



Designation: E 167 – 96

Standard Practice for Goniophotometry of Objects and Materials¹

This standard is issued under the fixed designation E 167; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 Goniophotometry is a general procedure for evaluating the manner in which an object or a material geometrically distributes the unabsorbed portion of incident light, whether by reflection or by transmission.

1.2 The two former, essentially identical, Practices for Goniophotometry, E 166 for transmitted light and E 167 for reflected light, are now combined in this one practice.

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

2. Referenced Documents

2.1 *ASTM Standards:*

E 284 Terminology of Appearance²

E 308 Practice for Computing the Colors of Objects by Using the CIE System²

E 1767 Practice for Specifying the Geometry of Observations and Measurements to Characterize the Appearance of Materials²

3. Terminology

3.1 *Definitions:*

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *directional reflectance factor, R_d , n* —the ratio of the flux reflected from a specimen in a specified solid angle to the flux reflected from the perfect reflecting diffuser under the same geometric and spectral conditions of measurement.

3.2.2 *directional transmittance factor, T_d , n* —the ratio of the flux transmitted by a specimen in a specified solid angle to the flux transmitted under the same geometric and spectral conditions of measurement but in the absence of the specimen.

¹ This recommended practice is under the jurisdiction of ASTM Committee E-12 on Appearance and is the direct responsibility of Subcommittee E12.03 on Geometry.

Current edition approved Nov. 10, 1996. Published February 1997. Originally published as E 167 – 60 T. Last previous edition E 167 – 91. Combined with E 166 – 63 (1970).

² *Annual Book of ASTM Standards*, Vol 06.01.

3.3 For other appearance terms and definitions see Terminology E 284.

4. Significance and Use

4.1 Spatial distribution of reflected or transmitted light is a physical property that can be used, in addition to shape and color, to characterize the appearance of an object or material.

4.2 Distribution of light by nearly uniform scattering in all directions, either by reflection or transmission, is termed diffusion. Distribution by reflection, mostly in and near the direction of specular (mirror) reflection, correlates with gloss. Distribution by reflection, mostly in and near the direction of the light source, is associated with retroreflection. Distribution by transmission, in a continuation of the direction of incidence, is termed regular transmission. As most objects and materials display varying combinations of these modes, and as the final visual effect is dependent upon this combination, goniophotometry provides an important technique for studying appearance.

4.3 Goniophotometric data may also be used in studying surface structure, rates of degradation, and suspended solids. It may also be used as a guide to choosing specific directions of illumination and view, to be used for more routine evaluation of objects or materials of a specific type.

5. Apparatus

5.1 *Geometric Components* (see Fig. 1 and Fig. 2):

5.1.1 *Specimen Mounting*, located at the intersection of the axes of the source arm and the receptor arm. In the reflection mode, the intersection should lie on the specimen surface; in the transmission mode it may lie within the specimen or at either face of the specimen, but the location should be specified.

5.1.2 *Source Arm*—A light source and lens for projecting an incident beam of light rays onto the specimen within a narrow cone about the central angle of incidence, i .

5.1.3 *Receptor Arm*—An optical system and detector for receiving rays that leave the specimen in a narrow cone about the central angle of view, v .

5.1.4 *Parallel- and Converging-Ray Light-Beam Configurations*—The parallel-ray configuration is shown in Fig. 1. This configuration has lenses in both source and

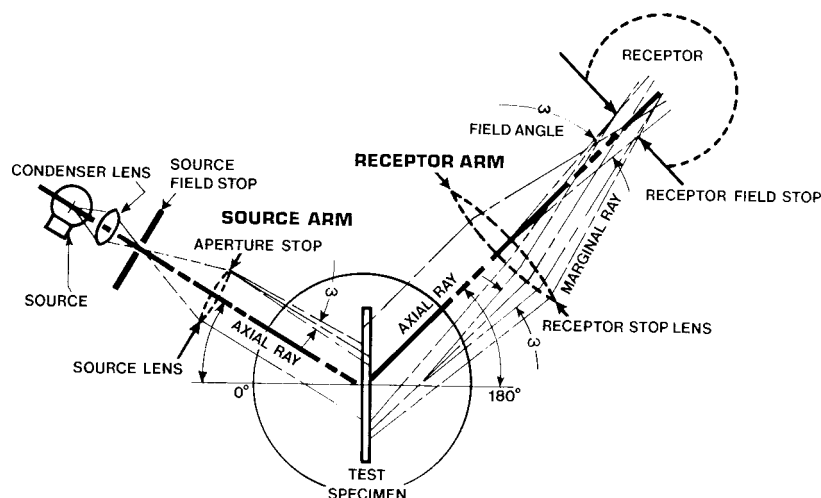


FIG. 1 Components of a Parallel-Beam Goniophotometer in Transmission Configuration

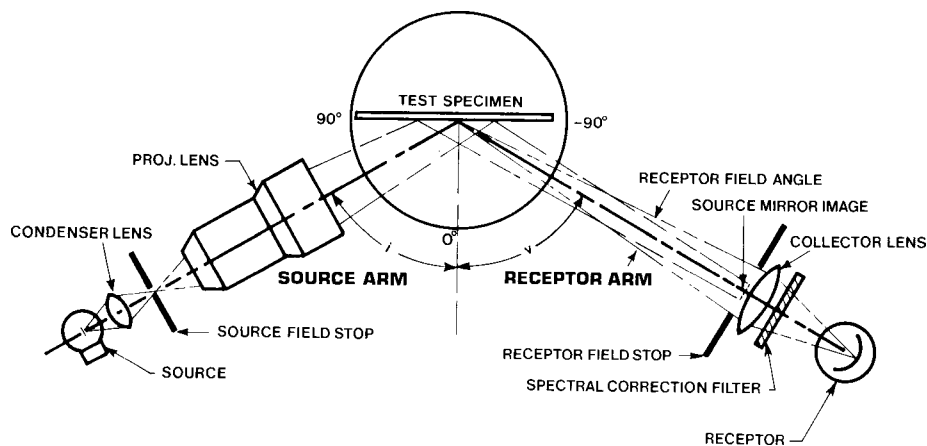


FIG. 2 Components of a Converging-Beam Goniophotometer in Reflection Configuration

receptor beams to render light rays, respectively, incident upon, and received from the specimen as nearly parallel as possible. Note that one of the lenses (the receptor lens in Fig. 1) must be larger than the other to avoid vignetting. The converging-ray configuration has only one lens, which, in the example shown in Fig. 2, is in the source arm. The principal rays of the converging beam design, shown in Fig. 2, are not parallel to each other as they strike and then leave the specimen. However, this design is less susceptible to vignetting, requires centering of only one, not two, lens systems, and offers higher angular resolution than the parallel beam design. For one or more of these reasons, it is widely used for goniophotometry.

NOTE 1—Two of the foregoing three components must be free to rotate about the intersection of their axes in the specimen plane, so that the angles of the incident and viewing beams, i and v , respectively, are variable at will. These angles are measured between the axis and the perpendicular to the illuminated specimen plane at the point of intersection. By convention, in retroreflection studies, incidence angles are designated as negative if both receptor and source arms are in the same quadrant and angle v is larger than angle i .

NOTE 2—Although Fig. 1 illustrates a parallel-beam configuration used in a transmission goniophotometer, and Fig. 2 shows a converging-beam configuration used in a reflection goniophotometer, either configuration can be used for either purpose.

NOTE 3—Most goniophotometric measurements are confined to a plane that is perpendicular to the specimen plane, hence are termed monoplanes. Where measurements in other planes are desired, the specimen may be rotated about an axis in its own plane. Alternatively, either the source or the receptor arm may be constructed to permit movement about an axis perpendicular to the specimen plane, as required.

5.1.5 *Source Aperture Stop*, s_i , should be variable to adjust the size of the specimen illuminated for measurement. Source and receptor field angles, ω_i and ω_v , should be variable to accommodate different types of specimens involving different measurement problems. These field angles are solid angles and may have either pyramidal or conical shapes.

NOTE 4—For a more detailed analysis of the geometry of light beams, consult references on optical instrument design and Practice E 1767.³

5.1.6 When specimens are translucent, the viewed area on the specimen from the receptor should always be larger than the illuminated area to minimize the edge loss.⁴

³ Smith, W. J., *Modern Optical Engineering*, McGraw-Hill, New York, 1966.

⁴ "The Translucent Blurring Effect—Method of Evaluation and Estimation," NIST Technical Note 594-12, National Institute of Standards and Technology, October 1976.