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Standard Guide for Retroreflective Composite Optics Laboratory Procedures[1]

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1. Scope

1.1 This guide presents a series of options for evaluating lot-to-lot consistency of retroreflective composite optics of the same type and form from the same manufacturer and does not recommend any specific course of action to be taken. This guide is meant to increase the awareness of information and approaches and is not meant to recommend any specific course of action per ASTM's Form and Style for ASTM Standards definition for a Guide.

1.1.1 This guide does not determine lab procedure selection or acceptance criteria for a specific retroreflective composite optics product for its intended use. It is the responsibility of the manufacturer and customer to negotiate these details based on their specific needs.

1.1.2 This guide is not intended to predict in-service performance levels.

1.1.3 This guide is not intended for comparison of different types of composite optics or manufacturers of composite optics.

1.2 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.3 *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.*

1.4 *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]

C702 Practice for Reducing Samples of Aggregate to Testing Size

D1921 Test Methods for Particle Size (Sieve Analysis) of Plastic Materials

D2486 Test Methods for Scrub Resistance of Wall Paints

D7428 Test Method for Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus

E1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45°:0° or 0°:45°) Geometry

E1710 Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer

2.2 *AASHTO Standards:*[3]

AASHTO TP-130-18 Producing Draw Down Panels and Measuring the Coefficient of Retroreflected Luminance (R_L) of Pavement Markings in a Laboratory Panel

3. Terminology

3.1 *Definitions:*

3.1.1 *installed pavement markings, n*—pavement markings applied to a road surface for the purpose of guiding traffic.

3.1.2 *pavement marking material, n*—a pigmented binder system used for lane delineation for highways, parking lots, and other areas subject to vehicular traffic; applicable pavement marking materials include waterborne traffic paint, solvent borne traffic paint, thermoplastic, plural component such as epoxy, modified epoxy, polyurea, and methyl methacrylate.

3.1.3 *pavement marking sample, n*—a properly cured pavement marking of specified width, length, and thickness applied to an appropriate, substrate panel; the pavement marking has

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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 American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

drop-on particles embedded in the surface of the marking to provide various performance characteristics such as retroreflectivity, color, and skid resistance.

3.1.3.1 *Discussion*—For the purpose of measuring retroreflectivity after scrubbing procedures in this document, the size of the scrub area of the pavement marking sample needs to meet or exceed the dimensional requirements for the retroreflectometer and satisfy the minimum measurement area requirements of Test Method E1710 (50 cm^2). For practical purposes, an area 70 mm by 200 mm (2.8 in. by 7.9 in.) meets the requirements for most commonly used retroflectometers, and exceeds the minimum requirements of Test Method E1710. Refer to your retroreflectometer manufacturer for details.

3.1.4 *retroreflective composite optics, n*—a multi-component retroreflective optical construction including but not limited to:

(1) A core covered with a pigmented adhesive and small glass or ceramic optical beads.

(2) A cluster of optical ceramic or glass beads distributed in a polymeric matrix.

(3) An optical glass bead core, covered with a pigmented adhesive and small glass or ceramic optical beads.

3.1.5 *substrate panel, n*—a panel used for the application of a pavement marking material to produce a pavement marking sample; the panel should be flat, dimensionally stable, compatible with the pavement marking material, bonds adhesively to the pavement marking material, and a dimension which complies with the sample size of the washability tester (scrub tester) and the measurement profile of Test Method E1710 (100 mm (4 in.) minimum wide by 250 mm (10 in.) minimum long panel).

4. Summary of Guide

4.1 This guide provides laboratory procedures, for retroreflective composite optics to: (*1*) evaluate retroreflective composite optics as received by the purchaser in bulk form, and (*2*) evaluate retroreflective composite optics applied in a pavement marking sample.

4.2 Determining which lab procedures to select and the acceptance criteria is outside the scope of this guide.

5. Significance and Use

5.1 The nighttime retroreflective properties of pavement markings are known to improve driving safety. Retroreflective composite optics have been developed to improve retroreflectivity in dry and rainy wet conditions. For customers purchasing these materials it's important to verify the consistency and performance. This guide provides a set of laboratory procedures which can be selected individually or together to evaluate lot-to-lot consistency of composite optics of the same type and manufacturer. These are not in-service performance procedures and don't necessarily predict in-service performance.

6. Sampling and Sample Preparation

6.1 To obtain representative samples from packaged containers, blenders, or storage tanks, sampling methods outlined in Practice C702 should be followed.

6.2 Isolate a retroreflective composite optics sample large enough for all lab procedures.

7. Retroreflective Composite Optics Lab Procedures

7.1 *Bulk Retroreflective Composite Optics Procedures*—These procedures are intended for lot-to-lot comparison of retroreflective composite optics for purposes of ensuring consistency. These lab procedures are not intended to predict on-road retroreflectivity performance as on-road retroreflectivity performance is impacted by many application and environmental factors.

7.1.1 *Retroreflective Composite Optics Bulk Color*—This is a lab procedure for measuring the color of the retroreflective composite optics in bulk form. A sample of retroreflective composite optics is placed in a small container and the color is measured using a handheld spectrophotometer per Test Method E1349 using a 0/45, 45/0 instrument with CIE illuminant D65 and 2° observer.

7.1.1.1 Into a petri dish approximately 12.7 mm (½ in.) deep and 88 mm (3½ in.) diameter, add about 50 g or approximately 40 mL of retroreflective composite optics.

7.1.1.2 Tap and shake the petri dish to level the layer of optics in the dish.

7.1.1.3 Place the port of the handheld spectrophotometer on the horizontal surface of retroreflective composite optics.

7.1.1.4 Take a measurement.

7.1.1.5 Record *Y*, *x*, *y*.

7.1.2 *Retroreflective Composite Optics Roller Mill Performance (Weight Retention)*—This is a lab procedure for measuring retroreflective composite optics performance in a roller mill as it relates to crushing and grinding. A retroreflective composite optics sample of known weight is placed in a ceramic ball mill with grind media and rolled at a specified rate for a specified number of revolutions. The sample is sieved, cleaned, dried, and weighed. The result is reported as percent weight (% wt.) retention compared to the original sample weight.

7.1.2.1 Measure a 250 mL sample of retroreflective composite optics.

7.1.2.2 Weigh the 250 mL sample and record the weight.

7.1.2.3 Place retroreflective composite optics in a ceramic ball mill jar with outside dimensions approximately 15.2 cm long by 15.2 cm diameter, excluding the mouth and neck.

7.1.2.4 Carefully place 1000 g of 19 mm (¾ in.) diameter clean ceramic balls into the ceramic ball mill jar with the sample.

7.1.2.5 Put the lid on the ball mill and secure.

7.1.2.6 Put the ball mill on a jar roller.

7.1.2.7 Roll the ceramic ball mill jar containing retroreflective composite optics and ceramic balls for 1500 revolutions at 100 rpm.

7.1.2.8 Pour the contents of the ball mill jar into a #3 sieve to separate the ceramic balls from the sample.

7.1.2.9 Sieve the retroreflective composite optics to remove fines and debris generated by milling. A sieve with opening size approximately half the diameter of the smallest retroreflective composite optics in the sample is recommended.

7.1.2.10 Clean and dry the sample per (Annex A1). Weigh the clean and dried sample.

7.1.2.11 Divide the weight of the processed sample by the original sample weight and multiply by 100.

(processed wt./original wt.) × 100 = percent weight retention

7.2 *Retroreflective Composite Optics Procedures in Pavement Marking Material:*

7.2.1 These procedures are intended for lot-to-lot comparison of retroreflective composite optics for purposes of ensuring consistency. These lab procedures are not intended to predict on-road retroreflectivity performance as on-road retroreflectivity performance is impacted by many application and environmental factors.

7.2.2 *Retroreflectivity in Pavement Marking Material*—This is a lab procedure for evaluating the initial dry retroreflectivity of retroreflective composite optics samples in pavement marking material. Retroreflective composite optics are uniformly applied to a liquid pavement marking material of specified wet film thickness on a panel at a desired drop rate. The pavement marking sample is cured completely and retroreflectivity is measured using a handheld retroreflectometer per Test Method E1710.

7.2.2.1 Prepare a drawdown per AASHTO TP-130-18 except using retroreflective composite optics at the desired drop rate instead of M-247 beads.

7.2.2.2 Measure coefficient of retroreflected luminance (R_L) of the drawdown sample using the reflectometer per Test Method E1710.

7.2.3 *Dry Scrub Procedure*—This is a lab procedure for measuring retroreflectivity loss as a result of bead loss for retroreflective composite optics applied to a pavement marking material. Retroreflective composite optics are uniformly applied to a liquid pavement marking material of specified wet film thickness on a panel at a desired drop rate. The sample is cured completely and dry scrubbed at a specified scrub rate and number of scrub cycles. Retroreflectivity is measured before and after scrubbing, and compared.

7.2.3.1 Refer to AASHTO TP-130-18 for the preparation of a highway marking drawdown except for containing retroreflective composite optics instead of M-247 beads. For the purposes of this procedure, the substrate panel dimensions should comply with 3.1.5 and the measurement dimension requirements of 3.1.3.

7.2.3.2 Use a retroreflectometer that complies with Test Method E1710.

7.2.3.3 Measure the initial retro of the drawdown using the reflectometer.

7.2.3.4 Use a straight-line washability machine as described in Test Methods D2486 with a modified scrub brush as described in Annex A2.

7.2.3.5 Secure a single pavement marking sample containing retroreflective composite optics in the washability machine, positioned to ensure a sufficiently large area is scrubbed uniformly for measurement using Test Method E1710.

7.2.3.6 Place the brush perpendicular to the sample to ensure the entire minimum surface area of the sample is scrubbed by the brush.

7.2.3.7 Perform the scrub procedure for 400 cycles at 40 cycles per minute on the drawdown.

7.2.3.8 When the procedure is finished, remove the drawdown and measure the coefficient of retroreflected luminance (R_L) using the retroreflectometer.

7.2.4 *Wet Scrub Durability Procedure*—This procedure simulates abrasion exposure of the retroreflective composite optics while constantly wet and evaluates the performance under these severe conditions. This procedure uses the same equipment as the dry scrub procedure but requires a waterproof substrate panel and is performed under constant immersion.

7.2.4.1 Refer to AASHTO TP-130-18 for the preparation of a highway marking drawdown except for containing retroreflective composite optics instead of M-247 beads. For the purposes of this procedure, the substrate panel is waterproof, and a dimension which complies with the sample size requirement in 3.1.5 and the measurement dimension requirements of 3.1.3.

7.2.4.2 Use a retroreflectometer that complies with Test Method E1710.

7.2.4.3 Measure the initial retro of the pavement marking sample using the reflectometer.

7.2.4.4 Use a straight-line washability machine as described in Test Methods D2486 with the modified scrub brush as described in Annex A2. Secure a single pavement marking sample containing retroreflective composite optics in the washability machine positioned to ensure a sufficiently large area is scrubbed uniformly for measurement using Test Method E1710.

7.2.4.5 Place the brush perpendicular to the sample to ensure the entire minimum surface area of the sample 100 mm (4 in.) wide by 300 mm (12 in.) is scrubbed by the brush.

7.2.4.6 Flood the sample evaluation area with water until the drawdown is completely submerged.

7.2.4.7 Perform the scrub test for 2000 cycles at 40 cycles per minute on the pavement marking sample.

7.2.4.8 When the test is finished, remove and dry the pavement marking sample, and measure the coefficient of retroreflected luminance (R_L) using the retroreflectometer.

7.2.5 *Dirt Pick-up Procedure*—This test is used to determine the impact of dirt pick-up on the retroreflective composite optics performance of the retroreflective performance of the retroreflective composite optics. This procedure uses the same equipment as the dry scrub test. Retroreflective composite optics are uniformly applied to a liquid pavement marking material of specified wet film thickness on a substrate panel at a desired drop rate and tested.

7.2.5.1 Refer to AASHTO TP-130-18 for the preparation of a highway marking drawdown except for containing retroreflective composite optics instead of M-247 beads. For the purposes of this procedure, choose a substrate panel which complies with the sample size requirement of 3.1.5 and measurement dimensional requirement of 3.1.3.

7.2.5.2 Use a retroreflectometer that complies with Test Method E1710.

7.2.5.3 Measure the initial retro of the pavement marking sample using the reflectometer.

7.2.5.4 Use a straight-line washability machine as described in Test Methods D2486 with modified scrub brush as described in Annex A2. Secure a single pavement marking sample containing retroreflective composite optics in the washability machine positioned to ensure a sufficiently large area is scrubbed uniformly for measurement using Test Method E1710.

7.2.5.5 Place the brush perpendicular to the sample to ensure the entire minimum surface area of the sample is scrubbed by the brush.

7.2.5.6 Apply ~80 g of prepared soil on top of the drawdown. Prepared soil is available from Textile Innovations Corporation or SDL Atlas Textile Testing Solutions.[4]

[4] Available from Textile Innovations Corporation, P.O. Box 8, Windsor NC 27983 or from SDL Atlas LLC, 3934 Airway Drive, SC 29732.

7.2.5.7 Perform the procedure for 500 cycles at 40 cycles per minute on the drawdown.

7.2.5.8 When the procedure is finished, remove the pavement marking sample, and measure the coefficient of retroreflected luminance (R_L) using the retroreflectometer.

7.2.5.9 Rinse the pavement marking sample under running tap water for ~15 s to remove any loose dirt. Allow the drawdown to dry, and measure the coefficient of retroreflected luminance (R_L) using the retroreflectometer.

8. Keywords

8.1 cap Y; chromaticity coordinates; color measurement; retroreflectivity; retroreflective composite optics

ANNEXES

(Mandatory Information)

A1. CLEANING RETROREFLECTIVE COMPOSITE OPTICS

A1.1 Remove fines from the sample by placing the retroreflective composite optics sample in a glass jar and vigorously shake by hand for 1 min to remove any loosely attached particles. Sieve the sample to separate the fines from the retroreflective composite optics. Select the sieve size to sufficiently capture the retroreflective composite optics yet allow the fines to pass. A sieve with opening size half the diameter of the smallest retroreflective composite optics in the sample is recommended.

A1.2 *Clean the Retroreflective Composite Optics*:

A1.2.1 Cleaning the retroreflective composite optics removes contaminants introduced in manufacturing and temporary coatings used for application and storage. Individual manufacturers may not require cleaning for testing. Consult with your manufacturer.

A1.2.2 Place the sample in a 1-L plastic beaker or suitable container and fill with a soap solution 12.7 mm (½ in.) above the top of the sample and let sit for 20 min. Suitable soap solutions include but are not limited to Concentrated Simple Green All Purpose Cleaner[5] at full strength, or 1:1 in water. Stir with a spatula for one minute and pour off the soap solution.

A1.2.3 Fill the beaker with water and stir with the spatula for 1 min.

A1.2.4 Pour off the rinse water.

A1.2.5 Repeat A1.2.3 and A1.2.4 until the rinse water is clean.

A1.2.6 Transfer the retroreflective composite optics to a sieve to remove excess water. A sieve with opening size approximately half the diameter of the smallest retroreflective composite optics in the sample is recommended.

A1.2.7 Spread the retroreflective composite optics evenly in a pan for drying. Tilt the pan about 30° to 45° to allow excess water to drain from the sieve. Air dry in a convection oven at 120 °F for 1 h, or until thoroughly dry.

[5] Concentrated Simple Green All Purpose Cleaner is a registered trademark of Sunshine Maker's, Inc.