INTERNATIONAL STANDARD

ISO 8254-3

First edition
2004-11-01

Paper and board — Measurement of specular gloss —

Part 3: 20° gloss with a converging beam, TAPPI method

Papier et carton — Mesurage du brillant spéculaire —

Partie 3: Brillant à 20° avec un faisceau convergent, méthode TAPPI

Reference number
ISO 8254-3:2004(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

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 8254-3 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*.

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*

Introduction

This part of ISO 8254 deals with the assessment of the specular gloss of paper and board at an angle of 20°, using a converging beam geometry commonly known as the TAPPI method and described in TAPPI T653 ([1] in the Bibliography). ISO 8254-1 and ISO 8254-2 deal with the measurement of specular gloss at 75°.

Although the word “measurement” is used, it should be noted that this is strictly speaking only an “assessment”, because the definition of gloss (see 3.1) relates to a scale of visual perception whereas the method described uses a physical measurement of mixed regular and diffuse reflection. The exact correlation between the visual perception and the scale established by the physical measurement is not known. However, this physical gloss scale has proved to be useful for a number of technical applications and consequently its standardization is justified.

Paper and board — Measurement of specular gloss —

Part 3:
20° gloss with a converging beam, TAPPI method

1 Scope

This part of ISO 8254 specifies a method for measuring the specular gloss of paper and board at an angle of 20° to the normal to the paper surface. It is applicable chiefly to highly glossy surfaces, such as cast-coated, lacquered, highly varnished or waxed papers and high-gloss ink films.

NOTE This part of ISO 8254 has been developed from TAPPI T653[1], from ISO 2813[2] and from ISO 8254-1.

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

3 Terms and definitions

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

3.1
gloss
mode of appearance by which reflected highlights of objects are perceived as superimposed on the surface due to the directionally selective properties of that surface

[CIE Publication No. 17.4:1987, definition 845.04.73[3]]

3.2
regular reflection
specular reflection
reflection in accordance with the laws of geometrical optics, without diffusion

[CIE Publication No. 17.4:1987, definition 845.04.45[3]]

3.3
diffuse reflection
diffusion by reflection in which, on the macroscopic scale, there is no regular reflection

[CIE Publication No. 17.4:1987, definition 845.04.47[3]]

3.4
specular gloss
measured variable equal to 100 times the ratio of the luminous flux reflected by the test-piece surface into a specified aperture at the specified angle of specular reflection to that reflected by a standard specularly reflecting surface under the same conditions

4 Principle

Light incident on the test-piece surface at an angle of 20° to the normal and reflected from the surface at an angle of 20° to the normal into a defined aperture is detected by a photodetector, the output of which is displayed on a meter. The gloss scale is established by reference to the reflection from a standard black glass of known refractive index.

5 Apparatus

5.1 Gloss meter

It has the general arrangement and relative dimensions of the principal parts described in Annex A. It consists of

a) a source of light,

b) a lens giving a converging beam of light incident on the test piece,

c) a suitable device, such as a suction plate to hold the test piece flat, if required, and

d) a photodetector to receive and measure certain of the rays reflected by the test piece.

These components are combined in a light-tight housing that is matte black inside and is structurally and optically stable at the operating temperature.

5.2 Gloss standards

5.2.1 Primary gloss standard: a flat, clean and polished surface, having a refractive index of 1,540 at 587,6 nm (the helium D-line). This may be shown by the Fresnel equations to measure 100 gloss units on a scale related to the theoretical primary gloss standard. The theoretical primary specular gloss standard is an ideal, completely reflecting plane mirror having an assigned gloss value of 2 199 (see [4] in the Bibliography).

5.2.2 High gloss reference standard: a clean plaque of polished black glass for which the 20° specular reflectance has been computed from its refractive index measured at a wavelength of 587,6 nm.

If the refractive index differs from 1,540, the gloss value shall be calculated as follows;

$$G = 100 * K \tag{1}$$

where

$$K(n,\varepsilon) = \frac{\left[\dfrac{n^2 \cos\varepsilon - \left(n^2 - \sin^2\varepsilon\right)^{0,5}}{n^2 \cos\varepsilon + \left(n^2 - \sin^2\varepsilon\right)^{0,5}}\right]^2 + \left[\dfrac{\left(n^2 - \sin^2\varepsilon\right)^{0,5} - \cos\varepsilon}{\left(n^2 - \sin^2\varepsilon\right)^{0,5} + \cos\varepsilon}\right]^2}{\left[\dfrac{1{,}540^2 \cos\varepsilon - \left(1{,}540^2 - \sin^2\varepsilon\right)^{0,5}}{1{,}540^2 \cos\varepsilon + \left(1{,}540^2 - \sin^2\varepsilon\right)^{0,5}}\right]^2 + \left[\dfrac{\left(1{,}540^2 - \sin^2\varepsilon\right)^{0,5} - \cos\varepsilon}{\left(1{,}540^2 - \sin^2\varepsilon\right)^{0,5} + \cos\varepsilon}\right]^2} \tag{2}$$

where

n is the refractive index of the glass;

ε is the angle of incidence.

When $\varepsilon = 20°$, the equation reduces to

$$K(n, 20°) = 10{,}994 \left(\left[\frac{0{,}939\,7\,n^2 - \left(n^2 - 0{,}117\right)^{0{,}5}}{0{,}939\,7\,n^2 - \left(n^2 - 0{,}117\right)^{0{,}5}} \right]^2 + \left[\frac{\left(n^2 - 0{,}117\right)^{0{,}5} - 0{,}939\,7}{\left(n^2 - 0{,}117\right)^{0{,}5} + 0{,}939\,7} \right]^2 \right) \quad (3)$$

NOTE If the refractive index is known, the gloss value may be calculated by adding or subtracting from 100,0 a value of 0,29 for each 0,001 departure of the refractive index from the standard value of 1,540. For example, for a glass of refractive index n = 1,523, the assigned gloss value G would be

$$\begin{aligned} G &= 100 - \frac{0{,}29\,(1{,}540 - n)}{0{,}001} \\ &= 290n - 346{,}60 \\ &= 95{,}1 \end{aligned} \quad (4)$$

This method is, however, valid only for refractive index values between 1,50 and 1,54. It is not applicable to quartz standards for which n is about 1,46.

5.2.3 Intermediate gloss standards, having a reflected flux distribution comparable with that of the paper to be tested. Such standards may consist of ceramic tiles which are sufficiently flat to remain stationary without rocking when placed in the measurement position and are uniform in gloss over a central region larger in area than the illuminated area defined by Equations (A.3) and (A.4). Each of these tiles shall be calibrated against the high gloss reference standard by a technically competent laboratory in an instrument conforming to 5.1.

5.2.4 Working standards, having reflected flux distributions corresponding to different gloss levels, calibrated in the instrument concerned against a range of intermediate gloss standards.

Store standards in a closed container when not in use. Keep them away from any dirt which may scratch or mar their surfaces. Never place standards face down on a surface which may be dirty or abrasive. Always hold standards by their side edges to avoid transferring oil from the skin to the standard surface. Clean standards in warm water and mild detergent solution, brushing gently with a soft nylon brush. (Do not use soap solutions to clean standards.) Rinse in hot running water (temperature near 65 °C) to remove detergent solution, followed by a final rinse in distilled water. Do not wipe intermediate gloss standards (5.2.3). The high gloss reference standard (5.2.2) may be dabbed gently with a lint-free paper towel or other lint-free absorbent material. Place rinsed standards in a warm oven to dry.

NOTE The refractive index of the surface, and consequently the gloss value of the high gloss reference standard (5.2.2), may change slowly over a period of a few years. This may be accompanied by a loss of uniformity. It is recommended that this standard be sent to a technically competent laboratory at least once every two years for a check on its calibration and for possible repolishing to restore its uniformity (see [5] in the Bibliography).

5.3 Zero-gloss standard, consisting of a black velvet-lined cavity or any other suitable type of black cavity.

NOTE A variety of suitable cavities are available, including those coated with a matte black paint or having an interior black pyramidal construction.

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 carried out 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

Avoiding watermarks, dirt and obvious defects, cut at least five test pieces (ten pieces if both sides are to be measured) each of sufficient size to completely cover the test-piece opening of the instrument. Keep the test piece clean and do not handle the area to be tested. Condition the test pieces in an atmosphere at 23 °C and 50 % relative humidity according to ISO 187.

NOTE Exposure of paper to high humidities may irreversibly decrease the gloss. If papers are tested at a relative humidity higher than 65 %, or if there is reason to believe that the sample may have been exposed to a relative humidity higher than 65 %, this should be stated in the test report.

8 Calibration of the instrument

8.1 Cover the test-piece opening with an opaque material and, with the gloss-meter source turned off, check and adjust the zero of the meter. Turn on the source and, after a suitable warm-up period, insert the high gloss reference standard (5.2.2) and adjust the scale controls to give an instrument reading equal to the value of the gloss standard.

8.2 Recheck the zero of the instrument with the test-piece opening either uncovered and exposed to a dark room or covered with a zero-gloss standard (5.3) to prevent external light from entering the receptor window. With the source turned on, the zero reading should agree with the source-off zero setting.

NOTE Disagreement in the zero readings suggests that unwanted light rays are entering the receptor window.

8.3 Reinsert the high gloss reference standard (5.2.2) and adjust the instrument as before to give the correct gloss value for the standard. Insert an intermediate gloss standard (5.2.3) or a working standard (5.2.4) and see that the instrument reads it correctly. If the reading differs by more than one gloss unit from the assigned value, the instrument should be checked for conformance to the geometrical, spectral and photometric requirements, and the standards should be checked with respect to their calibration.

NOTE Correct readings on the high gloss reference standard and intermediate gloss standard suggest that the instrument is in approximate, but not necessarily exact, conformance with the apparatus specifications.

9 Procedure

9.1 Insert a working standard at frequent intervals to ensure that the instrument remains in calibration throughout the period in which the gloss measurements are being made, and again at the end of the test.

9.2 Insert a test piece, make sure that it is flat and read the gloss value from the meter. Record the gloss value readings for all four directions, i.e. in the machine direction and counter-machine direction and in both cross directions. Repeat the measurements for a total of at least five test pieces.

9.3 If required, make similar measurements on the other side of the paper using new test pieces.

10 Calculation and expression of results

Calculate the mean and standard deviation for each side separately, and express the results to one decimal place. If required, calculate the means and standard deviations for the different directions separately.

11 Precision

No data are available.

12 Test report

The test report shall contain the following information:

a) the date and place of testing;

b) reference to this part of ISO 8254;

c) precise identification of the sample, including the sampling procedure;

d) the number of independent gloss readings, the average gloss value and the standard deviation for each side and for each sheet direction, as required;

e) any particular points observed in the course of the test;

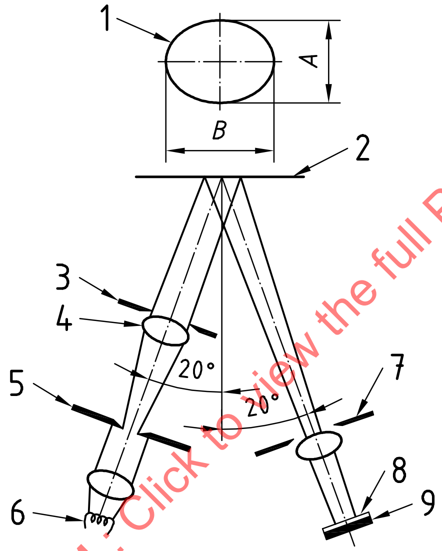
f) any departure from this part of ISO 8254 or any circumstances that may have affected the results.

Annex A
(normative)

Specification of the optical system of the gloss meter

A.1 Introduction

The gloss meter shall consist of a light source, a lens that directs a converging beam of light onto the test-piece surface, a source-field stop to define the required cone of light, and a receptor housing containing a lens and a photodetector to evaluate the intensity of the light flux within this cone. A general sketch of the optical system is shown in Figure A.1.



Key

1 elliptical illuminated area of test piece
2 test piece plane
3 aperture stop
4 source objective lens
5 source-field stop
6 lamp
7 round receptor window
8 filter
9 photodetector

Figure A.1 — 20° glossmeter optical system

A.2 Geometric conditions

The axis of the incident beam shall be at an angle of $(20,0 \pm 0,1)°$ to the perpendicular to the surface under test. The axis of the receptor shall coincide with the mirror image of the axis of the incident beam with a tolerance of $\pm 0,1°$. When a flat piece of polished glass or other front-surface mirror is placed in the test-piece position, an image of the source-field stop shall be formed at the centre of the receptor window.

The receptor window shall be round in shape and of such a diameter that the receptor aperture angle is a solid angle of (5,00 ± 0,40)° with respect to the centre of the illuminated area in the plane of the test piece (see Figure A.2). The diameter W of the receptor window is thus given by

$$W = 2D \tan(2{,}5 \pm 0{,}20)° \qquad \text{(A.1)}$$

where D is the distance from the plane of the sample to the plane of the receptor window.

The combination of source field stop and source objective lens shall ensure that the aperture stop is overfilled with light and shall yield an image of the source-field stop at the centre of the receptor window, such that the source-image aperture angle is a solid angle of (4,0 ± 0,4)° with respect to the centre of the illuminated area in the plane of the test piece (see Figure A.2). The diameter I of the image is thus given by:

$$I = 2D \tan(2{,}0 \pm 0{,}20)° \qquad \text{(A.2)}$$

The illuminated area of the test piece will be an ellipse with an unsharp contour with a short axis A (see Figure A.1) given by:

$$A = 4D \tan(2{,}0 \pm 0{,}20)° \qquad \text{(A.3)}$$

and a long axis B given by

$$B = \frac{4D \tan(2{,}0 \pm 0{,}20)°}{\cos 20°} \qquad \text{(A.4)}$$

NOTE 1 For a full description of the derivation of these equations, detailed reverse ray diagrams of the optical system originating at the centre of the test piece are required. The calculations are, however, a question of simple optics based upon the angles and distances specified and the reverse ray diagrams are therefore not included here.

NOTE 2 As an example, if D = 126 mm, then A = 17,6 mm and B = 18,7 mm, and the illuminated area of the test piece is $(\pi AB)/4$ = 258,5 mm^2. A should be larger than any structures in the surface, i.e. ⩾ 10 mm, and this means that the length D should be ⩾ 72 mm. If D is shorter than this distance, the number of test pieces should be increased accordingly in order to ensure that an adequate area of the sample is tested.

The diameter S of the aperture stop is given by:

$$S = 2(2D + F)\tan(2{,}0 \pm 0{,}2)° \qquad \text{(A.5)}$$

where F is the distance of the aperture stop from the plane of the test piece.

NOTE 3 Although F appears to be arbitrary, tests have shown that optimal results are obtained if F = (0,7 ± 0,1)D, and it is recommended that this relationship be followed.

The diameter of the source field stop and its distance from the aperture stop are dependent upon the choice of source objective lens. The angular diameter G of the source-field stop is related to the size of its image I on the receptor window and is calculated (see Figure A.2) as

$$G = (4{,}0 \pm 0{,}4)° \cdot \frac{D}{(F + D)} \qquad \text{(A.6)}$$

NOTE 4 If F = 0,7D, G = 2,35°

There shall be no vignetting of rays that lie within the field angles specified.