Designation: E 1809 – 96

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
Reprinted from the Annual Book of ASTM Standards. Copyright ASTM

Standard Test Method for Measurement of High-Visibility Retroreflective-Clothing Marking Material Using a Portable Retroreflectometer[1]

This standard is issued under the fixed designation E 1809; 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 test method covers the measurement of the retroreflective properties of high visibility pedestrian garments, such as vests, using a portable retroreflectometer that can be used in the field. The portable retroreflectometer is a hand-held instrument with a defined standard geometry corresponding to United States usage that can be placed in contact with retroreflective marking material to measure the retroreflection. The measurements can be compared to minimum requirements to determine the need for replacement.

1.2 This test method is designed for measuring retroreflective marking materials that have an area equal to or greater than that of the aperture of the retroreflectometer.

1.3 This test method is intended to be used for field measurement of retroreflective marking materials, but may be used to measure the performance of materials before placing the clothing in use.

1.4 *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 Appearance[2]

E 809 Practice for Measuring Photometric Characteristics of Retroreflectors[2]

E 810 Test Method for Coefficient of Retroreflection of Retroreflective Sheeting[2]

3. Terminology

3.1 The terminology used in this test method, in general, agrees with that used in Terminology E 284.

3.2 *Definitions*—The delimiting phrase *in retroreflection* applies to each of the following definitions when used outside the context of this or other retroreflection standards.

3.2.1 *coefficient of retroreflection, R_A, n—of a plane retroreflecting surface,* the ratio of the coefficient of luminous intensity (R_I) of a plane retroreflecting surface to its area (A), expressed in candelas per lux per square metre ($cd \cdot lx^{-1} \cdot m^{-2}$).

$$R_A = R_I/A \quad (1)$$

3.2.2 *entrance angle, β, n*—angle between the illumination axis and the retroreflector axis.

3.2.3 *instrument standard, n*—a working standard used to standardize the portable retroreflectometer.

3.2.4 *observation angle, n*—angle between the illumination axis and the observation axis.

3.2.5 *portable retroreflectometer, n*—a hand-held instrument that can be used in the field or in the laboratory to measure retroreflection.

3.2.5.1 *Discussion*—In this test method, *portable retroreflectometer* refers to a hand-held instrument that can be placed in contact with retroreflective marking material to measure the coefficient of retroreflection in a standard geometry.

3.2.6 *presentation angle, γ, n*—angle between the observation half-plane and the half-plane that originates on the illumination axis and that contains the retroreflector axis.

3.2.7 *retroreflection, n*—reflection in which the reflected rays are preferentially returned in directions close to the opposite of the direction of the incident rays, this property being maintained over wide variations of the direction of the incident rays.

3.2.8 *rotation angle, ε, n*—angle indicating the orientation of the specimen when it is rotated about the retroreflector axis.

3.2.8.1 *Discussion*—The rotation angle is the dihedral angle from the half-plane originating on the retroreflector axis and containing the positive part of the second axis to the half-plane originating on the retroreflector axis and containing the datum mark. Range: $-180° < \epsilon \leq 180°$.

4. Summary of Test Method

4.1 This test method involves the use of commercial portable retroreflectometers for determining the retroreflectivity of retroreflective marking material(s) on garments.

4.2 Unless otherwise specified by the user, the entrance angle shall be 5.0° and the observation angle shall be 0.33°.

4.2.1 The angles specified are those currently employed in the United States and may differ from angles used in other countries.

4.3 The portable retroreflectometer uses an instrument standard for standardization.

4.4 After standardization, the retroreflectometer is placed in

[1] This test method is under the jurisdiction of ASTM Committee E-12 on Appearance and is the direct responsibility of Subcommittee E12.10 on Retroreflection.

Current edition approved May 10, 1996. Published July 1996.

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

contact with the retroreflective marking material to be tested. Ensure that only the area to be tested is within the measurement area of the instrument. The retroreflective marking material and garment must be laid flat as a reading can be taken only on a planar surface.

4.5 The reading displayed by the retroreflectometer is recorded. The retroreflectometer is then moved to another position on the same retroreflective marking material and the measured value at this location is recorded. For each type and color of retroreflective marking material on each side, back and front of each garment to be tested, a minimum of five readings shall be taken and the average of each set of readings shall be recorded.

5. Significance and Use

5.1 Measurements made by this test method are related to visual observation of retroreflective marking material as seen by the human eye when illuminated by light sources such as a motor vehicle's headlights.

5.2 Retroreflective marking material used for pedestrian safety can degrade with time, exposure to sunlight, wear and cleaning, and the material requires periodic measurement to ensure that the performance of the retroreflective material provides adequate safety to the wearer.

5.3 This test method is not intended to be used for the measurement of retroreflective marking material for pedestrian safety at observation and entrance angles other than those specified herein.

6. Apparatus

6.1 *Portable Retroreflectometer*:

6.1.1 The retroreflectometer shall be portable with the capability of being placed at various locations on the retroreflective marking material.

6.1.2 The retroreflectometer shall be constructed so that its placement on the retroreflective marking material will prevent stray light from entering the measurement area of the instrument and affecting the reading.

6.2 Instrument standard or standards of desired color(s) and material(s) are required.

6.3 *Light Source Requirements*:

6.3.1 The projection optics shall be such that the illuminance at any point over the measurement area shall be within 10 % of the average illuminance.

6.3.2 The aperture angle of the source, as determined from the center of the measurement area, shall be not greater than 0.1°.

6.4 *Receiver Requirements*:

6.4.1 The receiver shall have sufficient sensitivity and range to accommodate coefficient of retroreflection values from 0.1 to 1999 candelas per lux per square metre (cd lx^{-1} m^{-2}).

6.4.2 The combined spectral distribution of the light source and the spectral responsivity of the receiver shall match the combined spectral distribution of CIE Illuminant *A* and the *V* (λ) spectral luminosity function according to the following criterion: for any choice of plano-parallel colored absorptive filter mounted in front of a white retroreflective sample, the ratio of the R_A measured with the filter to the R_A measured without the filter shall be within 10 % of the Illuminant *A* luminous transmittance of an air-spaced pair of two such filters.

6.4.2.1 In the retroreflectometer, the filter should be mounted with a downward tilt (for example, 1.0°) to avoid specular reflection into the receiver.

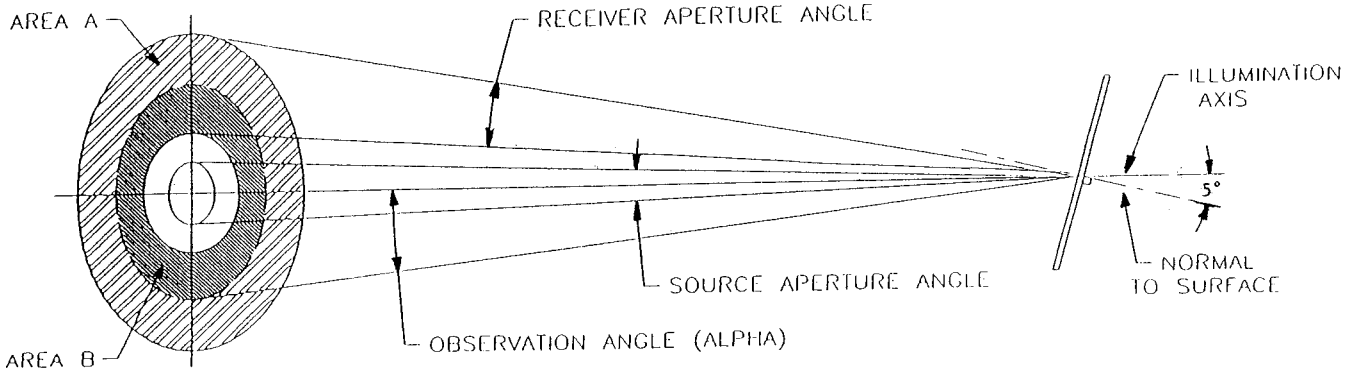
6.4.3 The receiver aperture may be either circular or an annular ring (see Fig. 1).

6.4.3.1 For field measurements, the annular ring receiver is the preferred configuration since it (*a*) increases the light throughput of the instrument and thus the sensitivity, and (*b*) ensures that directionality effects, which are difficult to establish in the field, are minimized, thus improving repeatability.

6.4.3.2 If evaluation of directionality is of concern to the user, the circular receiver aperture method provides meaningful data.

6.4.4 The aperture angle of the receiver is determined from the measurement area, and shall be not greater than 0.1°. For an annular aperture, the effective aperture angle is measured between the inner and outer ring limits (see Fig. 1).

6.4.5 The combined stability of the output of the light



AREA A = AREA B

FIG. 1 Annular Aperture and Angles for Portable Reflectometer for Measuring R_A