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

Papier tissue et produits tissue —

*Partie 16: Détermination des propriétés optiques — Opacité sur fond
papier — Méthode par réflexion en lumière diffuse*



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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 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](#)

ISO 12625-16 was prepared by European Committee for Standardization (CEN) Technical Committee CEN/TC 172 *Pulp, paper and board*, in collaboration with Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods for quality specifications for paper and board*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 12625 consists of the following parts, under the general title *Tissue paper and tissue products*:

- *Part 1: General guidance on terms*
- *Part 3: Determination of thickness, bulking thickness and apparent bulk density and bulk*
- *Part 4: Determination of tensile strength, stretch at break and tensile energy absorption*
- *Part 5: Determination of wet tensile strength*
- *Part 6: Determination of grammage*
- *Part 7: Determination of optical properties — Measurement of brightness and colour with D65/10° (outdoor daylight)*
- *Part 8: Water-absorption time and water-absorption capacity, basket-immersion test method*
- *Part 9: Determination of ball burst strength*
- *Part 11: Determination of wet ball burst strength*
- *Part 12: Determination of tensile strength of perforated lines — Calculation of perforation efficiency*
- *Part 15: Determination of optical properties — Measurement of brightness and colour with C/2° (indoor daylight)*
- *Part 16: Determination of optical properties — Opacity (paper backing) — Diffuse reflectance method*

Introduction

Optical measurements are affected by the geometry of the instruments used and by the texture of the material. The design of the instrument to be used according to this part of ISO 12625, and the routine to be adopted for its calibration are specified in ISO 2469.

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 is to be chosen which most closely relates to the interpretation to be placed upon the results. The method described in this part of ISO 12625 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 is not to 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. This part of ISO 12625 is to be read in conjunction with ISO 2469.

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Tissue paper and tissue products —

Part 16:

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

1 Scope

This part of ISO 12625 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 part of ISO 12625 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.

This part of ISO 12625 is not applicable to coloured tissue paper and tissue products which incorporate fluorescent dyes or pigments.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

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

3 Terms and definitions

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

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 irradiation

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.

[SOURCE: ISO 2471:2008]

3.2

luminance factor (C)
luminous reflectance factor
 $Y(C/2^\circ)$ -value

R_y

reflectance factor 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}_λ .

Note 3 to entry: The luminance factor (C) is also known as the $Y(C/2^\circ)$ -value. In previous editions of this International Standard, it was referred to as the luminous reflectance factor.

[SOURCE: ISO 2471:2008]

3.3

single-sheet luminance factor (C)

R_0

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

[SOURCE: ISO 2471:2008]

3.4

intrinsic luminance factor (C)

R_∞

luminance factor (C) 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

[SOURCE: ISO 2471:2008]

3.5

opacity (paper backing)

ratio of the single-sheet luminance factor (C), R_0 , to the intrinsic luminance factor (C), R_∞ , of the same sample

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

[SOURCE: ISO 2471:2008]

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 the provisions of 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. This should be achieved through the use of a fluorescent reference standard (5.2.2) as described in ISO 2470-1.

5.1.2 In the case of a **filter reflectometer**, a **filter** that, in conjunction with the optical characteristics of the basic instrument, gives an overall response equivalent to the CIE tristimulus value Y of the CIE 1931 standard colourimetric system of the test piece evaluated for the CIE illuminant C.

5.1.3 In the case of an **abridged spectrophotometer**, a **function** that permits calculation of the CIE tristimulus value Y of the CIE 1931 standard colourimetric 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 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 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 should 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.

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 an ISO/TC 6 authorized laboratory as described in ISO 2470-1.

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_{∞} 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 luminance factor R_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_{∞} and R_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.

This subclause implies that measurements of R_{∞} and R_0 shall be made alternately, but this is not an essential requirement of this part of ISO 12625. The five measurements of R_0 can be made before or after the five measurements of R_{∞} 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_{∞} and R_0 , calculate the opacity, in percent, to three significant figures, using Formula (1):

$$\text{Opacity} = \frac{100R_0}{R_{\infty}} \quad (1)$$

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.

11 Test report

The test report shall include the following information:

- a) a reference to this part of ISO 12625;
- 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 part of ISO 12625 or any other circumstances that might have affected the results.

Annex A (normative)

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

The desired reflectance factors of an abridged spectrophotometer are obtained by summing the products of the spectral radiance factors and the following weighting functions (Table A.1), given in ASTM E308-13¹⁾ for the CIE 1931 (2°) observer and the CIE illuminant C.

The instructions given in A.3 should be followed.

A.3 Data not available for the full wavelength range 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 and longest wavelength for which spectral data are available. That is:

- add the weights for wavelengths of 360 nm ..., 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 wavelength of 780 nm ..., down to the last wavelength for which measured data are not available, to the next lower weight, for which such data are available.

Table A.1 — ASTM E308-13 weighting functions for instruments 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

1) Reprinted, with permission, from ASTM E308-13 *Standard Practice for Computing the Colours of Objects by using the CIE-System*, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard can be obtained from ASTM (<http://www.astm.org/>).

Table A.1 (continued)

Wavelength nm	Y-weights 10 nm	Y-weights 20 nm
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	
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

Annex B (informative)

Precision

B.1 General

In July 2012, an international interlaboratory test was performed on six samples by nine different laboratories according to this part of ISO 12625. 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/TR 24498^[8] and TAPPI T 1200^[9]

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.^[3]

The repeatability and reproducibility limits reported 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 s_r %	Coefficient of variation $C_{V,r}$ %	Repeatability limit 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.