**Designation: ~~E2177 – 19~~ E2177 – 20**

# Standard Test Method for Measuring the Coefficient of Retroreflected Luminance ($R_L$) of Pavement Markings using the Bucket Method in a ~~Standard~~ Condition of ~~Wetness~~Wet Recovery[1]

This standard is issued under the fixed designation E2177; 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 wet retroreflective ($R_L$) properties of horizontal pavement marking materials, such as traffic stripes and road surface symbols, using a portable ~~or mobile~~ retroreflectometer that can be placed on or before the road marking to measure the retroreflection at the prescribed geometry.

1.2 This method of measuring the wet retroreflective properties ($R_L$) of pavement markings measures the wet retroreflectivity in a ~~standard~~ condition of ~~wetness~~ wet recovery (see Fig. 1).

1.2.1 ~~*Discussion*—~~This test condition typically exists (*1*) after a rainfall has ended and the pavement markings are still wet or (*2*) as the markings are wet from dew or humidity.

1.3 Retroreflective performance obtained with this test in ~~conditions~~condition of ~~wetness~~ wet recovery does not necessarily relate to how markings perform in conditions of rain, that is, as markings are being rained upon. Test Method E2832 defines a method to measure the performance of pavement markings in conditions of simulated rain.

1.4 This test method specifies the use of portable ~~or mobile~~ reflectometers that can measure pavement markings in accordance with Test Method E1710.[2] The entrance and observation angles required of the retroreflectometer in this test method are commonly referred to as "30 meter geometry."[2]

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

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[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] Reference ASTM E1710 "Standard Test Method for Measurement of Retroreflective Pavement Markings with CEN-Prescribed Geometry Using a Portable Retroreflectometer." The standard measurement condition is intended to represent the angles corresponding to a distance of 30 m for the driver of a passenger car with an eye height of 1.2 m and a headlight height of 0.65 m above the road. See Appendix X1.

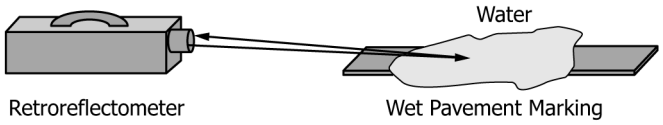


**FIG. 1 Illustration of Measurement**

## 2. Referenced Documents

2.1 *ASTM Standards:*[3]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E965 Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique
E1710 Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer
E2832 Test Method for Measuring the Coefficient of Retroreflected Luminance of Pavement Markings in a Standard Condition of Continuous Wetting ($R_{L\text{-}2}$)

2.2 *Other Standard:*

CEN–EN 1436 Road Marking Materials—Road Marking Performance for Road Users and Test Methods[4]

## 3. Terminology

3.1 *coefficient of retroreflected luminance, $R_L$,n*—the ratio of the luminance, $L$, of a projected surface to the normal illuminance, $E$, at the surface on a plane normal to the incident light, expressed in candelas per square meter per lux ($cd/m^2/lx^1$). Because of the low luminance of pavement markings, the units commonly used are millicandelas per square meter per lux ($mcd/m^2/lx$).

3.2 *condition of ~~wetness,~~ wet recovery, n*—the test condition is created by liberally wetting the pavement marking and waiting a ~~certain~~specific time period after wetting for water to run ~~off.~~off (recover) before taking a retroreflectivity reading.

3.2.1 *Discussion*—

Similar conditions exist when pavement markings are wet or damp such as typically found after a rain has ended or from dew and high humidity.

3.3 *mobile retroreflectometer, n*—a retroreflectometer that has been mounted to a vehicle for purposes of taking measurements while the vehicle is moving.

3.4 *portable retroreflectometer, n*—~~an~~ a hand held instrument that can be used in the field or laboratory for measuring the coefficient of retroreflected luminance, $R_L$.

3.5 *"recovery method" or "bucket method", n*—alternative names commonly used to describe this test method for achieving measurements in condition of ~~wetness.~~wet recovery.

3.6 *$R_{L\text{-}wet}$,n*—the retroreflectance value, $R_L$, obtained 45 s after wetting. (See Fig. 2.)

## 4. Significance and Use

4.1 The nighttime performance of pavement markings is determined by the coefficient of retroreflected luminance, $R_L$, be it dry or wet, and depends on the materials used, age, and wear pattern. These conditions shall be observed and noted by the user.

4.2 Under the same conditions of headlight illumination and driver's viewing, larger values of $R_L$ correspond to higher levels of visual performance at corresponding geometry.

4.3 The pavement marking's measured performance in the ~~standard~~ condition of ~~wetness~~ wet recovery is used to characterize the performance of the marking on the road when wet.

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

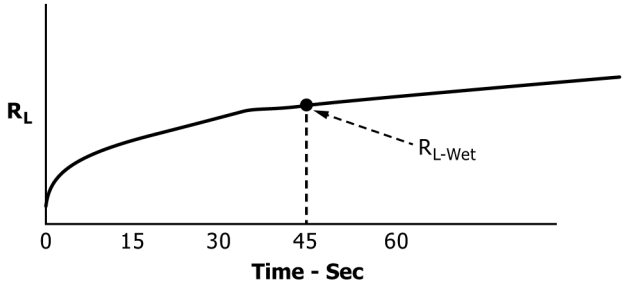


FIG. 2 Definition of $R_{L\text{-}Wet}$

4.4 Newly installed pavement markings may have a natural surface tension or release agents that prevent wetting of the product by water. The water will tend to "bead up" on the marking. This "non wetting" condition is usually short lived. Pavement markings that have been on the road for one month prior to testing usually do not exhibit this non-wetting phenomenon. (**Warning—** ~~Warning~~This~~ This~~ phenomenon produces an interference when assessing the wet characteristics of a pavement marking. Attempts to measure markings with this surface "non-wetting" or "beading" of the water may give higher values.)

4.5 The retroreflectivity, $R_L$, of pavement (road) markings degrades with traffic wear and requires periodic measurement to ensure that sufficient line visibility is provided to drivers.

4.6 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 the material measured.

4.7 As specified by Test Method E1710, the measurement geometry of the instrument is based on a viewing distance of 30 m, an eye height of 1.2 m and a headlight mounting height of 0.65 m (see Appendix X1).

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

## 5. Apparatus

5.1 *Portable ~~or Mobile~~ Retroreflectometer*—The reflectometer must comply with Test Method E1710.

5.2 *Stopwatch or Watch,* with second hand.

5.3 *Water,* for wetting the pavement marking.

5.3.1 A bucket capable of holding 3 ~~liters~~L shall be used to create the wet condition by pouring the water over the marking.

5.3.2 The water shall be clean tap water.

## 6. Sampling

6.1 The number of test results obtained at each test location and the spacing between test locations shall be specified by the user.

6.2 A test site shall consist of three measurement areas spaced as closely as possible, while maintaining a distance between measurement areas sufficient to ensure no interference in preparation and testing.

6.3 Test results for each line type shall be averaged for a final result.

## 7. Calibration and Precautions

7.1 The portable ~~or mobile~~ retroreflectometer shall be calibrated (standardized) using the instructions from the instrument manufacturer. A reference or working standard is used and is supplied with the instrument.

7.2 Transporting the portable reflectometer from an air conditioned area to the test site may result in fogging of mirrors in the instrument. If there is any doubt concerning the calibration or if the readings of a reference or working standard are not constant, allow the instrument to reach ambient conditions and recalibrate with the reference or working standard.

7.3 Verification must be made that there is no moisture on the instrument's lens when the instrument is being used for wet readings. Sometimes the reflectometer's lens will become "fogged over" in high temperatures due to water evaporation. When roads are hot one can pre-cool the road with water before applying the test method to prevent the reflectometer from fogging.

7.4 *Calibration Recheck*—If the subsequent readings on the reference standard deviate by more than 5 % from the initial one, re-calibration shall be performed. If the readings on the reference standard deviate by more than 10 % from the initial one, recalibrate and, in addition, re-measure previous measurements.

## 8. General Procedure

8.1 Both a dry and a wet measurement are usually taken in order to characterize the performance of the marking. The dry measurement establishes the effectiveness of the marking in a dry condition plus provides a bench mark for the marking to which the wet performance can be compared. However, the dry measurement is optional per this test method.

8.2 *Measuring Dry or Wet Retroreflectance ($R_L$) of Markings:*

8.2.1 Use the manufacturer's instructions for calibration and operation of the retroreflectometer.

8.2.2 Locate the area of the pavement marking to be measured.

8.2.3 Place the retroreflectometer squarely on or behind the measurement area with the illumination in the direction of travel. Ensure that the illuminated measurement area of the retroreflectometer fits within the width of the stripe, and take a measurement.

8.3 *Measuring Retroreflectance ($R_L$) in a Standard Condition of Wetness:*

8.3.1 A test result is obtained by averaging three measurements taken in a test site as described in 6.2.

8.3.2 Pour 3.0 ~~liters~~L of clean water from a bucket over the measurement area within 3 to 5 s and begin timing when the bucket is emptied. The water is poured evenly along the test surface so that the measuring field and its surrounding area is momentarily flooded by a crest of water (see Fig. 3).

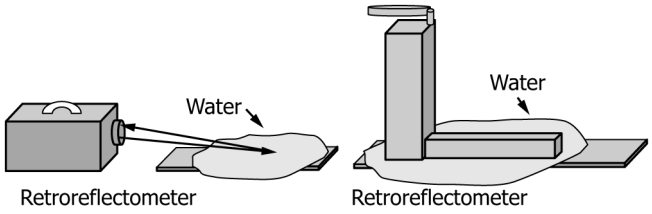


**FIG. 3 Illustration of Measurement**

8.3.3 Measure the coefficient of retroreflected luminance, $R_L$, of the wetted marking 45 s after pouring water on the marking as described in 8.3.2 (see Fig. 3).

8.4 *Records*—Record the dry and wet measurements in millicandelas per square meter per lux, (mcd/m$^2$/lx). Move to next measurement location which is separated sufficiently to provide meaningful data and repeat procedures in 8.2 and 8.3.

## 9. Test Report

9.1 Include the following in the test report.

9.1.1 Test date.

9.1.2 Measurements shall be expressed in millicandelas per square meter per lux (mcd/m$^2$/lx). The average of the readings shall be reported for wet and for dry conditions and for each traffic direction of interest.

9.1.3 Retroreflectivity readings shall be taken in the direction of traffic on each pavement marking. Markings which are exposed to bidirectional traffic (single or double centerlines, center skips, suicide lane lines etc.) shall be measured in both directions of travel.

9.1.4 Geographical coordinates of the test site. Global positioning system (GPS) location or distance from the nearest permanent site identification, such as a mileage marker or crossroad.

9.1.5 Identification of the pavement marking material tested: type, color, age, and the location on road (edge line, first line, second line, centerline, etc.).

9.1.6 Identification of the instrument used, value and date of calibration of the reference standard panel used.

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

9.1.8 Ambient temperature and other weather conditions.

9.1.9 Description of roadway slope and general drainage where measurement is made (that is, puddles on marking due to low spot in road, water drained due to road incline, etc.)

9.1.10 Description of road surface and road texture, that is, portland concrete cement (PCC) (broomed, brushed, worn), bituminous, chip seal, etc.



NOTE 1—Pavement texture may be identified and quantified by Test Method E965.

## 10. Factors That May Influence Measurements



10.1 There are several factors that may cause measurement variability when taking readings in the field. Some of these are:

10.1.1 Slight changes in the position of the reflectometer on or in front of the traffic line may yield different readings.

10.1.2 The magnitude of the wet measurement obtained may sometimes be dependent upon how well the water drains “off from” the marking. Steep inclines will allow the water to run off quickly and lead to higher values. Conversely, low areas or dips will allow the water to puddle and will give lower values.

10.1.3 Environmental conditions that can effect evaporation rate such as road temperature, air temperature, wind velocity, relative humidity, sun exposure and altitude.

**TABLE 1 Results of Precision Testing for E2177–10 Coefficient of Retroreflected Luminance of Pavement Markings in a Standard Condition of Wetness (mcd/m$^2$/lx)[A]**

| Sample | Average of the Labs' Averages | Repeatability Standard Deviation $s_r$ | Reproducibility Standard Deviation $S_R$ | Repeatability Limit r | Reproducibility Limit R | R/mean |
|---|---|---|---|---|---|---|
| O | 85.7 | 6.4 | 7.3 | 17.9 | 20.4 | 24 % |
| R | 737.4 | 52.3 | 65.2 | 146.4 | 182.6 | 25 % |
| H | 307 | 14.4 | 31.4 | 40.2 | 87.9 | 29 % |
| D | 197.3 | 15.9 | 24.8 | 44.4 | 69.4 | 35 % |
| Q | 1328.7 | 155.3 | 181.8 | 434.7 | 509.1 | 38 % |
| K | 164.6 | 20.6 | 23.6 | 57.7 | 66.1 | 40 % |
| N | 76.9 | 11.2 | 13 | 31.3 | 36.4 | 47 % |
| F | 166.1 | 23.5 | 36 | 65.8 | 100.9 | 61 % |
| At | 114.6 | 27.5 | 37.7 | 77.1 | 105.7 | 92 % |

[A] Test results were obtained from indoor testing using laboratory pavement marking specimens mounted to smooth rigid panels. Measurements taken outdoors on pavement markings applied to real road surfaces are likely to have higher variability for the reasons mentioned in Section 10.