Designation: E809 – 21

Standard Practice for Measuring Photometric Characteristics of Retroreflectors[1]

This standard is issued under the fixed designation E809; 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 practice describes the general procedures for instrumental measurement of the photometric characteristics of retroreflective materials and retroreflective devices.

1.2 This practice is a comprehensive guide to the photometry of retroreflectors but does not include geometric terms that are described in Practice E808.

1.3 This practice describes the parameters that are required when stating photometric measurements in specific tests and specifications for retroreflectors.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered 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 the user of this standard to establish appropriate safety, health, and 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]

E284 Terminology of Appearance

E308 Practice for Computing the Colors of Objects by Using the CIE System

E808 Practice for Describing Retroreflection

2.2 *CIE Documents:*[3]

CIE Publication No. 54.2 Retroreflection—Definition and Measurement

CIE Publication DS 17.2/E:2009 International Lighting Vocabulary

CIE Publication No. 69-1987 Methods of Characterizing Illuminance Meters and Luminance Meters

3. Terminology

3.1 Terms and definitions in Terminology E284 and E808 are applicable to this practice. In general, the terminology in this practice agrees with that in CIE Publications DS 17.2/E:2009 and 54.2.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *annular aperture, n*—the difference between the angular diameters of the external boundary circle and the internal boundary circle.

3.2.2 *circular aperture, n*—the angular diameter of a circular aperture surface.

3.2.3 *goniometer, n*—an instrument for measuring or setting angles.

3.2.4 *photopic receiver, n*—a receiver of radiation with a spectral responsivity which conforms to the $V(\lambda)$ distribution of the CIE Photopic Standard Observer that is specified in Practice E308.

3.2.5 *receiver aperture, n*—angular dimensions from the retroreflector center to the entrance aperture or pupil of the receiver.

3.2.6 *rectangular aperture, n*—the angular height and width of a rectangular aperture surface.

3.2.6.1 *Discussion*—The orientation of the sides of the rectangular aperture surface should be supplied together with the angular height and width.

3.2.7 *reflected illuminance, E_r, n*—illuminance at the receiver measured on a plane perpendicular to the observation axis.

3.2.7.1 *Discussion*—This quantity is used in the calculation of the coefficient of luminous intensity,

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[1] This practice is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.10 on Retroreflection.

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[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 U.S. National Committee of the CIE (International Commission on Illumination) (http://www.cie-usnc.org) or the CIE (cie.co.at) Webshop.

R_I: $R_I = (I/E_\perp) = (E_r d^2)/E_\perp$, where d is the distance from the retroreflector to the receptor.

3.2.8 *retroreflectometer aperture angles, n*—the maximum angular diameter of the pencil of light (see Fig. 1).

3.2.8.1 *Discussion*—In practice the illumination arrives at the retroreflector center within a narrow pencil of light surrounding the illumination axis and the light reflected to the photoreceptor is contained within another narrow pencil. The distribution of light within such pencils is the "aperture" function and the maximum angular diameter of the pencil is the "aperture angle." It is generally assumed that the aperture functions are rotationally symmetrical and even uniform, but this is often false, especially for illumination.

3.2.9 *retroreflector aperture surface, n*—the aperture surface of a retroreflector is given by the retroreflector itself, or by a diaphragm enclosing part of the retroreflector.

3.2.10 *retroreflector element aperture, n*—angular dimension of the aperture surface of a retroreflective element as seen from the receiver's center.

3.2.10.1 *Discussion*—The element aperture quantifies an error source in the setting of the observation angle. This is a critical feature for testing large retroreflective elements or at short distances. When using collimated optics, placing the source and receiver at virtual infinity, the retroreflector element aperture is virtually zero.

3.2.11 *retroreflector (or specimen) aperture, n*—angular dimensions from the source point of reference to the aperture surface of the retroreflector (or specimen).

3.2.11.1 *Discussion*—As the source and receiver are generally close to each other, distinction is not made between aperture angles seen from the source and receiver. When using collimated optics where the source and receiver are at virtual infinity, the retroreflector aperture is virtually naught. The retroreflector aperture describes the maximum variation of the entrance angle of the aperture surface of the retroreflector.

3.2.12 *source aperture, n*—angular dimensions from the retroreflector center to the exit aperture stop or pupil of the light source.

4. Summary of Practice

4.1 The fundamental procedure described in this practice involves measurements of retroreflection based on the ratio of the retroreflected illuminance at the observation position to the incident illuminance measured perpendicular to the illumination axis at the retroreflector. From these measurements, along with the geometry of test, various photometric quantities applicable to retroreflectors can be determined.

4.2 Also described are methods of comparative testing where unknown specimens are measured relative to an agreed-upon standard retroreflector (a substitution test method).

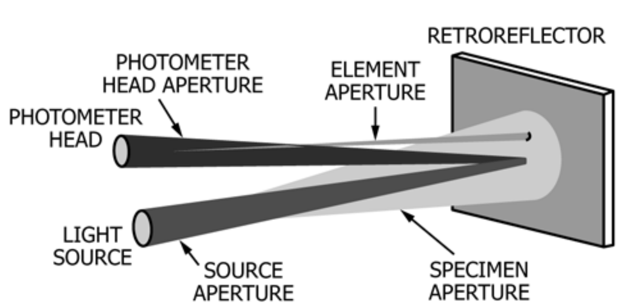

FIG. 1 Illustration of Apertures used in Retroreflection Measurement

5. Significance and Use

5.1 This practice describes procedures used to measure photometric quantities that relate to the visual perception of retroreflected light. The most significant usage is in the relation to the nighttime vehicle headlamp, retroreflector, and driver's eye geometry. For this reason the CIE Standard Source A is used to represent a tungsten vehicle headlamp and the receptor has the photopic, $V(\lambda)$, spectral responsivity corresponding to the light adapted human eye. Although the geometry must be specified by the user, it will, in general, correspond to the relation between the vehicle headlamp, the retroreflector, and the vehicle driver's eye position.

6. Uses and Applications

6.1 *Coefficient of Retroreflection*—This quantity is used to specify the performance of retroreflective sheeting. It considers the retroreflector as an apparent point source whose retroreflected luminous intensity is dependent on the area of the retroreflective surface involved. It is a useful engineering quantity for determining the photometric performance of such retroreflective surfaces as highway delineators or warning devices. The coefficient of retroreflection may also be used to determine the minimum area of retroreflective sheeting necessary for a desired level of photometric performance.

6.2 *Coefficient of Luminous Intensity*—This term is used to specify the performance of retroreflective devices. It considers the retroreflected luminous intensity as a function of the perpendicular illuminance incident on the device. It is recommended for use in describing performance of RPMs, taillight reflex reflectors and roadway delineators.

6.3 *Coefficient of Line Retroreflection (of a Reflecting Stripe)*—This term may be used to describe the retroreflective performance of long narrow strips of retroreflective materials, when the actual width is not as important as is the reflectivity per unit length.

6.4 *Reflectance Factor (of a Plane Reflecting Surface)*—This is a useful term for comparing surfaces specifically designed for retroreflection to surfaces which are generally considered to be diffuse reflectors. Since almost all natural surfaces tend to retroreflect slightly, materials such as $BaSO_4$ can have a reflectance factor much higher than one (as much as four) at small observation angles. Such diffuse reflectance standards should be used for calibration only at large observation angles, for example, 45°.

6.5 *Coefficient of Retroreflected Luminance* (also called *Specific Luminance*)—This term considers the retroreflector as a surface source whose projected area is visible as an area at the observation position. The coefficient of retroreflected luminance relates to the way the effective retroreflective surface is focused on the retina of the human eye and to the