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Standard Practice for Evaluating Nighttime Retroreflective Sheeting Effectiveness Using Positive-Contrast Textual Sign Scenario Performance Analysis[1]

This standard is issued under the fixed designation D8379/D8379M; 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 practice provides a framework to evaluate retroreflective sheeting performance in nighttime driving conditions without a need for field evaluations through a set of sign viewing scenarios representing common use-cases. The evaluation of performance of a specific sheeting is achieved by comparing the luminance provided by a sheeting to the luminance needed by drivers in each scenario. This comparison is expressed in terms of a "Performance Index," which is a measure for how well the luminance provided to the driver meets their needs, in each of the scenarios. Comparison of the performance index values for different sheeting allows the user to predict differences in nighttime retroreflective performance when those sheeting are used on installed signs.

1.2 The driver-needs data is based on textual signs (not on symbolic signs) with positive contrast (sign text being brighter than its background), and the headlamp illumination is assumed to be low-beams; therefore, performance index is applicable only to textual signs viewed under low-beam headlamp illumination.

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The value stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B209/B209M Specification for Aluminum and Aluminum-Alloy Sheet and Plate

B449 Specification for Chromates on Aluminum

D8 Terminology Relating to Materials for Roads and Pavements

E284 Terminology of Appearance

E808 Practice for Describing Retroreflection

E809 Practice for Measuring Photometric Characteristics of Retroreflectors

2.2 *BSI Standard:*[3]

BS 8408:2005 Road Traffic Signs. Testing and Performance of Microprismatic Retroreflective Sheeting Materials. Specification (Withdrawn)

3. Terminology

3.1 *Definitions*—For definitions of technical terms used in this practice, see Terminologies D8 and E284.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *legibility index, n*—a surrogate metric for the size of the image on the retina, expressed in terms of the longitudinal (roadway) distance to the sign divided by the height of the uppercase alphanumeric on the text.

3.2.2 *legibility range, n*—the range of distances to a sign, expressed longitudinally along the roadway centerline, that are between a legibility index of 40 ft/in. [4.8 m/cm] and 20 ft/in. [2.4 m/cm].

3.2.3 *performance index, n*—a measure that approximates a sign sheeting's performance, in terms of luminance observed by the driver, in a given scenario.

[1] This practice is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.38 on Highway Traffic Control Materials.

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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] Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsigroup.com.

3.2.4 *R_A multiplier, n*—a factor derived from the illuminance at the sign per headlight, measured facing the headlight in a scenario, while also incorporating windshield transmission and the cosine of viewing angle.

3.2.4.1 *Discussion*—R_A multiplier is defined at each distance for a single headlight, and when multiplied by the coefficient of retroreflection for the corresponding scenario and distance, the result is the luminance observed by the driver. The formula for obtaining the R_A multipliers is given in Appendix X1.

3.2.5 *scenario, n*—a particular use-case for retroreflective sign sheeting, determined by sign mounting location, vehicle type, the size of the text on the sign, and the surrounding scene complexity, as viewed by the driver within the legibility range.

4. Summary of Practice

4.1 This practice outlines a procedure to calculate the performance index of a retroreflective sheeting by comparing the luminance provided by the sheeting, to the luminance required by the driver in a set of nighttime traffic sign viewing scenarios.

4.2 The procedure requires the following steps:

4.2.1 Obtain retroreflective sheeting,

4.2.2 Prepare samples,

4.2.3 Select the scenarios of interest, for example, vehicle types, sign locations, and letter heights as defined in Table A1.1.

4.2.3.1 Determine the corresponding applicable tables under the "Measurement Angles and R_A Multiplier Table" column for the selected scenario(s) in Table A1.1 (Table A1.3 through Table A1.11). Also determine the corresponding performance index table(s) for the same scenarios under the "Performance Index Table" column for later use in 4.2.6.

NOTE 1—Table A1.3 through Table A1.11 provide the pre-determined measurement angles for the sheeting representing the angular combinations under which the sheeting is observed by the driver in the corresponding scenarios. If the user is not considering all scenarios at this time, it is still recommended that all pre-determined angular sets in Table A1.3 through Table A1.11 are considered for measurement for future purposes.

4.2.4 Measure sheeting R_A values for the set of pre-defined measurement angles given in the corresponding "Measurement Angles and R_A Multiplier Table(s)" Table A1.3 through Table A1.11.

4.2.5 Calculate the luminance observed by the driver for selected scenario(s) by multiplying the R_A values (from 4.2.4) with the corresponding R_A Multipliers, which are also given in Table A1.3 through Table A1.11 for right and left headlights separately, and add the luminance from the right and left headlights to determine total observed luminance. Do this calculation for each distance and for all three distinct headlights, representing the 25th, 50th, and the 75th percentile low-beams.

4.2.6 Calculate the performance index for each of the selected scenarios, at each distance and headlight percentile, by comparing the observed luminance (from 4.2.5) to the luminance required by the driver given tables in Annex A1, given in Table A1.12 through Table A1.15.

4.2.7 Calculate the overall performance index for each scenario by averaging the performance indexes calculated for each distance and each headlight percentile.

4.2.8 An example walkthrough for the calculation of performance index for one of the scenarios is provided in Annex A2.

5. Significance and Use

5.1 Retroreflective sheeting is commonly used to improve the nighttime visibility and legibility of traffic signs under vehicle headlight illumination. This standard provides a procedure for evaluating the nighttime retroreflective performance of sign sheeting used in roadway signing in terms of an overall average performance index for predefined road scenarios.

5.2 A procedure to characterize the relationship between sign luminance supply and driver luminance demand at night without conducting field work helps traffic engineers and transportation agencies responsible for specifying highway construction materials and maintaining roadway safety in making informed decisions about the performance of retroreflective sheeting on the signs. The procedure requires the comprehensive measurement of the retroreflective properties of a sheeting according to Practice E809 over a wide range of angles.

5.3 A variety of retroreflective sheeting is available for use on traffic signs. Coefficients of retroreflection are typically measured for a standard set of angle combinations and are used, in part, to certify conformance to a specification or standard. However, while coefficients of retroreflection on some standard angle sets can provide a general idea about a sheeting's retroreflectivity and help certify conformance to a standard, a more comprehensive analysis is needed to determine how well a sheeting is expected to serve drivers in general, or in specific use-cases. Drivers of different vehicles viewing a multitude of signs in the real world experience a much more complex set of angular combinations than those captured in the standard angle sets. Furthermore, drivers observe luminance, which is affected by not only the coefficient of retroreflection, but also by headlight illumination, distance from the vehicle to the sign, and light attenuation, among other factors.

5.4 This practice utilizes a set of driver sign viewing scenarios. When combined with the coefficients of retroreflection at the corresponding geometry, the luminance as observed by the driver is calculated. The luminance requirements of the driver for varying percentiles are also tabulated for the user. Comparing the luminance supply from the sign with the luminance demand of drivers provides an assessment of the expected "performance index" in each scenario.

5.5 The data on the luminance needs of the driver represents the visual performance of a subset of legal drivers in the United States of 55 years of age or older and may not represent the visual performance of the entire driver demographics.

6. Scenarios

6.1 A scenario refers to any unique combination of the variables listed in 6.2.1 – 6.2.4, at the levels outlined in Table