INTERNATIONAL STANDARD

ISO 8254-1

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Paper and board — Measurement of specular gloss —

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

Papiers et cartons — Mesurage du brillant spéculaire —

Partie 1: Brillant à 75° avec un faisceau convergent, méthode TAPPI

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.

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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 8254-1 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*.

This second edition cancels and replaces the first edition (ISO 8254-1:1999). It has been technically revised, in part to harmonize the wavelength specified in 5.2.1 with that specified in ISO 8254-2:2003 and ISO 8254-3:2004. The reference wavelength defining the high-gloss reference standard has been changed from 589,26 nm (sodium D line) to 587,56 nm (helium d line), but this change has a negligible effect on the measured specular gloss value.

ISO 8254 consists of the following parts, under the general title *Paper and board — Determination 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 "gloss" of a paper or board surface by determining an optical property called the "specular gloss" which is here defined in terms of a measurement made at 75° using a converging beam geometry, commonly known as the TAPPI method and described in TAPPI 480 om-92[1]. Other parts of this International Standard deal with measurements made at 75° using a collimated beam geometry known as the DIN method, and with measurements made at 20°. Gloss results are greatly dependent on the angle of measurement and on the type of incident beam (converging or collimated), so conditions of measurement shall be carefully defined.

The definition of gloss (3.1) relates to a mode 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 1: 75° gloss with a converging beam, TAPPI method

1 Scope

This part of ISO 8254 specifies a method for measuring the specular gloss of paper at an angle of 75° to the normal to the paper surface. Although its chief application is to coated papers, it may also be used for glossy uncoated papers such as supercalendered papers.

NOTE 1 This method does not provide an assessment of image-reflecting quality and should not be used for cast-coated, lacquered, highly varnished or waxed papers or for high-gloss ink films. For these purposes, measurements at other angles, for example 20°, are preferred, although the present method has been shown to be suitable for gloss measurements of most other ink films on paper or paperboard. Differences in the colour and the diffuse reflectances of these ink films have a negligible effect on gloss measured according to this part of ISO 8254. For example, measurements on white and black surfaces which are otherwise identical give a value for the white surface that is less than one gloss unit higher than the value for the black surface.

NOTE 2 The methods specified in ISO 2813, *Paints and varnishes — Determination of specular gloss of non-metallic paint films at 20°, 60° and 85°*, may be applicable to certain grades of paper.

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[5]]

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

[CIE Publication No. 17.4:1987, definition 845.04.45[5]]

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[5]]

3.4
specular angle
angle with respect to the normal to the surface, equal and opposite to and in the same plane as the angle of incidence

3.5
reflectometer
instrument for measuring quantities pertaining to the reception of reflected light

3.6
indicatrix
angular distribution of the reflected light

3.7
reflectometer value
measured variable which, for a given angle of incidence, is proportional to the integral of the reflection indicatrix within a defined solid angle and is equal to 100 times the ratio of the value obtained for the sample to that of a defined standard specularly reflecting surface

NOTE The value of 100 is a scale factor, since the defined specularly reflecting surface has an assigned reflectometer value of 100. It does not mean that the value is a percentage.

3.8
specular gloss
gloss observed or measured at the specular angle

3.9
specular gloss value
value equal to the reflectometer value measured in a reflectometer having the geometrical characteristics defined in Annex A and calibrated with respect to a defined primary gloss standard having the values specified in 5.2.1

NOTE 1 The specular gloss value is thus equal to 100 times the ratio of the luminous flux reflected by the test surface into a specified aperture at the specular angle to that from a standard specularly reflecting surface under the same conditions of illumination.

NOTE 2 The specular gloss value is a dimensionless quantity and is not a percentage.

4 Principle

Light incident on the test piece surface at an angle of 75° to the normal and reflected from the surface at an angle of 75° from the normal into a defined aperture is detected by a photodetector, the output of which is displayed.

5 Apparatus

5.1 Gloss meter, i.e. a reflectometer having the general arrangement and relative dimensions of the principal parts as described in Annex A. It shall consist of:

a) a source of light;

b) a lens giving a converging beam of light incident to the test piece;

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

d) a photodetector to receive and measure light reflected by the test piece under conditions specified in Annex A.

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

5.2 Gloss standards, consisting of the following.

5.2.1 Primary gloss standard. The theoretical primary specular gloss standard is an ideal, completely reflecting plane mirror having an assigned gloss value of 384,4 gloss units. A black glass which is flat and clean and has a polished surface, having a refractive index of 1,540 at 587,56 nm (the helium d line), may be shown by the Fresnel equation [3] to measure 100 gloss units on this scale.

5.2.2 High-gloss reference standard, consisting of a clean plaque of polished black glass for which the 75° specular reflectance has been computed from its refractive index as measured at a wavelength of 587,56 nm.

If the refractive index differs from 1,540, the gloss value, G, shall be calculated as:

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

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 $\varepsilon = 75°$, the equation reduces to:

$$K(n,75°) = 1{,}922\left(\left[\frac{0{,}2588n^2 - \left(n^2 - 0{,}933\right)^{0,5}}{0{,}2588n^2 + \left(n^2 - 0{,}933\right)^{0,5}}\right]^2 + \left[\frac{\left(n^2 - 0{,}933\right)^{0,5} - 0{,}2588}{\left(n^2 - 0{,}933\right)^{0,5} + 0{,}2588}\right]^2\right) \tag{3}$$

NOTE If the refractive index is known, the gloss value may be calculated by adding or subtracting from 100,0 a value of 0,067 for each 0,001 departure of the refractive index from the standard value of 1,540. For example, for a glass of refractive index 1,523, the assigned value would be

$$G = 100 - \frac{0{,}067(1{,}540 - n)}{0{,}001}$$

$$G = 67n - 3{,}2$$

$$G = 98{,}9 \tag{4}$$

These methods are however valid only for refractive index values between 1,50 and 1,54. They are 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 or other suitable material. The standards shall be sufficiently flat not to rock when placed in the measurement position and they shall be uniform in gloss over their central area. Each of these standards shall be calibrated against the high-gloss working standard by a reputable 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 they are not in use. Keep them away from any dirt which may scratch or mar their surfaces. Never place a standard face down on a surface which may be dirty or abrasive. Always hold a standard at the side edges to avoid transferring oil from one's 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). Place rinsed standards in a warm oven to dry.

NOTE 1 The high-gloss standard (5.2.2) may be dabbed gently with a lint-free paper towel or other lint-free absorbent material.

NOTE 2 The refractive index of the surface, and consequently the gloss value of the high-gloss standard (5.2.2) may slowly change over a period of a few years. This may be accompanied by a loss of uniformity. It is recommended that these standards be sent to a standardizing laboratory at least once every 2 years for a check on their calibration and for possible repolishing to restore their uniformity.

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 matt 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 according to ISO 186. Otherwise, the method of sampling should be reported and care should be taken to ensure that the test pieces are representative of the sample available.

7 Preparation of test pieces

Avoiding watermarks, dirt and obvious defects, cut at least ten test pieces 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.

The measurement area (see Annex A) is equal to (0,10 $d \times$ 0,05 d/cos 75°). If the dimension d (see Figure A.1) is equal to 100 mm, the size of the measurement area is therefore about 193 $mm^2 \pm 40\ mm^2$. Ten measurements thus provide a mean value for an area of about 2 000 mm^2. If the distance d is less than 100 mm, the measurement area is reduced in proportion to d^2 and it is recommended that a larger number of measurements be made in order to obtain a mean for a similar area of paper.

The exposure of paper to high humidities frequently decreases the gloss. If papers are known to have been exposed to a relative humidity higher than 65 %, this fact shall be stated in the test report.

8 Calibration of the instrument

8.1 Turn on the instrument and, after a suitable warm-up period, check the zero of the instrument in accordance with the manufacturer's instructions with the test piece opening covered with the zero-gloss standard (5.3). Check that the zero reading agrees with the mechanical zero setting.

NOTE Disagreement in the zero readings suggests that stray light is entering the receptor window.

8.2 Insert the high-gloss reference standard (5.2.2) or a high-gloss working standard (5.2.4) and adjust the instrument to give the correct value of gloss for the standard.

8.3 Insert an intermediate-gloss standard (5.2.3) or intermediate-gloss working standard (5.2.4) having a gloss comparable to the gloss of the paper to be tested and check that the instrument reads the value correctly.

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

If the reading differs by more than 1 gloss unit from the assigned value, the instrument should be checked for conformance to the geometric, spectral and photometric requirements, and the standards should be checked with respect to their calibration.

9 Procedure

Insert each test piece one at a time and record the specular gloss value. Determine the specular gloss for all four directions, i.e. in the machine direction and counter-machine direction and in both cross directions, and calculate the mean value. If the gloss of both sides of the paper is being determined, record data for the two sides of the paper separately.

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

Record data for at least five test pieces.

Calculate the means and the standard deviations, to the nearest unit, for each required side of the paper.

10 Precision

Precision data has been derived from the CEPI Comparative Testing Service, February 2007.

Table 1 presents data for two samples measured in accordance with this method by 12 laboratories, each result being based on 10 determinations.

Table 1 — Specular gloss units

Sample number	Mean	Standard deviation within laboratories	Reproducibility standard deviation
1	44,0	1,67	1,84
2	74,6	0,94	0,92

11 Test report

The test report shall contain the following information:

a) a reference to this part of ISO 8254;

b) the date and place of testing;

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

d) the number of independent specular gloss readings, the average specular gloss value and the standard deviation, for each required side separately;

e) any particular observations made in the course of the test;

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

Annex A
(normative)

Specification of the optical system of the gloss meter

A.1 Introduction

A schematic diagram of the optical system of the gloss meter is shown in Figure A.1.

The dashed line beginning at the lamp indicates the path of the ray of light passing through the condensing lenses and the geometric centre of a rectangular aperture stop (rectangular source-field stop) which becomes the effective source of light; through the source objective lens, through the geometric centre of the rectangular aperture stop and to the test piece. This axial ray of light intersects the plane of the test piece at a point defined as the centre of the test area. (This is not necessarily the geometric centre of the illuminated area of the test piece.) With a plane front-surface mirror as the test piece, the axial ray is specularly reflected and passes through the centre of the receptor window. The source objective lens makes an image of the source aperture at the receptor window. The distance, d, from the centre of the test area to the receptor window is used as the base from which to specify all other dimensions. The most critical dimensions are the angle of incidence, the position of the receptor window and the diameter of the receptor window.

NOTE No minimum value of the distance d is specified. No such limit is required provided that the mean result obtained refers to at least 2 000 mm^2 of the sample.

A.2 Light mixer

To achieve uniform weighting of the rays taking different paths through the receptor window, a light mixer shall be interposed between the receptor window and the photodetector. The positive lens shall be located adjacent to the receptor window and shall be arranged to collect all rays of light passing through the window, and to form an image of the illuminated surface of the test piece on the sensitive surface of the photodetector or on a diffusing screen immediately in front of this surface. No rays other than those reflected from the test piece surface shall be permitted to enter the receptor window.

A.3 Angle of incidence

The axial ray shall intersect the test piece plane at an angle of $\varepsilon_1 = (75{,}0 \pm 0{,}1)°$ to the normal.

A.4 Angle of reflected ray

The specularly reflected axial ray shall intersect the test piece plane at an angle of $\varepsilon_2 = \varepsilon_1 \pm 0{,}1°$ to the normal, i.e. $|\varepsilon_1 - \varepsilon_2| \leqslant 0{,}1°$.

A.5 Receptor window

The diameter of the receptor window is expressed in terms of the distance, d, from the centre of the test area to the entrance plane of the receptor window and shall be $0{,}2\,d \pm 0{,}005\,d$; the thickness of its edge shall not exceed $0{,}005\,d$. The axial ray, when reflected from a plane front-surface mirror in the test piece position, shall pass through the centre of the receptor window within $0{,}004\,d$ and shall be perpendicular to the plane of the receptor window.

A.6 Position and size of light source aperture

The position of the image of the light source aperture shall be in the plane of the receptor window with a tolerance, along the direction of the axial ray, of $\pm 0{,}04d$. The size of the rectangular image is $(0{,}1d \pm 0{,}005d) \times (0{,}05d \pm 0{,}005d)$, the short dimension of the rectangle lying in the plane of incidence (i.e. the plane containing the incident and specularly reflected axial ray).

A.7 Uniformity of light in source aperture

The distribution of light in the source aperture should be uniform. Details of a suitable system are given in References [1] and [2] in the Bibliography.

A.8 Position and size of the rectangular aperture stop

The rectangular aperture stop shall be located at a distance of $0{,}6d \pm 0{,}1d$ from the centre of the test area with its plane perpendicular to the axial ray. The size of the stop shall be $(0{,}1d \pm 0{,}01d) \times (0{,}05d \pm 0{,}005d)$, the short dimension being in the plane of incidence. No other stop or diaphragm shall be permitted to intercept the incident rays of light.

A.9 Uniformity of light in the aperture stop

The tolerances of the uniformity of the light in the aperture stop shall be the same as for the source aperture, i.e. ± 4 % of the mean value in each direction (see Clause A.6).

A.10 Spectral conditions

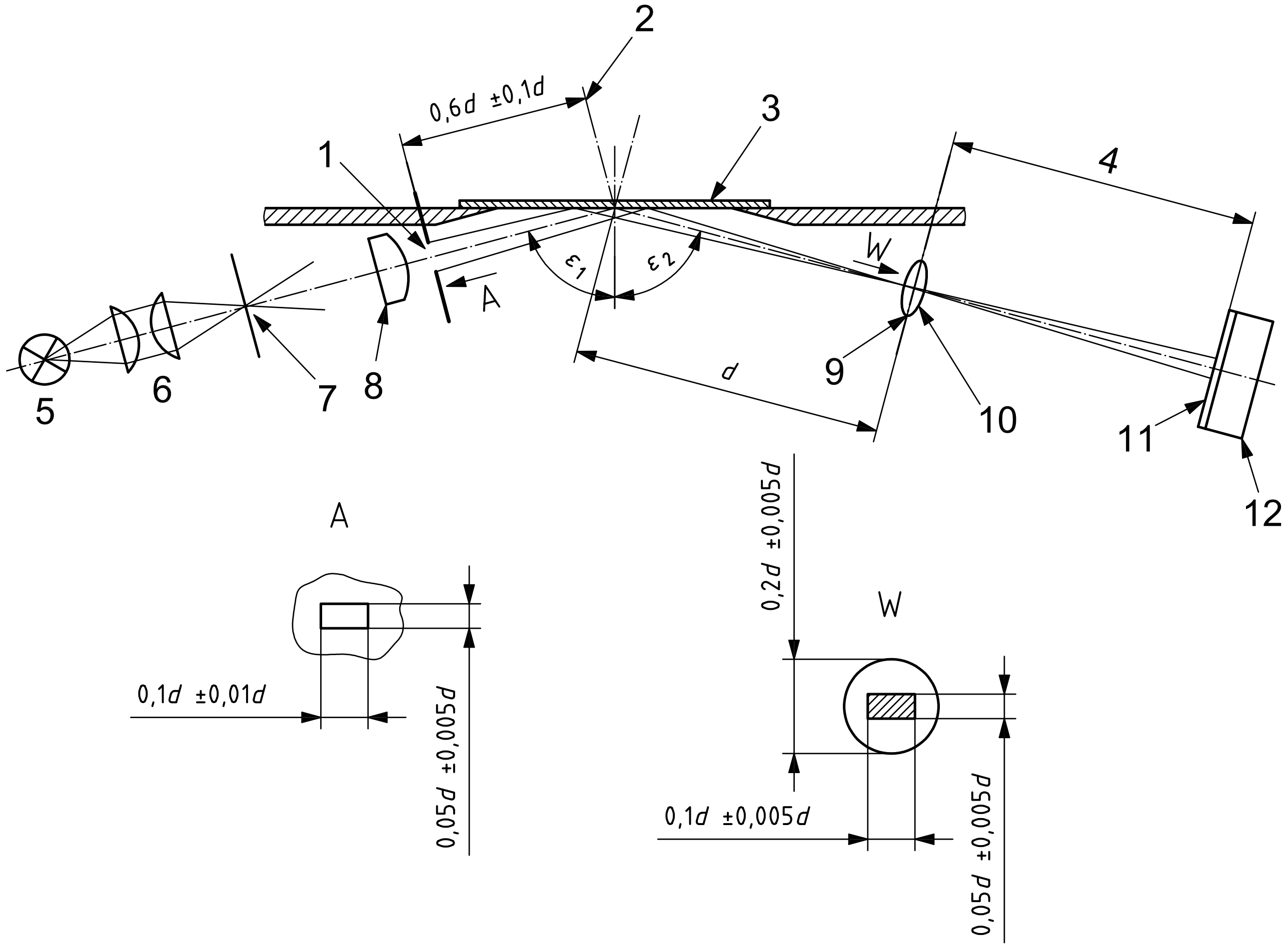
The incandescent source shall operate at a colour temperature of 2 850 K ± 100 K. The photoreceptor shall be spectrally corrected by means of a filter so as to give the combination a response corresponding to the CIE photopic luminous efficiency function, $V(\lambda)$. (CIE Publication No. 17.4:1987, definition 845-01-22[5]).

A.11 Photodetector

Any combination of photodetector and indicating device may be used, provided it gives a numerical indication of the light flux passing through the receptor window accurate over the entire scale to within ± 0,2 % unit of full scale; i.e. ± 0,2 scale division for a scale comprising 100 divisions.

A.12 Suction plate

If the instrument employs a suction plate for holding the test pieces, that plate shall be firmly mounted and sufficiently flat so that the image in the receptor window of a thin, flexible plastic film of uniform thickness (for example, optical-grade polyester film of thickness 0,08 mm) held by this suction plate is not measurably different in position and size from that of the image formed by the high-gloss standard.



Key

1 aperture stop
2 centre of test area
3 test piece
4 light mixer
5 lamp
6 condensing lenses
7 rectangular source-field stop
8 source objective lens
9 receptor window
10 lens
11 filter
12 photodetector

Figure A.1 — Schematic diagram of the optical system of the gloss meter

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