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Perfomance of reflecting surfaces for luminaires

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee EL/1, Light and lighting applications.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Perfomance of reflecting surfaces for luminaires

Performance des surfaces réfléchissantes pour luminaires

Bewertung von Reflektoroberflächen für den Einsatz in Leuchten

This European Standard was approved by CEN on 1 December 2012.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 16268:2013) has been prepared by Technical Committee CEN/TC 169 “Light and lighting”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2013, and conflicting national standards shall be withdrawn at the latest by July 2013.

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1 Scope

This European standard is applicable to the optical performance of untreated or coated materials supplied in plane sheet or strip form for use as a plane or formed reflector as well as preformed reflectors both as originally produced and after prescribed tests to determine probable maintained performance in service. This includes:

a) untreated base materials, including:

   1) aluminium,

   2) steel,

   3) plastic,

   4) glass.

b) surface treated materials, including:

   1) polished materials,

   2) anodised materials,

   3) vacuum metallised materials,

   4) painted materials,

   5) multilayer systems.

This European Standard is not applicable to fluorescent materials.

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.

EN 12665, *Light and lighting — Basic terms and criteria for specifying lighting requirements*

EN ISO 4892-3:2006, *Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps (ISO 4892-3:2006)*

EN ISO 6270-2:2005, *Paints and varnishes — Determination of resistance to humidity — Part 2: Procedure for exposing test specimens in condensation-water atmospheres (ISO 6270-2:2005)*

ISO 7668, *Anodizing of aluminium and its alloys — Measurement of specular reflectance and specular gloss of anodic oxidation coatings at angles of 20 degrees, 45 degrees, 60 degrees or 85 degrees*

ISO 9211-4:2012, *Optics and photonics — Optical coatings — Part 4: Specific test methods*

ISO 15184:2012, *Paints and varnishes — Determination of film hardness by pencil test*

CIE 15.3:2004, *Colorimetry*

CIE 130:1998, *Practical methods for the measurement of reflectance and transmittance*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12665, CIE 130:1998 and the following apply.

3.1
light reflecting surface of a luminaire
all reflecting surfaces of a luminaire with the main task of reflecting light and therefore with a total reflectance of at least 50 %

3.2
reflection
process by which radiation is returned by a surface or a medium, without change of frequency of its monochromatic components

3.3
total reflectance
reflectance
ρ_{tot}
ratio of the whole reflected luminous flux to the incident flux:

$$\rho_{tot} = \phi_{tot} / \phi_i = \frac{\int_0^\infty S(\lambda) \cdot \rho(\lambda) \cdot V(\lambda) d\lambda}{\int_0^\infty S(\lambda) \cdot V(\lambda) d\lambda} \quad (1)$$

where

$\rho(\lambda)$ is the total spectral reflectance of the sample;

$S(\lambda)$ is the relative spectral power distribution of the incident radiation of standard illuminant A;

ϕ_{tot} is the total luminous flux reflected by the sample;

ϕ_i is the total incident luminous flux on the sample,

$V(\lambda)$ is the relative spectral weighting function of standard Observer at 2°.

3.4
diffuse reflectance
ρ_d
ratio of the diffuse reflected part of the reflected luminous flux to the incident flux:

$$\rho_d = \phi_d / \phi_i = \frac{\int_0^\infty S(\lambda) \cdot \rho_d(\lambda) \cdot V(\lambda) d\lambda}{\int_0^\infty S(\lambda) \cdot V(\lambda) d\lambda} \quad (2)$$

where

ρ_d is the diffuse spectral reflectance characteristic of the sample;

ϕ_d is the diffuse reflected luminous flux;

ϕ_i is the incident luminous flux;

$S(\lambda)$ is the relative spectral power distribution of the incident radiation of standard illuminant A;

$V(\lambda)$ is the relative spectral weighting function of standard Observer at 2°.

3.5
specular reflectance
regular reflectance
ρ_r
reflection in accordance with the laws of geometrical optics, without diffusion, expressed as the ratio of the regular reflected part of the reflected luminous flux to the incident luminous flux:

$$\rho_r = \phi_r / \phi_i = \frac{\int_0^\infty S(\lambda) \cdot \rho_r(\lambda) \cdot V(\lambda) d\lambda}{\int_0^\infty S(\lambda) \cdot V(\lambda) d\lambda} \tag{3}$$

where

$\rho_r(\lambda)$ is the regular spectral reflectance characteristic of the sample;

ϕ_r is the specular reflected luminous flux;

ϕ_i is the incident luminous flux;

$S(\lambda)$ is the relative spectral power distribution of the incident radiation;

$V(\lambda)$ is the relative spectral weighting function of standard Observer at 2°.

3.6
reflectance class
performance classification for reflecting materials determined from the total reflectance and expressed as a character from A+ to H indicating decreasing reflectance efficiency

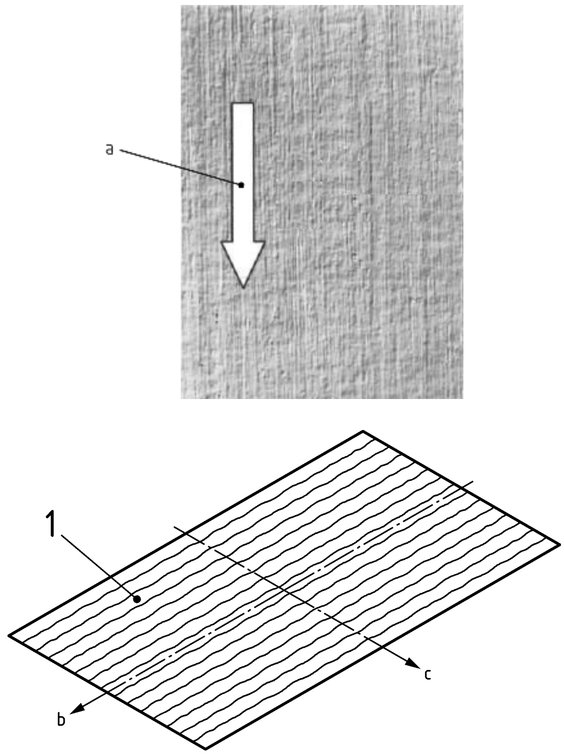
4 Measurement methods

4.1 General

The format of samples shall be plane and the minimum dimensions should be 100 mm x 100 mm.

For formed reflectors, a plane sample of the reflector should be taken or a plane sample of the same material should be produced in the same manner as the final reflector.

For materials manufactured by a linear process, measurements shall be made with the plane of incidence both parallel (i. e. longitudinal) to and perpendicular (i. e. transverse) to the linear process direction which shall be marked by the manufacturer on the samples, see Figure 1. The relevant symbols shall be marked by an index "L" for longitudinal direction and by "T" for transverse direction.



Key
1 sample
a rolling direction
b parallel direction
c perpendicular direction

Figure 1 — Illustration of measurement parallel and perpendicular to the linear process direction

For embossed structured surfaces, the width of the illuminated area on the sample inside the sphere according to Annex A shall be at least three times larger than the dimension of the structure. Depending on the kind of structure, measurements in three or four directions shall be considered. In Annex D, examples of structure are illustrated.

NOTE Due to the undulating surface of embossed materials, good contact between the sample and the rim of the sample port cannot be maintained at all points. The resulting light leakage can cause the results of measurements made on these materials to be lower than their actual total reflectance values.

4.2 Total reflectance ρ_{tot}

The measurement shall be made in accordance with Annex A and documented.

For materials manufactured by a linear process, measurements shall be made with the plane of incidence both parallel to and perpendicular to the linear process direction (see Figure 1). For all other materials measurement shall be done in two perpendicular directions.

Five measurements in each of these directions on different areas of the materials are required.

The mean longitudinal value and the mean transverse value across all samples shall be calculated.

The total reflectance shall be the higher value of the mean values.

The uncertainty of the measurement process shall be documented, stating the percentage of uncertainty and the method by which the value was determined.

4.3 Diffuse reflectance ρ_d

The diffuse reflectance ρ_d shall be measured according to Annex A and documented.

For materials manufactured by a linear process, measurements shall be made with the plane of incidence both parallel to and perpendicular to the linear process direction (see Figure 1). For all other materials, measurement shall be done in two perpendicular directions.

Five measurements in each of these directions on different areas of the materials are required.

The lowest longitudinal value and the lowest transverse value across all samples shall be recorded.

NOTE For diffuse reflectance measurement, the lowest value is taken in order to avoid errors due to sample distortion causing the specular reflected light to strike the edge of the sphere exit aperture.

The diffuse reflection shall be the mean of the two recorded values.

4.4 Specular reflectance ρ_r, ρ_{rL}, ρ_{rT}

Measurement shall be made according to Annex A in both longitudinal and transverse directions.

For nonlinear processed materials the measurements should be made in two perpendicular directions.

Five measurements in each of these directions on different areas of the materials are required.

The mean longitudinal value ρ_{rL} and the mean transverse value ρ_{rT} across all samples shall be calculated.

Values of transverse and longitudinal directions shall both be stated.

4.5 Colour

Colour shall be expressed in CIE L*a*b*-system using standard illuminant D65 (Daylight) (see CIE 15.3:2004).

Five measurements at different points of the surface shall be measured and the average values L, a*, b* shall be taken. Measurements made before and after the durability tests shall be made using the same instrument and the same method.

5 Durability test methods for evaluation of reflective materials based on maintained performance under different specified conditions

5.1 General

Different reflector materials show different rates of reflectance loss due to the effects of oxidation, humidity, UV exposure and abrasion. The durability tests used in this standard and described below are used to demonstrate within a short time of testing the likely relative deterioration of a reflector material in normal service and give an indication of the maintained performance.

It is the responsibility of the user of the material to perform suitable tests to determine the worst case operating condition (e.g. highest temperature reached on the reflector surface, etc.) within their application.

For each test on a batch of materials, a new sample with equal properties to the others is required.

Measurement of reflectance values shall be made according to Clause 4, Annex A and Annex B. All measurements before and after durability tests shall be made with the same instrument under the same measurement conditions.

The same panel shall be measured before and after each exposure.

Films and foils shall be tested on the proposed base material.

5.2 Temperature resistance

The test shall be carried out in air at one or more of the following temperatures T: 80 °C, 120 °C, 160 °C, 200 °C, 250 °C, 300 °C, 400 °C.

Temperature level T shall be recorded as shown in Table 2 and Table 3.

Test duration shall be 168 h without interruption.

The temperature resistance tests are carried out by placing test panels of the reflecting materials in an oven at the stated temperature. The temperature shall be maintained within +/- 5°C for the duration of the test.

The reflective surface shall not make contact with any other surface during the test.

The physical condition of the material shall be observed after the test and any deterioration shall be recorded (see Table 3).

5.3 Humidity resistance

The humidity test shall be carried out in a test cabinet with constant condensation at 40 °C for a duration of 168 h without interruption according to EN ISO 6270-2:2005, Table 1, code CH, using deionised water.

The reflective surface shall not make contact with any other surface during the test.

The physical condition of the material shall be observed after the test and any deterioration shall be recorded (see Table 3).

5.4 UV-Exposure resistance

Durability on exposure to UV- radiation shall be tested according to EN ISO 4892-3:2006, Table 4, cycle no. 5 for a duration of 504 h (three weeks).

The reflective surface shall not make contact with any other surface during the test.

The physical condition of the material shall be observed after the test and any deterioration shall be recorded (see Table 3).

5.5 Abrasion resistance

Measurements shall be made according to ISO 9211-4:2012 (see Annex B).

The physical condition of the material shall be observed after the test and any deterioration shall be recorded (see Table 3).

5.6 Scratch resistance

Measurements shall be made according to ISO 15184:2012 (see Annex B).

The physical condition of the material shall be observed after the test and any deterioration shall be recorded together with the hardness of the pencil causing the deterioration (see Table 3).

6 Classification

The Reflectance Class represents the total reflectance of the surface indicating the potential for energy efficiency of the material when used in a luminaire.

The reflecting surfaces of materials are classified according to Table 1.

Table 1 — Reflectance classes of reflecting surfaces of materials

Reflectance class	Total reflectance %
A+	97,0 to 100,0
A	93,0 to 96,9
B	88,0 to 92,9
C	82,0 to 87,9
D	76,0 to 81,9
E	70,0 to 75,9
F	64,0 to 69,9
G	58,0 to 63,9
H	50,0 to 57,9

Depending on luminaire design and geometry, a high diffuse reflectance can have a negative effect on the energy efficiency of a luminaire and this should be taken into account when interpreting Table 1.

7 Assignment of Reflectance Class

All reflector materials supplied in accordance with this standard shall be assigned a reflectance class character indicating the initial and the maintained reflectance performance determined from the results of total reflectance measurements before and after durability tests. For the assignment of maintained reflectance class, the following tests shall be made:

— temperature resistance according to 5.2;

— humidity resistance according to 5.3;

— UV-exposure resistance according to 5.4.

The maintained reflectance class shall be indicated by a letter allocated from Table 1 for each test.

8 Presentation of performance data

The manufacturer of the reflector material shall provide a data sheet of the type shown in Table 2 showing the quantitative results of the tests according to Clause 4 and durability tests according to Clause 5.

The manufacturer shall state the following measurement details:

— method used and type and manufacturer of measurement instruments;

— calibration standard;

— uncertainty for total reflectance measurements.

Furthermore, a qualitative results assessment sheet of the type shown in Table 3 shall be provided indicating the change in visual appearance.

Table 2 — Example for presentation of initial measurement values and values after duration tests for a given type of reflecting material [1)]

Type of reflecting material										
Test method	**Reflectance Class according to Table 1**	**Total reflectance** ρ_{tot} [%]	**Diffuse reflectance** ρ_d [%]	**Specular reflectance**				**Colour**		
				ρ_{rL} (20°) [%]	ρ_{rL} (60°) [%]	ρ_{rT} (20°) [%]	ρ_{rT} (60°) [%]	L *	a*	b*
Initial test values										
T (….°C) according to 5.2										
T (….°C) according to 5.2										
Humidity according to 5.3										
UV-exposure according to 5.4										

1) The user of this table is allowed to copy this present form.

Table 3 — Example for presentation of visual results after test [2)]

Type of reflecting Material				
Test method	**No change in visual appearance**	**Visible change**	**Significant damage to optical layers**	**Comments**
Temperature resistance (….°C) according to 5.2				
Temperature resistance (….°C) according to 5.2				
Humidity resistance according to 5.3				
UV-exposure resistance according to 5.4				
Abrasion resistance according to 5.5				
Scratch resistance according to 5.6				

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Annex A
(normative)

Measurement of total, diffuse and specular reflectance and colour

A.1 General

Accurate measurement of total and diffuse reflectance of the reflector surfaces requires the use of an integrating sphere designed to allow the measurement of flat samples. An integrating sphere (also known as an Ulbricht sphere) is an optical component consisting of a hollow sphere with its interior surfaces coated to give high diffuse reflectivity of substantially uniform spectral reflectance characteristics. The sphere is fitted with a number of apertures or “ports”, as described below, to allow the measurements to be made.

A minimum requirement for the measurement of the total reflectance of reflector surfaces is a port on which the sample is mounted, a port to allow the entry of the light beam and a port in which the detector is mounted. The detector port is mounted out of line with the direct reflected beam and is shielded by a small screen from direct light from the source or sample. The sphere may also be fitted with a port to hold a reference sample which is used interchangeably with the test sample in order to maintain a constant total reflective surface within the sphere.

For the measurement of diffuse reflectance, the sphere is also fitted with a port in the position at which regular or specular light strikes the sphere wall. This serves to allow escape of specular light to a light trap allowing the measurement of diffuse reflectance.

The sphere is fitted with a light source that provides a convergent beam, which, after reflection from a mirror sample held on the sample port, is focused on the sphere wall at the position of the specular beam exit port.

The sphere should be operated in a clean laboratory environment and attention should be given to the control of temperature in order to avoid fluctuation of measurement.

A.2 Measurement of total reflectance

A.2.1 General

Measurement of total reflectance shall be in accordance with CIE 130.

Total reflectance shall be measured in spatially integrated mode using an integrating sphere.

A.2.2 Geometry

A.2.2.1 Single or double beam

With single beam measurements, only one incoming beam is present and two consecutive measurements are required: one measurement when illuminating the sample and another measurement where the sample has been replaced by the calibration standard. This type of measurement requires that illumination (and detection) characteristics do not change between both measurements. This can be controlled using an additional monitoring of the illumination.

With double beam measurements, two incident beams are present, illuminating the sample and the calibration standard respectively. The two signals are measured with the same detector.

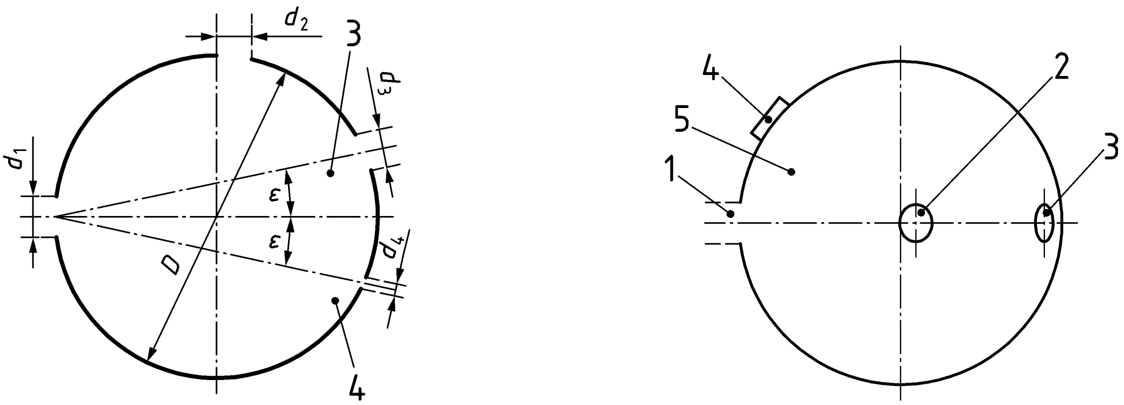
A.2.2.2 Substitution or comparison method

With the substitution method, sample and standard are placed at the same sphere port one after the other. As a result, the average sphere factor relating the flux incident on the sphere wall and the irradiation at the detector may be changed. This introduces a substitution error which can be minimised when the port area is low compared to the sphere area.

With the comparison method, sample and standard are both present in the sphere. In this way, the sphere factor does not change when measuring sample and standard. This method requires however one additional port in the sphere: a sample port and a reference port are needed. With single beam measurements, test sample and calibration standard are switched between these ports. With double beam measurements, sample and standard can be illuminated without switching.

A.2.2.3 Sphere configuration

The recommended sphere configuration is shown in Figure A.1.



a) Top view **b) Side view**

Key

d_1 diameter of sample port 1, ($d_1 \leq 0{,}1$ D)

d_2 diameter of standard port 2, ($d_2 = d_1$)

d_3 diameter of incoming light port 3, ($d_3 \leq 0{,}1$ D)

d_4 diameter of specular beam exit port 4, ($d_4 = 0{,}02$ D)

D inner diameter of sphere

ε angle of incidence of incoming beam, ($\varepsilon \leq 10°$)

1 sample port

2 calibration standard port

3 incoming light port

4 photometer

5 screen

Figure A.1 — Integrating sphere schematic diagram for a single beam instrument

The standard port is only required when applying the double beam method or when applying the single beam method using the comparison method. The total port area shall not exceed 10% of the sphere area.

A.2.3 Illumination

A.2.3.1 Spectrally integrated or spectrally resolved measurements

Measurements may be made by spectrally integrated or spectrally resolved methods.

With spectrally integrated measurements, the spectral distribution of the polychromatic illumination source shall correspond to standard illuminant A.

With spectrally resolved measurements, the spectral total reflectance can be determined.

The illumination can be polychromatic with a spectral distribution covering all visual wavelengths between 380 nm and 780 nm. In this case, the detector is a monochromator or spectrograph with a maximal bandwidth of 10 nm. A wavelength interval of maximum 10 nm can be used.

The illumination can be provided by a monochromator with a maximal bandwidth and wavelength interval of 10 nm. In this case, the detector shall have a sufficient sensitivity over all the visual wavelengths between 380 nm and 780 nm.

A.2.3.2 Geometry

The angle of incidence ε shall be smaller than 10° (see Figure A.1).

The angle between the optical axis and any ray of the beam shall be smaller than 5°.

The diameter of the irradiated area of the sample shall be sufficiently large in relation to surface structure features of the sample to provide a representative measurement of the reflectance characteristics and shall be sufficiently small compared to the diameter of the sample port to avoid a beam directly touching the sphere surface. An irradiated area diameter of between 0,5 d_1 and 0,8 d_1 is recommended.

A.2.4 Detection

A.2.4.1 General

The detector head mounted to the sphere should be provided with a suitable cosine correcting device located in front of the acceptance area of the detector head. The quality of this cosine response is expressed by f_2. This value shall be equal to or lower than 3,0 %.

A.2.4.2 Spectrally integrated or spectrally resolved

With spectrally integrated measurements, a photometric detector corrected with a spectral weighting function simulating the eye sensitivity $V(\lambda)$ is used. The quality of this weighting is expressed by $f_1^{'}$. This shall be equal to or lower than 3,0 %.

With polychromatic illumination and spectrally resolved detection, the detector is a monochromator or spectrograph with a maximum bandwidth of 10 nm. A wavelength interval of 10 nm can be used.

With monochromatic illumination, the detector shall have a sufficient sensitivity over the all visual wavelengths between 380 nm and 780 nm.

A.2.5 Calibration samples

Calibration standards shall be traceable to accredited national measuring laboratories.

For each series of measurements on a type of material, total reflectance shall be determined in the first step using both diffuse and specular calibration standards. A difference in the two results shall be less than 2 %.

NOTE A difference greater than 2 % indicates that there is a problem with the reflective surface of the sphere or the specular port plug.

Following this initial test, materials with a diffuse reflectance of greater than 30 % shall be measured using a diffuse calibration standard. For less diffuse materials, calibration shall be made using a specular standard.

A.3 Measurement of diffuse reflectance

Measurement of diffuse reflectance shall be made in accordance with CIE 130 together with the measurement of total reflectance according to A.2.

In order to measure diffuse reflectance, the sphere shall be fitted with a specular beam exit port 4 (see Figure A.1).

The standard size of the aperture of the specular beam exit port 4 shall be 0,02 D for standard diffuse reflectance measurements. The port 4 may have an overall diameter up to a maximum of 0,1 D in which case the 0,02 D aperture shall be formed by a reflective plug with a concentric aperture of 0,02 D.

The beam shall be convergent and when reflected by a calibration mirror located at the sample port be brought to a focus at the centre of the specular beam exit port d_4. The focus spot shall be of maximum dimensions of between 0,010 D and 0,015 D.

The coincidence of the specular reflected beam with the specular exit port shall be verified by visual observation before taking a reading.

A.4 Measurement of specular reflectance

A.4.1 General

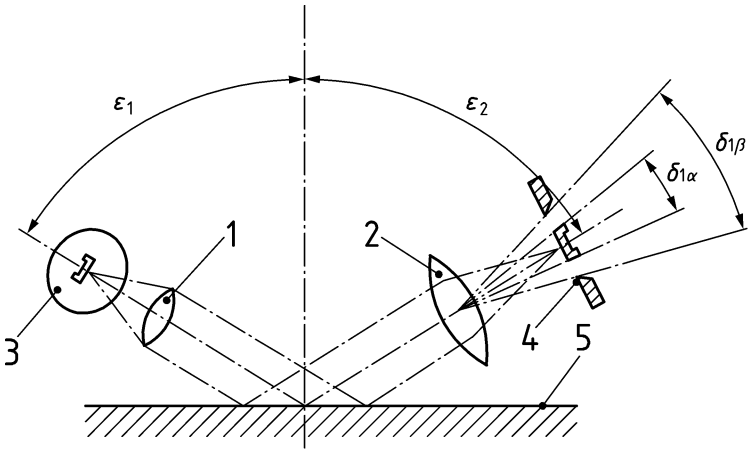
Specular reflectance and specular gloss are not unique physical properties of a surface. They vary with the angle of measurement and with the aperture dimensions that define the incident and the reflected beams, such that measurements of these properties are not independent of the apparatus being used.

NOTE Due to the lack of accuracy when measuring specular reflectance values of embossed surfaces, such measurements may be useful only for comparison purposes.

If specular reflectance measurements are made on embossed materials, the number of individual measurements used to determine an average specular reflectance should be increased to improve the reproducibility of the results. The number of measurements required will depend on the particular surface type and should be determined by experiment for each material.

A.4.2 Principle

The specular reflectance of a surface is measured by illuminating the surface of a material with a parallel or slightly collimated beam of light under defined geometric conditions and collecting the light reflected within a defined angle and measuring its intensity relative to the incident beam with a photocell. In this standard, the specular reflectance shall be measured under defined conditions according to ISO 7668 using measurement angles of 20° (method A) and 60° (method C), both angles being measured from the normal.



Key

1	collimating lens
2	Collector lens
3	light source (with optional photocell)
4	collector aperture
5	sample surface
$\delta_{1\alpha}$	source image angle
$\delta_{1\beta}$	receptor aperture angle
ε_1	incident angle (20° for Method A, 60° for Method C)
ε_2	receptor angle (20° for Method A, 60° for Method C)

Figure A.2 — Principle of measurement of specular reflectance

Annex B
(normative)

Measurement of abrasion and scratch resistance

B.1 Measurement of abrasion and wipe resistance according to ISO 9211-4:2012

B.1.1 General

Abrasion tests shall be conducted using an abrasion tester covered with a pad of cotton cheesecloth. The length of stroke of the tester shall be approximately 20 mm when the dimensions of the specimen permit. A stroke is defined as one pass in one direction on the surface being tested. The tester shall be operated in a cycling mode. A cycle is defined as one stroke in one direction, followed by a return stroke in the opposite direction. The head of the tester shall be approximately normal to the surface. The specimen shall be firmly held so that it does not slide during the test.

B.1.2 Cheesecloth

The rubbing head of the abrasion tester shall be covered with a pad of cotton cheesecloth approximately 5 mm thick and 10 mm in diameter. The yarn shall be made from cotton, free from waste and loading materials, carded, drawn and spun into single yarns. The warp of the cloth shall have 41 yarns to 47 yarns per 25 mm and the filling shall have 33 yarns to 39 yarns per 25 mm. The total number of yarns in a 25 mm by 25 mm square shall be 76 to 84. The mass shall be 45 g/m² to 54 g/m². The type of cheesecloth shall be bleached. Prior to use, it shall be laundered to remove completely the sizing agent and then dried.

B.1.3 Test conditions

The abrasion test shall be done by performing 50 strokes with the abrasion tester with a force of 5N ± 1 N.

B.1.4 Evaluation

The film on the specimen shall be visually examined in reflected light, with the unaided eye, for evidence of physical damage to the coating. Three categories of condition are recommended:

— no change;

— visible change;

— serious damage.

B.2 Measurement of scratch-resistance according to ISO 15184:2012

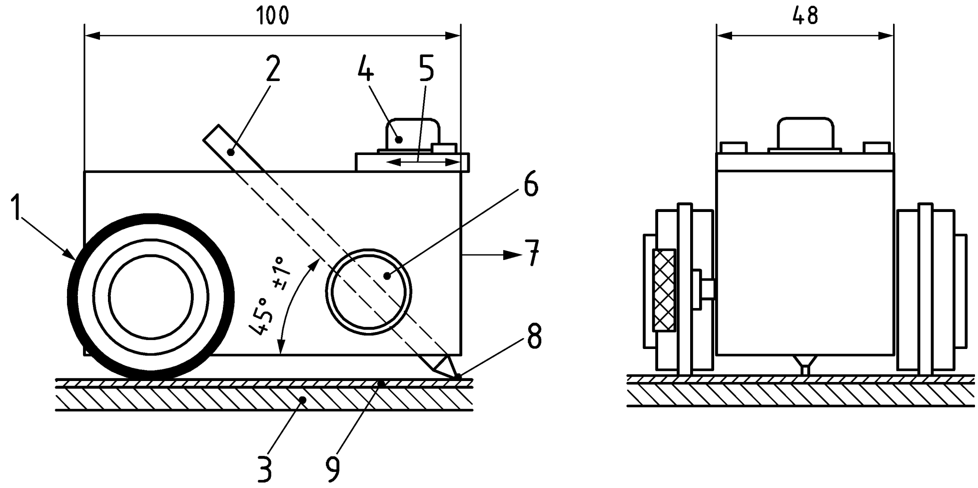
B.2.1 General

Scratch-resistance tests shall be conducted using a mechanical device pushed over the surface. During a test, a pencil is mounted on the device so that it presses down on the surface. After each move, the pencil has to be replaced by a pencil of increased hardness until defects occur.

B.2.2 Test instrument

The test is best performed using a mechanical device. An example of a suitable device is shown in Figure B.1. Although the test is preferably performed using a mechanical device, it can also be performed by hand. The device shown consists of a metal block fitted with two wheels, one on each side. In the middle of the metal block, there is a cylindrical hole inclined at an angle of (45 ± 1)°. With the help of a clamp, pencils can be fixed in the instrument so that they are always in the same position. Mounted on the top of the instrument is a level which is used to ensure that the test is carried out with the instrument horizontal. The instrument shall be designed so that with the instrument in the horizontal position the tip of the pencil exerts a load of (750 ± 10) g on the paint surface.

Dimensions in millimetres



Key

1 rubber O-ring
2 pencil
3 substrate
4 level
5 small, movable weight
6 clamp
7 direction of motion of instrument
8 pencil lead
9 paint film

Figure B.1 — Schematic diagram of test instrument according to ISO 15184:2012

B.2.3 Pencils

B.2.3.1 Pencil hardness

The resistance of the surface of a coating to marking, or the formation of some other defect, as a result of the action of a pencil with a lead of specified dimensions, shape and hardness which is pushed across the surface.

A set of wood drawing pencils of the following hardnesses shall be used:

9B - 8B - 7B - 6B - 5B - 4B - 3B - 2B - B - HB - F - H - 2H - 3H - 4H - 5H - 6H - 7H - 8H - 9H

Softer Harder

Pencils made by various manufacturers may be used by agreement between the interested parties, provided they give similar relative rating results.

EXAMPLE Some examples of pencil makes and manufacturers which have been found suitable are as follows[3)]

— Microtomic, manufactured by Faber Castell;

— Turquoise T-2375, manufactured by Empire Berol, USA;

— KOH-I-NOOR, type 1500, manufactured by Hardtmuth AG;

— Uni, manufactured by the Mitsubishi Pencil Co.

For comparative testing, it is recommended that pencils from the same manufacturer be used. Variations may be found between manufacturers and between batches from the same manufacturer.

B.2.4 Test conditions

The test shall be carried out at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) %, unless otherwise agreed. Approximately 5 mm to 6 mm of wood from the point of each pencil using a sharpener is removed, being careful to leave an undisturbed, unmarked, smooth cylinder of pencil lead. The tip of the lead shall be squared by holding the pencil in a vertical position and moving the pencil back and forth over abrasive paper, maintaining an angle of 90°. Continue until a flat, smooth, circular cross-section is obtained, free from chips or nicks in the edges.

Repeat this procedure each time a pencil is used.

Place the coated panel on a level, firm, horizontal surface. Insert a pencil in the test instrument and clamp it in position so that the instrument is horizontal with the tip of the pencil resting on the surface. Immediately after the tip of the pencil has come to rest on the coating, push the test panel, in the direction away from the operator, at a speed of 0,5 mm/s to 1 mm/s for a distance of at least 7 mm. Unless otherwise agreed, inspect the coating after 30 s with the naked eye for marking of the kind defined in B 2.5.

The damage can be assessed more easily after cleaning all fragments of pencil lead from the paint surface using a soft cloth or swab of cotton wool and an inert solvent. If this is done, take care that the solvent does not affect the hardness of the coating in the test area.

If no marking has occurred, repeat the test without overlap of the test areas, moving up the hardness scale until marking occurs over a distance of at least 3 mm.

If marking has occurred, repeat the test down the hardness scale until marking no longer occurs. Determine which of the defects of the kind defined in B 2.5 has been produced.

The hardness of the hardest pencil which does not mark the coating is the so-called pencil hardness.

B.2.5 Evaluation

Marking by pencil leads produces a range of defects in the surface of the coating.

These defects can occur simultaneously and are defined as follows:

— Plastic deformation: a permanent indentation in the surface without cohesive fracture.

— Cohesive fracture: the presence of a visible scratch or rupture in the surface, material having been removed from the coating.

— Combinations of the above.

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3) This information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Annex C
(informative)

Further important properties of reflective materials

C.1 Cleaning

The cleaning of the surface should be in accordance with manufacturers' instructions.

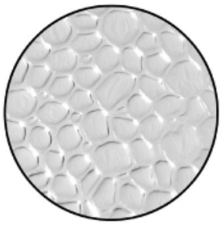
C.2 Solvent Resistance

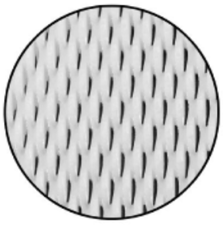
It should be noted that reflectors made of organic based materials may have limited solvent resistance. Notice should be taken for organic-based materials, such as laminated films or painted materials.

In applications where the reflector may come into contact with organic solvents, it may be necessary to undertake solvent resistance testing.

Annex D
(informative)

Examples of structured surfaces

Surface picture	Description of the surface
	Hammered Pattern small (concave). Also available in convex form. . It is generally accepted to measure only total reflectance. Abrasion resistance according to 5.5 and scratch resistance according to 5.6 cannot be tested satisfactorily on this surface.
	Hammered Pattern medium (concave). Also available in convex form. It is only possible to measure total reflectance. It is generally accepted to measure only total reflectance. Abrasion resistance according to 5.5 and scratch resistance according to 5.6 cannot be tested satisfactorily on this surface.
	Hammered Pattern large (concave). Also available in convex form. It is only possible to measure total reflectance. It is generally accepted to measure only total reflectance. Abrasion resistance according to 5.5 and scratch resistance according to 5.6 cannot be tested satisfactorily on this surface.
	Stucco. Typical uneven structure. It is generally accepted to measure only total reflectance. Abrasion resistance according to 5.5 and scratch resistance according to 5.6 cannot be tested satisfactorily on this surface.
	Dessin with small dots. It is generally accepted to measure only total reflectance. Abrasion resistance according to 5.5 and scratch resistance according to 5.6 cannot be tested satisfactorily on this surface.

Surface picture	Description of the surface
	Dessin with honey-comb structure (concave). Regularly structure also in convex available. It is generally accepted to measure only total reflectance. Abrasion resistance according to 5.5 and scratch resistance according to 5.6 cannot be tested satisfactorily on this surface.
	Dessin with soft faceted structure. It is generally accepted to measure only total reflectance. Abrasion resistance according to 5.5 and scratch resistance according to 5.6 cannot be tested satisfactorily on this surface.

Bibliography

[1] EN ISO 4892-1, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance (ISO 4892-1)*

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