INTERNATIONAL STANDARD

ISO 11475

First edition
1999-03-01

Paper and board — Determination of CIE whiteness, D65/10° (outdoor daylight)

Papier et carton — Determination du degré de blanc CIE, D65/10° (lumière du jour extérieure)

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 11475:1999
https://standards.iteh.ai/catalog/standards/sist/a8d95049-bdd6-4ec1-869f-ee261809a952/iso-11475-1999

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 11475 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*. It is based on the CIE whiteness formula, published in CIE Publication 15.2-1986, *Colorimetry*.

Annexes A and B form an integral part of this International Standard.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 11475:1999
https://standards.iteh.ai/catalog/standards/sist/a8d95049-bdd6-4ec1-869f-ee261809a952/iso-11475-1999

© ISO 1999

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet iso@iso.ch

Printed in Switzerland

Paper and board – Determination of CIE whiteness, D65/10° (outdoor daylight)

1 Scope

This International Standard specifies the procedure to be used for determining the whiteness of papers and boards. The values obtained correspond to the visual appearance of white papers and boards with or without fluorescent whitening agents when they are viewed under the CIE D65 daylight illuminant. It is based on reflectance data obtained over the full visible spectral range (VIS) in contrast to the measurement of ISO brightness which is limited to the blue region of VIS.

In addition, it specifies a method for adjustment of the UV-content to correspond to the D65 daylight illuminant [8] [9], insofar as results obtained when fluorescent whitening agents are present are dependent upon the UV-content of the radiation falling upon the sample. It is specific for the measurement of fluorescence in the blue region of the spectrum.

This method is not applicable to coloured papers containing fluorescent dyes.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

This International Standard should be read in conjunction with ISO 2469.

NOTE A related standard, ISO 11476 [4], specifying the procedure for obtaining values corresponding to the appearance of these products under indoor illumination is being prepared.

ISO 11475:1999
https://standards.iteh.ai/catalog/standards/sist/a8d95049-bdd6-4ec1-869f-ee261809a952/iso-11475-1999

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was 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 edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

3 Definitions

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

3.1
reflectance factor
R
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
intrinsic reflectance factor
reflectivity
R_∞
reflectance factor of a layer or pad of the 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

3.3
radiance factor
β
ratio of the radiance of a body to that of the perfect reflecting diffuser under the same conditions of illumination and viewing

NOTE For fluorescent (luminescent) materials, the total radiance factor, β, is the sum of two portions, the reflected radiance factor, β_S, and the luminescent radiance factor, β_L, so that

$$\beta = \beta_S + \beta_L$$

For non-fluorescent materials, the reflected radiance factor, β_S, is simply the reflectance factor, R.

3.4
CIE whiteness
W_{10}
measure of whiteness derived from the CIE tristimulus values determined under the conditions specified in this International Standard and expressed as whiteness units

3.5
green/red tint
$T_{W.10}$
measure of the deviation from whiteness of the test material towards the green or red region, and expressed as tint units

NOTE A positive value of $T_{W.10}$ indicates a greenish tint and a negative value indicates a reddish tint.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

3.6
fluorescence component
F_{10}
measure of the extent to which the whiteness of the material is affected by excitation of the added fluorescent whitening agent (FWA) under the conditions specified in this International Standard

ISO 11475:1999
https://standards.iteh.ai/catalog/standards/sist/a8d95049-bdd6-4ec1-869f-ee261809a952/iso-11475-1999

NOTE The suffix 10 is used to indicate that the value refers to the CIE 1964 (10°) observer.

4 Principle

The diffuse reflectivity of the material is determined under standardized conditions after adjustment of the instrument so that the relative UV-content of the illumination corresponds to that of the CIE standard D65 illuminant, and the CIE whiteness and tint are calculated. The fluorescence component of the whiteness is calculated from the difference between this reflectivity value and the value obtained when the fluorescence emission from the material is eliminated, for instance by the introduction into the light beams of a sharp cut-off UV-absorbing filter.

5 Apparatus and equipment

5.1 Reflectometer or **spectrophotometer**, having the geometric, spectral and photometric characteristics described in ISO 2469:1994, annex A, calibrated in accordance with the provisions of ISO 2469:1994, annex B, and equipped with a radiation source having an adequate UV-content and a means of adjusting the relative UV-content so that the measured CIE whiteness value agrees with that corresponding to the D65 illuminant [6].

For the measurement of reflectance factors with the fluorescence effect eliminated, the instrument shall be equipped with a sharp cut-off, UV-absorbing filter having a transmittance not exceeding 5,0 % at and below a wavelength of 410 nm and not exceeding 50 % at a wavelength of 420 nm. The cut-off filter shall have characteristics such that a reliable reflectance value is obtained at 420 nm. The reflectance value obtained at 420 nm shall then be considered for computational purposes to be the value which applies at all lower wavelengths, at which it is not possible to make any measurement.

For the measurement of fluorescent papers, photometric linearity up to a scale reading of at least 200 % is necessary in the wavelength region corresponding to the fluorescent emission.

5.1.1 In the case of a filter reflectometer, pairs of filters giving the photoelectric detectors of the reflectometer responses equivalent to the CIE tristimulus values X, Y, Z of the test piece, evaluated for the CIE standard illuminant D65 and CIE 1964 (10°) observer [7].

5.1.2 In the case of an abridged spectrophotometer, a means of calculating the weighted means according to the requirements of the CIE illuminant D65 and CIE 1964 (10°) observer using the weighting functions given in annex A [10].

5.2 Working standards

5.2.1 Two plates of flat opal glass or ceramic material, cleaned as described in ISO 2469.

5.2.2 A stable plastic or other tablet incorporating a fluorescent whitening agent.

5.3 Reference standards for calibration of the instrument and working standards

5.3.1 Non-fluorescent reference standard for calibration, fulfilling the requirements for ISO reference standards of level 3 as prescribed in ISO 2469:1994.

5.3.2 Fluorescent reference standard for use in adjusting the UV-content of the radiation incident upon the sample, having whiteness values and other relevant data as specified in annex B and fulfilling the requirements for ISO reference standards of level 3.

Use new reference standards sufficiently frequently to ensure satisfactory calibration and UV-adjustment.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

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 shall be stored upside down in a dust-free environment or with a protective cover.

ISO 11475:1999

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

https://standards.iteh.ai/catalog/standards/sist/ed3504f5-bd88-4e61-8093-ee261809a952/iso-11475-1999

6 Calibration

6.1 Using the values assigned to the non-fluorescent reference standard (5.3.1), calibrate the instrument with the UV-cut-off filters removed from the radiation beams. The setting of the UV-adjustment filter is not important at this stage.

6.2 Using the appropriate measurement procedure, measure the radiance factors of the fluorescent reference standard (5.3.2); calculate the whiteness value (10.1) and compare the value obtained with that assigned to the fluorescent reference standard.

A measured whiteness value higher than the assigned value indicates that the relative UV-content is too high and vice versa.

6.3 Using the UV-adjustment filter or other adjustment device, adjust the UV-content of the illumination until measurement gives the correct whiteness value.

NOTE If the UV-content is too low it may be necessary to replace the UV-adjustment filter with a filter which raises rather than lowers the relative UV-content.

6.4 Repeat the calibration as described in 6.1 using the non-fluorescent reference standard (5.3.1) with the UV-adjustment filter in the position which gave the correct whiteness value. Repeat the measurement of the whiteness of the fluorescent reference standard (5.3.2) as described in 6.2. If the whiteness value obtained does not agree with the assigned value, adjust the position of the UV-adjustment filter until measurement gives the correct whiteness value as described in 6.3.

6.5 Repeat 6.4 until the correct value for the whiteness of the fluorescent reference standard is obtained with the instrument correctly calibrated to the non-fluorescent reference standard. The UV-content is now correctly adjusted with respect to whiteness to a relative UV-content equivalent to the D65 illuminant. Record the setting of the UV-adjustment.

NOTE 1 This setting is equivalent to the D65 illuminant and CIE 1964 (10°) observer with respect to whiteness. Variations in the green/red tint value may still arise and it cannot be assumed that the tristimulus values and other parameters will also be exactly those applicable to the D65 illuminant.

NOTE 2 In some instruments, the procedure indicated in sections 6.2 to 6.5 is performed automatically.

6.6 Calibrate the fluorescent tablet (5.2.2) as working standard.

This working standard shall only be used in the specific instrument in which it is calibrated and shall only be used to monitor changes in the lamps. It shall be recalibrated against a fluorescent reference standard of level 3 (5.3.2) if the lamps are changed.

6.7 Calibrate the opal glass or ceramic plates (5.2.1) as working standards as described in ISO 2469.

6.8 After adjustment of the UV-content as in 6.1 to 6.5, insert the UV-cut-off filter and calibrate the instrument in this position with the UV-adjustment unchanged.

7 Sampling

Sampling is not included in this standard. If the mean quality of a lot is to be determined, sampling shall be according to ISO 186 [1]. Otherwise, the method of sampling should be reported and care should be taken to ensure that the test pieces are representative of the sample available.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 11475:1999
https://standards.iteh.ai/catalog/standards/sist/a8d95049-bdd6-4ec1-869f-ee261809a952/iso-11475-1999

8 Preparation of test pieces

Avoiding watermarks, dirt and obvious defects, cut rectangular test pieces approximately 75 mm × 150 mm. Assemble at least ten of the 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 on both 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 the distinction is not possible, as may be the case for papers manufactured on double-wire machines or those coated on both sides, ensure that the same side of the test piece is uppermost so that the CIE whiteness can be determined separately for each side of the paper or board.

NOTE Pulp sheets prepared in accordance with ISO 3688 [2] may be measured in the same way, but whiteness is not normally considered to be a pulp property.

9 Procedure

9.1 Remove the UV-cut-off filter from the light beam. Operate the reflectometer or spectrophotometer as described in ISO 2469.

9.2 Remove the protecting sheets from the pad of test pieces and measure the intrinsic total radiance factors of the top test piece.

9.3 Move the measured test piece to the bottom of the pad. Repeat 9.2 until at least 10 measurements have been made. Repeat on the reverse side of the paper or board.

9.4 If an assessment of the fluorescence component is required, place the UV-cut-off filter in the light beam. Operate the reflectometer or spectrophotometer as described in ISO 2469, and measure the intrinsic reflectance factor of the top test piece without UV-excitation.

9.5 Move the measured test piece to the bottom of the pad. Repeat 9.4 until at least 10 measurements have been made. Repeat on the reverse side of the paper or board.

NOTE Normally the CIE whiteness and tint values will be automatically calculated (10.1) for each test piece at the time of measurement. In some instruments it will be more convenient to measure the whiteness with and without fluorescence excitation on each test piece before proceeding to the next of the ten pieces.

10 Calculation and expression of results

10.1 Calculate the whiteness, W_{10} and tint, T_{10} values for each test piece, for the two sides separately, according to the following equations:

$$W_{10} = Y_{10} + 800\,(x_{n.10} - x_{10}) + 1\,700\,(y_{n.10} - y_{10}) \quad \ldots (1)$$

$$T_{W.10} = 900\,(x_{n.10} - x_{10}) - 650\,(y_{n.10} - y_{10}) \quad \ldots (2)$$

where

x_{10} and y_{10} are the chromaticity coordinates of the test piece, calculated as

$$x_{10} = \frac{X_{10}}{X_{10}+Y_{10}+Z_{10}}$$

$$y_{10} = \frac{Y_{10}}{X_{10}+Y_{10}+Z_{10}}$$

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 11475:1999
https://standards.iteh.ai/catalog/standards/sist/a8d95049-bdd6-4ec1-869f-
ee26fe85a99a/iso-11475-1999

X_{10} Y_{10} Z_{10} are the tristimulus values of the test piece for D65/10° conditions;

$x_{n.10}$ and $y_{n.10}$ are the chromaticity coordinates of the perfect reflecting diffuser for the illumination and observer specified ($x_{n.10}$ = 0,313 82 and $y_{n.10}$ = 0,331 00 for D65/10°).

10.2 The limiting values for a sample to be considered white are given by

$$40 < W_{10} < (5Y_{10} - 280) \quad \ldots (3)$$

$$-3 < T_{W.10} < 3 \quad \ldots (4)$$

10.3 Where relevant, calculate the whiteness without UV-excitation, $W_{0.10}$. Calculate the fluorescence component, F_{10}, of the CIE whiteness (D65/10°) as the difference between the two whiteness values measured with and without UV-excitation:

$$F_{10} = W_{10} - W_{0.10} \quad \ldots (5)$$

where

W_{10} is the whiteness determined when the illumination has the desired UV-content corresponding to the D65 illuminant;

$W_{0.10}$ is the whiteness determined when the radiation exciting fluorescence has been eliminated by a sharp cut-off UV-absorbing filter.

NOTE A cut-off filter which eliminates only the UV-component below 400 nm does not eliminate all the fluorescence effect.

10.4 Calculate the mean values and report the mean CIE whiteness (D65/10°) separately for both sides to the nearest integer, and the mean tint value to one decimal place. If either W_{10} or $T_{W.10}$ falls outside the limits given in 10.2, report that the sample is not white according to CIE. If $W_{0.10}$ falls outside the limits given in 10.2, it is not necessary to report this fact. Report the fluorescence component as the whiteness difference to the nearest integer.

11 Precision

In a comparative trial involving 24 different instruments the standard deviation of the different whiteness value results was 0,7 whiteness units.

12 Test report

The test report shall include the following information:

a) date and place of testing;

b) precise identification of the sample;

c) a reference to this International Standard;

d) the CIE whiteness value, the tint value and the fluorescence component of the whiteness for the two sides separately;

e) the type of apparatus used;

f) the type of illuminant used;

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

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 11475:1999
https://standards.iteh.ai/catalog/standards/sist/a8d95049-bdd6-4ec1-869f-ee261809a952/iso-11475-1999

Annex A
(normative)

Spectral characteristics of reflectometers for determining tristimulus values

A.1 Filter reflectometers

The required spectral characteristics of the reflectometer are arrived at by a combination of lamps, integrating sphere, glass optics, filters and photoelectric cells. The filters shall be such that they, together with the optical characteristics of the instrument, give overall responses equivalent to the CIE tristimulus values X_{10}, Y_{10}, Z_{10} of the CIE 1964 (10°) standard colorimetric system of the test piece evaluated for the CIE standard illuminant D65.

A.2 Abridged spectrophotometers

The desired tristimulus values are obtained by summing the products of the spectral reflectance factors and the weighting functions given in ASTM E308-95 [10] for the D65 illuminant and CIE 1964 (10°) observer.

iTeh STANDARD PREVIEW (standards.iteh.ai) ISO 11475:1999

Use tables A.1 and A.2 [1)], which 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.

"Check sum" 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, 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. Each value in a column has been rounded to three decimal digits. It is
Y these "White point" data, and no others, that must be used as X_n $_n$ 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 E308-95 [10], section 7.3.2.2, when the values are not available at the top or at the bottom of the range:

Wavelength range outside the 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 or longest wavelength for which spectral data are available.

That is:

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 E308-95 [10] (tables 6:19 and 6:20).