



Standard Test Method for Field Measurement of Raised Retroreflective Pavement Markers Using a Portable Retroreflectometer¹

This standard is issued under the fixed designation E1696; 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 raised retroreflective pavement markers at a prescribed geometry, by means of a portable retroreflectometer that can be used in the field. The measurements can be compared to minimum requirements to determine the need for replacement.

1.2 The observation angle specified for retroreflectometers in this test method is that currently specified for raised pavement markers in the United States and may differ from the angles used elsewhere. For other jurisdictions, replace the observations angle specified herein with the observation angle specified by the pertinent agency.

1.3 This test method is intended to be used for field measurement of raised retroreflective pavement markers but may also be used to measure the performance of new markers before they are placed in the field.

1.4 This test method covers measurements of raised pavement markers mounted on a road surface or mounted in snow-plowable metal castings.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *The 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*

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.

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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

3. Terminology

3.1 The terms and definitions in Terminology E284 are applicable to this test method. Some terms particular to retroreflection are defined and illustrated in Practice E808.

3.2 *Definitions*:

3.2.1 The delimiting phrase “in retroreflection” applies to each of the following definitions when used outside the context of this or other retroreflection standards.

3.2.2 *coefficient of luminous intensity, R_l , n* —of a retroreflector, ratio of the luminous intensity (I) of the retroreflector in the direction of observation to the illuminance (E_{int}) at the retroreflector on a plane perpendicular to the direction of incident light, expressed in candelas per lux ($\text{cd}\cdot\text{lx}^{-1}$).

3.2.2.1 *Discussion*—When values are low, the coefficient of (retroreflected) luminous intensity may be given in millicandelas per lux ($\text{mcd}\cdot\text{lx}^{-1}$). $R_l = (I/E_{\text{int}})$.

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

3.2.3.1 *Discussion*—In this test method, “portable retroreflectometer” refers to a hand-held instrument that can be placed over a raised retroreflective pavement marker to measure the coefficient of luminous intensity with a prescribed geometry.

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

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.

4. Summary of Test Method

4.1 This test method involves the use of commercial portable retroreflectometers for determining the coefficient of luminous intensity of pavement markers.

4.2 Entrance angle component β_1 shall be between -2° and 0° ; entrance angle component β_2 shall be $0^\circ \pm 2^\circ$.

4.3 Unless otherwise specified by the user, the observation angle shall be $0.2^\circ \pm 0.01^\circ$.

4.4 The observation half plane shall be vertical. Rotation angle shall be 0° (see Fig. 1 and Fig. 2).

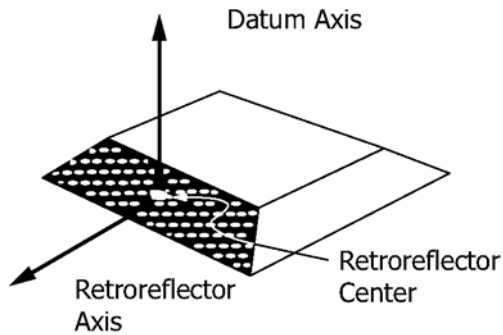
4.5 The aperture angles of the source and of the receiver shall each be 0.1° with a tolerance of $\pm 0.04^\circ$ on the sum of the two aperture angles.

4.6 The aperture angle of an individual retroreflective element shall be 0.02° max (see Practice E809). For a portable photometer this aperture angle can be achieved by interposing a collimating lens in the illumination and observation axes.

4.7 A portable standard shall be used for standardization.

4.8 After standardization place the retroreflectometer directly over the marker to be tested making sure that the road-axis marking on the retroreflectometer is parallel to the lane line of the road.

4.9 The reading displayed by the retroreflectometer is recorded. The retroreflectometer is removed from the marker, then replaced and the reading recorded again. If the difference in readings is greater than 10 %, the process is to be repeated a third time.



Location of retroreflector axis, datum axis and retroreflector center for use in testing raised pavement markers.

Retroreflector Center-located on the surface of the effective retroreflective area, centered both vertically and horizontally.

Retroreflector Axis-extends parallel to the road surface from retroreflector center.

Datum Axis-extends vertically from the road surface plane starting at retroreflector center.

FIG. 1 Position of Marker for Photometry

5. Significance and Use

5.1 Measurements of R_l made by this test method, with the 0.2° observation angle, are related to visual observation of raised retroreflective pavement markers at distances of approximately 220 m (720 ft) for cars or approximately 440 m (1440 ft) for trucks when illuminated by tungsten filament light sources such as car headlights.

5.2 There are some castings that block vehicle illumination of a portion of the marker mounted within it. In this case, measured R_l can be significantly lower than when the marker is photometered outside the casting, but will correspond to the visual observation.

5.3 The test method is not applicable to raised pavement markers mounted in depressions cut into the pavement.

5.4 The coefficient of luminous intensity of raised retroreflective pavement markers degrades with traffic wear and requires periodic measurement to ensure that sufficient visibility is provided to the driver.

5.5 The quality of the pavement markers as to materials used, age and wear pattern, will have an effect on the coefficient of (retroreflected) luminous intensity. These conditions need to be observed and noted by the user.

6. Apparatus

6.1 *Portable Retroreflectometer:*

6.1.1 The retroreflectometer shall be portable with the capability of being positioned over markers installed on the roadway surface.

6.1.2 The retroreflectometer shall be constructed so that placement on the road will preclude any stray light from entering the area being tested under daylight conditions.

6.1.3 The retroreflectometer shall be constructed so that it can be placed over the marker with the illumination axis approximately parallel to the road surface.

6.1.4 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 $V(\lambda)$ photopic spectral luminous efficacy function according to the following two criteria for all λ_0 between 470 nm and 640 nm:

$$0.9 < \frac{\sum_{\lambda=360}^{830} \exp\left(\left(\frac{\lambda - \lambda_0}{25}\right)^2\right) S(\lambda)R(\lambda) \sum_{\lambda=360}^{830} A(\lambda)V(\lambda)}{\sum_{\lambda=360}^{830} \exp\left(\left(\frac{\lambda - \lambda_0}{25}\right)^2\right) A(\lambda)V(\lambda) \sum_{\lambda=360}^{830} S(\lambda)R(\lambda)} < 1.1$$

and also

$$\left(\frac{\sum_{\lambda=670}^{1000} S(\lambda)R(\lambda)}{\sum_{\lambda=360}^{1000} S(\lambda)R(\lambda)} \right) < 0.02$$

where:

- $S(\lambda)$ = instrument illumination spectral power distribution,
- $R(\lambda)$ = instrument spectral responsivity,
- $A(\lambda)$ = CIE Standard Illuminant A, and
- $V(\lambda)$ = CIE photopic luminous efficacy function.

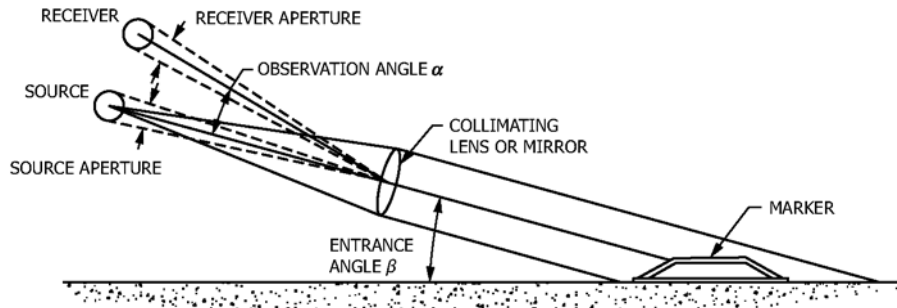


FIG. 2 Angles and Apertures for Collimating Type Portable Retroreflector for Raised Retroreflective Pavement Markers

The λ_0 shall be chosen at 5 nm intervals and the summations shall be at 5 nm intervals.

NOTE 1—A user can partially verify the instrument spectral correction by making a pair of R_t measurements on a crystal-white unmetallized large-prism retroreflector, one measurement with and one measurement without a calibrated absorptive filter interposed. For relevance, the filter's colors should resemble some retroreflective marker's color. The filter should be mounted with approximately 1° downward tilt to avoid specular reflection into the receiver. The transmittance of the filter (in air) must be squared and a value for luminous transmittance of CIE illuminant A calculated. The ratio of the two R_t measurements should match the luminous transmittance value to within approximately 10%. The verification can be repeated for several colors of interest.

NOTE 2—The second criterion can alternatively be met by means of a filter test. A 3 mm thick Schott RG-665 filter glass shall be mounted in front of a crystal-white unmetallized large-prism retroreflector, the R_t measured, and the value divided by the R_t measured without the filter. The ratio shall be less than 2%. The filter should be mounted with approximately 1° downward tilt to avoid specular reflection into the receiver.

6.1.5 When using a standard similar in color, material, and type to the sample, measured R_t shall not deviate by more than 10% from measurements made on a laboratory photometer conforming to Practice E809 with observation angle, α , as specified and $\beta_1 = \beta_2 = \epsilon = 0^\circ$.

6.1.6 If, for convenience, the user chooses to use a white standard for all markers, a correction factor shall be applied to the readings obtained with the white standard. To determine the correction factor, (1) standardize the instrument using a white standard; (2) without changing the instrument settings, note the reading for a selected prephotometered standard similar in color, material, and type to the markers to be tested; and (3) divide the known retroreflectance of the selected prephotometered standard by the reading noted in (2). Multiply all readings obtained for markers of a particular color, material, and type by the correction factor obtained for that color, material, and type.

6.1.7 For the convenience of the user, a road-axis marking should 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 illuminance over the entire test area shall be within 10% of the average illuminance.

6.2.2 The source shall be regulated such that the illumination of the test area does not change by more than $\pm 1\%$ for the duration of the test.

6.2.3 For measurement of surface mounted markers, the lower edge of the illumination shall be no more than 1 mm above ground level at the distance of the marker's leading edge.

6.2.4 For measurement of markers in castings, the lower edge of the illumination shall be within ± 0.5 mm of ground level at the distance where the marker lens intersects the ground level.

6.3 Receiver Requirements:

6.3.1 The receiver shall have sufficient sensitivity and range to accommodate coefficient of luminous intensity values expected in use, typically 1 to 1999 mcd·lx⁻¹.

6.3.2 The receiver response shall not vary more than $\pm 2\%$ for the duration of the test.

6.4 Measurement Geometry:

6.4.1 The light source and receiver shall be at optical infinity to ensure that the angular aperture of an individual retroreflecting element shall be not more than 0.02° .

6.4.2 The light source and receiver shall be separated from each other by a center to center distance corresponding to $0.2^\circ \pm 0.01^\circ$ observation angle.

7. Procedure

7.1 Turn on the retroreflector and allow it to reach equilibrium.

7.2 With the retroreflector positioned on the road surface near the markers to be tested, adjust the retroreflector zero knob for reading of 0 ± 2 in the least significant figure. For laboratory use the retroreflector shall be zeroed on the same non-retroreflective surface on which the marker is to be positioned for test.

7.3 At approximately the same location on the road where the retroreflector was adjusted for zero, place an instrument standard similar in color, material, and type to the marker being tested and having a known and relatively constant retroreflectivity. The instrument standard shall be checked on a laboratory photometer (see Practice E809) at regular intervals, and the standard value shall be adjusted.

7.4 Position the retroreflector over the instrument standard and turn on the instrument. After warm up for the time recommended by the manufacturer, typically 15 s, set the instrument gain so that the meter shows the value of the instrument standard.

7.5 Place the retroflectometer over the marker to be photometered making sure that there are no impediments to seating the instrument on the roadway surface. Record the value of the measurement in $\text{mcd}\cdot\text{lx}^{-1}$.

7.6 Remove the retroreflectometer, reposition the retroreflectometer over the marker, and again record the reading. If the two readings differ by more than 10 %, again remove and reposition the retroreflectometer and take a third reading.

7.7 Wipe the surface of the marker with a soft rag very wet with detergent and water using care not to abrade the marker surface. Dry thoroughly by patting with a paper towel.

7.8 Repeat 7.6 and 7.7 and record readings for the markers after cleaning.

8. Report

8.1 Report the following information:

8.1.1 The test date,

8.1.2 The marker location including distance from the nearest permanent site identification such as a mileage marker or crossroad,

8.1.3 The identification of the instrument used,

8.1.4 The average reading before cleaning and average reading after cleaning. The readings will be the coefficient of luminous intensity in millicandelas per lux (mcd/lx),

8.1.5 Remarks as to condition of the marker such as percentage of area undamaged, and

8.1.6 The value and date of standardization and identification of the reference standard used.

9. Sources of Error

9.1 There are many factors that cause high variability when taking readings in the field.

9.1.1 Retroreflectometers with differing entrance angles, observation angles, or angular apertures, or combination thereof will give different readings.

9.1.2 Retroreflectometers lacking a collimating lens to eliminate the effects of size of the retroreflecting element will give different readings and are not recommended (see 4.6).

9.1.3 Slight differences in the seating of the retroreflectometer around the marker may give different readings.

9.1.4 Differences in the cleanliness of the marker will cause differences in reading. For instance, a marker photometered shortly after a rain will read higher than the same marker photometered after a long dry spell.

10. Precision and Bias

10.1 These data are under development.

11. Keywords

11.1 portable retroreflectometers; raised retroreflective pavement markers; retroreflection

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