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Specification for Minimum Retroreflectance of Newly Applied Pavement Marking Using Portable Hand-Operated Instruments (Withdrawn 2006)[3]

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[4]

## 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 ($mcd \cdot m^{-2} \cdot lx^{-1}$).

3.2.2 *co-entrance angle, $\beta_C$, n*—the complement of the entrance angle ($90° - \beta$).

3.2.3 *co-viewing angle, $\nu_C$, n*—the complement of the viewing angle ($90° - \nu$).

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.

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[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] 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] The last approved version of this historical standard is referenced on www.astm.org.

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

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°.

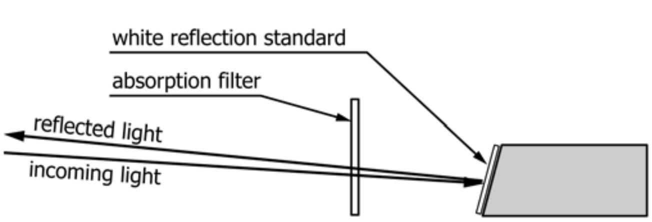



**FIG. 1 White Reflection Standard and Absorption Filter for Testing Spectral Match**

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.

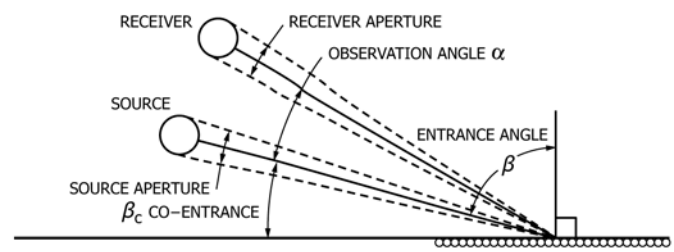



FIG. 2a Angles and apertures for non-collimating portable retroreflectometer

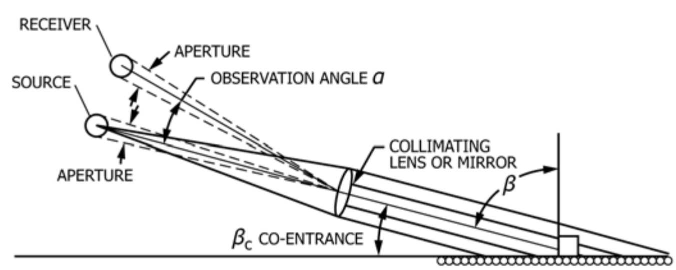



FIG. 2b Angles and apertures for collimating optics portable retroreflectometer

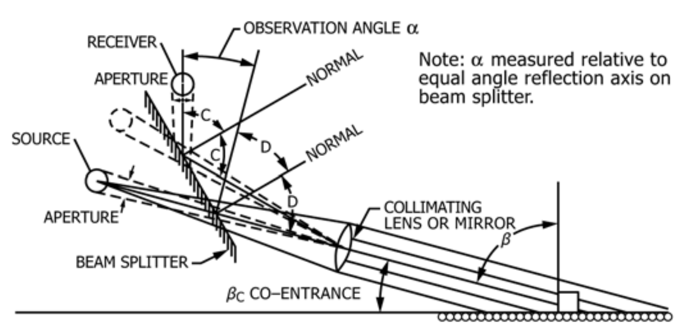



FIG. 2c Angles and apertures for portable retroreflectometer with collimating and beam splitter design

**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**

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.

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.

NOTE 6—Depth tolerance requires that the larger of the two areas, detected or illuminated area, has sufficient reserve and spatially uniform characteristics (either illumination or sensitivity). This is illustrated in Fig. 5 in a simplified manner, where illumination and detection beams are indicated by respectively solid and broken lines, and the shaded parallelogram represents the largest region of space where measurement occurs and where longitudinally butted repetitions of the region neither omit, nor double, any points above some fixed depth.

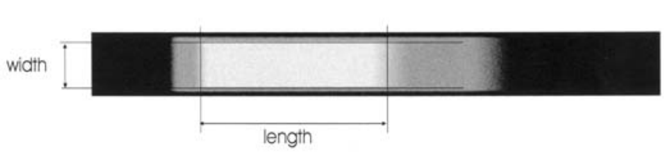
NOTE 7—Shifts in height positions and tilts of a retroreflectometer are unavoidable in practical field measurements due to surface texture, particles on the surface, or vertical curvature of the pavement marking or low profile. A fixed-aim instrument must have the specified tolerance for practical conditions.

NOTE 8—The longitudinal movements indicated in Fig. 4 serve to compensate for the shift in the location of the measurement area with the lift of the retroreflectometer, so that the same spot on the panel is measured irrespective of the lift. For arrangement A the detected area is the measurement area, and the shift is 1 mm/tan (2.29°) = 25 mm for each mm lift of the instrument, where 2.29° is the value of the co-viewing angle in the prescribed geometry. For arrangement B the illuminated area is the measurement area, and the shift is 1 mm/tan (1.24°) = 46 mm for each mm lift of the instrument, where 1.24° is the value of the co-entrance angle in the prescribed geometry.

6.4.7.2 For fixed-aim instruments, larger lifts in steps of 1 mm may be used to verify an instrument's capabilities to measure profiled pavement markings.

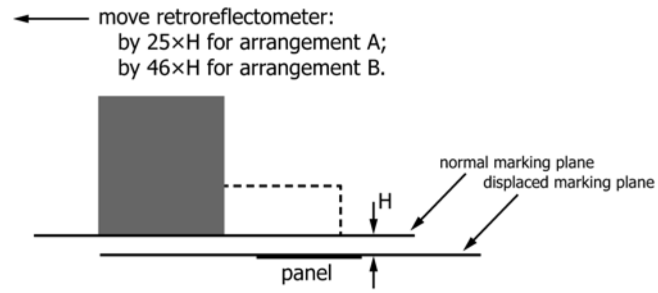
NOTE 9—To be able to reliably measure the $R_L$ of profiled pavement markings having profiles higher than 2 mm requires larger tolerances than specified in 6.4.7.1. For example, an instrument that can be lifted by 4 mm before the measured $R_L$ value exceeds the variation of ±10 % has the capability, when resting on the tops of profiles of a profiled pavement marking, to reach 4r mm down without significant loss of signal. When reaching down by 4 mm, the measurement area shifts by 4 by 25 mm = 100 mm for an instrument with arrangement A, and 4 by 46 mm = 184 mm, for an instrument with arrangement B. Refer to Note 8.

Such an instrument can be used to measure profiled pavement markings, when profiles are up to 4 mm high, because it is able to reach through the gaps down to the bottom surface between the profiles. The instrument can also be used to measure profiled pavement markings with profiles higher than 4 mm provided that the structure of the profiles is such that no 1.24° downward illumination can penetrate deeper than 4 mm below the tops of the profiles. This is for instance the case, when the profiles cover the whole width of the pavement marking, have approximately constant height and a spacing of at most 184 mm.




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**




NOTE 1—The retroreflectometer is moved backwards in proportion to the height position H in order to measure the same spot on the panel.

**FIG. 4 Lift Test for a Fixed-Aim Portable Retroreflectometer**

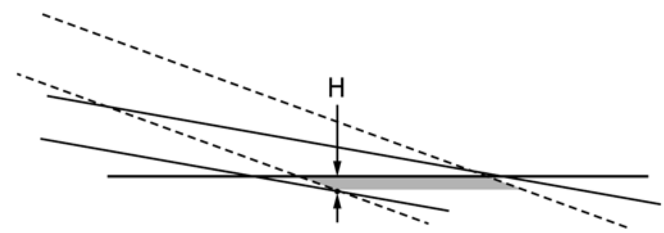



FIG. 3a Depth tolerance H determined by the illumination and detection beams (Arrangement A)

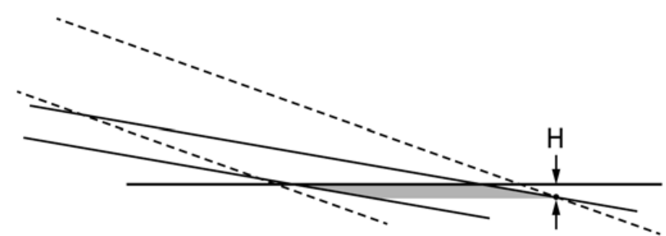



FIG. 3b Depth tolerance H determined by the illumination and detection beams (Arrangement B)

**FIG. 5 Depth Tolerances**

6.4.7.3 When measuring profiled pavement markings with a fixed-aim instrument, ensure that the particular instrument has the capability to measure the particular profiled pavement marking.

NOTE 10—Most types of profiled pavement markings have moderate profile heights of up to 3 mm, or maximum 5 mm. Some profiled pavement markings are, however, intended to induce acoustic or vibration effects by the passage of wheels, and have higher profile heights often combined with large gaps between profiles.

6.4.7.4 For fixed-aim instruments, when measuring profiled pavement markings, move the instrument laterally using sufficiently small steps, while maintaining it essentially in the plane defined by the tops of the profiles, take and average the readings at each location covering in total one or more profile spacings.

NOTE 11—The stepping distance should be at most the length of the measurement area defined in 6.4.6. For markings with regularly spaced profiles, the stepping distance D should be selected so that D × N, where N is and integral number, equals a small integral number of profile spacings, for example one or two. Readings are taken at N locations and the average is used to represent the $R_L$ of the profiled pavement marking.

The readings may vary from location to location, as different parts of the profiled pavement marking are measured (tops and sides of profiles and gap bottom), but maintaining the instrument in essentially the same plane secures that the average represents the retrorefletively as it affects a driver.

When profile spacings are significantly smaller than the length of the measurement area of the particular instrument, the readings may be fairly constant, and a single reading at one location may be sufficient.

6.4.7.5 For aiming instruments, follow the manufacturer's instructions concerning ability and method of measuring non-profiled and profiled pavement markings.

## 7. Sampling

7.1 The number of readings to be taken at each test location and the spacing between test locations shall be specified by the user. As a guide, the current version of Specification D6359 may be referred to.

7.2 Recommendations concerning the number of readings and spacing will be made in a later revision of this test method. These will provide guidance to establish the instrument precision and repeatability under the best possible conditions using a spatially uniform sample. The new recommendations will also give guidance on obtaining "good" measurements at a local position or patch for newly installed pavement markings and worn pavement markings.

## 8. Standardization

8.1 The retroreflectometer shall be standardized using an instrument standard consisting of a separate panel of marking material with a known and reproducible coefficient of retroreflected luminance measured at the same geometry as used in the portable retroreflectometer. The instrument standard shall be standardized in accordance with Test Method D4061, with the datum mark indicated on the standard. The instrument standard panel(s) shall have a standardization value of the coefficient of retroreflected luminance, $R_L$, within the expected pavement marking range. The standardization values shall be maintained by checking against other standards or using Test Method D4061 sufficiently often to ensure that no large uncertainties in the measurement can occur.

8.2 Subsequent to this standardization, an internal or secondary reference surface, either diffuse white or retroreflecting surface, may be used to maintain the standardization of the instrument during brief periods of transport to the test site area.

8.3 Note that transporting the instrument from an air conditioned area to the test site may result in fogging of mirrors (if any) in the instrument. If there is any doubt concerning the calibration or the readings are not constant, allow the instrument to reach ambient conditions and recalibrate with the instrument standard.

## 9. Procedure

9.1 Use the manufacturer's instructions for operation of the retroreflectometer, which generally uses the following procedure:

9.1.1 Ambient temperature shall be not less than 4°C (40°F).

9.1.2 The surface of the marking shall be clean and dry.

9.1.3 Turn on the retroreflectometer, and allow it to reach equilibrium following the manufacturer's instructions.

9.1.4 If the retroreflectometer has a zero-adjust control, set the display to 0 ± 2 in the least significant digit, with the instrument placed on a very black low retroreflectance panel.

9.1.5 If a standard panel is used, standardize the retroreflectometer by placing it on the instrument standard panel and setting the standardization control to the standardized value for that geometry.

9.1.6 For instruments with an internal reference surface, insert that surface into the light path and read the signal from the display. Record this reading.

9.1.7 Place the retroreflectometer squarely on the pavement marking material, ensuring that the measurement area of the retroreflectometer fits within the width of the stripe. The reading direction of the retroreflectometer shall be placed in the direction of traffic. Readings shall be taken for each direction of traffic and averaged separately for centerlines.

9.1.8 Record the retroreflectometer reading, and then move to other locations on the same sample set separated sufficiently to provide meaningful data (typically 1 metre), and record the results.

9.1.9 At intervals of one h or less, check the standardization and readjust the setting if the reading of either the internal standard or instrument standard has changed by more than 5 %.

## 10. Test Report

10.1 Include the following in the test report:

10.1.1 Test date.

10.1.2 Average of the readings at each test location, expressed as millicandelas per square metre per lux ($mcd \cdot m^{-2} \cdot lx^{-1}$). The average of the readings shall be reported for each traffic direction for centerlines.

10.1.3 Geographical location of the test site, including distance from the nearest permanent site identification, such as a mileage marker or crossroad.

10.1.4 Identification of the pavement marking material tested: type, color, age, and transverse location on road (edge line, first line, second line, and center).

10.1.5 Identification of the instrument used.

10.1.6 Value and date of standardization of the instrument standard panel used.

10.1.7 Entrance, viewing, and observation angles used to obtain the readings.

TABLE 1 Results of Precision Testing for Coefficient of Retroreflected Luminance (mcd/lx/m$^2$)

| Sample | Average of the Labs' Averages | Repeatability Standard Deviation $s_r$ | Reproducibility Standard Deviation $S_R$ | Repeatability Limit r | Reproducibility Limit R | R/mean |
|---|---|---|---|---|---|---|
| N | 575.8 | 14.4 | 22.9 | 40.3 | 64.2 | 11 % |
| D | 331.4 | 4.7 | 14.1 | 13.2 | 39.5 | 12 % |
| Ap | 266.5 | 8.8 | 15.4 | 24.7 | 43 | 16 % |
| O | 508.7 | 5.8 | 30.2 | 16.4 | 84.6 | 17 % |
| R | 1310.8 | 17.9 | 86.1 | 50 | 241.1 | 18 % |
| At | 302.7 | 5.8 | 23.3 | 16.2 | 65.2 | 22 % |
| K | 1854.7 | 44.9 | 144.2 | 125.6 | 403.9 | 22 % |
| Q | 1985.8 | 56.3 | 176.2 | 157.7 | 493.3 | 25 % |
| H | 584.6 | 15.2 | 54.6 | 42.6 | 152.9 | 26 % |
| F | 519.8 | 11.3 | 52.2 | 31.7 | 146.1 | 28 % |

10.1.8 Remarks concerning the overall condition of the line, such as rubber skid marks, carryover of asphalt, snow plow damage, and other factors that may affect the retroreflection measurement.

10.1.9 Ambient temperature.

## 11. Sources of Error

11.1 There are many factors that cause high variability when taking readings in the field. Some of these are as follows:

11.1.1 Slight changes in the position of the retroreflectometer on the traffic line may yield different readings.

11.1.2 Transverse lines may yield less uniform readings than longitudinal lines. Transverse lines have high wear in the wheel track area and less wear in the non-wheel track area.

11.1.3 The refractive index of the glass spheres and their depth of embedment as well as population on the pavement marking material will affect the readings.

11.1.4 The pigment loading of the binder, road films, dirt, salt, dust, water, etc. will also affect the readings.

11.1.5 The entrance angle with respect to the specimen plane will be affected by the physical characteristics of the specimen.

## 12. Precision and Bias[5]

12.1 The precision of this test method is based on an interlaboratory study of ASTM E1710, Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer, conducted in 2010. Ten laboratories participated in this study. Each of the labs was asked to report fifteen replicate test results for ten different materials. Every "test result" reported represents a single determination or measurement. The testing was conducted with pavement marking samples on rigid and flat panels Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report: RR:E12-1005.

12.1.1 *Repeatability Limit (r)*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material; "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

12.1.1.1 Repeatability limits are listed in Table 1.

12.1.2 *Reproducibility Limit (R)*—Two test results shall be judged not equivalent if they differ by more than the "*R*" value for that material; "*R*" is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

12.1.2.1 Reproducibility limits are listed in Table 1.

12.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

12.1.4 Any judgment in accordance with statements 12.1.1 and 12.1.2 would have an approximate 95 % probability of being correct.

12.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

12.3 The precision statement was determined through statistical examination of 1494 results, from ten laboratories, reporting up to fifteen replicate analyses, on a total of ten different materials, which were described as:

Ap: AASHTO M247 Type II beads on water-based paint
At: AASHTO M247 Type II beads on thermoplastic
D: AASHTO M247 Type III beads on water-based paint
F: AASHTO Type III and V beads on profiled thermoplastic
H: AASHTO Type I and IV beads on inverted profile thermoplastic
K: Cluster-style optics on polyurea
N: AASHTO Type I beads on profiled MMA
O: Preformed tape
Q: Preformed tape
R: Preformed tape

12.4 To judge the equivalency of two test results, it is recommended to choose the material closest in characteristics to the test specimen.

## 13. Keywords

13.1 pavement markings; portable retroreflectometers; retroreflection

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E12-1005. Contact ASTM Customer Service at service@astm.org.