INTERNATIONAL STANDARD

ISO 2471

Third edition
1998-02-15

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

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.

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.

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

This third edition cancels and replaces the second edition (ISO 2471:1977), of which it constitutes a technical revision.

Annex A forms an integral part of this International Standard. Annex B is for information only.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

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 luminous-reflectance-factor data obtained by measurement under specified conditions. The reflectance 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 is restricted to white and near-white papers (and boards). Paper or board that has been treated with a fluorescent dyestuff or exhibits significant fluorescence may be measured, but the agreement between values obtained with different instruments may be unsatisfactory and there may be difficulty in assessing the meaning of results.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 186:1994, *Paper and board — Sampling to determine average quality.*

ISO 2469:1994, *Paper, board and pulps — Measurement of diffuse reflectance factor.*

ASTM E 308-96, *Computing the Colors of Objects by Using the CIE System.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 reflectance factor, R**:** The ratio, expressed as a percentage, of the radiation reflected by a body to that reflected by the perfect reflecting diffuser under the same conditions.

3.2 luminous reflectance factor, R_y**:** The reflectance factor defined with reference to the CIE illuminant C and the CIE 1931 colour matching function $\bar{y}(\lambda)$, and corresponding to the attribute of visual perception of the reflecting surface.

3.3 single-sheet luminous reflectance factor, R_0: The luminous reflectance factor of a single sheet of paper with a black cavity as backing.

3.4 intrinsic luminous reflectance factor, R_∞: The luminous reflectance factor 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): The ratio, expressed as a percentage, of the single-sheet luminous reflectance factor, R_0, to the intrinsic luminous reflectance factor, R_∞, of the same sample.

4 Principle

The luminous reflectance factor of a single sheet of the paper over a black cavity and the intrinsic luminous reflectance factor of the paper are determined by measurement according to ISO 2469. The opacity is calculated as the ratio of these two values.

5 Apparatus

5.1 Reflectometer, having the geometric, spectral and photometric characteristics described in ISO 2469, Annex A, equipped for the measurement of luminous reflectance factor, and calibrated in accordance with the provisions of ISO 2469, Annex B.

5.2 Filter-function. 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 standard illuminant C.

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 standard illuminant C using the weighting functions given in Annex A.

5.3 Working standards: two plates of flat opal glass or ceramic material, cleaned and calibrated as described in ISO 2469.

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

5.4 Reference standards, issued by an ISO/TC 6 authorized laboratory in accordance with the provisions of ISO 2469 for calibration of the instrument and the working standards.

5.5 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 — The condition of the black cavity should be checked by reference to the instrument maker.

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.

7 Preparation of test pieces

Avoiding watermarks, dirt and obvious defects, cut rectangular test pieces approximately 75 mm x 150 mm. Assemble at least ten 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.

NOTE — 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 Remove the protecting sheets from the test-piece pad. Without touching the test area, use the procedure appropriate to the instrument, and the working standard, to measure the intrinsic reflectance factor R_∞ of the top side of the test-piece pad. Read and record the value to the nearest 0,05 % of the reflectance factor.

8.2 Remove the top test piece from the pad and, with the black cavity backing the test piece, measure the luminous reflectance factor R_0, for the same area of the test piece. Read and record the value to the nearest 0,05 % of the luminous reflectance factor.

8.3 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.

8.4 Turn the pad upside down and repeat procedures 8.1 to 8.3 for the other side.

9 Calculation of results

9.1 Using the corresponding values of R_∞ and R_0, calculate the opacity to three significant figures separately for each side of each test piece:

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

9.2 Calculate the mean opacity for each side and the standard deviation. If the mean values differ by more than 0,2 % and if this difference is statistically significant, 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 will be small. For extremely two-sided papers, the opacities measured from opposite sides may differ significantly, i.e. by more than 0,5 %.

10 Precision

Data from 29 laboratories measuring a paper having an opacity of 94,2 % showed a coefficient of variation of 0,3 % (Source CTS, Collaborative Testing Services, Inc., April 1995).

11 Test report

The test report shall include the following details:

a) date and place of testing;

b) precise identification of the sample;

c) a reference to this International Standard;

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

e) the type of instrument used;

f) 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 luminous reflectance factor

A.1 For filter colorimeters

The required spectral characteristics of the reflectometer are arrived at by a combination of lamps, integrating spheres, glass optics, filters and photoelectric cells. 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 standard illuminant C.

A.2 For abridged spectrophotometers

The desired reflectance factors are obtained by summing the products of the spectral reflectance factors and the following weighting functions (Table A.1), given in ASTM E 308-96 for the CIE 1931 (2°) observer and the CIE illuminant C.

The instructions given in A.3 should be followed.

A.3 Data available only for wavelength ranges shorter than 360 nm – 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.