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Paper, board and pulps — Measurement of diffuse radiance factor (diffuse reflectance factor)

Papier, carton et pâtes — Mesurage du facteur de luminance énergétique diffuse (facteur de réflectance diffuse)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

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

This fifth edition cancels and replaces the fourth edition (ISO 2469:2007), which has been technically revised.

Introduction

The radiance factor depends on the conditions of measurement, particularly the spectral and geometric characteristics of the instrument used. The diffuse radiance factor as defined by this International Standard is determined using instruments having the characteristics given in Annex A and calibrated according to the procedure specified in Annex B.

The diffuse radiance factor is the sum of the reflected radiance factor and the luminescent radiance factor, and the luminescent radiance factor of a luminescent (fluorescent) object is dependent on the spectral power distribution of the illumination. If adequately accurate measurements are to be carried out on fluorescent objects, the UV-content of the instrument illumination must therefore be adjusted to produce the same amount of fluorescence for a fluorescent reference standard as the selected CIE illuminant. The preparation of fluorescent reference standards to enable this adjustment to be made is described in Annex C. The use of these fluorescent reference standards is described in detail in the International Standards describing the measurement of the properties of the materials containing fluorescent whitening agents.

The spectral diffuse radiance factor or the weighted diffuse radiance factor applicable to one or several specified wavelength bands is often used to characterize the properties of pulp, paper and board. Examples of diffuse radiance factors associated with specified wavelength bands are the ISO brightness (diffuse blue radiance factor) and the luminance factor.

The diffuse radiance factor or diffuse reflectance factor is also used as the basis for calculating optical properties, such as opacity, colour, whiteness and the Kubelka-Munk scattering and absorption coefficients. These various properties are described in detail in specific International Standards, and for all of these, ISO 2469 is the primary normative reference.

Paper, board and pulps — Measurement of diffuse radiance factor (diffuse reflectance factor)

1 Scope

This International Standard describes the general procedure for measuring the diffuse radiance factor of all types of pulp, paper and board. More particularly, it specifies in detail in Annex A the characteristics of the equipment to be used for such measurements, and in Annex B the procedures to be used for calibrating that equipment.

This International Standard may be used to measure the diffuse radiance factors and related properties of materials containing fluorescent whitening agents, provided that the UV-content of the instrument illumination has been adjusted to give the same level of fluorescence as a fluorescent reference standard for a selected CIE illuminant, in accordance with the specific International Standard describing the measurement of the property in question.

This International Standard describes in Annex C the preparation of fluorescent reference standards, although the procedures for using these standards are not included, since their use is described in detail in the specific International Standards describing the measurement of the properties of materials containing fluorescent whitening agents.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ASTM E308-06, *Standard Practice for Computing the Colors of Objects by Using the CIE System*

3 Terms and definitions

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

NOTE It is intended that these terms and definitions and their symbols be included in ISO/TR 10688, in order to have a single and common reference document for International Standards for measurement of optical properties of paper, board and pulps.

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 1 to entry: For luminescent (fluorescent) 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 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 to entry: The ratio is often expressed as a percentage.

Note 2 to entry: This International Standard prescribes diffuse illumination and normal detection in an instrument constructed and calibrated in accordance with the provisions of this standard. The term "diffuse radiance factor" is used here both for bidirectional and sphere geometries.

3.3
intrinsic diffuse radiance factor
R_∞
diffuse radiance 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 factor

Note 1 to entry: The radiance factor of a single non-opaque sheet is dependent on the background and is not a material property.

3.4
reflectance factor
ratio of the radiation reflected by a surface element of a body in the direction delimited by a given cone with its apex at the surface element to that reflected by the perfect reflecting diffuser under the same conditions of illumination

Note 1 to entry: The ratio is often expressed as a percentage.

Note 2 to entry: This term may be used only when it is known that the test material exhibits no luminescence (fluorescence).

3.5
diffuse reflectance factor
R
ratio of the reflection from a body to that from the perfect reflecting diffuser under the same conditions of diffuse illumination and normal detection

Note 1 to entry: The ratio is often expressed as a percentage.

Note 2 to entry: This International Standard specifies diffuse illumination and normal detection in an instrument constructed and calibrated in accordance with the provisions of this standard.

3.6
intrinsic diffuse reflectance factor
R_∞
diffuse 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

Note 1 to entry: The reflectance factor of a single non-opaque sheet is dependent on the background and is not a material property.

3.7
international reference standard of level 1
IR1
perfect reflecting diffuser (see CIE publication 17.4, No 845.04.54), ideal spectrally uniform isotropic Lambertian diffuser with a reflectance equal to 1 at all wavelengths

Note 1 to entry: Reflectance is defined as the ratio of the reflected to the incident radiation, see Annex E.

3.8
international reference standard of level 2
IR2
standard whose radiance (reflectance) factors have been determined by a standardizing laboratory in relation to the IR1 as defined by ISO 4094

Note 1 to entry: This International Standard refers to two types of IR2:

A non-fluorescent IR2 whose spectral reflectance factors have been determined by a standardizing laboratory in relation to the IR1. A non-fluorescent IR2 is used to calibrate the photometric scale of an authorized laboratory's reference instrument.

A white fluorescent IR2 whose spectral radiance factors corresponding to a specified CIE illuminant have been determined by a standardizing laboratory. A fluorescent IR2 standard is used to adjust the UV level of an authorized laboratory's reference instrument.

3.9
international reference standard of level 3
IR3
reference standard
standard whose radiance factors have been determined by an authorized laboratory in relation to an IR2, as defined by ISO 4094

Note 1 to entry: This International Standard refers to two types of IR3:

A non-fluorescent IR3 whose spectral reflectance factors have been determined by an authorized laboratory in relation to the IR2. A non-fluorescent IR3 is used to calibrate the photometric scale of a testing laboratory's reference instrument.

A white fluorescent IR3 whose calibration values have been determined by an authorized laboratory in relation to the IR2. A testing laboratory uses a fluorescent IR3 to adjust the relative amount of UV radiation incident on the sample to a specified level.

3.10
working standard
physical standard whose radiance (reflectance) factors have been determined by calibration with a suitable international reference standard (IR3) for subsequent use on a single instrument that conforms to this International Standard

3.11
primary working standard
working standard which is used routinely to validate and calibrate a given measuring instrument for its intended use

Note 1 to entry: The calibrated radiance (reflectance) factors of the primary working standard may not be transferred to a different instrument, even of the same type (see 3.10). However, it is possible to use a primary working standard for validation purposes only on instruments of the same type.

3.12
control plate
secondary working standard which is used on an infrequent basis to monitor and validate the performance of a given primary working standard

Note 1 to entry: When one or more control plates give anomalous results on a given instrument, it may be necessary to re-calibrate the primary working standard used with that instrument with an appropriate international reference standard (IR3).

4 Principle

A test piece is irradiated diffusely in a standard instrument and the light reflected (and emitted as a result of fluorescence) in a direction normal to the surface is passed to a detection system. This detection system may consist either of a defined optical filter and photodetector or of an array of photodetectors where each detector responds to a specific effective wavelength. The desired radiance factors are determined directly from the output from the photodetector in the former case or by calculation from the detector array outputs using appropriate weighting functions in the latter case.

5 Apparatus

5.1 Reflectometer, having the geometric, spectral and photometric characteristics described in Annex A.

5.2 Reference standards. For photometric calibration of the instrument and its working standards, a non-fluorescent reference standard issued by an authorized laboratory and fulfilling the requirements for an International reference standard of level 3 (see 3.9) as specified in Annex B.

Use reference standards sufficiently frequently to ensure satisfactory calibration.

NOTE If fluorescent materials are to be measured, a fluorescent reference standard issued by an authorized laboratory is required to enable the UV-content of the instrument illumination to be adjusted to produce the same amount of fluorescence as the selected CIE illuminant. This UV adjustment procedure is described in detail in Annex C. The use of these fluorescent reference standards is described in the International Standards for the determination of specific optical properties.

5.3 Working standards. For measurements on non-fluorescent materials, two working standards of opal glass, ceramic or other suitable material with flat surfaces.

NOTE In some instruments, the function of the primary working standard (see 6.3) may be fulfilled by a built-in internal standard.

For measurements on white fluorescent materials, stable fluorescent working standards of plastic or other material incorporating a fluorescent whitening agent are required. These working standards are described in the relevant International Standards.

5.4 Black cavity, for calibration or validation of the low end of the photometric scale. This black cavity shall have a radiance factor which does not differ from its nominal value by more than 0,2 percentage points at all wavelengths. The black cavity should be stored upside-down in a dust-free environment or with a protective cover. During calibration, the instrument shall be adjusted to the nominal value of the black cavity.

It is not yet possible to institute a system of reference standards to enable testing laboratories to check the reflectance factor of the black cavity. At the time of delivery, the level should be guaranteed by the instrument maker. Questions concerning the use and condition of the black cavity should be resolved by contacting the instrument maker.

6 Photometric calibration of the instrument and its working standards

6.1 Calibration of the instrument

Using the procedure appropriate to the instrument, calibrate the photometric scale of the instrument with an IR3 and, when the measurements are to be made on fluorescent materials, carry out a UV-calibration with a fluorescent IR3. Make a measurement on the IR3 in order to check that the calibration

is satisfactory. The deviation between the measured and the assigned brightness and/or tristimulus values of the IR3 used for the primary calibration should not exceed 0,05 .

NOTE Although barium sulfate powders for pressing tablets are commercially available for which the absolute spectral radiance factors are given on the container, these values are not considered to be traceable according to the principles of modern metrology, and tablets based on barium sulfate powder are not considered to be suitable for use as an IR3 as required by this International Standard.

All calibrations are thus related to the IR1 through a calibration chain comprising an IR2 and an IR3 to which absolute values have been assigned respectively by a standardizing laboratory and by an authorized laboratory using an instrument conforming to this International Standard.

Handle each IR3 carefully and protect the test area from contamination. Store it in darkness, when not in use.

6.2 Calibration of the working standards for its intended use

Clean the working standards (see 6.4) and measure their radiance factors using the IR3 and read off and record the values to the nearest 0,01 percentage point. This calibration of the working standard is instrument-specific, for given conditions of measurement. The working standard shall only be used for subsequent calibration on the same instrument and for the same instrument conditions that it was originally calibrated.

NOTE In order to achieve agreement with the reference instrument, a working standard may be assigned multiple calibration values, depending upon the working level and the purpose of the measurement. This applies, for example, if the working standard is translucent or glossy and if the linearity of the instrument scale is poor so, in this case, the calibration is both sample and instrument specific.

6.3 Use of working standards

Use one plate as a primary working standard for checking and calibrating a given instrument, and use the other much less frequently as a control plate for checking the primary working standard. The frequency with which the instrument needs to be calibrated depends on the type of instrument. Frequent calibration of the instrument tends to introduce undesirable fluctuations in the instrument, and the instrument should be recalibrated only when a check with the primary working standard indicates that calibration is necessary. Check the primary working standard periodically against the control plate. If any change in the radiance factor is noticed, clean the primary working standard by the procedure described in 6.4. If the change persists, clean and recalibrate both working standards against an appropriate IR3 reference standard.

The primary working standard should be checked against the control plate sufficiently often to ensure that any change in the primary working standard is discovered before an error is introduced into the calibration.

6.4 Cleaning the working standards

Handle with care. If cleaning is necessary, follow the manufacturer's instructions. In the case of working standards of opal glass or ceramic material, rinse with distilled water and detergent free from fluorescent ingredients while rubbing with a soft brush. Rinse thoroughly in distilled water and dry in the air in a dust-free environment without allowing anything to touch the surface. Leave them in a desiccator until they are optically stable.

NOTE In the case of ceramic material standards, it is recommended to avoid getting water onto the back of the material, as the backing of a ceramic is very porous and may require days of drying in a dessicator to restore the optical properties.