BS ISO 5631-3:2015

BSI Standards Publication

Paper and board — Determination of colour by diffuse reflectance

Part 3: Indoor illumination conditions (D50/2°)

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National foreword

This British Standard is the UK implementation of ISO 5631-3:2015. It supersedes BS ISO 5631-3:2014 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PAI/11, Methods of test for paper, board and pulps.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Paper and board — Determination of colour by diffuse reflectance —

Part 3: **Indoor illumination conditions (D50/2°)**

Papier et carton — Détermination de la couleur par réflectance diffuse —
Partie 3: Conditions d'éclairage intérieur (D50/2°)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document ISO/TC 6, *Paper, board and pulps*.

This third edition cancels and replaces the second edition (ISO 5631-3:2014). The major change is to allow for calculations using ASTM E308 for instruments that have bandpass correction and still maintain the procedure for instruments without bandpass correction.

ISO 5631 consists of the following parts, under the general title *Paper and board — Determination of colour by diffuse reflectance*:

— *Part 1: Indoor daylight conditions (C/2°)*

— *Part 2: Outdoor daylight conditions (D65/10°)*

— *Part 3: Indoor illumination conditions (D50/2°)*

Introduction

The colour of an object can be uniquely characterized by means of a triplet of colour coordinates such as the CIE *X,Y, Z* tristimulus values or the CIELAB 1976 *L**, *a**, *b** coordinates for a specified CIE illuminant and CIE standard observer.

Apart from the optical properties of the sample, the values of such coordinates depend upon the conditions of measurement, particularly the spectral and geometric characteristics of the instrument used. This part of ISO 5631 should therefore be read in conjunction with ISO 2469.

This part of ISO 5631 describes the measurement and description of colour in terms of the CIE illuminant D50 and the CIE 1931 (2°) standard observer. The method is especially applicable to the comparison of papers in graphic arts situations since these particular illuminant/observer conditions are required by ISO 13655 for the graphic arts industry. It is, however, emphasized that this is only a partial approach to the graphic arts conditions, since ISO 13655 also specifies measurement with a 45:0 or 0:45 geometry of a single sheet over a specified black backing and also requires that the illumination in the light booth be adjusted to CIE illuminant D50 conditions.

The other parts of this International Standard describe measurements and calculations carried out in an analogous manner using either the CIE illuminant C and the CIE 1931 (2°) standard observer (ISO 5631-1) or the CIE standard illuminant D65 and the CIE 1964 (10°) standard observer (ISO 5631-2). The choice of illuminant conditions is important when determining the colour coordinates of white papers containing a fluorescent whitening agent. In ISO 5631-2, the UV content of the illumination is much higher, approximating UV levels encountered in outdoor viewing conditions

Paper and board — Determination of colour by diffuse reflectance —

Part 3:
Indoor illumination conditions (D50/2°)

1 Scope

This part of ISO 5631 specifies a method for measuring the colour of paper and board by the diffuse reflectance method with the elimination of specular gloss.

This part of ISO 5631 is primarily intended for measuring the colour of paper and board to be used in the graphic arts industry, where that industry specifies the measurement of colour under D50/2° conditions in accordance with ISO 13655. This method differs from ISO 13655, in that the UV content of the illumination is adjusted to a different level.

The method can be used to determine the colour of papers or boards that contain fluorescent whitening agents, provided the UV content of the illumination on the test piece has been adjusted to conform to that in the CIE illuminant C, using a fluorescent reference standard that fulfils the requirements for international fluorescent reference standards of level 3 (IR3) as prescribed by ISO 2469 with an assigned ISO brightness value (C/2°) provided by an authorized laboratory, as described in ISO 2470-1.

This part of ISO 5631 is not applicable to coloured papers or boards that incorporate fluorescent dyes or pigments.

2 Normative references

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

ISO 186, *Paper and board — Sampling to determine average quality*

ISO 2469, *Paper, board and pulps — Measurement of diffuse radiance factor (diffuse reflectance factor)*

ISO 2470-1, *Paper, board and pulps — Measurement of diffuse blue reflectance factor — Part 1: Indoor daylight conditions (ISO brightness)*

ASTM E308, *Standard Practice for Computing the Colors of Objects by Using the CIE System*

CIE Publication 15:2004, *Colorimetry*, 3rd ed

3 Terms and definitions

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

3.1
radiance factor
β
ratio of the radiance of a surface element of a body in the direction delimited by a given cone, with its apex at the surface element, to that of the perfect reflecting diffuser under the same conditions of illumination

Note 1 to entry: For fluorescent (luminescent) materials, the total radiance factor, β, is the sum of two portions, the reflected radiance factor, β_R, and the luminescent radiance factor, β_L, so that $\beta = \beta_{\mathrm{R}} + \beta_L$.

For non-fluorescent materials, the reflected radiance factor, β_R, is numerically equal to the reflectance factor, *R*.

3.2
intrinsic radiance factor
β_∞
radiance factor of a layer or pad of material thick enough to be opaque, such that increasing the thickness of the pad by doubling the number of sheets results in no change in the measured radiance factor

Note 1 to entry: The intrinsic radiance factor is often expressed as a percentage.

3.3
reflectance factor
R
ratio of the radiation reflected by a surface element of a body in the direction delimited by a given cone, with its apex at the surface element to that of the perfect reflecting diffuser under the same conditions of illumination

Note 1 to entry: The ratio is often expressed as a percentage.

Note 2 to entry: The reflectance factor is influenced by the backing if the body is translucent.

3.4
intrinsic reflectance factor
R_∞
reflectance factor of a layer or pad of material thick enough to be opaque, such that increasing the thickness of the pad by doubling the number of sheets results in no change in the measured reflectance factor

Note 1 to entry: The reflectance factor of a non-opaque sheet is dependent on the background and is not a material property.

3.5
tristimulus values
X, Y, Z
amount of the three reference colour stimuli, in a given chromatic system, required to match the stimulus considered

Note 1 to entry: In this part of ISO 5631, the CIE illuminant D50 and the CIE 1931 (2°) standard observer are used to define the trichromatic system.

Note 2 to entry: No subscript is applied to conform to the CIE convention that tristimulus values have no subscript when the CIE 1931 (2°) standard observer is used [the subscript 10 is applied for tristimulus values that are obtained using the CIE 1964 (10°) standard observer].

3.6
CIELAB colour space
three-dimensional, approximately uniform colour space, produced by plotting, in rectangular coordinates L^*, a^*, b^*, quantities defined by the formulae given in Clause 9

Note 1 to entry: The quantity, L^*, is a measure of the lightness of the test piece, where $L^* = 0$ corresponds to black and $L^* = 100$ is defined by the perfect reflecting diffuser. Visually, the quantities a^* and b^* represent respectively the red-green and yellow-blue axes in colour space, such that

$+a^*$ is a measure of the degree of redness of the test piece,

$-a^*$ is a measure of the degree of greenness of the test piece,

$+b^*$ is a measure of the degree of yellowness of the test piece, and

$-b^*$ is a measure of the degree of blueness of the test piece.

If both a^* and b^* are equal to zero, the test piece is achromatic.

4 Principle

The light reflected from a sample under specified UV illumination conditions is analysed either by a tristimulus-filter colourimeter or by an abridged spectrophotometer, and the colour coordinates are then calculated for D50/2° conditions.

5 Apparatus

5.1 Reflectometer, having the geometric, spectral, and photometric characteristics described in ISO 2469, and calibrated in accordance with the provisions of ISO 2469.

If materials containing fluorescent whitening agents are to be measured, the reflectometer shall be equipped with a radiation source having an adequate UV-content control, adjusted to a UV condition corresponding to the C illuminant by the use of a reference standard, as described in ISO 2470-1.

5.1.2 In the case of a filter reflectometer, a set of filters that, in conjunction with the optical characteristics of the basic instrument, give overall responses equivalent to the CIE tristimulus values *X, Y*, and *Z* of the CIE 1931 standard colourimetric system of the test piece evaluated for the CIE illuminant D50.

In the case of a filter reflectometer, the radiation falling upon the test piece shall have a UV content corresponding to that of the CIE illuminant C.

5.1.3 In the case of an abridged spectrophotometer, the instrument shall have a function that permits calculation of the CIE tristimulus values *X, Y,* and *Z* of the CIE 1931 standard colourimetric system of the test piece evaluated for the CIE illuminant D50, using the weighting functions given in Annex A, where the Tables A.1 and A.2 are used for instruments without bandpass correction and Tables A.3 and A.4 are used for instruments with bandpass correction.

In the case of an abridged spectrophotometer, the instrument shall have an adjustable filter with a cut-off wavelength of 395 nm or some other equivalent system, and this filter shall be adjusted or the system shall be calibrated with the help of the fluorescent reference standard (5.2.2), so that the UV content of the illumination falling upon the sample corresponds to that of the CIE illuminant C.

5.2 Reference standards, for calibration of the instrument and the working standards, used frequently enough to ensure satisfactory calibration and UV adjustment.

5.2.1 Non-fluorescent reference standard, for photometric calibration, issued by an authorized laboratory in accordance with the provisions of ISO 2469.

5.2.2 Fluorescent reference standard, for use in adjusting the UV content of the radiation incident upon the sample, having an ISO brightness value assigned by an authorized laboratory, as prescribed in ISO 2470-1.

5.3 Working standards, calibrated frequently enough to ensure that satisfactory calibration is maintained.

5.3.1 Two plates of flat opal glass, ceramic, or other suitable material, cleaned and calibrated as described in ISO 2469.

NOTE In some instruments, the function of the primary working standard can be taken over by a built-in internal standard.

5.3.2 Stable plastic or other tablet, incorporating a fluorescent whitening agent.

5.4 Black cavity, having a reflectance factor which does not differ from its nominal value by more than 0,2 %, at all wavelengths. The black cavity should be stored upside down in a dust-free environment or with a protective cover.

NOTE 1 The condition of the black cavity can be checked by reference to the instrument maker.

NOTE 2 The nominal value is given by the manufacturer.

6 Sampling and conditioning

If the tests are being made to evaluate a lot of paper or board, the sample shall be selected in accordance with ISO 186. If the tests are made on another type of sample, make sure that the test pieces taken are representative of the sample received.

Conditioning according to ISO 187 is recommended but not required, though preconditioning with elevated temperatures should not be applied since it might change the optical properties.

7 Preparation of test pieces

Avoiding watermarks, dirt, and obvious defects, cut rectangular test pieces approximately 75 mm × 150 mm. Assemble at least 10 test pieces in a pad with their top sides uppermost; the number should be such that doubling the number of test pieces does not alter the reflectance factor. Protect the pad by placing an additional sheet of paper or board on both the top and bottom of the pad. Avoid contamination and unnecessary exposure to light or heat.

Mark the top test piece in one corner to identify the sample and its top side, or to distinguish between the two sides.

If the top side can be distinguished from the wire side, it shall be uppermost; if not, as can be the case for papers manufactured on twin-wire machines, ensure that the same side of the sheet is uppermost.

8 Procedure

8.1 Ensure that calibration has been performed as described in ISO 2470-1 according to the instrument maker's instructions.

8.2 Remove the protective sheets from the top and the bottom of the test piece pad. Without touching the test area, use the procedure appropriate to the instrument to obtain the three CIE tristimulus values of the first test piece (or CIELAB values if the instrument is designed to report directly in this colour space). Read and record the tristimulus values to the nearest 0,01 unit.

8.3 Move the uppermost test piece to the bottom of the pad and determine the values for subsequent test pieces until at least 10 test pieces have been evaluated. If required, repeat the procedure for the other side of the test pieces.

9 Calculation

9.1 CIE tristimulus values

If the instrument has a bandpass of 5 nm or narrower, calculate the CIE tristimulus values in accordance with CIE Publication 15:2004, 3rd ed. In all other cases, calculate the tristimulus values using the appropriate weighting functions given in ASTM E308. If the instrument does not provide the CIE tristimulus values directly, obtain them by calculation using the tables provided in Annex A.

9.2 CIELAB coordinates

Calculate the CIELAB coordinates from the tristimulus values *X, Y, Z* by means of the following formulae:

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

$$a^* = 500\left[\left(X/X_n\right)^{1/3} - \left(Y/Y_n\right)^{1/3}\right] \tag{2}$$

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

where X_n, Y_n, Z_n are the tristimulus values of the perfect reflecting diffuser under D50/2° conditions. These are given as the “white point” values in Annex A.

Alternative equations shall, however, be used if any of the ratios X/X_n, Y/Y_n, $Z/Z_n \leq (24/116)^3$ are satisfied as follows:

a) If $(X/X_n) \leq (24/116)^3$, replace the term $(X/X_n)^{1/3}$ in Formula (2) by the expression $(841/108)\ (X/X_n) + 16/116$.

b) If $(Y/Y_n) \leq (24/116)^3$, replace the term $(Y/Y_n)^{1/3}$ in Formulae (1), (2) and (3) by the expression $(841/108)\ (Y/Y_n) + 16/116$.

c) If $(Z/Z_n) \leq (24/116)^3$, replace the term $(Z/Z_n)^{1/3}$ in Formula (3) by the expression $(841/108)\ (Z/Z_n) + 16/116$.

NOTE 1 The term $(24/116)^3$ is approximately equal to 0,008 856.

NOTE 2 The term (841/108) is approximately equal to 7,787.

NOTE 3 Formula (1) transforms to $L^* = 903{,}3(Y/Y_n)$ when $(Y/Y_n) \leq (24/116)^3$.

9.3 Dispersion of the results

Since the three-dimensional statistical calculations are extremely complicated, the following simple procedure for assessing the dispersion is recommended.

Calculate the mean values $< L^* >$, $< a^* >$, and $< b^* >$ of the L^*, a^*, and b^* values.

Calculate for each test piece, the deviation ΔE_{ab}^* from the mean according to the following formula:

$$\Delta E_{ab}^* = \sqrt{\left[\left(\Delta L^*\right)^2 + \left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2\right]} \tag{4}$$

where ΔL^*, Δa^*, and Δb^* are the differences between the L^*, a^*, and b^* values of the test piece and the corresponding mean values $< L^* >$, $< a^* >$, and $< b^* >$.

Calculate the mean $< \Delta E_{ab}{}^* >$ value. This is known as the Mean Colour Difference from the Mean (MCDM) value and defines the dispersion in terms of a sphere of radius $< \Delta E_{ab}{}^* >$ about the mean point in CIELAB space.

NOTE This calculation uses the expression for the colour difference between two samples which can be calculated in these coordinates as:

$$\Delta E_{ab}{}^* = \sqrt{\left[\left(\Delta L^*\right)^2 + \left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2 \right]} \tag{5}$$

where ΔL^*, Δa^*, and Δb^* are the differences between the L^*, a^*, and b^* values of the two samples.

The calculation of colour differences is, however, not covered by this part of ISO 5631.

10 Expression of results

Report the L^*, a^*, and b^* values to three significant figures and the dispersion as the MCDM value to two significant figures.

NOTE Information about the nature of the variations can be obtained by calculating the mean ΔL^*, Δa^*, and Δb^* as defined in Formula (4), but this is not covered by this part of ISO 5631.

11 Precision

Information relating to the precision of the method is not yet available.

12 Test report

The test report shall include the following information:

a) a reference to this part of ISO 5631, i.e. ISO 5631-3;

b) the date and place of testing;

c) the precise identification of the sample and the side or sides tested;

d) whether the test pieces were conditioned and, if so, the conditioning atmosphere used;

e) the average colour coordinates and the mean colour difference from the mean (see 9.3) for the required side(s) of the sample;

f) the type of instrument used;

g) any departure from this part of ISO 5631 which could have affected the results.

Annex A
(normative)

Spectral characteristics of reflectometers for determining tristimulus values

A.1 Filter reflectometers

The required spectral characteristics of the reflectometer are arrived at by a combination of lamps, integrating sphere, glass optics, filters and photodetectors. The filters shall be such that they, together with the optical characteristics of the instrument, give overall responses equivalent to the CIE tristimulus values *X, Y, Z* of the CIE 1931 (2°) standard colourimetric system for the test piece evaluated for the CIE illuminant D50.

A.2 Abridged spectrophotometers

A.2.1 General

The desired tristimulus values are obtained by summing the products of the spectral reflectance factors and the weighting functions given in ASTM E308[1)] for the C illuminant and CIE 1931 (2°) observer.

"Checksum" and "white point" data are given at the bottom of each column in Tables A.1, A.2, A.3 and A.4. The "checksum" is the algebraic sum of the entries. It provides, for convenience, a check value to ensure that the tables have been copied correctly, should copying be required. These checksums may not be identical with the "white point" data located below them because of roundoff. Each value in a column has been rounded to three decimal digits. It is these "white point" data, and no other, that shall 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".

Apply the following instructions, given in ASTM E308, when the values are not available at the top or at the bottom of the range.

Wavelength range less than 360 nm to 780 nm. When data for $\beta(\lambda)$ 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 or longest wavelength for which spectral data are available, i.e.:

a) add the weights for all wavelengths (360 nm, ...) for which measured data are not available to the next higher weight for which such data are available;

b) add the weights for all wavelengths (..., 780 nm) for which measured data are not available to the next lower weight for which such data are available.

In the absence of fluorescence, the spectral radiance factor can be replaced by, or referred to as, the spectral reflectance factor, $R(\lambda)$.

A.2.2 Procedure for using data without bandpass correction

Use Tables A.1 and A.2 when the spectral data have not been corrected for bandpass dependence and for which the bandpass is approximately equal to the measurement interval; Table A.1 is to be used when

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the data have been obtained at 10 nm measurement intervals; Table A.2 is to be used when the data has been obtained at 20 nm measurement intervals. Tables A.1 and A.2 apply a correction for spectral bandpass dependence built into the calculation of the tristimulus values.

A.2.3 Procedure for using data with bandpass correction

Use Tables A.3 and A.4 when the spectral data have been already corrected for bandpass dependence (e.g. by the instrument manufacturer) and for which the bandpass is approximately equal to the measurement interval; Table A.3 is to be used when the data have been obtained at 10 nm measurement intervals; Table A.4 is to be used when the data have been obtained at 20 nm measurement intervals.

NOTE 1 Tables A.3 and A.4 were added to this part of ISO 5631 to allow for calculation using instrumentation that does not require bandpass correction, i.e. has already been built into the instrument and applied to the reported raw data.

NOTE 2 Raw reflectance data will differ from instruments, depending upon whether or not they have built-in bandpass correction. However, after the appropriate weighting table is used, the resulting colourimetric values will be nearly identical.

Table A.1 — Weighting functions (D50/2°) for instruments without bandpass correction and measuring at 10 nm intervals (Source: ASTM E308)

Wavelength 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

Table A.1 *(continued)*

Wavelength nm	$W_{.X}$	$W_{.Y}$	$W_{.Z}$
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 A.2 — Weighting functions (D50/2°) for instruments without bandpass correction and measuring at 20 nm intervals (Source: ASTM E308)

Wavelength nm	$W_{.X}$	$W_{.Y}$	W_{2Z}
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

Table A.2 *(continued)*

Wavelength nm	$W_{.X}$	$W_{.Y}$	W_{2Z}
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 A.3 — Weighting functions (D50/2°) for instruments with bandpass correction and measuring at 10 nm intervals (Source: ASTM E308)

Wavelength 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

Table A.3 *(continued)*

Wavelength nm	$W_{\cdot X}$	$W_{\cdot Y}$	$W_{\cdot Z}$
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 A.4 — Weighting functions (D50/2°) for instruments with bandpass correction and measuring at 20 nm intervals (Source: ASTM E308)

Wavelength nm	$W_{\cdot X}$	$W_{\cdot Y}$	W_{2Z}
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

Table A.4 *(continued)*

Wavelength nm	$W_{.X}$	$W_{.Y}$	W_{2Z}
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**

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