



**International
Standard**

ISO 12625-16

**Tissue paper and tissue products —
Part 16:
Determination of optical properties
— Diffuse reflectance method for
opacity (paper backing)**

Papier tissue et produits tissue —

*Partie 16: Détermination des propriétés optiques — Méthode par
réflectance diffuse de l'opacité sur fond papier*

**Second edition
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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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 document 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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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 12625-16:2015), which has been technically revised.

The main changes are as follows:

- Information has been added to [Annex A](#) to explain calculations for instruments with bandpass correction; [Table A.2](#) provides weighting functions needed for calculations related to instruments with bandpass correction.

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

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. Although optical properties are intrinsic properties of tissue paper, they are not functional properties.

The opacity value depends on the principle used for its evaluation, and a method should be chosen which most closely relates to the interpretation to be placed upon the results. The method described in this document is applicable when it is desired to measure that property of a tissue paper or tissue product which governs the extent to which one sheet visually obscures print on underlying sheets. It should not be confused with methods based on the reduction in a standard contrast by interposition of the paper opacity (white backing), formerly known as contrast ratio, nor with the assessment of the amount and condition of light penetrating a sheet (transparency or translucency).

The calculation of opacity requires luminance-factor data obtained by measurement under specified conditions. The luminance factor depends on the conditions of measurement, and particularly on the spectral and geometric characteristics of the instrument used for its determination.

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Tissue paper and tissue products —

Part 16:

Determination of optical properties — Diffuse reflectance method for opacity (paper backing)

1 Scope

This document specifies the testing procedures for the instrumental determination of the opacity of tissue paper or tissue products by diffuse reflectance using a paper backing.

This document contains specific instructions for the preparation of test pieces of single-ply and multi-ply products, where special preparation/procedures might be necessary.

It can be used to determine the opacity of tissue paper and tissue products containing fluorescent whitening agents, provided the UV content of the radiation incident on the test piece has been adjusted to conform to that in the CIE illuminant C using a fluorescent reference standard provided by an authorized laboratory as described in ISO 2470-1.

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

ISO 4094, *Paper, board and pulps — General requirements for the competence of laboratories authorized for the issue of optical reference transfer standards of level 3*

ISO/CIE 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

ISO/CIE 11664-2, *Colorimetry — Part 2: CIE standard illuminants*

ASTM E308-13, *Standard Practice for Computing the Colors of Objects by Using the CIE System*

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
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 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 may be used only when it is known that the test material exhibits no luminescence (fluorescence).

Note 3 to entry: The reflectance factor is influenced by the backing if the body is translucent.

[SOURCE: ISO 2469:2024, 3.4, modified — R added and based on ISO 5631-1:2022, 3.3, Note 3 to entry added.]

**3.2
luminance factor (C)**

luminous reflectance factor

$Y(C/2^\circ)$ -value

R_y

reflectance factor (3.1) or radiance factor defined with reference to the CIE illuminant C and the visual efficiency function $V(\lambda)$

Note 1 to entry: The visual efficiency function describes the sensitivity of the eye to light, so that the luminance factor (C) corresponds to the attribute of visual perception of the reflecting surface.

Note 2 to entry: For computational purposes, the function is identical with the CIE 1931 colour-matching function $\bar{y}(\lambda)$.

[SOURCE: ISO 2471:2008, 3.2]

**3.3
single-sheet luminance factor (C)**

$R_{y,0}$

luminance factor (C) (3.2) of a single sheet of paper with a black cavity as backing

[SOURCE: ISO 2471:2008, 3.3, modified — The symbol has been changed.]

**3.4
intrinsic luminance factor (C)**

$R_{y,\infty}$

luminance factor (C) (3.2) 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 reflectance factor (3.1)

[SOURCE: ISO 2471:2008, 3.4, modified — The symbol has been changed.]

**3.5
opacity**

<paper backing> ratio of the single-sheet luminance factor (C) (3.3), $R_{y,0}$, to the intrinsic luminance factor (C) (3.4), $R_{y,\infty}$, of the same sample

Note 1 to entry: Opacity is expressed as a percentage.

[SOURCE: ISO 2471:2008, 3.5]

4 Principle

The luminance factor of a single sheet of the tissue paper or tissue product over a black cavity and the intrinsic luminance factor of the tissue paper or tissue product are determined. The opacity is calculated as the ratio of these two luminance factor values.

5 Apparatus

5.1 Reflectometer

5.1.1 Reflectometer, having the geometric, spectral and photometric characteristics described in ISO 2469, calibrated in accordance with ISO 2469 and equipped for the measurement of luminance factor (C).

The materials to be measured can contain fluorescent whitening agents. The reflectometer shall therefore be equipped with a radiation source adjusted to correspond to the CIE illuminant C described in ISO 11664-2. This should be achieved through the use of a fluorescent reference standard (5.2.2) as described in ISO 2470-1.

5.1.2 Filter reflectometer, having a filter which, in conjunction with the optical characteristics of the basic instrument, gives an overall response equivalent to the CIE tristimulus value Y , described in ISO/CIE 11664-1, of the CIE 1931 standard colorimetric system of the test piece evaluated for the CIE illuminant C.

5.1.3 Abridged spectrophotometer whose function permits the calculation of the CIE tristimulus value Y , described in ISO/CIE 11664-1, of the CIE 1931 standard colorimetric system of the test piece, evaluated for the CIE illuminant C using the weighting functions given in [Annex A](#).

5.2 Reference standards

The reference standards for calibrating the instrument and the working standards should be used with sufficient regularity to ensure satisfactory performance.

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 in order to adjust the UV setting of the instrument to conform to UV(C) conditions, as described in ISO 2470-1.

5.3 Working standards

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 fulfilled by a built-in internal standard.

5.4 Black cavity

The black cavity should have 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 manufacturer.

NOTE 2 The nominal value is given by the manufacturer.

6 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 made on another type of sample, the test pieces taken shall be 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.

On finished products, one single sheet can be made of several plies. Do not try to separate the constituting plies.

7 Conditioning

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

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

8 Preparation of test pieces

Cut test pieces of at least 50 mm × 50 mm or 50 mm diameter, which are free from any dirt, perforation, and any obvious defects. 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.

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

If necessary, 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 and ensure that the same side of the sheet is uppermost.

9 Procedure

9.1 Because the sample can contain a fluorescent whitening agent, check that the UV setting of the instrument has been adjusted to conform to UV(C) conditions, using a fluorescent reference standard provided by a laboratory authorized to issue optical reference transfer standards of level 3 according to ISO 4094.

9.2 Remove the protective sheets from the pad of test pieces.

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, which does not intrude into the measurement sphere.

Without touching the test area, use the procedure appropriate to the instrument to measure the intrinsic luminance factor $R_{y\infty}$ of the top side of the test-piece pad. Read and record the value to the nearest 0,01 % of the reflectance factor.

9.3 Remove the top test piece from the pad and, with the black cavity backing the test piece, measure the single-sheet luminance factor $R_{y,0}$ for the same area of the test piece. Read and record the value to the nearest 0,01 % of the luminance factor.

[Subclauses 9.2](#) and [9.3](#) describe the two independent measurements which are necessary for the determination of opacity. This is not intended to imply that the two measurements shall necessarily be made in this order.

9.4 Move the measured test piece to the bottom of the pad. Repeat the measurements of $R_{y,\infty}$ and $R_{y,0}$, moving the top test piece to the bottom of the pad after each pair of measurements, until five pairs of measurements have been made.

The measurements of $R_{y,\infty}$ and $R_{y,0}$ should be made alternately. The five measurements of $R_{y,0}$ can be made before or after the five measurements of $R_{y,\infty}$ if such a procedure is preferred, or the measurements can be made alternately.

9.5 Turn the pad upside down and repeat procedures 9.2 to 9.4 for the other side, if required.

10 Calculation

10.1 Using the corresponding values of $R_{y,0}$ and $R_{y,\infty}$ calculate the opacity in percent, to three significant figures, using [Formula \(1\)](#):

$$\frac{100R_{y,0}}{R_{y,\infty}} \quad (1)$$

10.2 Calculate the mean opacity and the standard deviation. When both sides (top and reverse side) are measured, if the differences between the two means are greater than 0,5 %, the sides should be identified and the results reported separately. If the difference is equal to or less than 0,5 %, the overall average shall be reported as in [Annex B](#).

11 Test report

The test report shall include the following information:

- a) a reference to this document, i.e. ISO 12625-16:2024;
- b) the date and place of testing;
- c) a precise identification of the sample;
- d) the conditioning atmosphere;
- e) all details necessary to identify the material;
- f) the type of instrument used and a reference to the authorized laboratory providing international reference standards of level 3 for calibration of the instrument;
- g) the opacity, including the mean value and standard deviation and, if necessary, data for the two sides separately;
- h) any departure from this document or any other circumstances that might have affected the results.

Annex A (informative)

Spectral characteristics of reflectometers for measuring luminous factor

A.1 Filter colourimeters

The required spectral characteristics of a filter colourimeter are arrived at by a combination of lamps, integrating spheres, glass optics, filters, and photoelectric detectors. The filters should be such that they, together with the optical characteristics of the instrument, give a response equivalent to the CIE tristimulus Y-value for the CIE 1931 (2°) standard observer of the test piece established for the CIE illuminant C.

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 E308-13 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](#) and [A.2](#). The “check-sum” 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 might 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 E308-13, section 7.3.2.2, 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 $R(\lambda)$ 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.:

- 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;
- 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.

A.2.2 Procedure for Using Data without Bandpass Correction

Use [Table A.1](#) when the spectral data have not been corrected for bandpass dependence and for which the bandpass is approximately equal to the measurement interval; column 2, [Table A.1](#) shall be used when the data have been obtained at 10-nm measurement intervals; column 3, [Table A.1](#) shall be used when the data has been obtained at 20-nm measurement intervals. These tables 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 [Table A.2](#) 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;

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column 2, [Table A.2](#) shall be used when the data have been obtained at 10-nm measurement intervals; column 3, [Table A.2](#) shall be used when the data have been obtained at 20-nm measurement intervals.

NOTE 1 [Table A.2](#) was added to this document to allow for calculation using instrumentation that does not require bandpass correction, i.e. that has already been built into the instrument and applied to the reported raw data.

NOTE 2 Raw reflectance data will differ for instruments with built-in bandpass correction from those without. However, after the appropriate weighting table is used, the resulting colorimetric values will be nearly identical.

Table A.1 — Weighting functions (C/2°) for instruments without bandpass correction and measuring at 10 nm and 20 nm intervals, respectively

Wavelength nm	Y-weights 10 nm	Y-weights 20 nm
360	0,000	0,000
370	0,000	
380	0,000	0,000
390	0,000	
400	0,002	0,001
410	0,007	
420	0,032	0,044
430	0,118	
440	0,259	0,491
450	0,437	
460	0,684	1,308
470	1,042	
480	1,600	3,062
490	2,332	
500	3,375	6,596
510	4,823	
520	6,468	12,925
530	7,951	
540	9,193	18,650
550	9,889	
560	9,898	20,143
570	9,186	
580	8,008	16,095
590	6,621	
600	5,302	10,537
610	4,168	
620	3,147	6,211
630	2,174	
640	1,427	2,743
650	0,873	
660	0,492	0,911
670	0,250	
680	0,129	0,218
690	0,059	
700	0,028	0,049
710	0,014	

Table A.1 (continued)

Wavelength nm	Y-weights 10 nm	Y-weights 20 nm
720	0,006	0,011
730	0,003	
740	0,001	0,002
750	0,001	
760	0,000	0,001
770	0,000	
780	0,000	0,000
Check sum	99,999	99,998
White point	100,000	100,000

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Table A.2 — Weighting functions (C/2°) for instruments with bandpass correction and measuring at 10 nm and 20 nm intervals, respectively

Wavelength nm	Y-weights 10 nm	Y-weights 20 nm
360	0,000	0,000
370	0,000	
380	0,000	0,000
390	0,001	
400	0,002	-0,001
410	0,009	
420	0,038	0,085
430	0,123	
440	0,261	0,511
450	0,443	
460	0,692	1,382
470	1,061	
480	1,612	3,206
490	2,358	
500	3,414	6,910
510	4,842	
520	6,449	12,876
530	7,936	
540	9,145	18,258
550	9,831	
560	9,834	19,588
570	9,148	
580	7,990	15,991
590	6,629	
600	5,321	10,696
610	4,177	
620	3,146	6,261
630	2,196	
640	1,442	2,902

Table A.2 (continued)

Wavelength nm	Y-weights 10 nm	Y-weights 20 nm
650	0,887	
660	0,503	1,008
670	0,261	
680	0,132	0,257
690	0,062	
700	0,029	0,055
710	0,014	
720	0,007	0,012
730	0,003	
740	0,001	0,003
750	0,001	
760	0,000	0,001
770	0,000	
780	0,000	0,000
Check sum	100,000	100,001
White point	100,000	100,000

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Annex B (normative)

Precision

B.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 assessed.

For each considered sample, five replicates have been performed on the top side.

The calculations have been made according to ISO/TS 24498 and TAPPI T 1200^[2].

The repeatability standard deviation reported in [Table B.1](#) is the “pooled” repeatability standard deviation, that is, the standard deviation 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 reported in [Table B.1](#) and [B.2](#), respectively, 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 might 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 $R = 1,96\sqrt{2} \cdot s$.

B.2 Opacity

Table B.1 — Estimation of the repeatability

Samples	Number of laboratories	Mean opacity - UV (C) %	Repeatability standard deviation	Coefficient of variation	Repeatability limit
			s_r %	$C_{v,r}$ %	r %
toilet-4-ply white	8 ^a	76,2	0,5	0,7	1,4
toilet-3-ply white	8 ^a	83,6	0,4	0,5	1,1
toilet-3-ply white	8 ^a	91,8	0,4	0,4	1,0
hanky-4-ply white	8 ^a	74,7	0,3	0,4	0,8
towel-2-ply white	8 ^a	67,6	0,4	0,5	1,0
base sheet 1 ply	8 ^a	41,6	1,0	2,4	2,7

^a One outlier.