Designation: E 308 – 01

Standard Practice for Computing the Colors of Objects by Using the CIE System[1]

This standard is issued under the fixed designation E 308; 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.

This standard has been approved for use by agencies of the Department of Defense.

INTRODUCTION

Standard tables (Tables 1-4) of color matching functions and illuminant spectral power distributions have since 1931 been defined by the CIE, but the CIE has eschewed the role of preparing tables of tristimulus weighting factors for the convenient calculation of tristimulus values. There have subsequently appeared numerous compilations of tristimulus weighting factors in the literature with disparity of data resulting from, for example, different selections of wavelength intervals and methods of truncating abbreviated wavelength ranges. In 1970, Foster et al. **(1)**[2] proposed conventions to standardize these two features, and Stearns **(2)** published a more complete set of tables. Stearns' work and later publications such as the 1985 revision of E 308 have greatly reduced the substantial variations in methods for tristimulus computation that existed several decades ago.

The disparities among earlier tables were largely caused by the introduction of computations based on 20-nm wavelength intervals. With the increasing precision of modern instruments, there is a likelihood of a need for tables for narrower wavelength intervals. Stearns' tables, based on a 10-nm interval, did not allow the derivation of consistent tables with wavelength intervals less than 10 nm. The 1-nm table must be designated the basic table if others with greater wavelength intervals are to have the same white point, and this was the reason for the 1985 revision of E 308, resulting in tables that are included in the present revision as Tables 5.

The 1994 revision was made in order to introduce to the user a method of reducing the dependence of the computed tristimulus values on the bandpass of the measuring instrument, using methods that are detailed in this practice. These changes, however, lead to tables (Tables 6 in this practice) that are substantially different from the Tables 5 that have been in use since 1985. There is accordingly a danger, if the new tables are introduced but not universally adopted, that there may again be, perhaps for several decades, a significant disparity among the tables of tristimulus weighting factors commonly used. It is highly desirable that this should be avoided.

1. Scope

1.1 This practice provides the values and practical computation procedures needed to obtain CIE tristimulus values from spectral reflectance, transmittance, or radiance data for object-color specimens.

1.2 Procedures and tables of standard values are given for computing from spectral measurements the CIE tristimulus values *X, Y, Z, and chromaticity coordinates x, y for the CIE 1931 standard observer and* X_{10}, Y_{10}, Z_{10} *and* x_{10}, y_{10} *for the CIE 1964 supplementary standard observer.*

1.3 Standard values are included for the spectral power of six CIE standard illuminants and three CIE recommended fluorescent illuminants.

1.4 Procedures are included for cases in which data are available only in more limited wavelength ranges than those recommended, or for a measurement interval wider than that recommended by the CIE. This practice is applicable to spectral data obtained according to Practice E 1164 with 1-, 5-, 10-, or 20-nm measurement interval.

1.5 Procedures are included for cases in which the spectral data are, and those in which they are not, corrected for bandpass dependence. For the uncorrected cases, it is assumed that the spectral bandpass of the instrument used to obtain the data was approximately equal to the measurement interval and was triangular in shape. These choices are believed to correspond to the most widely used industrial practice.

1.6 This practice includes procedures for conversion of

[1] This practice is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.04 on Color and Appearance Analysis.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this practice.

results to color spaces that are part of the CIE system, such as CIELAB and CIELUV **(3)**. Equations for calculating color differences in these and other systems are given in Test Method D 2244.

TABLE 1 Spectral Tristimulus Values (Color-Matching Functions) $\bar{x}$, $\bar{y}$, $\bar{z}$ of the CIE 1931 Standard (2°) Observer, at 5 nm Intervals from 380 to 780 nm (See Note 2 and Ref (3))

λ(nm)	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$
380	0.0014	0.0000	0.0065
385	0.0022	0.0001	0.0105
390	0.0042	0.0001	0.0201
395	0.0076	0.0002	0.0362
400	0.0143	0.0004	0.0679
405	0.0232	0.0006	0.1102
410	0.0435	0.0012	0.2074
415	0.0776	0.0022	0.3713
420	0.1344	0.0040	0.6456
425	0.2148	0.0073	1.0391
430	0.2839	0.0116	1.3856
435	0.3285	0.0168	1.6230
440	0.3483	0.0230	1.7471
445	0.3481	0.0298	1.7826
450	0.3362	0.0380	1.7721
455	0.3187	0.0480	1.7441
460	0.2908	0.0600	1.6692
465	0.2511	0.0739	1.5281
470	0.1954	0.0910	1.2876
475	0.1421	0.1126	1.0419
480	0.0956	0.1390	0.8130
485	0.0580	0.1693	0.6162
490	0.0320	0.2080	0.4652
495	0.0147	0.2586	0.3533
500	0.0049	0.3230	0.2720
505	0.0024	0.4073	0.2123
510	0.0093	0.5030	0.1582
515	0.0291	0.6082	0.1117
520	0.0633	0.7100	0.0782
525	0.1096	0.7932	0.0573
530	0.1655	0.8620	0.0422
535	0.2257	0.9149	0.0298
540	0.2904	0.9540	0.0203
545	0.3597	0.9803	0.0134
550	0.4334	0.9950	0.0087
555	0.5121	1.0000	0.0057
560	0.5945	0.9950	0.0039
565	0.6784	0.9786	0.0027
570	0.7621	0.9520	0.0021
575	0.8425	0.9154	0.0018
580	0.9163	0.8700	0.0017
585	0.9786	0.8163	0.0014
590	1.0263	0.7570	0.0011
595	1.0567	0.6949	0.0010
600	1.0622	0.6310	0.0008
605	1.0456	0.5668	0.0006
610	1.0026	0.5030	0.0003
615	0.9384	0.4412	0.0002
620	0.8544	0.3810	0.0002
625	0.7514	0.3210	0.0001
630	0.6424	0.2650	0.0000
635	0.5419	0.2170	0.0000
640	0.4479	0.1750	0.0000
645	0.3608	0.1382	0.0000
650	0.2835	0.1070	0.0000
655	0.2187	0.0816	0.0000
660	0.1649	0.0610	0.0000
665	0.1212	0.0446	0.0000
670	0.0874	0.0320	0.0000
675	0.0636	0.0232	0.0000
680	0.0468	0.0170	0.0000
685	0.0329	0.0119	0.0000
690	0.0227	0.0082	0.0000
695	0.0158	0.0057	0.0000
700	0.0114	0.0041	0.0000
705	0.0081	0.0029	0.0000
710	0.0058	0.0021	0.0000
715	0.0041	0.0015	0.0000
720	0.0029	0.0010	0.0000
725	0.0020	0.0007	0.0000
730	0.0014	0.0005	0.0000
735	0.0010	0.0004	0.0000
740	0.0007	0.0002	0.0000
745	0.0005	0.0002	0.0000
750	0.0003	0.0001	0.0000
755	0.0002	0.0001	0.0000
760	0.0002	0.0001	0.0000
765	0.0001	0.0000	0.0000
770	0.0001	0.0000	0.0000
775	0.0001	0.0000	0.0000
780	0.0000	0.0000	0.0000
Summation at 5 nm intervals:			
$\Sigma\bar{x}(\lambda) = 21.3714$			
$\Sigma\bar{y}(\lambda) = 21.3711$			
$\Sigma\bar{z}(\lambda) = 21.3715$			

TABLE 2 Spectral Tristimulus Values (Color-Matching Functions) $\bar{x}_{10}$, $\bar{y}_{10}$, $\bar{z}_{10}$ of the CIE 1964 Supplementary Standard (10°) Observer, At 5 nm Intervals from 380 to 780 nm (See Note 2 and Ref 3)

λ(nm)	$\bar{x}_{10}(\lambda)$	$\bar{y}_{10}(\lambda)$	$\bar{z}_{10}(\lambda)$
380	0.0002	0.0000	0.0007
385	0.0007	0.0001	0.0029
390	0.0024	0.0003	0.0105
395	0.0072	0.0008	0.0323
400	0.0191	0.0020	0.0860
405	0.0434	0.0045	0.1971
410	0.0847	0.0088	0.3894
415	0.1406	0.0145	0.6568
420	0.2045	0.0214	0.9725
425	0.2647	0.0295	1.2825
430	0.3147	0.0387	1.5535
435	0.3577	0.0496	1.7985
440	0.3837	0.0621	1.9673
445	0.3867	0.0747	2.0273
450	0.3707	0.0895	1.9948
455	0.3430	0.1063	1.9007
460	0.3023	0.1282	1.7454
465	0.2541	0.1528	1.5549
470	0.1956	0.1852	1.3176
475	0.1323	0.2199	1.0302
480	0.0805	0.2536	0.7721
485	0.0411	0.2977	0.5701
490	0.0162	0.3391	0.4153
495	0.0051	0.3954	0.3024

TABLE 2 *Continued*

λ(nm)	$\bar{x}_{10}(\lambda)$	$\bar{y}_{10}(\lambda)$	$\bar{z}_{10}(\lambda)$
500	0.0038	0.4608	0.2185
505	0.0154	0.5314	0.1592
510	0.0375	0.6067	0.1120
515	0.0714	0.6857	0.0822
520	0.1177	0.7618	0.0607
525	0.1730	0.8233	0.0431
530	0.2365	0.8752	0.0305
535	0.3042	0.9238	0.0206
540	0.3768	0.9620	0.0137
545	0.4516	0.9822	0.0079
550	0.5298	0.9918	0.0040
555	0.6161	0.9991	0.0011
560	0.7052	0.9973	0.0000
565	0.7938	0.9824	0.0000
570	0.8787	0.9556	0.0000
575	0.9512	0.9152	0.0000
580	1.0142	0.8689	0.0000
585	1.0743	0.8256	0.0000
590	1.1185	0.7774	0.0000
595	1.1343	0.7204	0.0000
600	1.1240	0.6583	0.0000
605	1.0891	0.5939	0.0000
610	1.0305	0.5280	0.0000
615	0.9507	0.4618	0.0000
620	0.8563	0.3981	0.0000
625	0.7549	0.3396	0.0000
630	0.6475	0.2835	0.0000
635	0.5351	0.2283	0.0000
640	0.4316	0.1798	0.0000
645	0.3437	0.1402	0.0000
650	0.2683	0.1076	0.0000
655	0.2043	0.0812	0.0000
660	0.1526	0.0603	0.0000
665	0.1122	0.0441	0.0000
670	0.0813	0.0318	0.0000
675	0.0579	0.0226	0.0000
680	0.0409	0.0159	0.0000
685	0.0286	0.0111	0.0000
690	0.0199	0.0077	0.0000
695	0.0138	0.0054	0.0000
700	0.0096	0.0037	0.0000
705	0.0066	0.0026	0.0000
710	0.0046	0.0018	0.0000
715	0.0031	0.0012	0.0000
720	0.0022	0.0008	0.0000
725	0.0015	0.0006	0.0000
730	0.0010	0.0004	0.0000
735	0.0007	0.0003	0.0000
740	0.0005	0.0002	0.0000
745	0.0004	0.0001	0.0000
750	0.0003	0.0001	0.0000
755	0.0002	0.0001	0.0000
760	0.0001	0.0000	0.0000
765	0.0001	0.0000	0.0000
770	0.0001	0.0000	0.0000
775	0.0000	0.0000	0.0000
780	0.0000	0.0000	0.0000

Summation at 5 nm intervals:

$\Sigma\bar{x}_{10}(\lambda) = 23.3294$
$\Sigma\bar{y}_{10}(\lambda) = 23.3324$
$\Sigma\bar{z}_{10}(\lambda) = 23.3343$

TABLE 3 Relative Spectral Power Distributions S(λ) of CIE Standard Illuminants *A*, *C*, D_{50}, D_{55}, D_{65}, and D_{75} at 5-nm Intervals from 380 to 780 nm (See Note 2 and Ref 3)

λ (nm)	*A* *S*(λ)	*C* *S*(λ)	D_{50} *S*(λ)	D_{55} *S*(λ)	D_{65} *S*(λ)	D_{75} *S*(λ)
380	9.80	33.00	24.49	32.58	49.98	66.70
385	10.90	39.92	27.18	35.34	52.31	68.33
390	12.09	47.40	29.87	38.09	54.65	69.96
395	13.35	55.17	39.59	49.52	68.70	85.95
400	14.71	63.30	49.31	60.95	82.75	101.93
405	16.15	71.81	52.91	64.75	87.12	106.91
410	17.68	80.60	56.51	68.55	91.49	111.89
415	19.29	89.53	58.27	70.07	92.46	112.35
420	20.99	98.10	60.03	71.58	93.43	112.80
425	22.79	105.80	58.93	69.75	90.06	107.94
430	24.67	112.40	57.82	67.91	86.68	103.09
435	26.64	117.75	66.32	76.76	95.77	112.14
440	28.70	121.50	74.82	85.61	104.86	121.20
445	30.85	123.45	81.04	91.80	110.94	127.10
450	33.09	124.00	87.25	97.99	117.01	133.01
455	35.41	123.60	88.93	99.23	117.41	132.68
460	37.81	123.10	90.61	100.46	117.81	132.36
465	40.30	123.30	90.99	100.19	116.34	129.84
470	42.87	123.80	91.37	99.91	114.86	127.32
475	45.52	124.09	93.24	101.33	115.39	127.06
480	48.24	123.90	95.11	102.74	115.92	126.80
485	51.04	122.92	93.54	100.41	112.37	122.29
490	53.91	120.70	91.96	98.08	108.81	117.78
495	56.85	116.90	93.84	99.38	109.08	117.19
500	59.86	112.10	95.72	100.68	109.35	116.59
505	62.93	106.98	96.17	100.69	108.58	115.15
510	66.06	102.30	96.61	100.70	107.80	113.70
515	69.25	98.81	96.87	100.34	106.30	111.18

TABLE 3 *Continued*

λ (nm)	*A* *S*(λ)	*C* *S*(λ)	D_{50} *S*(λ)	D_{55} *S*(λ)	D_{65} *S*(λ)	D_{75} *S*(λ)
520	72.50	96.90	97.13	99.99	104.79	108.56
525	75.79	96.78	99.61	102.10	106.24	109.55
530	79.13	98.00	102.10	104.21	107.69	110.44
535	82.52	99.94	101.43	103.16	106.05	108.37
540	85.95	102.10	100.75	102.10	104.41	106.29
545	89.41	103.95	101.54	102.53	104.23	105.60
550	92.91	105.20	102.32	102.97	104.05	104.90
555	96.44	105.67	101.16	101.48	102.02	102.45
560	100.00	105.30	100.00	100.00	100.00	100.00
565	103.58	104.11	98.87	98.61	98.17	97.81
570	107.18	102.30	97.74	97.22	96.33	95.62
575	110.80	100.15	98.33	97.48	96.06	94.91
580	114.44	97.80	98.92	97.75	95.79	94.21
585	118.08	95.43	96.21	94.59	92.24	90.60
590	121.73	93.20	93.50	91.43	88.69	87.00
595	125.39	91.22	95.59	92.93	89.35	87.11
600	129.04	89.70	97.69	94.42	90.01	87.23
605	132.70	88.83	98.48	94.78	89.80	86.68
610	136.35	88.40	99.27	95.14	89.60	86.14
615	139.99	88.19	99.16	94.68	88.65	84.86
620	143.62	88.10	99.04	94.22	87.70	83.58
625	147.24	88.06	97.38	92.33	85.49	81.16
630	150.84	88.00	95.72	90.45	83.29	78.75
635	154.42	87.86	97.29	91.39	83.49	78.59
640	157.98	87.80	98.86	92.33	83.70	78.43
645	161.52	87.99	97.26	90.59	81.86	76.61
650	165.03	88.20	95.67	88.85	80.03	74.80
655	168.51	88.20	96.93	89.59	80.12	74.56
660	171.96	87.90	98.19	90.32	80.21	74.32
665	175.38	87.22	100.60	92.13	81.25	74.87
670	178.77	86.30	103.00	93.95	82.28	75.42
675	182.12	85.30	101.07	91.95	80.28	73.50
680	185.43	84.00	99.13	89.96	78.28	71.58
685	188.70	82.21	93.26	84.82	74.00	67.71
690	191.93	80.20	87.38	79.68	69.72	63.85
695	195.12	78.24	89.49	81.26	70.67	64.46
700	198.26	76.30	91.60	82.84	71.61	65.08
705	201.36	74.36	92.25	83.84	72.98	66.57
710	204.41	72.40	92.89	84.84	74.35	68.07
715	207.41	70.40	84.87	77.54	67.98	62.26
720	210.36	68.30	76.85	70.24	61.60	56.44
725	213.27	66.30	81.68	74.77	65.74	60.34
730	216.12	64.40	86.51	79.30	69.89	64.24
735	218.92	62.80	89.55	82.15	72.49	66.70
740	221.67	61.50	92.58	84.99	75.09	69.15
745	224.36	60.20	85.40	78.44	69.34	63.89
750	227.00	59.20	78.23	71.88	63.59	58.63
755	229.59	58.50	67.96	62.34	55.01	50.62
760	232.12	58.10	57.69	52.79	46.42	42.62
765	234.59	58.00	70.31	64.36	56.61	51.98
770	237.01	58.20	82.92	75.93	66.81	61.35
775	239.37	58.50	80.60	73.87	65.09	59.84
780	241.68	59.10	78.27	71.82	63.38	58.32

TABLE 4 Relative Spectral Power Distributions S(λ) of CIE Fluorescent Illuminants *F2*, *F7*, and *F11* at 5-nm Intervals from 380 to 780 nm (See Note 2 and Ref 3)

λ(nm)	*F2*	*F7*	*F11*
380	1.18	2.56	0.91
385	1.48	3.18	0.63
390	1.84	3.84	0.46
395	2.15	4.53	0.37
400	3.44	6.15	1.29
405	15.69	19.37	12.68
410	3.85	7.37	1.59
415	3.74	7.05	1.79
420	4.19	7.71	2.46
425	4.62	8.41	3.38

TABLE 4 *Continued*

λ(nm)	*F2*	*F7*	*F11*
430	5.06	9.15	4.49
435	34.98	44.14	33.94
440	11.81	17.52	12.13
445	6.27	11.35	6.95
450	6.63	12.00	7.19
455	6.93	12.58	7.12
460	7.19	13.08	6.72
465	7.40	13.45	6.13
470	7.54	13.71	5.46
475	7.62	13.88	4.79
480	7.65	13.95	5.66
485	7.62	13.93	14.29
490	7.62	13.82	14.96

TABLE 4 *Continued*

λ(nm)	*F2*	*F7*	*F11*
495	7.45	13.64	8.97
500	7.28	13.43	4.72
505	7.15	13.25	2.33
510	7.05	13.08	1.47
515	7.04	12.93	1.10
520	7.16	12.78	0.89
525	7.47	12.60	0.83
530	8.04	12.44	1.18
535	8.88	12.33	4.90
540	10.01	12.26	39.59
545	24.88	29.52	72.84
550	16.64	17.05	32.61
555	14.59	12.44	7.52
560	16.16	12.58	2.83
565	17.56	12.72	1.96
570	18.62	12.83	1.67
575	21.47	15.46	4.43
580	22.79	16.75	11.28
585	19.29	12.83	14.76
590	18.66	12.67	12.73
595	17.73	12.45	9.74
600	16.54	12.19	7.33
605	15.21	11.89	9.72
610	13.80	11.60	55.27
615	12.36	11.35	42.58
620	10.95	11.12	13.18
625	9.65	10.95	13.16
630	8.40	10.76	12.26
635	7.32	10.42	5.11
640	6.31	10.11	2.07
645	5.43	10.04	2.34
650	4.68	10.02	3.58
655	4.02	10.11	3.01
660	3.45	9.87	2.48
665	2.96	8.65	2.14
670	2.55	7.27	1.54
675	2.19	6.44	1.33
680	1.89	5.83	1.46
685	1.64	5.41	1.94
690	1.53	5.04	2.00
695	1.27	4.57	1.20
700	1.10	4.12	1.35
705	0.99	3.77	4.10
710	0.88	3.46	5.58
715	0.76	3.08	2.51
720	0.68	2.73	0.57
725	0.61	2.47	0.27
730	0.56	2.25	0.23
735	0.54	2.06	0.21
740	0.51	1.90	0.24
745	0.47	1.75	0.24
750	0.47	1.62	0.20
755	0.43	1.54	0.24
760	0.46	1.45	0.32
765	0.47	1.32	0.26
770	0.40	1.17	0.16
775	0.33	0.99	0.12
780	0.27	0.81	0.09

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[3]

E 284 Terminology of Appearance[3]

E 313 Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates[3]

E 1164 Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation[3]

2.2 *ANSI Standard:*

PH2.23 Lighting Conditions for Viewing Photographic Color Prints and Transparencies[4]

2.3 *CIE/ISO Standards:*

CIE Standard S 001/ISO IS 10526, Colorimetric Illuminants[4,45]

CIE Standard S 002/ISO IS 10527, Colorimetric Observers[4,45]

CIE Standard D 001, Colorimetric Illuminants and Observers (Disk)[5]

2.4 ASTM Adjuncts:

Computer disk containing Tables 5 and 6[6]

3. Terminology

3.1 Definitions of terms in Terminology E 284 are applicable to this practice (see also Ref **(4)**).

3.2 *Definitions:*

3.2.1 *bandpass, n—of a passband*, the wavelength range over which the radiant power through the passband is at least half of its maximum value within the passband (syn: *bandwidth*) (see *passband*).

3.2.2 *chromaticity, n*—the color quality of a color stimulus definable by its chromaticity coordinates.

3.2.3 *chromaticity coordinates, n*—the ratio of each of the tristimulus values of a psychophysical color (see section 3.2.7.11) to the sum of the tristimulus values.

3.2.3.1 *Discussion*—In the CIE 1931 standard colorimetric system, the chromaticity coordinates are: $x = X/(X + Y + Z)$, $y = Y/(X + Y + Z)$, $z = Z/(X + Y + Z)$; in the CIE 1964 supplementary colorimetric system, the same equations apply with all symbols having the subscript 10 (see 3.2.6.).

3.2.4 *CIE, n*—the abbreviation for the French title of the International Commission on Illumination, Commission Internationale de l'Éclairage.

3.2.5 *CIE 1931 (x, y) chromaticity diagram, n*—chromaticity diagram for the CIE 1931 standard observer, in which the CIE 1931 chromaticity coordinates are plotted, with *x* as abscissa and *y* as ordinate.

3.2.6 *CIE 1964 (x_{10}, y_{10}) chromaticity diagram, n*—chromaticity diagram for the CIE 1964 supplementary

[3] *Annual Book of ASTM Standards*, Vol 06.01.

[4] Available from American National Standards Institute, 13th Floor, 11 W. 42nd St., New York, NY 10036.

[5] Available from USNC-CIE Publications Office, c/o Mr. Thomas M. Lemons, TLA-Lighting Consultants, 7 Pond Street, Salem, MA 01970-4819.

[6] Computer disk of 72 tables is available from ASTM Headquarters. Request Adjunct No. ADJE0308a.

standard observer, in which the CIE 1964 chromaticity coordinates are plotted, with x_{10} as abscissa and y_{10} as ordinate.

3.2.6.1 *Discussion*—Fig. 1 shows the CIE 1931 and 1964 chromaticity diagrams, including the locations of the spectrum locus and the connecting purple boundary.

3.2.7 *CIE 1976 (u′, v′) or (u'_{10}, v'_{10}) chromaticity diagram, n*—chromaticity diagram in which the CIE 1976 *L* u* v** (CIELUV) chromaticity coordinates are plotted, with u' (or u'_{10}) as abscissa and v' (or v'_{10}) as ordinate.

3.2.8 *CIE 1931 standard colorimetric system, n*—a system for determining the tristimulus values of any spectral power distribution using the set of reference color stimuli, *X, Y, Z* and the three CIE color–matching functions $\bar{x}$ (λ), $\bar{y}$ (λ), $\bar{z}$ (λ) adopted by the CIE in 1931.

3.2.9 *CIE 1964 supplementary standard colorimetric system, n*—a system for determining the tristimulus values of any spectral power distribution using the set of reference color stimuli X_{10}, Y_{10}, Z_{10} and the three CIE color-matching functions $\bar{x}_{10}$(λ), $\bar{y}_{10}$(λ), $\bar{z}_{10}$(λ) adopted by the CIE in 1964 (see Note 1).

NOTE 1—Users should be aware that the CIE 1964 (10°) supplementary system and standard observer assume no contribution or constant contribution of rods to vision. Under some circumstances, such as in viewing highly metameric pairs in very low light levels (where the rods are unsaturated), the amount of rod participation can vary between the members of the pair. This is not accounted for by any trichromatic system of colorimetry. The 10° system and observer should be used with caution in such circumstances.

3.2.10 *color, n—of an object*, aspect of object appearance distinct from form, shape, size, position or gloss that depends upon the spectral composition of the incident light, the spectral reflectance, transmittance, or radiance of the object, and the spectral response of the observer, as well as the illuminating and viewing geometry.

3.2.11 *color, n—psychophysical*, characteristics of a color stimulus (that is, light producing a visual sensation of color) denoted by a colorimetric specification with three values, such as tristimulus values.

3.2.12 *color–matching functions, n*— the amounts, in any trichromatic system, of three reference color stimuli needed to match, by additive mixing, monochromatic components of an equal–energy spectrum.

3.2.13 *fluorescent illuminant, n*—illuminant representing the spectral distribution of the radiation from a specified type of fluorescent lamp.

3.2.14 *CIE recommended fluorescent illuminants, n*—a set of spectral power distributions of 12 types of fluorescent lamps, the most important of which are *F2*, representing a cool white fluorescent lamp with correlated color temperature 4200 K, *F7*, a broad-band (continuous-spectrum) daylight lamp (6500 K), and *F11*, a narrow-band (line-spectrum) white fluorescent lamp (4000 K).

3.2.15 *luminous, adj*—weighted according to the spectral luminous efficiency function *V* (λ) of the CIE.

3.2.16 *opponent-color scales, n*—scales that denote one color by positive scale values, the neutral axis by zero value, and an approximately complementary color by negative scale values, common examples being scales that are positive in the red direction and negative in the green direction, and those that

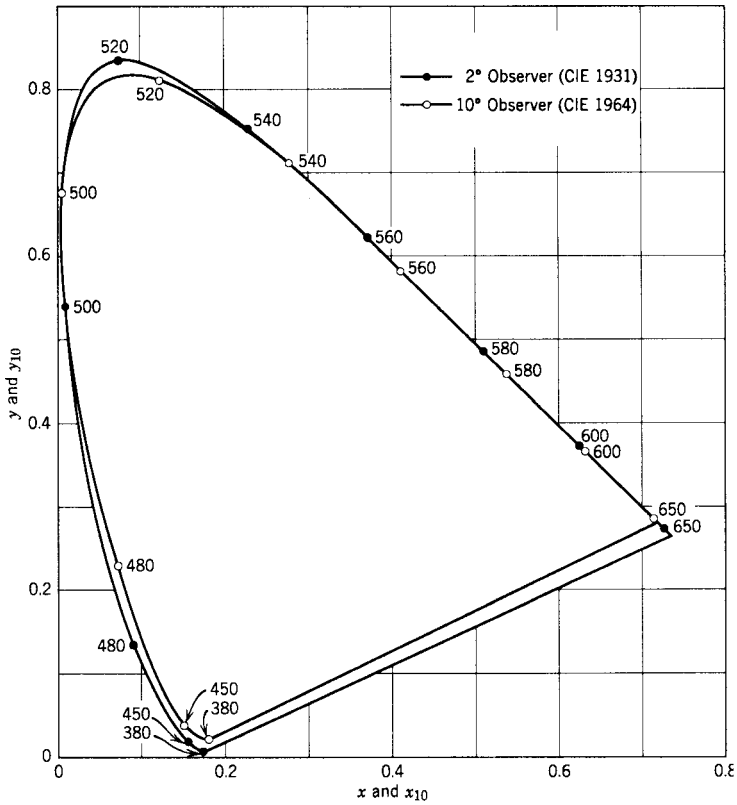


FIG. 1 The CIE 1931 *x*, *y* and 1964 x_{10}, y_{10} Chromaticity Diagrams (5) (see Note 2)

are positive in the yellow direction and negative in the blue direction.

3.2.17 *CIELAB color scales*, *n*—CIE 1976 *L**, *a**, *b** opponent-color scales, in which *a** is positive in the red direction and negative in the green direction, and *b** is positive in the yellow direction and negative in the blue direction.

3.2.18 *CIELUV color scales*, *n*—CIE 1976 *L**, *u**, *v** opponent-color scales, in which *u** is positive in the red direction and negative in the green direction, and *v** is positive in the yellow direction and negative in the blue direction.

3.2.19 *passband*, *n*—a narrow portion of a dispersed spectrum, selected by the exit slit of a monochromator or the equivalent, for the purpose of defining an emitted spectral power function.

3.2.19.1 *Discussion*—The shape of the spectral transmittance function of the passband may be triangular, trapezoidal, or rectangular, among others, but is usually symmetrical.

3.2.20 *spectral*, *adj—for radiometric quantities*, pertaining to monochromatic radiation at a specified wavelength or, by extension, to radiation within a narrow wavelength band about a specified wavelength.

3.2.21 *standard illuminant*, *n*—a luminous flux, specified by its spectral distribution, meeting specifications adopted by a standardizing organization.

3.2.22 *CIE standard illuminant A*, *n*—colorimetric illuminant, representing the full radiator at 2855.6 K, defined by the CIE in terms of a relative spectral power distribution.

3.2.23 *CIE standard illuminant C*, *n*—colorimetric illuminant, representing daylight with a correlated color temperature of 6774 K, defined by the CIE in terms of a relative spectral power distribution.

3.2.24 *CIE standard illuminant D_{65}*, *n*—colorimetric illuminant, representing daylight with a correlated color temperature of 6504 K, defined by the CIE in terms of a relative spectral power distribution.

3.2.24.1 *Discussion*—Other illuminants of importance defined by the CIE include the daylight illuminants D_{50}, D_{55}, and D_{75}. Illuminant D_{50} is used by the graphic arts industry for viewing colored transparencies and prints (see ANSI PH2.23).

3.2.25 *standard observer*, *n*—an ideal observer having visual response described by the CIE color-matching functions (see CIE S002 and Ref **(3)**).

3.2.26 *CIE 1931 standard observer*, *n*—ideal colorimetric observer with color-matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$ corresponding to a field of view subtending a 2° angle on the retina; commonly called the "2° standard observer."

3.2.27 *CIE 1964 supplementary standard observer*, *n*—ideal colorimetric observer with color-matching functions $\bar{x}_{10}(\lambda)$, $\bar{y}_{10}(\lambda)$, $\bar{z}_{10}(\lambda)$ corresponding to a field of view subtending a 10° angle on the retina; commonly called the "10° standard observer" (see Note 1).

3.2.28 *tristimulus values*, *n*—see 3.2.8 and 3.2.9.

3.2.29 *tristimulus weighting factors, $S\bar{x}$, $S\bar{y}$, $S\bar{z}$*, *n*—factors obtained from products of the spectral power *S* of an illuminant and the spectral color-matching functions $\bar{x}$, $\bar{y}$, $\bar{z}$ (or $\bar{x}_{10}$, $\bar{y}_{10}$, $\bar{z}_{10}$) of an observer, usually tabulated at wavelength intervals of 10 or 20 nm, used to compute tristimulus values by multiplication by the spectral reflectance, transmittance, or radiance (or the corresponding factors) and summation.

3.2.29.1 *Discussion*—Proper account should be taken of the spectral bandpass of the measuring instrument.

4. Summary of Practice

4.1 *Selection of Parameters*—The user of this practice must select values of the following parameters:

4.1.1 *Observer*—Select either the CIE 1931 standard colorimetric observer (2° observer) or the CIE 1964 supplementary standard observer (10° observer), tabulated in this practice, CIE Standard S 002 or D 001, or Ref **(3)** (see 3.2.25 and Note 1).

4.1.2 *Illuminant*—Select one of the CIE standard or recommended illuminants tabulated in this practice, CIE Standard S 001 or D 001, or Ref **(3)** (see 3.2.21).

4.1.3 *Measurement Interval*—Select the measurement interval of the available spectral data. This practice provides for 1-, 5-, 10-, or 20-nm measurement intervals. For best practice the measurement interval should be selected to be as nearly as possible equal to the instrument bandpass.

4.2 *Procedures*—The user should ascertain whether or not the spectral data have been corrected for bandpass dependence. The accuracy of tristimulus values is significantly improved by incorporating a correction for bandpass dependence into either the spectral data or the tables of tristimulus weighting factors (see 7.2). The procedures used depend on this and on the measurement interval.

4.2.1 For data obtained at 1- or 5-nm measurement interval, the procedures of 7.2 should be followed.

4.2.2 For data obtained at 10- or 20-nm measurement interval, the tables of tristimulus weighting factors contained in Tables 5 should be used with spectral data that have been corrected for bandpass dependence. The tables contained in Tables 6 should be used with spectral data that have not been so corrected; these tables include a provision that minimizes the error introduced by bandpass dependence when employing a triangular passband equal in half width to the measurement interval.

4.2.3 A flow chart to ensure the use of proper combinations of data and tables is given in Fig. 2. The procedures of the practice are given in detail in 7.1.

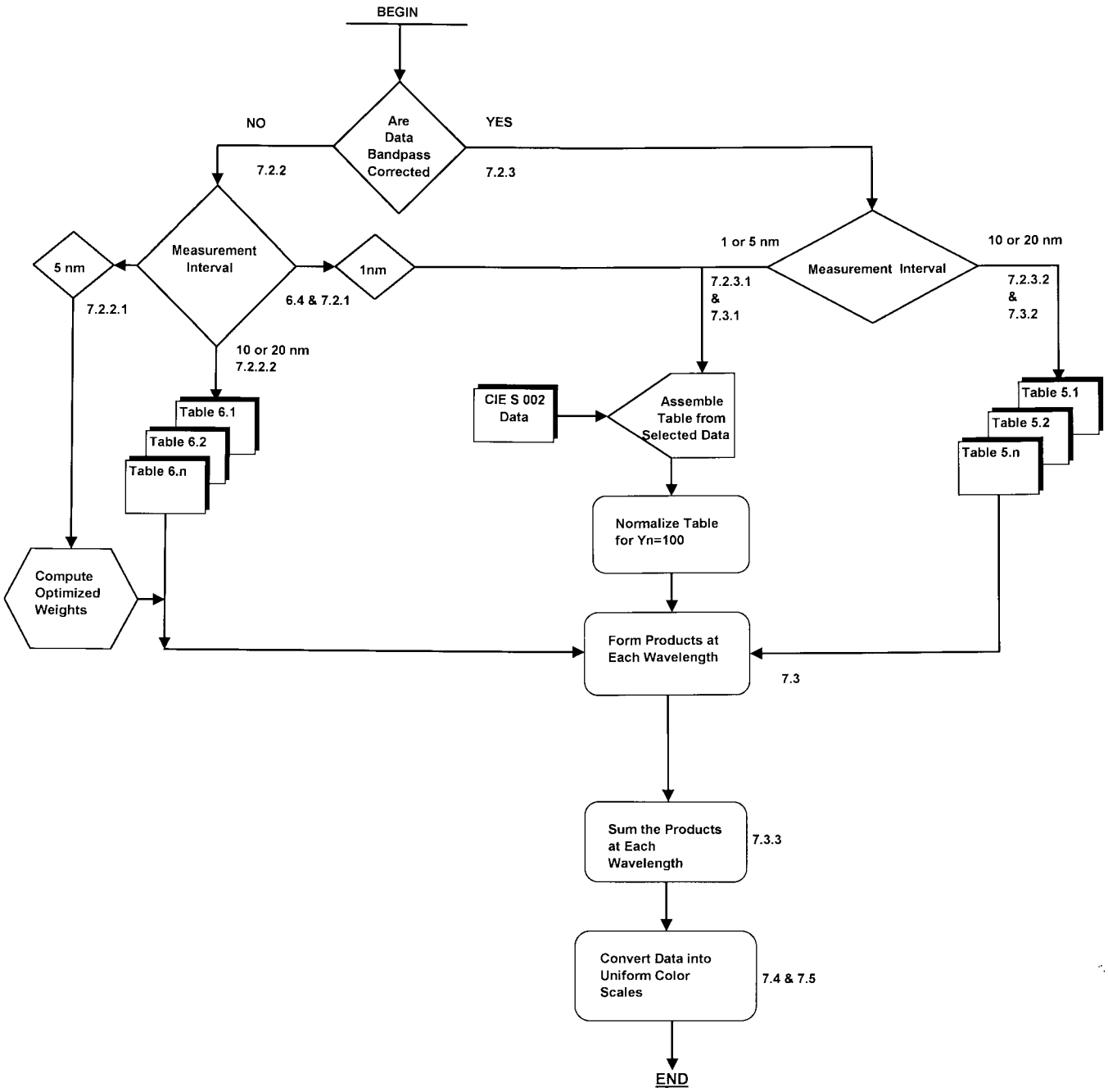
4.3 *Calculations*—CIE tristimulus values *X, Y, Z* or X_{10}, Y_{10}, Z_{10} are calculated by numerical summation of the products of tristimulus weighting factors for selected illuminants and observers with the reflectance factors (or transmittance or radiance factors) making up the spectral data.

4.4 The tristimulus values so calculated may be further converted to coordinates in a more nearly uniform color space such as CIELAB or CIELUV.

5. Significance and Use

5.1 The CIE colorimetric systems provide numerical specifications that are meant to indicate whether or not pairs of color stimuli match when viewed by a CIE standard observer. The CIE color systems are not intended to provide visually uniform scales of color difference or to describe visually perceived color appearances.

5.2 This practice provides for the calculation of tristimulus values *X, Y, Z* and chromaticity coordinates *x, y* that can be



NOTE 1—References to Section 7. Calculations are Included.

FIG. 2 Flow Chart for Selecting Methods and Tables for Tristimulus Integration

used directly for psychophysical color stimulus specification or that can be transformed to nearly visually uniform color scales, such as CIELAB and CIELUV. Uniform color scales are preferred for research, production control, color-difference calculation, color specification, and setting color tolerances. The appearance of a material or an object is not completely specified by the numerical evaluation of its psychophysical color, because appearance can be influenced by other properties such as gloss or texture.

6. Procedure

6.1 *Selecting Standard Observer*—When colorimetric results are required that will be compared with previous results obtained for the CIE 1931 standard observer, use the values in Table 1 for that observer. When new results are being computed, consider using the values in Table 2 for the CIE 1964 supplementary standard observer, but see Note 1.

6.1.1 Whenever correlation with visual observations using fields of angular subtense between about 1° and about 4° at the eye of the observer is desired, select the CIE 1931 standard colorimetric observer.

6.1.2 Whenever correlation with visual observations using fields of angular subtense greater than 4° at the eye of the

observer is desired, select the CIE 1964 supplementary standard colorimetric observer (but see Note 1).

6.2 *Selecting Standard or Recommended Illuminants*— Select illuminants according to the type of light(s) under which objects will be viewed or for which their colors will be specified or evaluated.

6.2.1 When incandescent (tungsten) lamplight is involved, use values for CIE illuminant *A*.

6.2.2 When daylight is involved, use values for CIE illuminant *C* or D_{65}.

6.2.3 When fluorescent-lamp illumination is involved, use 4200 K standard cool white (*F*2) unless results are desired for 6500 K broad-band daylight (*F*7) or 4000 K narrow-band white (*F*11) fluorescent illumination.

6.3 *Selecting the Measurement Interval*— For greater accuracy select the 5-nm measurement interval over the 10-nm interval where spectral data are available at 5-nm intervals. Likewise, select the 10-nm measurement interval over the 20-nm interval where spectral data are available at 10-nm intervals. If the 20-nm interval is selected, users should ensure themselves that the resulting accuracy is sufficient for the purpose for which the results are intended. For many industrial applications use of the 20-nm interval may be satisfactory.

6.3.1 If the instrument used has a selectable measurement interval, select the interval that most nearly equals the bandpass of the instrument throughout the spectrum. If the instrument has an adjustable bandpass, adjust the bandpass to be approximately equal to the measurement interval.

6.3.2 The measurement interval should never be greater than the bandpass (half width of the passband). The use of a measurement interval less than the bandpass does not improve the *accuracy* of the computation, but may improve the *repeatability* by providing redundant spectral data.

6.4 *Other Miscellaneous Conditions*— While the above selections cover the majority of industrial practices, the possibility exists that other conditions could be encountered. Further, the deconvolution routine used to produce Tables 6 is not unique and uses approximating techniques that, while providing overall a good approximation to the true value, may not in a specific instance provide the best approximation. Therefore, other procedures than those included in this practice may be used provided that the results are consistent with those obtained by use of the procedures in the practice.

7. Calculations

7.1 *General Procedures*—The general procedures for computing CIE tristimulus values are summarized as follows:

7.1.1 *Procedures as Specified by the CIE*— The CIE procedures are specified in Ref **(3)** and summarized in Refs (5 to 9). The fundamental definition is in terms of integrals,

$$X = k \int_{\lambda} R(\lambda)\, S(\lambda)\, \bar{x}(\lambda)\, d\lambda \tag{1}$$

$$Y = k \int_{\lambda} R(\lambda)\, S(\lambda)\, \bar{y}(\lambda)\, d\lambda$$

$$Z = k \int_{\lambda} R(\lambda)\, S(\lambda)\, \bar{z}(\lambda)\, d\lambda$$

where:

$R(\lambda)$ = the reflectance, transmittance, or radiance factor (on a scale of zero to one for the perfect reflecting diffuser),

$S(\lambda)$ = the relative spectral power of a CIE standard illuminant, and

$\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$ = the color-matching functions of one of the CIE standard observers.

The integration is carried out over the entire wavelength region in which the color-matching functions are defined, 360 to 830 nm. The normalizing factor *k* is defined as

$$k = 100 / \int_{\lambda} S(\lambda)\, \bar{y}(\lambda)\, d\lambda \tag{2}$$

The CIE notes that in all practical calculations of tristimulus values the integration is approximated by a summation, giving the equations as follows:

$$X = k \sum_{\lambda} R(\lambda)\, S(\lambda)\, \bar{x}(\lambda)\, \Delta\lambda \tag{3}$$

$$Y = k \sum_{\lambda} R(\lambda)\, S(\lambda)\, \bar{y}(\lambda)\, \Delta\lambda$$

$$Z = k \sum_{\lambda} R(\lambda)\, S(\lambda)\, \bar{z}(\lambda)\, \Delta\lambda$$

with:

$$k = 100 / \sum_{\lambda} S(\lambda)\, \bar{y}(\lambda)\, \Delta\lambda. \tag{4}$$

7.1.2 *Procedure Using Tristimulus Weighting Factors*—It is common industrial practice to carry out the summation to tristimulus values in two steps. In the first of these, a set of normalized tristimulus weighting factors W_x, W_y, W_z is calculated as follows:

$$W_x(\lambda) = k\, S(\lambda)\, \bar{x}(\lambda)\Delta\lambda \tag{5}$$

$$W_y(\lambda) = kS(\lambda)\, \bar{y}(\lambda)\, \Delta\lambda$$

$$W_z(\lambda) = kS(\lambda)\, \bar{z}(\lambda)\, \Delta\lambda$$

for λ = 360, ... 780 nm, (see Note 2), and where:

$$k = 100 / \sum_{360}^{780} S(\lambda)\, \bar{y}(\lambda)\, \Delta\lambda \tag{6}$$

For a given selection of illuminant, observer, measurement interval Δλ, and measurement bandpass, this calculation needs to be done only once, since the spectral reflectance (or transmittance or radiance) factor $R(\lambda)$ is not included in the weighting factors *W*. In the second step, tristimulus values *X*, *Y*, *Z* (or X_{10}, Y_{10}, Z_{10}) are calculated using the values of *W* and $R(\lambda)$ in the following equations:

$$X = \sum_{360}^{780} W_x(\lambda)\, R(\lambda)\Delta\lambda \tag{7}$$

$$Y = \sum_{360}^{780} W_y(\lambda)\, R(\lambda)\Delta\lambda$$

$$Z = \sum_{360}^{780} W_z(\lambda)\, R(\lambda)\, \Delta\lambda$$

NOTE 2—While 360 nm is recommended as the starting wavelength for summation and elsewhere in this practice, CIE data reproduced in Tables 1-4, and the spectrum locus scale of Fig. 1, begin only at 380 nm; since

the missing data cannot be supplied in all cases, these references to 380 nm should remain. In the region between 360 and 379 nm, values of color matching functions are so small that their inclusion or omission in the calculations would not lead to significant differences in the resulting tristimulus values.

7.2 *Summary of Calculations* (see Note 2)—A general outline of the procedure is given in Fig. 2 in the form of a flow chart. Begin by determining whether or not the spectral data have been corrected for bandpass dependence.

NOTE 3—For reflecting materials, calculate tristimulus values from spectral data obtained relative to the perfect reflecting diffuser. For transmitting materials, calculate by use of the incident light as the reference.

7.2.1 *Procedure for 1-nm Measurement Interval*—Use the 1-nm spectral data in CIE S001 and S002 (or on CIE D001 Disk) and (Eq 3) and (Eq 4).

7.2.2 *Procedures for Spectral Data With Bandpass Correction:*

7.2.2.1 *Procedure for Data Obtained at 5-nm Measurement Intervals*—Prepare tables of tristimulus weighting factors for desired illuminant-observer combinations, using the spectral data in Tables 1-4 (see Note 2), and (Eq 5) and (Eq 6). Use the tables so prepared as described in 7.3 (see Note 4).

NOTE 4—Using the previous procedure at 10 nm or 20 nm intervals by omitting intermediate tabulated values is not allowed. Use the procedures of 7.2.3.2 and 7.3 instead.

7.2.2.2 *Procedures for Data Obtained at 10- or 20-nm Measurement Intervals*—Select the appropriate tables of tristimulus weighting factors from those in Tables 5 and use them as described in 7.3.

7.2.3 *Procedures for Spectral Data Without Bandpass Correction*:

7.2.3.1 *Procedure for Data Obtained at 5-nm Measurement Intervals*—Prepare optimized tables of tristimulus weighting factors for desired illuminant-observer combinations, using the spectral data in Tables 1-4 (see Note 2), and procedures described in the literature **(10, 11)**. Use the tables so prepared as described in 7.3.

7.2.3.2 *Procedures for Data Obtained at 10- or 20-nm Measurement Intervals*—Select the appropriate tables of tristimulus weighting factors from Tables 6 and use them as described in 7.3.

7.3 *Use of Tristimulus Weighting Factors*:

7.3.1 *Use of Data Obtained at 5-nm Measurement Intervals*—Use the color-matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$, from Table 1, for the 1931 CIE standard colorimetric observer, or when desired the functions $\bar{x}_{10}(\lambda)$, $\bar{y}_{10}(\lambda)$, $\bar{z}_{10}(\lambda)$, from Table 2, for the 1964 CIE supplementary standard colorimetric observer. Select the desired CIE standard or recommended illuminant, for example *A*, *C*, or one of the *D* or *F* illuminants from Table 3 or Table 4. At each wavelength multiply the tabulated value of the observer color-matching functions by the tabulated value of the relative spectral power of the illuminant $S(\lambda)$, and by the spectral reflectance (or transmittance) factor $R(\lambda)$ (or $T(\lambda)$) of the specimen. Obtain the sum of these products at 5 nm intervals over the wavelength range 360 to 780 nm and use (Eq 3) and (Eq 4).

7.3.2 *Use of Data Obtained at 10- or 20-nm Measurement Intervals*:

7.3.2.1 *Data Available over the Wavelength Range 360 to 780 nm*—Select the appropriate tables of tristimulus weighting factors, computed for triangular bandpass and 10- or 20-nm measurement intervals, for the desired observer and illuminant, from among the 36 sets included in Tables 5 **(12)** for bandpass-corrected data, and from among the 36 sets included in Tables 6 for data that have not been corrected for bandpass dependence. No normalization of any data from Tables 5 or 6 is required.

7.3.2.2 *Data Available only for Wavelength Ranges Shorter than 360 to 780 nm*—When data for $R(\lambda)$, $T(\lambda)$, or $\beta(\lambda)$ are not available for the full wavelength range, add the weights at the wavelengths for which data are not available to the weights at the shortest and longest wavelength for which spectral data are available. That is: add the weights for wavelengths 360, ..., up to the last wavelength for which measured data are not available, to the next higher weight, for which such data are available; add the weights for wavelengths of 780, ..., down to the last wavelength for which measured data are not available, to the next lower weight, for which such data are available.

7.3.3 *Tristimulus Values*—Obtain the products of $R(\lambda)$, $T(\lambda)$ or $\beta(\lambda)$ and the weights selected in 7.3.1 or 7.3.2, including any modifications, and sum to obtain the CIE tristimulus values *X, Y, Z,* or X_{10}, Y_{10}, Z_{10}.

7.4 *Chromaticity Coordinates*—Obtain chromaticity coordinates *x, y, z* (for the CIE 1931 standard observer) by dividing each tristimulus value *X, Y, Z* by the sum of all three: $x = X/(X + Y + Z)$; $y = Y/(X + Y + Z)$; and $z = Z/(X + Y + Z)$, or use the same procedure with all quantities having the subscript 10 for the CIE 1964 supplementary standard observer.

7.5 *CIE 1976 Uniform Color Spaces*— When a color space more nearly uniform than *X, Y, Z* is desired, use CIELAB or CIELUV.

7.5.1 *CIELAB or L*a*b**—This approximately uniform color space is produced by plotting in rectangular coordinates the quantities *L**, *a**, *b** defined as follows:

$$L^* = 116(Y/Y_n)^{1/3} - 16 \tag{8}$$

$$a^* = 500[(X/X_n)^{1/3} - (Y/Y_n)^{1/3}]$$

$$b^* = 200[(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$$

where:

$$X/X_n;\ Y/Y_n;\ Z/Z_n > 0.01. \tag{9}$$

The tristimulus values X_n, Y_n, Z_n define the color of the normally white object-color stimulus. Usually, the white object-color stimulus is given by the spectral radiant power of one of the CIE standard illuminants, for example, *C*, D_{65} or another of daylight quality, reflected into the observer's eye by the perfect reflecting diffuser. Under these conditions, X_n, Y_n, Z_n are the tristimulus values of the standard illuminant with Y_n equal to 100 obtained by use of the same method used to obtain *X, Y, Z* (see 7.6).

7.5.1.1 The CIE 1976 (*L*a*b**) space fails to approximate uniform color spacing when one or more of the ratios X/X_n, Y/Y_n, and Z/Z_n is less than 0.01.

7.5.1.2 In calculating L^*, values of Y/Y_n less than 0.01 may be included if the normal formula is used for values of Y/Y_n greater than 0.008856, and the following modified formula is used for values of Y/Y_n equal to or less than 0.008856:

$$L^* = 903.3(Y/Y_n) \qquad Y/Y_n \le 0.008856 \tag{10}$$

7.5.1.3 In calculating a^* and b^* values of X/X_n, Y/Y_n, Z/Z_n less than 0.01 may be included if the normal equations are replaced by the following modified equations for *all* calculations of a^* and b^*:

$$a^* = 500[f(X/X_n) - f(Y/Y_n)] \tag{11}$$
$$b^* = 200[f(Y/Y_n) - f(Z/Z_n)]$$

where:

$$f(X/X_n) = (X/X_n)^{1/3} \qquad X/X_n > 0.008856 \tag{12}$$
$$f(X/X_n) = 7.787(X/X_n) + 16/116 \qquad X/X_n \le 0.008856$$
$$f(Y/Y_n) = (Y/Y_n)^{1/3} \qquad Y/Y_n > 0.008856$$
$$f(Y/Y_n) = 7.787(Y/Y_n) + 16/116 \qquad Y/Y_n \le 0.008856$$
$$f(Z/Z_n) = (Z/Z_n)^{1/3} \qquad Z/Z_n > 0.008856$$
$$f(Z/Z_n) = 7.787(Z/Z_n) + 16/116 \qquad Z/Z_n \le 0.008856$$

7.5.2 *CIELUV or L*u*v**—This approximately uniform color space is produced by plotting in rectangular coordinates the quantities L^*, u^*, v^* defined as follows (see also Note 5):

$$L^* = 116(Y/Y_n)^{1/3} - 16 \qquad Y/Y_n > 0.01 \tag{13}$$
$$u^* = 13L^*(u' - u'_n)$$
$$v^* = 13L^*(v' - v'_n)$$

with:

$$u' = \frac{4X}{X + 15Y + 3Z} \tag{14}$$
$$v' = \frac{9Y}{X + 15Y + 3Z}$$
$$u'_n = \frac{4X_n}{X_n + 15Y_n + 3Z_n}$$
$$v'_n \frac{9Y_n}{X_n + 15Y_n + 3Z_n}$$

7.5.2.1 In calculating L^* values for Y/Y_n less than 0.01, use the same equation given in 7.5.1.3.

NOTE 5—The CIE 1976 $L^*u^*v^*$ space incorporates, for constant L^*, a (u', v') chromaticity diagram which is a projective transformation of the CIE 1931 (x, y) chromaticity diagram. Straight lines in the (x, y) chromaticity diagram remain straight in the (u', v') diagram.

7.5.3 *LCH Versions of CIELAB and CIELUV*:

7.5.3.1 It may be useful to calculate CIE 1976 hue and chroma coordinates as follows, combining them with L^* to provide alternative sets of LCH coordinates within the CIELAB and CIELUV spaces:

CIE 1976 hue angles:

$$h_{ab} = \tan^{-1}(b^*/a^*) \quad \text{or} \quad h_{uv} = \tan^{-1}(v^*/u^*) \tag{15}$$

CIE 1976 chromas:

$$C^*_{ab} = [(a^*)^2 + (b^*)^2]^{1/2} \quad \text{or} \quad C^*_{uv} = [(u^*)^2 + (v^*)^2]^{1/2} \tag{16}$$

7.5.3.2 Differences in hue angle between two specimens can be correlated with differences in their visually perceived hue, and differences in their chroma can similarly be correlated with differences in their visually perceived chroma (see also Test Method D 2244).

7.6 *Tristimulus Values* X_n, Y_n, Z_n:

7.6.1 It is emphasized that the tristimulus values of the nominally white object-color stimulus must always be calculated by the same method used to calculate tristimulus values for other colors with which they are to be used. This implies not only use of the same illuminant and observer, but also of the same measurement interval, bandpass, band shape, and method of summation. When using Tables 5 or 6 for measurement intervals of 10 or 20 nm, the values tabulated as "White Point" at the bottoms of the tables must always be the ones used for X_n, Y_n, and Z_n.

7.6.2 Use values of X_n, Y_n, and Z_n meeting the above requirements in the calculation of CIELAB coordinates and in some single-number color scales such as those for indexes of yellowness and whiteness, among others (see Practice E 313).

8. Report

8.1 The report of color calculations shall include the following:

8.1.1 *Specimen Identification*:

8.1.2 *Source of Data*—Give instrument identification, illuminating and viewing geometry, spectral bandpass, and date of measurement.

8.1.3 *Standard Observers*—Indicate whether the reported data were computed for the CIE 1931 standard observer (2°) or the CIE 1964 supplementary standard observer (10°), or specify any other observers that were used.

8.1.4 *Standard or Recommended Illuminants*—Indicate which of the following illuminants were used, or specify any other illuminants that were used: *A*, *C*, D_{50}, D_{55}, D_{65}, D_{75}, *F*2, *F*7, *F*11.

8.1.5 *Bandpass Correction*—Indicate whether or not the spectral data were corrected for bandpass, and which sets of tables of tristimulus weighting factors were used.

8.1.6 *Method of Calculation*—Indicate whether the procedures for 1-nm bandpass and measurement interval, or for 5-nm triangular bandpass and measurement interval, or a specific abridged procedure (for 10- or 20-nm triangular bandpass and measurement interval) were used, and give the wavelength range of the spectral data used.

8.1.7 *Tristimulus Values*—Report as *X*, *Y*, *Z* or X_{10}, Y_{10}, Z_{10}.

8.1.8 *Chromaticity Coordinates*—Report as *x*, *y* or x_{10}, y_{10}.

8.1.9 As an alternative to 8.1.7 or 8.1.8, report CIELAB results as $L^*a^*b^*$ or $L^*C^*_{ab}h_{ab}$, or CIELUV results as $L^*u^*v^*$ or $L^*C^*_{uv}h_{uv}$.

9. Precision and Bias

9.1 *Precision*—The precision of results calculated by use of Tables 1-5 is limited by the precision of the measured spectral data and round-off of the data used in the calculations. The precision of Tables 6, incorporating correction for bandpass dependence, is believed to be about 4.5 log units (digits). Thus the precision of the results is expected to be limited by the precision of the spectral data, not of the tables.

9.2 *Bias*—In the calculation procedures of 7.2, the bias is the same as the precision when the same spectral data are used.

Bias of the abridged calculation procedures of 7.3 depends on the measurement interval and wavelength range, the complexity of the spectral character of the specimen, and the degree to which the passband of the measuring instrument conforms to the width and ideal triangular shape assumed in computing the tables. Least bias is obtained with the smallest measurement interval, the largest wavelength range, and the best correspondence of passband width and shape.

9.2.1 The uncertainty of the tristimulus values depends on the uncertainty of the spectral measurements.

9.2.2 The use of Tables 6, which incorporate the correction for bandpass dependence, has been shown **(11)** to reduce, on average, the bias of these calculations by about 0.1 to 0.3 CIELAB unit of color difference, when compared to calculations in which the bandpass correction is ignored. The actual reduction in bias in any given case depends on the spectral character of the data used.

9.2.3 The bias introduced by conversion of text to numeric formats, and that introduced by floating-point processor noise, are mostly insignificant.

10. Keywords

10.1 CIELAB; CIELUV; CIE system; color coordinates; tristimulus integration; tristimulus values; tristimulus weighting factors

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(**1**) Foster, W. H., Jr., Gans, R., Stearns, E. I., and Stearns, R. E., "Weights for Calculation of Tristimulus Values from Sixteen Reflectance Values," *Color Engineering*, Vol 8, No. 3, 1970, pp. 35–47.

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(**4**) Commission Internationale de l'Éclairage, Publication CIE No. 17, *International Lighting Vocabulary*, 3rd ed., 1970; 4th ed., 1987. Central Bureau of the CIE, Vienna.

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(**9**) Billmeyer, F. W., and Fairman, H. S., "CIE Method for Calculating Tristimulus Values," *Color Research and Application*, Vol 12, 1987, pp. 27–36.

(**10**) Stearns, E. I., and Stearns, R. E., "An Example of a Method for Correcting Radiance Data for Bandpass Error," *Color Research and Application*, Vol 13, 1988, pp. 257–259.

(**11**) Venable, W. H., "Accurate Tristimulus Values from Spectral Data," *Color Research and Application*, Vol 14, 1989, pp. 260–267.

(**12**) Fairman, H. S., "The Calculation of Weight Factors for Tristimulus Integration," *Color Research and Application*, Vol 10, 1985, pp. 199–203.

INTRODUCTION TO TABLES 5 AND 6

Tables 5 and 6 consist of sets of 36 tables each, containing tristimulus weighting factors for a variety of CIE standard and recommended illuminants and the CIE 1931 and 1964 standard observers. Both 10-nm and 20-nm measurement intervals are represented for all illuminant-observer combinations. The tables are presented with three decimal digits of precision. These digits should be carried in the calculations until the final values sought are calculated, and only then should the results be rounded to the appropriate number of significant digits available in the measured data.

TABLE 5 Index for Tables 5.1 Through 5.36 and Tables 6.1 Through 6.36

Tables	Illuminant	Observer	Measurement Interval	Tables	Illuminant	Observer	Measurement Interval
5.1, 6.1	A	1931	10 nm	5.19, 6.19	D_{65}	1964	10 nm
5.2, 6.2	A	1931	20	5.20, 6.20	D_{65}	1964	20
5.3, 6.3	A	1964	10	5.21, 6.21	D_{75}	1931	10
5.4, 6.4	A	1964	20	5.22, 6.22	D_{75}	1931	20
5.5, 6.5	C	1931	10	5.23, 6.23	D_{75}	1964	10
5.6, 6.6	C	1931	20	5.24, 6.24	D_{75}	1964	20
5.7, 6.7	C	1964	10	5.25, 6.25	F2	1931	10
5.8, 6.8	C	1964	20	5.26, 6.26	F2	1931	20
5.9, 6.9	D_{50}	1931	10	5.27, 6.27	F2	1964	10
5.10, 6.10	D_{50}	1931	20	5.28, 6.28	F2	1964	20
5.11, 6.11	D_{50}	1964	10	5.29, 6.29	F7	1931	10
5.12, 6.12	D_{50}	1964	20	5.30, 6.30	F7	1931	20
5.13, 6.13	D_{55}	1931	10	5.31, 6.31	F7	1964	10
5.14, 6.14	D_{55}	1931	20	5.32, 6.32	F7	1964	20
5.15, 6.15	D_{55}	1964	10	5.33, 6.33	F11	1931	10
5.16, 6.16	D_{55}	1964	20	5.34, 6.34	F11	1931	20
5.17, 6.17	D_{65}	1931	10	5.35, 6.35	F11	1964	10
5.18, 6.18	D_{65}	1931	20	5.36, 6.36	F11	1964	20

Note that in the case of the values in Tables 5 the interpolation procedure, and in the case of the values in Tables 6 the approximating procedure, lead to some small values with a negative sign. This sign is correct, and the corresponding entry must be carried in the calculations as a negative number.

The data labeled "Check Sum" at the bottom of each column in each table of Tables 5 and 6 is the algebraic sum of the entries above. It provides as a convenience the assurance that the tables have been copied correctly should copying be required. These check sums may not be identical to the "White Point" data located below them because of roundoff. Each value in a column has been rounded to three decimal digits. The "White Point" is the analytic total of the double-precision values at each wavelength, rounded to three decimal digits. It is these "White Point" data, and no others, that must be used as

X_n, Y_n, Z_n when converting tristimulus values calculated by use of these tables to CIELAB or CIELUV coordinates or for any other purpose requiring the ratio of the tristimulus value of the specimen to that of the white point.

The tables of Tables 5 have been prepared for use with spectral measurement data that have previously been corrected for spectral bandpass dependence. The tables of Tables 6 have been prepared to apply a correction for spectral bandpass dependence built into the calculation of the tristimulus values. Accordingly, users should determine the status of their spectral data and select from Tables 5 or Tables 6 for data previously corrected, or not corrected, respectively, for bandpass dependence.

The tables presented here were calculated from the data on CIE Standard D 001 (see 2.3) and have been reproduced here photographically to avoid any possible transcription errors.

Tables 5.1 through Tables 6.36 are indexed by illuminant, observer, and measurement interval in the accompanying Index Table.

Table 5.1 Illuminant A, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.000	0.000	0.001
380	0.001	0.000	0.005
390	0.005	0.000	0.021
400	0.017	0.000	0.083
410	0.070	0.002	0.333
420	0.272	0.008	1.309
430	0.644	0.027	3.144
440	0.924	0.061	4.635
450	1.036	0.117	5.461
460	1.017	0.209	5.838
470	0.779	0.362	5.128
480	0.428	0.618	3.639
490	0.160	1.039	2.332
500	0.024	1.802	1.513
510	0.059	3.091	0.962
520	0.428	4.756	0.533
530	1.210	6.320	0.305
540	2.313	7.599	0.162
550	3.735	8.571	0.075
560	5.511	9.219	0.036
570	7.573	9.456	0.021
580	9.718	9.224	0.017
590	11.583	8.543	0.013
600	12.706	7.547	0.010
610	12.671	6.360	0.005
620	11.347	5.061	0.002
630	9.010	3.716	0.001
640	6.551	2.559	0.000
650	4.345	1.639	0.000
660	2.626	0.971	0.000
670	1.457	0.533	0.000
680	0.794	0.289	0.000
690	0.406	0.147	0.000
700	0.207	0.075	0.000
710	0.109	0.039	0.000
720	0.056	0.020	0.000
730	0.029	0.010	0.000
740	0.014	0.005	0.000
750	0.007	0.003	0.000
760	0.004	0.001	0.000
770	0.002	0.001	0.000
780	0.001	0.000	0.000
Check Sum	**109.849**	**100.000**	**35.584**
White Point	**109.850**	**100.000**	**35.585**

Table 5.2 Illuminant A, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	−0.001
380	−0.002	0.000	−0.008
400	0.020	0.000	0.088
420	0.614	0.017	2.944
440	1.812	0.118	9.121
460	1.982	0.410	11.430
480	0.889	1.204	7.444
500	0.023	3.720	3.035
520	0.902	9.446	1.095
540	4.619	15.187	0.314
560	11.082	18.429	0.070
580	19.472	18.411	0.031
600	25.292	15.107	0.018
620	22.531	10.092	0.005
640	13.195	5.145	0.000
660	5.312	1.954	0.000
680	1.564	0.566	0.000
700	0.402	0.145	0.000
720	0.107	0.039	0.000
740	0.027	0.010	0.000
760	0.007	0.002	0.000
780	0.002	0.001	0.000
Check Sum	**109.852**	**100.003**	**35.586**
White Point	**109.850**	**100.000**	**35.585**

Table 5.3 Illuminant A, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	0.000
390	0.002	0.000	0.008
400	0.025	0.003	0.110
410	0.134	0.014	0.615
420	0.377	0.039	1.792
430	0.686	0.084	3.386
440	0.964	0.156	4.944
450	1.080	0.259	5.806
460	1.006	0.424	5.812
470	0.731	0.696	4.919
480	0.343	1.082	3.300
490	0.078	1.616	1.973
500	0.022	2.422	1.152
510	0.218	3.529	0.658
520	0.750	4.840	0.382
530	1.642	6.100	0.211
540	2.842	7.250	0.102
550	4.336	8.114	0.032
560	6.200	8.758	0.001
570	8.262	8.988	0.000
580	10.227	8.760	0.000
590	11.945	8.304	0.000
600	12.746	7.468	0.000
610	12.337	6.323	0.000
620	10.817	5.033	0.000
630	8.560	3.744	0.000
640	6.014	2.506	0.000
650	3.887	1.560	0.000
660	2.309	0.911	0.000
670	1.276	0.499	0.000
680	0.666	0.259	0.000
690	0.336	0.130	0.000
700	0.166	0.065	0.000
710	0.082	0.032	0.000
720	0.040	0.016	0.000
730	0.020	0.008	0.000
740	0.010	0.004	0.000
750	0.005	0.002	0.000
760	0.003	0.001	0.000
770	0.001	0.001	0.000
780	0.001	0.000	0.000
Check Sum	**111.146**	**100.000**	**35.203**
White Point	**111.144**	**100.000**	**35.200**

Table 5.4 Illuminant A, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	−0.001
380	−0.009	−0.001	−0.041
400	0.060	0.005	0.257
420	0.773	0.078	3.697
440	1.900	0.304	9.755
460	1.971	0.855	11.487
480	0.718	2.146	6.785
500	0.043	4.899	2.321
520	1.522	9.647	0.743
540	5.677	14.461	0.196
560	12.445	17.474	0.005
580	20.554	17.584	−0.003
600	25.332	14.896	0.000
620	21.571	10.080	0.000
640	12.179	5.068	0.000
660	4.668	1.830	0.000
680	1.324	0.513	0.000
700	0.318	0.123	0.000
720	0.075	0.029	0.000
740	0.018	0.007	0.000
760	0.005	0.002	0.000
780	0.001	0.001	0.000
Check Sum	**111.145**	**100.001**	**35.201**
White Point	**111.144**	**100.000**	**35.200**

Table 5.5 Illuminant C, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.001	0.000	0.004
380	0.004	0.000	0.017
390	0.018	0.001	0.084
400	0.076	0.002	0.358
410	0.325	0.009	1.547
420	1.292	0.038	6.207
430	2.968	0.123	14.496
440	3.959	0.261	19.860
450	3.931	0.443	20.728
460	3.360	0.692	19.286
470	2.283	1.061	15.022
480	1.116	1.612	9.479
490	0.363	2.358	5.286
500	0.048	3.414	2.868
510	0.092	4.842	1.512
520	0.578	6.449	0.720
530	1.519	7.936	0.381
540	2.786	9.145	0.195
550	4.285	9.831	0.086
560	5.877	9.834	0.038
570	7.323	9.148	0.020
580	8.414	7.990	0.015
590	8.985	6.629	0.010
600	8.958	5.321	0.007
610	8.324	4.177	0.003
620	7.055	3.146	0.001
630	5.327	2.196	0.000
640	3.692	1.442	0.000
650	2.352	0.887	0.000
660	1.360	0.503	0.000
670	0.713	0.261	0.000
680	0.364	0.132	0.000
690	0.172	0.062	0.000
700	0.080	0.029	0.000
710	0.039	0.014	0.000
720	0.019	0.007	0.000
730	0.009	0.003	0.000
740	0.004	0.001	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**98.074**	**100.000**	**118.230**
White Point	**98.074**	**100.000**	**118.232**

Table 5.6 Illuminant C, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	−0.001	0.000	−0.006
380	−0.011	0.000	−0.054
400	0.089	−0.001	0.393
420	2.919	0.085	14.033
440	7.649	0.511	38.518
460	6.641	1.382	38.120
480	2.364	3.206	19.564
500	0.069	6.910	5.752
520	1.198	12.876	1.442
540	5.591	18.258	0.357
560	11.750	19.588	0.073
580	16.794	15.991	0.026
600	17.896	10.696	0.013
620	14.018	6.261	0.003
640	7.457	2.902	0.000
660	2.746	1.008	0.000
680	0.712	0.257	0.000
700	0.153	0.055	0.000
720	0.034	0.012	0.000
740	0.007	0.003	0.000
760	0.002	0.001	0.000
780	0.000	0.000	0.000
Check Sum	**98.077**	**100.001**	**118.234**
White Point	**98.074**	**100.000**	**118.232**

Table 5.7 Illuminant C, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	−0.002
390	0.006	0.001	0.025
400	0.102	0.011	0.457
410	0.594	0.060	2.728
420	1.705	0.179	8.117
430	3.025	0.372	14.933
440	3.944	0.638	20.229
450	3.919	0.941	21.068
460	3.178	1.340	18.361
470	2.047	1.948	13.768
480	0.856	2.695	8.218
490	0.171	3.502	4.273
500	0.040	4.387	2.088
510	0.325	5.291	0.986
520	0.970	6.274	0.493
530	1.971	7.319	0.252
540	3.271	8.339	0.117
550	4.755	8.896	0.035
560	6.319	8.928	0.001
570	7.637	8.311	0.000
580	8.464	7.253	0.000
590	8.855	6.158	0.000
600	8.589	5.032	0.000
610	7.747	3.969	0.000
620	6.427	2.990	0.000
630	4.837	2.116	0.000
640	3.240	1.350	0.000
650	2.011	0.807	0.000
660	1.143	0.451	0.000
670	0.597	0.234	0.000
680	0.292	0.114	0.000
690	0.136	0.053	0.000
700	0.062	0.024	0.000
710	0.028	0.011	0.000
720	0.013	0.005	0.000
730	0.006	0.002	0.000
740	0.003	0.001	0.000
750	0.001	0.000	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**97.287**	**100.002**	**116.147**
White Point	**97.285**	**100.000**	**116.145**

Table 5.8 Illuminant C, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	−0.001	0.000	−0.005
380	−0.040	−0.004	−0.187
400	0.262	0.022	1.120
420	3.508	0.364	16.803
440	7.662	1.249	39.339
460	6.326	2.727	36.719
480	1.851	5.369	17.043
500	0.072	8.754	4.191
520	1.955	12.599	0.909
540	6.561	16.605	0.212
560	12.610	17.753	0.004
580	16.954	14.592	−0.003
600	17.141	10.080	0.000
620	12.823	5.977	0.000
640	6.579	2.733	0.000
660	2.304	0.902	0.000
680	0.576	0.223	0.000
700	0.115	0.044	0.000
720	0.022	0.009	0.000
740	0.005	0.002	0.000
760	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**97.286**	**100.000**	**116.145**
White Point	**97.285**	**100.000**	**116.145**

Table 5.9 Illuminant D50, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.001
370	0.001	0.000	0.005
380	0.003	0.000	0.013
390	0.012	0.000	0.057
400	0.060	0.002	0.285
410	0.234	0.006	1.113
420	0.775	0.023	3.723
430	1.610	0.066	7.862
440	2.453	0.162	12.309
450	2.777	0.313	14.647
460	2.500	0.514	14.346
470	1.717	0.798	11.299
480	0.861	1.239	7.309
490	0.283	1.839	4.128
500	0.040	2.948	2.466
510	0.088	4.632	1.447
520	0.593	6.587	0.736
530	1.590	8.308	0.401
540	2.799	9.197	0.196
550	4.207	9.650	0.085
560	5.657	9.471	0.037
570	7.132	8.902	0.020
580	8.540	8.112	0.015
590	9.255	6.829	0.010
600	9.835	5.838	0.007
610	9.469	4.753	0.004
620	8.009	3.573	0.002
630	5.926	2.443	0.001
640	4.171	1.629	0.000
650	2.609	0.984	0.000
660	1.541	0.570	0.000
670	0.855	0.313	0.000
680	0.434	0.158	0.000
690	0.194	0.070	0.000
700	0.097	0.035	0.000
710	0.050	0.018	0.000
720	0.022	0.008	0.000
730	0.012	0.004	0.000
740	0.006	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**96.421**	**99.997**	**82.524**
White Point	**96.422**	**100.000**	**82.521**

Table 5.10 Illuminant D50, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	−0.001	0.000	−0.003
380	−0.007	0.000	−0.034
400	0.100	0.001	0.459
420	1.651	0.044	7.914
440	4.787	0.325	24.153
460	4.897	1.018	28.125
480	1.815	2.413	15.027
500	0.044	6.037	4.887
520	1.263	13.141	1.507
540	5.608	18.442	0.375
560	11.361	18.960	0.069
580	16.904	16.060	0.026
600	19.537	11.646	0.014
620	15.917	7.132	0.003
640	8.342	3.245	0.000
660	3.112	1.143	0.000
680	0.857	0.310	0.000
700	0.178	0.064	0.000
720	0.044	0.016	0.000
740	0.011	0.004	0.000
760	0.002	0.001	0.000
780	0.001	0.000	0.000
Check Sum	**96.423**	**100.002**	**82.522**
White Point	**96.422**	**100.000**	**82.521**

Table 5.11 Illuminant D50, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	−0.002
390	0.004	0.000	0.017
400	0.083	0.009	0.371
410	0.427	0.044	1.966
420	1.049	0.110	4.989
430	1.668	0.204	8.231
440	2.487	0.403	12.758
450	2.814	0.677	15.129
460	2.404	1.012	13.886
470	1.565	1.490	10.528
480	0.671	2.108	6.442
490	0.135	2.779	3.392
500	0.035	3.850	1.824
510	0.317	5.143	0.960
520	1.010	6.513	0.513
530	2.098	7.791	0.269
540	3.341	8.525	0.120
550	4.745	8.877	0.035
560	6.183	8.742	0.001
570	7.560	8.222	0.000
580	8.733	7.485	0.000
590	9.273	6.449	0.000
600	9.586	5.613	0.000
610	8.959	4.592	0.000
620	7.419	3.452	0.000
630	5.471	2.392	0.000
640	3.721	1.550	0.000
650	2.268	0.910	0.000
660	1.316	0.519	0.000
670	0.728	0.285	0.000
680	0.354	0.138	0.000
690	0.155	0.060	0.000
700	0.076	0.029	0.000
710	0.036	0.014	0.000
720	0.015	0.006	0.000
730	0.008	0.003	0.000
740	0.004	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**96.721**	**99.999**	**81.429**
White Point	**96.720**	**100.000**	**81.427**

Table 5.12 Illuminant D50, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	−0.001	0.000	−0.004
380	−0.028	−0.003	−0.130
400	0.227	0.021	0.994
420	2.059	0.207	9.821
440	4.874	0.803	25.080
460	4.741	2.045	27.526
480	1.441	4.145	13.316
500	0.065	7.734	3.613
520	2.066	13.058	0.982
540	6.698	17.059	0.228
560	12.397	17.467	0.003
580	17.346	14.898	−0.003
600	19.013	11.159	0.000
620	14.807	6.921	0.000
640	7.481	3.107	0.000
660	2.654	1.039	0.000
680	0.705	0.273	0.000
700	0.136	0.053	0.000
720	0.029	0.011	0.000
740	0.007	0.003	0.000
760	0.001	0.001	0.000
780	0.000	0.000	0.000
Check Sum	**96.718**	**100.001**	**81.426**
White Point	**96.720**	**100.000**	**81.427**

Table 5.13 Illuminant D55, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.001
370	0.001	0.000	0.006
380	0.004	0.000	0.017
390	0.015	0.000	0.073
400	0.074	0.002	0.353
410	0.284	0.008	1.350
420	0.924	0.027	4.440
430	1.886	0.077	9.208
440	2.805	0.186	14.076
450	3.119	0.352	16.447
460	2.769	0.570	15.893
470	1.877	0.872	12.353
480	0.929	1.338	7.891
490	0.301	1.960	4.399
500	0.042	3.101	2.593
510	0.092	4.822	1.506
520	0.610	6.779	0.758
530	1.622	8.476	0.409
540	2.835	9.314	0.199
550	4.231	9.706	0.085
560	5.654	9.467	0.037
570	7.089	8.848	0.020
580	8.431	8.009	0.015
590	9.044	6.674	0.010
600	9.503	5.641	0.007
610	9.070	4.553	0.003
620	7.616	3.398	0.002
630	5.593	2.306	0.000
640	3.897	1.522	0.000
650	2.420	0.913	0.000
660	1.416	0.524	0.000
670	0.779	0.285	0.000
680	0.394	0.143	0.000
690	0.176	0.064	0.000
700	0.088	0.032	0.000
710	0.046	0.016	0.000
720	0.020	0.007	0.000
730	0.011	0.004	0.000
740	0.005	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.676**	**99.999**	**92.151**
White Point	**95.682**	**100.000**	**92.149**

Table 5.14 Illuminant D55, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	−0.001	0.000	−0.004
380	−0.008	0.000	−0.037
400	0.128	0.001	0.589
420	1.963	0.053	9.414
440	5.471	0.372	27.599
460	5.430	1.129	31.172
480	1.964	2.608	16.244
500	0.047	6.350	5.134
520	1.297	13.522	1.548
540	5.677	18.677	0.379
560	11.359	18.956	0.069
580	16.674	15.848	0.025
600	18.887	11.262	0.013
620	15.139	6.781	0.003
640	7.803	3.034	0.000
660	2.860	1.050	0.000
680	0.776	0.281	0.000
700	0.162	0.058	0.000
720	0.040	0.014	0.000
740	0.010	0.003	0.000
760	0.002	0.001	0.000
780	0.001	0.000	0.000
Check Sum	**95.681**	**100.000**	**92.148**
White Point	**95.682**	**100.000**	**92.149**

Table 5.15 Illuminant D55, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	−0.002
390	0.005	0.001	0.022
400	0.102	0.011	0.457
410	0.515	0.053	2.370
420	1.245	0.130	5.922
430	1.944	0.238	9.596
440	2.829	0.459	14.517
450	3.144	0.757	16.906
460	2.651	1.116	15.309
470	1.703	1.621	11.453
480	0.721	2.265	6.921
490	0.143	2.947	3.597
500	0.037	4.029	1.908
510	0.329	5.329	0.995
520	1.034	6.671	0.525
530	2.130	7.910	0.273
540	3.367	8.592	0.121
550	4.749	8.885	0.035
560	6.151	8.696	0.001
570	7.479	8.133	0.000
580	8.580	7.355	0.000
590	9.019	6.272	0.000
600	9.218	5.398	0.000
610	8.540	4.377	0.000
620	7.020	3.267	0.000
630	5.139	2.247	0.000
640	3.459	1.441	0.000
650	2.094	0.840	0.000
660	1.204	0.475	0.000
670	0.660	0.258	0.000
680	0.319	0.124	0.000
690	0.141	0.055	0.000
700	0.068	0.027	0.000
710	0.033	0.013	0.000
720	0.014	0.005	0.000
730	0.007	0.003	0.000
740	0.004	0.001	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.800**	**100.002**	**90.926**
White Point	**95.799**	**100.000**	**90.926**

Table 5.16 Illuminant D55, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	−0.001	0.000	−0.005
380	−0.033	−0.003	−0.155
400	0.280	0.026	1.232
420	2.440	0.246	11.639
440	5.542	0.913	28.514
460	5.232	2.254	30.369
480	1.554	4.453	14.325
500	0.067	8.098	3.775
520	2.114	13.376	1.002
540	6.749	17.191	0.229
560	12.335	17.380	0.002
580	17.028	14.630	−0.003
600	18.293	10.739	0.000
620	14.014	6.548	0.000
640	6.965	2.892	0.000
660	2.427	0.950	0.000
680	0.636	0.246	0.000
700	0.123	0.048	0.000
720	0.027	0.010	0.000
740	0.006	0.002	0.000
760	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.799**	**99.999**	**90.924**
White Point	**95.799**	**100.000**	**90.926**

Table 5.17 Illuminant D65, 1931 Observer 10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.001
370	0.002	0.000	0.010
380	0.006	0.000	0.026
390	0.022	0.001	0.104
400	0.101	0.003	0.477
410	0.376	0.010	1.788
420	1.200	0.035	5.765
430	2.396	0.098	11.698
440	3.418	0.226	17.150
450	3.699	0.417	19.506
460	3.227	0.664	18.520
470	2.149	0.998	14.137
480	1.042	1.501	8.850
490	0.333	2.164	4.856
500	0.045	3.352	2.802
510	0.098	5.129	1.602
520	0.637	7.076	0.791
530	1.667	8.708	0.420
540	2.884	9.474	0.202
550	4.250	9.752	0.086
560	5.626	9.419	0.037
570	6.988	8.722	0.019
580	8.214	7.802	0.014
590	8.730	6.442	0.010
600	9.015	5.351	0.007
610	8.492	4.263	0.003
620	7.050	3.145	0.001
630	5.124	2.113	0.000
640	3.516	1.373	0.000
650	2.167	0.818	0.000
660	1.252	0.463	0.000
670	0.678	0.248	0.000
680	0.341	0.124	0.000
690	0.153	0.055	0.000
700	0.076	0.027	0.000
710	0.040	0.014	0.000
720	0.018	0.006	0.000
730	0.009	0.003	0.000
740	0.005	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.049**	**99.999**	**108.882**
White Point	**95.047**	**100.000**	**108.883**

Table 5.18 Illuminant D65, 1931 Observer 20 nm Interval

nm	W_x	W_y	W_z
360	−0.001	0	−0.005
380	−0.008	0	−0.039
400	0.179	0.002	0.829
420	2.542	0.071	12.203
440	6.670	0.453	33.637
460	6.333	1.316	36.334
480	2.213	2.933	18.278
500	0.052	6.866	5.543
520	1.348	14.106	1.611
540	5.767	18.981	0.382
560	11.301	18.863	0.068
580	16.256	15.455	0.025
600	17.933	10.699	0.013
620	14.020	6.277	0.003
640	7.057	2.743	0.000
660	2.527	0.927	0.000
680	0.670	0.242	0.000
700	0.140	0.050	0.000
720	0.035	0.013	0.000
740	0.008	0.003	0.000
760	0.002	0.001	0.000
780	0.000	0.000	0.000
Check Sum	**95.044**	**100.001**	**108.882**
White Point	**95.047**	**100.000**	**108.883**

Table 5.19 Illuminant D65, 1964 Observer 10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	−0.002
390	0.008	0.001	0.033
400	0.137	0.014	0.612
410	0.676	0.069	3.110
420	1.603	0.168	7.627
430	2.451	0.300	12.095
440	3.418	0.554	17.537
450	3.699	0.890	19.888
460	3.064	1.290	17.695
470	1.933	1.838	13.000
480	0.802	2.520	7.699
490	0.156	3.226	3.938
500	0.039	4.320	2.046
510	0.347	5.621	1.049
520	1.070	6.907	0.544
530	2.170	8.059	0.278
540	3.397	8.668	0.122
550	4.732	8.855	0.035
560	6.070	8.581	0.001
570	7.311	7.951	0.000
580	8.291	7.106	0.000
590	8.634	6.004	0.000
600	8.672	5.079	0.000
610	7.930	4.065	0.000
620	6.446	2.999	0.000
630	4.669	2.042	0.000
640	3.095	1.290	0.000
650	1.859	0.746	0.000
660	1.056	0.417	0.000
670	0.570	0.223	0.000
680	0.274	0.107	0.000
690	0.121	0.047	0.000
700	0.058	0.023	0.000
710	0.028	0.011	0.000
720	0.012	0.005	0.000
730	0.006	0.002	0.000
740	0.003	0.001	0.000
750	0.001	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.809**	**100.000**	**107.307**
White Point	**94.811**	**100.000**	**107.304**

Table 5.20 Illuminant D65, 1964 Observer 20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	−0.001	0	−0.007
380	−0.043	−0.004	−0.2
400	0.378	0.035	1.667
420	3.138	0.320	14.979
440	6.701	1.104	34.461
460	6.054	2.605	35.120
480	1.739	4.961	15.986
500	0.071	8.687	4.038
520	2.183	13.844	1.031
540	6.801	17.327	0.229
560	12.171	17.153	0.002
580	16.465	14.150	−0.003
600	17.230	10.118	0.000
620	12.872	6.012	0.000
640	6.248	2.593	0.000
660	2.126	0.832	0.000
680	0.544	0.210	0.000
700	0.105	0.041	0.000
720	0.023	0.009	0.000
740	0.005	0.002	0.000
760	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.811**	**99.999**	**107.303**
White Point	**94.811**	**100.000**	**107.304**

Table 5.21 Illuminant D75, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.002
370	0.003	0.000	0.013
380	0.007	0.000	0.035
390	0.028	0.001	0.132
400	0.124	0.003	0.587
410	0.457	0.012	2.176
420	1.439	0.043	6.916
430	2.809	0.115	13.714
440	3.926	0.260	19.702
450	4.182	0.472	22.055
460	3.600	0.741	20.660
470	2.364	1.098	15.551
480	1.133	1.632	9.621
490	0.357	2.321	5.209
500	0.048	3.551	2.967
510	0.103	5.365	1.676
520	0.655	7.281	0.814
530	1.698	8.873	0.427
540	2.912	9.567	0.204
550	4.256	9.766	0.086
560	5.584	9.350	0.036
570	6.879	8.586	0.019
580	8.032	7.629	0.014
590	8.478	6.256	0.010
600	8.677	5.151	0.006
610	8.105	4.068	0.003
620	6.673	2.977	0.001
630	4.804	1.981	0.000
640	3.274	1.279	0.000
650	2.008	0.757	0.000
660	1.151	0.426	0.000
670	0.618	0.226	0.000
680	0.309	0.112	0.000
690	0.139	0.050	0.000
700	0.068	0.025	0.000
710	0.036	0.013	0.000
720	0.016	0.006	0.000
730	0.008	0.003	0.000
740	0.004	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.967**	**99.999**	**122.636**
White Point	**94.972**	**100.000**	**122.638**

Table 5.22 Illuminant D75, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	−0.001	0.000	−0.005
380	−0.008	0.000	−0.040
400	0.227	0.003	1.054
420	3.031	0.085	14.551
440	7.661	0.520	38.631
460	7.071	1.469	40.551
480	2.410	3.191	19.889
500	0.056	7.269	5.860
520	1.385	14.525	1.657
540	5.823	19.169	0.383
560	11.215	18.727	0.067
580	15.895	15.113	0.024
600	17.264	10.302	0.012
620	13.272	5.940	0.003
640	6.573	2.554	0.000
660	2.323	0.852	0.000
680	0.607	0.219	0.000
700	0.126	0.045	0.000
720	0.032	0.011	0.000
740	0.008	0.003	0.000
760	0.001	0.001	0.000
780	0.000	0.000	0.000
Check Sum	**94.971**	**99.998**	**122.637**
White Point	**94.972**	**100.000**	**122.638**

Table 5.23 Illuminant D75, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	−0.002
390	0.010	0.001	0.042
400	0.167	0.018	0.749
410	0.816	0.083	3.755
420	1.911	0.200	9.091
430	2.855	0.350	14.089
440	3.900	0.632	20.011
450	4.155	1.000	22.341
460	3.396	1.430	19.612
470	2.112	2.008	14.205
480	0.866	2.721	8.316
490	0.167	3.438	4.197
500	0.041	4.546	2.151
510	0.360	5.842	1.090
520	1.094	7.061	0.556
530	2.197	8.158	0.281
540	3.408	8.696	0.122
550	4.708	8.809	0.034
560	5.985	8.462	0.001
570	7.150	7.776	0.000
580	8.055	6.903	0.000
590	8.329	5.793	0.000
600	8.293	4.857	0.000
610	7.519	3.854	0.000
620	6.060	2.820	0.000
630	4.349	1.902	0.000
640	2.864	1.193	0.000
650	1.711	0.687	0.000
660	0.964	0.380	0.000
670	0.516	0.202	0.000
680	0.247	0.096	0.000
690	0.109	0.042	0.000
700	0.052	0.020	0.000
710	0.026	0.010	0.000
720	0.011	0.004	0.000
730	0.006	0.002	0.000
740	0.003	0.001	0.000
750	0.001	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.413**	**99.997**	**120.641**
White Point	**94.416**	**100.000**	**120.641**

Table 5.24 Illuminant D75, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	−0.002	0.000	−0.008
380	−0.051	−0.005	−0.238
400	0.466	0.043	2.058
420	3.723	0.381	17.775
440	7.645	1.261	39.311
460	6.717	2.886	38.950
480	1.882	5.358	17.279
500	0.073	9.139	4.237
520	2.229	14.168	1.050
540	6.822	17.382	0.228
560	12.000	16.917	0.002
580	15.994	13.746	−0.003
600	16.479	9.678	0.000
620	12.105	5.653	0.000
640	5.782	2.399	0.000
660	1.941	0.759	0.000
680	0.489	0.189	0.000
700	0.094	0.037	0.000
720	0.021	0.008	0.000
740	0.005	0.002	0.000
760	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.415**	**100.001**	**120.641**
White Point	**94.416**	**100.000**	**120.641**

Table 5.25 Illuminant F2, 1931 Observer 10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.001	0.000	0.003
390	−0.001	0.000	−0.006
400	0.082	0.002	0.391
410	0.169	0.005	0.802
420	0.173	0.001	0.806
430	2.860	0.136	14.065
440	3.931	0.234	19.588
450	1.338	0.162	7.114
460	1.421	0.294	8.161
470	1.011	0.470	6.652
480	0.502	0.723	4.257
490	0.166	1.078	2.418
500	0.022	1.614	1.356
510	0.045	2.425	0.757
520	0.310	3.466	0.387
530	0.793	4.424	0.223
540	2.935	9.137	0.175
550	5.305	12.533	0.122
560	6.428	10.676	0.039
570	10.089	12.520	0.028
580	13.508	12.872	0.024
590	13.082	9.655	0.015
600	11.989	7.125	0.009
610	9.453	4.746	0.004
620	6.393	2.850	0.001
630	3.711	1.529	0.000
640	1.929	0.753	0.000
650	0.906	0.341	0.000
660	0.387	0.143	0.000
670	0.152	0.055	0.000
680	0.059	0.021	0.000
690	0.023	0.008	0.000
700	0.008	0.003	0.000
710	0.003	0.001	0.000
720	0.001	0.000	0.000
730	0.001	0.000	0.000
740	0.000	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**99.185**	**100.002**	**67.391**
White Point	**99.186**	**100.000**	**67.393**

Table 5.26 Illuminant F2, 1931 Observer 20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	−0.002
380	−0.011	0.000	−0.050
400	−0.017	−0.005	−0.115
420	1.856	0.072	9.030
440	6.133	0.367	30.621
460	2.598	0.575	15.095
480	1.069	1.430	8.827
500	0.021	3.263	2.724
520	0.460	6.535	0.778
540	5.710	17.665	0.317
560	14.283	23.949	0.109
580	25.551	24.192	0.039
600	23.791	14.379	0.017
620	12.941	5.764	0.003
640	3.944	1.507	0.000
660	0.745	0.267	0.000
680	0.097	0.034	0.000
700	0.013	0.004	0.000
720	0.002	0.001	0.000
740	0.000	0.000	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**99.186**	**99.999**	**67.393**
White Point	**99.186**	**100.000**	**67.393**

Table 5.27 Illuminant F2, 1964 Observer 10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	−0.001
390	−0.009	−0.001	−0.041
400	0.133	0.014	0.603
410	0.311	0.032	1.425
420	0.310	0.025	1.418
430	2.977	0.395	14.861
440	4.074	0.617	20.711
450	1.393	0.354	7.553
460	1.402	0.593	8.103
470	0.946	0.900	6.363
480	0.401	1.261	3.852
490	0.081	1.671	2.039
500	0.019	2.165	1.030
510	0.169	2.764	0.515
520	0.543	3.517	0.277
530	1.093	4.262	0.154
540	3.562	8.685	0.107
550	6.166	11.838	0.055
560	7.209	10.117	−0.001
570	10.967	11.867	0.000
580	14.182	12.191	0.000
590	13.453	9.357	0.000
600	11.997	7.032	0.000
610	9.183	4.707	0.000
620	6.075	2.825	0.000
630	3.517	1.537	0.000
640	1.767	0.736	0.000
650	0.808	0.324	0.000
660	0.339	0.134	0.000
670	0.133	0.052	0.000
680	0.049	0.019	0.000
690	0.019	0.007	0.000
700	0.007	0.003	0.000
710	0.003	0.001	0.000
720	0.001	0.000	0.000
730	0.000	0.000	0.000
740	0.000	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**103.280**	**100.001**	**69.023**
White Point	**103.279**	**100.000**	**69.027**

Table 5.28 Illuminant F2, 1964 Observer 20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	−0.002
380	−0.024	−0.002	−0.109
400	0.102	0.004	0.375
420	2.135	0.251	10.426
440	6.365	0.969	32.397
460	2.572	1.178	15.110
480	0.874	2.509	8.033
500	0.025	4.319	2.072
520	0.886	6.692	0.518
540	6.923	16.756	0.190
560	16.002	22.655	0.021
580	26.885	23.029	−0.004
600	23.817	14.131	0.000
620	12.349	5.743	0.000
640	3.633	1.487	0.000
660	0.643	0.245	0.000
680	0.080	0.031	0.000
700	0.009	0.004	0.000
720	0.001	0.000	0.000
740	0.000	0.000	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**103.277**	**100.001**	**69.027**
White Point	**103.279**	**100.000**	**69.027**

Table 5.29 Illuminant F7, 1931 Observer 10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.000	0.000	−0.001
380	0.001	0.000	0.007
390	0.004	0.000	0.019
400	0.110	0.003	0.521
410	0.269	0.007	1.282
420	0.475	0.009	2.249
430	3.951	0.183	19.408
440	5.466	0.331	27.269
450	2.547	0.300	13.501
460	2.585	0.534	14.846
470	1.840	0.854	12.103
480	0.915	1.318	7.764
490	0.302	1.964	4.405
500	0.041	2.979	2.499
510	0.087	4.507	1.404
520	0.556	6.177	0.691
530	1.258	6.924	0.347
540	3.644	11.327	0.217
550	5.522	13.146	0.130
560	4.932	8.167	0.029
570	7.145	8.839	0.019
580	9.610	9.176	0.017
590	8.888	6.553	0.010
600	8.828	5.241	0.007
610	7.951	3.991	0.003
620	6.485	2.892	0.001
630	4.721	1.947	0.000
640	3.106	1.213	0.000
650	1.949	0.735	0.000
660	1.093	0.404	0.000
670	0.449	0.164	0.000
680	0.181	0.066	0.000
690	0.078	0.028	0.000
700	0.032	0.011	0.000
710	0.013	0.005	0.000
720	0.005	0.002	0.000
730	0.002	0.001	0.000
740	0.001	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.042**	**99.998**	**108.747**
White Point	**95.041**	**100.000**	**108.747**

Table 5.30 Illuminant F7, 1931 Observer 20 nm Interval

nm	W_x	W_y	W_z
360	−0.001	0.000	−0.005
380	−0.014	0.000	−0.069
400	0.000	−0.006	−0.043
420	2.766	0.101	13.418
440	8.886	0.544	44.448
460	4.834	1.051	27.991
480	1.948	2.602	16.086
500	0.063	6.128	5.010
520	0.982	11.733	1.388
540	6.956	21.654	0.392
560	11.482	19.792	0.091
580	17.742	16.706	0.024
600	17.563	10.523	0.013
620	12.929	5.773	0.003
640	6.345	2.464	0.000
660	2.143	0.786	0.000
680	0.356	0.128	0.000
700	0.052	0.019	0.000
720	0.009	0.003	0.000
740	0.001	0.001	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.042**	**100.002**	**108.747**
White Point	**95.041**	**100.000**	**108.747**

Table 5.31 Illuminant F7, 1964 Observer 10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	−0.001
390	−0.007	−0.001	−0.034
400	0.168	0.017	0.757
410	0.486	0.050	2.229
420	0.715	0.067	3.341
430	4.000	0.524	19.933
440	5.496	0.842	27.981
450	2.569	0.639	13.889
460	2.473	1.046	14.292
470	1.669	1.587	11.224
480	0.709	2.230	6.810
490	0.144	2.951	3.603
500	0.035	3.873	1.840
510	0.308	4.979	0.927
520	0.943	6.080	0.479
530	1.674	6.466	0.232
540	4.286	10.438	0.129
550	6.229	12.041	0.059
560	5.360	7.501	−0.002
570	7.528	8.122	0.000
580	9.783	8.424	0.000
590	8.861	6.158	0.000
600	8.563	5.015	0.000
610	7.486	3.837	0.000
620	5.977	2.780	0.000
630	4.337	1.897	0.000
640	2.757	1.149	0.000
650	1.685	0.676	0.000
660	0.929	0.367	0.000
670	0.380	0.149	0.000
680	0.147	0.057	0.000
690	0.062	0.024	0.000
700	0.025	0.010	0.000
710	0.010	0.004	0.000
720	0.004	0.001	0.000
730	0.001	0.001	0.000
740	0.001	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.793**	**100.001**	**107.688**
White Point	**95.792**	**100.000**	**107.686**

Table 5.32 Illuminant F7, 1964 Observer 20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	−0.001	0.000	−0.003
380	−0.035	−0.004	−0.163
400	0.172	0.010	0.668
420	3.151	0.358	15.311
440	8.954	1.381	45.662
460	4.644	2.090	27.187
480	1.545	4.429	14.195
500	0.077	7.818	3.693
520	1.694	11.650	0.894
540	8.187	19.913	0.231
560	12.502	18.144	0.017
580	18.097	15.414	−0.005
600	17.023	10.030	0.000
620	11.964	5.576	0.000
640	5.664	2.350	0.000
660	1.817	0.710	0.000
680	0.290	0.112	0.000
700	0.039	0.015	0.000
720	0.006	0.002	0.000
740	0.001	0.000	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.791**	**99.998**	**107.687**
White Point	**95.792**	**100.000**	**107.686**

Table 5.33 Illuminant F11, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.001	0.000	0.002
390	−0.005	0.000	−0.022
400	0.059	0.002	0.281
410	0.097	0.003	0.463
420	0.024	−0.004	0.087
430	2.687	0.128	13.207
440	3.952	0.237	19.705
450	1.471	0.177	7.819
460	1.328	0.274	7.621
470	0.723	0.295	4.685
480	0.448	0.803	4.044
490	0.326	1.905	4.458
500	0.020	1.104	1.005
510	0.006	0.499	0.121
520	−0.012	0.244	0.038
530	−0.155	0.163	0.037
540	8.983	26.955	0.483
550	10.520	26.054	0.291
560	0.993	1.348	−0.007
570	1.064	1.283	0.002
580	6.717	6.191	0.011
590	8.697	6.590	0.010
600	6.188	3.669	0.005
610	27.072	13.415	0.009
620	13.847	6.329	0.003
630	4.003	1.614	0.000
640	0.864	0.335	0.000
650	0.541	0.203	0.000
660	0.301	0.111	0.000
670	0.096	0.035	0.000
680	0.046	0.017	0.000
690	0.028	0.010	0.000
700	0.014	0.005	0.000
710	0.018	0.007	0.000
720	0.002	0.001	0.000
730	0.000	0.000	0.000
740	0.000	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**100.964**	**100.002**	**64.358**
White Point	**100.962**	**100.000**	**64.350**

Table 5.34 Illuminant F11, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
380	−0.008	0.000	−0.038
400	−0.073	−0.006	−0.381
420	1.561	0.062	7.606
440	6.149	0.384	30.772
460	2.422	0.422	13.794
480	0.938	1.995	8.635
500	0.129	2.294	3.297
520	−0.611	−0.646	−0.159
540	14.491	40.892	0.642
560	7.174	16.775	0.162
580	9.760	7.999	−0.002
600	26.160	14.828	0.015
620	30.433	14.217	0.008
640	1.969	0.627	0.000
660	0.344	0.113	0.000
680	0.080	0.028	0.000
700	0.034	0.012	0.000
720	0.011	0.004	0.000
740	−0.001	0.000	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**100.962**	**100.000**	**64.351**
White Point	**100.962**	**100.000**	**64.350**

Table 5.35 Illuminant F11, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	0.000
390	−0.010	−0.001	−0.044
400	0.099	0.010	0.451
410	0.182	0.019	0.829
420	0.098	0.003	0.415
430	2.796	0.372	13.964
440	4.103	0.625	20.873
450	1.534	0.388	8.310
460	1.314	0.554	7.586
470	0.681	0.578	4.498
480	0.343	1.380	3.625
490	0.176	2.955	3.789
500	0.009	1.506	0.773
510	0.034	0.564	0.074
520	0.005	0.257	0.028
530	−0.145	0.170	0.027
540	10.852	25.656	0.293
550	12.320	24.661	0.148
560	1.096	1.274	−0.010
570	1.157	1.214	0.000
580	7.036	5.881	0.000
590	8.982	6.382	0.000
600	6.204	3.629	0.000
610	26.264	13.321	0.000
620	13.228	6.279	0.000
630	3.797	1.631	0.000
640	0.794	0.329	0.000
650	0.481	0.192	0.000
660	0.264	0.104	0.000
670	0.084	0.033	0.000
680	0.038	0.015	0.000
690	0.023	0.009	0.000
700	0.011	0.004	0.000
710	0.014	0.005	0.000
720	0.002	0.001	0.000
730	0.000	0.000	0.000
740	0.000	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**103.866**	**100.000**	**65.629**
White Point	**103.863**	**100.000**	**65.607**

Table 5.36 Illuminant F11, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
380	−0.016	−0.002	−0.072
400	0.004	−0.006	−0.070
420	1.742	0.207	8.545
440	6.391	1.000	32.600
460	2.422	0.909	13.937
480	0.722	3.297	7.710
500	0.043	3.310	2.674
520	−0.644	−0.590	−0.157
540	17.324	38.846	0.376
560	8.355	15.868	0.075
580	10.221	7.635	−0.011
600	25.881	14.619	0.000
620	29.246	14.139	0.000
640	1.789	0.630	0.000
660	0.282	0.098	0.000
680	0.066	0.025	0.000
700	0.026	0.010	0.000
720	0.008	0.003	0.000
740	−0.001	0.000	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**103.861**	**99.998**	**65.607**
White Point	**103.863**	**100.000**	**65.607**

Table 6.1 Illuminant A, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.000	0.000	0.001
380	0.001	0.000	0.005
390	0.004	0.000	0.018
400	0.017	0.000	0.081
410	0.057	0.002	0.272
420	0.246	0.007	1.178
430	0.660	0.025	3.214
440	0.942	0.059	4.710
450	1.039	0.113	5.454
460	1.043	0.205	5.969
470	0.790	0.353	5.209
480	0.416	0.608	3.602
490	0.148	1.012	2.277
500	0.016	1.749	1.493
510	0.028	3.047	0.963
520	0.388	4.778	0.505
530	1.187	6.345	0.305
540	2.288	7.625	0.157
550	3.702	8.594	0.071
560	5.484	9.255	0.034
570	7.562	9.496	0.020
580	9.739	9.265	0.018
590	11.644	8.567	0.013
600	12.811	7.563	0.010
610	12.782	6.365	0.004
620	11.460	5.076	0.002
630	8.991	3.689	0.001
640	6.536	2.543	0.000
650	4.296	1.616	0.000
660	2.583	0.954	0.000
670	1.405	0.514	0.000
680	0.780	0.283	0.000
690	0.388	0.140	0.000
700	0.200	0.072	0.000
710	0.106	0.038	0.000
720	0.054	0.020	0.000
730	0.028	0.010	0.000
740	0.014	0.005	0.000
750	0.007	0.002	0.000
760	0.003	0.001	0.000
770	0.002	0.001	0.000
780	0.001	0.000	0.000
Check Sum	**109.848**	**99.997**	**35.586**
White Point	**109.850**	**100.000**	**35.585**

Table 6.2 Illuminant A, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
380	0.013	0.000	0.060
400	−0.026	0.000	−0.123
420	0.483	0.009	2.306
440	1.955	0.106	9.637
460	2.145	0.385	12.257
480	0.848	1.119	7.301
500	−0.112	3.247	2.727
520	0.611	9.517	1.035
540	4.407	15.434	0.274
560	10.804	18.703	0.055
580	19.601	18.746	0.034
600	26.256	15.233	0.018
620	23.295	10.105	0.003
640	12.853	4.939	0.000
660	4.863	1.784	0.000
680	1.363	0.495	0.000
700	0.359	0.129	0.000
720	0.100	0.036	0.000
740	0.023	0.008	0.000
760	0.006	0.002	0.000
780	0.002	0.001	0.000
Check Sum	**109.849**	**99.998**	**35.584**
White Point	**109.850**	**100.000**	**35.585**

Table 6.3 Illuminant A, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	0.000
390	0.002	0.000	0.007
400	0.018	0.002	0.078
410	0.118	0.012	0.540
420	0.372	0.038	1.760
430	0.686	0.082	3.374
440	0.982	0.154	5.024
450	1.094	0.255	5.876
460	1.024	0.414	5.882
470	0.747	0.688	5.023
480	0.326	1.073	3.236
490	0.061	1.589	1.926
500	0.003	2.397	1.129
510	0.189	3.503	0.638
520	0.717	4.857	0.377
530	1.617	6.096	0.205
540	2.823	7.290	0.100
550	4.296	8.116	0.028
560	6.177	8.799	−0.003
570	8.285	9.039	0.001
580	10.218	8.758	0.000
590	12.041	8.350	0.000
600	12.850	7.492	0.000
610	12.441	6.337	0.000
620	10.872	5.025	0.000
630	8.604	3.753	0.000
640	5.951	2.469	0.000
650	3.846	1.537	0.000
660	2.259	0.891	0.000
670	1.242	0.485	0.000
680	0.643	0.250	0.000
690	0.324	0.126	0.000
700	0.160	0.062	0.000
710	0.078	0.030	0.000
720	0.039	0.015	0.000
730	0.019	0.007	0.000
740	0.010	0.004	0.000
750	0.005	0.002	0.000
760	0.002	0.001	0.000
770	0.001	0.001	0.000
780	0.001	0.000	0.000
Check Sum	**111.143**	**99.999**	**35.201**
White Point	**111.144**	**100.000**	**35.200**

Table 6.4 Illuminant A, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
380	0.007	0.000	0.037
400	−0.016	0.000	−0.088
420	0.691	0.066	3.226
440	2.025	0.285	10.278
460	2.158	0.796	12.345
480	0.642	2.043	6.555
500	−0.160	4.630	1.966
520	1.284	9.668	0.721
540	5.445	14.621	0.171
560	12.238	17.766	−0.013
580	20.755	17.800	0.004
600	26.325	15.129	−0.001
620	22.187	10.097	0.000
640	11.816	4.858	0.000
660	4.221	1.643	0.000
680	1.154	0.452	0.000
700	0.282	0.109	0.000
720	0.068	0.026	0.000
740	0.017	0.007	0.000
760	0.004	0.002	0.000
780	0.001	0.000	0.000
Check Sum	**111.144**	**99.998**	**35.201**
White Point	**111.144**	**100.000**	**35.200**

Table 6.5 Illuminant C, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.001	0.000	0.003
380	0.004	0.000	0.017
390	0.015	0.000	0.069
400	0.074	0.002	0.350
410	0.261	0.007	1.241
420	1.170	0.032	5.605
430	3.074	0.118	14.967
440	4.066	0.259	20.346
450	3.951	0.437	20.769
460	3.421	0.684	19.624
470	2.292	1.042	15.153
480	1.066	1.600	9.294
490	0.325	2.332	5.115
500	0.025	3.375	2.788
510	0.052	4.823	1.481
520	0.535	6.468	0.669
530	1.496	7.951	0.381
540	2.766	9.193	0.187
550	4.274	9.889	0.081
560	5.891	9.898	0.036
570	7.353	9.186	0.019
580	8.459	8.008	0.015
590	9.036	6.621	0.010
600	9.005	5.302	0.007
610	8.380	4.168	0.003
620	7.111	3.147	0.001
630	5.300	2.174	0.000
640	3.669	1.427	0.000
650	2.320	0.873	0.000
660	1.333	0.492	0.000
670	0.683	0.250	0.000
680	0.356	0.129	0.000
690	0.162	0.059	0.000
700	0.077	0.028	0.000
710	0.038	0.014	0.000
720	0.018	0.006	0.000
730	0.008	0.003	0.000
740	0.004	0.001	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**98.074**	**99.999**	**118.231**
White Point	**98.074**	**100.000**	**118.232**

Table 6.6 Illuminant C, 1931 Observer
20 nm Interval

360	0.000	0.000	0.000
380	0.066	0.000	0.311
400	−0.164	0.001	−0.777
420	2.373	0.044	11.296
440	8.595	0.491	42.561
460	6.939	1.308	39.899
480	2.045	3.062	18.451
500	−0.217	6.596	4.728
520	0.881	12.925	1.341
540	5.406	18.650	0.319
560	11.842	20.143	0.059
580	17.169	16.095	0.028
600	18.383	10.537	0.013
620	14.348	6.211	0.002
640	7.148	2.743	0.000
660	2.484	0.911	0.000
680	0.600	0.218	0.000
700	0.136	0.049	0.000
720	0.031	0.011	0.000
740	0.006	0.002	0.000
760	0.002	0.001	0.000
780	0.000	0.000	0.000
Check Sum	**98.073**	**99.998**	**118.231**
White Point	**98.074**	**100.000**	**118.232**

Table 6.7 Illuminant C, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	0.000
390	0.006	0.001	0.025
400	0.071	0.007	0.317
410	0.519	0.054	2.362
420	1.690	0.173	7.995
430	3.050	0.364	15.015
440	4.055	0.638	20.751
450	3.974	0.936	21.364
460	3.207	1.316	18.457
470	2.067	1.938	13.957
480	0.792	2.693	7.968
490	0.123	3.489	4.126
500	0.008	4.395	2.006
510	0.297	5.276	0.935
520	0.939	6.275	0.480
530	1.944	7.299	0.244
540	3.259	8.401	0.114
550	4.739	8.926	0.030
560	6.340	8.995	−0.003
570	7.694	8.357	0.001
580	8.479	7.236	0.000
590	8.929	6.171	0.000
600	8.630	5.020	0.000
610	7.794	3.966	0.000
620	6.446	2.978	0.000
630	4.848	2.114	0.000
640	3.191	1.323	0.000
650	1.986	0.793	0.000
660	1.114	0.439	0.000
670	0.577	0.226	0.000
680	0.280	0.109	0.000
690	0.130	0.050	0.000
700	0.059	0.023	0.000
710	0.027	0.010	0.000
720	0.012	0.005	0.000
730	0.005	0.002	0.000
740	0.003	0.001	0.000
750	0.001	0.000	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**97.286**	**99.999**	**116.144**
White Point	**97.285**	**100.000**	**116.145**

Table 6.8 Illuminant C, 1964 Observer
20 nm Interval

360	0.000	0.000	0.000
380	0.043	0.002	0.213
400	−0.122	−0.004	−0.622
420	3.216	0.301	15.025
440	8.476	1.239	43.144
460	6.668	2.577	38.431
480	1.430	5.320	15.661
500	−0.249	8.742	3.219
520	1.734	12.466	0.897
540	6.364	16.891	0.187
560	12.790	18.284	−0.014
580	17.338	14.617	0.004
600	17.597	10.019	−0.001
620	13.045	5.925	0.000
640	6.283	2.581	0.000
660	2.055	0.800	0.000
680	0.488	0.191	0.000
700	0.100	0.039	0.000
720	0.021	0.008	0.000
740	0.004	0.002	0.000
760	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**97.282**	**100.000**	**116.144**
White Point	**97.285**	**100.000**	**116.145**

Table 6.9 Illuminant D50, 1931 Observer 10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.001	0.000	0.005
380	0.003	0.000	0.014
390	0.008	0.000	0.039
400	0.058	0.002	0.277
410	0.191	0.005	0.906
420	0.751	0.021	3.603
430	1.592	0.060	7.747
440	2.519	0.158	12.593
450	2.824	0.310	14.834
460	2.556	0.511	14.659
470	1.717	0.776	11.344
480	0.832	1.246	7.240
490	0.250	1.783	3.934
500	0.025	2.892	2.447
510	0.047	4.610	1.432
520	0.538	6.586	0.688
530	1.590	8.435	0.403
540	2.770	9.185	0.186
550	4.210	9.733	0.080
560	5.662	9.503	0.035
570	7.092	8.882	0.019
580	8.681	8.225	0.016
590	9.175	6.728	0.010
600	9.966	5.884	0.008
610	9.556	4.752	0.003
620	8.099	3.584	0.002
630	5.835	2.392	0.000
640	4.199	1.633	0.000
650	2.539	0.954	0.000
660	1.517	0.560	0.000
670	0.831	0.304	0.000
680	0.423	0.153	0.000
690	0.178	0.064	0.000
700	0.096	0.035	0.000
710	0.049	0.018	0.000
720	0.020	0.007	0.000
730	0.012	0.004	0.000
740	0.006	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**96.422**	**99.998**	**82.524**
White Point	**96.422**	**100.000**	**82.521**

Table 6.10 Illuminant D50, 1931 Observer 20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
380	0.021	0.000	0.100
400	−0.013	0.003	−0.060
420	1.297	0.023	6.170
440	5.218	0.290	25.788
460	5.326	0.984	30.489
480	1.554	2.291	13.965
500	−0.191	5.461	4.224
520	0.915	13.421	1.430
540	5.528	18.956	0.313
560	11.324	19.226	0.057
580	17.119	16.204	0.028
600	20.222	11.611	0.014
620	16.400	7.117	0.002
640	7.922	3.030	0.000
660	2.835	1.043	0.000
680	0.741	0.268	0.000
700	0.150	0.054	0.000
720	0.044	0.016	0.000
740	0.009	0.003	0.000
760	0.002	0.001	0.000
780	0.001	0.000	0.000
Check Sum	**96.424**	**100.002**	**82.520**
White Point	**96.422**	**100.000**	**82.521**

Table 6.11 Illuminant D50, 1964 Observer 10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.001	0.000	0.002
390	0.002	0.000	0.009
400	0.059	0.006	0.263
410	0.385	0.040	1.751
420	1.087	0.112	5.154
430	1.598	0.190	7.864
440	2.556	0.398	13.066
450	2.888	0.675	15.511
460	2.437	1.000	14.023
470	1.574	1.469	10.623
480	0.630	2.130	6.312
490	0.096	2.715	3.227
500	0.006	3.842	1.796
510	0.284	5.138	0.919
520	0.965	6.500	0.501
530	2.101	7.872	0.263
540	3.317	8.532	0.114
550	4.745	8.931	0.031
560	6.194	8.780	−0.003
570	7.547	8.214	0.001
580	8.847	7.557	0.000
590	9.218	6.375	0.000
600	9.712	5.663	0.000
610	9.035	4.597	0.000
620	7.465	3.447	0.000
630	5.426	2.366	0.000
640	3.713	1.541	0.000
650	2.208	0.882	0.000
660	1.289	0.509	0.000
670	0.714	0.279	0.000
680	0.338	0.131	0.000
690	0.144	0.056	0.000
700	0.075	0.029	0.000
710	0.035	0.014	0.000
720	0.014	0.005	0.000
730	0.008	0.003	0.000
740	0.004	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**96.720**	**100.001**	**81.427**
White Point	**96.720**	**100.000**	**81.427**

Table 6.12 Illuminant D50, 1964 Observer 20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
380	0.001	−0.001	0.010
400	0.035	0.009	0.131
420	1.856	0.174	8.631
440	5.234	0.748	26.634
460	5.206	1.975	29.874
480	1.104	4.046	12.054
500	−0.238	7.459	2.948
520	1.816	13.203	0.969
540	6.614	17.441	0.186
560	12.430	17.746	−0.014
580	17.595	14.952	0.004
600	19.678	11.219	−0.001
620	15.166	6.902	0.000
640	7.075	2.898	0.000
660	2.387	0.931	0.000
680	0.612	0.240	0.000
700	0.111	0.043	0.000
720	0.030	0.012	0.000
740	0.006	0.002	0.000
760	0.001	0.000	0.000
780	0.001	0.000	0.000
Check Sum	**96.720**	**99.999**	**81.426**
White Point	**96.720**	**100.000**	**81.427**

Table 6.13 Illuminant D55, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.001	0.000	0.006
380	0.004	0.000	0.019
390	0.011	0.000	0.051
400	0.072	0.002	0.343
410	0.232	0.006	1.105
420	0.897	0.026	4.303
430	1.872	0.071	9.113
440	2.881	0.181	14.405
450	3.169	0.348	16.648
460	2.831	0.567	16.238
470	1.874	0.849	12.388
480	0.896	1.346	7.807
490	0.266	1.902	4.187
500	0.026	3.042	2.570
510	0.050	4.806	1.490
520	0.554	6.779	0.707
530	1.624	8.605	0.411
540	2.807	9.303	0.188
550	4.236	9.789	0.080
560	5.660	9.497	0.035
570	7.052	8.829	0.018
580	8.575	8.123	0.015
590	8.968	6.574	0.010
600	9.626	5.681	0.008
610	9.151	4.550	0.003
620	7.698	3.406	0.002
630	5.508	2.258	0.000
640	3.916	1.523	0.000
650	2.356	0.885	0.000
660	1.393	0.514	0.000
670	0.757	0.277	0.000
680	0.383	0.139	0.000
690	0.162	0.059	0.000
700	0.087	0.031	0.000
710	0.045	0.016	0.000
720	0.018	0.007	0.000
730	0.011	0.004	0.000
740	0.005	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.678**	**99.998**	**92.150**
White Point	**95.682**	**100.000**	**92.149**

Table 6.14 Illuminant D55, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
380	0.027	0.000	0.127
400	−0.016	0.004	−0.072
420	1.578	0.029	7.506
440	5.983	0.334	29.586
460	5.881	1.094	33.691
480	1.663	2.481	15.012
500	−0.202	5.771	4.413
520	0.950	13.833	1.471
540	5.611	19.197	0.314
560	11.328	19.214	0.057
580	16.931	16.001	0.028
600	19.527	11.196	0.013
620	15.581	6.759	0.002
640	7.384	2.823	0.000
660	2.600	0.956	0.000
680	0.669	0.242	0.000
700	0.137	0.049	0.000
720	0.040	0.014	0.000
740	0.008	0.003	0.000
760	0.001	0.001	0.000
780	0.001	0.000	0.000
Check Sum	**95.682**	**100.001**	**92.148**
White Point	**95.682**	**100.000**	**92.149**

Table 6.15 Illuminant D55, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.001	0.000	0.003
390	0.003	0.000	0.012
400	0.073	0.008	0.326
410	0.466	0.048	2.122
420	1.291	0.133	6.120
430	1.870	0.222	9.203
440	2.910	0.454	14.875
450	3.224	0.755	17.323
460	2.686	1.104	15.458
470	1.710	1.599	11.543
480	0.675	2.289	6.773
490	0.101	2.882	3.418
500	0.007	4.021	1.876
510	0.296	5.329	0.952
520	0.989	6.657	0.513
530	2.134	7.993	0.267
540	3.345	8.600	0.115
550	4.751	8.939	0.031
560	6.162	8.732	−0.003
570	7.468	8.126	0.001
580	8.697	7.426	0.000
590	8.966	6.199	0.000
600	9.336	5.442	0.000
610	8.610	4.380	0.000
620	7.061	3.261	0.000
630	5.097	2.222	0.000
640	3.446	1.430	0.000
650	2.039	0.814	0.000
660	1.178	0.465	0.000
670	0.647	0.253	0.000
680	0.305	0.119	0.000
690	0.131	0.051	0.000
700	0.067	0.026	0.000
710	0.032	0.012	0.000
720	0.012	0.005	0.000
730	0.007	0.003	0.000
740	0.004	0.001	0.000
750	0.001	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.799**	**100.001**	**90.928**
White Point	**95.799**	**100.000**	**90.926**

Table 6.16 Illuminant D55, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
380	0.001	−0.001	0.013
400	0.044	0.010	0.165
420	2.237	0.210	10.414
440	5.965	0.856	30.366
460	5.721	2.183	32.860
480	1.170	4.359	12.878
500	−0.246	7.830	3.064
520	1.870	13.538	0.992
540	6.678	17.576	0.186
560	12.373	17.649	−0.013
580	17.314	14.694	0.004
600	18.909	10.768	−0.001
620	14.336	6.522	0.000
640	6.563	2.688	0.000
660	2.177	0.849	0.000
680	0.551	0.216	0.000
700	0.101	0.039	0.000
720	0.027	0.011	0.000
740	0.006	0.002	0.000
760	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.798**	**99.999**	**90.928**
White Point	**95.799**	**100.000**	**90.926**

Table 6.17 Illuminant D65, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.002	0.000	0.009
380	0.006	0.000	0.029
390	0.016	0.000	0.077
400	0.097	0.003	0.460
410	0.311	0.009	1.477
420	1.164	0.033	5.581
430	2.400	0.092	11.684
440	3.506	0.221	17.532
450	3.755	0.413	19.729
460	3.298	0.662	18.921
470	2.141	0.973	14.161
480	1.001	1.509	8.730
490	0.293	2.107	4.623
500	0.028	3.288	2.769
510	0.054	5.122	1.584
520	0.581	7.082	0.736
530	1.668	8.833	0.421
540	2.860	9.472	0.191
550	4.257	9.830	0.081
560	5.632	9.446	0.034
570	6.960	8.709	0.018
580	8.344	7.901	0.015
590	8.676	6.357	0.009
600	9.120	5.379	0.007
610	8.568	4.259	0.003
620	7.119	3.149	0.001
630	5.049	2.070	0.000
640	3.522	1.370	0.000
650	2.112	0.794	0.000
660	1.229	0.454	0.000
670	0.658	0.240	0.000
680	0.331	0.120	0.000
690	0.142	0.051	0.000
700	0.074	0.027	0.000
710	0.039	0.014	0.000
720	0.016	0.006	0.000
730	0.009	0.003	0.000
740	0.005	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.047**	**100.001**	**108.882**
White Point	**95.047**	**100.000**	**108.883**

Table 6.18 Illuminant D65, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
380	0.040	0.000	0.187
400	−0.026	0.004	−0.120
420	2.114	0.041	10.065
440	7.323	0.411	36.235
460	6.815	1.281	39.090
480	1.843	2.797	16.753
500	−0.219	6.291	4.727
520	1.003	14.463	1.532
540	5.723	19.509	0.314
560	11.284	19.106	0.058
580	16.548	15.600	0.027
600	18.528	10.607	0.013
620	14.397	6.240	0.002
640	6.646	2.540	0.000
660	2.290	0.842	0.000
680	0.574	0.208	0.000
700	0.120	0.043	0.000
720	0.034	0.012	0.000
740	0.007	0.003	0.000
760	0.001	0.000	0.000
780	0.001	0.000	0.000
Check Sum	**95.046**	**99.998**	**108.883**
White Point	**95.047**	**100.000**	**108.883**

Table 6.19 Illuminant D65, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	−0.001
380	0.001	0.000	0.004
390	0.005	0.000	0.020
400	0.097	0.010	0.436
410	0.616	0.064	2.808
420	1.660	0.171	7.868
430	2.377	0.283	11.703
440	3.512	0.549	17.958
450	3.789	0.888	20.358
460	3.103	1.277	17.861
470	1.937	1.817	13.085
480	0.747	2.545	7.510
490	0.110	3.164	3.743
500	0.007	4.309	2.003
510	0.314	5.631	1.004
520	1.027	6.896	0.529
530	2.174	8.136	0.271
540	3.380	8.684	0.116
550	4.735	8.903	0.030
560	6.081	8.614	−0.003
570	7.310	7.950	0.001
580	8.393	7.164	0.000
590	8.603	5.945	0.000
600	8.771	5.110	0.000
610	7.996	4.067	0.000
620	6.476	2.990	0.000
630	4.635	2.020	0.000
640	3.074	1.275	0.000
650	1.814	0.724	0.000
660	1.031	0.407	0.000
670	0.557	0.218	0.000
680	0.261	0.102	0.000
690	0.114	0.044	0.000
700	0.057	0.022	0.000
710	0.028	0.011	0.000
720	0.011	0.004	0.000
730	0.006	0.002	0.000
740	0.003	0.001	0.000
750	0.001	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.813**	**99.997**	**107.304**
White Point	**94.811**	**100.000**	**107.304**

Table 6.20 Illuminant D65, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
380	0.003	−0.001	0.025
400	0.056	0.013	0.199
420	2.951	0.280	13.768
440	7.227	1.042	36.808
460	6.578	2.534	37.827
480	1.278	4.872	14.226
500	−0.259	8.438	3.254
520	1.951	14.030	1.025
540	6.751	17.715	0.184
560	12.223	17.407	−0.013
580	16.779	14.210	0.004
600	17.793	10.121	−0.001
620	13.135	5.971	0.000
640	5.859	2.399	0.000
660	1.901	0.741	0.000
680	0.469	0.184	0.000
700	0.088	0.034	0.000
720	0.023	0.009	0.000
740	0.005	0.002	0.000
760	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.812**	**100.001**	**107.306**
White Point	**94.811**	**100.000**	**107.304**

Table 6.21 Illuminant D75, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.003	0.000	0.012
380	0.008	0.000	0.038
390	0.021	0.001	0.098
400	0.120	0.003	0.567
410	0.378	0.010	1.798
420	1.403	0.040	6.728
430	2.820	0.108	13.727
440	4.028	0.254	20.146
450	4.244	0.467	22.301
460	3.677	0.739	21.106
470	2.350	1.071	15.552
480	1.087	1.642	9.485
490	0.313	2.262	4.951
500	0.029	3.484	2.929
510	0.058	5.371	1.657
520	0.599	7.281	0.754
530	1.702	9.005	0.430
540	2.890	9.564	0.192
550	4.265	9.845	0.081
560	5.592	9.375	0.034
570	6.853	8.571	0.018
580	8.161	7.725	0.015
590	8.429	6.174	0.009
600	8.777	5.176	0.007
610	8.176	4.064	0.003
620	6.737	2.980	0.001
630	4.728	1.938	0.000
640	3.279	1.275	0.000
650	1.956	0.735	0.000
660	1.128	0.417	0.000
670	0.599	0.219	0.000
680	0.301	0.109	0.000
690	0.128	0.046	0.000
700	0.067	0.024	0.000
710	0.036	0.013	0.000
720	0.014	0.005	0.000
730	0.009	0.003	0.000
740	0.004	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.972**	**99.999**	**122.639**
White Point	**94.972**	**100.000**	**122.638**

Table 6.22 Illuminant D75, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
380	0.050	0.000	0.235
400	−0.030	0.005	−0.142
420	2.571	0.051	12.243
440	8.429	0.475	41.731
460	7.578	1.434	43.498
480	1.982	3.045	18.114
500	−0.231	6.706	4.973
520	1.042	14.911	1.575
540	5.798	19.708	0.314
560	11.210	18.953	0.057
580	16.196	15.245	0.026
600	17.836	10.201	0.012
620	13.604	5.892	0.002
640	6.169	2.358	0.000
660	2.102	0.773	0.000
680	0.518	0.188	0.000
700	0.109	0.039	0.000
720	0.031	0.011	0.000
740	0.007	0.002	0.000
760	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.972**	**99.997**	**122.638**
White Point	**94.972**	**100.000**	**122.638**

Table 6.23 Illuminant D75, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	−0.001
380	0.001	0.000	0.005
390	0.006	0.001	0.026
400	0.119	0.013	0.535
410	0.745	0.077	3.396
420	1.985	0.205	9.410
430	2.773	0.330	13.652
440	4.009	0.628	20.503
450	4.254	0.998	22.859
460	3.437	1.417	19.790
470	2.112	1.986	14.275
480	0.805	2.751	8.104
490	0.116	3.374	3.981
500	0.008	4.534	2.105
510	0.328	5.863	1.043
520	1.051	7.042	0.539
530	2.203	8.241	0.274
540	3.392	8.711	0.116
550	4.713	8.858	0.030
560	5.997	8.493	−0.003
570	7.149	7.773	0.001
580	8.154	6.959	0.000
590	8.303	5.736	0.000
600	8.386	4.885	0.000
610	7.580	3.855	0.000
620	6.088	2.811	0.000
630	4.312	1.879	0.000
640	2.843	1.179	0.000
650	1.669	0.666	0.000
660	0.940	0.371	0.000
670	0.504	0.197	0.000
680	0.236	0.092	0.000
690	0.102	0.040	0.000
700	0.051	0.020	0.000
710	0.025	0.010	0.000
720	0.010	0.004	0.000
730	0.006	0.002	0.000
740	0.003	0.001	0.000
750	0.001	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.416**	**100.002**	**120.640**
White Point	**94.416**	**100.000**	**120.641**

Table 6.24 Illuminant D75, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
380	0.003	−0.002	0.029
400	0.071	0.015	0.252
420	3.555	0.339	16.605
440	8.252	1.195	42.050
460	7.268	2.815	41.829
480	1.358	5.270	15.257
500	−0.266	8.912	3.401
520	2.006	14.363	1.045
540	6.791	17.776	0.182
560	12.060	17.154	−0.013
580	16.311	13.796	0.004
600	17.015	9.671	−0.001
620	12.327	5.601	0.000
640	5.403	2.212	0.000
660	1.733	0.676	0.000
680	0.421	0.165	0.000
700	0.080	0.031	0.000
720	0.021	0.008	0.000
740	0.005	0.002	0.000
760	0.001	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**94.415**	**99.999**	**120.640**
White Point	**94.416**	**100.000**	**120.641**

Table 6.25 Illuminant F2, 1931 Observer 10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.001	0.000	0.004
390	−0.007	0.000	−0.038
400	0.082	0.002	0.390
410	0.175	0.005	0.836
420	−0.048	−0.010	−0.293
430	2.994	0.139	14.707
440	4.235	0.248	21.081
450	1.115	0.145	5.992
460	1.462	0.290	8.373
470	1.020	0.463	6.727
480	0.487	0.714	4.211
490	0.150	1.063	2.353
500	0.008	1.592	1.318
510	0.025	2.406	0.738
520	0.292	3.473	0.370
530	0.656	4.112	0.214
540	2.917	9.247	0.176
550	5.409	12.968	0.124
560	6.217	10.369	0.034
570	10.109	12.644	0.027
580	13.826	13.167	0.024
590	13.136	9.598	0.014
600	12.110	7.113	0.009
610	9.497	4.706	0.003
620	6.361	2.802	0.001
630	3.637	1.484	0.000
640	1.867	0.723	0.000
650	0.864	0.324	0.000
660	0.363	0.134	0.000
670	0.140	0.051	0.000
680	0.054	0.020	0.000
690	0.021	0.008	0.000
700	0.008	0.003	0.000
710	0.003	0.001	0.000
720	0.001	0.000	0.000
730	0.001	0.000	0.000
740	0.000	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**99.188**	**100.004**	**67.395**
White Point	**99.186**	**100.000**	**67.393**

Table 6.26 Illuminant F2, 1931 Observer 20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
380	−0.015	−0.001	−0.075
400	0.126	0.006	0.604
420	0.723	0.016	3.459
440	7.638	0.413	37.775
460	2.320	0.518	13.826
480	0.931	1.364	8.340
500	−0.106	3.077	2.271
520	0.034	5.636	0.725
540	5.711	18.719	0.319
560	13.144	23.526	0.088
580	27.390	25.997	0.044
600	24.880	13.965	0.017
620	12.425	5.247	0.001
640	3.276	1.258	0.000
660	0.613	0.222	0.000
680	0.082	0.030	0.000
700	0.014	0.005	0.000
720	0.002	0.001	0.000
740	0.000	0.000	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**99.188**	**99.999**	**67.394**
White Point	**99.186**	**100.000**	**67.393**

Table 6.27 Illuminant F2, 1964 Observer 10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.001	0.000	0.003
390	−0.020	−0.001	−0.097
400	0.130	0.014	0.588
410	0.326	0.034	1.494
420	0.088	−0.005	0.303
430	3.107	0.407	15.491
440	4.387	0.658	22.288
450	1.169	0.312	6.415
460	1.441	0.587	8.294
470	0.954	0.895	6.428
480	0.383	1.257	3.794
490	0.060	1.664	1.973
500	0.002	2.156	0.989
510	0.151	2.752	0.492
520	0.528	3.519	0.267
530	0.934	3.956	0.148
540	3.551	8.791	0.108
550	6.295	12.243	0.056
560	6.984	9.828	−0.004
570	11.012	11.985	0.000
580	14.508	12.451	0.000
590	13.512	9.315	0.000
600	12.111	7.032	0.000
610	9.208	4.671	0.000
620	6.030	2.776	0.000
630	3.450	1.496	0.000
640	1.702	0.704	0.000
650	0.767	0.305	0.000
660	0.317	0.125	0.000
670	0.122	0.048	0.000
680	0.045	0.017	0.000
690	0.017	0.007	0.000
700	0.006	0.002	0.000
710	0.002	0.001	0.000
720	0.001	0.000	0.000
730	0.000	0.000	0.000
740	0.000	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**103.281**	**100.002**	**69.030**
White Point	**103.279**	**100.000**	**69.027**

Table 6.28 Illuminant F2, 1964 Observer 20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
380	−0.038	−0.005	−0.171
400	0.234	0.028	1.066
420	1.022	0.100	4.782
440	7.898	1.121	39.933
460	2.301	1.042	13.716
480	0.686	2.475	7.408
500	−0.133	4.279	1.613
520	0.444	5.769	0.511
540	6.953	17.713	0.191
560	14.911	22.281	−0.001
580	28.878	24.639	0.002
600	24.810	13.883	0.000
620	11.708	5.211	0.000
640	3.014	1.241	0.000
660	0.516	0.197	0.000
680	0.073	0.030	0.000
700	0.010	0.004	0.000
720	0.001	0.001	0.000
740	0.000	0.000	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**103.288**	**100.009**	**69.050**
White Point	**103.279**	**100.000**	**69.027**

Table 6.29 Illuminant F7, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.000	0.000	−0.001
380	0.001	0.000	0.005
390	−0.004	0.000	−0.021
400	0.105	0.003	0.499
410	0.266	0.007	1.265
420	0.203	−0.005	0.904
430	4.113	0.186	20.179
440	5.834	0.346	29.065
450	2.301	0.278	12.246
460	2.650	0.527	15.185
470	1.855	0.842	12.235
480	0.889	1.303	7.684
490	0.273	1.933	4.285
500	0.016	2.937	2.432
510	0.052	4.495	1.372
520	0.537	6.254	0.661
530	1.118	6.620	0.329
540	3.686	11.541	0.214
550	5.727	13.711	0.131
560	4.699	7.698	0.021
570	7.124	8.867	0.019
580	9.875	9.422	0.017
590	8.833	6.445	0.010
600	8.895	5.236	0.007
610	7.999	3.978	0.003
620	6.510	2.879	0.001
630	4.709	1.929	0.000
640	3.068	1.192	0.000
650	1.924	0.723	0.000
660	1.076	0.397	0.000
670	0.417	0.152	0.000
680	0.168	0.061	0.000
690	0.073	0.026	0.000
700	0.029	0.011	0.000
710	0.013	0.005	0.000
720	0.005	0.002	0.000
730	0.002	0.001	0.000
740	0.001	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.042**	**100.002**	**108.747**
White Point	**95.041**	**100.000**	**108.747**

Table 6.30 Illuminant F7, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
380	−0.007	−0.001	−0.033
400	0.121	0.007	0.578
420	1.323	0.028	6.323
440	10.790	0.584	53.336
460	4.665	0.963	27.365
480	1.708	2.492	15.213
500	−0.218	5.611	4.189
520	0.379	11.237	1.309
540	7.709	23.952	0.351
560	10.453	18.318	0.071
580	18.791	17.848	0.030
600	17.996	10.198	0.013
620	13.114	5.650	0.001
640	5.970	2.291	0.000
660	1.965	0.720	0.000
680	0.204	0.074	0.000
700	0.073	0.026	0.000
720	0.003	0.001	0.000
740	0.003	0.001	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.042**	**100.000**	**108.746**
White Point	**95.041**	**100.000**	**108.747**

Table 6.31 Illuminant F7, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.000	0.000	0.001
390	−0.021	−0.001	−0.101
400	0.156	0.016	0.700
410	0.493	0.051	2.259
420	0.461	0.030	2.055
430	4.148	0.535	20.642
440	5.863	0.885	29.819
450	2.334	0.589	12.685
460	2.532	1.034	14.581
470	1.682	1.578	11.335
480	0.677	2.224	6.711
490	0.106	2.935	3.483
500	0.004	3.858	1.770
510	0.278	4.979	0.888
520	0.934	6.139	0.462
530	1.518	6.168	0.221
540	4.342	10.634	0.126
550	6.462	12.551	0.058
560	5.108	7.073	−0.006
570	7.520	8.149	0.000
580	10.048	8.637	0.000
590	8.809	6.065	0.000
600	8.627	5.018	0.000
610	7.521	3.826	0.000
620	5.988	2.766	0.000
630	4.332	1.886	0.000
640	2.715	1.126	0.000
650	1.659	0.663	0.000
660	0.912	0.359	0.000
670	0.354	0.138	0.000
680	0.134	0.052	0.000
690	0.058	0.022	0.000
700	0.023	0.009	0.000
710	0.009	0.003	0.000
720	0.003	0.001	0.000
730	0.001	0.001	0.000
740	0.001	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.791**	**99.999**	**107.689**
White Point	**95.792**	**100.000**	**107.686**

Table 6.32 Illuminant F7, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
380	−0.036	−0.005	−0.161
400	0.246	0.031	1.106
420	1.824	0.177	8.525
440	10.807	1.533	54.683
460	4.506	1.899	26.455
480	1.222	4.373	13.104
500	−0.261	7.596	2.884
520	1.147	11.062	0.890
540	9.029	21.938	0.199
560	11.459	16.827	0.000
580	19.208	16.389	0.002
600	17.412	9.821	−0.001
620	12.049	5.451	0.000
640	5.311	2.182	0.000
660	1.641	0.638	0.000
680	0.169	0.067	0.000
700	0.055	0.021	0.000
720	0.001	0.000	0.000
740	0.002	0.001	0.000
760	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**95.791**	**100.001**	**107.686**
White Point	**95.792**	**100.000**	**107.686**

Table 6.33 Illuminant F11, 1931 Observer
10 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.001	0.000	0.005
390	−0.009	0.000	−0.048
400	0.061	0.002	0.291
410	0.107	0.003	0.511
420	−0.205	−0.014	−1.044
430	2.800	0.130	13.758
440	4.264	0.251	21.231
450	1.277	0.164	6.849
460	1.367	0.280	7.848
470	0.695	0.255	4.495
480	0.435	0.754	3.956
490	0.341	2.063	4.778
500	−0.004	1.088	0.792
510	0.007	0.469	0.054
520	−0.001	0.229	0.032
530	−0.925	−2.067	0.000
540	9.613	29.254	0.535
550	11.438	28.030	0.300
560	0.196	−0.695	−0.031
570	0.602	0.870	0.002
580	7.021	6.565	0.012
590	9.070	6.866	0.011
600	4.247	2.617	0.004
610	29.903	14.812	0.010
620	13.567	6.132	0.003
630	3.446	1.329	0.000
640	0.630	0.240	0.000
650	0.534	0.199	0.000
660	0.297	0.110	0.000
670	0.084	0.031	0.000
680	0.043	0.016	0.000
690	0.028	0.010	0.000
700	0.013	0.005	0.000
710	0.020	0.007	0.000
720	0.001	0.000	0.000
730	0.000	0.000	0.000
740	0.000	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**100.964**	**100.005**	**64.354**
White Point	**100.962**	**100.000**	**64.350**

Table 6.34 Illuminant F11, 1931 Observer
20 nm Interval

nm	W_x	W_y	W_z
360	0.000	0.000	0.000
380	−0.014	−0.001	−0.076
400	0.100	0.005	0.509
420	0.256	−0.001	1.093
440	8.207	0.419	40.877
460	1.559	0.623	9.228
480	0.600	0.507	8.258
500	1.524	7.107	4.371
520	−5.091	−14.004	−0.965
540	20.536	58.821	1.039
560	3.973	7.524	−0.034
580	9.894	9.370	0.032
600	24.253	13.848	0.011
620	37.637	17.208	0.009
640	−4.377	−2.270	−0.002
660	2.164	0.978	0.001
680	−0.411	−0.200	0.000
700	0.172	0.075	0.000
720	−0.025	−0.012	0.000
740	0.006	0.003	0.000
760	−0.001	−0.001	0.000
780	0.000	0.000	0.000
Check Sum	**100.962**	**99.999**	**64.351**
White Point	**100.962**	**100.000**	**64.350**

Table 6.35 Illuminant F11, 1964 Observer
10 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
370	0.000	0.000	0.000
380	0.001	0.000	0.004
390	−0.019	−0.001	−0.088
400	0.102	0.011	0.460
410	0.196	0.021	0.897
420	−0.134	−0.028	−0.756
430	2.908	0.381	14.502
440	4.426	0.666	22.492
450	1.339	0.355	7.327
460	1.348	0.566	7.783
470	0.657	0.513	4.313
480	0.329	1.316	3.539
490	0.176	3.206	4.053
500	−0.006	1.464	0.581
510	0.039	0.510	0.020
520	0.015	0.238	0.024
530	−1.070	−1.951	0.005
540	11.643	27.854	0.327
550	13.374	26.520	0.149
560	0.159	−0.660	−0.023
570	0.674	0.822	0.000
580	7.362	6.226	0.000
590	9.374	6.653	0.000
600	4.309	2.597	0.000
610	29.011	14.710	0.000
620	12.930	6.080	0.000
630	3.263	1.353	0.000
640	0.571	0.232	0.000
650	0.473	0.187	0.000
660	0.261	0.103	0.000
670	0.073	0.029	0.000
680	0.036	0.014	0.000
690	0.023	0.009	0.000
700	0.010	0.004	0.000
710	0.015	0.006	0.000
720	0.001	0.000	0.000
730	0.000	0.000	0.000
740	0.000	0.000	0.000
750	0.000	0.000	0.000
760	0.000	0.000	0.000
770	0.000	0.000	0.000
780	0.000	0.000	0.000
Check Sum	**103.869**	**100.006**	**65.609**
White Point	**103.863**	**100.000**	**65.607**

Table 6.36 Illuminant F11, 1964 Observer
20 nm Interval

nm	$W_{10,x}$	$W_{10,y}$	$W_{10,z}$
360	0.000	0.000	0.000
380	−0.029	−0.005	−0.142
400	0.181	0.026	0.869
420	0.414	0.019	1.729
440	8.515	1.220	43.348
460	1.544	0.977	9.002
480	0.319	1.693	7.470
500	1.673	8.341	3.484
520	−5.992	−13.547	−0.739
540	24.601	55.948	0.625
560	4.494	7.060	−0.051
580	10.526	8.885	0.014
600	24.099	13.702	−0.004
620	36.033	17.112	0.001
640	−4.279	−2.247	0.000
660	2.026	0.952	0.000
680	−0.397	−0.198	0.000
700	0.155	0.072	0.000
720	−0.025	−0.013	0.000
740	0.006	0.003	0.000
760	−0.001	−0.001	0.000
780	0.000	0.000	0.000
Check Sum	**103.863**	**99.999**	**65.606**
White Point	**103.863**	**100.000**	**65.607**