Designation: ~~D5767 – 95 (Reapproved 2012)~~ D5767 – 17

Standard Test ~~Methods~~Method for Instrumental Measurement of Distinctness-of-Image (DOI) Gloss of ~~Coating~~Coated Surfaces[1]

This standard is issued under the fixed designation D5767; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 ~~This~~These test ~~method describes~~methods describe the measurement of the distinctness-of-image (DOI) gloss of coating surfaces using electro-optical measuring techniques. ~~The coatings must be applied to planar rigid surfaces. The scale values obtained from the alternative methods cited do not agree.~~

1.2 The coatings assessed shall be applied to planar rigid surfaces.

1.3 *Test Method*—~~Three test methods are covered as follows:~~The light through a small slit is projected on the specimen surface and its reflected image intensity is measured through a sliding combed shutter to provide a value of image clarity.

~~1.2.1 *Test Method A*—Gloss reflectance factor measurements are made on the specimen at the specular viewing angle and at an angle slightly off the specular viewing angle. The values obtained are combined to provide a DOI value. Very narrow source and receptor aperture angles are used in the measurements.~~

~~1.2.2 *Test Method B*—The light through a small slit is projected on the specimen surface and its reflected image intensity is measured through a sliding combed shutter to provide a value of image clarity.~~

~~1.2.3 *Test Method C*—The light through a pattern is projected on the specimen surface and its reflected image intensity is measured directly to provide a value of image clarity.~~

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of ~~whoever uses~~ the user of this standard to ~~consult and~~ establish appropriate ~~safety~~ safety, health and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D523 Test Method for Specular Gloss
D823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels
D2457 Test Method for Specular Gloss of Plastic Films and Solid Plastics
D3964 Practice for Selection of Coating Specimens for Appearance Measurements
D4039 Test Method for Reflection Haze of High-Gloss Surfaces
E284 Terminology of Appearance
E430 Test Methods for Measurement of Gloss of High-Gloss Surfaces by Abridged Goniophotometry
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *~~Other~~ISO Standards:*[3]

ISO 10216 ~~Anodized Aluminum and Aluminum Alloys—Instrumental Determination of Image Clarity of Anodic Oxidation Coatings—Instrumental Method~~Anodizing of aluminum and its alloys—Instrumental determination of image clarity of anodic oxidation coatings—Instrumental method

[1] This test method is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.03 on Geometry. Current edition approved ~~July 1, 2012~~June 15, 2017. Published ~~August 2012~~September 2017. Originally approved in 1995. Last previous edition approved in ~~2004~~2012 as D5767 – 95 ~~(2004).~~(2012). DOI: ~~10.1520/D5767-95R12.~~10.1520/D5767-17.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

~~DIMENSIONS HA-NSIC~~
~~A- Light Source – 12V; 20W~~
~~B- Lens – f 45 mm~~
~~C- Pattern C1 – 6 mm~~
~~C2 – 63.5µ m~~
~~C3 – 63.5µm~~
~~D- Pattern/Lens Dist. – 26 mm~~
~~E- Lens – f 50 mm~~
~~F- Lens/Test Spec. Dist – 100 mm~~
~~G- Light Angle – 1.39°~~
~~H- Inc./Ref. Angle – 20°~~
~~I- Test Spec./Sen. Dist. – 489 mm~~
~~J- Im. Seh. 1024ch ccd – 14.33 mm~~

TABLE 1 Reflectance Precision Data

Test Specimen	Average or Central Tendency of Test Data $\bar{X}$	Repeatability Standard Deviation Within Laboratory S_r	Reproducibility Standard Deviation Between Laboratories S_R	95 % Repeatability Limit Within a Laboratory r	95 % Reproducibility Limit Between Laboratories R
Comb Width C = 0.125					
A-1	50.6	0.8	2.6	2.3	7.4
A-2	12.3	0.7	2.3	1.9	6.4
A-3	2.0	0.2	0.5	0.5	1.4
A-4	1.8	0.2	0.5	0.5	1.4
Comb Width C = 0.25					
A-1	89.4	0.5	1.6	1.5	4.6
A-2	58.4	0.6	1.6	1.6	4.5
A-3	3.7	0.1	0.4	0.3	1.1
A-4	2.6	0.1	0.3	0.2	0.6
Comb Width C = 0.5					
A-1	93.1	0.3	1.0	0.8	2.9
A-2	86.2	0.3	1.0	0.9	2.9
A-3	13.0	0.2	1.3	0.5	3.6
A-4	5.1	0.1	0.5	0.2	1.5
Comb Width C = 1.0					
A-1	94.4	0.3	0.8	0.9	2.2
A-2	91.5	0.3	0.7	0.9	1.9
A-3	48.4	0.3	1.0	1.0	2.7
A-4	21.9	0.2	0.8	0.5	2.1
Comb Width C = 2.0					
A-1	95.6	0.3	0.5	0.8	1.3
A-2	94.5	0.3	0.9	0.9	2.6
A-3	89.2	0.3	0.7	0.9	1.8
A-4	67.6	0.2	1.1	0.6	3.0

~~FIG. 4 Testing Apparatus for Image Clarity Measurement~~

ISO 17221 Plastics—Determination of image clarity (degree of sharpness of reflected or transmitted image)

3. Terminology

~~3.1 Terms and Definitions in Terminology E284 are applicable to these methods.~~

3.1 ~~*Definitions:*~~*Definitions*—Terms and definitions in Terminology E284 are applicable to these methods.

3.1.1 *distinctness-of-image (DOI) gloss, n*—aspect of gloss characterized by the sharpness of images of objects produced by reflection at a surface. **E284**

3.1.1.1 *Discussion*—

This quality is sometimes called ~~Image Clarity.~~image clarity.

3.1.2 *gloss reflectance factor, R_s, n*—ratio of the specularly reflected part of the (whole) flux reflected from the specimen to the flux reflected from a specified gloss standard under the same geometric and spectral conditions of measurements. **E284**

3.1.2.1 *Discussion*—

The gloss standard may be a black glass or mirror and may be assigned one of a variety of scale values as specified.

3.1.3 *specular angle, n*—~~the~~ angle of reflection equal and opposite to the angle of incidence. **E284**

4. Significance and Use

4.1 An important aspect of the appearance of glossy coating surfaces is the distinctness (clarity) of images reflected by them. The values obtained ~~by the measuring procedures given in these methods generally~~in this measuring procedure correlate well with visual ratings for DOI (image clarity).

4.2 Although Test Methods D523 and D4039 are useful in characterizing some aspects of glossy appearance, they do not provide satisfactory ratings for DOI (image clarity).

4.3 The measurement conditions given conform to the conditions specified in Test Methods E430.

4.4 The measurement conditions given in ~~Test Methods B and C~~ this test method conform to the conditions specified in ISO 10216.

4.5 The scale values obtained with the measuring procedures of ~~these methods~~ this test method range from 0 to 100 with a value of 100 representing perfect DOI (image clarity).

4.6 The DOI (image clarity) scale value does not, of itself, indicate any specific cause for reduction in reflected image sharpness. Surface irregularities such as haze, orange peel, and wrinkle, when present, may be cited as causes for reduction of image sharpness.

5. Apparatus

5.1 *Image Clarity Meter,* [4]consisting of a light source, a sliding combed shutter, a photo-receiver, and a device for analyzing image intensities (see Fig. 1).

5.2 *Principle*—The light through a small slit is projected on the specimen surface and its reflected image intensity through a sliding combed shutter is measured.

5.3 *Geometric Conditions*—The axis of the incident beam shall be 60° from the perpendicular to the specimen surface and the photo-receiver shall be at the mirror reflection of the axis of the incident beam. The source slit is 0.1 ± 0.02 mm in width and the photo-receiver shall receive a reflected image through a combed shutter of 18 slits of 7.5 mm in width.

NOTE 1—A more complete description of the spectral response function of this instrument is in ISO 17221.

6. Preparation and Selection of Test Specimens

6.1 ~~These~~This test ~~methods do~~method does not cover techniques for the preparation of test specimens. Whenever preparation of test specimens is required, use one of the procedures given in Practices D823. Selection of specimens for measurement should be done in accordance with Practice D3964.

7. ~~Correlation of Results of Test Methods A, B and C to Visual Perception of Image Distinction of Coating Surfaces~~ Reference Standards

7.1 ~~An analysis~~ The following analysis may be used to establish the specular gloss value, G_s, of the ~~results of~~ working standard:

$$Q = [(n)^2 - \sin^2(\theta)\ ]^{1/2} \quad (1)$$

~~a~~

$$r_{\parallel} = \left[\frac{\cos(\theta)\ - Q}{\cos(\theta)\ + Q}\right]^2 \quad (2)$$

$$r_{\perp} = \left[\frac{(n\ )^2\cos(\theta)\ - Q}{(n\ )^2\cos(\theta)\ + Q}\right]^2 \quad (3)$$

~~round~~

$$I = 0.5[(r_{\perp}) + (r_{\parallel})] \quad (4)$$

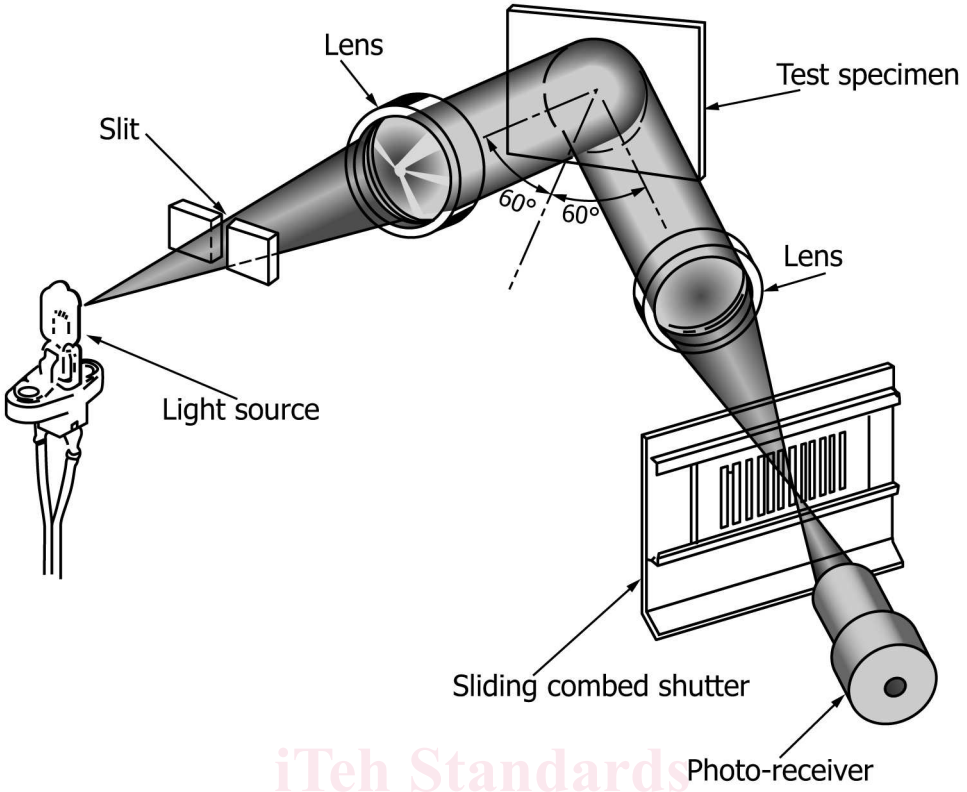
$$G_s = \frac{100\, I_{WS}}{I_{PS}} \quad (5)$$

~~robin~~

where:

Θ = angle of incidence of the collimated ray with respect to the normal in the rarer optical medium,
n = ratio of the index of refraction of the denser optical medium divided by the density of the rarer optical medium,
Q = placeholder for a reocurring expression in the equations,
$r_{\perp}$ = intensity, relative to that of the incident wave, of the specular reflection for the part of the reflected wave polarized perpendicular to the plane of incidence,

[4] The sole source of supply of the meter Model HA-ICM, Image Clarity, known to the committee at this time is Suga Test Instruments Co., Ltd., 4–14, Shinjuku 5–chome, Shinjuku-ku, Tokyo, 160 Japan. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.



DIMENSIONS HA-ICM
A—Slit—0.1 mm
B—Light Angle—22°
C—Slit/Lens Dist.—50 mm
D—Lens—f ~~50mm~~50 mm
E—Lens/Test Spec. Dist.—50 mm
F—Test Spec./Lens Dist.—50 mm
G—Lens—f 50 mm
H—Lens/Com. Shut. Dist.—50 mm
I—Light Angle—22°
J—Shut./Slit Length—10 mm
K—Shut./Slit Width—0.5 mm
L—Shut./Slit Space—0.5 mm

FIG. 1 ~~Testing Apparatus for~~Diagrammatical Representation of Image Clarity Measurement

$r_{\perp}$ = intensity, relative to that of the incident wave, of the specular reflection for the part of the reflected wave polarized parallel to the plane of incidence,
I = mean intensity of parallel and perpendicular waves,
I_{WS} = refers to the I value of the working standard,
I_{PS} = refers to the I value of the primary standard, and
G_S = specular gloss reading of a working standard with respect to the reading of the primary standard at a nominal value of 100 gloss units.

~~conducted by Task Group D 01.26.11 demonstrates the level of correlation between instruments currently included in these test methods and with visual perception.~~

7.1.1 For additional information on Eq 1, see Wyszecki and Stiles.[5]

Note 2—*Index of Refraction Sensitivity*—Each 0.01 increment in the index of refraction of polished black glass produces a change in the measured value of approximately 1.6 scale units for the 60° geometry.

Note 3—To determine the scale value:

7.1.1.1 Calculate the first surface Fresnel reflectance (see Test Method D2457) for n_D = 1.567. The specular angle is 60°. The calculated value is 10.0056 % or 100.0 units.

7.1.1.2 Assign this the full scale value of 100.0 units (see Test Method D523).

7.1.1.3 Repeat the calculation for n_D = 1.527. Using the same specular angle of 60°, the calculated value is 9.3636 % or 93.6 units.

[5] Wyszecki, G. and Stiles, W. S., *Color Science: Concepts and Methods, Quantitative Data and Formulae*, Second ed., John Wiley and Sons, New York, 1982, p. 52

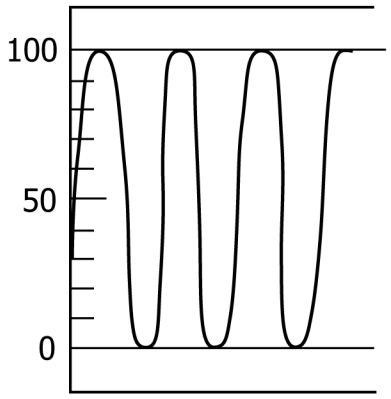


FIG. 2 Wave ~~Form of Received Light Obtained with Black~~Form—Standardization ~~Working Standard~~

7.1.1.4 The new scale value for the working black, glass standard for 60° is 100 × (9.3626/10.0056) = 0.9357 or 93.6 units.

7.2 *Verification Standards*—De-polished, opaque, black glasses and ceramic tiles having uniform, planar surfaces are suitable for verification standards when calibrated against a primary or working standard on an image clarity meter known to meet the requirements of the test method.

8. Procedure

8.1 *Standardization*—Standardize by adjusting the apparatus to read the assigned value of the polished black working standard.

8.2 *Verification*—Read the verification standards whose assigned values lie within the range of the instrument scale. The readings of the verification standards should agree within ±1 unit of their assigned values.

8.3 Place the specimen to be read on a flat surface.

8.4 Place the apparatus on the specimen surface and read *C*, the value of image clarity. Take readings at three different areas of the specimen surface.

8.5 Take reading of the working standard at the end of series of specimen readings to ensure that the apparatus has remained in calibration throughout the operation.

9. Calculation

9.1 Calculate the image clarity value from the maximum and the minimum light intensities, which the photo-receiver measures, using Eq 6 (see Fig. 2 and Fig. 3):

$$C = \frac{M - m}{M + m} \times 100 \tag{6}$$

where:

C = image clarity value, %,
M = maximum light intensity, and
m = minimum light intensity.

9.2 When the test specimen has a completely flat and smooth surface and the shutter is slid laterally, the reflected image of the slit at the sliding combed shutter passes completely through the space of the comb when the center of the comb space coincides with the image. This generates a maximum light intensity on the photo-receiver. When not completely flat and smooth, depending on the degree of dispersion of the light, the image cannot pass through the comb completely and generates a minimum light intensity. These maximum and minimum light intensities are used to calculate the image clarity value.

9.3 The instrument calculates and displays the image clarity value, *C*, directly.

10. Report

10.1 Report the following information:
10.1.1 *Image Clarity Values:*
10.1.1.1 Mean image clarity values and
10.1.1.2 Comb width.
10.1.2 *Operational Logistics:*
10.1.2.1 Date and location of test performed,
10.1.2.2 Operator performing test,

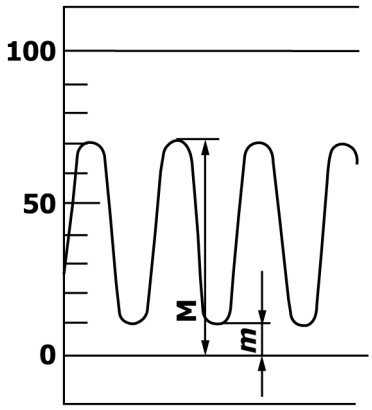


FIG. 3 ~~Example of Wave Form of Received Light Obtained with Test~~ Wave Form—Test Specimen

10.1.2.3 Facility where test performed,
10.1.2.4 Name of test instrument,
10.1.2.5 Model number of test instrument,
10.1.2.6 Last calibration date of instrument, and
10.1.2.7 Calibration standard identification.
10.1.3 *Sample Identification:*
10.1.3.1 Information regarding identification of sample and
10.1.3.2 Information regarding direction of measurement on sample.

11. Precision and Bias

11.1 *Precision:*

11.1.1 The experiment and data gathered for this section were acquired and computed in accordance with the requirements as outlined in Practice E691.[6] The materials used as test specimens to derive the precision data represent a diverse sampling of real-world materials. The intent is to show typical results that may be experienced by the user so that they can access in general terms the usefulness of these test methods to their proposed application. These data should guide the user as to the variability that can be expected within test results and between test results obtained in different laboratories.

11.1.2 There is no absolute or agreed upon material standard for image clarity; therefore, all precision data are presented in relative image clarity units. Hence, it is not possible to access bias.

11.2 *Repeatability Statement*—The repeatablity data were obtained in April 2014 using four different materials as test specimens. They were: (1) a painted steel plate with a mirror finish designated Test Specimen A-1, (2) a painted steel plate whose surface contains large orange peel designated Test Specimen A-2, (3) a painted steel plate whose surface contains medium orange peel designated Test Specimen A-3, and (4) a painted steel plate whose surface contains small orange peel desingated Test Specimen A-4. Ten consecutive measurements were gathered in the shortest period of time. The measurement test sequence was performed with replacement. The repeatability standard deviation has been determined for each test specimen and spacing on the optical mask. The data are presented in Table 1. The 95 % repeatability limit for each test specimen and the optical mask spacing are presented in Table 1.

11.3 *Reproducibilty Statement*—The reproducibility data were obtained from an instrument population of six different instruments in different locations by different operators on different days with the same test specimens in April 2014 using four different materials as test specimens. The test specimens were: (1) a painted steel plate with a mirror finish designated Test Specimen A-1, (2) a painted steel plate whose surface contains large orange peel designated Test Specimen A-2, (3) a painted steel plate whose surface contains medium orange peel designated Test Specimen A-3, and (4) a painted steel plate whose surface contains small orange peel designated Test Specimen A-4. The reproducibility standard deviation for each test specimen and spacing on the optical mask has been determined and are presented in Table 1. The 95 % repeatability limit for each test specimen and spacing on the optical mask are presented in Table 1.

11.4 *Bias*—No information can be presented on the bias of these test methods because there is no material having accepted reference values available.

[6] ~~The sole source of supply of the meter Model HA-NSIC, Image Clarity, known to the committee at this time is Suga Test Instruments Co., Ltd., 4–14, Shinjuku 5–chome, Shinjuku-ku, Tokyo, 160 Japan. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a~~Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E12-1009~~meeting of the responsible technical committee.~~. Contact ASTM Customer Service at[1] ~~which you may attend.~~service@astm.org.