~~Designation:E1710–05~~ Designation: E1710 – 11

Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer[1]

This standard is issued under the fixed designation E1710; 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 horizontal pavement marking materials containing retroreflecting beads, such as traffic stripes and surface symbols, using a portable retroreflectometer that can be placed on the road delineation to measure the retroreflection at a prescribed geometry.

NOTE 1—The restriction to bead based materials is for the purpose of ensuring a sufficiently gradual optical response function (from points of the source aperture to points of the receiver aperture) to allow generous sized instrument source and receiver apertures.

1.2 The entrance and observation angles of the retroreflectometer affect the readings. As specified by the European Committee for Standardization (CEN), the entrance and observation angles shall be 88.76° and 1.05°, respectively.

1.3 This test method is intended to be used for field measurement of pavement markings but may be used to measure the performance of materials on sample panels before placing the marking material in the field.

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]

D4061 Test Method for Retroreflectance of Horizontal Coatings

D6359 Specification for Minimum Retroreflectance of Newly Applied Pavement Marking Using Portable Hand-Operated Instruments

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E284 Terminology of Appearance

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E809 Practice for Measuring Photometric Characteristics of Retroreflectors

2.2 *Other Standard:*

CEN EN 1436 Road Marking Materials—Road Marking Performance for Road Users[3]

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 test methods:

3.2.1 *coefficient of retroreflected luminance, R_L, n*—the ratio of the luminance, L, of a projected surface to the normal illuminance, $E_\perp$, at the surface on a plane normal to the incident light, expressed in candelas per square metre per lux ($cd \cdot m^{-2} \cdot lx^{-1}$).

3.2.1.1 *Discussion*—Because of the low luminance of pavement markings, the units used commonly are millicandelas per square metre per lux ($mcd \cdot m^{-2} \cdot lx^{-1}$).

---

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

~~Current edition approved Jan. 1, 2005. Published February 2005. Originally approved in 1995. Last previous edition approved in 1997 as E1710–97. DOI: 10.1520/E1710-05.~~

Current edition approved June 1, 2011. Published June 1, 2011. Originally approved in 1995. Last previous edition approved in 2005 as E1710 – 05. DOI: 10.1520/E1710–11.

[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 European Committee for Standardization (CEN), 36 rue de Stassart, B-1050, Brussels, Belgium, http://www.cenorm.be.

3.2.2 *co-entrance angle,* β_C, *n*—the complement of the entrance angle (90° – β).

3.2.3 *co-viewing angle,* v_C, *n*—the complement of the viewing angle (90° – *v*).

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

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

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

3.2.6.1 *Discussion*—In this test method, "portable retroreflectometer" refers to a hand-held instrument that can be placed over roadway delineation to measure the coefficient of retroreflected luminance with a prescribed geometry.

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

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

3.2.9 *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.

3.2.10 *viewing angle*, *n*—the angle between the retroreflector axis and the observation axis.

3.2.10.1 *Discussion*—The retroreflector axis for pavement markings is normal to the marking.

4. Summary of Test Method

4.1 This test method involves the use of commercial portable retroreflectometers for determining the coefficient of retroreflected luminance of horizontal coating materials used in pavement markings.

4.2 The entrance angle is fixed at 88.76° (co-entrance angle 1.24°).

4.3 The observation angle is fixed at 1.05°.

4.4 The presentation angle shall be 0°.

4.5 The portable retroreflectometers use either a built-in reference white for standardization or use an external panel of known coefficient of retroreflected luminance, or both.

4.6 The retroreflectometer is placed directly over the pavement marking to be measured, ensuring that the measurement area of the retroreflectometer fits within the width of the stripe, and the reading displayed by the retroreflectometer is recorded.

4.7 The retroreflectometer is then moved to other positions on the pavement marking, and the readings are recorded and averaged.

4.8 Readings shall be taken and averaged in each direction of traffic for a centerline.

5. Significance and Use

5.1 The quality of the stripe is determined by the coefficient of retroreflected luminance, R_L, and depends on the materials used, age, and wear pattern. These conditions shall be observed and noted by the user.

5.2 Under the same conditions of illumination and viewing, larger values of R_L correspond to higher levels of visual performance.

5.3 Retroreflectivity of pavement (road) markings degrade with traffic wear and require periodic measurement to ensure that sufficient line visibility is provided to drivers.

5.4 For a given viewing distance, measurements of R_L made with a retroreflectometer having a geometry corresponding to that viewing distance are a good indicator of the visual ranking of material measured.

5.5 As specified by CEN, the measurement geometry of the instrument is based on a viewing distance of 30 m, a headlight mounting height of 0.65 m directly over the stripe, and an eye height of 1.2 m directly over the stripe.

5.6 It shall be the responsibility of the user to employ an instrument having the specified observation and entrance angles.

6. Apparatus

6.1 *Portable Retroreflectometer* :

6.1.1 The retroreflectometer shall be portable, with the capability of being placed on various horizontal pavement markings in different locations.

6.1.2 The retroreflectometer shall be constructed so that placement on the highway pavement markings will preclude any stray light from entering the measurement area of the instrument and affecting the reading.

6.1.3 For the convenience of the user, a marking shall be placed on the instrument to permit it to be aligned with the direction of traffic.

6.2 *Light Source Requirements*:

6.2.1 The projection optics shall be such that the distribution of the illuminance over the measurement area will be within 10 % of the average illuminance.

6.2.2 The aperture angle of the light source as determined from the center of the measurement area shall not be larger than a rectangle subtending 10 min of arc (0.17°) by 20 min of arc (0.33°).

6.2.2.1 Rectangle aperture dimensions are given with the first side parallel to the observation half plane.

NOTE 2—The maximum source aperture dimensions are in agreement with CEN EN 1436. There is experimental evidence that for this test method, using this maximum source aperture together with the maximum receiver aperture in 6.3.3 produces R_L measurements within 1.5 % of those using two

10-min circular apertures as specified in Test Method D4061.

6.3 *Receiver Requirements*:

6.3.1 The receiver shall have sufficient sensitivity and range to accommodate coefficient of retroreflected luminance values expected in use, typically 1 to 2000 $mcd \cdot m^{-2} \cdot lx^{-1}$.

6.3.2 The combined spectral distribution of the light source and the spectral responsivity of the receiver shall match the combined spectral distribution of CIE Standard Illuminant A and the V(λ) spectral luminous efficacy function. The match shall ensure correct measurement of at least white and yellow pavement marking materials according to the following criterion:

6.3.2.1 A white (spectrally neutral) reflection standard and two plano parallel long pass absorption filters with pass wavelengths at respectively approximately 515 nm and 550 nm, providing colors of yellow and amber, are used.

6.3.2.2 The white reflection standard is measured. An absorption filter is inserted in front of the white reflection standard, so that illumination and measurement takes place through the filter, and a new measurement is made. The filter shall be mounted with a small tilt to avoid signal by surface reflection, and at some distance from the standard to avoid surface reflection back to the standard. See Fig. 1.

6.3.2.3 The ratio of the R_L measured with a filter to the R_L measured without the filter shall be within 5 % of the Illuminant A luminous transmittance of an air-spaced pair of two such filters.

6.3.2.4 Filters of colors other than described above may be used to demonstrate the ability of a retroreflectometer to measure pavement marking materials of such colors. A long pass absorption filter with a pass wavelength at approximately 715 nm corresponding to infrared may also be used. The R_L with the infrared filter inserted is theoretically zero, but a measured R_L up to 5 % of the R_L of the white standard may be acceptable.

6.3.3 The aperture of the receiver as determined from the center of the measurement area shall not be larger than a square subtending 20 min of arc (0.33°) by 20 min of arc (0.33°).

NOTE 3—The maximum receiver aperture dimensions are in agreement with CEN EN 1436. There is experimental evidence that for this test method, using this maximum receiver aperture together with the maximum source aperture in 6.2.2 produces R_L measurements within 1.5 % of those using two 10-min circular apertures as specified in Test Method D4061.

6.3.4 Instruments with annular apertures are not recommended for measuring pavement markings.

6.3.5 The combined stability of the output of the light source and receiver shall be such that readings will not change more than ±1 % after 10 s when the retroreflectometer is in contact with the pavement marking and ready to measure.

6.3.6 The linearity of the retroreflectometer photometric scale over the range of readings expected shall be within 2 %. Correction factors may be used to ensure a linear response. A method for determining linearity is found in Annex A2, Method for Determining Photoreceptor Linearity, of Practice E809.

6.4 *Measurement Geometry*:

6.4.1 The light source and receiver may be either at optical infinity or at a finite distance from the measurement area, and they shall be separated from each other by a distance corresponding to an observation angle of 1.05 ± 0.02°.

6.4.2 The entrance angle of the retroreflectometer shall be 88.76° ± 0.02° with respect to the entrance aperture plane.

6.4.3 The presentation angle of the retroreflectometer shall be 0° and shall be stated in the instrument specifications.

6.4.4 See Fig. 2 for a diagram of the optics geometry.

6.4.5 The length of the detected area shall either be fully included within the length of the illuminated area (called "arrangement A") or the length of the illuminated area shall be fully included within the length of the detected area (called arrangement B").

NOTE 4—Arrangement B is advantageous to arrangement A in the sense that it leads to less variation of the measured R_L value with small tilts of the retroreflectometer that are unavoidable in practical field measurements.

6.4.6 The smaller of the two areas, detected or illuminated area, is the measurement area and shall be at least 50 cm^2. See Fig. 3 for a method of testing this area.

NOTE 5—The plate mentioned in Fig. 3 needs in most cases to be a glass plate with a diffuse upper surface, so that the area can be studied from the underside.

6.4.7 Retroreflectometers can be characterized as "fixed- aim instruments" or "aiming instruments." A fixed-aim instrument has no facility for adjustment of its tilt once it is placed on the pavement marking, while an aiming instrument has a facility for adjustment of its tilt and some facility for indication of the consequent position of the measurement area defined in 6.4.6.

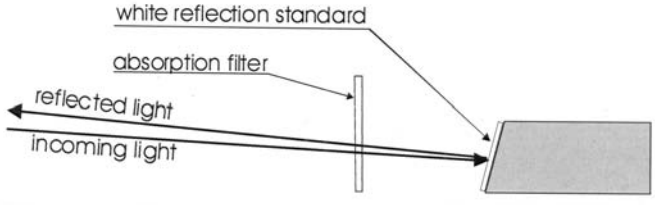


FIG. 1 White Reflection Standard and Absorption Filter for Testing Spectral Match

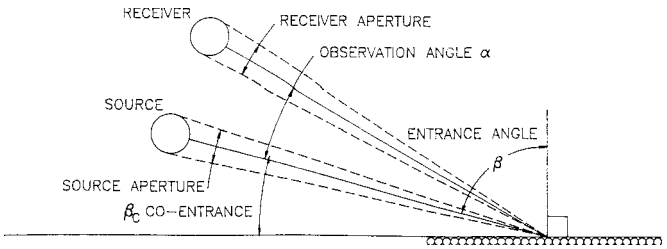


FIG. 2a Angles and apertures for non-collimating portable retroreflectometer

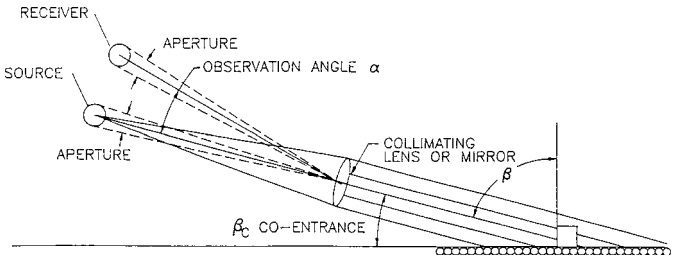


FIG. 2b Angles and apertures for collimating optics portable retroreflectometer

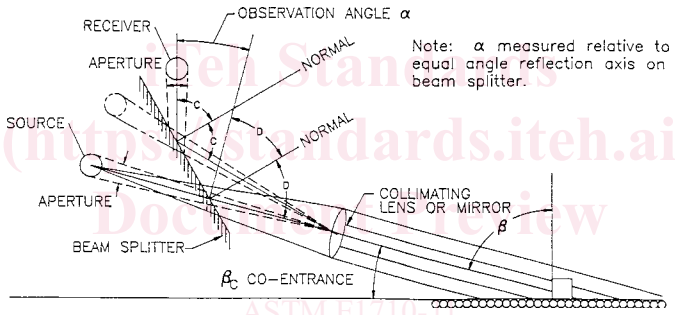
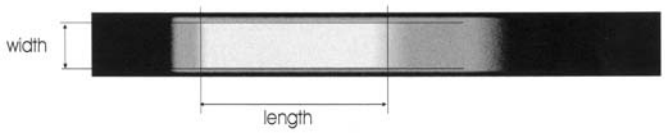


FIG. 2c Angles and apertures for portable retroreflectometer with collimating and beam splitter design

FIG. 2 Optics Geometry Diagram for Portable Road Marking Reflectometer: a) Angles and Apertures for Non-Collimating Portable Reflectometer; b) Angles and Apertures for Collimating Optics Portable Reflectometer; c) Angles and Apertures for Portable Reflectometer with Collimating and Beam Splitter Design



NOTE 1—The double brightness area is the measurement area. Its length is measured from 'middle of blur' to 'middle of blur.'

FIG. 3 With an Auxiliary Light Through the Detector Aperture Stop, the Detected and Illuminated Areas are Projected onto a Plate in the Ground Plane

6.4.7.1 For fixed-aim instruments, the height tolerance shall be verified to extend from −1 mm to +2 mm by the following test: R_L values measured on a panel shall vary at most ±10 %, when the height position between panel surface and retroreflectometer H is changed from 0 mm to −1 mmm, 1 mm or 2 mm. The R_L values measured on a panel when height position (H) between panel surface and the instrument's normal marking plane is either −1 mm, +1 mm, or +2 mm shall all be between 0.9× and 1.1× the R_L value measured when H is zero. See Fig. 4 for a method of testing the variation.