INTERNATIONAL STANDARD

ISO 2470-2

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Paper, board and pulps — Measurement of diffuse blue reflectance factor —

Part 2: Outdoor daylight conditions (D65 brightness)

Papier, carton et pâtes — Mesurage du facteur de réflectance diffuse dans le bleu —

Partie 2: Conditions de lumière du jour extérieure (degré de blancheur D65)

Reference number
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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 2470-2 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*.

ISO 2470 consists of the following parts, under the general title *Paper, board and pulps — Measurement of diffuse blue reflectance factor*:

— *Part 1: Indoor daylight conditions* (*ISO brightness)*

— *Part 2: Outdoor daylight conditions (D65 brightness)*

Introduction

The reflectance factor (radiance factor) depends on the conditions of measurement, particularly the spectral and geometric characteristics of the instrument used. This part of ISO 2470 should therefore be read in conjunction with ISO 2469, which defines the geometric characteristics of the instrument and also defines the photometric calibration procedure to be adopted.

The radiance factor of fluorescent materials, for which this property is most interesting, is also dependent on the ultraviolet (UV content) of the illumination falling upon the sample. This part of ISO 2470 should therefore be read in conjunction with ISO 11475, which describes the procedure for adjusting the UV content in this type of instrument to match the CIE standard illuminant D65.

It is important to ensure that the property defined in this part of ISO 2470 is not confused with the property known as ISO brightness, which is determined under conditions corresponding to the CIE-illuminant C, where the UV content is much lower, approximating UV levels encountered in indoor viewing conditions.

Paper, board and pulps — Measurement of diffuse blue reflectance factor —

Part 2: Outdoor daylight conditions (D65 brightness)

1 Scope

This part of ISO 2470 specifies a method for measuring the D65 brightness of pulps, papers and boards.

This part of ISO 2470 is limited in its scope to white and near-white pulps, papers and boards, particularly those exhibiting fluorescence which promotes the appearance of whiteness. The measurement can only be made in an instrument in which the ultraviolet energy level of the illumination has been adjusted to correspond to the CIE standard illuminant D65 using a fluorescent reference standard.

The source employed in this part of ISO 2470 excites almost twice as much fluorescence as the illuminant in ISO 2470-1. Consequently, this part of ISO 2470 is better suited for measuring the fluorescent contribution to the brightness. However, D65 brightness should not be confused with ISO brightness which closely approximates the brightness of papers viewed under indoor conditions.

NOTE The property called ISO brightness is measured with an instrument adjusted to a much lower UV content than that specified in this part of ISO 2470. The measurement of ISO brightness is described in ISO 2470-1.

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 186, *Paper and board — Sampling to determine average quality*

ISO 2469:2007, *Paper, board and pulps — Measurement of diffuse radiance factor*

ISO 3688, *Pulps — Preparation of laboratory sheets for the measurement of diffuse blue reflectance factor (ISO brightness)*

ISO 7213, *Pulps — Sampling for testing*

ISO 11475:2004, *Paper and board — Determination of CIE whiteness, D65/10° (outdoor daylight)*

3 Terms and definitions

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

3.1
radiance factor
β
ratio of the radiance of a surface element of a body in the direction delimited by a given cone with its apex at the surface element to that of the perfect reflecting diffuser under the same conditions of illumination

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 numerically equal to the reflectance factor R.

3.2
diffuse radiance [reflectance] factor
R
ratio of the radiation reflected and emitted from a body to that reflected from the perfect reflecting diffuser under the same conditions of diffuse illumination and normal detection

NOTE 1 The ratio is often expressed as a percentage.

NOTE 2 The diffuse radiance [reflectance] factor is influenced by the backing if the body is translucent.

NOTE 3 This part of ISO 2470 prescribes diffuse illumination and normal detection in an instrument calibrated in accordance with the provisions of this part of ISO 2470.

3.3
intrinsic radiance [reflectance] factor
R_∞
diffuse radiance [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 radiance [reflectance] factor

NOTE The radiance [reflectance] factor of a single non-opaque sheet is dependent on the background and is not a material property.

3.4
D65 brightness
$R_{457,D65}$
intrinsic 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 The filter function is described more fully by the weighting function factors given in Annex A and Table A.1.

4 Principle

A test piece is illuminated diffusely in a standard instrument and the light reflected normal to the surface is either allowed to pass through a defined optical filter and then measured by a photodetector or measured by an array of photosensitive diodes, where each diode responds to a different effective wavelength. The brightness is then determined directly from the output from the photodetector or by calculation from the photosensitive diode outputs using the appropriate weighting function.

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, and equipped for the measurement of blue reflectance factor as defined in Annex A.

5.1.1 In the case of a filter reflectometer, the radiation falling upon the test piece shall have a UV content corresponding to that of the CIE standard illuminant D65, adjusted or verified by the help of the fluorescent reference standard (5.2.2).

5.1.2 In the case of an abridged spectrophotometer, the instrument shall have a UV-adjustable filter with a cut-off wavelength of 395 nm or some other system for adjustment and control, and this filter shall be adjusted or the system shall be calibrated with the help of the fluorescence reference standard (5.2.2), so that the UV content of the illumination falling upon the sample corresponds to that of the CIE standard illuminant D65.

5.2 Reference standards for calibration of the instrument and the working standards, to be used sufficiently frequently 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, having a CIE whiteness (D65/10°) value assigned by an ISO/TC6 authorized laboratory as prescribed in ISO 11475:2004, Annex B.

NOTE Greater precision in the D65 brightness measurement would be attained if a fluorescent reference standard having an assigned D65 brightness value were used. It is, however, important for the industry to have only one UV-filter adjustment for all measurements under CIE standard illuminant D65 conditions. For this reason, a reference standard having an assigned CIE whiteness (D65/10°) value as prescribed in ISO 11475 is preferred.

5.3 Working standards, as follows.

5.3.1 Two plates of flat opal glass, ceramic or other suitable non-fluorescent 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.

5.3.2 Stable plastic or other tablet, incorporating a fluorescent whitening agent.

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

6 Sampling and conditioning

If the tests are being made to evaluate a lot of paper or board, the sample should be selected in accordance with ISO 186. If a lot of pulps is to be evaluated, the sample should be selected in accordance with ISO 7213. 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 with elevated temperatures should not be applied since it might change the optical properties.

7 Preparation of test pieces

Regarding pulp samples, prepare laboratory sheets in accordance with ISO 3688.

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 radiance 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 Calibrate the instrument according to the instrument maker's instructions, using a non-fluorescent (5.2.1) ISO level 3 reference standard (IR3) or a working standard (5.3.1) calibrated in relation to an IR3. If the instrument is of the abridged spectrophotometer type, and if the material to be measured contains or is suspected to contain a fluorescent component, adjust the setting of the UV-adjustment filter or of a system having a corresponding function (see 5.1.2) using the fluorescent (5.2.2) and non-fluorescent (5.2.1) ISO level 3 standards in accordance with the instrument maker's instructions.

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 D65 brightness of the top side of the test piece pad. Read and record the value to the nearest 0,05 %, or better, radiance factor.

8.3 Move the measured test piece to the bottom of the pad and determine the D65 brightness for the next and similarly for the following test pieces, until a total of not less than ten test pieces has been measured.

8.4 If required, turn the pad upside down and repeat the procedure for the other side.

NOTE 1 If, in the case of fluorescent samples, measurements are made with UV-exclusion filters with a cut-off wavelength of 420 nm, placed in the light beams, it is possible to determine the D65 brightness of the non-fluorescent substrate and thus to calculate the contribution of the fluorescent whitening agent to the D65-brightness, but this is outside the scope of this part of ISO 2470.

NOTE 2 In the case of a non-fluorescent material, the D65 brightness and the ISO brightness are identical.

9 Expression of results

Calculate the mean intrinsic radiance factor and its standard deviation separately for each side measured, as the D65-brightness of the paper, board or pulp in percent to the nearest 0,5 % radiance factor. If both sides were measured and the mean values differ by more than 0,5 %, and if this difference is statistically significant, the two sides shall be identified and the results reported separately. If the difference is equal to or less than 0,5 %, the overall average shall be reported.

Although the measurements should be made to the nearest 0,05 % radiance factor in accordance with the precision of the instrument, the final result should be expressed only to the nearest 0,5 % radiance factor as an indication of the lack of resolution in adjusting the UV filter.

10 Precision

Data available for fluorescent papers after adjustment of UV content of the irradiation falling on the test piece as described in this part of ISO 2470 indicate, for a medium level of fluorescence, a coefficient of variation between different laboratories of the order of 1 %.

11 Test report

The test report shall include the following information:

a) a reference to this part of ISO 2470;

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 mean D65 brightness and standard deviation for each required side, or the mean and standard deviation of the two sides, to the nearest 0,5 % radiance factor;

f) the type of instrument used;

g) any departure from this part of ISO 2470 or any circumstances or influences that may have affected the results.

Annex A
(normative)

Spectral characteristics of instruments for measuring D65 brightness

A.1 Filter colorimeters

The effective wavelength of the reflectometer, 457,0 nm $\pm$ 0,5 nm, and the half-peak bandwidth of 44 nm are arrived at with a combination of lamps, integrating sphere, glass optics, filters and photoelectric detectors, taking into consideration that these parameters are dependent upon

a) the relative spectral distribution of the radiant flux leaving the integrating sphere,

b) the relative spectral transmittance of the glass optics,

c) the relative spectral transmittance of the filters and spectral sensitivity of the detection system,

d) the relative spectral responsitivity of the photoelectric detectors, each being a function of wavelength.

A.2 Abridged spectrophotometers

The $F(\lambda)$ of the brightness function at 5 nm intervals is indicated in Table A.1. In an abridged spectrophotometer measuring at 10 nm or 20 nm intervals, the appropriate values given in Table A.1 for the different wavelengths should be used in the calculation of D65 brightness without any attempt to recalculate intermediate values.

For the range of white and near-white papers for which this part of ISO 2470 is applicable, no further treatment of these functions is necessary.

Furthermore, in the case of a filter instrument, the area under the curve of $F(\lambda)$ for wavelengths exceeding 700 nm should be small enough for measurement not to be affected by any infrared fluorescent radiation generated in the sample.

Table A.1 — The relative spectral distribution function $F(\lambda)$ of a reflectometer equipped for measuring D65 brightness

Wavelength nm	$F(\lambda)$	5 nm weights	$F(\lambda)$	10 nm weights	$F(\lambda)$	20 nm weights
400	1,0	0,107	1,0	0,213	1,0	0,425
405	2,9	0,309				
410	6,7	0,715	6,7	1,430		
415	12,1	1,291				
420	18,2	1,942	18,2	3,885	18,2	7,728
425	25,8	2,752				
430	34,5	3,680	34,5	7,364		
435	44,9	4,790				
440	57,6	6,145	57,6	12,295	57,6	24,459
445	70,0	7,467				
450	82,5	8,801	82,5	17,609		
455	94,1	10,038				
460	100,0	10,668	100,0	21,345	100,0	42,463
465	99,3	10,593				
470	88,7	9,462	88,7	18,933		
475	72,5	7,734				
480	53,1	5,665	53,1	11,334	53,1	22,548
485	34,0	3,627				
490	20,3	2,166	20,3	4,333		
495	11,1	1,184				
500	5,6	0,597	5,6	1,195	5,6	2,378
505	2,2	0,235				
510	0,3	0,032	0,3	0,064		
Sum	**937,4**	**100,000**	**468,5**	**100,000**	**235,5**	**100,000**

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[2] ISO 2470-1, *Paper, board, and pulps — Measurement of diffuse blue reflectance factor — Part 1: Indoor daylight conditions (ISO brightness)*

[3] ISO 4094:2005, *Paper, board and pulps — International calibration of testing apparatus — Nomination and acceptance of standardizing and authorized laboratories*

[4] ISO 10526, *CIE standard illuminants for colorimetry*

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