Designation: D 4280 – 03

Standard Specification for Extended Life Type, Nonplowable, Raised Retroreflective Pavement Markers[1]

This standard is issued under the fixed designation D 4280; 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 nonplowable, retroreflective raised pavement markers for nighttime lane marking and delineation.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 The following precautionary caveat pertains only to the test methods portion, Section 9, of this specification: *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:*

C 184 Test Method for Fineness of Hydraulic Cement by the 150-µm (No. 100) and 75-µm (No. 200) Sieves[2]

C 430 Test Method for Fineness of Hydraulic Cement by the 45-µm (No. 325) Sieve[2]

D 5 Test Method for Penetration of Bituminous Materials[3]

D 36 Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)[4]

D 70 Test Method for Specific Gravity and Density of Semi–Solid Bituminous Materials (Pycnometer Method)[3]

D 92 Test Method for Flash and Fire Points by Cleveland Open Cup[5]

D 1754 Test Method for Effects of Heat and Air on Asphaltic Materials (Thin-Film Oven Test)[3]

D 1856 Test Method for Recovery of Asphalt from Solution by Absorn Method[3]

D 2171 Test Method for Viscosity of Asphalts by Vacuum Capillary Viscometer[3]

D 2172 Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures[3]

D 2669 Test Method for Apparent Viscosity of Petroleum Waxes Compounded with Additives (Hot Melts)[6]

D 4402 Test Method for Viscosity Determinations of Unfilled Asphalts Using the Brookfield Thermosel Apparatus[4]

D 5329 Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements[3]

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[7]

E 284 Terminology of Appearance[8]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[7]

E 808 Practice for Describing Retroreflection[8]

E 809 Practice for Measuring Photometric Characteristics of Retroreflectors[8]

E 811 Practice for Measuring Colorimetric Characteristics of Retroreflectors Under Nighttime Conditions[8]

2.2 *Federal Specifications:*[9]

FF-W-1825A Wool and Gauze, Metallic

TT-T-291 Thinner, Paint, Mineral Spirits, Regular and Odorless

2.3 *AASHTO Standards:*[10]

AASHTO M237 Epoxy Resin Adhesive for Bonding Traffic Markers to Hardened Concrete

3. Terminology

3.1 *Definitions:*

3.1.1 *cleanability*—the ability of a raised retroreflective marker to keep its optical surfaces clean under traffic and environmental conditions.

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[2] *Annual Book of ASTM Standards*, Vol 04.01.

[3] *Annual Book of ASTM Standards*, Vol 04.03.

[4] *Annual Book of ASTM Standards*, Vol 04.04.

[5] *Annual Book of ASTM Standards*, Vol 05.01.

[6] *Annual Book of ASTM Standards*, Vol 05.02.

[7] *Annual Book of ASTM Standards*, Vol 14.02.

[8] *Annual Book of ASTM Standards*, Vol 06.01.

[9] Available from U.S. Government Printing Office, Washington, DC 20402.

[10] Available from American Association of State Highway and Transportation Officials, 444 N. Capitol, Washington, DC 20001.

3.1.2 *coefficient of luminous intensity, R_I*—the ratio of the luminous intensity (*I*) of the retroreflector in the direction of observation to the illuminance (*E*) at the retroreflector on a plane perpendicular to the direction of the incident light, expressed in candelas per lux (cd/lx) (see Practice E 808 and Terminology E 284).

3.1.2.1 *Discussion*—When values are low the coefficient of (retroreflected) luminous intensity may be given in millicandelas per lux. In inch-pound units, R_I is given in candelas per footcandle (cd/fc). Historically, the term "specific intensity" and symbol ("SI") have been used to designate this term but "R_I" is preferred.

3.1.3 *color*—chromaticity, according to the CIE (Commission Internationale de l'Eclairage) 1931 colorimetric system.

3.1.4 *horizontal entrance angle*—the angle in the horizontal plane between the direction of incident light and the normal to the leading edge of the marker.

3.1.4.1 *Discussion*—This angle corresponds to the entrance angle β2 when the marker is positioned for photometry. The direction given in Practice E 808 should be used when designating this angle.

3.1.5 *observation angle*—the angle between the illumination axis and the observation axis. (See also Practice E 808.)

3.1.6 *retroreflection*—reflection in which radiation is returned in directions close to the direction from which it came, this property being maintained over wide variations of the direction of incident radiation.

3.1.7 *retroreflective element*—a minimal optical unit that produces retroreflection, for example, a cube corner or a biconvex structure.

4. Classification

4.1 Markers should be classified as to type, color, and abrasion resistance.

4.1.1 *Types of Markers*:

4.1.1.1 *Type A*—Two-way reflective markers, one color.

4.1.1.2 *Type B*—One-way reflective markers, one color.

4.1.1.3 *Type E*—Two-way reflective markers, two colors.

4.1.2 *Retroreflected Color of Markers*:

4.1.2.1 *W*—White.

4.1.2.2 *Y*—Yellow.

4.1.2.3 *R*—Red.

4.1.2.4 *B*—Blue.

4.1.2.5 *G*—Green.

4.1.3 *Abrasion Resistance*:

4.1.3.1 *Designated H*—Marker with hard, abrasion-resistant lens surface.

4.1.4 *Flexural Strength*:

4.1.4.1 *Designated F*—Marker with sufficient longitudinal strength for application to flexible, asphaltic concrete pavement.

4.2 Show classification in the order detailed in 4.1.1 through 4.1.3.1: type, color, abrasion resistance, and flexural strength. For example, ERWF is a two-way red-and-white marker without abrasion resistant surface and with sufficient flexural strength for application to flexible pavement.

5. Ordering Information

5.1 Orders for material under this specification should include the following information:

5.1.1 Quantity,

5.1.2 Type of marker: retroreflective one way, or retroreflective two way,

5.1.3 Color of marker,

5.1.4 Abrasion resistance, if needed, and

5.1.5 Flexural strength if needed.

NOTE 1—Flexural strength is not critical when application is to portland cement concrete pavement, but is critical when application is to some soft asphaltic concrete pavements.

6. Requirements for Retroreflective Markers

6.1 *Construction*:

6.1.1 The marker shall be comprised of materials with adequate chemical, water, and UV resistance for the intended use.

6.1.2 Marker height shall not exceed 20.3 mm (0.80 in.).

6.1.3 Marker width shall not exceed 130 mm (5.1 in.).

6.1.4 The angle between the face of the marker and the base shall be no greater than 45°, except as provided in 6.1.4.1.

6.1.4.1 If the angle between the face of the marker and the base is greater than 45°, or if the marker front has protuberances of more than 1 mm (0.04 in.), then as part of type acceptance, the marker shall be subjected to a 6-month road test during the time of the year when weather and traffic conditions are most critical to cleanability. Cleanability is determined by measuring coefficient of luminous intensity before and after washing the marker lens.

6.1.5 The base of the marker shall be substantially free from gloss or substances that may reduce its bond to adhesive.

6.1.6 The base of the marker shall be flat within 1.3 mm (0.05 in.). If the bottom of the marker is configurated, the protruding faces of the configurations shall not deviate more than 1.3 mm (0.05 in.) from a plane.

6.1.7 Construction not meeting the requirements of 6.1.2, 6.1.3, 6.1.4, 6.1.6, or 6.1.7, but meeting the performance requirements of 6.2, will be acceptable following a 12-month road test to determine cleanability, durability, and adhesion to the road.

6.2 *Performance Requirements*:

6.2.1 Coefficient of luminous intensity measured in accordance with 9.1 shall be not less than the values in Table 1.

6.2.2 Because no practical laboratory procedures have been determined to provide complete, reliable, and predictive information on adhesive bond strength, the user is encouraged to seek information from alternative sources such as field tests. A field test of duration 12 months is recommended. A control marker is chosen with known satisfactory adhesion. The test markers may be required to experience no more than 1.5 times as great an adhesion failure rate as the controls. The test severity should be such that between 3 % and 20 % of the controls fail during the field test. There must be adequate numbers of test markers and controls for statistical validity.

6.2.3 *Physical Properties*:

TABLE 1 Coefficient of Luminous Intensity R_I

NOTE 1—The retroreflector axis and datum axis of the marker are as shown in Fig. 2 and Fig. 3.
NOTE 2—Entrance angle component β1 and rotation angle ϵ are 0°.
NOTE 3—The SI values in the table are to be regarded as the standard. The English values are provided for information.

Entrance Angle Component β2	Observation Angle α	Minimum Value R_I, mcd/lx				
		White	Yellow	Red	Green	Blue
0°	0.2°	279	167	70	93	26
+ 20°/−20°	0.2°	112	67	28	37	10
Entrance Angle Component β2	Observation Angle α	Minimum Value R_I, cd/fc				
		White	Yellow	Red	Green	Blue
0°	0.2°	3.0	1.8	0.75	1.0	0.28
+ 20°/−20°	0.2°	1.2	0.72	0.30	0.4	0.11

6.2.3.1 *Flexural Strength* (designation F markers only)—When tested in accordance with 9.2.1, a marker shall withstand 8914 N (909 kgf, 2000 lbf) without breakage.

NOTE 2—Method 9.2.1 tests longitudinal flexural strength, distinct from the flexural strength tested in previous editions of this specification.

6.2.3.2 *Compressive Strength*—When tested in accordance with 9.2.2, a marker shall support a load of 2727 kg (6000 lb) without breakage or significant deformation of the marker. Significant deformation shall be understood to be 3.3 mm (0.13 in.).

6.2.4 *Color*—When the retroreflector is illuminated by CIE Standard Source A and when measured in accordance with 9.3, the color of the retroreflected light shall fall within the color gamuts given by the following corner points and shown in Fig. 1.

6.2.4.1 *White*

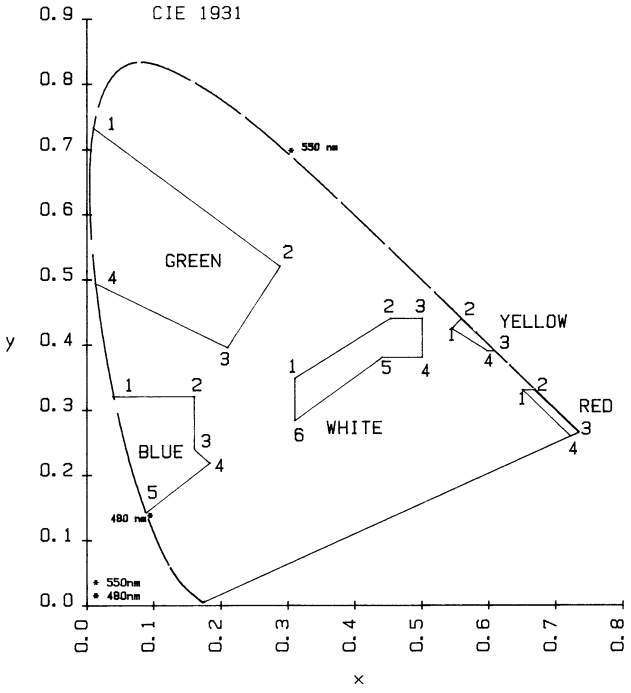

FIG. 1 Color Gamut per 6.2.4

Point No.	*x*	*y*
1	0.310	0.348
2	0.453	0.440
3	0.500	0.440
4	0.500	0.380
5	0.440	0.380
6	0.310	0.283

6.2.4.2 *Yellow*

Point No.	*x*	*y*
1	0.545	0.424
2	0.559	0.439
3	0.609	0.390
4	0.597	0.390

6.2.4.3 *Red*

Point No.	*x*	*y*
1	0.650	0.330
2	0.668	0.330
3	0.734	0.265
4	0.721	0.259

6.2.4.4 *Blue*

Point No.	*x*	*y*
1	0.039	0.320
2	0.160	0.320
3	0.160	0.240
4	0.183	0.218
5	0.088	0.142

6.2.4.5 *Green*

Point No.	*x*	*y*
1	0.009	0.733
2	0.288	0.520
3	0.209	0.395
4	0.012	0.494

6.2.5 *Resistance to Lens Cracking*:

6.2.5.1 *Lens Impact Strength*—When impacted in accordance with 9.4.1, the face of the lens shall show no more than two radial cracks longer than 6.4 mm (0.25 in.). There shall be no radial cracks extending to the edge of the abrasion resistant area. There shall be no delamination.

6.2.5.2 *Temperature Cycling*—When subjected to temperature cycling in accordance with 9.4.2 there shall be no cracking or delamination.

7. Sampling

7.1 For markers not resistant to abrasion, sample size shall be twenty markers for each lot of 10 000 markers or less and forty markers for each lot of more than 10 000 markers. For

markers with an abrasion resistant surface, ten additional samples shall be required. Lot size shall not exceed 25 000 markers.

8. Number of Tests and Retests

8.1 For coefficient of luminous intensity (9.1.1), the entire sample of retroreflective pavement markers shall be tested. Failure of more than 10 % of the reflective faces shall be cause for rejection of the entire lot represented by the sample. For abrasion resistant markers, in addition to the test of 9.1.1, four reflective faces passing the photometric requirements of 9.1.1 shall be subjected to abrasion (9.1.2) and remeasured; failure of more than one sample shall be cause for rejection of the entire lot.

8.2 For longitudinal flexural strength (9.2.1), compressive strength (9.2.2), and color (9.3), three specimens shall be tested. Specimens previously subjected to photometry (9.1.1), color (9.3) and the abrasion specified for 9.1.2 are acceptable for tests of longitudinal flexural strength (9.2.1) and compressive strength (9.2.2). Failure of more than one specimen shall be cause for rejection of the entire lot.

8.3 For lens impact strength (9.4.1) and resistance to temperature cycling (9.4.2), ten specimens shall be tested for each requirement. Failure of more than one of the specimens in either test shall be cause for rejection of the entire lot.

8.4 In the event of failure that would result in rejection of a lot, and at the discretion of the purchaser, a resample may be taken consisting of double the number of samples originally tested. Tolerances for resamples shall be in the same ratio as specified above.

9. Test Methods

9.1 *Coefficient of Luminous Intensity*:

9.1.1 *Procedure*—Measure coefficient of luminous intensity in accordance with Practice E 809. Angular aperture of the source and angular aperture of the receiver shall each be no larger than 0.1°. Angular aperture of the retroreflective elements shall be no larger than 0.02°. If the retroreflective elements are no larger than 5.3 mm (0.21 in.) in diameter, suggested test dimensions are 15.2 m (50 ft) distance, 25.4 mm (1.0 in.) diameter receptor, and 25.4 mm (1.0 in.) diameter source. Other test distances are acceptable provided that the stated angular aperture requirements are met and that the marker subtends no more than 1° at the source. Measure the distance from the light source exit pupil to the center of the retroreflective face of the marker. The base of the marker shall lie on a plane parallel to the illumination axis and perpendicular to the observation half-plane. Refer to Fig. 2, Fig. 3, and Practice E 809. Any vertical surfaces on the marker, for example, on its leading edge, that could specularly reflect the source into the receiver shall be covered. The tolerance on entrance angle shall be ±0.5°.

9.1.2 For abrasion resistant markers, measure coefficient of luminous intensity after abrasion with a 25.4-mm (1-in.) diameter flat pad of No. 3 coarse steel wool conforming to Federal Specification FF-W-1825A. Place the steel wool pad on the reflector lens. Apply a load of 216 ± 2 N (22 ± 0.2 kgf, 50 ± 0.5 lbf) and rub the entire lens surface 100 times.

NOTE 3—Some two-color units may intentionally have only one of the retroreflected faces covered with an abrasion-resistant surface and, if so, the unprotected face should not be abraded.

9.2 *Physical Properties*:

9.2.1 *Longitudinal Flexural Strength*:

9.2.1.1 Condition markers at 23.0 ± 2.0°C (73.4 ± 3.6°F) for 4 h prior to testing.

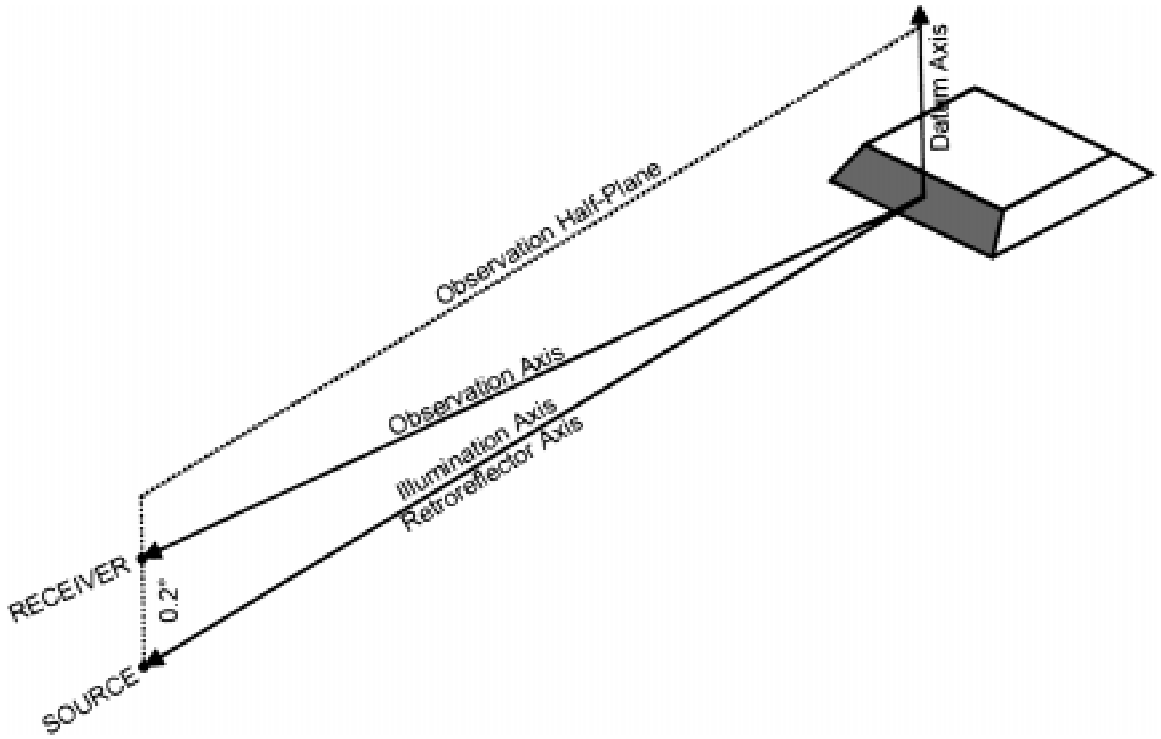

FIG. 2 Position of Marker for Photometry, 0° Entrance Angle

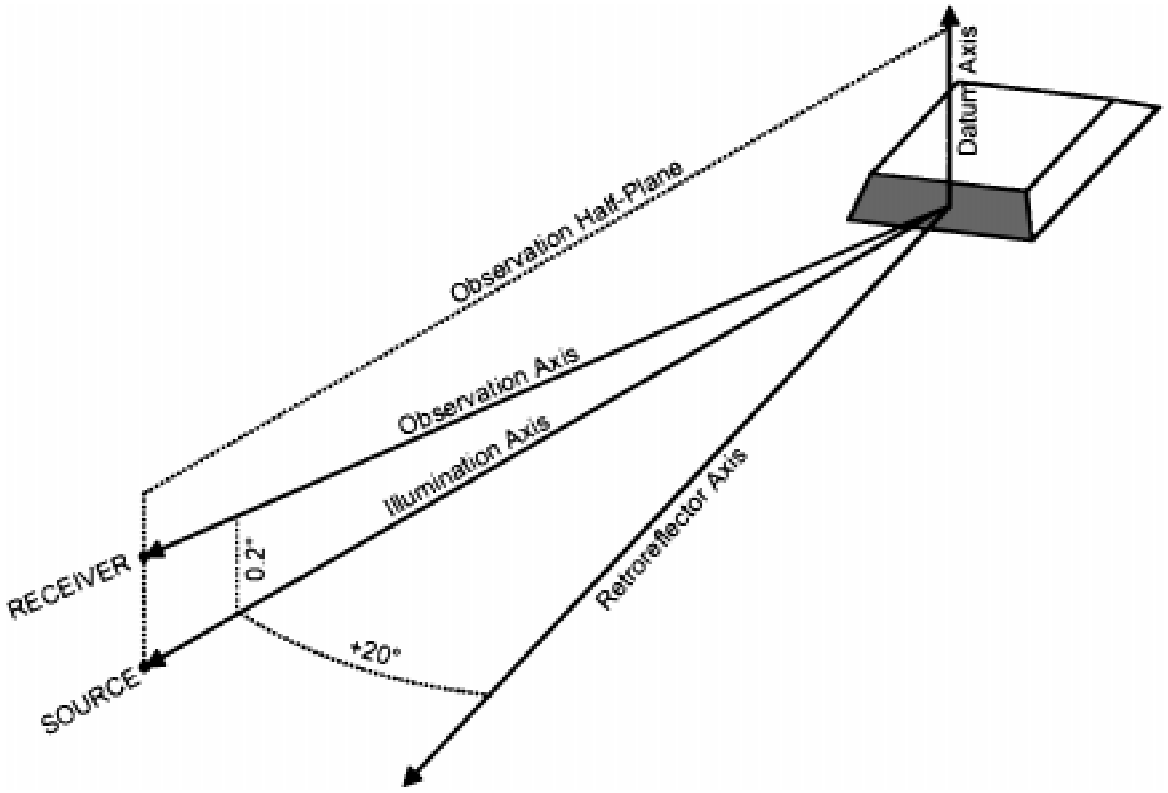

FIG. 3 Position of Marker for Photometry, +20° Entrance Angle

9.2.1.2 Place two 12.7 × 25.4 mm (0.5 × 1.0 in.) steel bars, each longer than the width of the marker base, on their 12.7-mm (0.5-in.) faces, onto the platen of the compression apparatus. Place durometer 70 Shore A elastomeric pads approximately 3 mm (0.12 in.) thick onto the bars. Place marker base down onto the pads. Marker shall have its lengthwise (roadway) direction perpendicular to the two bars. Spacing of bars shall depend on length of marker base, being as great as possible without bars protruding beyond the extreme lengthwise points of the marker base. Place a durometer 70 Shore A elastomeric pad approximately 25 mm (1 in.) thick and larger than the marker top on top of marker. Place a third 12.7 mm × 25.4 mm (0.5 in. × 1.0 in.) steel bar, longer than the width of marker top, on its 12.7-mm (0.5-in.) face onto the top of the pad, positioned parallel to the other bars and centered over the marker top (see Fig. 4).

9.2.1.3 Apply load to the top of the marker at a rate of 5.0 mm (0.2 in.)/min through the top steel bar until the marker breaks. Breakage shall constitute complete rupture or other loss of integrity evidenced by a sudden decrease in load. Record load at break to the nearest N (kgf, lbf).

9.2.1.4 *Precision and Bias*:

TABLE 2 Precision and Bias

Material	Repeatability Std. Dev. (%)	Reproducibility Std. Dev. (%)	Repeatability Limit (%)	Reproducibility Limit (%)
4 by 4 in. RPM	4.54	6.94	12.72	19.44

(*a*) *Interlaboratory Test Program*—An interlaboratory study of longitudinal flexural strength for nonplowable raised pavement markers for extended life was conducted in accordance with Practice E 691 in eight laboratories using four marker models with ten nearly identical specimens of each model for each laboratory. The four marker models were as follows:

1. marker with molded ABS body
2. marker with molded polycarbonate shell and interior
3. marker with molded acrylic shell and urethane potting
4. marker with molded acrylic shell and urethane potting

(*1*) Mean measurement values for the four models varied from 990 kg to 1370 kg.

(*2*) The individual statistical results for each set were averaged to obtain one set of repeatability and reproducibility results.

(*3*) The terms repeatability limit and reproducibility limit are used as specified in Practice E 177.

(*b*) *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in this test method for measuring longitudinal flexural strength, no statement on bias is being made.

9.2.2 *Compressive Strength*:

9.2.2.1 Condition markers at 23.0 ± 2.0°C (73.4± 3.6°F) for 4 h prior to testing.

9.2.2.2 Position marker base down at the center of a 13-mm (0.5-in.) thick flat steel plate larger than the marker.

9.2.2.3 On top of the marker place a 9.5-mm (0.37-in.) thick elastomeric pad larger than the marker and having a Shore A durometer of 60.

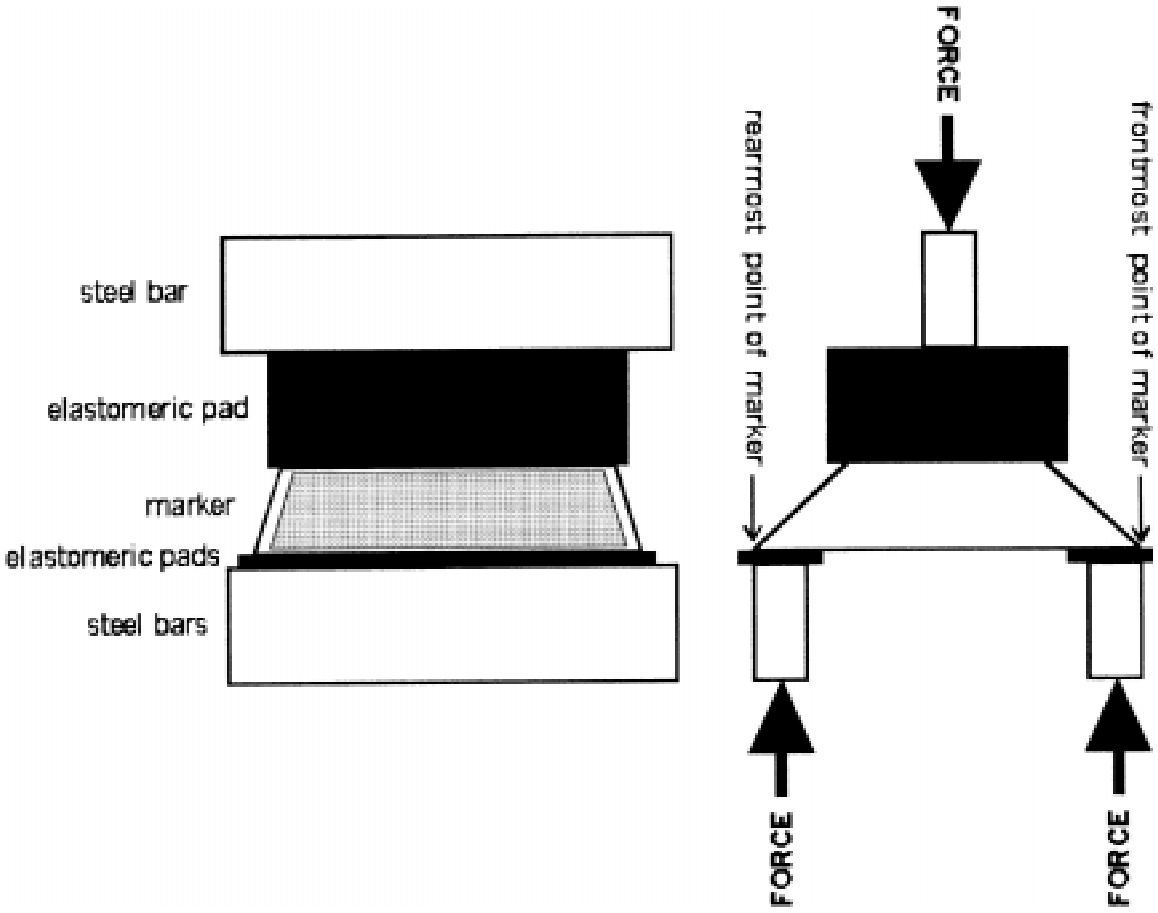

FIG. 4 Longitudinal Flexural Strength Test

9.2.2.4 On top of the elastomeric pad place a 13-mm (0.5-in.) thick flat steel plate larger than the marker.

9.2.2.5 Apply a load at a rate of 2.5 mm (0.1 in.)/ min.

9.3 *Color*—Measure color in accordance with Practice E 811 at 0.2° observation angle and 0° entrance angle. The source and receptor angular apertures shall each be 6 min of arc.

9.4 *Resistance to Lens Cracking*:

9.4.1 *Lens Impact Strength*—Condition the markers in a convection oven at 55°C (130°F) for 1 h.

9.4.1.1 While at the elevated temperature, impact the reflective face of the marker by allowing a 0.19-kg (0.42-lb) dart fitted with a 6.4-mm (0.25-in.) radius semi-spherical head to drop 457 mm (18 in.) perpendicularly onto the approximate center of the reflective surface. For impact testing, set the marker on a steel fixture designed to hold the reflecting face horizontal, and place the fixture on a solid surface such as a concrete floor.

9.4.1.2 Inspect for cracking and delamination.

9.4.2 *Resistance to Temperature Cycling*—Subject samples to 3 cycles of 60°C (140°F) for 4 h followed by − 7°C (20°F) for 4 h.

9.4.2.1 Inspect for cracking and delamination.

9.4.3 *Precision and Bias*—No statement is made about either the precision or bias of the test for resistance to lens cracking since the result merely states whether there is conformance to the criteria for success specified in the procedure.

10. Packaging

10.1 Shipments shall be made in containers which are acceptable to common carriers and packaged in such a manner as to ensure delivery in perfect condition. Any damaged shipments shall be replaced by the contractor. Each package shall be clearly marked as to the name of the manufacturer, type, color, quantity enclosed, and date of manufacture.

11. Keywords

11.1 delamination; pavement markers; prismatic markers; raised pavement markers; retroreflective markers

ANNEX

(Mandatory Information)

A1. SPECIFICATION FOR BITUMINOUS ADHESIVE FOR PAVEMENT MARKERS

A1.1 Scope

A1.1.1 This specification establishes the requirements for bituminous installation adhesive to be used for placement of nonplowable, raised, retroreflective, pavement markers. The adhesive shall be suitable for bonding the above markers to portland cement concrete, asphaltic concrete, and chip sealed road surfaces and applicable when road surface and marker temperatures are in the range from 4.4 to 71°C (40 to 160°F). The adhesive properties will not deteriorate when heated to and applied at temperatures up to 218°C (425°F) using either air or oiljacketed melters.

A1.2 General Properties of Adhesive

A1.2.1 The bituminous installation adhesive is an asphaltic material with a homogeneously mixed mineral filler. The adhesive shall not contain rubber polymers since necessary application temperatures cause decomposition, resulting in unsatisfactory performance. The adhesive shall conform to the following requirements:

Property	Minimum	Maximum	Test Method
Softening point, °C (°F)	93 (200)	127 (260)	D 36
Penetration at 25°C, mm × 10^{-1}	10	18	D 5
Penetration at 60°C, mm × 10^{-1}	45	65	D 5 as in A1.4.8
Flow, mm (in.)	—	5.1 (0.2)	D 5329, as modified in A1.4.1
Heat stability flow, mm (in.)	—	5.1 (0.2)	As in A1.4.2
Viscosity at 204°C (400°F), P	30	75	D 2669, as modified in A1.4.3, or D4402
Flash point, C.O.C., °C (°F)	228 (550)	—	D 92
Shelf life, years	2	—	

A1.3 General Properties of Filler-Free Material and of Filler Alone

A1.3.1 Asphalt properties determined on the filler-free material derived from the extraction and Abson recovery process as explained in A1.4.4 are as follows:

Property	Minimum	Maximum	Test Method
Penetration, 100 g, 5s, 25°C (77°F)	25	—	D 5
Viscosity, 135°C (275°F), P	12	100	D 2171
Viscosity ratio, 135°C (275°F)	—	2.2	As explained in A1.4.5

A1.3.2 Filler properties determined using the filler separation technique described in A1.4.6.

Property	Minimum	Maximum	Test Method
Filler content, % by weight	65	75	As in A1.4.6
Filler fineness, % passing			
45-µm (No. 325) sieve	75	—	C 430
75-µm (No. 200) sieve	95	—	C 184
150-µm (No. 100) sieve	100	—	C 184

A1.4 Test Methods

A1.4.1 Determine flow in accordance with Section 8 on Flow of Test Methods D 5329, with the exception that the oven temperature shall be 70 ± 1°C (158 ± 2°F) and sample preparation shall be in accordance with Section 7.1 of Test Method D 5.

A1.4.2 Determine heat stability flow in accordance with Section 8 on Flow of Test Methods D 5329, with the exception that 1000 g of adhesive shall be placed in a covered quart can, heated to 218°C (425°F), and maintained at this temperature for 4 h prior to preparing the sample panel in accordance with Section 7.1 of Test Method D 5.

A1.4.3 Determine viscosity in accordance with Test Method D 2669 or D 4402. If using Test Method D 2669, use a spindle speed of 10 r/min, and heat the adhesive to approximately 210°C (410°F) and allow to cool; determine viscosity at 204.4 ± 0.5°C (400 ± 1°F). If using Test Method D 4402, the test method describes the spindle and speed to be used with various models.

A1.4.4 Determine properties of the base asphalt on the material obtained from the following extraction and Abson recovery methods. Extract the asphalt by heating the adhesive just to the point where it will easily flow and then transfer 125 to 150 g into 400 mL of trichloroethylene with a temperature of 52 to 65°C (125 to 150°F). Thoroughly stir this mixture to dissolve the asphalt. Decant the trichloroethylene-asphalt mixture and recover the asphalt using the Abson recovery method in accordance with Test Method D 1856 as modified by the following. The extraction methods of Test Methods D 2172 shall not apply and there shall be no filtration of the solvent-asphalt mixture. Centrifuge the extraction solution of trichloroethylene and asphalt for at least 30 min at 770 times gravity in a batch centrifuge. A continuous centrifuge can be used if the extract solution is charged at a rate not to exceed 150 mL/min while the unit is operating at a speed calculated to produce a centrifuge force of not less than 3000 times gravity as specified in 9.2 of Test Method D 1856. Decant this solution into the distillation flask, taking care not to include any filler sediment. Apply heat and bubble carbon dioxide slowly to bring the solution temperature to 149°C (300°F). At this point, the carbon dioxide flow is increased to 800 to 900 mL/min. Maintain the solution temperature at 160 to 168°C (320 to 335°F) with this carbon dioxide flow rate for at least 20 min and until the trichloroethylene vapors have been completely removed from the distillation flask. Repeat the above extraction-recovery method as necessary to obtain the desired quantity of asphalt. Use the asphalt recovered to determine penetration, 135°C (275°F) viscosity, and 135°C (275°F) viscosity ratio.

A1.4.5 Determine the 135°C (275°F) viscosity ratio by comparing the 135°C (275°F) viscosity on the base asphalt before and after the Thin-Film Oven Test. Perform the Thin-Film Oven Test in accordance with Test Method D 1754. Determine the specific gravity by pycnometer in accordance with Test Method D 70 for use in the Thin-Film Oven Test. Calculate the 135°C (275°F) viscosity ratio by dividing the viscosity after the Thin-Film Oven Test by the original 135°C (275°F) viscosity.

A1.4.6 To determine the filler content, use the data from the separation described in A1.4.4. The samples used for the asphalt recovery are weighed before the extractions. The extracted filler is weighed after extraction. The bitumen is determined by difference.

A1.4.7 Determine the fineness of the filler according to Test Method C 430 for material finer than the 45 µm (No. 325) sieve. Using a second test sample, determine the percentage of the material passing the 150 µm (No. 100) and 75 µm (No. 200) sieve according to Test Method C 184.

A1.4.8 Determine penetration at 60°C (140°F) in accordance with Section 8 of Test Method D 5 where the conditions of test are the following:

Temperature, °C (°F)	Load, g	Time, s
60 (140)	100	5

A1.5 Packaging and Labeling

A1.5.1 The adhesive shall be packaged in self-releasing cardboard containers that will stack properly. The containers shall be divided into compartments so that four equal individual parts are obtained from each container. The containers shall have a net weight of approximately 25 kg (55 pd). The label for the container shall clearly show the manufacturer, quantity, lot or batch number, and an indication that the material is bituminous adhesive for pavement markers.

APPENDIX

(Nonmandatory Information)

X1. STORAGE, PLACEMENT AND APPLICATION OF NONPLOWABLE MARKERS

X1.1 *Storage*—Markers should be stored indoors and should be protected from any source of moisture both during shipment to the jobsite and at the jobsite. The markers should be maintained at a high enough temperature as to preclude moisture condensation, and, at the time of placement, both the markers and their containers should be dry.

X1.2 *Placement of Nonplowable Markers*—Before beginning pavement marker application, the contractor should accurately and adequately lay out, by reference points, the location of all pavement markers, to ensure their proper placement. Pavement markers should not be placed on pavement surfaces that show visible evidence of cracking, checking, spalling, or failure of underlying base material. If, during the preinstallation layout operation, it is determined that a marker would be placed at a point with one of the aforementioned pavement surface defects or at a pavement construction joint or within the intersection of a driveway or public street as the result of typical marker spacing, the affected marker should be relocated longitudinally a sufficient distance to a point approved by the engineer. The distance the marker may be relocated should not exceed 10 % of the typical marker spacing. Where it would be necessary to relocate the marker a distance greater than 10 % of the typical marker spacing, the affected marker should be deleted. The reflective face of the marker should be perpendicular to a line parallel to the roadway centerline.

X1.3 *Application of Nonplowable Markers*—Markers should be cemented to the pavement with Rapid Set Type adhesive conforming to the provisions of AASHTO M237, Type I, or Standard Set Type adhesive conforming to AASHTO M237, Type II, or with bituminous adhesive.

X1.3.1 The engineer should be the judge as to when Rapid Set Type adhesive has set sufficiently to bear traffic.

X1.3.2 Regardless of the type of adhesive used, markers should not be placed under the following conditions:

X1.3.2.1 When either the pavement or the air temperature is 0°C (32°F) or less when using rapid set epoxy, 10°C (50°F) or less when using standard set epoxy or 4.4°C (40°F) or less when using bitumen,

X1.3.2.2 If the relative humidity of the air is greater than 80 %,

X1.3.2.3 If the pavement is not surface dry, and

X1.3.2.4 On new asphalt concrete surfacing until the surfacing has been opened to public traffic for a period of not less than 14 days.

X1.3.3 The portion of the highway surface to which the marker is to be bonded by the adhesive should be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive. A wire brush should be used, if necessary, to loosen and remove dirt, and the surface should be brushed or blown clean. New portland cement concrete should be blast cleaned. The adhesive should be placed uniformly on the cleaned pavement surface or on the bottom of the marker in a quantity sufficient to result in complete coverage of the area of contact of the marker with no voids present and with a slight excess after the marker has been lightly pressed in place; ideally there will be approximately 0.060 in. adhesive between the marker and the pavement.

X1.3.4 For epoxy installations, excess adhesive around the edge of the marker, excess adhesive on the pavement, and adhesive on the exposed surfaces of the markers should be immediately removed. Soft rags moistened with mineral spirits conforming to Federal Specification TT-T-291 or kerosine may be used, if necessary, to remove adhesive from exposed faces of pavement markers. No other solvent should be used.

X1.3.5 For epoxy installations, the marker should be protected against impact until the adhesive has hardened to the degree designated by the engineer.

X1.3.6 The epoxy adhesive requires that the mixing operation and placing of the markers be done rapidly. When hand mixing the Standard Set Type adhesive, not more than 1 L (1

qt) should be mixed at one time, and the markers should be aligned and pressed into place within 5 min after mixing operations are started. Any mixed batch which becomes so viscous that the adhesive cannot be readily extruded from under the marker on application of slight pressure should not be used. Rapid Set Type adhesive should not be mixed by hand.

X1.3.7 The Rapid Set Type adhesive should be mixed by a 2-component type automatic mixing and extrusion apparatus. When machine mixing the Standard Set Type adhesive, or the Rapid Set Type adhesive, the markers should be placed within 60 s after the adhesive has been mixed and extruded and no further movement of the marker should be allowed. In addition, no more than 90 s should be permitted between the time the adhesive is in place on the roadway and not subject to further movement. The mixed adhesive should not remain in the mixing head for more than 45 s. Adhesive remaining in the mixing head longer than this period should be wasted before resuming the operation.

X1.3.8 Automatic mixing equipment for the epoxy adhesive should use positive displacement pumps and should properly meter the two components in the specified ratio, ±5 % by volume of either component. At the beginning of each day and at any other time ordered by the engineer, the ratio should be checked by the contractor in the presence of the engineer. This check should be made by disconnecting the mixing heads, or using suitable bypass valves, and filling two suitable containers with the unmixed components. The mixing head should properly mix the two components so that there is no trace of black or white streaks in the mixed material.

X1.3.9 Voids in a cured, undisturbed sample of the mixed adhesive obtained from the extrusion nozzle should not exceed 4 %.

X1.3.10 Bituminous adhesive should be dispensed from a thermostatically controlled melter-applicator at a temperature of 141 to 218°C (375 to 425°F). The material should be stirred frequently to ensure even heating. The adhesive should be dispensed in a puddle larger than the bottom of the marker, and the marker should be dropped onto the puddle as quickly as possible, preferably within 5 s of adhesive placement. The marker should be pressed lightly onto the adhesive. The adhesive will set up in approximately 2 min and typically requires no protection from traffic.