



Designation: E 1767 – 95

Standard Practice for Specifying the Geometry of Observations and Measurements to Characterize the Appearance of Materials¹

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INTRODUCTION

The appearance of objects depends on how they are illuminated and viewed. When measurements are made to characterize appearance attributes such as color or gloss, the measured values depend on the geometry of the illumination and the instrumentation receiving light from the specimen. This practice for specifying the geometry in such applications is largely based on an international standard ISO 5/1, dealing with the precise measurement of optical density in photographic science, based on an earlier American National Standard, which was based on a publication by McCamy.²

1. Scope

1.1 This practice covers the geometry of illuminating and viewing specimens and the corresponding geometry of optical measurements to characterize the appearance of materials. It establishes terms, symbols, a coordinate system, and functional notation to describe the geometric orientation of a specimen, the geometry of the illumination (or optical irradiation) of a specimen, and the geometry of collection of flux reflected or transmitted by the specimen, by a measurement standard, or by the open sampling aperture.

1.2 Optical measurements to characterize the appearance of retroreflective materials are of such a special nature that they are treated in other ASTM standards and are excluded from the scope of this practice.

1.3 The measurement of transmitted or reflected light from areas less than 0.5 mm in diameter may be affected by optical coherence, so measurements on such small areas are excluded from consideration in this practice, although the basic concepts described in this practice have been adopted in that field of measurement.

1.4 The specification of a method of measuring the reflecting or transmitting properties of specimens, for the purpose of characterizing appearance, is incomplete without a full description of the spectral nature of the system, but spectral conditions are not within the scope of this practice. The use of functional notation to specify spectral conditions is described in ISO 5/1.

2. Referenced Documents

2.1 *ASTM Standards:*

E 284 Terminology of Appearance³

2.2 *Other Standard:*

ISO 5/1 Photography—Density Measurements—Part 1: Terms, Symbols and Notations⁴

3. Terminology

3.1 *Definitions:*

3.1.1 The terminology used in this practice is in accordance with Terminology E 284.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anormal angle, n* —an angle measured from the normal, toward the reference plane, to the central axis of a distribution, which may be a distribution of flux in an incident beam or an angular distribution of sensitivity of a receiver.

3.2.2 *aspecular angle, n* —the angle subtended at the origin by the specular axis and the axis of the receiver, the positive direction being from the specular axis toward the normal.

3.2.3 *aspecular azimuthal angle, n* —the angle subtended, at the specular axis in a plane normal to the specular axis, by the projection of the axis of the receiver and the projection of the x -axis on that plane, measured from the projection of the x -axis in a right-handed sense with respect to the specular axis.

3.2.4 *efflux, n* —radiant flux reflected by a specimen or reflection standard, in the case of reflection observations or measurements, or transmitted by a specimen or open sampling

¹ This 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, 1995. Published January 1996.

² McCamy, C. S., "Concepts, Terminology, and Notation for Optical Modulation", *Photographic Science and Engineering*, Vol 10, 1966, pp. 314–325.

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

⁴ Available from American National Standards Institute, 13th Floor, 11 W. 42nd St., New York, NY 10036.

aperture, in the case of transmission observations or measurements, and sensed by the receiver.

3.2.5 *efflux, adj*—associated with the radiant flux reflected by a specimen or reflection standard, in the case of reflection observations or measurements, or transmitted by a specimen or open sampling aperture, in the case of transmission observations or measurements, and sensed by the receiver.

3.2.6 *efflux sampling aperture, n*—the region on the reference plane from which flux is sensed by the receiver.

3.2.7 *influx, n*—radiant flux directed toward a specimen, a reflection standard, or open sampling aperture.

3.2.8 *influx, adj*—associated with radiant flux directed toward a specimen, a reflection standard, or open sampling aperture.

3.2.9 *influx sampling aperture, n*—the region on the reference plane within which flux is incident.

3.2.10 *optical modulation, n*—a ratio indicating the magnitude of the propagation by a specimen of radiant flux from a specified illuminator or irradiator to a specified receiver, a general term for reflectance, transmittance, reflectance factor, transmittance factor, or radiance factor.

3.2.11 *plane of incidence, n*—the plane containing the axis of the incident beam and the normal to the specimen.

3.2.11.1 *Discussion*—This plane is not defined if the axis of the incident beam is normal to the specimen.

3.2.12 *reference plane, n*—the plane in which the surface of the specimen is placed for observation or measurement.

3.2.13 *sampling aperture, n*—the limited area of the specimen selected for measurement, the smaller of the influx sampling aperture or the efflux sampling aperture.

3.2.14 *specular axis, n*—the ray resulting from specular reflection at an ideal plane mirror in the reference plane, of the ray at the axis of the incident beam.

3.2.14.1 *Discussion*—This term is applied to illuminators providing an incident beam of small angular subtense, not to diffuse or annular illuminators.

3.3 Symbols: Symbols:

- o = the point of origin of a rectangular coordinate system, in the reference plane, at the center of the influx sampling aperture.
- x = distance from the origin, measured along an axis, the x -axis, in the reference plane and passing through point o .
- y = distance from the origin, measured along an axis, the y -axis, in the reference plane, passing through point o , and normal to the x -axis.
- z = distance from the origin, measured on an axis, the z -axis, normal to the reference plane, passing through point o , and having its positive direction in the direction of the vector component of incident flux normal to the sampling aperture.
- θ = anormal angle.
- α = aspecular angle.
- β = aspecular azimuthal angle.
- η = azimuthal angle, measured in the reference plane, from the positive x -axis, in the direction of the positive y -axis.

- κ = half angle of a cone.
- i = subscript for incident.
- r = subscript for reflected.
- t = subscript for transmitted.
- G = general symbol, in functional notation, for influx geometry.
- g = general symbol, in functional notation, for efflux geometry.
- m = subscript for half angle subtended by the entrance pupil of a test photometer.
- n = subscript for half angle subtended by a test source.
- M = optical modulation.

4. Summary of Practice

4.1 This practice provides a method of specifying the geometry of illuminating and viewing a material or the geometry of instrumentation for measuring an attribute of appearance. In general, for measured values to correlate well with appearance, the geometric conditions of measurement must simulate the conditions of viewing.

5. Significance and Use

5.1 This practice is for the use of manufacturers and users of equipment for visual appraisal or measurement of appearance, those writing standards related to such equipment, and others who wish to specify precisely conditions of viewing or measuring attributes of appearance. The use of this practice makes such specifications concise and unambiguous. The functional notation facilitates direct comparison of the geometric specifications of a viewing situation and a measuring instrument.

6. Coordinate System

6.1 The standard coordinate system is illustrated in Fig. 1. It is a left-handed rectangular coordinate system, following the usual optical convention of incident and transmitted flux in the positive direction and the usual convention for the orientation of x and y for the reflection case. The coordinates are related to a reference plane in which the first surface of the specimen is placed for observation or measurement. The origin is at the center of the area on the specimen being observed or measured. The influx and efflux sampling apertures are taken to be normal to and centered on the z axis.

6.2 Instruments are usually designed to minimize the variation of the product of illumination and receiver sensitivity, as a function of the azimuthal angle η . That practice minimizes the variation in modulation as the specimen is rotated in its own plane. Even in instruments with an integrating sphere, residual nonuniformity, known as “directionality”, can cause variations in measurements of textured specimens. To minimize variation due to this effect, the “warp”, “grain”, or other “machine direction” of specimens must be consistently oriented with respect to the x -axis, which is directed according to the following rules, intended to place the positive x -axis in the azimuthal direction for which the product of illumination and receiver sensitivity is a minimum.

6.2.1 For an integrating-sphere instrument with diffuse illumination, the positive x -axis is directed from the center of the specular port (or the normal to the specimen) toward the center of the exit port.