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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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Contents

Page

Foreword .... **iv**

Introduction .... **v**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Principle **2**

5 Equipment **2**
- 5.1 Reflectometer 2
- 5.2 Gloss standards 2
  - 5.2.1 Zero-gloss standards 2
  - 5.2.2 Primary gloss standards 2
  - 5.2.3 Working standards 3
  - 5.2.4 Intermediate gloss standards 3

6 Sampling **4**

7 Preparation of test pieces **4**
- 7.1 Conditioning 4
- 7.2 Preparation 4

8 Procedure **4**
- 8.1 Calibration 4
- 8.2 Determination of reflectometer value 5
- 8.3 Calculation and expression of results 5

9 Test report **5**

Annex A (normative) **Description of the instrument** **6**

Annex B (informative) **Nominated organizations for calibration of intermediate gloss standards** **10**

Bibliography **11**

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.

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 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 second edition cancels and replaces the first edition (ISO 8254-2:2003), which has been editorially revised (minor revision) to update the bibliographic references.

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 with a converging beam, TAPPI method*

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

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 centred 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 part of ISO 8254, 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 part of ISO 8254 describes measurement at an angle of incidence of 75° using a parallel beam geometry commonly known as the 75° DIN method. Precision data are not available at the time of publication.

NOTE 4 EN 14086 describes measurement at an angle of 45°.

Paper and board — Measurement of specular gloss —

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

1 Scope

This part of ISO 8254 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 part of ISO 8254. It should be the preferred method for paper and board surfaces of gloss levels below 20, measured according to this part of ISO 8254. Materials containing optical brightening agents may be measured.

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

ISO 187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

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

CIE 038-1977, *Radiometric and photometric characteristics of materials and their measurement*

3 Terms and definitions

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

3.1
indicatrix
angular distribution of the reflected light which is measured as illuminance (lm m^{-2}) on the receptor

3.2
reflectometer
instrument for measuring quantities pertaining to reflection

3.3
reflectometer value
measured value 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 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 to entry: The defined specularly reflecting surface thus has an assigned reflectometer value of 100. Reflectometer values are therefore not percentages.

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.

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 realization 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 three 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

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

For $\varepsilon_1 = 75°$:

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

It is recommended that the refractive index be defined by means of the critical angle of total reflection, i.e. by means of an Abbe 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 matte. A reflectometer system conforming to the description given in Annex A shall 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 shall be assigned only for a particular direction of the incident light radiation and the working gloss standard should 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 organizations.

For the purpose of this part of ISO 8254, an intermediate gloss standard with an assigned reflectometer value of about 20 is required.

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.

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

NOTE An organization capable of calibrating gloss standards is listed in Annex B.

6 Sampling

Sampling is not included in this part of ISO 8254. If the mean quality of a lot is to be determined, sampling shall be in accordance with ISO 186. If the tests are made on another 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 ISO 187 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 shall not be touched by hand.

If the measurement field area (see 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 follows:

$$N = 5 \cdot \frac{100}{A} \quad (4)$$

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 part of ISO 8254 until the fault is remedied.

NOTE Possible sources of error are the following:

— the optical system of the reflectometer does not conform to this part of ISO 8254;

— 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 include the following information:

a) the date and place of testing;

b) the 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)

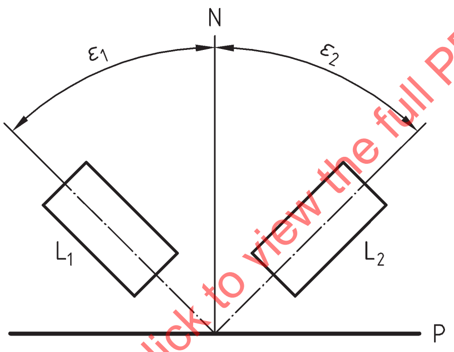
Description of the instrument

A.1 Design of the reflectometer value

The instrument used for the measurement of reflectometer values according to this part of ISO 8254 shall have a design with the features described in this Annex.

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 centre line striking the test piece at an angle ε_1.



Key

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.

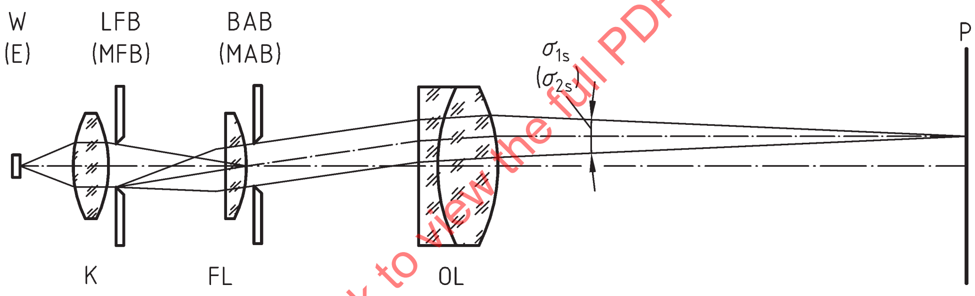
The luminous part (W) of the lamp (e.g. filament of an incandescent bulb) is focused by the condenser lens (K) as an enlarged image in the plane of the light source aperture diaphragm (BAB). It has a rectangular cross-section and its edges are parallel and perpendicular to the incidence plane. The cross-sectional 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: σ1P and σ1S (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 setup 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 mm^2. [9] 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 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.



Key

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

NOTE The plane is perpendicular to the incidence plane, including the optical collimator/receptor axis. Symbols for the decollimator are given in parentheses.

Figure A.2 — Basic structure of the collimator and the decollimator

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.2.1 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*(*A*) of the light which illuminates the test piece shall be equivalent to that of the CIE standard illuminant A. The relative spectral sensitivity *s* (*A*) of the receptor shall be adjusted to conform to the relative spectral luminous efficiency *V*(*A*), taking into consideration the transmittance factor *t*(*A*) of the optical system (see CIE Publication No. 15.3) so that

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

where

- $V(\lambda)$ spectral luminous efficiency;
- $S(\lambda, A)$ spectral power distribution of the CIE standard illuminant A;
- a proportionality constant;
- $S(\lambda)$ spectral power distribution of the luminous source;
- $s(\lambda)$ relative spectral sensitivity of the receptor;
- $\tau(\lambda)$ spectral transmittance 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.

A.2.3 Linearity and drift to display

When the light reflected by the test piece surface reaches the photoelectronic receptor, it produces an electric current. This current shall be proportional to the intensity of the light, with a proportionality error not exceeding 0,5 %.

The drift of the reflectometer value within 12 h shall not exceed 1 % of the measurement value or 0,1 of a reflectometer unit, depending on which value is greater.

For larger drifts more frequent calibrations are necessary.