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Anodizing of aluminium and its alloys — Measurement of reflectance characteristics of aluminium surfaces using a goniophotometer or an abridged goniophotometer

Anodisation de l'aluminium et de ses alliages — Mesurage des caractéristiques de réflectivité des surfaces d'aluminium à l'aide d'un goniophotomètre normal ou simplifié

Reference number
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Foreword

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ISO 7759 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 2, *Organic and anodic oxidation coatings on aluminium*.

This second edition cancels and replaces the first edition (ISO 7759:1983), which has been technically revised.

Introduction

The visual appearance of metallic finishes is important commercially on metals for automotive, architectural, and other uses where these metals undergo special finishing processes to produce the desired appearance. For end-products which use such finished metals, it is important that parts placed together have the same appearance. Specular reflectance is one of the properties measured, but additional measurements are usually required to identify adequately the appearance of any metal surface. In the method described in this International Standard, several important aspects of surface appearance are identified and can be measured. Those surfaces having identical sets of numbers will normally have the same reflectance characteristics and the same appearance (see References [1], [2] and [3]).

Anodizing of aluminium and its alloys — Measurement of reflectance characteristics of aluminium surfaces using a goniophotometer or an abridged goniophotometer

1 Scope

This International Standard specifies a method for the measurement of the reflectance characteristics of high-gloss anodized aluminium surfaces.

The method described is also suitable for the measurement of the reflectance characteristics of other high-gloss metal surfaces.

The method is not suitable for diffuse-finish metal surfaces and does not measure colour.

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.

CIE 38:1977, *Radiometric and Photometric Characteristics of Materials and their Measurement*

3 Terms and definitions

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

3.1
goniophotometer
instrument in which specimens can be illuminated at selected angles of incidence and in which the light reflected in different directions can be measured

3.2
abridged goniophotometer
goniophotometer having a fixed angle of incidence and specific fixed direction(s) at which light reflected from the specimen is measured

NOTE The instrument described in this International Standard uses an angle of incidence of 30° and directions for measurement of reflected light of −30°, −30° ± 0,3°, −30° ± 2°, −30° ± 5°, and −45°, although some suitable instruments can be measured only on one side of the 30° angle.

4 Principle

4.1 The visual appearance of an anodized aluminium surface is characterised by means of six different properties (see 4.2 to 4.7) of the reflected light coming from a narrow-source beam incident on the surface at an angle of 30°.

4.2 Specular reflectance, R_s, is measured at 30° to the specimen normal using narrow source and receiver field angles (0,50° wide, maximum in the plane of the angle of reflection).

4.3 Distinctness of reflected image, R_i, is determined from the slightly off-specular reflectance ($R_{30 \pm 0,3}$) measured at 29,7° and 30,3°, the instrument integrating the light received from both of these apertures.

4.4 Narrow-angle haze, H_n, is determined from reflectance measurements taken at angles of 28° or 32° or both, i.e. at 2° away from the specular beam ($R_{30 \pm 2}$).

4.5 Wide-angle haze, H_w, is determined from reflectance measurements taken at angles of 25° or 35° or both, i.e. 5° away from the specular beam ($R_{30 \pm 5}$).

4.6 Diffuseness, R_d, is determined from a reflectance measurement taken at an angle of 45°, i.e.15° away from the specular beam (R_{45}).

4.7 Directionality, D_h, of the surface, derived from the ratio of two measurements of the narrow-angle haze, H_n, the first taken when the incident light is perpendicular to the direction of the surface texture and the second when the incident light is parallel to the surface texture, i.e. the rolling, extrusion or machining direction.

5 Apparatus

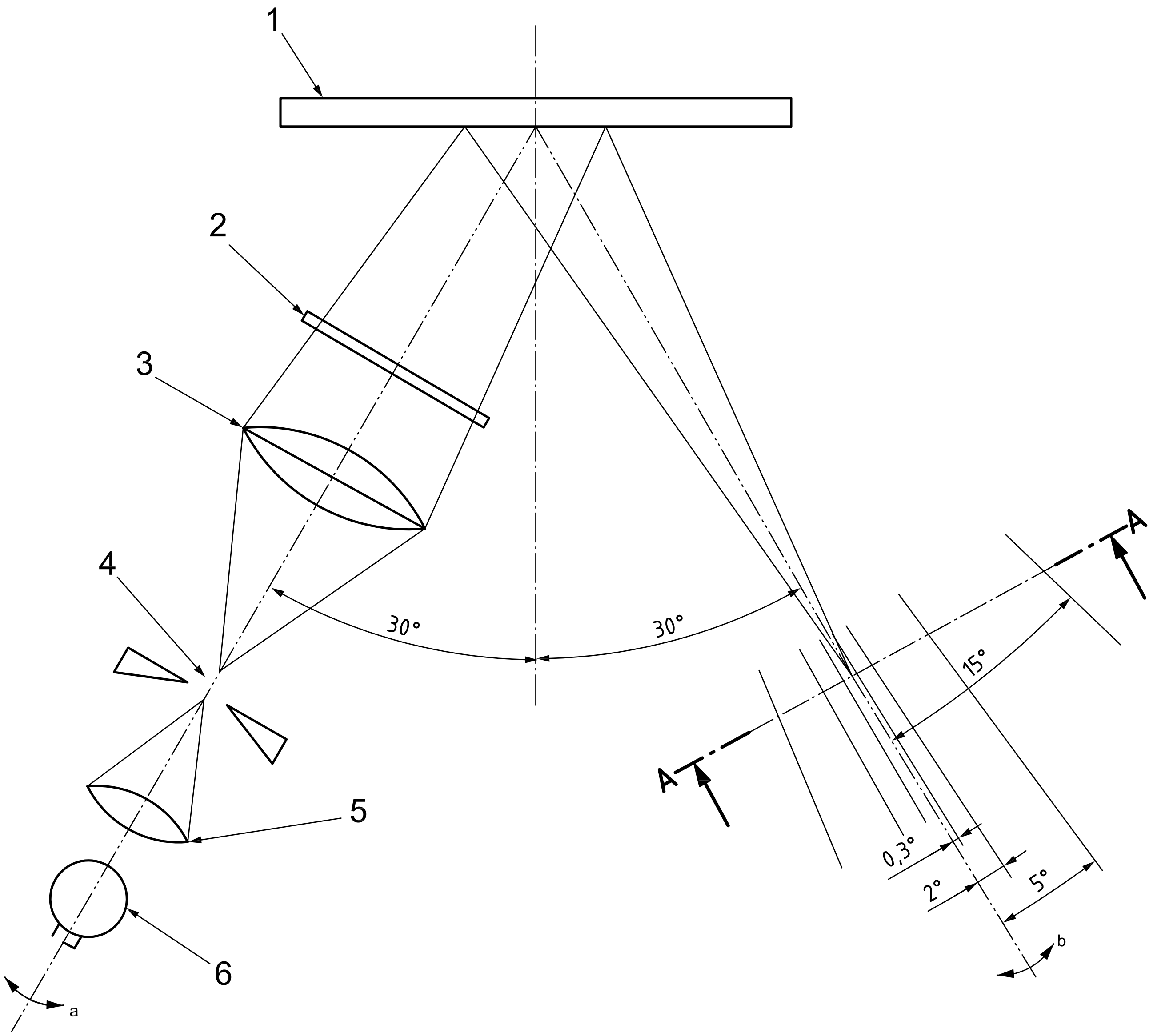
5.1 **Goniophotometer** or **abridged goniophotometer**, see Figures 1 and 2, capable of achieving the specific beam and field angles given in Table 1. The voltage regulation of the instrument shall be set to ±0,01 %.

NOTE Details of the precision and accuracy of goniophotometers are given in Annex A.

Table 1 — Dimensions of the mirror image of the source-slit, and of the receiver windows measured in the same plane (see Figures 1 and 2)

Values in degrees

Parameter	Source-slit mirror image	Specular receiver window	Distinctness-of-image receiver window	Haze receiver windows		Diffuseness receiver window
Angle of centre of window (measured from perpendicular to specimen surface)	30,0 ± 0,4	30,0 ± 0,4	30,30 ± 0,04 and 29,70 ± 0,04	28,0 ± 0,4 and 32,0 ± 0,4	25,0 ± 0,4 and 35,0 ± 0,4	45,0 ± 0,4
Width (in the plane of the angle of reflection)	0,44 ± 0,01	0,40 ± 0,01	0, 14 ± 0,01	0,4 ± 0,1	0,5 ± 0,1	2,0 ± 0,2
Length (across the plane of the angle of reflection)	5,0 ± 1,0	3,0 ± 1,0	3,0 ± 1,0	3,0 ± 1,0	3,0 ± 1,0	3,0 ± 1,0

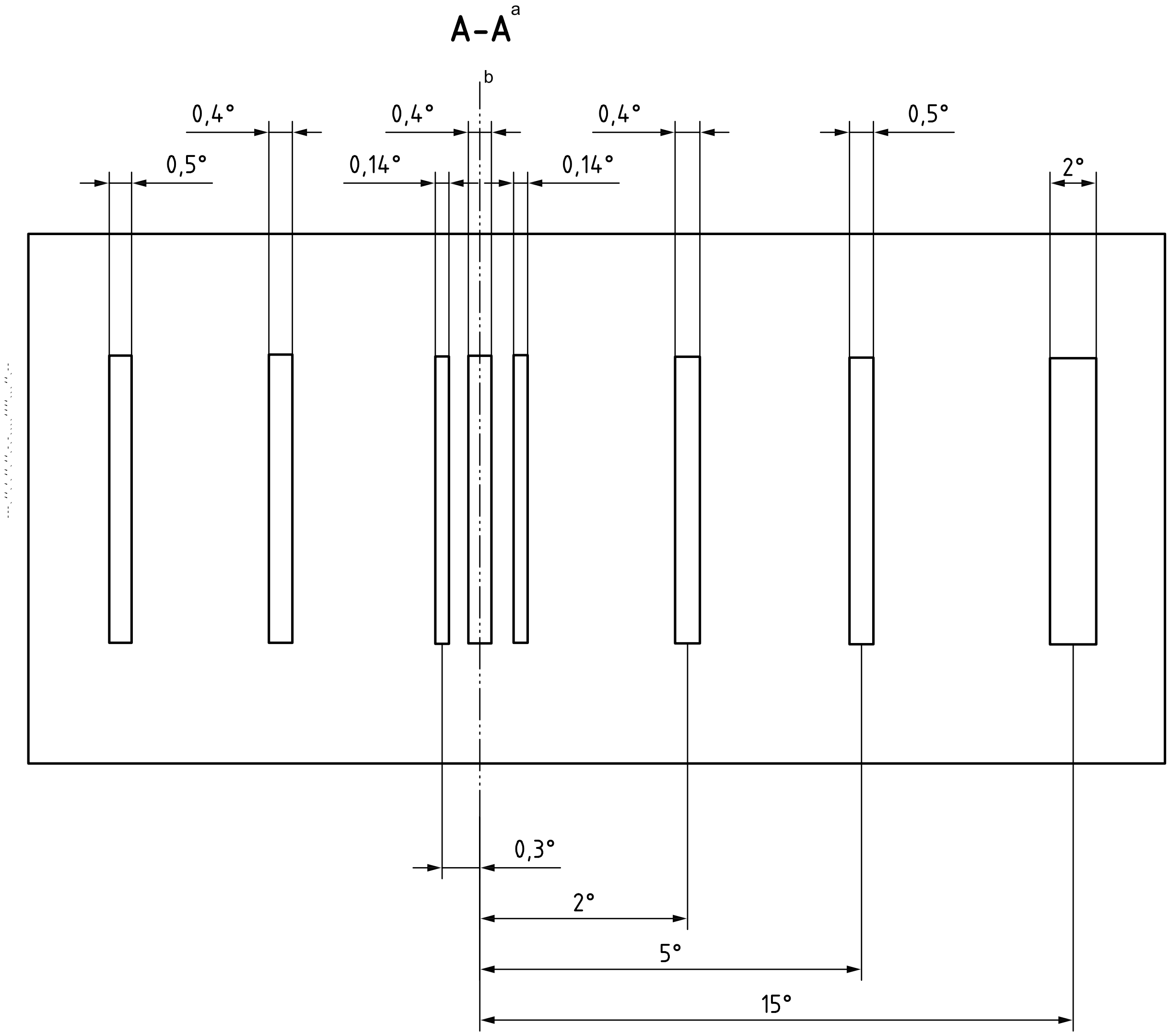


Key

1 test piece
2 neutral density filter (for high-specularity materials)
3 source object lens
4 source slit
5 condenser lens
6 lamp

a Source-arm centre-line adjustment for maximum peak (optional).
b Receiver-window array centre-line adjustment for maximum peak (optional).

Figure 1 — Optical diagram of a typical abridged goniophotometer: general geometry of measurement
(angles not to scale)



a Sectional drawing from Figure 1.

b Centre of reflected beam.

Figure 2 — Optical diagram of a typical abridged goniometer: arrangement of receiver windows
(not to scale)

5.2 Rotatable clamp, of the type shown in Figure 3, for flattening and positioning the specimen during measurement.

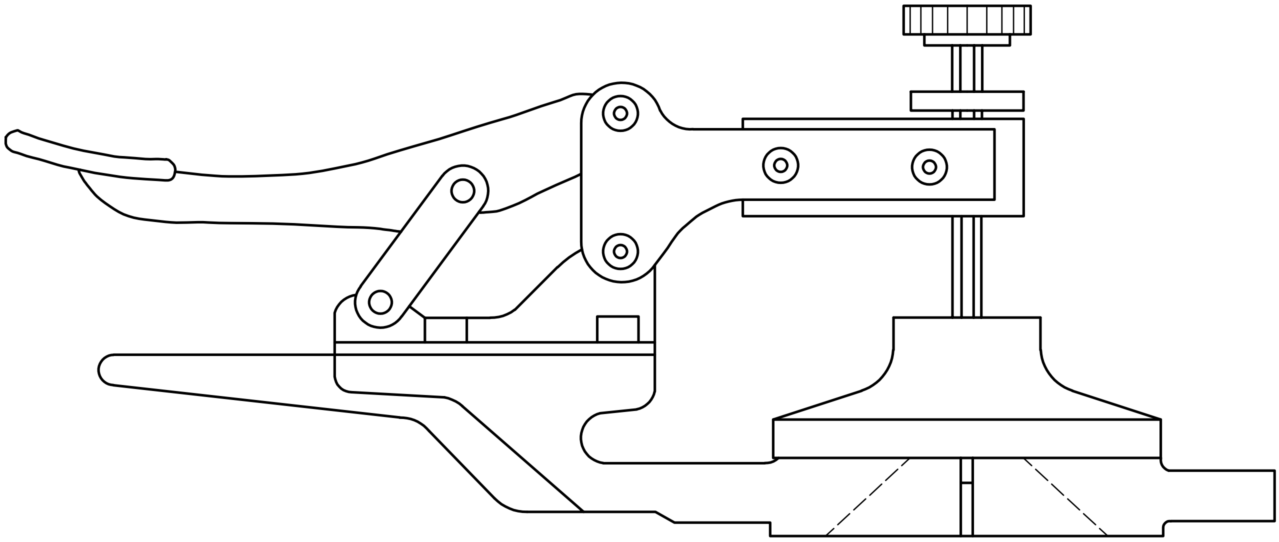


Figure 3 — Rotatable clamp suitable for flattening the test piece and positioning it during measurement

5.3 Reflectance standards

5.3.1 Three calibrated reflectance standards shall be available.

a) Aluminium evaporated onto plate glass and covered with a protective coating of silicon monoxide, and calibrated for specular reflectance and distinctness of the reflected image. The specular reflectance shall be 85 % ± 10 %.

b) Chromium evaporated onto plate glass and covered with a protective coating of silicon monoxide and calibrated for specular reflectance and distinctness of the reflected image. The specular reflectance shall be 62 % ± 10 %.

c) Reflecting plate with a white diffuse surface from which reflected light has a substantially constant luminance over the angular range of the instrument.

Where the distinctness of the reflected image is being measured, standards intermediate in reflectance and made from anodized aluminium may be useful.

5.3.2 It is essential that standards are kept clean and free from scratches, as well as from contact with contaminating materials. Follow the cleaning method specified by the instrument manufacturer and check standards at regular intervals against reference standards held in reserve.

6 Preparation and calibration of apparatus

6.1 General conditions

Use the instrument (see 5.1) in a clean dry area free from draughts. Switch the instrument on at least 30 min before use.

6.2 Geometric conditions

The direction of incidence shall be 30°. The directions of view shall be opposite to the directions of incidence at angles of –30°, –30° ± 0,3°, –30° ± 2°, –30° ± 5° and –45°. The angular dimensions of the mirror reflected image of the source-slit in the plane of measurement, and the angular dimensions of the receiver windows in this plane of measurement, shall be as shown in Table 1.

6.3 Spectral conditions

The measurement shall be made using a source of visible light with appropriate filters, such that the spectral product of the light source, spectral filters and spectral response of the light detector shall closely simulate the spectral product of CIE Standard Illuminant C (or D_{65}) and the standard observer function, in accordance with CIE 38:1977.

6.4 Calibration

Adjust the instrument to read the same arbitrary reflectance value for the intensity of light reflected from the diffuse white standard [see 5.3.1 c)] through the specular, distinctness-of-image and haze apertures. Adjust the instrument to read the values of specular reflectance and distinctness of reflected image assigned to the aluminium mirror [see 5.3.1 a)]. If the instrument does not then read the values for the chromium standard [see 5.3.1 b)] within the limits set by the instrument manufacturer, refocus or recalibrate following the manufacturer's instructions.

7 Procedure

Measure the test piece and insert it with the plane of measurement parallel to the longitudinal direction. Clamp the test piece to ensure adequate flatness during observation. To locate the exact longitudinal direction, rotate the clamp (5.2) with the specimen in it to the maximum indication of specular reflectance or distinctness of reflected image, whichever is the more sensitive. After observations in the longitudinal direction, rotate the test piece in the clamp through 90° for the required transverse observations. Measure three separate areas in each direction. Take readings on the reflectance standards (5.3) at frequent intervals and at the end of a series of observations to ensure that the instrument has remained in calibration throughout the operation.

8 Expression of results

8.1 General

Calculate the mean of the three readings on the test piece in both the longitudinal and transverse directions, and for each of the apertures (see Clause 4), using the equations given in 8.2 to 8.7.

8.2 Specular reflectance R_s

$$R_\mathrm{s} = R_{30}$$

8.3 Distinctness of reflected image R_i

$$R_\mathrm{i} = \left(1 - \frac{R_{30 \pm 0,3}}{R_\mathrm{s}}\right) \times 100$$

8.4 Narrow-angle haze H_n

$$H_\mathrm{n} = \left(\frac{R_{30 \pm 2}}{R_\mathrm{s}}\right) \times 100$$

8.5 Wide-angle haze H_w

$$H_\mathrm{w} = \left(\frac{R_{30 \pm 5}}{R_\mathrm{s}}\right) \times 100$$

8.6 Diffuseness R_d

$$R_d = \left(\frac{R_{45}}{R_s} \right) \times 100$$

8.7 Directionality D_h

$$D_h = \left(\frac{H_{n(T)}}{H_{n(L)}} \right) \times 100$$

where T refers to the transverse and L refers to the longitudinal direction.

9 Test report

The test report shall include at least the following information:

a) a reference to this International Standard;

b) the type, application and identification of the product tested;

c) the instrument used, including the manufacturer's name, model and serial number;

d) the reflectance standards used (see 5.3.1) and their assigned reflectance values;

e) the specular reflectance, quoting longitudinal and transverse direction values and their mean (see 8.2);

f) the distinctness of the reflected image, quoting longitudinal and transverse direction values and their mean (see 8.3);

g) the narrow-angle haze, quoting longitudinal and transverse direction values and their mean (see 8.4);

h) the wide-angle haze, quoting longitudinal and transverse direction values and their mean (see 8.5);

i) the diffuseness, quoting longitudinal and transverse direction values and their mean (see 8.6);

j) the directionality (see 8.7);

k) identification of any test pieces whose individual values on any scale differ by more than 3,0 from the mean;

l) any deviation, by agreement or otherwise, from the procedure specified;

m) the date of the test.

Annex A
(informative)

Precision and accuracy of goniophotometers

A.1 An indication of the accuracy of goniophotometer measurements is shown in Table A.1 by the values of Spearman-rank correlation coefficients. The data were obtained with a set of 20 aluminium and stainless-steel test pieces selected for a wide range of reflectance characteristics. Measurements using an abridged goniophotometer were compared with visual assessments made by viewing in the longitudinal direction only. Visual judgements of haze were made by ranking the specimens according to the amount of near-specular reflection (milkiness) adjacent to the image of a concentrated light source. The abridged goniophotometer was also compared with a second abridged goniophotometer of different manufacture, a goniophotometer and two other instruments used for image clarity measurements. A more complete report of these findings is available in Reference [3].

A.2 Instrument reproducibility data are shown in Table A.2. Five panels of anodized aluminium sheet, ranging from 12 to 77 in specular reflectance and 24 to 97 in distinctness of reflected image, were calibrated with a goniophotometer and then measured with three abridged goniophotometers. One of the abridged goniophotometers used optical-fibre receiver windows and two instruments had receiver windows of segmented silicon photocells.

Table A.1 — Spearman-rank correlation coefficients for distinctness of reflected image and haze when comparing various instruments1)

Comparison between	Distinctness of reflected image	Haze at 2°	Haze at 5°
Instrument I and visual assessment	0,91	0,82	0,96
Instrument I and instrument II	—	—	0,98
Instrument I and instrument III	0,93	—	0,96
Instrument I and instrument IV	0,87	—	—
Instrument I and instrument V	0,94	—	—
Instrument I: DoriGon abridged goniophotometer Instrument II: Alcoa abridged goniophotometer Instrument III: D10-5 full goniophotometer Instrument IV: Alcoa Dori meter Instrument V: D36B distinctness-of-image glossmeter			

Table A.2 — Instrument reproducibility data

Number of instruments	Root-mean-square differences from goniophotometer assigned values	
	Specular reflectance R_{30}	Distinctness of reflected-image R_i
One instrument with receiver windows filled with optical fibres	1,4	1,5
Average two instruments with segmented silicon photocell light receivers	2,2	1,1

1) Example(s) of suitable instruments available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these instruments.

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[2] CHRISTIE, J.S., *Instruments for Metallic Appearance, Appearance of Metallic Materials,* ASTM STP 478, American Society for Testing Materials, ASTTA, 1971

[3] CHRISTIE, J.S., *An Instrument for the Geometric Attributes of Metallic Appearance,* Applied Optics, (9), September 1969

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