INTERNATIONAL STANDARD

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Paper and board — Determination of opacity (paper backing) — Diffuse reflectance method

Papier et carton — Détermination de l'opacité sur fond papier — Méthode de 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 2471 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*.

This fourth edition cancels and replaces the third edition (ISO 2471:1998), which has been technically revised, in that a UV adjustment to conform to the CIE illuminant C is required if fluorescent whitening agents are present in the paper or board.

Introduction

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 International Standard is applicable when it is desired to measure that property of a paper which governs the extent to which one sheet visually obscures printed matter on underlying sheets of similar paper. 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. This International Standard should therefore be read in conjunction with ISO 2469.

Paper and board — Determination of opacity (paper backing) — Diffuse reflectance method

1 Scope

This International Standard specifies a method for the determination of the opacity (paper backing) of paper by diffuse reflectance.

It can be used to determine the opacity of papers or boards which contain 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 ISO/TC 6 authorized laboratory as described in ISO 2470-1.

This International Standard is not applicable to coloured papers or boards which 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 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 The ratio is often expressed as a percentage.

3.2
luminance factor (C)
luminous reflectance factor
Y(C/2°)-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 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 For computational purposes, the $V(\lambda)$ function is identical with the CIE 1931 colour-matching function $\bar{y}(\lambda)$.

NOTE 3 The luminance factor (C) is also known as the Y(C/2°)-value. In previous editions of this International Standard it was referred to as the luminous reflectance factor.

3.3
single-sheet luminance factor (C)
R_0
luminance factor (C) of a single sheet of paper with a black cavity as backing

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

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 Opacity is expressed as a percentage.

4 Principle

The luminance factor of a single sheet of the paper over a black cavity and the intrinsic luminance factor of the paper 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).

Because materials to be measured may contain fluorescent whitening agents, 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 **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 colorimetric 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 colorimetric system of the test piece, evaluated for the CIE illuminant C using the weighting functions given in Annex A.

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

5.2.1 Non-fluorescent reference standard for photometric calibration, issued by an ISO/TC 6 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, 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 manufacturer.

NOTE 2 The nominal value is given by the manufacturer.

6 Sampling and conditioning

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.

Conditioning according to ISO 187 is recommended but not required, but preconditioning at 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 of the 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 an additional sheet 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. If the top side can be distinguished from the wire side, it shall be uppermost; if not, as may be the case for papers manufactured on double-wire machines, ensure that the same side of the sheet is uppermost.

8 Procedure

8.1 Because the sample may 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.

8.2 Remove the protecting sheets from the test-piece pad. 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.

8.3 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 8.2 and 8.3 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.

8.4 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 International Standard. The five measurements of R_0 may be made before or after the five measurements of R_∞ if such a procedure is preferred, or the measurements may be made alternately.

8.5 Turn the pad upside down and repeat procedures 8.2 to 8.4 for the other side.

9 Calculation of results

9.1 Using the corresponding values of R_∞ and R_0, calculate the opacity, in percent, to three significant figures, separately for each side of each test piece using Equation (1):

$$\text{Opacity} = \frac{100 R_0}{R_\infty} \tag{1}$$

9.2 Calculate the mean opacity for each side and the standard deviation. If the differences between the two means are greater than 0,2 %, the sides should be identified and the results reported separately. If the difference is equal to or less than 0,2 %, the overall average shall be reported.

NOTE For most papers, the difference in the opacity value obtained when measuring from opposite sides is small. For extremely two-sided papers, the opacities measured from opposite sides can differ significantly, i.e. by more than 0,5 %.

10 Precision

The following data were supplied by the Comparative Testing Service of the Confederation of European Paper Industries (CEPI-CTS) in January 2007 based on an average of 10 measurements per sample.

Sample	Number of laboratories	Mean opacity %	Mean standard deviation within laboratories	Mean standard deviation between laboratories
Paper 1	17	32,5	0,18	0,60
Paper 2	16	98,2	0,14	0,38

11 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) date and place of testing;

c) precise identification of the sample;

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

e) the opacity, including the mean value and standard deviation and, if necessary, data for the two sides separately;

f) the type of instrument used;

g) any departure from this International Standard, or any circumstances or influences that may have affected the results.

Annex A
(normative)

Spectral characteristics of reflectometers for measuring luminance factor

A.1 Filter colorimeters

The required spectral characteristics of a filter colorimeter 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 E308-06[1)] for the CIE 1931 (2°) observer and the CIE illuminant C.

The instructions given in Clause 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 wavelengths 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.

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