International Standard 7759

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Anodizing of aluminium and its alloys — Measurement of reflectivity characteristics of aluminium surfaces using abridged goniophotometer or goniophotometer

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

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Foreword

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0 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 appearance desired. For end-products which use such finished metals, it is important that parts placed together have the same appearance. Specular reflectivity is one of the properties measured, but additional measurements are usually required to identify adequately the appearance of any metal. In the present method, several important aspects of the surface appearance are identified and can be measured. Those surfaces having identical sets of numbers normally will have the same reflectivity characteristics and the same appearance (see Bibliography [1] and [2]).

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1 Scope and field of application

This International Standard specifies a method for the measurement of the reflectivity characteristics responsible for the appearance of high-gloss metal surfaces.

The method is not suitable for diffuse-finish metal surfaces, nor does it measure colour, which is another appearance attribute.

2 Principle

2.1 Visual appearance of the anodized aluminium surface is described by means of five geometrically different measurements of the reflected light coming from a narrow source beam which is incident on the surface at an angle of 30°.

2.2 Specular reflectivity (R_s) is measured at 30° to the specimen normal using narrow source and receiver field angles (0,5° wide, maximum in the plane of the angle of reflection).

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

2.4 Narrow angle haze is determined from a reflectivity measurement taken at an angle of 32°, that is at 2° away from the specular beam (R_{32}).

2.5 Wide angle haze is determined from a reflectivity measurement taken at an angle of 35°, that is at 5° away from the specular beam (R_{35}).

2.6 Diffuseness is determined from a reflectivity measurement taken at an angle of 45°, that is at 15° away from the specular beam (R_{45}).

2.7 Directionality of the surface is obtained from the ratio of two measurements of the narrow angle haze, R_{32}, 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., rolling, extrusion or machining direction).

3 Apparatus

3.1 Abridged goniophotometer (see figure 1) or a **full goniophotometer** which can be set to the specific beam and field angles given in table 1.

A goniophotometer is an instrument with which specimens can be illuminated at selected angles while the light reflected (or transmitted) by the specimens in different directions is measured.

An abridged goniophotometer has a fixed angle of incidence (in this case 30°), and specific fixed directions of view in which light from the specimen can be taken for measurement (in this case −30°, −30° ± 0,3°, −32°, −35° and −45°).

Details of precision and accuracy of goniophotometers are given in the annex.

3.2 Rotatable clamp, of the type shown in figure 2, for flattening and positioning the specimen during measurement.

3.3 Standards.

3.3.1 Three calibrated standards shall be available:

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

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

c) White diffuse surface reflecting plate from whose surface the reflected light is of substantially constant intensity over the angular range of the instrument.

3.3.2 It is essential that the standards be 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 the standards at regular intervals against reference standards held in reserve.

4 Preparation and calibration of apparatus

4.1 Location

The instrument (3.1) shall be used in a clean dry area free from draughts. Standard laboratory conditions are recommended. Voltage regulation to ± 0,01 % shall be incorporated in the instrument or supplied separately. If the instrument is not kept on standby, it should be given at least a 30 min warm-up prior to use.

4.2 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°, −32°, −35° 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.

4.3 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 Source C (or D_{65}) and the standard observer function.

4.4 Calibration

Adjust the instrument to read the same reflectivity (arbitrary) for the intensity of light reflected from the diffuse white standard [3.3.1 c)] through the specular, distinctness-of-image and haze apertures. Adjust the instrument to read the values of specular reflectivity and distinctness-of-reflected-image assigned to the aluminium mirror [3.3.1 a)]. If the instrument does not then read the chromium standard [3.3.1 b)] within the limits set by the instrument manufacturer, refocus or recalibrate following the manufacturer's instructions.

5 Procedure

After calibration, measure each of the test specimens. Insert each with the plane of measurement parallel to the longitudinal direction and clamp the specimen to ensure adequate flatness during observation. To locate the exact longitudinal direction, rotate the clamp (3.2) with the specimen in it to the maximum indication of specular reflectivity or distinctness-of-reflected-image, whichever is the more sensitive. After observations in the longitudinal direction, rotate the specimen in the clamp through 90° for the required transverse observations. Measure three specimen areas in each direction for each of the samples. Take readings on the standards (3.3) at frequent intervals and at the end of the series of observations to ensure that the instrument has remained in calibration throughout the operation.

6 Calculation

Calculate the averages of the three readings for each specimen in both the longitudinal and transverse directions, and for each of the apertures (clause 2).

6.1 Specular reflectivity, R_s

$$R_s = R_{30}$$

6.2 Distinctness-of-reflected-image, D/I

$$D/I = \left[1{,}0 - \frac{R_{30} \pm 0{,}3}{R_s} \right] \times 100$$

6.3 Narrow angle haze, H_n

$$H_n = \left(\frac{R_{32}}{R_s} \right) \times 100$$

6.4 Wide angle haze, H_w

$$H_w = \left(\frac{R_{35}}{R_s} \right) \times 100$$

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6.5 Diffuseness, R_d

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

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6.6 Directionality, D

$$D = \frac{H_{32\,(T)}}{H_{32\,(L)}} \times 100$$

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

NOTE

$$D = \frac{H_{n\,(T)}}{H_{n\,(L)}} \times 100$$

7 Test report

The test report shall contain the following information:

a) the specular reflectivity, quoting longitudinal and transverse direction values and their average;

b) the distinctness-of-reflected-image, quoting longitudinal and transverse directions and their average;

c) the narrow angle haze, quoting longitudinal and transverse direction values and their average;

d) the wide angle haze, quoting longitudinal and transverse direction values and their average;

e) the diffuseness, quoting longitudinal and transverse direction values and their average;

f) the directionality;

g) identification of the instrument used by model and serial number. Identify all standards by number and assigned values of reflectivity as used. Identify the samples by types and designation;

h) a report of any samples whose individual values on any scale differ by more than 3,0 from the average value reported.

Table 1 — Dimensions of the mirror image of the source-slit, and of the receptor windows measured in the plane of the receiving windows (see fig. 1)

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 ± 0,25	30[1)]	30,3 ± 0,22[2)] or 29,7 ± 0,02	32 ± 0,1 or 35 ± 0,1	45 ± 0,5
Width (in the plane of the angle of reflection)	0,44 ± 0,02	0,4 ± 0,02	0,14 ± 0,02	0,4 ± 0,1 or 0,5 ± 0,1	2 ± 0,2
Length (across the plane of the angle of reflection)	5,0 ± 1	3,0 ± 1	3,0 ± 1	3,0 ± 1	3,0 ± 1

1) To be within ± 0,1° of the actual specular direction.

2) Apertures to be symmetrically placed on each side of the R_{30} aperture and 0,3° from it.

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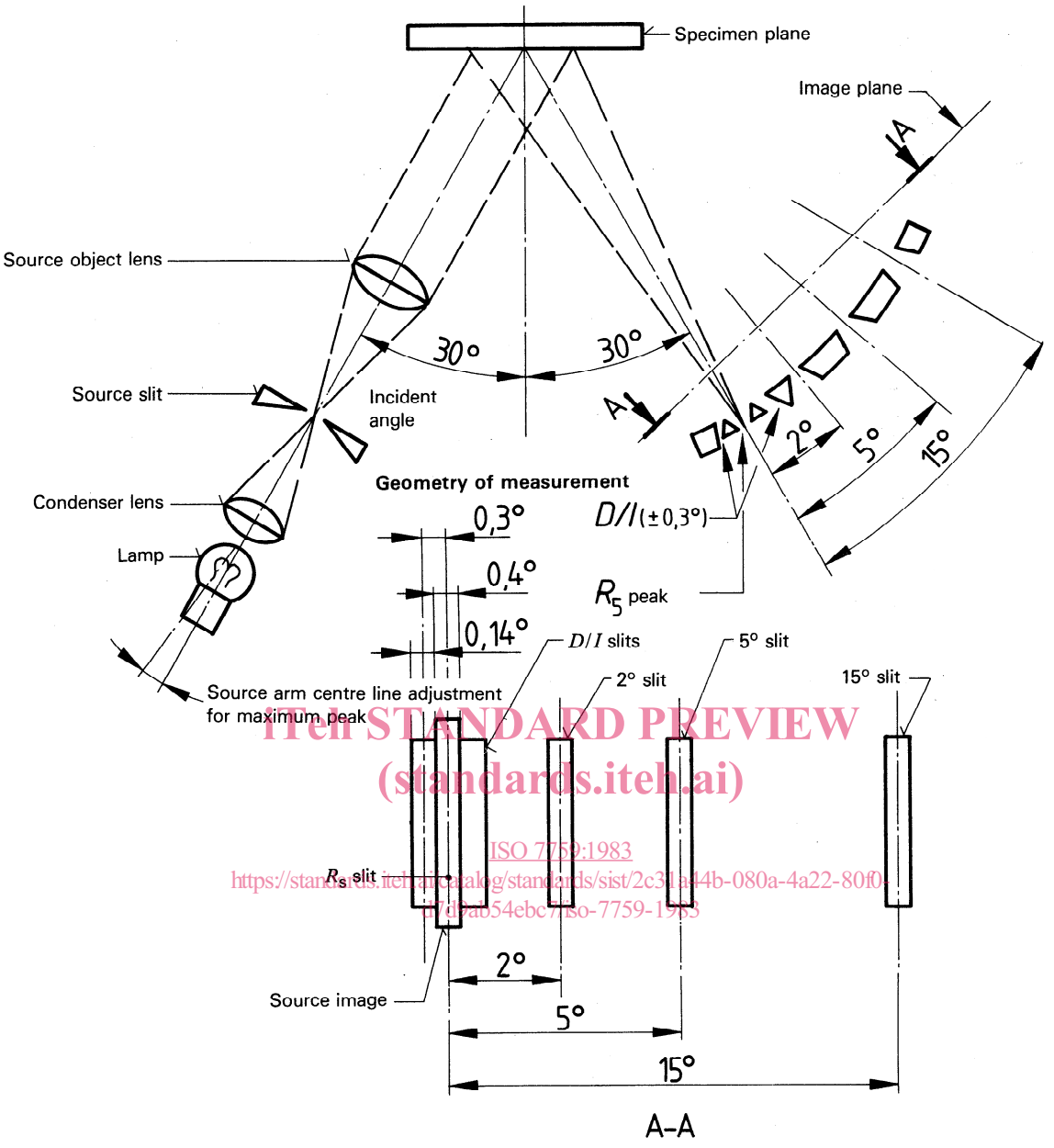

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Figure 1 — Optical diagram of the abridged goniophotometer

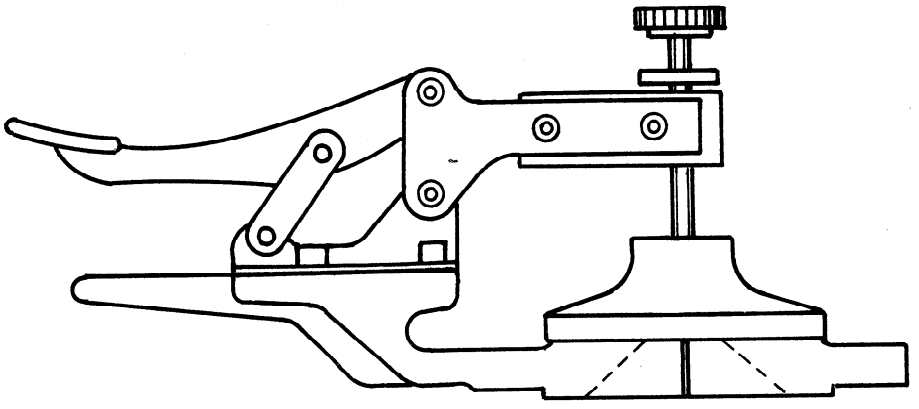

Figure 2 — A rotatable clamp suggested for flattening the specimen and positioning it during measurement

Annex

Precision and accuracy of goniophotometers

A.1 An indication of the accuracy of goniophotometer measurements is shown in table 2 by the values of Spearman rank correlation coefficients. The data were obtained with a set of 20 aluminium and stainless steel specimens selected for a wide range of reflectivity characteristics. Measurements using an abridged goniophotometer (I) were compared with visual assessments made by sighting in the L 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 instrument of different manufacturer (II), a full goniophotometer (III) and two other instruments (IV and V) used for image clarity measurements. A more complete report of these findings appears in [3] of Bibliography.

A.2 Instrument reproducibility data are shown in table 3. Five panels of anodized aluminium sheet, ranging from 12 to 77 in specular reflectivity and 24 to 97 in distinctness-of-reflected-image, were calibrated with a full goniophotometer and then measured with three abridged goniophotometers. One of the abridged goniophotometers had optical fibres filling the receptor windows and two instruments had receptor windows of segmented silicon photocells.

Table 2 — Spearman rank correlation coefficients for distinctness-of-reflected-image and haze when comparing various instruments

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	—	—

I DoriGon abridged goniophotometer
II Alcoa abridged goniophotometer
III D10-5 full goniophotometer
IV Alcoa Dori meter
V D36B distinctness-of-image glossmeter

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Table 3 — Instrument reproducibility data

Number of instruments	RMS differences from goniophotometer assigned values	
	Specular reflectivity R_{30}	Distinctness-of-reflected-image D/I
One instrument with receptor windows filled with optical fibres	1,4	1,5
Average, two instruments with segmented silicon photocell light receivers	2,2	1,1

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