INTERNATIONAL STANDARD

ISO 5631

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Paper and board — Determination of colour (C/2°) — Diffuse reflectance method

Papier et carton — Détermination de la couleur (C/2°) — Méthode par réflectance diffuse

Reference number
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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 5631 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps.*

Annex A forms a normative part of this International Standard.

Introduction

The colour of an object can be uniquely characterized by means of a triplet of colour coordinates such as the 1931 CIE tristimulus values, the CIELAB 1976 L^*, a^*, b^* coordinates or the dominant wavelength, excitation purity and luminous reflectance.

The values of such coordinates depend upon the conditions of measurement, particularly the spectral and geometric characteristics of the instrument used. This International Standard should therefore be read in conjunction with ISO 2469.

This method describes the measurement and description of colour in terms of the CIE illuminant C and the CIE 1931 (2°) standard observer. The measurement and calculations can be carried out in an analogous manner with respect to the CIE standard illuminant D65 and the CIE 1964 (10°) standard observer or with other illuminant/observer combinations, but this is not in accordance with this International Standard.

Paper and board — Determination of colour (C/2°) — Diffuse reflectance method

1 Scope

This International Standard specifies a method for measuring the colour of paper and board by the diffuse reflectance method with the elimination of specular gloss.

This International Standard is not applicable to coloured papers or boards which incorporate fluorescent dyes or pigments. It may be used to determine the colour of papers or boards which contain fluorescent whitening agents provided the UV-content of the illumination 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.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

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

CIE Publication 15.2:1986, *Colorimetry.*

ASTM E 308-95, *Standard Practice for Computing the Colors of Objects by Using the CIE System.*

3 Terms and definitions

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

3.1
reflectance factor
R
ratio of the radiation reflected by a body to that reflected by the perfect reflecting diffuser under the same conditions of illumination and detection

NOTE 1 The reflectance factor is expressed as a percentage.

NOTE 2 The reflectance factor is influenced by the backing if the body is translucent.

3.2
intrinsic reflectance factor
R_∞
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 leads to no change in the measured reflectance factor

3.3
tristimulus values
X, Y, Z
amounts of the three reference colour stimuli, in a given trichromatic system, required to match the stimulus considered

NOTE In this International Standard, the CIE 1931 standard observer and the CIE illuminant C are used to define the trichromatic system.

3.4
CIELAB colour space
three-dimensional approximately uniform colour space, produced by plotting, in rectangular coordinates, L^*, a^*, b^* quantities defined by the equations given in clause 9

4 Principle

The light reflected from a sample under specified conditions is analysed either by a tristimulus-filter colorimeter or by an abridged spectrophotometer, and the colour coordinates are then calculated.

5 Apparatus

5.1 Reflectometer, having the geometric, spectral and photometric characteristics described in ISO 2469 and calibrated in accordance with the provisions of ISO 2469.

NOTE In the 1994 edition of ISO 2469 the reflectometer characteristics are described in annex A and the calibration service is described in annex B. When ISO 2469 is revised, the numbering may change; users of editions subsequent to 1994 should therefore determine which elements of text specify these characteristics and this service.

5.2 Filter-function

In the case of a filter reflectometer, a set of filters that, in conjunction with the optical characteristics of the basic instrument, give overall responses equivalent to the CIE tristimulus values X, Y and Z of the CIE 1931 standard colorimetric system of the test piece evaluated for the CIE illuminant C.

In the case of an abridged spectrophotometer, a function that permits calculation of the CIE tristimulus values X, Y and Z 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.

5.3 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. For maximum accuracy, reference standards having assigned values within the maximum range expected for the particular product to be tested should be selected.

If there is reason to suspect that the instrument has poor linearity or that the deviations from the true colour matching and observer functions are greater than can be tolerated, the use of product-specific reference standards should be considered.

5.4 Working standards, calibrated in the instrument concerned against ISO reference standards of level 3 supplied by an authorized laboratory (see ISO 2469). Calibrate the working standards sufficiently frequently to ensure that satisfactory calibration is maintained.

Use newly calibrated reference standards sufficiently frequently to ensure that the reflectometer is maintained in agreement with the reference instrument.

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 1 The condition of the black cavity can be checked by reference to the instrument maker.

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, 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 × 150 mm. Assemble at least ten test pieces in a pad with their top sides uppermost; the number should be such that doubling the number of test pieces does not alter the reflectance factor. Protect the pad by placing an additional sheet of paper or board 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, or to distinguish between the two sides.

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 twin-wire machines, ensure that the same side of the sheet is uppermost.

8 Procedure

Remove the protecting sheets from the top and bottom of the test piece pad. Without touching the test area, use the working standard and the procedure appropriate to the instrument to obtain the three CIE tristimulus values of the first test piece (or CIELAB values if the instrument is designed to report directly in this colour space). Read and record the values to the nearest 0,05 unit. Move the uppermost test piece to the bottom of the pad and determine the values for succeeding test pieces until at least ten test pieces have been evaluated. If required, repeat the procedure for the other side of the test pieces.

9 Calculation

9.1 CIE tristimulus values

If the instrument has a bandpass of 5 nm or narrower, calculate the CIE tristimulus values in accordance with CIE Publication 15.2:1986. In all other cases, calculate the tristimulus values using the appropriate weighting functions given in ASTM E 308-95. If the instrument does not provide the CIE tristimulus values directly, obtain them by calculation using the tables provided in annex A.

9.2 CIELAB coordinates

Calculate the CIELAB coordinates from the tristimulus values X, Y, Z by means of the following equations:

$$L^* = 116\,(Y/Y_n)^{1/3} - 16 \qquad (1)$$

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

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

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 annex A.

Corrections shall be introduced for very dark samples.

If $Y/Y_n \leqslant 0{,}008\,856$, replace the expression for L^* by

$$L^* = 903{,}3\left(Y/Y_n\right) \quad (4)$$

and if any of the ratios X/X_n, Y/Y_n, $Z/Z_n \leqslant 0{,}008\,856$, replace it in the equations for a^* and b^* by the expression:

$$7{,}787\ F + 16/116 \quad (5)$$

where F is X/X_n, Y/Y_n or Z/Z_n, as the case may be.

9.3 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 of $<L^*>$, $<a^*>$ and $<b^*>$.

Calculate for each test piece, the deviation ΔE_{ab}^* from the mean according to the equation

$$\Delta E_{ab}^* = \sqrt{\left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\right]} \quad (6)$$

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 $<\Delta E_{ab}^*>$ value. This is known as the Mean Colour Difference from the Mean (MCDM) value and defines the dispersion in terms of a sphere of radius $<\Delta E_{ab}^*>$ about the mean point in CIELAB space.

NOTE This calculation uses the expression for the colour difference between two samples which may be calculated in these coordinates as:

$$\Delta E_{ab}^* = \sqrt{\left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\right]} \quad (7)$$

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

The calculation of colour differences is not, however, a part of this International Standard.

10 Expression of results

Report the L^* a^* b^* values to three significant figures and the dispersion as the MCDM value to two significant figures.

NOTE Information about the nature of the variations can be obtained by calculating the mean ΔL^*, Δa^* and Δb^* as defined in equation (6), but this is not a part of this International Standard.

11 Test report

The test report shall include the following information:

a) the date and place of testing;

b) a reference to this International Standard;

c) the precise identification of the sample and the side or sides tested;

d) the average colour coordinates and the mean colour difference from the mean (see 9.3) for the top side of the sample and for the other side if required;

e) the type of instrument used;

f) any departure from this International Standard which may have affected the results.

Annex A
(normative)

Calculation of tristimulus values

The desired reflectance factors are obtained by summing the products of the spectral reflectance factors and the weighting functions (Tables A.1 and A.2)[1)] given in ASTM E 308-95 for the CIE 1931 (2°) observer and the CIE illuminant C.

ASTM E 308-95 presents two sets of tables. The tables given in this annex should normally be used. They have been prepared to apply a correction for spectral bandpass dependence built into the calculation of the tristimulus values, using data for which the bandpass is approximately equal to the measurement interval.

The figure labelled "Check sum" at the bottom of each column of the tables given in this annex is the algebraic sum of the entries. It provides, as a convenience, a check value to ensure that the tables have been copied correctly should copying be required. These check sums may not be identical to the "White point" data located below them because of roundoff. These "White point" data must be used as X_n, Y_n, Z_n when converting tristimulus values calculated using these tables to CIELAB coordinates.

The following instructions, given in ASTM E 308-95, section 7.3.2.2, should be applied 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.:

a) 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;

b) 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.

1) Tables taken from ASTM E 308-95 (tables 6.5 and 6.6).