576	96,006 5	98,444 8
577	95,951 9	98,563 1
578	95,897 2	98,681 4
579	95,842 6	98,799 7
580	95,788 0	98,918 0
581	95,077 8	98,376 1
582	94,367 5	97,834 2
583	93,657 3	97,292 2
584	92,947 0	96,750 3
585	92,236 8	96,208 4
586	91,526 6	95,666 5
587	90,816 3	95,124 6
588	90,106 1	94,582 6
589	89,395 8	94,040 7
590	88,685 6	93,498 8
591	88,817 7	93,917 7
592	88,949 7	94,336 6
593	89,081 8	94,755 5
594	89,213 8	95,174 4
595	89,345 9	95,593 3

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Table B.1 *(continued)*

λ/nm	$S_{D65}(\lambda)$	$S_{D50}(\lambda)$
596	89,478 0	96,012 2
597	89,610 0	96,431 1
598	89,742 1	96,850 0
599	89,874 1	97,268 9
600	90,006 2	97,687 8
601	89,965 5	97,845 9
602	89,924 8	98,004 1
603	89,884 1	98,162 2
604	89,843 4	98,320 3
605	89,802 6	98,478 4
606	89,761 9	98,636 6
607	89,721 2	98,794 7
608	89,680 5	98,952 8
609	89,639 8	99,111 0
610	89,599 1	99,269 1
611	89,409 1	99,246 3
612	89,219 0	99,223 6
613	89,029 0	99,200 8
614	88,838 9	99,178 1
615	88,648 9	99,155 3
616	88,458 9	99,132 5
617	88,268 8	99,109 8
618	88,078 8	99,087 0
619	87,888 7	99,064 3
620	87,698 7	99,041 5
621	87,257 7	98,709 5
622	86,816 7	98,377 6
623	86,375 7	98,045 6
624	85,934 7	97,713 6
625	85,493 6	97,381 6
626	85,052 6	97,049 7
627	84,611 6	96,717 7
628	84,170 6	96,385 7
629	83,729 6	96,053 8
630	83,288 6	95,721 8
631	83,329 7	96,035 3
632	83,370 7	96,348 9
633	83,411 8	96,662 4
634	83,452 8	96,976 0
635	83,493 9	97,289 5
636	83,535 0	97,603 0
637	83,576 0	97,916 6
638	83,617 1	98,230 1
639	83,658 1	98,543 7

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Table B.1 *(continued)*

λ/nm	$S_{D65}(\lambda)$	$S_{D50}(\lambda)$
640	83,699 2	98,857 2
641	83,332 0	98,538 2
642	82,964 7	98,219 2
643	82,597 5	97,900 2
644	82,230 2	97,581 2
645	81,863 0	97,262 2
646	81,495 8	96,943 2
647	81,128 5	96,624 2
648	80,761 3	96,305 2
649	80,394 0	95,986 2
650	80,026 8	95,667 2
651	80,045 6	95,919 5
652	80,064 4	96,171 7
653	80,083 1	96,424 0
654	80,101 9	96,676 2
655	80,120 7	96,928 5
656	80,139 5	97,180 8
657	80,158 3	97,433 0
658	80,177 0	97,685 3
659	80,195 8	97,937 5
660	80,214 6	98,189 8
661	80,420 9	98,671 2
662	80,627 2	99,152 5
663	80,833 6	99,633 9
664	81,039 9	100,115
665	81,246 2	100,597
666	81,452 5	101,078
667	81,658 8	101,559
668	81,865 2	102,041
669	82,071 5	102,522
670	82,277 8	103,003
671	81,878 4	102,616
672	81,479 1	102,229
673	81,079 7	101,842
674	80,680 4	101,455
675	80,281 0	101,068
676	79,881 6	100,681
677	79,482 3	100,294
678	79,082 9	99,907 1
679	78,683 6	99,520 0
680	78,284 2	99,133 0
681	77,427 9	97,957 8
682	76,571 6	96,782 6
683	75,715 3	95,607 4

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