Designation: D4383 – 21

Standard Specification for Plowable, Raised Retroreflective Pavement Markers[1]

This standard is issued under the fixed designation D4383; 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 several types of plowable, retroreflective pavement markers for lane marking and delineation.

1.2 Retroreflective markers are intended for nighttime visibility under both wet and dry conditions.

1.3 The values stated in inch-pound 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.

1.4 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.5 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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]

A536 Specification for Ductile Iron Castings
C778 Specification for Standard Sand
D5/D5M Test Method for Penetration of Bituminous Materials
D36/D36M Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)
D71 Test Method for Relative Density of Solid Pitch and Asphalt (Displacement Method)
D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester
D113 Test Method for Ductility of Asphalt Materials
D1785 Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
D3111 Practice for Flexibility Determination of Hot-Melt Adhesives by Mandrel Bend Test
D4280 Specification for Extended Life Type, Nonplowable, Raised Retroreflective Pavement Markers
D4402/D4402M Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer
E18 Test Methods for Rockwell Hardness of Metallic Materials
E284 Terminology of Appearance
E308 Practice for Computing the Colors of Objects by Using the CIE System
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E808 Practice for Describing Retroreflection
E809 Practice for Measuring Photometric Characteristics of Retroreflectors
E811 Practice for Measuring Colorimetric Characteristics of Retroreflectors Under Nighttime Conditions

2.2 *Federal Specification:*[3]

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

2.3 *AASHTO Standard:*[4]

AASHTO M 237 Epoxy Resin Adhesive for Bonding Traffic Markers to Hardened Concrete

[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.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

[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.

3. Terminology

3.1 *Definitions:*

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

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 E808 and Terminology E284).

3.1.2.1 *Discussion*—The values presented for the coefficient of luminous intensity are presented in SI units, which are the accepted worldwide norm for expressing this value, rather than in inch-pounds units. 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 foot-candle (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*—expressed by chromaticity coordinates according to the CIE (Commission Internationale de l'Eclairage 1931) standard 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 component β2 when the marker is positioned for photometry. (See Practice E808.) The direction given in Practice E808 should be used when designating this angle.

3.1.5 *observation angle*—the angle at the reflector between the illumination axis and the observation axis. (See Practice E808.)

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *retroreflective pavement markers, 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 holder sometimes used to protect markers from plow blades where the lens is positioned above the pavement surface or used to hold the lens when positioned below the pavement surface (inlaid). The holder may be metallic, nonmetallic, or a combination of both metallic and nonmetallic components.

4. Classification

4.1 Markers shall be classified as to type, color, and category (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 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 Category 1: Marker mounted in a metallic holder and installed in a plunge cut in the pavement in such a manner that the marker protrudes above the pavement surface.

4.1.3.2 Category 2: Marker mounted in a holder consisting of a nonmetallic body with metallic rails that provide the marker protection from the plows and installed in a plunge cut in the pavement in such a manner that the marker protrudes above the pavement surface.

4.1.3.3 Category 3: Marker mounted in a nonmetallic holder and installed in a plunge cut groove in the pavement in such a manner that the marker is recessed below the pavement surface.

4.1.3.4 Category 4: Conventional, nonplowable marker installed in a recess below the pavement surface.

4.1.4 Show classification in the order detailed in 4.1.1 – 4.1.3: type, color, and category.

4.2 Category 1 and 2 holders shall be classified as to the design installed height of the holder above the pavement surface.

4.3 Category 3 holders shall be classified as to the designed depth of both the groove and the plunge cut for marker placement that would allow the marker residing in the holder to be positioned below the surface of the pavement at a minimum of 0.12 in. (3.0 mm).

4.4 Category 4 markers shall be classified as to the designed depth of the cut for placement that would allow the marker to be positioned below the surface of the pavement at a minimum of 0.06 in. (1.5 mm).

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 for Category 1 and 2 markers.

5.2.2 Design installed length and minimum depth of the groove and placement and minimum depth of the plunge cut for Category 3 markers.

6. Performance Requirements

6.1 *Retroreflectivity:*

6.1.1 For new markers, coefficient of luminous intensity (RI) measured in accordance with 10.1 shall be not less than the values in Table 1.

6.1.2 After abrading the marker per 10.2, coefficient of luminous intensity at 0° entrance angle measured in accordance with 10.1 shall be not less than the values in Table 1 multiplied by 0.5.

TABLE 1 Coefficient of Luminous Intensity R_I

NOTE 1—The retroreflector axis and datum axis of the marker are as shown in Figs. 2 and 3.

NOTE 2—Entrance angle component β1 and rotation angle ε are 0°.

NOTE 3—The values presented for the coefficient of luminous intensity in the table are given in SI units, which are the accepted worldwide norm for expressing this value, rather than in inch-pound units. The values in *cd/fc* are provided for information.

Entrance Angle 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 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	0.40	0.11

NOTE 1—No laboratory abrasion test has been established for markers having biconvex optical elements.

NOTE 2—Some two-color markers may intentionally have only one of the retroreflective faces abrasion resistant, in which case the second face should not be abraded.

NOTE 3—No laboratory abrasion test can be expected to model the full range of surface wear of pavement markers in use.

6.2 *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:

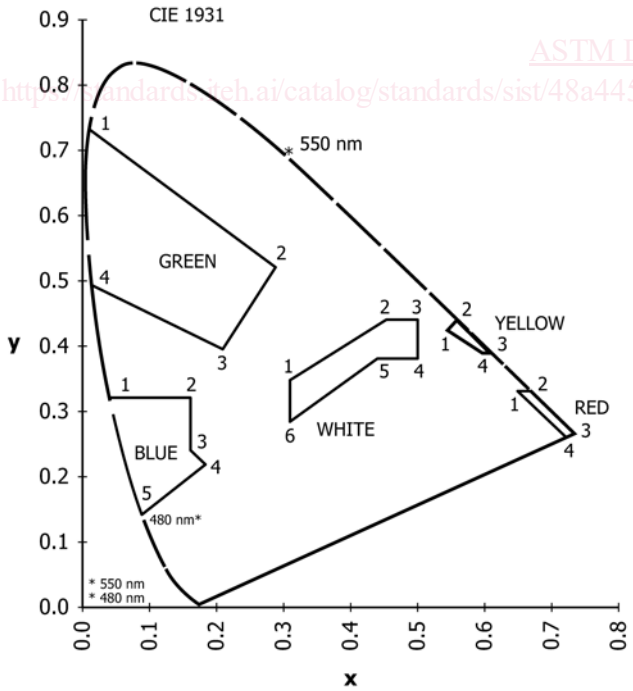

FIG. 1 Color Gamut per 6.2

6.2.1 *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

6.2.2 *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

6.2.3 *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 *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

6.2.5 *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

6.3 *Lens Impact Strength*—When impacted in accordance with 10.4.2, the face of the lens shall show no more than two radial cracks longer than 0.25 in. (6.4 mm). There shall be no radial cracks extending to the edge of the abrasion-resistant area. There shall be no delamination.

6.4 *Temperature Cycling*—When subjected to temperature cycling in accordance with 10.4.3, there shall be no cracking or delamination.

6.5 *Adhesive Bond Strength*—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 twelve 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× 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.

6.6 *Compressive Strength*—Tested in accordance with 10.5, a marker shall support a load of 6000 lbf (26 700 N, 2720 kgf) without breakage or significant deformation of the marker. Significant permanent deformation shall be understood to be 0.13 in. (3.2 mm). For markers laminated to an elastomeric pad, remove the pad before testing.

6.7 *Ramp Hardness of Category 1 and 2 Holders*—Measured in accordance with 10.6, the hardness of the ramps shall be 51-55 HRC.

7. Construction Requirements for Retroreflective Markers

7.1 To withstand plowing, snow-plowable 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 plow blades, mounting in a nonmetallic holder and recessing within a groove below the pavement surface, or by other methods approved by the purchaser.

7.2 *Retroreflective Markers:*

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

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

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 0.05 in. (1.3 mm). If the bottom of the marker is configurated, the outermost faces of the configurations shall not deviate more than 0.05 in. (1.3 mm) 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 *Category 1 and 2 Holders* (designed to position the lens above the pavement surface)*:*

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

7.3.2 The Category 1 holders and the ramps of Category 2 holders shall be nodular iron, conforming to Specification A536, Grade 80-55-06, hardened to 51-55 HRC, when tested according to Test Methods E18.

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. It shall have means for indexing the pavement surface, such as tabs.

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.

7.4 *Category 3 Holders* (designed to position the lens below the pavement surface)*:*

7.4.1 The holder shall be constructed of a nonmetallic material of sufficient strength to withstand the environmental conditions to which it is exposed during in-service life.

7.4.2 The installed depth of the holder shall not exceed 1.0 in. (25.4 mm) below the road surface.

7.4.3 The holder shall be designed to be recessed below the pavement surface to withstand plow impact. It shall have means for indexing the pavement surface, such as tabs.

7.4.4 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 ten 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 (6.1.2), 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 compressive strength (6.6) and color (6.2), 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 compressive strength. Failure of more than one specimen shall be cause for rejection of the lot.

9.4 For lens impact strength (6.3), resistance to temperature cycling (6.4), 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 In the event of failure that would result in rejection of a lot, and at the direction 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 – 9.4.

10. Test Methods

10.1 *Coefficient of Luminous Intensity:*

10.1.1 *Procedure*—Measure coefficient of luminous intensity in accordance with Practice E809. 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 0.21 in. (5.3 mm) diameter, suggested test dimensions are 50 ft (15.2 m) distance, 1.0 in. (25.4 mm) diameter receptor and 1.0 in. (25.4 mm) 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 Figs. 2 and 3 and Practice E809. 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°. Maintain laboratory and condition markers to 73.4 ± 3.6 °F (23 ± 2 °C), 50 ± 25 % RH.

10.1.2 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.

10.1.3 Before photometry, gently wipe the face of the marker with a soft damp towel, then dry with a soft towel.

10.1.4 *Interlaboratory Study of Precision:*

10.1.4.1 The calculations, results, and terminology used to prepare this statement follow Practice E691.

10.1.4.2 A set of markers conforming to this specification was photometered at six laboratories. The set comprised 150 lenses, equally divided among the five colors of 6.2 and also equally divided among three optical types: those having prisms approximately 0.1 in. (2.5 mm) in diameter; those having prisms approximately 0.012 in. (0.3 mm) in diameter; and those having discrete biconvex elements.

NOTE 4—The sample markers met the dimensional requirements of Specification D4280. The results of the interlaboratory study are applicable also to markers meeting the dimensional requirements of the present specification.

10.1.4.3 Each laboratory photometered each lens at 0.2° observation angle at each of 0°, +20°, and –20° entrance angles in accordance with 10.1.1, and the measurements were repeated on a second day.

10.1.4.4 The precision statistics are given in Table 2. For each lens, precision statistics were calculated as percentages of the interlaboratory mean R_I value for that lens. The precision statistics were averaged over the ten specimens of like color and optical type. The precision statistics for +20° entrance angle and for –20° entrance angle were averaged for the reported ±20° entrance angle. The differences in precision statistics among the five colors were small enough to allow average values to be reported. The differences in precision statistics among the three optical types were small enough to allow average values to be reported.

10.1.4.5 There is no estimate of bias. There is no reference laboratory in North America by which to establish bias for this measurement.

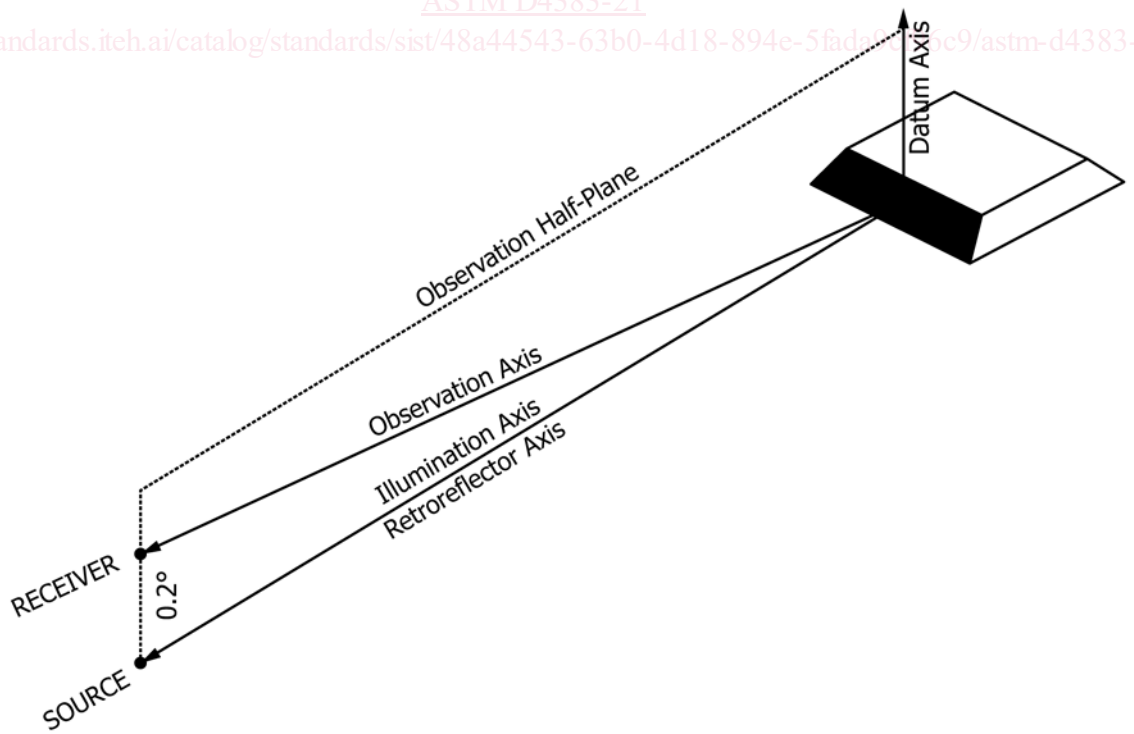

FIG. 2 Position of Marker for Photometry, 0° Entrance Angle

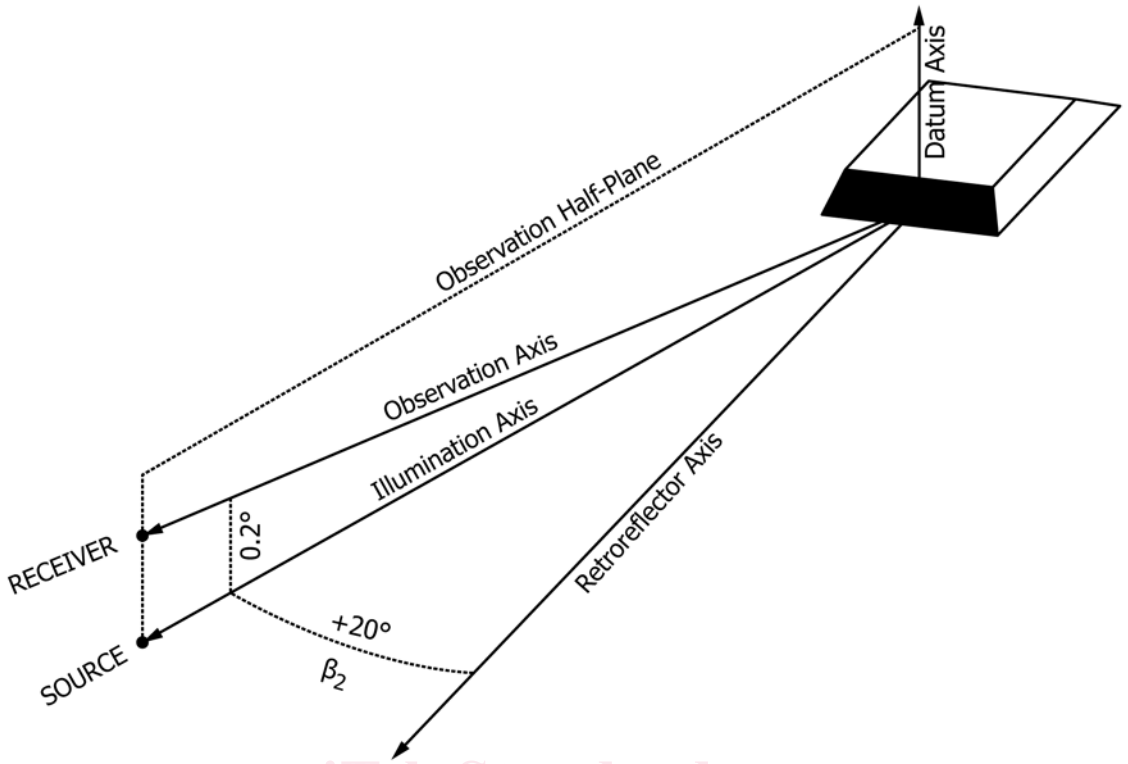

FIG. 3 Position of Marker for Photometry, +20° Entrance Angle

TABLE 2 Precision for Coefficient of Luminous Intensity

Entrance Angle	S_r Repeatability Standard Deviation	S_R Reproducibility Standard Deviation	r 95 % Repeatability Limit	R 95 % Reproducibility Limit
0°	1.5 %	6.7 %	4.1 %	18.5 %
±20°	4.0 %	9.0 %	11.1 %	25.0 %

10.2 *Abrasion Resistance:*

10.2.1 The abrasion resistance test method is only applicable to markers having a smooth, continuous lens surface.

10.2.2 Sand shall fall 9.8 ± 0.1 ft (3.00 ± 0.03 m) uniformly onto the front of a marker having its retroreflector axis vertical. Distance shall be measured to the marker's leading edge.

10.2.3 Sand shall be natural silica sand from the St. Peters or Jordan sandstone deposits (located in the central United States) and shall meet the requirements of Specification C778 20-30 sand, and under no circumstances shall sand labeled "ASTM C778 Graded Sand" be substituted.

10.2.3.1 This sand is characterized by its roundness of grains and its exceptionally high silicon dioxide content.

10.2.4 Sand shall not be reused.

10.2.5 Sand shall fall at least 9.4 ft (2.85 m) before reaching a calibration aperture, a horizontal rectangular opening 1.57 ± 0.04 in. (4.0 ± 0.1 cm) by 4.72 ± 0.04 in. (12.0 ± 0.1 cm), under which the marker is centered with the marker width in the 4.72 in. (12 cm) direction.

10.2.6 A total of 2.5 ± 0.05 kg of sand shall fall through a calibration aperture at a rate maintained in the range from 0.4 to 1.0 kg/min.

10.2.7 The abrasion resistance test shall be performed at 25 ± 5 °C and 50 ± 25 % RH, with the markers pre-conditioned to those ranges.

10.2.8 *Abrasion Apparatus:*

10.2.8.1 The apparatus shall consist of a vertical pipe with a sieve at the top, a calibration aperture with deflectors at the bottom, a marker support, and a means for collecting the sand that passes through the calibration aperture.

10.2.8.2 Sand shall fall within the full unobstructed pipe from the sieve to the plane of the calibration aperture.

10.2.8.3 The pipe shall have inner diameter at least 5.9 in. (15 cm). Smooth plastic pipe conforming to Specification D1785 may be used. The pipe shall be within 0.2° of vertical.

10.2.8.4 The sieve shall be used to establish the beginning point of the sand drop and also to limit sand flow. Sand may fall no more than 1.2 in. (3 cm) onto the sieve.

10.2.8.5 The calibration aperture shall be formed from four sharp horizontal edges which are the upper edges of angled deflectors. See Fig. 4. Sand falling within the calibration aperture is not deflected; sand falling outside the calibration aperture is deflected away from the aperture and cannot strike the marker.

10.2.8.6 The marker shall be mounted with its leading edge no farther than 5.9 in. (15 cm) from the plane of the calibration aperture. The marker shall be mounted with no fixturing within 1 cm of its front face. Fixturing must be such to allow free flow of sand around the marker. Plane of marker base shall be within 1° of vertical. Marker leading edge shall be within 2° of horizontal.

10.2.8.7 All sand passing through the calibration aperture, including any that bounces off the marker, must be collected

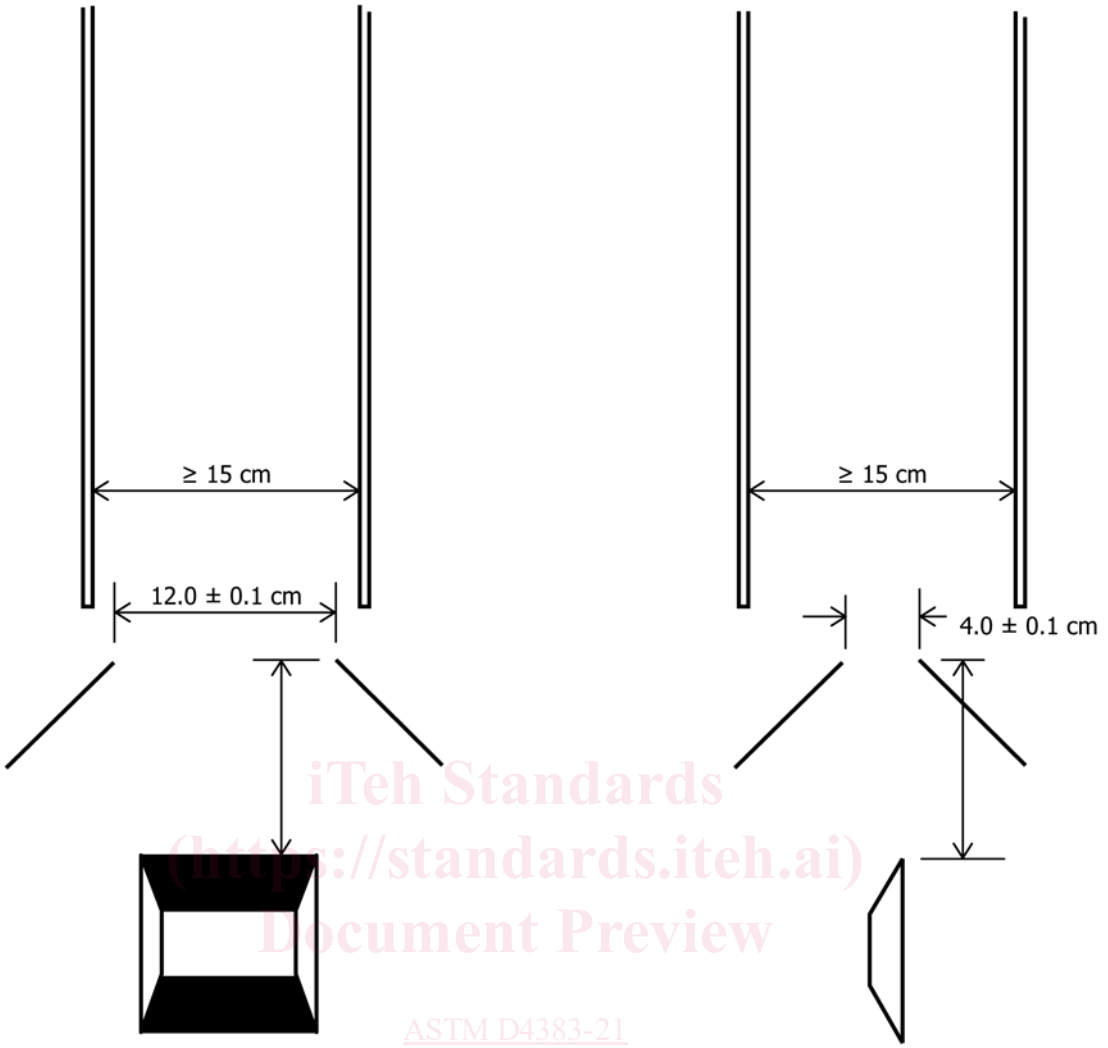

FIG. 4 Abrasion Resistance Test Apparatus

and weighed. Sand that does not pass through the calibration aperture must not be included in this weight.

10.2.8.8 Sand must flow equally through all parts of the calibration aperture. This shall be verified by placing at least ten vials having approximately 0.4-in. (1-cm) mouths at the height of the marker under the aperture. When enough sand has dropped through the apparatus that at least one of the vials has received at least 0.2 oz (5 g), the least filled vial shall have received at least 75 % as much weight of sand as the most filled vial. After determining the flow stability of the apparatus, verify uniformity as often as necessary.

10.2.9 *Interlaboratory Study of Precision:*

10.2.9.1 The calculations, results, and terminology used to prepare this statement follow Practice E691, except for minor modifications to accommodate the unequal numbers of samples tested at the participating laboratories.

10.2.9.2 The measured quantity is the unitless ratio of the coefficient of luminous intensity (R_I) at 0° entrance angle after abrasion to the coefficient of luminous intensity (R_I) at 0° entrance angle before abrasion. The repeatability of the measurement therefore depends on both the repeatability of the R_I measurement and the repeatability of the abrasion. The reproducibility of the measurement depends primarily on the reproducibility of the abrasion.

10.2.9.3 The sample markers were of three types: LPG, LPC, SPC, depending on their optics and front surface. *LP* denotes having prisms approximately 0.1 in. (2.5 mm) in diameter and *SP* denotes having prisms approximately 0.01 in. (0.3 mm) in diameter. *G* denotes glassed and *C* denotes coated. The markers of each type were as identical as practical manufacturing allowed. All reflectors were white.

NOTE 5—The sample markers met the dimensional requirements of Specification D4280. The results of the interlaboratory study are applicable also to markers meeting the dimensional requirements of the present specification.

10.2.9.4 The study included four laboratories. Each laboratory photometered, abraded, and re-photometered between ten and 20 markers of each type. Markers were conditioned to within 3.6 °F (2 °C) for the pre-abrasion and post-abrasion photometry.

10.2.9.5 The precision statistics are given in Table 3.

10.2.9.6 The data given in Table 4 suggest upper limits to the contribution of manufacturing variation within the three types to the precision statistics.