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Second edition
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Tissue paper and tissue products —

Part 15: Determination of optical properties — Measurement of brightness and colour with C/2° (indoor daylight) illuminant

Papier tissue et produits tissue —

Partie 15: Détermination des propriétés optiques — Mesurage du degré de blancheur et de la couleur avec l'illuminant C/2° (lumière du jour à l'intérieur)

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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).

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

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

This document was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 172, *Pulp, paper and board,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 12625-15:2015), which has been technically revised.

The main changes are as follows:

— removed alternative formulae in 11.2.1 because they are not relevant for tissue paper;

— updated tables in Annex A to include data to 0,01 and corrected errors in the tables;

— changed C/2° Brightness to ISO Brightness.

A list of all parts in the ISO 12625 series can be found on the ISO website.

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

Introduction

Brightness and colour measurement can be performed under various illumination and observation conditions. This document deals with C/2° conditions, which refer to an indoor daylight.

D65/10° conditions (outdoor daylight) are considered in ISO 12625-7. Although both International Standards deal with brightness and colour, results obtained are usually different and do not correlate.

Optical measurements are affected by the geometry of the instruments used and by the texture of the material.

The optical properties are related to the visual appearance of the material in a specified illumination condition. Although optical properties are intrinsic properties of tissue paper, they are not functional properties.

Brightness should not be confused with the optical property called CIE-whiteness, which is based on reflectance data obtained over the full visible spectral range (VIS). In contrast, brightness is limited to the blue region of VIS (visible spectrum).

As preferences for the properties specified can vary by country/market, two other test methods for the determination of optical properties were developed in addition to this document: ISO 12625-7 and ISO 12625-16.

Tissue paper and tissue products —

Part 15: Determination of optical properties — Measurement of brightness and colour with C/2° (indoor daylight) illuminant

1 Scope

This document specifies testing procedures for the instrumental determination of brightness and colour of tissue paper and tissue products viewed in indoor daylight conditions. It also gives specific instructions for the preparation of test pieces (single-ply, multi-ply products) and for the optical measurements of products, where special precautions can be necessary.

NOTE The properties called D65 brightness and colour are measured with an instrument adjusted to a much higher UV content than that specified in this document.

2 Normative references

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

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

ISO 187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

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

ISO 2470-1:2016, *Paper, board and pulps — Measurement of diffuse blue reflectance factor — Part 1: Indoor daylight conditions (ISO brightness)*

ISO 2470-2, *Paper, board and pulps — Measurement of diffuse blue reflectance factor — Part 2: Outdoor daylight conditions (D65 brightness)*

ISO/CIE 11664-4, *Colorimetry — Part 4: CIE 1976 L*a*b* colour space*

3 Terms and definitions

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

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

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

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

3.1
diffuse radiance factor
R
ratio of the radiation reflected and emitted from a body to that reflected from the perfect reflecting diffuser under the same conditions of diffuse illumination and normal detection

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

[SOURCE: ISO 2469:2014, 3.2]

3.2
intrinsic diffuse radiance factor
R_∞
diffuse radiance factor (3.1) of a layer or pad of material thick enough to be opaque, i.e. 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 ratio is often expressed as a percentage.

Note 2 to entry: The radiance factor of a single non-opaque sheet is dependent on the background and is not a material property.

[SOURCE: ISO 2469:2014, 3.3, modified — Note 2 to entry added.]

3.3
reflectance factor
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 reflected by 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: This term shall only be used when it is known that the test material exhibits no luminescence (fluorescence).

[SOURCE: CIE S 017 ILV:2020, 17-24-070]

3.4
ISO brightness
intrinsic diffuse radiance factor (3.2) measured with a reflectometer having the characteristics described in ISO 2469, equipped with a filter or corresponding function having an effective wavelength of 457 nm (and a half bandwidth of 44 nm), and adjusted so that the UV content of the irradiation incident upon the test piece corresponds to that of the CIE illuminant C

Note 1 to entry: The filter function is described more fully by the weighing function factors given in ISO 2470-1.

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

Note 1 to entry: In this document as in ISO 5631-1, the CIE illuminant C 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].

[SOURCE: CIE S 017 ILV:2020, 17-23-038]

3.6
C/2° colour
L^*, a^*, and b^* values of the sample according to the CIELAB 1976 system, described in ISO/CIE 11664-4 corresponding to the CIE illuminant C, described in ISO/CIE 11664-2 and the CIE 1964 standard colorimetric (2°) observer, described in ISO/CIE 11664-1, determined by the measurement under the conditions specified in ISO 5631-1

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

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

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

d) $-b^*$ 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 grey.

4 Principle

A test piece is illuminated diffusely in a standard instrument and the light reflected normal to the surface is either allowed to pass through a defined optical filter, and then measured by a photodetector or measured by an array of photosensitive diodes, where each diode responds to a different effective wavelength. The brightness is then determined directly from the output from the photodetector or by calculation from the photosensitive diode outputs using the appropriate weighting function and colour coordinates are calculated for C/2° conditions.

5 Apparatus

5.1 Reflectometer or spectrophotometer, having the geometric, spectral and photometric characteristics described in ISO 2469 and calibrated in accordance with ISO 2469 and ISO 2470-2, and equipped for the measurement of blue reflectance factor.

5.1.1 A filter reflectometer, with the radiation falling upon the test piece shall have a UV content corresponding to that of the CIE illuminant C, adjusted or verified by using the fluorescent reference standard (5.2.2).

5.1.2 An abridged spectrophotometer, with an adjustable filter with a cut-off wavelength of 395 nm or some other system for adjustment and control, and this filter shall be adjusted or the system shall be calibrated using 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 standard for calibration of the instrument

5.2.1 Non-fluorescent reference standard, for photometric calibration, issued by an ISO 4094 authorized laboratory, in accordance with 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 2470-1:2016, Annex B.

5.3 Working standards

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

NOTE In some instruments, the function of the primary working standard is taken over by a built–in internal standard.

5.3.2 Black cavity, having a reflectance factor that does not differ from its nominal values 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 The condition of the black cavity can be checked by reference to the instrument maker.

6 Calibration

6.1 Using the values assigned to the non-fluorescent reference standard (5.2.1), calibrate the instrument according to the instruments maker's instruction with the UV-cut-off filters removed from the radiation beams. The setting of the UV-adjustment filter is not important at this stage.

6.2 Using the appropriate measurement procedure, measure the ISO brightness value of the fluorescent reference standard (5.2.2) and compare the measured ISO brightness value with the ISO brightness value assigned to the fluorescent reference standard.

A measured ISO brightness value higher than that assigned unit indicates that the relative UV-content is too high and vice versa.

6.3 Using the UV-adjustment filter or other adjustment device, adjust the UV-content of the illumination until measurement gives the correct ISO brightness value.

6.4 Repeat 6.1, 6.2, and 6.3 until the correct value for the ISO brightness of the fluorescent reference standard is obtained with the instrument correctly calibrated to the non-fluorescent reference standard. The UV-content is now correctly adjusted with respect to a relative UV-content equivalent to the CIE illuminant C. Record the setting of the UV-adjustment.

NOTE In some instruments, the procedure indicated in 6.2 to 6.4 is performed automatically.

6.5 Assign reference values to working standards.

Perform ISO brightness and colour C/2° CIE-L^*, a^*, and b^* measurements on the non-fluorescent material (5.3.1). Assign these reference values to the non-fluorescent material as working standard.

This working standard may only be used in the specific instrument in which its value was assigned and shall only be used to monitor changes in the lamps. A new value shall be assigned with a fluorescent reference standard of level 3 (5.2.2), if the lamps are changed or the used working standards show deviations more than 1 brightness unit.

NOTE Instead of using L^*, a^*, b* values, R_x, R_y, R_z can also be used as assigned reference values.

7 Sampling

If the tests are being made to evaluate a lot, the sample shall be selected in accordance with ISO 186. If the tests are being made on another type of sample, make sure, the specimens taken are representative of the sample received. When sampling finished roll products, eliminate at least the first six layers and the last six layers because of the possible presence of adhesive or mechanical damage.

Mark the samples for identification, and make sure that the two sides of the paper or of the product can be distinguished.

8 Conditioning

Condition the samples in accordance with ISO 187 and keep them in the standard atmosphere throughout the test. Preconditioning with elevated temperatures shall not be applied since it might change the optical properties.

9 Preparation of test pieces

Cut test pieces of at least 50 mm × 50 mm or 50 mm in diameter, which are free from dirt, perforation, and any defect. Assemble sufficient test pieces in a pad with their top sides uppermost; the number of test pieces should be such that doubling the number does not alter the reflectance factor. This is known as the intrinsic diffuse radiance factor.

Protect the pad by placing a protecting sheet on both the top and bottom of the pad. Avoid contamination and unnecessary exposure to light or heat.

If the pads are very voluminous and bulky, steps shall be taken to expel the air. The pads should be carefully compressed between the protecting sheets.

Mark the pad in one corner to identify the sample and the marked side.

10 Procedure

10.1 General

Remove the protecting sheets from the pad of test pieces. Measure the optical properties on the top side and, if required, the reverse side as well following the procedure described in 10.2 and/or 10.3.

Steps should be taken, without damaging the material, to ensure that the pad is pressed against the measuring opening under sufficient pressure to give a compact pad that does not intrude into the measurement sphere.

10.2 Measurement of ISO brightness

The UV-content of the illumination shall be adjusted to correspond to the CIE illuminant C as described in Clause 6.

Measure the ISO brightness (reflectance factor at an effective wavelength of 457 nm) of the marked side of the test-piece pad. Read and record the value to the nearest 0,05 % reflectance factor or better. Move the uppermost test piece to the bottom of the pad and determine the reflectance factor for the next test piece, and similarly for the following test pieces, until a total of at least 10 readings have been made.

If required, turn the test pad upside down and repeat the procedure on the other side. Calculate the ISO brightness as indicated in 11.1.

NOTE 1 It is possible to determine the ISO brightness without the contribution of the fluorescent whitening agent in the case of fluorescent samples by making measurements with a 420 nm cut-off filter in the light beam; however, this is outside of the scope of this document.

NOTE 2 In the case of non-fluorescent samples, the ISO brightness and the D65 brightness are identical.

10.3 Measurement of colour (C/2°)

The UV-content in the illumination shall be adjusted to correspond to the CIE illuminant C as described in Clause 6.

If a filter instrument is used, check that the correct filters are inserted in the light beams.

Determine the *X*, *Y*, and *Z* tristimulus values for the marked side of the top test piece (or CIELAB values, if the instrument is designed to report directly in this colour space). Record the results to the nearest 0,1 unit, move the uppermost test piece to the bottom of the pad and repeat the measurement for the next; proceed in this way until at least 10 readings have been made. If required, turn the test pad upside down and repeat the procedure on the other side.

Calculate the CIELAB colour coordinates as described in ISO/CIE 11664-4 for each test piece. Calculate the colour coordinates as indicated in 11.2.

11 Calculation

11.1 ISO brightness

Calculate the mean ISO brightness value as the ISO brightness of the sample in percent to the nearest 0,1 % and its standard deviation. Table A.1 and Table A.2 provide examples of precision data for ISO brightness.

When both sides (top and reverse side) are measured, calculate and report the mean brightness value for the two sides separately.

11.2 Colour C/2°

11.2.1 Single values

Calculate the single colour values as CIE-L^*, a^*, and b^* coordinates of the sample from the tristimulus values *X, Y, Z*, using Formulae (1) to (3):

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

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

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

where X_n, Y_n, Z_n are the tristimulus values of the perfect reflecting diffuser under C/2° conditions. These are given as the "white point" values in ISO 5631-1:2022, Annex A.

NOTE If any of the ratios $X_{10}/X_{10.n}$, $Y_{10}/Y_{10.n}$, and $Z_{10}/Z_{10.n} \leq (24/116)^3$, Formulae (1) to (3) are no longer valid and alternative formulae are proposed in ISO 5631-2. Tissue papers and tissue products have such optical properties that these alternative formulae will not be needed (for more information, refer to ISO 5631-2).

11.2.2 Mean value

Calculate the mean C/2° colour values as CIE-L^*, a^*, and b^* coordinates of the sample to the nearest 0,01 value. Table A.3 provides examples of precision data for C/2° colour.

When both sides (top and reverse side) are measured, calculate and report the mean CIE-L^*, a^*, and b^* values for two sides separately.

11.2.3 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 $\Delta E_{ab}{}^*$ from the mean according to Formula (4):

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

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 < ΔE_{ab}^* > value. This is known as the mean C/2° colour difference from the mean (MCDM) value and defines the dispersion in terms of a sphere radius < ΔE_{ab}^* > about the mean point in CIELAB space.

NOTE 1 The use of the symbolism <x> refers to the mean of x. This is used because the values L^*, a^*, b^* and ΔE_{ab}^* cannot be formatted with the bar above.

NOTE 2 This calculation uses the expression for the colour C/2° differences between two samples which can be calculated in these coordinates as Formula (5):

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

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

12 Test report

The test report shall include at least the following information:

a) a reference to this document, i.e. ISO 12625-15:2022;

b) date and place of testing;

c) conditioning atmosphere used;

d) all details necessary to identify the material;

e) the type of instrument used and a reference to the authorized laboratory providing international reference standards of level 3 for calibration of the instrument;

f) the mean and standard deviation ISO brightness and/or the C/2° colour values (as described in 11.2.1, 11.2.2 and 11.2.3) and if required, the mean of the two sides (top and reverse side);

g) any departure from this document or any other circumstance that may have affected the results.

Annex A
(informative)

Precision

A.1 General

In July 2012, an international interlaboratory test was performed on six samples by nine different laboratories according to this document. White and near white base papers and converted products were considered for all the tested properties, but for colour measurements, three coloured products were also assessed.

For each series of sample, 10 measurements have been performed on the top side.

The calculations were made in accordance with ISO/TR 24498:2006 and TAPPI T 1200.

The repeatability standard deviation reported in Table A.1 is the "pooled" repeatability standard deviation that is the standard deviation that is calculated as the root-mean-square of the standard deviations of the participating laboratories. This differs from the conventional definition of repeatability in ISO 5725-1.

The repeatability and reproducibility limits in Table A.2 are estimates of the maximum difference which should be expected in 19 of 20 instances, when comparing two test results for material similar to those described under similar test conditions. These estimates may not be valid for different materials or different test conditions.

NOTE Repeatability and reproducibility limits are calculated by multiplying the repeatability and reproducibility standard deviations by 2,77, where $R = 1,96\sqrt{2} \cdot s$.

A.2 ISO Brightness

Table A.1 — Estimation of repeatability

Samples	Number of laboratories	Mean ISO brightness %	Repeatability standard deviation s_r %	Coefficient of variation $C_{V,r}$ %	Repeatability limit r %
toilet-4-ply white	9	82,2	0,15	0,19	0,42
toilet-3-ply white	7[b]	76,6	0,15	0,19	0,41
toilet-3-ply white	8[a]	57,2	0,17	0,29	0,46
hanky-4-ply white	8[a]	87,0	0,07	0,08	0,19
towel-2-ply white	8[a]	81,1	0,25	0,30	0,68
base sheet 1 ply	7[b]	84,6	0,13	0,15	0,35

[a] One outlier.

[b] Two outliers.