Designation: D7942 – 15

Standard Specification for Thermoplastic Pavement Markings in Non Snow Plow Areas[1]

This standard is issued under the fixed designation D7942; 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 specification covers a reflectorized thermoplastic based pavement striping material of the class that is applied to the road surface in a molten state by screed/extrusion or ribbon extrusion means. Retroreflectivity of the pavement marking compound is achieved initially by surface application of retroreflective optics at the time of pavement marking application. Upon cooling to normal pavement temperature, the pavement marking material produces an adherent reflectorized stripe of specified thickness and width capable of resisting deformation by traffic. The pavement marking compound includes retroreflective optics (glass beads or composite optics, or both) that are incorporated into the material at the time of manufacture that provide retroreflective properties during the service life of the material.

1.1.1 This specification is limited to:

1.1.1.1 Longitudinal applications in non snow plow areas,

1.1.1.2 Standard (non-profile) pavement marking applications, and

1.1.1.3 Applications on smooth asphalt or concrete surfaces. Asphalt seal coat applications, which use large aggregate resulting in a very rough, open grade finish, are excluded from this specification.

1.1.2 This specification includes:

1.1.2.1 Compositional and physical property requirements of the thermoplastic pavement marking material,

1.1.2.2 Requirements for the optics that are used to reflectorize the thermoplastic pavement marking material after application,

1.1.2.3 Field performance requirements for the installed thermoplastic pavement markings, and

1.1.2.4 Material application requirements.

1.2 The values stated in inch-pounds units are to be regarded as the standard except where noted in the document. The values given in parentheses are mathematical conversions to SI units that 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D36 Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)

D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester

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

D6628 Specification for Color of Pavement Marking Materials

D7307 Practice for Sampling of Thermoplastic Traffic Marking Materials

D7308 Practice for Sample Preparation of Thermoplastic Traffic Marking Materials

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

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

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

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

G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

2.2 *AASHTO Standards:*[3]

AASHTO M247 Standard Specification for Glass Beads Used in Traffic Paints

AASHTO T250 Standard Method of Test for Thermoplastic

[1] This specification 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.

Current edition approved Jan. 1, 2015. Published January 2015. DOI: 10.1520/D7942-15.

[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.

Traffic Line Material

3. Terminology

3.1 *Definitions:*

3.1.1 *binder*—mixture of rosins, synthetic resins, waxes, polymers, and plasticizers that form the continuous phase in the Pavement Marking Compound.

3.1.2 *pavement marking compound*—a homogeneous mixture of binder, fillers, extenders, pigments and intermixed retroreflective optics.

3.1.3 *retroreflective optics:*

3.1.3.1 *glass beads*—spherical glass 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.

(1) small glass beads—also referred to as standard glass beads. This can refer to a number of products of various sizes, but as defined in this document it refers to a glass bead product meeting the requirements of AASHTO M247 Type 1 or Type 2.

(2) large glass beads—these glass beads meet the requirements of AASHTO M247 Type 3, Type 4, or Type 5 as called for in the specification.

(3) high refractive index glass beads—these glass beads typically meet the requirements of AASHTO M247 Type 1 or Type 2 except the refractive index of the glass bead is between 1.90 and 1.95.

3.1.3.2 *composite optics*—A 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).

3.1.3.3 *non AASHTO glass beads*—A manufacturer may provide a product outside the requirements found under section 3.1.3.1 in which case the performance requirements of this specification must still be met.

3.1.4 *thermoplastic pavement markings*—a pavement marking compound brought to a molten state by heating to the manufacturer's recommended temperature under agitation and then applied to the pavement while in the molten state. Retroreflective optics are applied (dropped on) to the surface of the molten marking immediately after application to provide initial retroreflectivity.

4. Classification

4.1 The thermoplastic pavement markings are classified into categories with specific retroreflectivity performance levels. See 9.6.

4.2 The annex contains application recommendations for typical installations to meet each performance class.

4.3 The thermoplastic pavement markings can be provided with a contrast marking process consisting of a black thermoplastic pavement marking that improves the visual marking contrast for daytime visibility.

5. Ordering Information

5.1 The purchaser must specify the Pavement Marking Class when ordering. In addition the purchaser has the option of requiring a contrast marking application.

6. Materials and Manufacture

6.1 The thermoplastic material shall be available in white, yellow and black.

6.2 The thermoplastic material shall be homogeneously composed of pigment, filler, resins and optics.

6.3 *Glass Beads General Requirements*—Glass beads shall provide the marking with good night visibility without compromising day visibility and be of a composition designed to be highly resistant to traffic wear and to the effects of weathering.

6.4 *Intermix Glass Beads*—The glass beads shall conform to the requirements of AASHTO M247 Type 1, Type 2, or Type 3 and shall be either uncoated or have an adhesion promoting coating.

6.5 *Drop-on Glass Beads*—The drop-on beads shall meet the requirements of AASHTO M247 as required in this specification. When a double drop application of glass beads is required the larger beads shall be placed on the top surface of the thermoplastic first followed by the application of the smaller beads.

6.5.1 *Specific Properties*—The AASHTO M247 Type 3, Type 4, and Type 5 glass beads used for drop-on beads shall have an adhesion promoting coating. AASHTO M247 Type 1 and Type 2 glass spheres used for drop-on beads shall have a coating which will provide enhanced adhesion, moisture resistance, and proper embedment in the pavement marking.

6.6 *Composite Optics*—The composite optics shall be provided according to the manufacturer's specifications.

6.7 The thermoplastic material shall not deteriorate on contact with sodium chloride, calcium chloride or other deicing chemicals or because of oil content of paving materials or oil droppings.

6.8 *Composition*—The pigment, beads and filler shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects.

6.9 *Set Time*—When applied at a temperature range of 412 ± 12°F (211 ± 7°C) and thickness of up to 0.125 in. (4.736 mm) the material shall set to bear traffic in not more than 2 minutes when the air temperature is 50 ± 3°F (10 ± 2°C) and not more than 10 minutes when the air temperature is 90 ± 3°F (32 ± 2°C).

6.10 *Storage Life*—Thermoplastic material furnished in granular and block form shall meet the above requirements for a minimum period of 1 year. The thermoplastic must melt uniformly with no evidence of skins or unmelted particles during this one year period. Material not meeting the above requirements shall be replaced by the manufacturer.

7. Chemical Composition

7.1 *Composition of the Thermoplastic Pavement Marking Material (percent by weight)*—See Table 1.

8. Physical Properties

8.1 *Laboratory Properties:*

8.1.1 *Color*—The thermoplastic materials after heating for 4 h ± 5 min at 425 ± 3°F (218 ± 2°C) under agitation shall meet

TABLE 1 Composition of the Thermoplastic Pavement Marking Material (percent by weight)

Component	White	Yellow	Black
Binder[B]	20.0 min.	20.0 min.	20.0 min.
Intermix Retroreflective Optics[C]	40.0 min.	40.0 min.	–
Titanium Dioxide (ASTM Type II)	10.0 min.	–	–
Yellow and Black Pigments	–	[A]	[A]

[A] Amount of yellow and black pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, providing all other requirements of this specification are met. The thermoplasticmaterial shall comply with all applicable Federal requirements found in RCRA (Resource Conservation and Recovery Act).
[B] The binder shall consist of a mixture of synthetic resins, polymers, and plasticizers. The purchaser shall have the option of requiring the binder system to be either an alkyd or a hydrocarbon based system.
[C] The retroreflective optics shall consist of glass beads, composite optics or a combination thereof.

the following requirements when tested according to Test Method D4960 using a CIE 2 degree standard observer and standard illuminant D65. Yellowness index shall be calculated according to Practice E313.

8.1.1.1 *White:*

(a) Daylight Reflectance at 45°/0°: 75 % minimum

(b) Yellowness Index at 45°/0°: 12 Maximum

8.1.1.2 *Yellow:*

(a) Daylight reflectance at 45°/0°: 42 to 56 %

(b) The initial daytime CIE chromaticity for yellow materials without drop-on retroreflective optics shall fall within the following coordinates:

Initial Yellow Daytime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.490	0.560	0.460	0.420
y	0.510	0.440	0.400	0.440

(c) Color Stability after Accelerated Weathering ASTM Designation: Practice G155, Table X3.1 Cycle I, 1500 h exposure time. Prepare sample by dipping a sheet aluminum panel into the molten thermoplastic and removing it to obtain a 0.06 to 0.120 in. (1.5 to 3 mm) coating thickness of thermoplastic on the panel. Place the panel in the weathering apparatus for 1500 h. After accelerated weathering, measure the Yellow Color or Yellowness Index. Material shall meet the color stability requirements below after this exposure. This requirement is not intended to be predictive of the 3 to 5 year service life of the marking but can be used as a screening tool to identify materials that will fail.

White – Yellowness Index – 20 Maximum

Yellow Daytime Chromaticity Coordinates (after accelerated weathering)

	1	2	3	4
x	0.490	0.560	0.460	0.420
y	0.510	0.440	0.400	0.440

8.1.2 *Cracking Resistance at Low Temperature*—The material shall show no cracks when tested in accordance to AASHTO T250.

8.1.3 *Softening Point*—After heating the thermoplastic material for 4 h ± 5 min at 425 ± 3°F (218 ± 2°C) and testing in accordance with Test Method D36, the materials shall have a softening point of 215 ± 15°F (102.5 ± 9.5°C).

8.1.4 *Indentation Resistance*—The hardness shall be between 40 and 75 units after 15 s when tested in accordance to Test Method D7735. The durometer and the sample shall be maintained at 115°F (46°C).

8.1.5 *Flash Point*—The thermoplastic material shall have a flashpoint of no less than 500°F (260°C) when tested in accordance with Test Method D92 COC.

9. Performance Requirements

9.1 Installed pavement markings shall meet the following service life requirements:

Traffic Volume (AADTpl)[A]	Minimum Years of Service Life
<5000	5
5000 – 15000	4
15000 – 25000	3
>25000	<3

[A] AADTpl is defined as the annual average daily traffic count per traffic lane.

9.2 The service life of the installed markings shall be defined by the following field performance criteria:

9.3 *Daytime Color (during service life)*—The markings shall meet the requirements of Specification D6628 with the exception of "Y" (reflectance).

9.4 *Night Time Color (during service life)*—The markings shall meet the requirements of Specification D6628.

9.5 *Durability*—Defined as no more than 10 % loss (visible daytime road presence) in any 1000 ft section of continuous or broken pavement markings. Any markings installed less than 6 in. from a construction joint are not covered in this specification.

9.6 *Retroreflectivity (180 days)*—The minimum dry retroreflectivity of the markings when tested 180 days or less after installation shall be as follows when tested according to Test Method E1710:

Dry Retroreflectivity (Test Method E1710)[A]	Class 1	Class 2	Class 3
White (mcd/m^2/lux)	300	450	800
Yellow (mcd/m^2/lux)	200	350	525

[A] The values presented for the coefficient of retroreflected luminance (R_L) are presented in SI units, which are the accepted worldwide norm for expressing this value, rather than in inch-pounds.

9.7 *Retroreflectivity (retained)*—The minimum dry retroreflectivity of the markings of all classes when tested from 181 days after installation through the end of service life of the markings shall be as follows when tested according to Test Method E1710:

White: 150 mcd/m^2/lux

Yellow: 125 mcd/m^2/lux

NOTE 1—The values presented for the coefficient of retroreflected luminance (R_L) are presented in SI units, which are the accepted worldwide norm for expressing this value, rather than in inch-pounds.

9.8 In considering compliance to the performance requirements of this specification any area where the markings are tracked, contaminated by foreign material, damaged by unusual traffic patterns or natural or man-made disasters shall be excluded.

10. Installation Requirements

10.1 *Pavement Surface Requirements*—The pavement surface shall be new or meet the requirements of Annex A1.3 prior

to thermoplastic application, or both. This specification does not cover recoating (capping) over old thermoplastic (refurbishing).

10.2 *Application Thickness*—The pavement marking materials shall be applied at a minimum thickness of 100 mils as measured above the plane of the pavement surface and shall discount the presence of the drop-on optics.

10.3 *Application Method*—The markings shall be applied by either extrude or ribbon extrude method.

10.4 *Application Temperatures:*

10.4.1 The thermoplastic material shall be applied at a minimum temperature of 400°F (205°C) and shall not exceed the manufacturer's recommended maximum temperature For any deviation of this guideline (upper or lower end of the material temperature) the manufacturer should be contacted for review and approval of said deviation in order to prevent potential bonding or applications issues.

10.4.2 *Pavement and Ambient Temperatures*—The minimum ambient and pavement surface temperatures shall be 55°F (12.8°C) and rising for standard extrusion application and 60°F (15.5°C) and rising for ribbon extrusion application.

10.5 *Drop-on Optics*—The application of the drop-on optics shall be according to the pavement marking manufacturer's recommendation and shall result in installed markings that achieve the retroreflective performance requirements of this specification.

NOTE 2—Refer to X1.1 of the appendix for typical optics applications that will yield acceptable retroreflectivity performance for each class of pavement markings identified in this specification.

10.6 *Other Installation Requirements*—For additional installation requirements refer to the Annex section of this document.

11. Other Requirements

11.1 The performance requirements of this specification are void if product failure occurs due to unusual or unanticipated conditions beyond the control of the material manufacturer including, but not limited to, failure of the road surface, unusual road or traffic conditions, snowplow blade damage, studded tires, or other external forces not characteristic of normal traffic wear, and unusually severe weather, floods or other acts of God.

11.2 Application requirements pertaining to this specification can be found in the annex.

12. Dimensions, Mass, and Permissible Variations

12.1 All markings shall be applied to the dimensions as called for in the project drawings and specifications and any variation shall be within the permissible tolerance set forth in said specifications.

12.2 The contractor who applies the markings has total responsibility of this portion of the specification and shall provide any corrective action as required by the terms of the project specification.

13. Workmanship, Finish, and Appearance

13.1 The markings shall meet the requirements for workmanship and appearance as set forth in the specific project plans of the purchasing party. The contractor who applies the markings has total responsibility for these requirements and shall provide any corrective action as required in order to meet the terms of the project specification.

14. Sampling and Sample Preparation

14.1 *For Laboratory Testing of Composition and Physical Properties*—The thermoplastic material shall be sampled according to Practice D7307 and the samples shall be prepared for testing according to Practice D7308.

14.2 *For Field Testing:*

14.2.1 *Retroreflectivity*—The markings shall be tested according to the sampling and testing protocol set forth in Practice D7585.

14.2.2 *Color (Daytime and Night Time)*—The markings shall be tested according to the sampling and testing protocol set forth in Practice D7585.

14.2.3 *Durability*—The markings shall be evaluated in a visual drive through during daytime conditions. Evaluations shall be conducted in approximately 1000 ft segments. Areas of failure are not to be noted if the failure occurs due to unusual or unanticipated conditions beyond the control of the material manufacturer including, but not limited to, failure of the road surface, unusual road or traffic conditions, snowplow blade damage, studded tires, or other external forces not characteristic of normal traffic wear, and unusually severe weather, floods or other acts of God.

15. Number of Tests and Retests

15.1 Testing shall be done according to the applicable referenced standard.

ANNEX

(Mandatory Information)

A1. APPLICATION PROCEDURES FOR THERMOPLASTIC PAVEMENT MARKINGS

A1.1 Scope

A1.1.1 This specification covers the application requirements for Thermoplastic Pavement Markings referenced in this specification. This includes the requirements that must be met by the installer and the conditions that must be met when the product is applied to the pavement.

A1.2 Approved Contractor

A1.2.1 Contractors that install thermoplastic pavement markings covered in this specification must be approved by the manufacturer as a qualified installer.

A1.3 Application

A1.3.1 *Surface Preparation:*

A1.3.1.1 *Moisture*—The contractor shall ensure that the surface is adequately dry prior to the installation of the thermoplastic pavement marking material. If necessary all surfaces shall be inspected for moisture content prior to application of thermoplastic. This can be accomplished by one of two methods.

(1) Place a sample of hot thermoplastic pavement marking material, covering an area of approximately 1 ft^2, on a piece of tarpaper placed on the pavement. Allow the material to cool to ambient temperature, and then inspect the underside of the tarpaper in contact with the pavement. Pavement will be considered dry if there is no condensation on the tarpaper.

(2) Place a 1-ft^2 piece of clear plastic on the pavement, and tape down the edges with duct tape. The pavement is considered dry if, when inspected after 15 min, no condensation has occurred on the underside of the plastic.

A1.3.1.2 *Cleaning*—All surfaces shall be clean and dry before thermoplastic can be applied. Loose dirt and debris shall be removed by blowing compressed air over the area to be striped. Existing pavement markings shall be removed by an appropriate, approved method to a minimum level of 90 % removal. Any remaining markings must be well adhered to the pavement surface. Markings may be applied to existing temporary paint lines provided the paint is a single coat of paint and the thickness is less than 10 mils. If the thermoplastic is to be applied over existing paint lines, the paint line shall be swept with a mechanical sweeper or wire brush to remove poorly adhered paint and dirt that would interfere with the proper bonding of the thermoplastic. Laitance and curing compound shall be removed from all new Portland cement concrete surfaces by loose grain abrasive pressure blasting or wire brushing. All dust and grinding debris must be removed completely before applying the primer.

A1.3.1.3 *Layout*—The pavement markings shall be placed in proper alignment with guidelines, established specifications, or contract documents. Deviation from the alignment established shall not exceed 2 in. per 200 ft of roadway nor shall any deviation be abrupt. Longitudinal markings shall be offset at least 6 in. from construction joints of Portland cement concrete surfaces and joints and shoulder breaks of asphalt surfaces.

A1.3.1.4 *Concrete Applications:*

(1) Surface Preparation and Curing Compound Removal—Clean, and remove curing compound as necessary to insure that the markings adhere to the pavement. Obtain approval for all surface preparation methods prior to implementing.

(2) Pavements shall be free of grease, oil, mud, dust, dirt, grass, loose gravel and other deleterious material prior to applying pavement markings.

(3) Prepare the pavement surface, including removal of curing compound, a minimum of 2 in. wider than the pavement markings to be placed, such that, an additional 1 in. of prepared area is on all sides of the pavement markings after they are applied.

(4) Remove all curing compound and surface laitance from application area of Portland cement concrete pavements. Remove curing compound by shot blasting, sand blasting, or water blasting. Ensure that the surface is free of all residue, laitance and debris prior to applying the pavement marking.

(5) When surface preparation and curing compound removal operations are completed, blow the pavement surface clean by compressed air to remove residue or debris.

(6) Curing compound removal will be paid for at the applicable contract unit price. All other surface preparation will be considered incidental to the work covered by this specification.

(7) Apply a two part epoxy primer recommended by the pavement marking manufacturer to pavement surfaces before applying pavement marking material as required in this specification.

(8) Conduct all pavement surface preparation including curing compound removal in such a manner that the pavement or joint material is not damaged or left in a condition that will mislead or misdirect the motorist. Repair damage to the pavement, or joint materials caused by surface preparation or removal of curing compound at no cost to the Purchaser. The contract must specify who has the responsibility for meeting this requirement.

(9) Where pavement surface preparation results in obscuring existing pavement markings of a lane occupied by traffic, immediately remove the residue, including dust, by approved methods.

A1.3.2 *Primer Application*—Primer shall be used on all Portland cement concrete surfaces. A primer shall be used on asphalt surfaces that are over two years old or on asphalt surfaces that are worn or oxidized to a condition where 50 % or more of the wearing surface is exposed aggregate, or both. The primer shall be a two part epoxy primer recommended by the pavement marking manufacturer and shall be applied at the rate and manner specified.

A1.4 Drop-on Retroreflective Optic Application

A1.4.1 *Requirements*—The Retroreflective Optics used for striping projects must be approved by the pavement marking manufacturer before using on the project. The approval shall specify the vendor and the specific part number.

A1.4.2 *Application Rate*—The retroreflective optics can be applied at the rates outlined in the Annex for retroreflective optics application or per the manufacturer's recommendations provided that all other requirements of this specification are met. This application rate shall be determined by testing the retroreflective optics output over time and referenced to the targeted speed of the application equipment to determine the rate in weight per unit area. The validity of this calculation can be confirmed by monitoring the retroreflective optics usage verses pavement marking applied. Consideration must be given to insure that the markings are properly covered by the drop-on retroreflective optics. For example if the pavement marking that is being applied is 4 in. in width then the retroreflective optics coverage calculation should be made as if the marking was 4.5 in. wide. In this way there can be a minimum 0.25 in. overspray of the retroreflective optics, which will ensure proper coverage across the entire width of the marking, including the edges.

A1.4.3 *Application Method*—The Retroreflective Optics shall be applied by a mechanical dispenser properly calibrated and adjusted to provide proper application rates and uniform distribution of the retroreflective optics across the cross-section of the entire width of the line. The dispensers shall be positioned immediately behind the thermoplastic application device to ensure that the retroreflective optics are applied to the thermoplastic material while it is still in the molten state. The retroreflective optics shall be embedded in the thermoplastic at approximately 60 % of their diameter. When applying a double drop application the larger sized retroreflective optics shall be applied first followed by the smaller retroreflective optics.

A1.5 Equipment Requirements

A1.5.1 *General Requirements*—The equipment used to install the thermoplastic pavement marking material shall:

A1.5.1.1 Provide continuous uniform heating to temperatures exceeding 400°F (204°C), mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the line dispensing device shall prevent accumulation and clogging. All parts of the equipment that comes in contact with the material shall be constructed for easy accessibility and exposure for cleaning and maintenance. The equipment shall operate so that all mixing and conveying parts including the line dispensing device, maintains the material at the temperature required by the manufacturer.

A1.5.1.2 Be maintained in satisfactory condition.

A1.5.1.3 Meet or exceed the requirements of the National Board of Fire Underwriters and the RICC: for this application.

A1.5.1.4 Use an automatic retroreflective optics dispenser attached to the pavement marking equipment.

A1.5.1.5 A hand-held thermometer capable of accurately measuring the temperature of the marking material during application.

A1.5.2 *Material Placement Requirements*—The equipment shall be capable of placing:

A1.5.2.1 At least 40 000 ft of 4-in. solid or broken markings per day at the specified thickness,

A1.5.2.2 Linear markings up to 8 in. wide in a single pass,

A1.5.2.3 Markings other than solid or broken lines,

A1.5.2.4 A center-line and no-passing barrier-line configuration consisting of 1 broken line with 2 solid lines at the same time to the alignment, spacing, and thickness required. for 3-line application,

A1.5.2.5 White line from both sides,

A1.5.2.6 Lines with clean edges, uniform cross section and thickness, and reasonably square ends,

A1.5.2.7 Skip lines between 10 and 10½ ft, an approximate stripe-to-gap ratio of 1 to 3,

A1.5.2.8 A stripe-gap cycle between 39½ and 40½ ft, automatically,

A1.5.2.9 Retroreflective optics uniformly applied to the thermoplastic markings at the specified rates and embedment, and

A1.5.2.10 Double-drop retroreflective optics applications from separate independent applicators, when required.

APPENDIX

(Nonmandatory Information)

X1. TYPICAL RETROREFLECTIVE OPTICS APPLICATIONS

X1.1 The following are typical retroreflective optics applications that can be used to achieve the required retroreflectivity performance of each Class of pavement markings identified in section 9.6 of this specification. inclusive. However, The type of retroreflective optics and drop rates shall be at the option of the manufacturer, providing all other requirements of this specification are met.

X1.1.1 *Class 1*—Class 1 markings may be applied with a single drop-on application of either AASHTO M247 Type 1 or Type 2 glass beads applied at a rate of 8 to 10 lb per 100 ft^2.

X1.1.2 *Class 2*—Class 2 markings may be applied with a double drop-on optic application with the first drop consisting of approximately 8 to 10 lb/100 ft^2 of AASHTO Type 3, Type

4, or Type 5 glass beads and the second drop consisting of approximately 6 to 8 lb/100 ft^2 of AASHTO Type 1 or Type 2 glass beads.

X1.1.3 *Class 3*—Class 3 markings may be applied with either a single drop application of high index beads or a multi-drop application of a combination of retroreflective optics of which one component is a high refractive index bead or a composite optic.