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**Paper, board and pulps — Measurement  
of diffuse blue reflectance factor  
(ISO brightness)**

*Papier, carton et pâtes — Mesurage du facteur de réflectance diffuse dans  
le bleu (degré de blancheur ISO)*

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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.

International Standard ISO 2470 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Working Group WG 3, *Optical properties*.

This third edition cancels and replaces the second edition (ISO 2470:1977). This edition differs from the 1977 edition in that it describes the use of abridged spectrophotometers and also prescribes a routine for adjusting the relative UV-content of the illumination in this type of instrument to a defined level when materials containing fluorescent whitening agents are to be measured.

Annexes A and B form a normative part of this International Standard.

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## Introduction

The reflectance factor depends on 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 which defines the geometric characteristics of the instrument and the calibration procedure. This edition of ISO 2470 differs from the 1977 edition in that it describes the use of abridged spectrophotometers and also prescribes a routine for adjusting the relative UV-content of the illumination in this type of instrument to a defined level when materials containing fluorescent whitening agents are to be measured.

The definition of ISO brightness is historically linked to the Zeiss Elrepho instrument having as a light source an incandescent lamp which excites fluorescence to only a limited extent. It is specified here that, in instruments of the abridged spectrophotometer type, the UV-content of the illumination be adjusted using a suitable filter to conform to the CIE illuminant C as defined by a fluorescent reference standard having an assigned value of ISO brightness as described in annex B. Only if this is done may the property measured on a fluorescent material be called ISO brightness.

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# Paper, board and pulps — Measurement of diffuse blue reflectance factor (ISO brightness)

## 1 Scope

This International Standard specifies a method for measuring the diffuse blue reflectance factor (ISO brightness) of pulps, papers and boards.

This International Standard is limited in its scope to white and near-white pulps, papers and boards. Materials exhibiting fluorescence which promotes the appearance of whiteness may be measured but the ultraviolet energy level of the illumination must be adjusted using a fluorescent calibration standard if standardization and agreement between instruments is to be achieved.

NOTE A brightness value associated with an instrument setting adjusted to conform to the CIE standard illuminant D65 (cf. ISO 11475<sup>[1]</sup>), which has a much higher UV-content than the CIE illuminant C specified in this International Standard, is outside the scope of this International Standard and consequently is not "ISO brightness". Such a property may be called "D65 brightness".

## 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, *Paper and board — Sampling to determine average quality.*

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

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

ISO 4094, *Paper, board and pulps — International calibration of testing apparatus — Nomination and acceptance of standardizing and authorized laboratories.*

ISO 7213, *Pulps — Sampling for testing.*

## 3 Terms and definitions

For the purposes of this International Standard, the following terms and 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

$R_{\infty}$

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

### 3.3

#### diffuse blue reflectance factor

#### ISO brightness

$R_{457}$

intrinsic 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 width at half-height of 44 nm, and adjusted so that the UV-content of the illumination incident upon the test piece corresponds to that of the CIE illuminant C

NOTE 1 In the 1994 edition of ISO 2469 the reflectometer characteristics are described in annex A. 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.

NOTE 2 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 glass filter and then measured by a photocell or measured by an array of diodes, where each diode responds to a different effective wavelength. The brightness is then determined directly from the output from the photocell, or by calculation from the 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.

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.

**5.1.1** 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 illuminant C.

**5.1.2** In the case of an abridged spectrophotometer, the instrument shall have an adjustable filter with a cut-off wavelength of 395 nm, and this filter shall be adjusted with the help of the fluorescent reference standard (5.2.2), so that the UV-content of the illumination falling upon the sample corresponds to that of the CIE illuminant C. For this purpose, a reference standard with an assigned ISO-brightness value provided by an ISO/TC 6 authorized laboratory is required.

### 5.2 Reference standards for calibration of the instrument and the working standards

Use reference standards 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 an ISO-brightness value assigned as prescribed in annex B.

### 5.3 Working standards

**5.3.1 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.

**5.3.2 A 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

If the tests are being made to evaluate a lot of paper or board, the sample shall be selected in accordance with ISO 186. If the tests are being made to evaluate a lot of pulp, the sample shall 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.

## 7 Preparation of test pieces

### 7.1 Pulp

Prepare sheets in accordance with ISO 3688. Remove the protective filter papers and assemble the test sheets in a pad, with the top side uppermost. Laboratory sheets of sufficient size may be cut into several test pieces.

### 7.2 Paper or board

Avoiding watermarks, dirt and obvious defects, cut rectangular test pieces of 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 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 twin-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 ISO reference standard of level 3 (IR 3) (5.2.1) or a working standard calibrated in relation to an IR 3 (5.3.1). 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 UV-content of the illumination using the fluorescent (5.2.2) and non-fluorescent (5.2.1) ISO level 3 standards in an iterative procedure according to the instrument maker's instructions.

**8.2** Remove the protective 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 blue reflectance factor of the top side of the test piece pad. Read and record the value to the nearest 0,05 % reflectance factor.

**8.3** Move the measured test piece to the bottom of the pad and determine the intrinsic blue reflectance factor for the next and similarly for the following test pieces, until a total of not less than ten test pieces has been measured or, in the case of pulp, until all the test sheets have been measured.

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

**NOTE** If, in the case of fluorescent samples, measurements are made with 420 nm cut-off filters placed in the light beams, it is possible to determine the ISO brightness of the non-fluorescent substrate and thus to calculate the contribution of the fluorescent whitening agent to the brightness, but this is outside the scope of this International Standard.

## 9 Expression of results

Report the mean intrinsic reflectance factor, separately for both sides, as the diffuse blue reflectance factor (ISO brightness) of the paper, board or pulp in per cent to the nearest 0,05 % reflectance factor.

## 10 Precision

The coefficient of variation of results obtained on non-fluorescent papers is of the order of 0,3 %. No data are yet available for fluorescent papers after adjustment of the UV-content of the illumination as described in 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) precise identification of the sample;
- d) the mean diffuse blue reflectance factor (ISO brightness) for each required side, or the mean of the two sides, to the nearest 0,05 % reflectance factor;
- 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 instruments for measuring ISO brightness

#### A.1 Filter colorimeters

The effective wavelength of the reflectometer,  $457,0 \text{ nm} \pm 0,5 \text{ nm}$ , is arrived at with a combination of lamps, integrating sphere, glass optics, filters and photoelectric detectors. The filters shall be such that the relative spectral distribution function  $F(\lambda)$  of the reflectometer is as indicated in Table A.1.

$F(\lambda)$  is the product of the following variables:

- 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 R457 filters;
- d) the relative spectral responsivity of the photoelectric detectors, each being a function of the wavelength.

NOTE Although it was not stated in the first edition of this International Standard (ISO 2470:1973), usage and the requirement with regard to fluorescent samples presuppose that the instrument is fitted with an incandescent lamp so that the illumination on the sample corresponds closely to the CIE standard illuminant A.

#### A.2 Abridged spectrophotometers

In an abridged spectrophotometer measuring at 10 nm or 20 nm intervals, the appropriate values given in Table A.1 for the different wavelengths shall be used in the calculation of ISO brightness without any attempt to interpolate intermediate values.

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

**Table A.1 — The relative spectral distribution function  $F(\lambda)$  of a reflectometer equipped for measuring ISO 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		
<b>Sum</b>	<b>937,4</b>	<b>100,000</b>	<b>468,5</b>	<b>100,000</b>	<b>235,5</b>	<b>100,000</b>

Furthermore, 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.

## Annex B (normative)

### UV-calibration service

#### B.1 General

In this International Standard, reference is made to special reference standards which are required to enable the relative UV-content in the illumination falling on the test piece to be adjusted to conform to the CIE illuminant C.

To enable this to be done, the following procedure is established.

#### B.2 Standardizing laboratories

A laboratory, or laboratories, equipped to make primary spectrofluorimetric measurements using the two-monochromator method is appointed by ISO/TC 6 as "standardizing laboratory" in accordance with the provisions of ISO 4094. This laboratory issues "ISO reference standards of level 2" (IR 2) to the authorized laboratories. Such reference standards shall be assigned spectral total radiance factor data for the CIE illuminant C.

#### B.3 Authorized laboratories

**B.3.1** Laboratories having the necessary technical competence and maintaining reference instruments having the characteristics specified in ISO 2469 are appointed by ISO/TC 6 as "authorized laboratories" in accordance with the provisions of ISO 4094.

NOTE It is anticipated that these authorized laboratories will be the same as those authorized in accordance with the requirements of ISO 2469, but the standardizing laboratories will not necessarily be the same as those appointed according to ISO 2469 since different equipment is required.

**B.3.2** The authorized laboratory shall make necessary adjustments to correct for differences in the basic photometric level between the instrument at the standardizing laboratory and the level specified for the authorized laboratory in ISO 2469, before calculating the ISO-brightness value of the IR 2 and using this value to adjust the UV-content of the reference instrument. The calculations shall be carried out using 10 nm data and the weighting functions given in annex A.

**B.3.3** The authorized laboratory shall take steps to ensure that directional effects in the IR 2 which may affect the measurements at the standardizing laboratory are recognized and taken into account when determining the value to be used when transferring this calibration to an instrument providing a diffuse illumination.

#### B.4 IR 3 fluorescent reference standards

**B.4.1** The fluorescent reference standards shall consist of white paper, uniform in radiance factor and aged for a sufficient time to give the paper an optical stability of 4 to 6 months without a deterioration in the ISO-brightness value of more than 0,1 units.

**B.4.2** The standards shall be prepared in the form of opaque pads and shall have a smooth non-glossy surface. The pad shall be covered with a suitable protective cover.

NOTE Fluorescent tablets and tiles are suitable local working standards but have been shown not to be suitable for use as transfer standards for this procedure which is specific for white papers ([4] in the bibliography).