INTERNATIONAL STANDARD

ISO 2469

Fourth edition
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Paper, board and pulps — Measurement of diffuse radiance factor

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

Reference number
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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 2469 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*.

This fourth edition of ISO 2469 cancels and replaces the third edition (ISO 2469:1994) and ISO 2469:1994/Cor.1:1998, which have been technically revised. Primarily, certain instrumental features and computational routines are more rigorously defined in order to meet the requirements of technological advances and in order to ensure a high precision and reproducibility in the measurement results.

In addition, the property mentioned in the title has been changed from “diffuse reflectance factor” to “diffuse radiance factor” as an acknowledgement of the fact that many grades of paper now contain added fluorescent whitening agents. For any given material, the total radiance factor is the sum of the reflected radiance factor and the luminescent radiance factor, and it is this total property which is the subject of this International Standard. For pulps and papers not containing any fluorescent component, the radiance factor and the reflectance factor are synonymous, see Annex E.

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 radiance factor is the sum of the reflected radiance factor and the luminescent radiance factors, and the radiance factor of a luminescent (fluorescent) object is dependent on the spectral power distribution of the illumination. The content of UV radiation in the illumination must therefore be set to a specified level if adequately accurate measurements are to be carried out on fluorescent objects. 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 radiance factor or the weighted radiance factor applicable to one or several specified wavelength bands is often used to characterize the properties of pulp, paper and board. Examples of radiance factors associated with specified wavelength bands are the ISO brightness (diffuse blue radiance factor) and the luminance factor.

The radiance factor or 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 specified in specific International Standards, for all of which this International Standard is the primary normative reference.

Paper, board and pulps — Measurement of diffuse radiance 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 radiance factors and related properties of materials containing fluorescent whitening agents, provided that the UV radiation content in the illumination has been adjusted to the level specified in 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 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 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.

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 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 The ratio is often expressed as a percentage.

NOTE 2 This International Standard prescribes diffuse illumination and normal detection in an instrument constructed and calibrated in accordance with the provisions of this standard.

3.3
intrinsic 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 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 The ratio is often expressed as a percentage.

NOTE 2 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 The ratio is often expressed as a percentage.

NOTE 2 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 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 The reflectance factor of a single non-opaque sheet is dependent on the background and is not a material property.

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

NOTE Reflectance is defined as the ratio of the reflected to the incident radiation, see Annex E.

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

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

NOTE 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 fluorescent IR3 whose calibration values have been determined 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.

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 calibration of the instrument and the working standards, a non-fluorescent reference standard for photometric calibration of the instrument and its working standards, issued by an ISO/TC 6 authorized laboratory and fulfilling the requirements for an ISO 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 ISO/TC 6 authorized laboratory is required to enable the UV-content of the illumination to be adjusted to correspond to the appropriate CIE illuminant, as specified in Annex C. The use of these fluorescent reference standards is described in the International Standards concerned.

5.3 Two non-fluorescent 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 fluorescent materials, which require a fluorescent reference standard (see 5.2) to enable the UV-content of the illumination to be adjusted, 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 instrument with an 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 percentage points.

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 non-fluorescent working standards

The non-fluorescent working standards shall be calibrated against ISO reference standards of level 3 in the instrument in which they are to be used.

Using the procedure appropriate to the instrument, calibrate the instrument with an IR3. Clean the working standards (see 6.4), measure the working standards and read off and record to the nearest 0,01 percentage point the radiance factors of the cleaned working standards.

NOTE In order to achieve agreement with the reference instrument, a working standard may be assigned multiple values, depending upon the working level and the purpose of the measurement. This applies if the working standard is translucent or glossy and if the linearity of the instrument scale is poor.

6.3 Use of non-fluorescent working standards

Use one plate as a primary working standard for checking and calibrating the 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 non-fluorescent working standards

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 it in a desiccator until it is optically stable.

7 Sampling

If the tests are being made to evaluate a lot, the sample should be selected in accordance with ISO 186. If the tests are made on another type of sample, make sure that the test pieces taken are representative of the sample received.

8 Preparation of the test pieces

Prepare the test pieces according to the instructions given in the relevant International Standard for the determination of radiance factors or optical properties based on the measurement of radiance factors.

If it is desired simply to measure the radiance factor, rather than some other optical property defined by another International Standard, follow the following procedure.

Avoiding watermarks, dirt and obvious defects, cut rectangular test pieces approximately 75 mm × 150 mm, taking care to avoid touching the future test area.

If it is desired to measure the intrinsic radiance factor, assemble 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.

NOTE 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 throughout the pad.

If sufficient sheets are not available or if it is desired to measure a background-dependent radiance factor, select a suitable background and include a description of this background in the report.

9 Procedure

Determine the radiance factor as specified in the relevant International Standard for the determination of radiance factors or optical properties based on the measurement of radiance factors.

If it is desired simply to measure the radiance factor, rather than some other optical property defined by another International Standard, follow the following procedure.

9.1 Verification of calibration

Check the calibration of the instrument using a non-fluorescent working standard calibrated in relation to an IR3 (5.3). Recalibrate the instrument if necessary.

NOTE If the instrument is of the spectrophotometer type, and if the material to be measured contains or is suspected to contain a fluorescent component, the UV content of the illumination must be adjusted to match the desired illuminant using the fluorescent (5.2) and non-fluorescent (see 5.2) ISO level 3 standards in an iterative procedure according to the instrument maker's instructions. The procedure for UV-adjustment to match the CIE standard illuminant D65 is given in ISO 11475 and for UV-adjustment to match the CIE illuminant C in ISO 2470.