



Designation: D 4383 – 02

## Standard Specification for Plowable, Raised Retroreflective Pavement Markers<sup>1</sup>

This standard is issued under the fixed designation D 4383; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 1. Scope

1.1 This specification covers a type of plowable, retroreflective, raised pavement marker for lane marking and delineation.

1.2 Retroreflective markers are intended for nighttime visibility.

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

1.4 The following precautionary caveat pertains only to the test methods portion, Section 10, 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:

- A 536 Specification for Ductile Iron Castings<sup>2</sup>
- C 184 Test Method for Fineness of Hydraulic Cement by the 150- $\mu$ m (No. 100) and 75- $\mu$ m (No. 200) Sieves<sup>3</sup>
- C 430 Test Method for Fineness of Hydraulic Cement by the 45- $\mu$ m (No. 325) Sieve<sup>4</sup>
- D 5 Test Method for Penetration of Bituminous Materials<sup>5</sup>
- D 36 Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)<sup>6</sup>
- D 70 Test Method for Specific Gravity and Density of Semi-Solid Bituminous Materials (Pycnometer Method)<sup>5</sup>
- D 92 Test Method for Flash and Fire Points by Cleveland Open Cup<sup>7</sup>
- D 788 Classification System for Poly(Methyl Methacrylate) (PMMA) Molding and Extrusion Compounds<sup>8</sup>
- D 1754 Test Method for Effect of Heat and Air on Asphaltic

- Materials (Thin-Film Oven Test)<sup>5</sup>
- D 1856 Test Method for Recovery of Asphalt from Solution by Abson Method<sup>5</sup>
- D 2171 Test Method for Viscosity of Asphalts by Vacuum Capillary Viscometer<sup>5</sup>
- D 2669 Test Method for Apparent Viscosity of Petroleum Waxes Compounded with Additives (Hot Melts)<sup>9</sup>
- D 2712 Test Method for Hydrocarbon Traces in Propylene Concentrates by Gas Chromatography<sup>9</sup>
- D 3407 Test Methods for Joint Sealants, Hot-Poured, for Concrete and Asphalt Pavements<sup>10</sup>
- D 3935 Specification for Polycarbonate (PC) Unfilled and Reinforced Material<sup>11</sup>
- D 4402 Test Method for Viscosity Determination of Asphalts at Elevated Temperatures Using a Rotational Viscometer<sup>6</sup>
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>12</sup>
- E 284 Terminology of Appearance<sup>13</sup>
- E 308 Practice for Computing the Colors of Objects by Using the CIE System<sup>13</sup>
- E 808 Practice for Describing Retroreflection<sup>13</sup>
- E 809 Practice for Measuring Photometric Characteristics of Retroreflectors<sup>13</sup>
- E 811 Practice for Measuring Colorimetric Characteristics of Retroreflectors Under Nighttime Conditions<sup>13</sup>
- 2.2 *Federal Specifications:*<sup>14</sup>
  - FF-W-1825A Wool and Gauze, Metallic
  - TT-T-291 Thinner, Paint, Mineral Spirits, Regular and Odorless
- 2.3 *AASHTO Standards:*<sup>15</sup>
  - AASHTO No. M237 Epoxy Resin Adhesive for Bonding Traffic Markers to Hardened Concrete
  - AASHTO No. T237 Testing Epoxy Resin Adhesive

### 3. Terminology

#### 3.1 Definitions:

- <sup>9</sup> *Annual Book of ASTM Standards*, Vol 05.02.
- <sup>10</sup> Discontinued; see 1995 *Annual Book of ASTM Standards*, Vol 04.03.
- <sup>11</sup> *Annual Book of ASTM Standards*, Vol 08.02.
- <sup>12</sup> *Annual Book of ASTM Standards*, Vol 03.01.
- <sup>13</sup> *Annual Book of ASTM Standards*, Vol 06.01.
- <sup>14</sup> Available from U.S. Government Printing Office, Washington, DC 20402.
- <sup>15</sup> Available from American Association of State Highway and Transportation Officials, 444 N. Capitol, Washington, DC 20001.

<sup>1</sup> 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 July 10, 2002. Published October 2002. Originally published as D 4383 – 84. Last previous edition D 4383 – 01.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 01.02.

<sup>3</sup> Discontinued; see 2001 *Annual Book of ASTM Standards*, Vol 04.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 04.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 04.03.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 04.04.

<sup>7</sup> *Annual Book of ASTM Standards*, Vol 05.01.

<sup>8</sup> *Annual Book of ASTM Standards*, Vol 08.01.

3.1.1 *coefficient of luminous intensity,  $R_l$*  (specific intensity)—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).

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

3.1.2 *color*—expressed by chromaticity coordinates according to the CIE (Commission Internationale de l’Eclairage 1931) standard colorimetric system.

3.1.3 *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.

3.1.3.1 *Discussion*—This angle corresponds to the entrance angle component  $\beta_2$  when the marker is positioned for photometry. (See Practice E 808.) The direction given in Practice E 808 should be used when designating this angle.

3.1.4 *observation angle*—the angle at the reflector between the illumination axis and the observation axis. (See Practice E 808.)

3.2 *Description of Term Specific to This Standard:*

3.2.1 *raised retroreflective pavement markers, raised retroreflective marker, retroreflective marker, and marker*—used interchangeably in this specification to refer to a molded plastic prismatic retroreflector, the reflecting area of which is covered with an abrasion-resistant lens surface. The terms do not include the metal holder sometimes used to protect markers from plow blades.

**4. Classification**

4.1 Markers shall be classified as to type, color, and intended application.

4.1.1 *Types of Markers:*

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

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

4.1.1.3 *Type D*—One-way retroreflective markers, two colors (one-way retroreflective red with nonretroreflecting white surface on opposite side).

4.1.1.4 *Type E*—Two-way retroreflective marker, two colors.

4.1.2 *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, and

4.1.2.5 *G*—Green.

4.1.3 *Intended Application of Markers:*

4.1.3.1 Marker to be mounted in a holder.

4.1.3.2 Marker to be mounted in a recess.

4.1.4 Show classification in the order detailed in 4.1.1-4.1.3.2: type, color, and application.

4.2 Holders shall be classified as to the design installed height of the holder above the pavement.

**5. Ordering Information**

5.1 Orders for markers 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, and

5.1.3 Color of marker.

5.2 Orders for holders under this specification should include the following information:

5.2.1 Design installed maximum height of the holder.

**6. Performance Requirements**

6.1 *Coefficient of Luminous Intensity Before Abrasion*—Measured in accordance with 10.1 the coefficient of luminous intensity  $R_l$  of the retroreflective faces before abrasion shall be not less than the values in Table 1.

6.2 *Abrasion Resistance*—After abrasion in accordance with 10.2, the coefficient of luminous intensity  $R_l$  of the retroreflective faces measured in accordance with 10.1 shall be not less than the values in Table 1.

NOTE 1—On two-color units the red lens may not be covered with an abrasion-resistant lens surface and if so should not be abraded.

6.3 *Color*—When the retroreflector is illuminated by a CIE Standard Source A and when measured in accordance with 10.3, the color of the retroreflected light shall fall within the color gamuts given by the following corner points and shown in Fig. 1:

6.3.1 *White*

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

6.3.2 *Yellow*

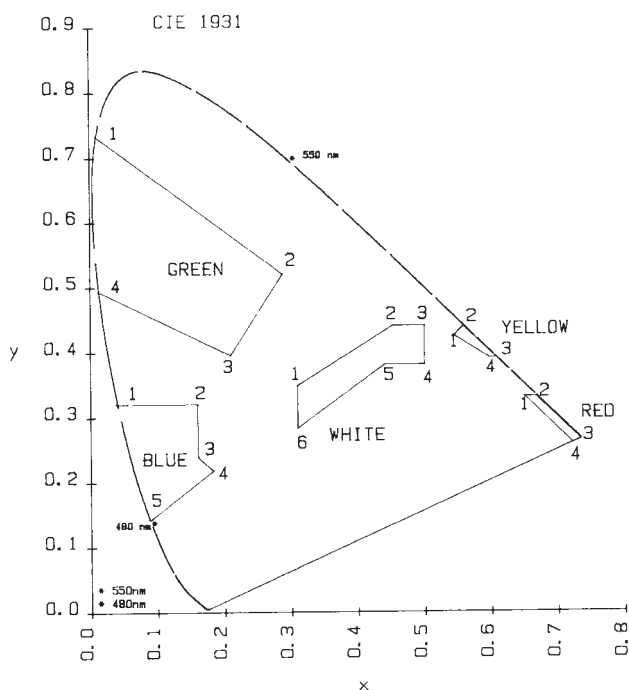
Point No.	x	y
1	0.545	0.424
2	0.559	0.439
3	0.609	0.390
4	0.597	0.390

6.3.3 *Red*

**TABLE 1 Coefficient of Luminous Intensity  $R_l$**

NOTE 1—Entrance angle component  $\beta_1$  and rotation angle  $\epsilon$  are  $0^\circ$ .

Entrance Angle $\beta_2$	Observation Angle $\alpha$	Minimum Value $R_l$ , mcd/lx				
		White	Yellow	Red	Green	Blue
$0^\circ$	$0.2^\circ$	279	167	70	93	26
	$+20^\circ/-20^\circ$	112	67	28	37	10
Entrance Angle $\beta_2$	Observation Angle $\alpha$	Minimum Value $R_l$ , cd/ftc				
		White	Yellow	Red	Green	Blue
$0^\circ$	$0.2^\circ$	3.0	1.8	0.75	1.0	0.28
	$+20^\circ/-20^\circ$	1.2	0.72	0.3	0.4	0.11



**FIG. 1 Color Gamut per 6.3**

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

**6.3.4 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

**6.3.5 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

**6.4 Lens Impact Strength**—When impacted in accordance with 10.5.1 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.

**6.4.1 Temperature Cycling**—When subjected to temperature cycling in accordance with 10.5.2 there shall be no cracking or delamination.

**6.5 Adhesive Bond Strength:**

**6.5.1** For markers intended to be installed in recesses, adhesive bond strength measured in accordance with 10.4.1 shall be not less than 3.4 MPa (500 psi). For adhesives other than those stipulated in 10.4.5 the strength criteria shall be established by the purchaser.

**6.5.2** For markers installed in holders, adhesive bond strength measured in accordance with 10.4.2 shall be not less than 45.4 kg (100 lb).

**6.5.3** For replacement markers not installed in holders, adhesive bond strength measured in accordance with 10.4.3 shall be not less than 0.08 MPa (12 psi).

**6.6 Compressive Strength**—Tested in accordance with 10.6, a marker shall support a load of 2721 kg (6000 lb) without breakage or significant deformation of the marker. Significant deformation shall be understood to be 3.2 mm (0.13 in.). For markers laminated to an elastomeric pad, remove the pad before testing.

**6.7 Ramp Hardness of Holders**—Measured in accordance with 10.7, the hardness of the ramps shall be 51-55 HRC.

**7. Construction Requirements for Retroreflective Markers**

**7.1** To withstand plowing, raised retroreflective markers are protected either by recessing within a groove below the pavement surface (see Appendix X1), mounting within a holder having metal ramps to deflect plowblades, or by other methods approved by the purchaser.

**7.2 Retroreflective Markers:**

**7.2.1** The retroreflective marker shall be the prismatic type molded of polymethyl methacrylate (Classification D 788, Grade 8), impact modified polymethyl methacrylate (Classification D 788, see Note 2) or polycarbonate (Specification D 3935, Grade PC110B34750).

**NOTE 2**—A grade has not been stipulated because the committee responsible has not yet assigned a number.

**7.2.2** The marker width shall be approximately 102 mm (4 in.).

**7.2.3** The angle between the face of the marker and the base shall be no greater than 45°.

**7.2.4** Markers to be mounted in a holder may preferably be laminated to an elastomeric pad.

**7.2.5** The base of the marker shall be flat within 1.3 mm (0.05 in.). If the bottom of the marker is configured, the outermost faces of the configurations shall not deviate more than 1.3 mm (0.05 in.) from a flat surface.

**7.2.6** Other construction meeting the performance requirements will be acceptable following a six-month road test during the time of the year when weather and traffic conditions are most critical to determine cleanability and durability.

**7.3 Holder:**

**7.3.1** The installed height of the holder shall not exceed 10.9 mm (0.43 in.) above the road surface.

**7.3.2** The holder shall be nodular iron, conforming to Specification A 536, Grade 80-55-06, hardened to 51-55 HRC, when tested according to Test Methods E 18.

**7.3.3** To minimize plow blade impact and damage to the casting, the plow blade deflecting ramps of the holder shall be angled not more than 6° to the surface of the road.

**7.3.4** The ramps shall be so designed that there shall be no vertical surfaces above the road level that can be contacted by the plow blade moving in the normal travel direction of the road.

**7.3.5** Surfaces of the holder shall be free of scale, dirt, rust, oil, grease, or any other contaminant which may reduce its bond to the adhesive with which the holder is installed or with which the marker is mounted.

7.3.6 The holder shall be designed to be partially recessed below the pavement surface to withstand plow impact.

7.3.7 Other holder constructions may be acceptable at the option of the purchaser following a six-month road test during the time of the year when weather conditions are most critical to determine durability.

## 8. Sampling

8.1 For markers supplied not mounted in holders, 26 markers selected at random will constitute a representative sample for each lot consisting of 10 000 markers or less. Forty markers will constitute a representative sample for lots consisting of more than 10 000 markers. The lot size shall not exceed 25 000 markers.

8.2 For markers supplied mounted in holders, the purchaser may require the sample quantities specified in 8.1 or, alternatively for practicality of testing, may require 10 samples of the markers installed in holders and, in addition, require that the manufacturer submit 26 or 40 loose markers, as in 8.1, certified to be representative of the markers shipped in holders.

## 9. Number of Tests and Retests

9.1 For coefficient of luminous intensity before abrasion (6.1), the entire sample of retroreflective pavement markers shall be photometered in accordance with 10.1. The failure of more than 10 % of the retroreflective faces shall be cause for rejection of the entire lot represented by the sample.

9.2 For abrasion resistance (6.2), four retroreflective faces passing the photometric requirements of (6.1) shall be subjected to abrasion in accordance with 10.2 and rephotometered in accordance with 10.1; the failure of more than one retroreflective face shall be cause for rejection of the entire lot.

9.3 For adhesive bond strength (6.5), compressive strength (6.6), and color (6.3), three specimens shall be tested for each requirement. Specimens previously subjected to measurement of coefficient of luminous intensity before abrasion, 10.1, measurement of abrasion resistance, 10.2, and to color tests may be used for tests of adhesive bond strength and compressive strength. Failure of more than one specimen shall be cause for rejection of the lot.

9.4 For lens impact strength (6.4.1), resistance to temperature cycling (7.4.2), and ramp hardness of holders (6.7), ten specimens shall be tested for each requirement. Failure of more than one of the specimens in any one test shall be cause for rejection of the entire lot.

9.5 At the discretion of the purchaser, a resample may be taken consisting of double the number of samples originally taken. Tolerances for resamples shall be in the same ratio as specified in 9.1 through 9.4.

## 10. Test Methods

10.1 *Coefficient of Luminous Intensity*—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  $0.1^\circ$ . Angular aperture of the retroreflective elements shall be no larger than  $0.02^\circ$ . If the retroreflective elements are no larger than 5.3 mm (0.21 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  $1^\circ$  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 Figs. 2 and 3 and Practice E 809. The tolerance on entrance angle shall be  $\pm 0.5^\circ$ .

10.1.1 If the markers are mounted in a holder photometer the markers in the holder, and if the holder shadows the retroreflective area divide the measured coefficient of luminous intensity by the ratio of the unshadowed retroreflective area to the total retroreflective area for comparison with Table 1.

### 10.2 *Determination of Abrasion Resistance:*

10.2.1 Select at random four retroreflective faces previously passing the photometric test of 10.1.

10.2.2 Place on the selected retroreflective face a  $25.4 \pm 5$ -mm ( $1 \pm 0.2$ -in.) diameter flat pad of No. 3 coarse steel wool conforming to Federal Specification FF-W-1825A. Apply a load of  $22 \pm 0.2$  kg ( $50 \pm 0.5$  lb) and rub the entire surface 100 times.

10.2.3 Photometer in accordance with 10.1.

10.2.4 Remove markers mounted in a holder for abrasion and photometry after abrasion.

10.3 *Color*—Measure color in accordance with Practice E 811 at  $0.2^\circ$  observation angle and  $0^\circ$  entrance angle. The source and receptor angular aperture shall each be 6 min of arc.

### 10.4 *Adhesive Bond Strength:*

#### 10.4.1 *For Markers Intended to Be Installed in Recesses:*

10.4.1.1 Measure adhesive bond strength in accordance with Sections 12 and 13 of AASHTO No. T237 but substitute a pavement marker for the concrete block and a 25.4-mm (1.0-in.) diameter plug for the specified 50.8-mm (2.0-in.) plug. Position the pavement marker against a test plate having a hole through which the plug can be inserted and attached to a tensile member.

10.4.1.2 Adhesive used for test should conform to AASHTO No. M237, Type 1.

10.4.1.3 Conditioning temperature for components shall be  $23.0 \pm 2.0^\circ\text{C}$  ( $73.4 \pm 3.6^\circ\text{F}$ ).

10.4.1.4 Cure the assembly for 24 h at  $23.0 \pm 2.0^\circ\text{C}$  ( $73.4 \pm 3.6^\circ\text{F}$ ).

10.4.1.5 Rate of loading shall be 5.1 mm (0.2 in.)/min.

#### 10.4.2 *For Markers Installed in Holders:*

10.4.2.1 Adhere a 25.4-mm (1.0-in.) diameter pipe plug to the center of the top surface of the marker with epoxy conforming to AASHTO No. M237, Table 1. Allow 24 h cure at  $23.0 \pm 2.0^\circ\text{C}$  ( $73.4 \pm 3.6^\circ\text{F}$ ).

10.4.2.2 Position the holder against a test plate having a hole through which the plug can be inserted and attached to a tensile member. The hole shall be large enough that it will permit the marker to pass through.

10.4.2.3 Determine force required to separate the marker from the holder at a rate of loading of 5.1 mm (0.2 in.)/min.

#### 10.4.3 *For Replacement Markers Not Installed in Holders:*