

INTERNATIONAL STANDARD

ISO 2813

Fourth edition
2014-10-01

Paints and varnishes — Determination of gloss value at 20°, 60° and 85°

*Peintures et vernis — Détermination de l'indice de brillance à 20°, 60°
et 85°*



Reference number
ISO 2813:2014(E)

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Published in Switzerland

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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.

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 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This fourth edition cancels and replaces the third edition (ISO 2813:1994), which has been technically revised. It also incorporates the Technical Corrigendum ISO 2813:1994/Cor.1:1997.

The main technical changes are:

- a) the title has been changed;
- b) the scope has been extended to include gloss measurement of metallic coatings;
- c) the term "specular gloss" has been replaced by "gloss";
- d) the gloss value is indicated in gloss units (GU);
- e) a new annex ([Annex A](#)) concerning possible sources of error has been added;
- f) a new annex ([Annex B](#)) concerning calibration standards has been added;
- g) a new annex ([Annex C](#)) concerning gloss calculation of primary reference standards has been added;
- h) a new annex ([Annex D](#)) concerning details on precision has been added;
- i) the precision data are the results of a large interlaboratory test.

Paints and varnishes — Determination of gloss value at 20°, 60° and 85°

1 Scope

This International Standard specifies a method for determining the gloss of coatings using the three geometries of 20°, 60° or 85°. The method is suitable for the gloss measurement of non-textured coatings on plane, opaque substrates.

NOTE On test specimens different from these mentioned above, comparative gloss measurements are possible. However, it is not ensured that the obtained gloss values correspond to the visual gloss perception (see [Annex A](#)).

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 1514, *Paints and varnishes — Standard panels for testing*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 4618:2014, *Paints and varnishes — Terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618 and the following apply.

3.1 gloss

optical property of a surface, characterized by its ability to reflect light specularly

Note 1 to entry: Examples of degrees of gloss are high gloss, gloss, silk gloss, semigloss, satin, matt, and dead matt.

[SOURCE: ISO 4618:2014, 2.132]

3.2 geometry

identification of a method of gloss measurement using a specified angle with assigned apertures

3.3 gloss value

ratio multiplied by 100 of the luminous flux reflected from a specimen to that reflected by a glass surface with a refractive index of 1,567 at a wavelength of 587,6 nm in specular direction for a specified reflection angle and specified aperture angles of light source and receptor

Note 1 to entry: The gloss value is indicated in gloss units (GU). It is not permitted to interpret and express gloss values as "% reflection".

Note 2 to entry: Gloss values measured on coatings are expressed rounded to the nearest integer (without decimals).

Note 3 to entry: To define the gloss scale, polished black glass with a refractive index of 1,567 at a wavelength of 587,6 nm is assigned to the value of 100 for 20°, 60° and 85° geometries.

Note 4 to entry: A glass surface with a reflective index of 1,567 at a wavelength of 546,1 nm (which is the central wavelength of the spectral luminous efficiency function) may be used.

Note 5 to entry: The gloss value is influenced by the surface characteristics, e.g. roughness, texture, structure, of the sample.

4 Principle

With a reflectometric apparatus, gloss values are determined on coated surfaces, correlating with the visual gloss perception. In this context (glossmeter), the ratio of the gloss of the coating and the gloss of a polished plane glass plate with specified reference refractive index is obtained.

The method of gloss measurement is specified by the following parameters:

- measuring angles;
- field stop apertures;
- spectral adaptation;
- reference refractive index.

5 Basic principles of the gloss measurement

Gloss is a visual perception caused by looking at surfaces. The specular reflection of objects is even more distinct when light is reflected more directionally from the surface. The incident light is reflected on high-gloss surfaces only in the main specular direction. On matt surfaces the light is not only reflected in the main specular direction but also diffusely scattered in all solid angles. The more uniformly the light is scattered into the space the smaller is the intensity of the directed component and the matter the surface appears.

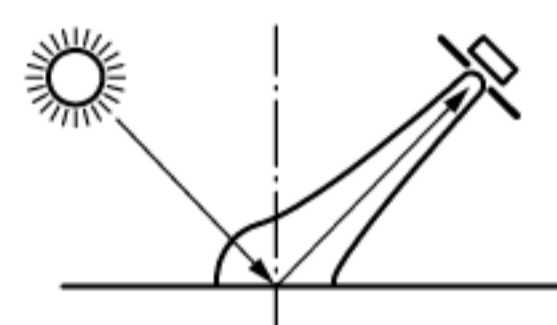
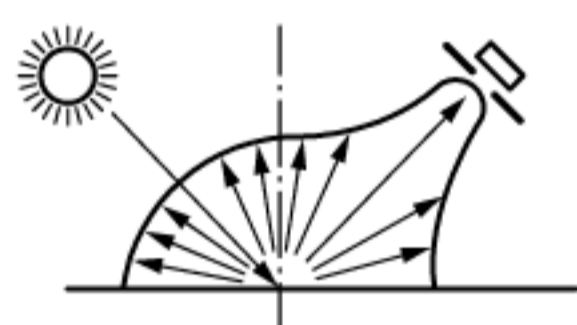
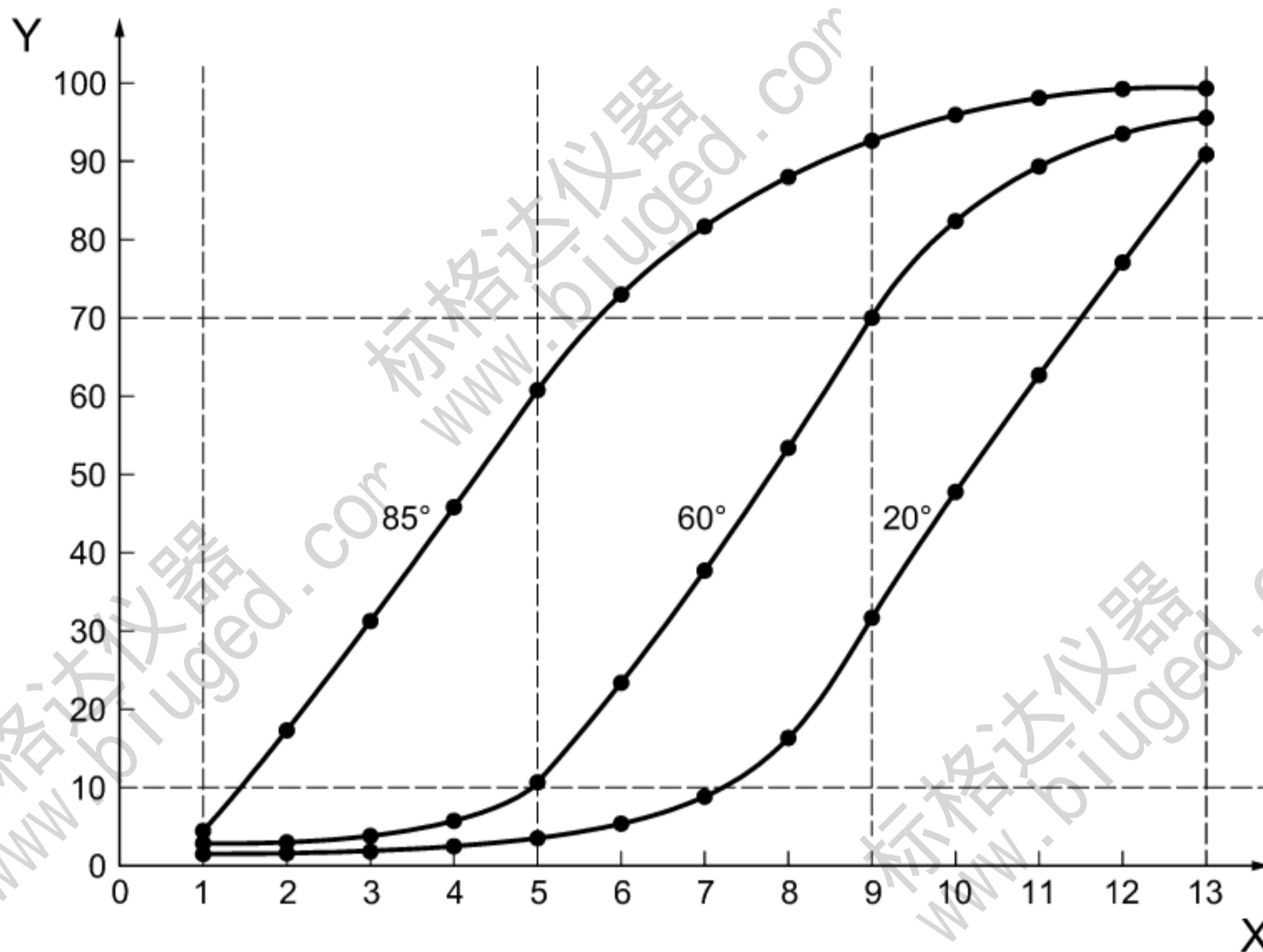
The principle of gloss measurement is based on the measurement of the directionally reflected light. In this context its intensity is measured in a defined angular field around the reflection angle. The intensity of the reflected light depends on the surface material and the incident angle. Accordingly, on coated surfaces with increasing incident angle more light is reflected. The remaining light is refracted at the interface air/coating, and within the coating diffusion and/or absorption of the light occurs.

The gloss values are not related to the intensity of the incident light but to the reflection properties of a black, polished glass standard with specified refractive index.

For different viewing angles the gloss perception can vary widely. For example matt surfaces can appear glossy under grazing incidence of light and low viewing angle, because under these reflection conditions a lot of light is reflected directionally and also the intensity of diffusion is low.

[Figure 1](#) illustrates the relation between the gloss perception of visually equally classified coating specimens (from matt to glossy) and the assigned gloss values for the measuring angles of 20°, 60° and 85°.

EXAMPLE Visual classification 9 corresponds to 35 GU under 20°, 70 GU under 60° and 95 GU under 85°.



Key

- Y gloss value
- X increasing gloss perception from matt to glossy

Figure 1 — Gloss curves

Due to the non-linearity of the characteristic curves in accordance with [Figure 1](#), the gloss for each measuring angle can only be differentiated over a specific range. In practice – depending on the degree of gloss of the specimen surface – the following measuring angles have been proved (see [Figure 2](#)):

- 20° geometry for high-gloss surfaces;
- 60° geometry for semigloss surfaces;
- 85° geometry for matt surfaces.

For each gloss value the geometry shall be indicated.

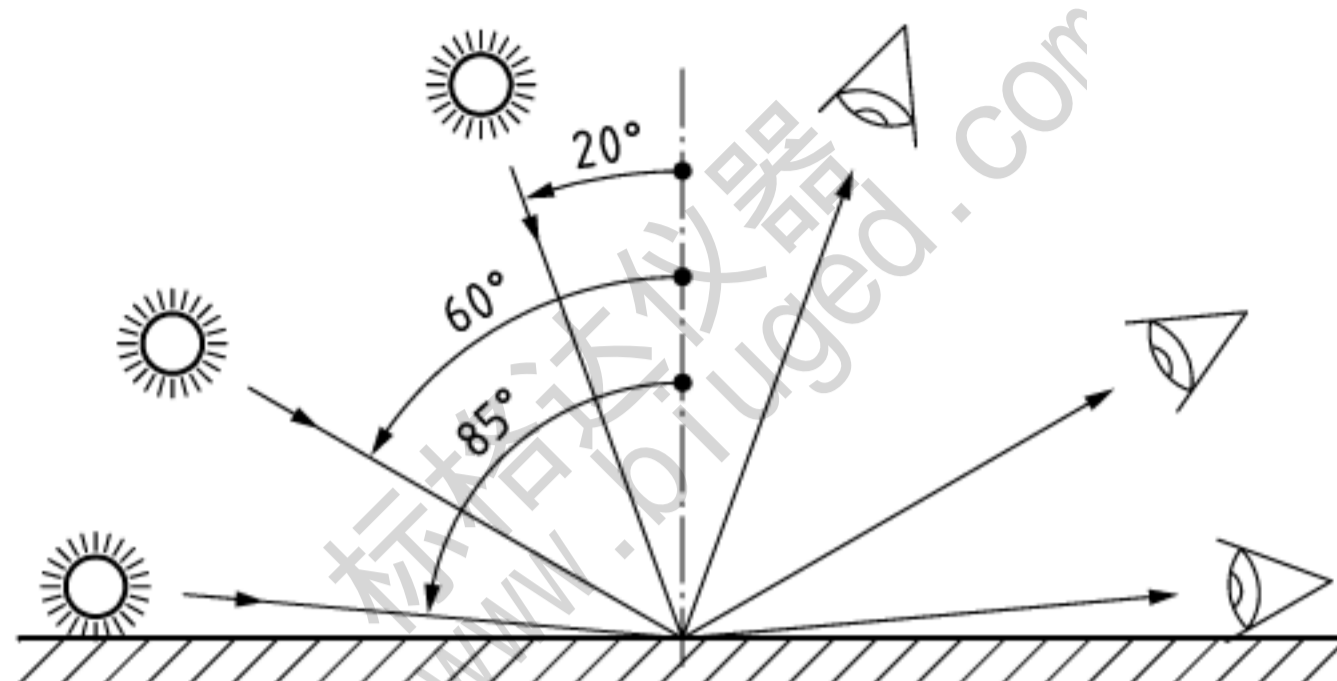


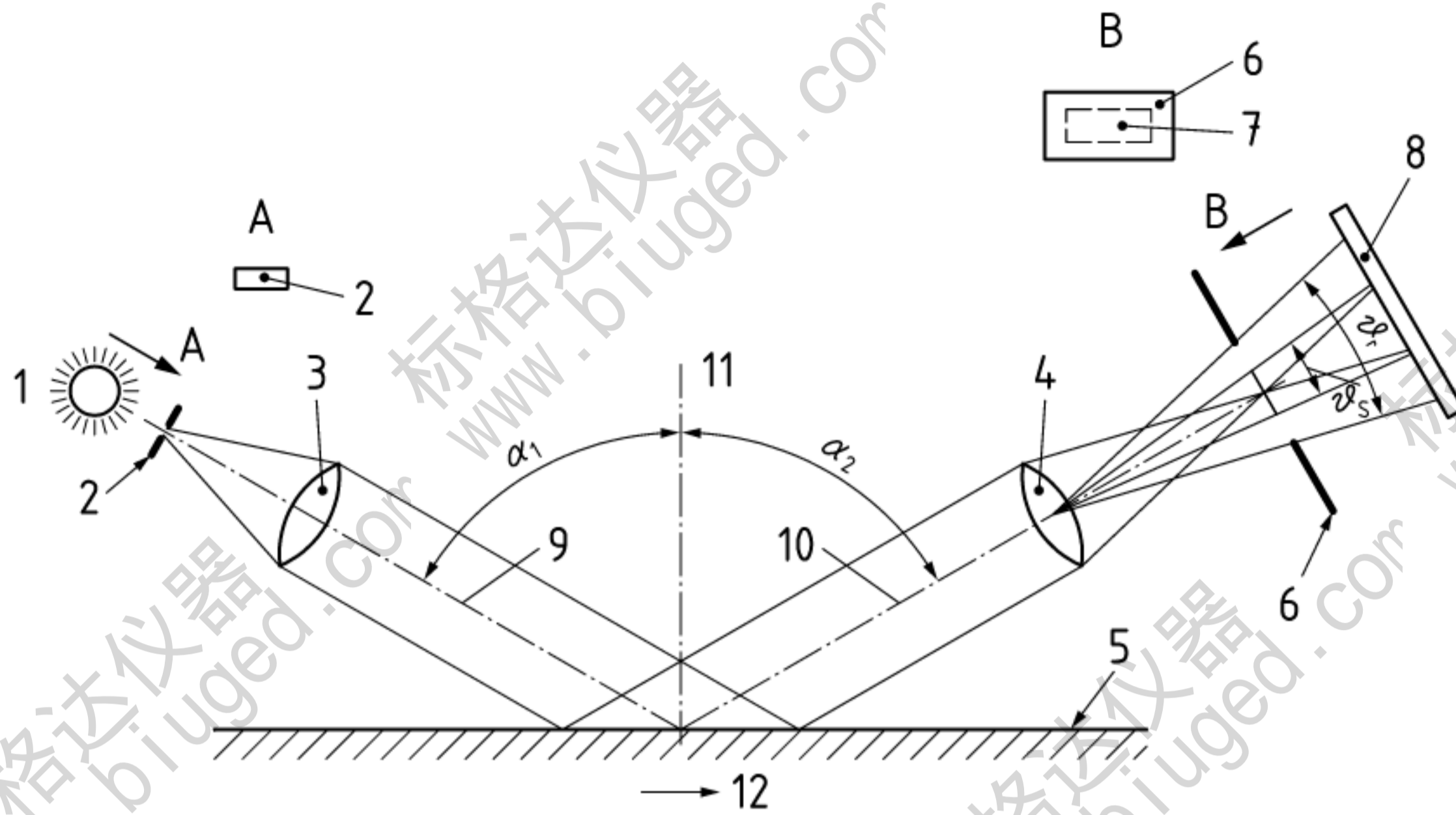
Figure 2 — Measuring angles

6 Apparatus and calibration equipment

6.1 Glossmeter

6.1.1 Optical construction and course of beam

The course of beam of the glossmeter is illustrated in [Figure 3](#). The light of a source is collimated onto the test surface at a specified angle, and the reflected light is received by a lens at the same angle and focused onto a photo detector.



Key

- | | | | |
|---|---|---------------|-------------------------------------|
| 1 | light source (source) | 9 | optical axis of the incident beam |
| 2 | source image aperture | 10 | optical axis of the receptor beam |
| 3 | source lens | 11 | surface normal of the test specimen |
| 4 | receptor lens | 12 | direction of measurement |
| 5 | test surface | α_1 | angle between 9 and 11 |
| 6 | receptor field stop | α_2 | angle between 10 and 11 |
| 7 | image of the source aperture in the receptor field stop | ϑ_r | receptor aperture angle |
| 8 | photo detector (receptor) | ϑ_s | source image aperture angle |

Figure 3 — Course of beam of the glossmeter

6.1.2 Geometries

The axis of the incident beam shall be at an angle (α_1) of $(20,0 \pm 0,1)^\circ$, $(60,0 \pm 0,1)^\circ$, or $(85,0 \pm 0,1)^\circ$ to the normal to the surface under test. With a flat piece of polished black glass or a front-reflecting mirror instead of the test panel position, the source field stop shall be reproduced at the centre of the receptor field stop.

The optical axis of the receptor beam shall coincide with the mirror image of the optical axis of the incident beam to within $\pm 0,1^\circ$, i.e. the condition $|\alpha_1 - \alpha_2| \leq 0,1^\circ$ shall be fulfilled (see [Figure 3](#)).

The dimensions of the source aperture and the receptor aperture and the permissible tolerances shall be as indicated in [Table 1](#).

There shall be no vignetting of rays that lie within the specified angular fields.

The direction of measurement (see [Figure 3](#)) shall be obvious on the apparatus.

Table 1 — Angles of source image aperture and receptor aperture

	Aperture angle	
	In parallel to plane of reflection	Perpendicular to the plane of reflection
Source image aperture (all geometries)	$0,75^\circ \pm 0,10^\circ$	$2,5^\circ \pm 0,1^\circ$
Receptor aperture (20° geometry)	$1,80^\circ \pm 0,05^\circ$	$3,6^\circ \pm 0,1^\circ$
Receptor aperture (60° geometry)	$4,4^\circ \pm 0,1^\circ$	$11,7^\circ \pm 0,2^\circ$
Receptor aperture (85° geometry)	$4,0^\circ \pm 0,3^\circ$	$6,0^\circ \pm 0,3^\circ$

NOTE 1 In Figure 3 the plane of reflection corresponds to the plane of illustration.

NOTE 2 In Figure 3 only the aperture angles in parallel to the plane of reflection are illustrated.

NOTE 3 By specifying the aperture angles it is ensured that for the gloss measurement only a maximum proportion of the scattered light is received.

6.1.3 Filtering at the receptor

Filtering at the receptor shall be done in such a way that the transmittance of the filter $\tau(\lambda)$ is given by Formula (1).

$$\tau(\lambda) = k \frac{V(\lambda) \times S_C(\lambda)}{L(\lambda)_{\text{rel}} \times L_S(\lambda)} \quad (1)$$

where

$V(\lambda)$ is the CIE photopic luminous efficiency;

$S_C(\lambda)$ is the spectral power distribution of CIE illuminant C;

$L(\lambda)_{\text{rel}}$ is the relative spectral sensitivity of the receptor;

$L_S(\lambda)$ is the spectral power distribution of the illuminating source;

k is a calibration constant.

NOTE By means of such filtering the gloss values refer to a uniform illuminant (C) and are adapted spectrally to the gloss perception of an observer.

6.1.4 Technical requirements for the glossmeter

The receptor measurement device shall give a reading proportional to the light flux passing the receptor field stop with a deviation of 1 GU at maximum.

The apparatus shall be calibratable and adjustable.

NOTE For glossmeters with automatically proceeding calibration routine the calibration and adjustment are carried out automatically.

6.2 Measurement standards (certified reference material, working measurement standards)¹⁾

6.2.1 High-gloss standard A (working measurement standard)

Plane black glass or ceramic plate with the following properties:

- surface grinded and polished;
- gloss values ≥ 88 GU.

Thickness, rear side, and edges shall be made in such a way that interfering light, scattered light and reflected light from the edges and the rear side are avoided.

The following parameters shall be recorded on the standard:

- direction of measurement;
- geometry (geometries);
- assigned gloss value(s).

The measurement standard shall conform to [Annex B](#).

6.2.2 Medium-gloss standard B (working measurement standard)

For testing the linearity medium-gloss standards may be used. The medium-gloss standard may be of ceramic tile, black glass, or other materials with uniform gloss. Thickness, rear side, and edges shall be constructed in a way so that interfering light, scattered light, and reflected light from the edges and the rear side are avoided.

The following parameters shall be recorded on the standard:

- direction of measurement;
- geometry (geometries);
- assigned gloss value(s).

The measurement standard shall conform to [Annex B](#).

6.2.3 Zero standard C (working measurement standard)

Plane plate made of metal, glass, or rigid plastic [e.g. poly(methyl methacrylate) - PMMA] with or without a coating whose gloss for all geometries is lower than 0,1 GU.

NOTE 1 Black flock has been proved suitable for use as coating material for the zero standard.

NOTE 2 Glossmeters with automatically proceeding calibration routine do not require a zero standard, since the zero calibration and the offset adjustment are carried out with the light source turned off.

The measurement standard shall conform to [Annex B](#).

6.2.4 Certified reference material (CRM)

Plane black glass or ceramic plate or quartz glass plate with the following properties:

- plane surface grinded and polished;
- gloss values ≥ 88 GU.

1) See ISO/IEC Guide 99.

ISO 2813:2014(E)

Thickness, rear side, and edges shall be made in such a way that interfering light, scattered light, and reflected light from the edges and the rear side are avoided.

The following parameters shall be recorded on the standard:

- direction of measurement;
- geometry (geometries);
- assigned gloss value(s).

The measurement standard shall conform to [Annex B](#) and [Annex C](#).

7 Test panels

7.1 Substrate

Unless otherwise agreed, select the substrate in regard to the intended practical use from the substrates described in ISO 1514. The test panels shall be plane and free of deformations (see [Annex A](#)).

7.2 Preparation and coating

Prepare each test panel in accordance with ISO 1514 and coat it in accordance with the specified method with the coating material or multi-coat system to be tested.

7.3 Drying and conditioning

Dry/harden (stove, if applicable) and age, if applicable, each coated test panel for the specified period of time and under the specified conditions. Condition the coated test panels before the test at $(23 \pm 2) ^\circ\text{C}$ and a relative humidity of $(50 \pm 5) \%$ for at least 16 h. Other conditions for conditioning shall be agreed and indicated in the test report.

Finger prints, dust, or other contaminations on the surface lead to changed and/or imprecise gloss values. Consequently, the coated test panels shall be stored and handled accordingly.

In the case of aged samples, the preparation has to eliminate the potential dust, without altering the surface.

7.4 Thickness of coating

Determine the dry film thickness of the coating, in micrometres, in accordance with one of the methods specified in ISO 2808.

For comparative measurements the film thicknesses shall correspond.

8 Calibration and adjustment of the glossmeter

8.1 Preparation of the apparatus

Calibrate the apparatus at the start of every period of operation and during operation at intervals sufficiently frequent to ensure correct measuring values.

8.2 Zero point check

Use the zero standard ([6.2.3](#)) to check the zero point.

If the measuring value on this standard is not within $\pm 0,1$ GU of zero, adjust the apparatus or subtract the deviation from subsequent readings.

NOTE Glossmeters with automatically proceeding calibration routine do not require a zero standard, since the zero calibration and the offset adjustment are carried out with the light source turned off.

8.3 Calibration and adjustment

Adjust the instrument with a high-gloss reference standard (standard A, working measurement standard, see 6.2.1) to the assigned gloss value.

NOTE For glossmeters with automatically proceeding calibration routine the calibration and adjustment are carried out automatically.

9 Procedure

9.1 Selection of geometry

Specify the optimal geometry based on the gloss value of the test specimen for the measuring angle of 60° .

- The method with a geometry of 60° can be used for all coatings. For high-gloss or matt coatings the 20° or 85° geometry might be more appropriate.
- For high-gloss coatings which give higher gloss values than about 70 GU (gloss units) for the 60° geometry, the method for the 20° geometry allows for a better differentiation.
- For matt coatings which give lower gloss values than about 10 GU (gloss units) for the 60° geometry, the method for the 85° geometry allows for a better differentiation.

NOTE 1 The determination of the loss of gloss caused by marring, weathering or other surface disfigurements often requires a change of the measuring geometry when measuring gloss after the exposure. This results in lower repeatability and reproducibility limits.

NOTE 2 It can be beneficial to take measurements on high-gloss surfaces using the 60° geometry, if after exposure, e.g. weathering, the surface is matter and consequently requires measurements with the 60° geometry. When following this procedure, the precision is much better compared to taking measurements using the 20° geometry prior to and after exposure.

9.2 Gloss measurement

By means of the glossmeter, measure on at least five representative positions with the appropriate geometry and the agreed direction of measurement. If the deviation of the readings is less than 5 GU, report the mean value rounded to full unit as the gloss value. Otherwise, take further readings and report the mean value of all values.

In the course of one series of measurement on several specimens the identical geometry shall be used for measuring.

NOTE For parameters and sources of errors for the determination of gloss, see [Annex A](#).

10 Precision

10.1 General

The following precision data have been obtained under laboratory conditions on real samples. For details, see [Annex D](#).

NOTE These data might not be compatible with the precision data stated by many instrument manufacturers. Manufacturer's data are typically based on ideal standards.

In practice, there are parameters that can lead to significantly higher deviations of measuring values. For details, see [Annex A](#).

10.2 Repeatability limit

The repeatability limit r is the value below which the absolute difference between the mean values of two separate sets of three values, obtained on a coating of the same product on plate glass, can be expected to lie when this method is used under repeatability conditions. In this case, the results are obtained on identical material by one operator in one laboratory within a short interval of time using the same equipment and following the standardized test method. In this International Standard, r is given in [Table 2](#), with a 95 % probability.

Table 2 — Repeatability limit, r

Geometry	Repeatability limit r
20°	3
60°	2
85°	1

10.3 Reproducibility limit

The reproducibility limit R is the value below which the absolute difference between the mean values of two separate sets of three values, obtained on a coating of the same product on plate glass, can be expected to lie when this method is used under reproducibility conditions. In this case, the results are obtained on identical material by operators in different laboratories within a short interval of time using the same equipment and following the standardized test method. In this International Standard, R is given in [Table 3](#), with a 95 % probability.

Table 3 — Reproducibility limit, R

Geometry	Reproducibility limit R
20°	4
60°	3
85°	2

11 Test report

The test report shall contain at least the following information:

- a) all details for complete identification of the coating tested (manufacturer, trade name, batch number, etc.);

- b) a reference to this International Standard (ISO 2813);
- c) any details on the preparation of test specimens, including
 - 1) material (including thickness) and surface preparation of the substrate (see 7.1),
 - 2) method for coating the substrate (see 7.2),
 - 3) duration and conditions for hardening (drying/hardening, including stoving) of the coating and, if applicable, ageing conditions of the coating before measuring (see 7.3),
 - 4) dry film thickness of the coating, in micrometres, including the method of measurement in accordance with ISO 2808 and indication if it is a single coat or a multi-coat system (see 7.4);
- d) identification (type, manufacturer) of the glossmeter used;
- e) the geometry used;
- f) if there is anisotropy, the selected direction of measurement (see Annex A for examples);
- g) the results of the test as indicated in Clause 9;
- h) any deviation from the specified test method;
- i) any unusual features (anomalies) observed during the test;
- j) the date of the test.

Annex A
(normative)

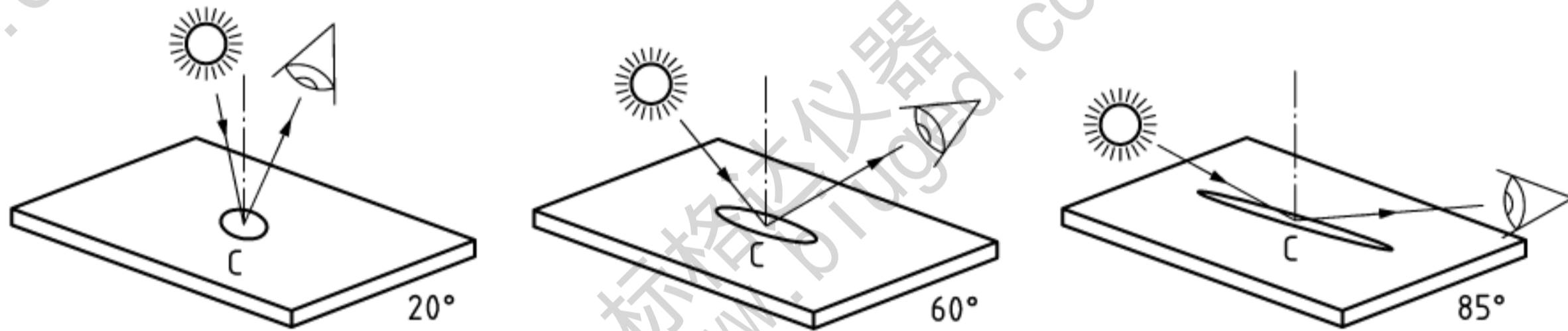
Possible sources of error

A.1 General

For some coatings, especially satin coatings, the gloss value depends on the conditions of drying/hardening and on the method of application.

A.2 Topographical effects

For rough, uneven, and textured surfaces comparative measurements of similar test specimens are only permitted when the dimensions of the textures are small in comparison to the dimension of the illuminated measuring area (see [Figure A.1](#)). The type of texture properties, such as orange peel, brush marks, etc., shall be described in the test report. For test specimens on which an anisotropism (directionality) of the gloss are recognizable, the direction of measurement relative to the direction of anisotropism shall be taken into account and indicated in the test report. For comparative measurements (especially in cases of dispute) the same direction of measurement shall be observed generally.



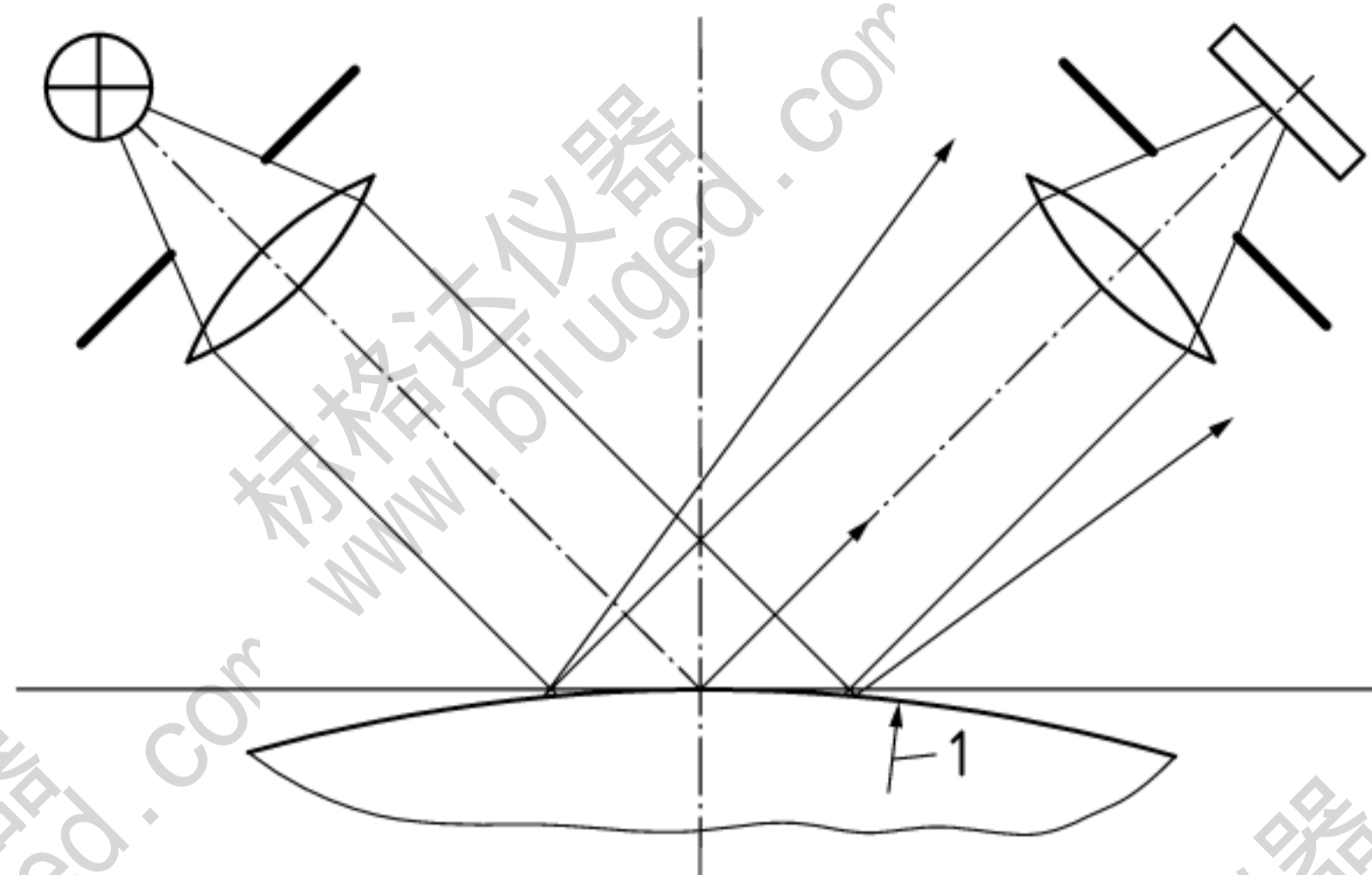
Key
C measuring area

Figure A.1 — Size of measuring area depending on the geometry

For the determination of gloss, an averaging over the measuring area is always done. Consequently, when using glossmeters with small measuring area, a higher number of single measurements distributed over the surface might be required.

A.3 Geometrical effects

On curved or uneven surfaces gloss measurements in accordance with this International Standard are possible only comparatively. Measuring on convex curved surfaces (see [Figure A.2](#)) is possible comparatively for identical coating materials and application parameters as well as identical direction of measurement with a positioning apparatus. However, the measuring values often do not correlate with the visual gloss perception and the gloss values of equally coated, plane test panels.



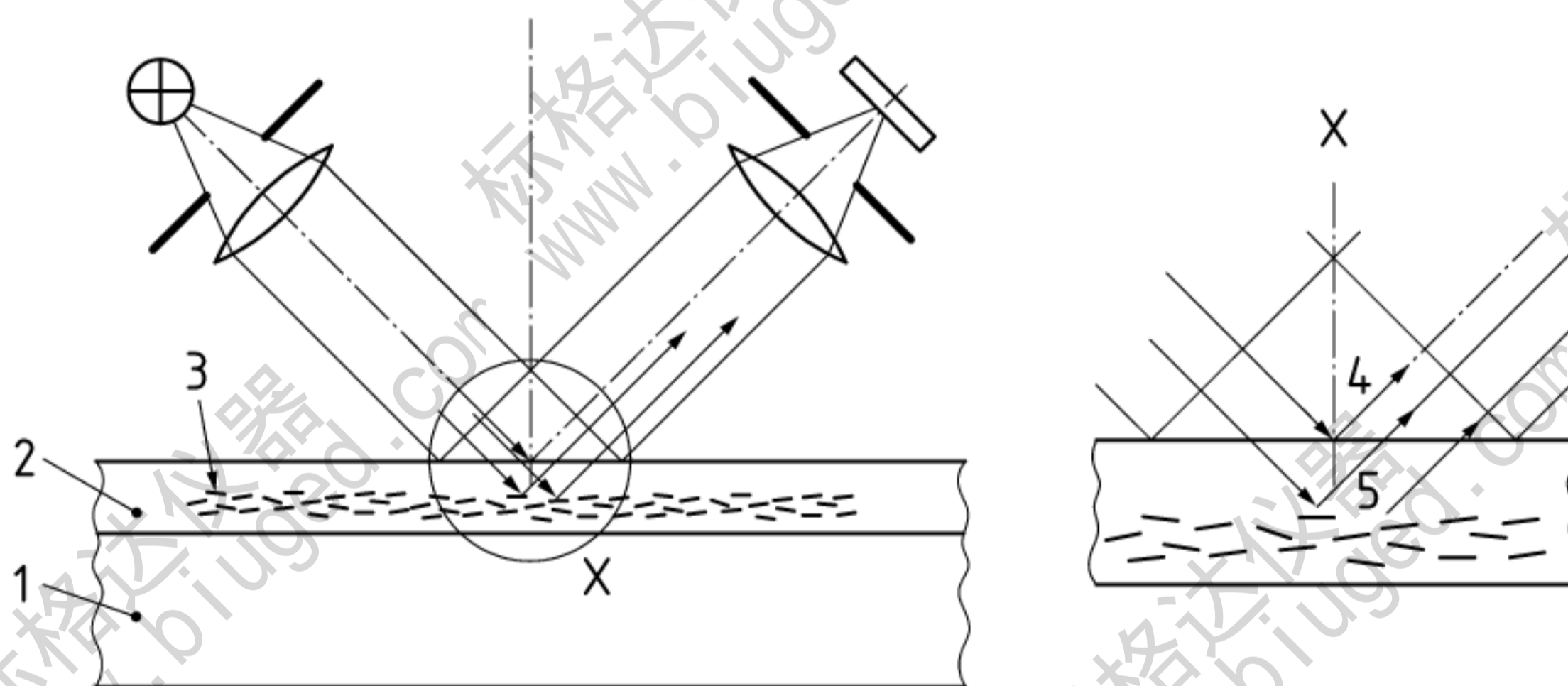
Key

- 1 radius of curvature

Figure A.2 — Gloss measurement on curved surface

A.4 Optical effects

Measuring on metallic and effect coatings (see Figure A.3) is only possible comparatively for identical coating materials and application, however, the gloss values often do not correlate with the visual gloss perception.



Key

- 1 substrate
- 2 coating
- 3 metallic pigmentation
- 4 reflection on coating surface
- 5 reflection on metallic pigment

Figure A.3 — Gloss measurement on metallic coating

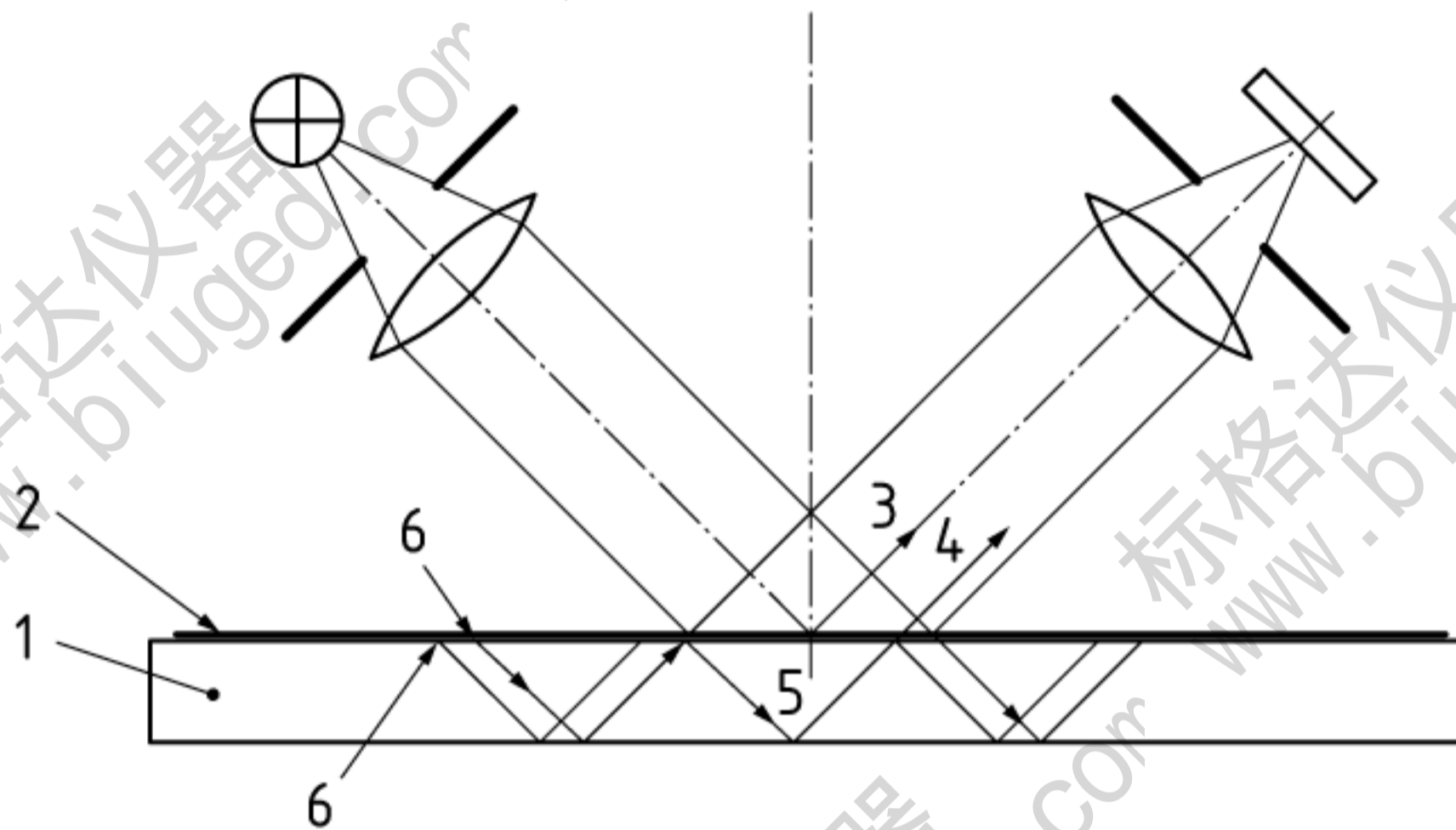
For comparative measuring on matt surfaces, it is required that chromaticity and lightness do not differ significantly.

For high-gloss clear coating systems the refractive index of the coating might have such a dominant influence on the measured gloss value that this value does not correlate with the visual gloss perception anymore.

The method of gloss measurement described in this International Standard shall generally not be applied for luminescent coatings.

For translucent coatings the gloss of the substrate might influence the measurement.

Measurements on coated glass plates are also possible only comparatively. The thickness of the glass and the properties of the rear side influence the measuring result (see [Figure A.4](#)).



Key

- 1 glass plate
- 2 coating (translucent)
- 3 reflection on top side of coated glass
- 4 reflection on rear side of coated glass
- 5 multiple reflection in the glass
- 6 interfering light

Figure A.4 — Gloss measurement on coated glass plate

For small specimens, the measuring result might be disturbed by interfering light when the illuminated measuring area is not entirely covered by the test specimen.

For translucent coatings on glass plates, the measuring value might be falsified by interfering light (see [Figure A.4](#)).

NOTE For devices with compensation of interfering light the effects caused by interfering light are eliminated automatically.

A.5 Physical effects

Temperature changes and high humidity might result in measuring errors caused by condensation in the glossmeter as well as on the test specimen.

In this case, it can be necessary to wait for a homogenization of temperatures before realizing the measurements.

Annex B (normative)

Calibration standards

B.1 Classification and use of the calibration standards

For the calibration and adjustment of the glossmeter, the following reference standards should be used:

- high-gloss standard A (working measurement standard for the high-gloss unit)
- medium-gloss standard B (working measurement standard to check the linearity)
- zero standard C (working measurement standard to check the zero point)
- certified reference material CRM (measurement standard to check the working measurement standard A)

For the daily checking of the glossmeter only the working measurement standards A and C are used.

NOTE Glossmeters with automatically proceeding calibration routine do not require a zero standard, since the zero calibration and the offset adjustment are carried out with the light source turned off. However, zero-point deviations caused by changes of the course of the beam (e.g. caused by contaminations on the lenses) are not corrected when calibrating automatically. Consequently, it is recommended to check the zero point in regular time intervals by means of the zero standard C.

Standards B and CRM are mainly used in the context of inspection equipment monitoring.

B.2 Production of calibration standards

The standard A and the CRM are of black glass, quartz glass or ceramics, respectively, with plane surface and shall be made in such a way that interfering light, scattered light, and reflected light from the edges and the rear side are avoided (sufficient thickness; rear side and edges roughened).

The surface of standard A and the CRM shall be polished, the surface of working measurement standard B shall have a defined, homogenous texture.

The surface of the CRM shall be plane enough so that by measuring with optical methods a maximum of two interference rings within 10 mm will be observed.

Since the optical properties of glass or ceramic surfaces might change by ageing, certified reference materials are frequently made of quartz (in a wedge profile to avoid reflection of light on the rear side).

For standard C a rigid, plane, black flock-coated plate is sufficient. For higher reliability a light trap might be used as zero reference standard.

The standards A, C and CRM are valid for all geometries. In contrast, for medium gloss generally a separate standard is required for each geometry.

The following specifications shall be recorded durably on the standards:

- direction of measurement;
- geometry (geometries);
- assigned gloss value(s) with a measurement uncertainty of $\pm 0,5$ GU for the high-gloss standard A, $\pm 1,0$ GU for the medium-gloss standard B, and $\pm 0,1$ GU for the zero standard C.

B.3 Handling of the calibration standards

The surfaces of the standards shall be handled with care and kept clean.

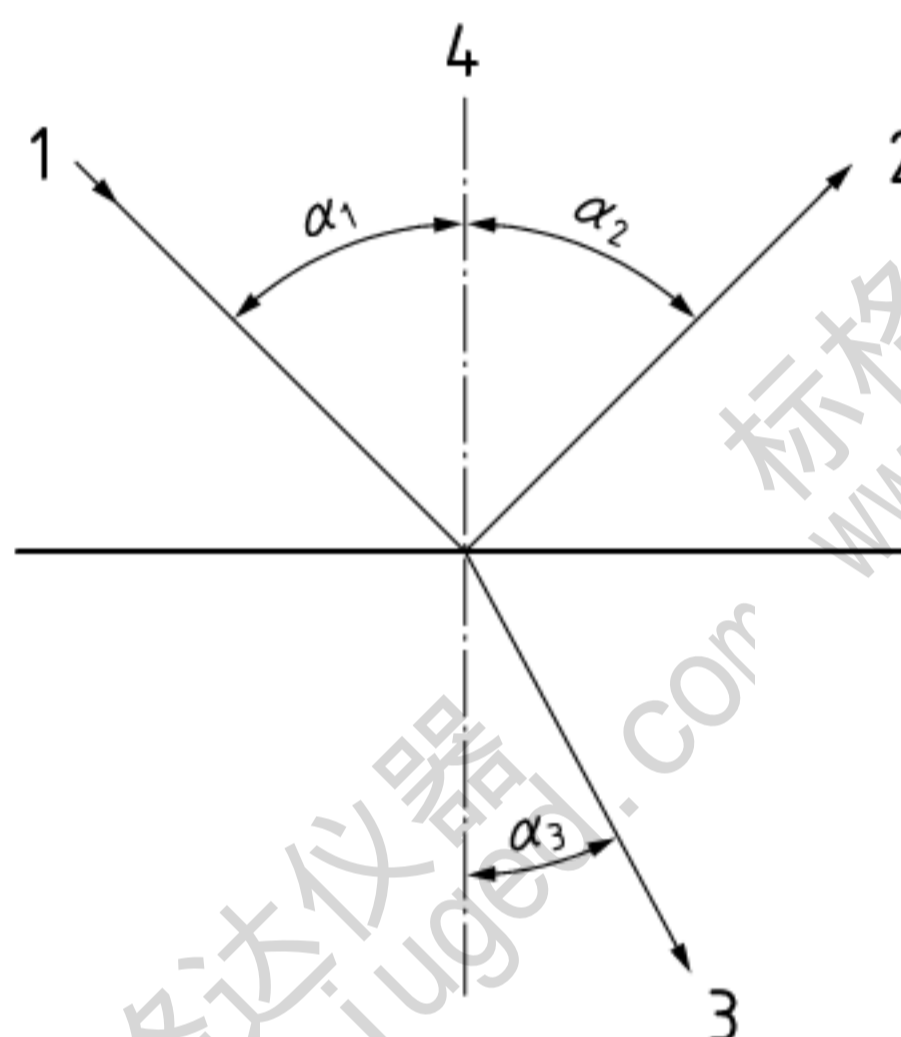
The high-gloss standards A and CRM shall be particularly handled and stored with care.

Annex C (informative)

Gloss calculation of primary reference standards

C.1 Physical basis

Light irradiation from air (refractive index 1) onto a (solid) medium with refractive index $n > 1$ results in a reflected and a refracted transmitted beam (see [Figure C.1](#)).



Key

- 1 optical axis of the incident beam (source beam)
- 2 optical axis of the reflected beam (receptor beam)
- 3 optical axis of the refracted transmitted beam
- 4 surface normal of the interface air/medium
- α_1 angle between 1 and 4 (measuring angle), in degrees
- α_2 angle between 2 and 4, in degrees
- α_3 angle between 3 and 4, in degrees

Figure C.1 — Reflection and transmission on an optical interface

The law of reflection gives

$$\alpha_1 = \alpha_2 \quad (\text{C.1})$$

and the Snelliusian law

$$\sin \alpha_1 = n \times \sin \alpha_3 \quad (\text{C.2})$$

For the calculation of the reflectance – that is the ratio of the intensities of reflected and incident light – it should be differentiated between light polarization in parallel to the plane of reflection and perpendicular to it.

NOTE In [Figure C.1](#) the plane of reflection corresponds to the plane of illustration.

In accordance with the classic Fresnel theory:

$$\rho_s = \left[\frac{\sin(\alpha_1 - \alpha_3)}{\sin(\alpha_1 + \alpha_3)} \right]^2 \quad (C.3)$$

$$\rho_p = \left[\frac{\tan(\alpha_1 - \alpha_3)}{\tan(\alpha_1 + \alpha_3)} \right]^2 \quad (C.4)$$

where

ρ_s is the reflectance for light polarization perpendicular to plane of reflection;

ρ_p is the reflectance for light polarization in parallel to plane of reflection;

α_i is the angle as described in the key of [Figure C.1](#) ($i = 1, 3$).

NOTE 1 The Formulae C.3 and C.4 are valid for the precondition that the medium on which the reflection occurs is dielectric (not metallic), isotropic (no directionality of the refractive index), and poorly absorbent.

NOTE 2 The angle α_3 can be calculated by means of Formula C.2 from the angle α_1 and the refractive index n .

The total reflectance ρ for unpolarized light is the arithmetic mean value of ρ_s and ρ_p :

$$\rho = \frac{\rho_s + \rho_p}{2} \quad (C.5)$$

C.2 Gloss calculation

For black glass plates with a refractive index of 1,567 the gloss value 100 GU is assigned for all geometries. For glass plates with a refractive index deviating from 1,567 the gloss is calculated by means of a correction factor K to $K \times 100$ GU.

For the correction factor:

$$K(n, \alpha_1) = \frac{\rho(n, \alpha_1)}{\rho(1,567, \alpha_1)} = A(\alpha_1) \times [2 \rho(n, \alpha_1)] \quad (C.6)$$

where

n is the refractive index of the standard plate at the wavelength used;

α_1 is the measuring angle, in degrees;

$\rho(n, \alpha_1)$ is the total reflectance for the refractive index n and the measuring angle α_1 ;

$\rho(1,567, \alpha_1)$ is the total reflectance for the refractive index 1,567 and the measuring angle α_1 ;

$A(\alpha_1)$ is a factor only depending on α_1 ;

$K(n, \alpha_1)$ is the correction factor for the refractive index n and the measuring angle α_1 .

From Formulae C.3 to C.6, it results:

$$K(n, \alpha_1) = A(\alpha_1) \times \left[\left[\frac{\sin(\alpha_1 - \alpha_3)}{\sin(\alpha_1 + \alpha_3)} \right]^2 + \left[\frac{\tan(\alpha_1 - \alpha_3)}{\tan(\alpha_1 + \alpha_3)} \right]^2 \right] \quad (\text{C.7})$$

with

$$A(20^\circ) = 10,187\ 8 \quad (\text{C.8})$$

$$A(60^\circ) = 4,997\ 0 \quad (\text{C.9})$$

$$A(85^\circ) = 0,807\ 6 \quad (\text{C.10})$$

The angle α_3 is to be calculated by means of Formula C.2 from angle α_1 and the refractive index n :

$$\alpha_3 = \arcsin \left(\frac{\sin \alpha_1}{n} \right) \quad (\text{C.11})$$

NOTE 1 Formula C.7 is not intended to be used for converting gloss values, which have been obtained on coated test specimens or on medium-gloss reference standards for one geometry, into gloss values for a different geometry. This is generally not possible.

NOTE 2 It is not suitable to calculate the refractive index of the coating by means of Formula C.7 from measured gloss values.

The gloss values calculated by means of Formula C.7 for refractive index values in the range of 1,400 to 1,800 and for the measuring angles of 20°, 60°, and 85°, are listed in [Table C.1](#), as an example.

Table C.1 — Gloss values of primary reference standards depending on refractive index and geometry

Refractive index n at 587,6 nm	Gloss value for measuring angle		
	20°	60°	85°
1,400	57,0	71,9	96,6
1,410	59,4	73,7	96,9
1,420	61,8	75,5	97,2
1,430	64,3	77,2	97,5
1,440	66,7	79,0	97,6
1,450	69,2	80,7	98,0
1,458^a	71,2	82,1	98,1
1,460	71,8	82,4	98,2
1,470	74,3	84,1	98,4
1,480	76,9	85,8	98,6
1,490	79,5	87,5	98,8
1,500	82,0	89,1	99,0

a Refractive index of a conventional type of quartz glass.
b Refractive index of a conventional type of black glass.
c Reference refractive index.

Table C.1 (continued)

Refractive index n at 587,6 nm	Gloss value for measuring angle		
	20°	60°	85°
1,510	84,7	90,8	99,2
1,520	87,3	92,4	99,3
1,530	90,0	94,1	99,5
1,534^b	91,1	94,7	99,5
1,540	92,7	95,7	99,6
1,550	95,4	97,3	99,8
1,560	98,1	98,9	99,9
1,567^c	100,0	100,0	100,0
1,570	100,8	100,5	100,0
1,580	103,6	102,1	100,2
1,590	106,3	103,6	100,3
1,600	109,1	105,2	100,4
1,610	111,9	106,7	100,5
1,620	114,3	108,4	100,6
1,630	117,5	109,8	100,7
1,640	120,4	111,3	100,8
1,650	123,2	112,8	100,9
1,660	126,1	114,3	100,9
1,670	129,0	115,8	101,0
1,680	131,8	117,3	101,1
1,690	134,7	118,8	101,2
1,700	137,6	120,3	101,2
1,710	140,5	121,7	101,3
1,720	143,4	123,2	101,3
1,730	146,4	124,6	101,4
1,740	149,3	126,1	101,4
1,750	152,2	127,5	101,5
1,760	155,2	128,9	101,5
1,770	158,1	130,4	101,6
1,780	161,1	131,8	101,6
1,790	164,0	133,2	101,6
1,800	167,0	134,6	101,7
^a	Refractive index of a conventional type of quartz glass.		
^b	Refractive index of a conventional type of black glass.		
^c	Reference refractive index.		

NOTE 3 It is not suitable to obtain the gloss values of primary reference standards by means of (linear) interpolation of the data in [Table C.1](#). The gloss values of primary reference standards are intended to be determined only based on Formula C.7.

Annex D (informative)

Details on precision

D.1 General remark on the interlaboratory test

A total of 14 laboratories participated in an interlaboratory test on gloss measurement using different glossmeters.

D.2 Samples

A total of 48 different coatings on different substrates were tested, using all three geometries, i.e. 20°, 60° and 85°.

The test included six standard tiles.

Prior to the test, all glossmeters were calibrated with certified calibration standards.

D.3 Glossmeters

Six different glossmeters with one, two or three geometries in one unit were used.

D.4 Number of measurements

Five measurements were taken on each sample.

D.5 Expression of results

The statistical evaluation was carried out following ISO 5725-2 and ISO/TR 22971.

Outliers were eliminated, which are not considered for calculating the precision data.

For the calculation of the repeatability limit, r , and the reproducibility limit, R , specified in [Clause 10](#), only those measurements were considered which followed exactly the specifications of this International Standard. This means, that for all determinations of the gloss always the correct geometry was chosen. There was no overlap of measuring ranges (see [Figure 1](#)). Since the repeatability limit and reproducibility limit are different for each measuring angle, the limits for these angles are stated separately. See [Table D.1](#).

Table D.1 — Repeatability limit, r , and reproducibility limit, R

Geometry	Repeatability limit $r = 2,77 s_r^a$	Reproducibility limit $R = 2,77 s_R^a$
20°	3 (5)	4 (16)
60°	2 (3)	3 (4)
85°	1 (3)	2 (4)

NOTE The figures in brackets result from overlap with other geometries.

^a s_r and s_R are the estimates of the repeatability and reproducibility variances.

The evaluation shows that single, small surface defects do not disturb the measurements. A surface structure, e.g. a visible orange peel surface, has a big influence on the measurement result.

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