



Designation: E 430 – 97 (Reapproved 2003)

Standard Test Methods for Measurement of Gloss of High-Gloss Surfaces by Goniophotometry¹

This standard is issued under the fixed designation E 430; 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 These test methods cover the measurement of the reflection characteristics responsible for the glossy appearance of high-gloss surfaces. Two test methods, A and B, are provided for evaluating such surface characteristics at specular angles of 30° and 20°, respectively. These test methods are not suitable for diffuse finish surfaces nor do they measure color, another appearance attribute.

1.2 As originally developed by Tingle and others (see Refs 1 and 2),² the test methods were applied only to bright metals. Recently they have been applied to high-gloss automotive finishes and other nonmetallic surfaces.

2. Referenced Documents

2.1 *ASTM Standards:*

D 523 Test Method for Specular Gloss³

D 2457 Test Method for Specular Gloss of Plastic Films and Solid Plastics⁴

E 171 Specification for Standard Atmospheres for Conditioning and Testing Flexible Barrier Materials⁵

E 179 Guide for Selection of Geometric Conditions for Measurement of Reflectance and Transmission Properties of Materials³

E 284 Terminology of Appearance³

E 308 Practice for Computing the Colors of Objects by Using the CIE System³

E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filler) Colorimetry³

3. Terminology

3.1 *Definitions:*

3.1.1 *Reflectance and Related Terms:*

3.1.1.1 *reflectance, ρ , n* —ratio of the reflected radiant or luminous flux to the incident flux in the given conditions. (E 284)

(1) *Discussion*—The term *reflectance* is often used in a general sense or as an abbreviation for *reflectance factor*. Such usage is not assumed in this method. The definition may require that the term be modified by adjectives denoting the spectral and geometric conditions of measurement.

3.1.1.2 *reflectance factor, R , n* —ratio of the flux reflected from the specimen to the flux reflected from the perfect reflecting diffuser under the same spectral and geometric conditions of measurement. (E 284)

3.1.1.3 *gloss reflectance factor, R_g , 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 measurement.

(1) *Discussion*—The gloss standard may be a black glass or a mirror, and may be assigned one of a variety of scale values G_s as specified. (E 284)

3.1.2 *Gloss and Types of Gloss:*

3.1.2.1 *gloss, n* —angular selectivity of reflected light, responsible for the degree to which reflected highlights or images of objects may be seen as superimposed on a surface. (E 284)

(1) *Discussion*—Gloss is responsible for the object's glossy appearance, not for an observer's perception of the appearance. At least six types or characteristics of gloss may be observed depending upon the character of the surface and the spatial distribution of the reflected light (3).

3.1.2.2 *specular gloss, n* —ratio of flux reflected in specular direction to incident flux for a specified angle of incidence and source and receptor angular apertures. (E 284)

3.1.2.3 *distinctness-of-image gloss, n* —aspect of gloss characterized by the sharpness of images of objects produced by reflection at a surface. (E 284)

3.1.2.4 *sheen, n* —the specular gloss at a large angle of incidence for an otherwise matte specimen. (The usual angle for measurement is 85°.) (E 284)

3.1.3 *Terms Relating to Surface Characteristics:*

¹ These test methods are under the jurisdiction of ASTM Committee E12 on Color and Appearance and are the direct responsibility of Subcommittee E12.03 on Geometry.

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² The boldface numbers in parentheses refer to the list of references at the end of this method.

³ *Annual Book of ASTM Standards*, Vol 06.01.

⁴ *Annual Book of ASTM Standards*, Vol 08.02.

⁵ *Annual Book of ASTM Standards*, Vol 15.09.

3.1.3.1 *directionality, n*—perceived, the degree to which the appearance of a surface changes as the surface is rotated in its own plane, under fixed conditions of illumination and viewing. (E 284)

3.1.3.2 *texture, n*—the visible surface structure depending on the size and organization of small constituent parts of a material; typically, the surface structure of a woven fabric. (E 284)

3.1.4 Other Terms:

3.1.4.1 *aperture angle, 2_{κ} , n*—angle subtended at a point on a specimen by the maximum dimension of the illuminator or receiver, within which the flux in a directional beam is contained.

(1) *Discussion*—In optics, the symbol κ is used for the half angle; hence the recommended symbol here is 2_{κ} . (E 284)

3.1.4.2 *goniophotometer, n*—instrument that measures flux as a function of angles of illumination or observation. (E 284)

3.2 Terms Specific to This Test Method:

3.2.1 Terms Relating to Reflection Haze:

3.2.1.1 *reflection haze, H, n*—for a specified specular angle, ratio of flux reflected at a specified angle (or angles) from the specular direction to the flux similarly reflected at the specular angle by a specified gloss standard.

(1) *Discussion*—Modifiers may be used to specify the angles at which the haze is measured (for example, 2° or 5°); whether H or a logarithmic form is to be stated; or whether H is to be compensated for the luminance of the specimen by multiplication by Y_{specimen}/Y_n , where n denotes the reference white; or any combination of these.

3.2.2 Terms Relating to Metallic Reflection:

3.2.2.1 *metallic brightness, n*—freedom of a metal surface from diffuse haze or texture.

3.2.3 Terms Relating to Specimen Directionality:

3.2.3.1 *'with-machine' direction, n*—the axis of a specimen that is parallel to the direction of mill rolling or extrusion, or other surface-finish texture.

3.2.3.2 *'across-machine' direction, n*—the perpendicular to 'with-machine' direction.

3.3 Other appearance terms and definitions in Terminology E 284 are applicable to this test method.

4. Summary of Test Method

4.1 Several geometrically different measures of light reflected by a surface are proposed for use in describing its gloss appearance. In Test Method A, gloss reflectance factor is measured at 30° to the specimen normal using narrow illuminator and receiver aperture angles (0.5° wide maximum). Distinctness-of-image gloss is measured at 29.7 or 30.3° or both. Narrow-angle (2°) reflection haze is measured at 28 or 32° or both, and wide-angle (5°) reflection haze at 25 or 35° or both. The ratio of reflectance factors for 28 or 32° or both, perpendicular and parallel to the machine direction of the specimen, is computed as a measure of directionality. In Method B, specular gloss is measured at 20° according to Test Method D 523, and narrow-angle reflection haze is measured at 18.1 and 21.9° . For additional information on the selection of geometric conditions, see Guide E 179.

5. Significance and Use

5.1 The gloss of metallic finishes is important commercially on metals for automotive, architectural, and other uses where these metals undergo special finishing processes to produce the appearances desired. It is important for the end-products which use such finished metals that parts placed together have the same glossy appearance.

5.2 It is also important that automotive finishes and other high-gloss nonmetallic surfaces possess the desired finished appearance. The present method identifies by measurements important aspects of finishes. Those having identical sets of numbers normally have the same gloss characteristics. It usually requires more than one measurement to identify properly the glossy appearance of any finish (see Refs 3 and 4).

6. Apparatus

6.1 The apparatus shall be either an abridged goniophotometer (see Fig. 1 and Fig. 2) or a full goniophotometer (see Fig. 3) that can be set to the specified specular, off-specular, and aperture angles given in Table 1 and Table 2. The abridged goniophotometer may have a fixed angle of incidence (for Test Method A, 30° ; for Test Method B, 20°) and specific fixed directions of view at which the flux from the specimen is measured (see Table 1 and Table 2).⁶

6.1.1 *Geometric Conditions for Test Method A*—The direction of incidence shall be 30° . The directions of view shall be opposite the direction of incidence at 30° for specular reflectance, 29.7 or 30.3° for distinctness of image comparisons, 28 or 32° for narrow-angle haze comparisons, and 25 or 35° for wide-angle haze comparisons. 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.

6.1.2 *Geometric Conditions for Test Method B*—The direction of incidence shall be $20 \pm 0.1^{\circ}$. The directions of view shall be opposite the direction of incidence, at 20° for specular gloss measurement and at 18.1 and 21.9° for narrow-angle reflection haze measurement. The angular dimensions of the specularly 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 2.

6.1.3 *Spectral Conditions*—The measurement shall be made with visible light to give results in accordance with the CIE spectral luminous efficiency function $V(\lambda)$ identical with \bar{y} in the CIE 1931 standard observer and CIE standard illuminant C (see Practice E 308 and Test Method E 1347). If another illuminant A, is used, this shall be specified in the report.

6.1.4 *Polarization*—The incident flux shall be unpolarized and the receiver shall be insensitive to the state of polarization of the reflected luminous flux.

⁶ The sole source of supply of the apparatus known to the committee at this time for Method A is Hunter Associates Laboratory, Reston, VA, and for Method B is BVK-Gardner USA, Columbia, MD. 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.

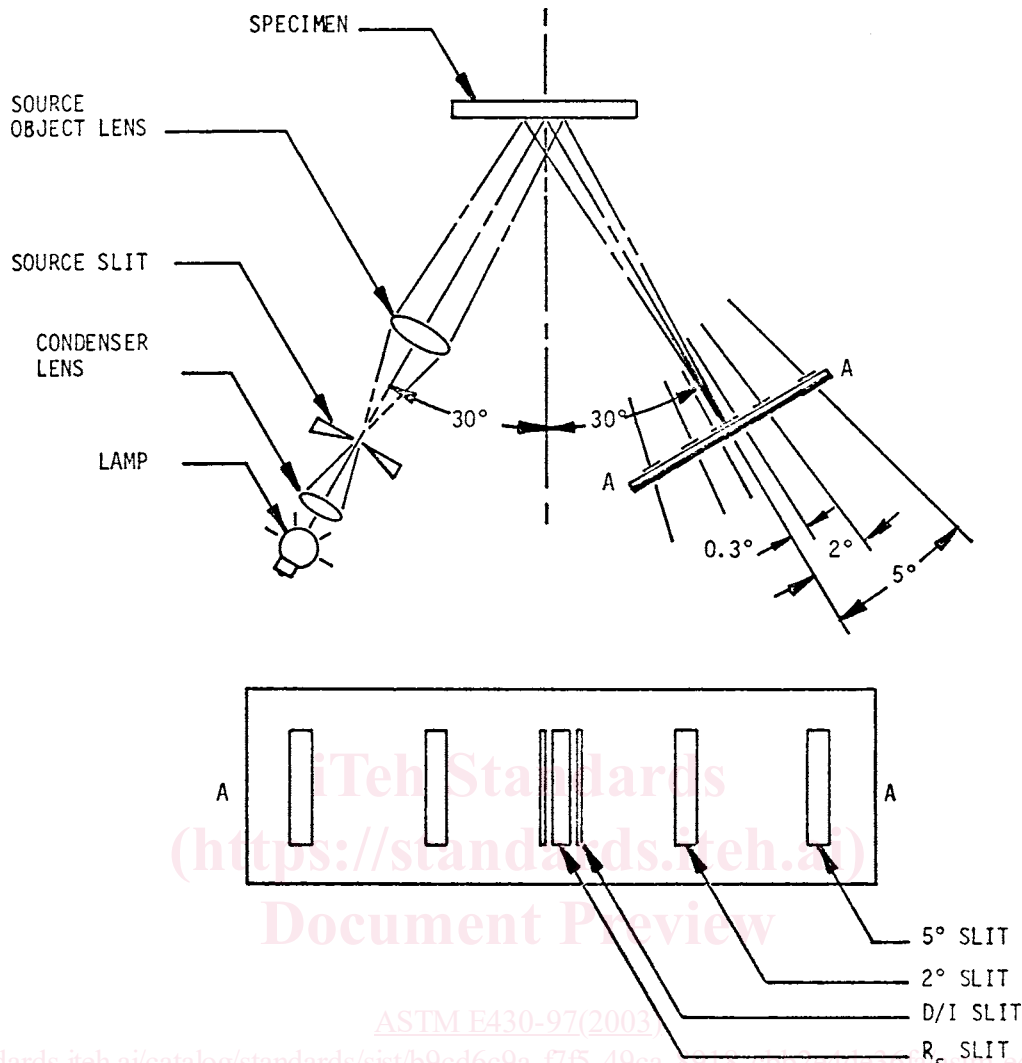


FIG. 1 Optical Diagram of the Abridged Goniophotometer

6.1.5 *Clamp*—For Test Method A, a rotatable clamp of the type shown in Fig. 4 may be used for flattening and positioning the specimen during measurement.

7. Standards

7.1 Three calibrated standards of good planarity shall be available in either a set of metals or a set of nonmetals, depending upon which type of surface is measured.

7.2 High-Gloss Standards:

7.2.1 *High-Gloss Standard for Metals* shall be of aluminum, evaporated onto glass and covered with a protective coating of silicon monoxide, and calibrated for specular gloss and distinctness-of-image gloss.

7.2.2 *High-Gloss Standard for Nonmetals* shall be of highly polished black glass with a refractive index of approximately $n_D = 1.527$, calibrated for specular gloss and reflection haze, and assigned a scale value of $G_s = 89.4$ for a specular angle of 30° (Test Method A) or $G_s = 89.2$ for a specular angle of 20° (Test Method B).

NOTE 1—To determine the scale value, calculate the first-surface (Fresnel) reflectance (Test Method D 2457, Section 5.1) for $n_D = 1.567$

and the specular angle of interest; for 30° it is 5.0436 % and for 20° it is 4.9078 %. Assign this a scale value of 100 (Test Method D 523, Section 7.1). Repeat the calculation for $n_p = 1.527$ and the same specular angle; the result for 30° is 4.5069 % and for 20° , 4.3769 %. The new scale value for 30° is $100 \times (4.5069/5.0436) = 89.4$, and for 20° , $100 \times (4.3769/4.9078) = 89.2$. (The latter value is also given in Test Method D 523.)

7.3 Intermediate Standards:

7.3.1 *Intermediate Standard for Metals* shall be of either chromium evaporated onto glass and covered with a protective coating of silicon monoxide, or of bright sheet aluminum with protective coating and calibrated for specular gloss and distinctness-of-image gloss.

7.3.2 *Intermediate Standard for Nonmetals* shall be of a ceramic material, such as porcelain enamel on steel, and calibrated for specular gloss and distinctness-of-image gloss.

7.4 *Diffuse Standards* shall have a reflectance factor substantially constant over the angular range of the instrument.

7.5 *Care of Standards*—It is essential that the standards be kept clean and free of scratches as well as from contact with contaminating materials. The cleaning method specified by the