Designation: E2540 – 08

Standard Test Method for
Measurement of Retroreflective Signs Using a Portable Retroreflectometer at a 0.5 Degree Observation Angle[1]

This standard is issued under the fixed designation E2540; 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 measurement of the retroreflective properties of sign materials such as traffic signs and symbols (vertical surfaces) using a portable retroreflectometer that can be used in the field. The portable retroreflectometer is a hand-held instrument with a defined standard geometry that can be placed in contact with sign material to measure the retroreflection in a standard geometry. The measurements can be compared to minimum requirements to determine the need for replacement. Entrance and observation angles specified in this test method are those used currently in the United States and may differ from the angles used elsewhere in the world.

1.2 This test method is intended to be used for the field measurement of traffic signs but may be used to measure the performance of materials before placing the sign in the field or before placing the sign material on the sign face.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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:*[2]
E284 Terminology of Appearance
E808 Practice for Describing Retroreflection
E809 Practice for Measuring Photometric Characteristics of Retroreflectors
E810 Test Method for Coefficient of Retroreflection of

Retroreflective Sheeting Utilizing the Coplanar Geometry

3. Terminology

3.1 The terminology used in this test method generally agrees with that used in Terminology E284.

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 *annular geometry, n*—the portable instrument retroreflection collection method where the retroreflected lux is collected in an annulus 0.1 degrees wide centered on the illumination axis.

3.2.1.1 *Discussion*—The angle measured from the illumination axis to the circle which divides the annulus into equal areas corresponds to a specific observation angle.

3.2.2 *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 ($cd \cdot lx^{-1} \cdot m^{-2}$).

3.2.3 *datum axis, n*—a designated half-line from the retroreflector center perpendicular to the retroreflector axis.

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

3.2.5 *entrance half-plane, n*—the half plane that originates on the line of the illumination axis and contains the retroreflector axis.

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

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

3.2.8 *observation half-plane, n*—the half plane that originates on the line of the illumination axis and contains the observation axis.

3.2.9 *orientation angle, ω_s, n*—the angle in a plane perpendicular to the retroreflector axis from the entrance half-plane to the datum axis, measured counter-clockwise from the viewpoint of the source.

3.2.10 *portable retroreflectometer, n*—a hand-held instrument that can be used in the field or in the laboratory for measurement of retroreflectance.

3.2.10.1 *Discussion*—In this test method, "portable retrore-flectometer" refers to a hand-held instrument that can be placed in contact with sign material to measure the retroreflection in a standard geometry.

3.2.11 *presentation angle, γ, n*—the dihedral angle from the entrance half-plane to the observation half-plane, measured counter-clockwise from the viewpoint of the source.

3.2.12 *retroreflection, n*—a reflection in which the reflected rays are returned preferentially 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.

3.2.13 *rotation angle, ε, n*—the angle in a plane perpendicular to the retroreflector axis from the observation half-plane to the datum axis, measured counter-clockwise from the viewpoint of the source.

3.3 Definitions of entrance angle components β_1 and β_2, as well as other geometrical terms undefined in this test method, may be found in Practice E808.

4. Summary of Test Method

4.1 This test method involves the use of commercial portable retroreflectometers for determining the retroreflectivity of highway signing materials.

4.2 The entrance angle shall be 4°.

4.3 The observation angle shall be 0.5°.

4.4 The portable retroreflectometer uses an instrument standard for standardization.

4.5 After standardization, the retroreflectometer is placed in contact with the sign to be tested, ensuring that only the desired portion of the sign is within the measurement area of the instrument.

4.6 The reading displayed by the retroreflectometer is recorded. The retroreflectometer is then moved to another position on the sign, and this value is recorded. A minimum of four readings shall be taken and averaged for each retroreflective color on the sign to be tested.

5. Significance and Use

5.1 Measurements made by this test method are related to the night time brightness of retroreflective traffic signs approximately facing the driver of a mid-sized automobile equipped with tungsten filament headlights at about 100 m distance.

5.2 Retroreflective material used on traffic signs degrades with time and requires periodic measurement to ensure that the performance of the retroflection provides adequate safety to the driver.

5.3 The quality of the sign as to material used, age, and wear pattern will have an effect on the coefficient of retrore-flection. These conditions need to be observed and noted by the user.

5.4 This test method is not intended for use for the measurement of signs when the instrument entrance and observation angles differ from those specified herein.

6. Apparatus

6.1 *Portable Retroreflectometer*—The retroreflectometer shall be portable, with the capability of being placed at various locations on the signs. The retroreflectometer shall be constructed so that placement on the sign will preclude stray light (daylight) 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).

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 1999.9 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 luminous efficiency 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.

6.4.3 The instrument may be either an instrument with point geometry, a "point instrument," or an instrument with annular geometry, an "annular instrument," depending on the shape of the receiver aperture (see Fig. 1). Point and annular instruments make geometrically different measurements of R_A, which may produce values differing on the order of 10 %. Both measurements are valid for most purposes, but the user should learn the type of instrument from its specifications sheet and be aware of certain differences in operation and interpretation. For both instrument types, the "up" position of the instrument shall be known. Both types of instruments may make additional measurements at observation angles other than the 0.5 degree of this specification and combine the measurement at two or more different observation angles if the readings at the different observation angles are reported separately.

6.4.3.1 The point instrument makes an R_A measurement with the source and receiver geometry virtually identical to an R_A measurement made on a range instrument following the procedure of Test Method E810. The 4° entrance angle would be set on a range instrument by setting $\beta_1 = -4°$; $\beta_2 = 0°$. This may be called "–4° entrance angle." The rotation angle (ε) for the point instrument is determined by the angular position of the instrument on the sign face. Assuming the retroreflector's datum axis to be upward, the rotation angle equals 0° when the instrument is upright. Clockwise rotation of the instrument on the sign face increases the rotation angle.
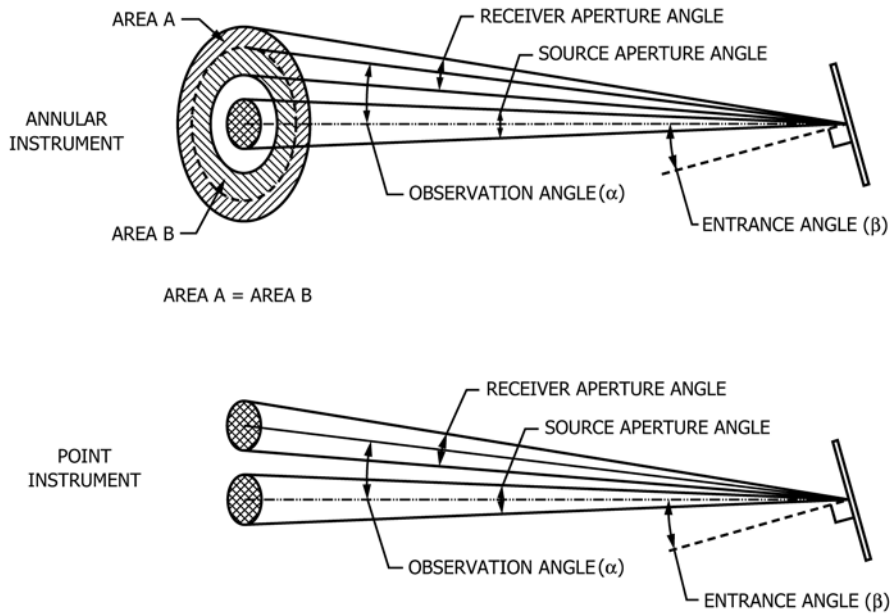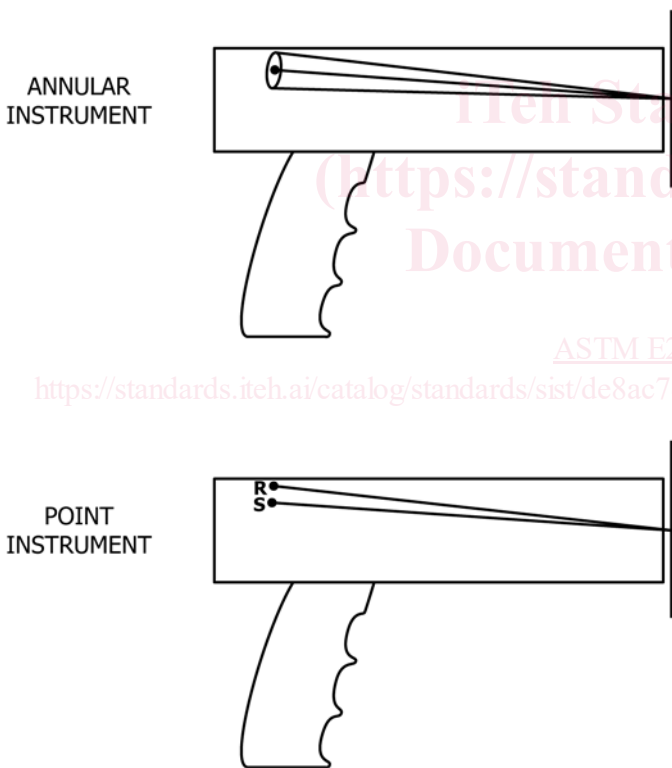
FIG. 1 Annular and Point Aperture Instrument Angles

NOTE 1—For each instrument type, the illumination beam is 4° downward. For the point instrument, receiver is above source.

FIG. 2 Upright Optical Schematics

6.4.3.2 For the point instrument the "up" marking shall be opposite the entrance half-plane. It shall be in the observation half-plane (see Fig. 2).

6.4.3.3 The annular instrument makes an R_A measurement similar to an average of a great number of R_A measurements on a range instrument with presentation angle (γ) varying between $-180°$ and $+180°$. For the 4° entrance angle the range instru-

ment would include the β_1 and β_2 settings indicated in Table 1. There is no definite rotation angle (ε) for the annular instrument. All values from $-180°$ to $+180°$ are included in the measurement.

6.4.3.4 For the annular instrument the "up" marking shall be opposite the entrance half-plane (see Fig. 2).

6.4.3.5 For both instrument types, the orientation angle (ω_s) is determined by the angular position of the instrument on the sign face. It is the rotation angle (ε) rather than the orientation angle (ω_s) which primarily affects retroreflection of signs measured at the small 4° entrance angle.

6.4.3.6 Rotationally insensitive sheetings, such as glass bead sheetings, have R_A values that are nearly independent of

TABLE 1 Laboratory Emulation of Annular Instrument Geometry

α	β_1	β_2	ε
0.5°	3.86°	−1.03°	−165°
0.5°	3.47°	−2.00°	−150°
0.5°	2.83°	−2.83°	−135°
0.5°	2.00°	−3.46°	−120°
0.5°	1.04°	−3.86°	−105°
0.5°	0.00°	−4.00°	−90°
0.5°	−1.04°	−3.86°	−75°
0.5°	−2.00°	−3.46°	−60°
0.5°	−2.83°	−2.83°	−45°
0.5°	−3.47°	−2.00°	−30°
0.5°	−3.86°	−1.03°	−15°
0.5°	−4.00°	0.00°	0°
0.5°	−3.86°	1.03°	15°
0.5°	−3.47°	2.00°	30°
0.5°	−2.83°	2.83°	45°
0.5°	−2.00°	3.46°	60°
0.5°	−1.04°	3.86°	75°
0.5°	0.00°	4.00°	90°
0.5°	1.04°	3.86°	105°
0.5°	2.00°	3.46°	120°
0.5°	2.83°	2.83°	135°
0.5°	3.47°	2.00°	150°
0.5°	3.86°	1.03°	165°
0.5°	4.00°	0.00°	180°