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Standard Guide for Testing of Preformed Thermoplastic Pavement Marking Material in the Laboratory and Installed Preformed Thermoplastic Pavement Markings in the Field¹

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1. Scope

1.1 In this guide, the user is informed which chemical and physical properties of preformed thermoplastic pavement markings are appropriate to be evaluated in the laboratory for determining quality and consistency with the appropriate sampling, sample preparation, and test methods to be used to make these evaluations.

1.2 In this guide, the user is informed which properties of installed, in-service preformed thermoplastic pavement markings are appropriate to evaluate with relevant test methods and sampling protocols.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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

C219 Terminology Relating to Hydraulic and Other Inorganic Cements

C501 Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser
D8 Terminology Relating to Materials for Roads and Pavements
D16 Terminology for Paint, Related Coatings, Materials, and Applications
D36/D36M Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)
D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester
D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
D522/D522M Test Methods for Mandrel Bend Test of Attached Organic Coatings
D570 Test Method for Water Absorption of Plastics
D638 Test Method for Tensile Properties of Plastics
D713 Practice for Conducting Road Service Tests on Fluid Traffic Marking Materials
D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D913 Practice for Evaluating Degree of Pavement Marking Line Wear
D1308 Test Method for Effect of Household Chemicals on Clear and Pigmented Coating Systems
D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
D1925 Test Method for Yellowness Index of Plastics (Withdrawn 1995)³
D2240 Test Method for Rubber Property—Durometer Hardness
D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
D2792 Practice for Solvent and Fuel Resistance of Traffic Paint
D4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
D4451 Test Method for Pigment Content of Paints by

¹ This guide is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.44 on Traffic Coatings.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. 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.

Low-Temperature Ashing

D4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

D4764 Test Method for Determination by X-ray Fluorescence Spectroscopy of Titanium Dioxide Content in Paint

D4796 Test Method for Bond Strength of Thermoplastic Pavement Marking Materials

D4797 Test Methods for Gravimetric Analysis of White and Yellow Thermoplastic Pavement Marking

D4960 Test Method for Evaluation of Color for Thermoplastic Pavement Marking Materials

D5381 Guide for X-Ray Fluorescence (XRF) Spectroscopy of Pigments and Extenders

D6493 Test Methods for Softening Point of Hydrocarbon Resins and Rosin Based Resins by Automated Ring-and-Ball Apparatus

D6628 Specification for Color of Retroreflective Pavement Marking Materials

D7307 Practice for Sampling of Thermoplastic Pavement Marking Materials

D7308 Practice for Sample Preparation of Thermoplastic Pavement Marking Materials

D7585/D7585M Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments

D7681 Test Method for Measuring Gradation of Glass Spheres Using a Flowing Stream Digital Image Analyzer

D7735 Test Method for Type A Durometer Hardness Testing of Thermoplastic Pavement Marking at Elevated Temperatures

D7942 Specification for Thermoplastic Pavement Markings in Non Snow Plow Areas

D7971 Guide for Measuring Roundness of Glass Spheres Using a Flowing Stream Digital Image Analyzer

D8160 Test Method for Un-notched Cantilever Beam Impact Resistance (Izod Impact) Testing of Thermoplastic Pavement Marking Materials

D8161 Test Method for Impact Resistance of Thermoplastic Pavement Marking Materials over a Highway Substrate by Means of a Striker Impacted by a Falling Weight

D8167 Test Method for In-Place Bulk Density of Soil and Soil-Aggregate by a Low-Activity Nuclear Method (Shallow Depth)

E28 Test Methods for Softening Point of Resins Derived from Pine Chemicals and Hydrocarbons, by Ring-and-Ball Apparatus

E179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials

E303 Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester

E308 Practice for Computing the Colors of Objects by Using the CIE System

E313 Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates

E1164 Practice for Obtaining Spectrometric Data for Object-Color Evaluation

E1347 Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry

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

E2367 Test Method for Measurement of Nighttime Chromaticity of Pavement Marking Materials Using a Portable Retroreflection Colorimeter

F2617 Test Method for Identification and Quantification of Chromium, Bromine, Cadmium, Mercury, and Lead in Polymeric Material Using Energy Dispersive X-ray Spectrometry

G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials

G155 Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials

2.2 *AASHTO Standards:*⁴

AASHTO M249 Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form)

AASHTO R98 Practice for Standard Practice for Determination of Size and Shape of Glass Beads Used in Traffic Markings by Means of Computerized Optical Method

AASHTO T250 Method of Test for Thermoplastic Traffic Line Material

2.3 *AMS Standard:*⁵

AMS STD 595a Colors Used in Government Procurement

2.4 *EPA Standards:*⁶

EPA 1311 Toxicity Characteristic Leaching Procedure

EPA 3052 Microwave Assisted Acid Digestion of Siliceous and Organically Based Matrices

EPA 6010D (SW-846) Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES)

EPA 7470A (SW-846) Mercury in Liquid Wastes (Manual Cold-Vapor Technique)

2.5 *DOT Specifications:*

AZDOT 704 Thermoplastic Pavement Markings⁷

AZDOT 705 Preformed Pavement Markings⁷

CADOT84–2.02B Traffic Striping Material⁸

FLDOT 971 Pavement Marking Materials⁹

3. Terminology

3.1 *Definitions*—For definitions used in this guide, refer to Terminologies **C219**, **D8**, and **D16**.

3.2 *Definitions of Terms Specific to This Standard:*

⁴ 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>.

⁵ Available from SAE International, 400 Commonwealth Dr., Warrendale, PA 15096, <https://www.sae.org>.

⁶ Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, <http://www.epa.gov>.

⁷ Available from Arizona Department of Transportation, <https://www.azdot.gov>.

⁸ Available from California Department of Transportation, <https://www.dot.ca.gov>.

⁹ Available from Florida Department of Transportation, <https://www.flhwy.com>.

3.2.1 *anti-skid particles (anti-skid aggregate, skid-resistant materials or particles)*, *n*—materials that are manmade (recycled glass and so forth); naturally mined (sand, quartz, and so forth); or naturally mined, purified, and furnaceed to make harder (calcined bauxite and so forth).

3.2.2 *composite optics*, *n*—multi-component retroreflective particle comprised of a pigmented core (typically white or yellow) combined with very small glass or ceramic beads having a refractive index of between 1.90 and 2.4.

3.2.3 *glass beads*, *n*—round spheres manufactured from glass of a specific refractive index and size distribution.

3.2.4 *hot-applied thermoplastic pavement marking(s)*, *n*—pavement markings in the form of linear markings or transverse markings such as, but not limited to, crosswalk lines, legends, arrows, and symbols applied with the use of hot-applied thermoplastic pavement marking material and, in most cases, a surface application of retroreflective optics, skid-resistant particles, or a combination of retroreflective optics and skid-resistant particles to the surface of the markings to provide the desired initial performance properties such as retroreflectivity and skid resistance of the final installed pavement marking.

3.2.5 *hot-applied thermoplastic pavement marking material(s)*, *n*—highly filled 100 % total solids pavement marking material that when heated to the manufacturer's recommended temperature under continuous agitation becomes molten and can be extruded or sprayed onto a pavement surface and when cooled forms a solid, durable delineator.

3.2.5.1 *Discussion*—This material is manufactured and provided to the user in several forms, including granular, pellets, flakes, and pre-melted solid blocks. If the user requires that the installed pavement markings resulting from the use of this material have immediate retroreflective properties or enhanced skid-resistant properties, the appropriate retroreflective optics or skid-resistant particles or both shall be applied to the surface of the pavement marking material at the time of application.

3.2.6 *preformed thermoplastic pavement marking(s)*, *n*—pavement markings in the form of linear markings or transverse markings such as, but not limited to, crosswalk lines, legends, arrows, symbols, and custom-cut designs applied with the use of preformed thermoplastic pavement marking material.

3.2.6.1 *Discussion*—Typically, this material is manufactured and provided to the user with retroreflective optics, skid particles, or a combination of retroreflective optics and skid particles applied to the surface of the pavement marking material; therefore, no additional materials are required to be added to the markings during the application of the product.

3.2.7 *preformed thermoplastic pavement marking material(s)*, *n*—factory formed pavement marking product in the form of rolls of specified width; pre-cut sheets of specified width and lengths; or in pre-cut custom designs composed of resin (binder), fillers, pigments, retroreflective optics and typically include surface-applied retroreflective optics, a combination of retroreflective optics and anti-skid particles, or anti-skid particles only that is applied to the pavement using a

suitable heat source such as a hand torch, infrared heater, and so forth as recommended by the manufacturer.

3.2.7.1 *Discussion*—The product is applied by positioning the marking at the desired location on the pavement and then heated to a semi-molten state with an external heat source to the manufacturer's recommended temperature and/or until the retroreflective optics or aggregate or both settle to the appropriate depth. Preformed thermoplastic pavement marking materials can be used for linear pavement markings or transverse markings such as, but not limited to, crosswalk lines, legends, arrows, symbols, and custom-cut designs. In terms of application, there are typically two types of preformed thermoplastic pavement markings. (**ITE Marking Handbook**)¹⁰

(1) *Preheating of the road surface to a certain temperature is required*—Requires that the pavement to which the marking is to be applied be heated to a specified temperature range before the application of the pavement marking product.

(2) *No preheating of the road surface to a given temperature is required*—Preheating of the pavement is not required before the application of the pavement marking product.

3.2.7.2 *Discussion*—A primer may be recommended by the manufacturer of the preformed thermoplastic pavement marking material for use on concrete pavements and aged asphalt surfaces to help ensure adequate bonding of the material to the pavement. These primers may be a single-component or two-part system applied to the pavement surface by spray or roll application or both according to the requirements of the manufacturer before the application of the preformed thermoplastic pavement marking material.

3.2.8 *retroreflectance/retroreflectivity*, *n*—property of a material or device in which, when directionally irradiated, the reflected rays are preferentially returned in directions close to the opposite of the direction of the incident rays; this property is maintained over wide variations in the direction of the incident rays.

3.2.9 *retroreflective optics*, *n*—particles manufactured for use with pavement marking materials to provide retroreflective properties to the marking allowing them to be visible when viewed at night under automobile headlights.

4. Summary of Guide

4.1 In this guide, the full array of properties is listed that may be evaluated with the appropriate sampling, sample preparation, and test methods to be used for preformed thermoplastic pavement marking materials. A listing of properties or test methods related to properties that are not appropriate with an explanation of why is provided in **Appendix X2**. In this guide, guidance on the recommended performance properties to evaluate and the appropriate testing methods for preformed thermoplastic pavement markings in the field is also provided.

5. Significance and Use

5.1 In this guide, guidance is provided as to which compositional and physical properties, with appropriate sampling,

¹⁰ ITE Marking Handbook, Section 9.3.7, Institute of Transportation Engineers, Washington, DC, 2001 edition.

sample preparation, and test methods, are recommended for consideration when evaluating the quality and consistency of preformed thermoplastic pavement marking materials. This is useful to assist manufacturers in their product research and development work, governmental agencies in the development of a suitable quality assurance sampling and testing program, and governmental agencies in the development of a suitable material specification for preformed thermoplastic pavement marking materials.

5.2 In this guide, guidance is provided on how to evaluate the field performance properties of preformed thermoplastic pavement markings on the roadway that contribute to the safety of the driving public. Governmental agencies can use this guide to evaluate the performance of these markings in the field and help determine when these markings need to be replaced. It can also be helpful in the development of field performance specifications for preformed thermoplastic pavement markings.

5.3 In **Appendix X2**, the properties and related test methods that have been found to be inappropriate and, therefore, should not be specified or evaluated as a property of preformed thermoplastic pavement marking material with an explanation as to why.

NOTE 1—Within the realm of pavement markings, preformed thermoplastic pavement marking materials are compositionally similar to hot-applied thermoplastic pavement marking materials; however, because of the difference in the form of the product as delivered to the customer, a different testing protocol is required. Preformed thermoplastic pavement marking material is typically provided to the user with surface applied optics/skid particles, which makes the product compositionally representative of the finished, installed pavement marking. On the other hand, hot-applied thermoplastic pavement marking material is provided to the user without the surface applied optics/skid particles and, therefore, is not compositionally representative of the finished, installed pavement marking, which includes retroreflective optics/skid particles applied to the surface of the pavement marking at the time of installation. The difference in the delivered form of preformed thermoplastic pavement marking material as compared to hot-applied thermoplastic pavement marking material makes the testing of some physical properties in the laboratory irrelevant or requires some modifications to the standard testing procedure to become relevant.

6. Sampling Recommendations

6.1 *Sampling of Preformed Thermoplastic Pavement Marking Materials*—When evaluating preformed thermoplastic pavement marking material delivered from the manufacturer before application, it is important to obtain a representative sample before testing. The product should be packaged with a batch (lot) number identification that ties the product to a particular manufacturing date and production run completed with similar raw materials. As the product is manufactured in a “finished form,” samples can be taken without any additional processing steps.

6.2 Identify the material to be sampled with the corresponding batch (lot) numbers. For batch numbers that represent more than 1000 ft² (93 m²) of the finished product, randomly select from the stock three test specimens consisting of approximately 2 ft² (0.2 m²) each. For batch numbers that represent less than 1000 ft² (93 m²) of the finished product, select a single test specimen randomly consisting of approximately 6 ft² (0.6 m²). Additional quantities of test specimens may be required based on the type and number of tests required.

6.3 Label all test specimens with the appropriate batch (lot) number for reference and future documentation.

6.4 When obtaining test specimens from the packaged product, it is a good practice to evaluate the material within the package noting any observed inconsistency or issues such as inconsistency of the surface applied retroreflective optics/anti-skid particles, inconsistency in color/appearance, flexibility, and so forth.

6.5 There may be occasions when the evaluation of the preformed thermoplastic pavement marking material without the surface applied optics/anti-skid particles is desired. This would require working with the manufacturer to obtain the desired sample that would be representative of the product being evaluated. Attempting to remove the surface applied optics/anti-skid particles on the finished product is difficult to accomplish and there is no way to be certain that all these materials have been removed before testing.

7. Compositional Requirements

7.1 Binder Content:

7.1.1 The binder provides the film-forming capability of the product, holding the pigment, fillers, retroreflective optics, and anti-skid particles together. The type and amount of binder(s) contribute greatly to the physical properties of the preformed thermoplastic pavement marking material such as, but not limited to, flexibility before melting, meltability, adhesion (bond) achieved during application, and weatherability after application.

7.1.2 Remove at least a 0.9 oz (25 g) test sample from the finished product samples. Determine the binder content of the test sample by following Practice **D4797**.

NOTE 2—Since preformed thermoplastic pavement marking materials are manufactured with an application of retroreflective optics or anti-skid particles or both on the surface, the binder content as determined by this method will be affected and will not represent the binder content of the material as formulated and processed before the surface applied retroreflective optics or anti-skid particles or both. So, as an example, if the preformed thermoplastic pavement marking material was being manufactured with 18 % binder base material to comply with a specification that required a minimum binder content of 18 % without consideration of the surface applied optics/anti-skid particles, the test results would be significantly below 18 % because of the dilution effects of the surface applied materials. One way to circumvent this problem would be to remove the applied surface-applied materials before performing Practice **D4797**. However, currently, there is no definitive methodology to insure 100 % removal of the surface-applied materials from the preformed thermoplastic pavement marking material. Another approach would be to request a sample of the preformed thermoplastic pavement marking material manufactured to the same formulation without the application of the surface-applied materials. However, this sample would not tie directly to the test specimens obtained from the product shipment from the manufacturer. The most appropriate way to address this issue is to develop specifications that take this into account when establishing the required binder content within the preformed thermoplastic pavement marking material specification.

7.2 *Retroreflective Optics Content*—Retroreflective optics can consist of composite optics or glass beads or both. The type and quantity of these materials determine the retroreflectivity capability of the material. This property is important as it provides visibility of the pavement marking to the driver in nighttime conditions. Retroreflective