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Paper and board — Measurement of specular gloss —

Part 2: 75° gloss with a parallel beam, DIN method

Papiers et cartons — Mesurage du brillant spéculaire —

Partie 2: Brillant à 75° avec un faisceau parallèle, méthode DIN

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 8254 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8254-2 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 6, *Paper, board and pulps*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European Standard..." to mean "...this International Standard...".

ISO 8254 consists of the following parts, under the general title *Paper and board — Measurement of specular gloss*:

— *Part 1: 75° gloss with a converging beam, TAPPI method*

— *Part 2: 75° gloss with a parallel beam, DIN method*

— *Part 3: 20° gloss*

Annex A forms a normative part of this part of ISO 8254. Annex B is for information only.

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Foreword

This document (EN ISO 8254-2:2003) has been prepared by Technical Committee CEN /TC 172, "Pulp, paper and board", the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 6 "Paper, board and pulps".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2003, and conflicting national standards shall be withdrawn at the latest by July 2003.

This Standard contains the following parts:

— Part 1: 75° gloss with a converging beam, TAPPI method

— Part 2: 75° gloss with a parallel beam, DIN method

— Part 3: 20° gloss

In addition, CEN has developed the European Standard EN 14086 "Paper and board - Measurement of specular gloss - 45° gloss with a parallel beam, DIN-method.

The European Standard EN 14086 and the International Standard ISO/DIS 8254-3 are intended for use with high gloss papers.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Visual gloss is a sensory impression which cannot yet be described completely. Some important physical variables which influence gloss are however known. The sensory perception of gloss under a suitable illumination results from a physical stimulus due to reflection of light from a surface. This reflection is defined by an indicatrix which changes with the angle of incidence. The maximum indicatrix value which is decisive for visual gloss impression is associated with specular reflection, at an angle of reflection which is approximately equal to the angle of incidence. The reflectometer value is determined by averaging the reflection in a defined angular region centered in the specular direction.

NOTE 1 A reflectometer value is a measure of the visual gloss only when the optical conditions of measurement, such as angles and apertures of illumination and observation are similar to the conditions of viewing.

NOTE 2 Because luminance and structure enter to some extent into the reflectometer value of the test piece, only the comparison of test pieces with nearly the same luminance and structure is meaningful. The influence of luminance on the measurement result decreases rapidly with increasing reflectometer value and increasing angle of reflection.

The proportion of specular reflection in the entire reflection increases with increasing angle of incidence. Very matt surfaces generate a noticeable degree of specular reflection and, therefore, a noticeable gloss effect only above a certain minimum angle of incidence. On the other hand, a large angle of incidence reduces the ability to differentiate between surfaces of high gloss.

NOTE 3 Manufacturers of coated papers usually divide their products into two classes, according to their surface gloss: matt coating and gloss coating. However, these classes are only defined approximately. The matt class has reflectometer values, measured according to this European Standard, from 0 to approximately 20. The glossy class has reflectometer values higher than this value. As there is no precise correlation between reflectometer values measured with different geometries, it is advisable to compare the reflectometer values only within a single class of papers and using the same measuring geometry.

This European Standard describes measurement at an angle of incidence of 75° using a parallel beam geometry commonly known as the 75° DIN method. A second European Standard describes measurement at an angle of 45° (see EN 14086).

1 Scope

This European Standard specifies a photometric test method for the assessment of visual gloss by means of a reflectometer value measured at an angle of 75°. It is applicable to plane paper and board surfaces of gloss levels below 65, measured according to this European Standard. It should be the preferred method for paper and board surfaces of gloss levels below 20, measured according to this European Standard. Materials containing optical brightening agents may be measured.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

CIE-Publication No. 38, *Radiometric and photometric characteristics.*

EN ISO 186, *Paper and board — Sampling to determine average quality (ISO 186:1994).*

EN 20187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples (ISO 187:1990).*

ISO 10110-5, *Optic and optical instruments — Preparation of drawings for optical elements and systems — Part 5: Surface form tolerances..*

3 Terms and definitions

For the purposes of this part of ISO 8254, the following terms and definitions apply.

3.1
indicatrix
angular distribution of the reflected light which is measured as illuminance on the receptor.

3.2
reflectometer
instrument for measuring quantities pertaining to reflection of light.

3.3
reflectometer value
measured variable which, for a given angle of incidence, is proportional to the integral of the reflection indicatrix within the solid angle defined by the apertures (see Annex A.2.1) and is equal to 100 times the ratio of the value obtained for the sample to that of a defined specularly reflecting surface (5.2.2).

3.4
specular gloss
reflectometer value as defined in 3.3.

NOTE 1 The defined specularly reflecting surface thus has an assigned reflectometer value of 100. Reflectometer values are therefore not percentages.

NOTE 2 These definitions are based on definitions in CIE-Publication No. 17.4.

4 Principle

The sample is illuminated with a collimated beam at an angle of 75 ° to the normal, and the reflectometer value is measured within a solid angle defined by a given aperture at an angle of reflection equal to the angle of incidence. The scale of the reflectometer is calibrated with reference to the reflection from a black glass plate or a quartz wedge with a specific refractive index.

5 Equipment

5.1 Reflectometer

The reflectometer shall consist of the following principal components: a collimator, a decollimator, an electric supply for the light source device, a photoelectronic receptor and a sample holder, as described in annex A.

5.2 Gloss standards

The reflectometer is calibrated by means of a zero-gloss standard and a high gloss standard with a reflectometer value between about 80 and 100. This high gloss standard can be either a primary gloss standard or a working gloss standard.

Intermediate gloss standards with assigned reflectometer values are used to check the adjustment of the device.

NOTE As reflectometer values of gloss standards may change due to environmental influences, they should be checked at least once per year.

5.2.1 Zero-gloss standards

A zero-gloss standard is a gloss standard which, in the ideal case, absorbs all light falling on it. A black cavity lined with black velvet or felt is one realisation of such a gloss standard that has been proven in practice.

5.2.2 Primary gloss standards

A primary gloss standard is a gloss standard whose reflectometer value can be calculated by means of its refractive index using the Fresnel equation. The reflectometer value is defined as being equal to 100 for a black glass plate or a fused quartz wedge with a nominal refractive index of n = 1,567 at a wavelength of 587,6 nm (He-d-line). A black glass plate or quartz wedge with a refractive index at a wavelength of 587,6 nm (see ISO 7944) known to 3 decimal places can be used as primary gloss standard. The top surface of the glass plate or quartz wedge shall be plane to within 2 fringes per centimetre as measured by an optical interference method in a wavelength region of (600 ± 100) nm according to ISO 10110-5. If the refractive index n differs from 1,567, the reflectometer value R shall be calculated as:

$$R = 100 \cdot K \tag{1}$$

where

$$K(n,\varepsilon_1) = \frac{\left[\dfrac{n^2\cos\varepsilon_1 - (n^2-\sin^2\varepsilon_1)^{½}}{n^2\cos\varepsilon_1 + (n^2-\sin^2\varepsilon_1)^{½}}\right]^2 + \left[\dfrac{(n^2-\sin^2\varepsilon_1)^{½} - \cos\varepsilon_1}{(n^2-\sin^2\varepsilon_1)^{½} + \cos\varepsilon_1}\right]^2}{\left[\dfrac{1{,}567^2\cos\varepsilon_1 - (1{,}567^2-\sin^2\varepsilon_1)^{½}}{1{,}567^2\cos\varepsilon_1 + (1{,}567^2-\sin^2\varepsilon_1)^{½}}\right]^2 + \left[\dfrac{(1{,}567^2-\sin^2\varepsilon_1)^{½} - \cos\varepsilon_1}{(1{,}567^2-\sin^2\varepsilon_1)^{½} + \cos\varepsilon_1}\right]^2} \tag{2}$$

For ε_1 = 75°:

$$K(n,75°) = 1{,}890 \cdot \left[\left[\frac{0{,}2588\cdot n^2 - (n^2-0{,}9330)^{½}}{0{,}2588\cdot n^2 + (n^2-0{,}9330)^{½}}\right]^2 + \left[\frac{(n^2-0{,}9330)^{½} - 0{,}2588}{(n^2-0{,}9330)^{½} + 0{,}2588}\right]^2\right] \tag{3}$$

NOTE It is recommended that the refractive index be defined by means of the critical angle of total reflection, i. e. by means of an Abbé refractometer.

5.2.3 Working standards

Any clean non-fluorescent flat surface, which has a reflectometer value between 80 and 100, can be used as a working gloss standard. Care has to be taken to ensure that only a negligible reflection from the reverse side of the gloss standard can reach the surface which is measured. This can be achieved by giving the gloss standard the shape of a wedge, or making it opaque. The surface which is not measured should be matt. A reflectometer system conforming to the description given in annex A must be used to establish the relationship with the primary gloss standard. When the gloss standard is measured in two perpendicular directions and in the directions of their diagonals, the difference shall not be more than ± 1 unit. If this is not the case, the reflectometer value of the working gloss standard must be assigned only for a particular direction of the incident light radiation and the working gloss standard must be used only in that direction.

5.2.4 Intermediate gloss standards

Intermediate gloss standards are gloss standards with assigned reflectometer values between 0 and 100 and which are calibrated by technically competent organisations.

For the purpose of this European Standard, an intermediate gloss standard with an assigned reflectometer value of about 20 is required.

NOTE 1 The surfaces of gloss standards should not be touched with hard instruments, as this can damage the surface. Gloss standards are generally put against the sample port of the reflectometer. Measurements should always be made at the same position on the gloss standard. If the sample port of the reflectometer is located at this place, any damage will be avoided. Gloss standards should be cleaned very carefully with a soft cloth to avoid surface deterioration.

NOTE 2 As reflectometer values of gloss standards may change due to environmental influence, they should be checked once per year.

NOTE 3 An organisation capable of calibrating gloss standards is listed in annex B.

6 Sampling

Sampling is not included in this European Standard. If the mean quality of a lot is to be determined, sampling shall be in accordance with EN ISO 186. If the tests are made on an other type of sample, make sure that the test pieces are representative of the sample received.

7 Preparation of test pieces

7.1 Conditioning

Condition the samples at 23°C and 50 % r.h. according to EN 20187 and keep them in this climate throughout the test.

7.2 Preparation

Prepare test pieces, ensuring that they are free from any scratches, dust, folds or other damage. For each side of the paper to be tested, cut at least five test pieces. The surface to be measured must not be touched by hand.

If the measurement field area (see annex A.1) is less than 100 mm², the minimum number of test pieces shall be increased. In that case, the minimum number of test pieces is determined as:

$$N = 5 \cdot \frac{100}{A} \tag{4}$$

where

A is the actual measurement area in mm²;

N is the minimum number of test pieces rounded to the next higher integer.

8 Procedure

8.1 Calibration

8.1.1 Place the zero-gloss standard (5.2.1) against the test piece port of the instrument. Adjust the reflectometer value to 0,0 ± 0,1 scale unit by means of the zero adjustment device.

8.1.2 Place the primary gloss standard (5.2.2) or a working standard (5.2.3) against the test piece port of the instrument. Adjust the reflectometer value by means of the calibration device so that the scale reading agrees with the value assigned to the primary gloss standard or the working gloss standard.

8.1.3 Place an intermediate gloss standard with a reflectometer value of about 20 (5.2.4) against the port of the reflectometer. Check that the reflectometer value agrees to within 0,5 reflectometer unit with the value assigned to the gloss standard.

If the reflectometer value does not agree with the assigned value within the given limits, no measurements may be made in accordance with this European Standard until the fault is remedied.

NOTE Possible sources of error are:

— the optical system of the reflectometer does not conform to this European Standard;

— the instrument scale is not linear;

— the intermediate gloss standard has deteriorated.

8.1.4 Check the calibration sufficiently frequently to ensure the stability of the instrument.

8.2 Determination of reflectometer value

Using the test piece holding device (see A.3), place the test piece against the sample port so that its surface is absolutely flat in the illuminated field. The illuminated field shall be free from any surface irregularities.

On each test piece make four measurements, one in each of the four directions in the plane of the paper. This means that two measurements shall be made with the incidence plane parallel to the machine direction and two measurements with the incidence plane perpendicular to the machine direction. In each of these pairs of measurements, the second measurement is made at an angle of 180° to the first measurement. Make the four measurements at different positions on each test piece, but make sure that each measurement is made at a position where the paper surface has not been damaged by a previous measurement. If the reverse side is to be measured, make measurements on new test pieces.

8.3 Calculation and expression of results

Calculate the mean reflectometer value and the standard deviation to one decimal place for each measured side of the material.

If required, calculate the mean reflectometer value and the standard deviation to one decimal place in the machine direction and cross direction separately.

9 Test report

The test report shall refer to this European Standard and state:

a) date an place of testing;

b) complete identification of the sample tested and the sampling method used;

c) the type of instrument used and the measurement field area;

d) the specular gloss results, expressed as mean reflectometer values together with the standard deviation for each measured side separately;

e) any observation about the structure and anisotropy of the test piece surfaces;

f) any departure from the standard procedure that may have affected the result.

Annex A
(normative)

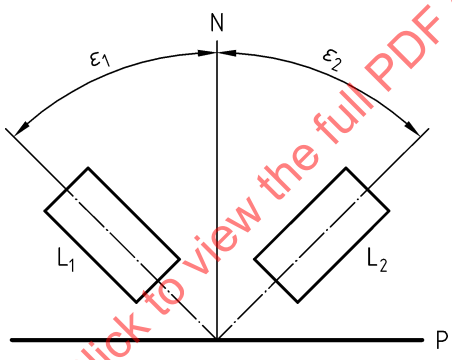
Description of the instrument

A.1 Design of the reflectometer value

The instrument used for the measurement of reflectometer values according to this European Standard shall have a design with the features described in this section:

Figure A.1 shows a schematic diagram of the optical system where the plane of the diagram is parallel to the optical incidence plane. This plane is the plane of the optical axis of the collimator and the decollimator, the angle of incidence ε_1 , the angle of reflection ε_2 and the line N, normal to the test piece.

The light collimator (L_1) shall give an almost parallel beam with a center line striking the test piece at an angle ε_1.



N normal to the surface;

P test piece;

L_1 illuminating collimator (short: collimator);

L_2 detection decollimator (short: decollimator);

ε_1 angle of incidence;

ε_2 angle of reflection.

Figure A.1 — Schematic diagram of the measurement geometry (section parallel to incidence plane)

Details of the optical system are given in Figure A.2. The circular lamp condenser diaphragm (LFB), which is positioned in the focal plane of the field lens (FL), is focused on the sample surface by the field lens (FL) and the object lens (OL).

NOTE Since the collimator is placed at an angle $\varepsilon_1 \neq 0$ in relation to the normal, an elliptical light field with unsharp edges is produced on the test piece.

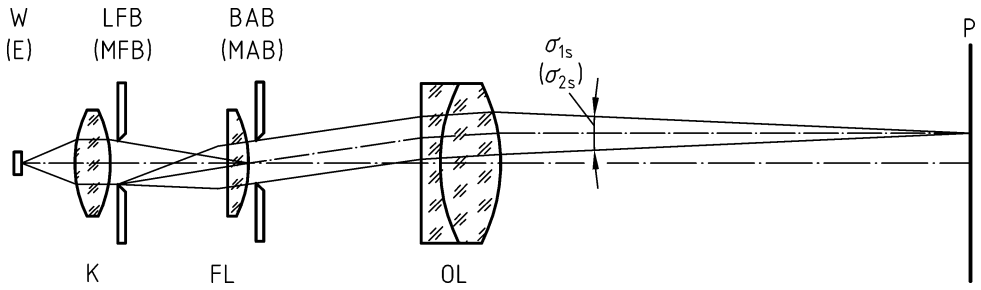
The luminous part (W) of the lamp (e.g. filament of an incandescent bulb) is focused by the condenser lens (K) as an enlarged image in the plane of the light source aperture diaphragm (BAB). It has a rectangular cross-section and its edges are parallel and perpendicular to the incidence plane. The cross-sectional area is in the focal plane of the object lens (OL) and acts as the light source for the almost parallel beam emerging from this object lens; its aperture angle is determined by the edge length of the light source aperture diaphragm (BAB) and the focal length of the object lens (OL). As these lengths (parallel to and perpendicular to the incidence plane) are not the same, different aperture angles result: σ_{1P} and σ_{1S} (see table A.1), where $\sigma_{1P} < \sigma_{1S}$ and the letters P and S denote the planes parallel to (P) and perpendicular to (S) the light incidence plane. The numbers 1 and 2 denote the collimator and the decollimator respectively.

The reflected radiation is detected at an angle ε_2 by the focal decollimator L_2 (figure A.1). The set-up of the decollimator L_2 is similar to that of light source collimator L_1, with the following differences:

a) the aperture of the measurement field area diaphragm MFB (figure A.2) is smaller than the aperture of the lamp condenser diaphragm (LFB) in order to ensure that the measurement field area is within the illuminated field. The diaphragm opening is circular. The area of the illuminated field must be at least five times greater than the largest element of the surface structure of the sample to be measured. A typical value of the surface structure element is of the order of 20 mm² [1]. The illumination of the illuminated field shall be uniform. This can be achieved when the distribution of light in the lamp condenser diaphragm (LFB) as well as in the light source aperture diaphragm (BAB) is in accordance with the conditions described in EN ISO 8254-1;

b) the receptor aperture angle σ_2 is greater than the light source aperture angle σ_1 (see table A.1);

c) the decollimator is equipped with a photoelectronic receptor (E) instead of a lamp (W) (see figure A.2). If the diameter of the photoelectronic receptor (E) is large enough to avoid vignetting, the condenser lens (K) is not necessary.



W incandescent lamp;

E photoelectronic receptor;

K condenser lens;

LFB lamp condenser diaphragm;

MFB measurement field area diaphragm;

FL field lens;

BAB light source aperture diaphragm;

MAB measurement aperture diaphragm;

σ_{1S} light source aperture angle in the plane perpendicular to the optical incidence plane;

(σ_{2S}) receptor aperture angle in the plane perpendicular to the optical incidence plane;

P test piece;

OL object lens.

Figure A.2 — Basic structure of the collimator and the decollimator. The plane is perpendicular to the incidence plane, including the optical collimator/receptor axis. (Symbols for the decollimator are given in parentheses.)

A.2 Properties of the reflectometer

The reflectometer shall possess facilities allowing adjustment of the zero point and a calibration at a reflectometer value R > 0. In addition the tolerances given in table A.1 shall be met.

A.1.1 Dimensions and tolerances of angles

Table A.1

Designation	Abbreviation	Minimum	Maximum
angle of incidence	ε_1	74,9°	75,1°
angle of reflection [a]	ε_2	ε_1 - 0,1°	ε_1 + 0,1°
light source aperture angle	σ_1		
- parallel to incidence plane	σ_{1P}	0,9°	1,1°
- perpendicular to incidence plane	σ_{1S}	2,4°	2,6°
receptor aperture angle	σ_2		
- parallel to incidence plane	σ_{2P}	1,8°	2,0°
- perpendicular to incidence plane	σ_{2S}	3,4°	3,6°

[a] The angle of reflection shall be adjusted by the manufacturer, taking into account the real angle of incidence.

A.2.2 Spectral adaptation

The spectral power distribution S_λ of the light which illuminates the test piece shall be equivalent to that of the CIE standard illuminant A. The relative spectral sensitivity s (λ) of the receptor shall be adjusted to conform to the relative spectral luminous efficiency V (λ), taking into consideration the transmission factor τ (λ) of the optical system (see CIE Publication No. 15.2) so that:

$$V(\lambda) \cdot S(\lambda, A) = a \cdot S(\lambda) \cdot \tau(\lambda) \cdot s(\lambda) \qquad \text{(A.1)}$$

where

V (λ) spectral luminous efficiency;

S (λ,A) spectral power distribution of the CIE standard illuminant A;

a proportionality constant;

S (λ) spectral power distribution of the luminous source;

s (λ) relative spectral sensitivity of the receptor;

τ (λ) spectral transmission factor of the filters and other optical components used in the path of the light rays of the reflectometer (according to CIE Publication No 38).

The departure from proportionality shall not exceed 10 % and is determined as the characteristic error parameter f_1 according to CIE-Publication No. 38.