
**Paper, board and pulps — Basic terms
and equations for optical properties**

*Papiers, cartons et pâtes — Équations et termes de base pour
propriétés optiques*

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Terms and definitions	1
2.1 Brightness	1
3 Calculations	9
3.1 Colour appearance, tristimulus values.....	9
3.2 Reflectance factor, Y -value, opacity, transmittance	13
3.2.1 Reflectance factor, R	13
3.2.2 Luminous reflectance factor, R_y	13
3.2.3 Y -value ($C/2^\circ$).....	14
3.2.4 Opacity.....	14
3.2.5 Transmittance from luminous reflectance factor measurements.....	14
3.3 Brightness	14
3.4 Light-scattering and light-absorption coefficients	15
3.4.1 Conditions for the Kubelka-Munk theory.....	15
3.4.2 Calculations of s and k	16
3.5 Chromaticity coordinates	17
3.6 Dominant wavelength.....	18
3.7 CIELAB colour space coordinates.....	18
3.8 Colour differences in CIELAB colour space.....	20
3.9 CIE-whiteness and Tint.....	21
3.9.1 CIE tint.....	21
3.9.2 CIE-whiteness, W	21
3.10 Fluorescence component.....	22
3.11 Metamerism index.....	23
3.12 Yellowness index	23
Bibliography	24

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.

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The committee responsible for this document is ISO/TC 6, *Paper, board and pulps*.

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Introduction

International Standards published by ISO/TC 6 for the determination of optical properties include a lot of definitions and formulae which are used to perform optical measurements and calculations on papers and boards.

It is very valuable for the pulp and paper industry utilizing these International Standards to have access to a single document which gathers together all the various formulae required for the calculation of these optical properties. This Technical Report is based on a SCAN-test document first published in 1994 and revised in 2003.

This Technical Report includes not only formulae but also the values of various constants which appear in these formulae. It is particularly valuable to have the various formulae but also these constants standardized and gathered into a single document when new software programs are being developed either by an instrument manufacturer or in an independent laboratory to ensure that exactly the same expressions are used for such calculations in all the laboratories worldwide when measurements are made in accordance with the ISO/TC 6 standards.

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Paper, board and pulps — Basic terms and equations for optical properties

1 Scope

This Technical Report provides a summary of the formulae used for determining the optical properties of pulp, paper and board. This Technical Report is to be used in conjunction with the particular International Standards for the determination of the desired optical properties.

This Technical Report provides the information necessary for those involved in development of software for computation of optical properties in accordance with current ISO standards.

2 Terms and definitions

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

2.1 Brightness

2.1.1

ISO brightness, R_{457}

diffuse blue reflectance factor, UV level C

intrinsic diffuse radiance (reflectance) factor measured with a reflectometer having the characteristics described in ISO 2469, equipped with a filter or corresponding function having an effective wavelength of 457 nm and a half bandwidth of 44 nm, and adjusted so that the UV content of the irradiation incident upon the test piece corresponds to that of the CIE illuminant C

Note 1 to entry: The filter function is described more fully by the weighting function factors given in ISO 2470-1, Annex A.

[SOURCE: ISO 2470-1:2009, 3.4, modified]

2.1.2

D65 brightness, R_{457D65}

diffuse blue reflectance factor, UV level D65

intrinsic diffuse radiance (reflectance) factor measured with a reflectometer having the characteristics described in ISO 2469, equipped with a filter or corresponding function having an effective wavelength of 457 nm and a half-peak bandwidth of 44 nm, and adjusted so that the UV content of the irradiation incident upon the test piece corresponds to that of the CIE standard illuminant D65

Note 1 to entry: The filter function is described more fully by the weighting function factors given in ISO 2470-2, Annex A and Table A.1.

[SOURCE: ISO 2470-2:2008, 3.4, modified]

2.2

CIE colour matching functions

$R(\lambda)$

functions in the CIE 1931 standard colorimetric system describing the tristimulus values X , Y , Z for monochromatic colour stimuli of equal radiance and where the wavelength λ is a variable

2.3

CIE colour matching functions

$$\bar{x}_{10}(\lambda), \bar{y}_{10}(\lambda), \bar{z}_{10}(\lambda)$$

functions in the CIE 1964 standard colorimetric system describing the tristimulus values X_{10} , Y_{10} , Z_{10} for monochromatic colour stimuli of equal radiance and where the wavelength λ is a variable

2.4

chromaticity coordinates

ratio of each of a set of three tristimulus values to their sum

Note 1 to entry: As the sum of the three chromaticity coordinates is equal to one, two of them are sufficient to define a chromaticity.

Note 2 to entry: In the CIE standard colorimetric systems, the chromaticity coordinates are represented by the symbols x, y, z and x_{10}, y_{10}, z_{10} .

[SOURCE: CIE S 017/E:2011 ILV, 17-145]

2.5

CIELAB colour space

three-dimensional approximately uniform colour space, produced by plotting in rectangular coordinates L^* , a^* , b^* quantities defined by the formulae given in [3.7](#)

Note 1 to entry: The quantity L^* is a measure of the lightness of the test piece, where $L^* = 0$ corresponds to black and $L^* = 100$ is defined by the perfect reflecting diffuser. Visually, the quantities a^* and b^* represent respectively the red-green and yellow-blue axes in colour space, such that

- $+a^*$ is a measure of the degree of redness of the test piece,
- $-a^*$ is a measure of the degree of greenness of the test piece,
- $+b^*$ is a measure of the degree of yellowness of the test piece, and
- $-b^*$ is a measure of the degree of blueness of the test piece.

If both a^* and b^* are equal to zero, the test piece is grey.

[SOURCE: ISO 5631-3:2014, 3.6, modified]

2.5.1

CIELAB colour ($C/2^\circ$)

$$(L^*, a^*, b^*)$$

L^* , a^* and b^* values of the sample according to the CIELAB 1976 system, evaluated according to the CIE 1931 (2°) standard colorimetric observer and the CIE illuminant C

2.5.2

CIELAB colour ($D65/10^\circ$)

$$(L^*, a^*, b^*)$$

L^* , a^* and b^* values of the sample according to the CIELAB 1976 system, evaluated according to the CIE 1964 (10°) standard colorimetric observer and the CIE standard illuminant D65

2.5.3

CIELAB colour ($D50/2^\circ$)

$$(L^*, a^*, b^*)$$

L^* , a^* and b^* values of the sample according to the CIELAB 1976 system, evaluated according to the CIE 1931 (2°) standard colorimetric observer and the CIE illuminant D50

2.5.4**CIELAB colour difference**

$$\Delta E_{ab}^*$$

distance in the CIELAB colour space between two colour stimuli

2.6**effective residual ink concentration****ERIC number**

ratio of the light absorption coefficient of pulp or paper containing ink to the light absorption coefficient of the ink itself, both being determined at a wavelength of 950 nm

Note 1 to entry: The ERIC number is dimensionless.

[SOURCE: ISO 22754:2008, 3.6]

2.7**fluorescence component** **$F_{B,S}$ or $F_{W,S}$ for specified CIE illuminant**

S

fluorescence component is used as a measure of the extent to which the brightness (F_B) or whiteness (F_W) of the material is affected by emission from added fluorescent whitening agent (FWA) when the light source of the specified CIE illuminant ($S = C$ or $D65$) emits UV radiation

Note 1 to entry: Relevant standards: ISO 2470-1, ISO 2470-2, ISO 11475, ISO 11476.

Note 2 to entry: Examples of codification:

- $F_{B,C}$: fluorescence component calculated for $C/2^\circ$ brightness measurement;
- $F_{W,D65}$: fluorescence component calculated for $D65/10^\circ$ whiteness measurement.

2.8**fluorescent whitening agent****FWA**

fluorescing materials absorbing ultraviolet light and converting it into visible blue light

Note 1 to entry: The fluorescing light adds to light reflected by the pulp in the blue range and compensates for the absorbed share of the light.

Note 2 to entry: The absorption maximum of the usual FWAs is around 360 nm in the UV range and their maximum of emission is in the blue range of the visible light at approximately 440 nm. By this fact, the yellow tint of the bleached pulp is compensated and seen by the human eye as white.

Note 3 to entry: FWAs in paper can only be effective when they are exposed to a light source with an adequate component of UV light. Light emitted by incandescent lamps and some LEDs have practically no UV component, ie radiation with a wavelength of less than 400 nm. FWAs are not sufficiently activated by such light sources. Daylight does contain an adequate UV component although the intensity of the light and the relative contribution of the UV component depends on the time of day, time of the year, geographical standpoint, weather conditions, etc.

Note 4 to entry: This term is often equivalent to *optical brightening agent (OBA)* (2.25).

[SOURCE: Bayer Blankophor — fluorescent whitening agents for the paper industry]

2.9**gloss**

<of a surface> mode of appearance by which reflected highlights of objects are perceived as superimposed on the surface due to the directionally selective properties of that surface

[SOURCE: CIE S 017/E:2011 ILV, 17-500]