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Standard Specification for Retroreflective Sheeting for Traffic Control[1]

This standard is issued under the fixed designation D 4956; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers flexible, non-exposed glass bead lens and microprismatic, retroreflective sheeting designed for use on traffic control signs, delineators, barricades, and other devices.

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

1.3 The following safety hazards caveat pertains only to the test methods portion, Section 7, 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:*

B 209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate[2]

B 209M Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric][2]

B 449 Practice for Chromate Treatments on Aluminum[3]

D 523 Test Method for Specular Gloss[4]

E 284 Terminology of Appearance[4]

E 308 Practice for Computing the Colors of Objects by Using the CIE System[4]

E 808 Practice for Describing Retroreflection[4]

E 810 Test Method for Coefficient of Retroreflection or Retroreflective Sheeting[4]

E 991 Practice for Color Measurement of Fluorescent Specimens[4]

E 1164 Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation[4]

E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry[4]

E 1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry[4]

G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials[5]

G 23 Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials[5]

G 147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests[5]

G 152 Practice for Operating Open-Flame Carbon-Arc Light Apparatus for Exposure of Nonmetallic Materials[5]

G 153 Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials[5]

2.2 *Federal Specifications:*

FP-92 Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects[6]

L-S-300C Federal Specification for Sheeting and Tape, Reflective: Non Exposed Lens[7]

2.3 *AASHTO Specification:*

M 268-84 I[8]

3. Terminology

3.1 *Definitions*—Definitions of terms are as described in Terminology E 284 and Practice E 808.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *reboundable sheeting, n*—retroreflective material intended to be attached to flexible impact resistant plastic devices, such as traffic drum-like channelizing devices.

4. Classification

4.1 Retroreflective sheeting shall consist of a white or colored sheeting having a smooth outer surface and that essentially has the property of a retroreflector over its entire surface. There are six types and five classes of retroreflective sheeting. Typical examples of materials and applications are provided for descriptive information only and are not intended to be limitations or recommendations.

[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 Materials.

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[2] *Annual Book of ASTM Standards*, Vol 02.02.

[3] *Annual Book of ASTM Standards*, Vol 02.05.

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

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

[6] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[7] Available from General Services Administration, 470 East L'Enfant Plaza S.W., Suite 8100, Washington, DC 20407.

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

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4.1.1 The typical applications for the retroreflective sheeting addressed in this specification are:

Type	Typical Application
I	Highway Signing, construction-zone devices, and delineators
II	Highway Signing, construction-zone devices, and delineators
III	Highway Signing, construction-zone devices, and delineators
IV	Highway Signing, construction-zone devices, and delineators
V	Delineators
VI	Temporary roll-up signs, warning signs, traffic cone collars, and post bands

4.2 Retroreflective sheeting shall be classified as follows:

4.2.1 *Type I*—A medium-intensity retroreflective sheeting referred to as "engineering grade" and typically enclosed lens glass-bead sheeting. Typical applications for this material are permanent highway signing, construction zone devices, and delineators.

4.2.2 *Type II*—A medium-high-intensity retroreflective sheeting sometimes referred to as "super engineering grade" and typically enclosed lens glass-bead sheeting. Typical applications for this material are permanent highway signing, construction zone devices, and delineators.

4.2.3 *Type III*—A high-intensity retroreflective sheeting, that is typically encapsulated glass-bead retroreflective material. Typical applications for this material are permanent highway signing, construction zone devices, and delineators.

4.2.4 *Type IV*—A high-intensity retroreflective sheeting. This sheeting is typically an unmetallized microprismatic retroreflective element material. Typical applications for this material are permanent highway signing, construction zone devices, and delineators.

4.2.5 *Type V*—A super-high-intensity retroreflective sheeting. This sheeting is typically a metallized microprismatic retroreflective element material. This sheeting is typically used for delineators.

4.2.6 *Type VI*—An elastomeric high-intensity retroreflective sheeting without adhesive. This sheeting is typically a vinyl microprismatic retroreflective material. This sheeting is typically used for orange temporary roll-up warning signs, traffic cone collars, and post bands.

4.3 *Backing Classes*— The backing required for retroreflective sheeting Types I through V shall be classified as follows:

4.3.1 *Class 1*—The adhesive backing shall be pressure-sensitive, require no heat, solvent, or other preparation for adhesion to smooth, clean surfaces.

4.3.2 *Class 2*—The adhesive backing shall have an adhesive that shall be activated by applying heat and pressure to the material. The temperature necessary to form a durable permanent bond shall be a minimum of 150°F (66°C).

4.3.2.1 The Class 2 material shall be repositionable under normal shop conditions and at substrate temperatures up to 100°F (38°C) and without damage to the material. The Class 2 material may be perforated to facilitate removal of air in heat-vacuum laminators, but the perforations must be of a size and frequency such that they do not cause objectionable blemishes when the sheeting is printed.

4.3.3 *Class 3*—The adhesive backing shall have a positionable low-tack pressure-sensitive adhesive that requires no heat, solvent, or other preparation for adhesion to smooth, clean surfaces. It shall be repositionable up to a temperature of 100°F (38°C) without damage to the material.

4.3.4 *Class 4*—The adhesive backing shall have a low-temperature pressure-sensitive adhesive that permits sheeting applications at temperatures down to + 20°F (−7°C) without the aid of heat, solvent, or other preparation for adhesion to smooth, dry, clean surfaces.

4.3.5 *Class 5*—This shall be a nonadhesive backing made of material commercially used for self-supporting products such as traffic cone collars, temporary roll-up warning signs, and post bands.

5. Ordering Information

5.1 The purchaser using this specification shall include the following information:

5.1.1 ASTM designation (D 4956),

5.1.2 Classification type (see Section 4),

5.1.3 Adhesive class (see 4.3),

5.1.4 Daytime color (see 6.3),

5.1.5 Length and width of sheets (see 8.1),

5.1.6 Length and width of rolls (see 8.2), and

5.1.7 Supplementary information, if required by the purchaser.

5.1.7.1 Compliance with the minimum coefficient of retroreflection for 0.1° observation angle is a supplementary requirement which shall apply only when specified. An observation angle of 0.1° may be specified where the long distance performance of a sheeting is to be a requirement,

5.1.7.2 Fungus-resistance testing requirements (see Supplementary Requirement S1),

5.1.7.3 Reboundable sheeting requirements (see Supplementary Requirement S2), and

5.1.8 Any additional information.

6. Performance Requirements

6.1 This is a summary of the minimum performance requirements for each type of retroreflective sheeting.

6.1.1 *Type I*—Minimum Coefficient of Retroreflection—Table 1; Outdoor Weathering—24 months, see 6.4; Reflectance or Daytime Luminance—Table 2; Other requirements: When the colors orange, yellow, or white are specified for construction work zone applications, the outdoor weathering will be 12 months.

6.1.2 *Type II*—Minimum Coefficient of Retroreflection—Table 3; Outdoor Weathering—36 months, see 6.4; Reflectance or Daytime Luminance—Table 2; Other requirements: When the colors orange, yellow, or white are specified for construction work zone application, the outdoor weathering will be 12 months.

6.1.3 *Type III*—Minimum Coefficient of Retroreflection—Table 4; Outdoor Weathering—36 months, see 6.4; Reflectance

TABLE 1 Type I Sheeting[A]

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	−4°	70	50	25	9.0	14	4.0	1.0
0.2°	+ 30°	30	22	7.0	3.5	6.0	1.7	0.3
0.5°	− 4°	30	25	13	4.5	7.5	2.0	0.3
0.5°	+ 30°	15	13	4.0	2.2	3.0	0.8	0.2

[A] Minimum Coefficient of Retroreflection (R_A) cd/fc/ft^2(cd·lx^{-1}·m^{-2}).

TABLE 2 Luminance Factor (*Y* %) (Daytime Luminance)[A]

Color	Minimum	Maximum
White	27	...
Yellow	15	45
Orange	14	30
Green	3.0	9.0
Red	2.5	12
Blue	1.0	10
Brown	4.0	9.0

[A]For Sheeting Types I, II, III and VI.

TABLE 3 Type II Sheeting[A]

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	−4°	140	100	60	30	30	10	5.0
0.2°	+ 30°	60	36	22	10	12	4.0	2.0
0.5°	− 4°	50	33	20	9.0	10	3.0	2.0
0.5°	+ 30°	28	20	12	6.0	6.0	2.0	1.0

[A]Minimum Coefficient of Retroreflection (R_A) cd/fc/ft^2(cd·lx $^{-1}$·m^{-2}).

TABLE 4 Type III Sheeting[A]

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.1°[B]	−4°	300	200	120	54	54	24	14
0.1°[B]	+ 30°	180	120	72	32	32	14	10
0.2°	− 4°	250	170	100	45	45	20	12
0.2°	+ 30°	150	100	60	25	25	11	8.5
0.5°	−4°	95	62	30	15	15	7.5	5.0
0.5°	+ 30°	65	45	25	10	10	5.0	3.5

[A]Minimum Coefficient of Retroreflection (R_A) cd/fc/ft ^{2}(cd·lx^{-1}·m^{-2}).
[B]Values for 0.1° observation angle are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

or Daytime Luminance—Table 2; Other Requirements: When the colors orange, yellow, or white are specified for construction work zone applications, the outdoor weathering will be 12 months.

6.1.4 *Type IV*—Minimum Coefficient of Retroreflection—Table 5; Outdoor Weathering—36 months, see 6.4; Reflectance or Daytime Luminance—Table 6; Other Requirements: When the colors orange, yellow, or white are specified for construction work zone applications, the outdoor weathering will be 12 months.

6.1.5 *Type V*—Minimum Coefficient of Retroreflection—Table 7; Outdoor Weathering—36 months, see 6.4; Reflectance or Daytime Luminance—Table 8; Other requirements: When the colors orange, yellow, or white are specified for construction work zone applications, the outdoor weathering will be 12 months.

6.1.6 *Type VI*—Minimum Coefficient of Retroreflection—Table 9; Outdoor Weathering—6 months, see 6.4; Reflectance

TABLE 5 Type IV Sheeting[A]

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.1°[B]	−4°	400	270	160	56	56	32	12
0.1°[B]	+ 30°	120	75	48	13	13	7	3.0
0.2°	− 4°	250	170	100	35	35	20	7.0
0.2°	+ 30°	80	54	34	9	9	5.0	2.0
0.5°	−4°	135	100	64	17	17	10	4.0
0.5°	+ 30°	55	37	22	6.5	6.5	3.5	1.4

[A]Minimum Coefficient of Retroreflection (R_A) cd/fc/ft ^{2}(cd·lx^{-1}·m^{-2}).
[B]Values for 0.1° observation angle are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

TABLE 6 Luminance Factor (*Y* %) (Daytime Luminance)[A]

Color	Minimum	Maximum
White	50	...
Yellow	30	45
Orange	15	30
Green	6.0	15
Red	4.0	15
Blue	3.0	8.0
Brown	1.0	6.0

[A](Typically Non-Metalized Microprismatic Material) For Sheeting Type IV.

TABLE 7 Type V Sheeting[A]

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue
0.1°[B]	−4°	2000	1300	800	360	360	160
0.1°[B]	+ 30°	1100	740	440	200	200	88
0.2°	− 4°	700	470	280	120	120	56
0.2°	+ 30°	400	270	160	72	72	32
0.5°	−4°	160	110	64	28	28	13
0.5°	+ 30°	75	51	30	13	13	6.0

[A]Minimum Coefficient of Retroreflection (R_A) cd/fc/ft^2(cd·lx^{-1}·m $^{-2}$).
[B]Values for 0.1° observation angle are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

TABLE 8 Luminance Factor (*Y* %) (Daytime Luminance)[A]

Color	Minimum	Maximum
White	15	...
Yellow	12	30
Orange	7.0	25
Green	2.5	11
Red	2.5	11
Blue	1.0	10
Brown	1.0	9.0

[A](Typically Metalized Microprismatic Delineator Material) For Sheeting Type V.

TABLE 9 Type VI Sheeting[A]

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue
0.1°[B]	−4°	400	280	100	72	80	40
0.1°[B]	+ 30°	110	77	26	20	22	11
0.2°	− 4°	250	170	70	30	35	20
0.2°	+ 30°	95	64	26	11	13	7.6
0.5°	−4°	200	136	56	24	28	18
0.5°	+ 30°	60	40	17	7.2	8.4	4.8

[A]Minimum Coefficient of Retroreflection (R_A) cd/fc/ft^2(cd·lx^{-1}·m $^{-2}$).
[B]Values for 0.1° observation angle are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

or Daytime Luminance—Table 2.

6.2 *Coefficient of Retroreflection*—The coefficient of retroreflection shall meet or exceed the minimum requirements of Table 1, Tables 3-5, Table 7 and Table 9 as specified in 7.3.

6.3 *Daytime Color*—The color of the sheeting shall conform to requirements of Table 10 and one of the following Table 2, Table 6, or Table 8 when tested in accordance with 7.4. Daytime and nighttime color shall have substantially the same hue.

6.4 *Accelerated Outdoor Weathering Requirements*—The retroreflective sheeting shall be weather resistant and show no appreciable cracking, scaling, pitting, blistering, edge lifting, or curling, or more than 1/32-in. (0.8-mm) shrinkage or expansion when tested in accordance with 7.6. Conduct retroreflectivity measurements after outdoor weathering at 0.2° observation and −4° and +30° entrance angles. The minimum

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TABLE 10 Color Specification Limits (Daytime)[A]

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404
Green[B]	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346
Blue[B]	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390

[A]The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimetric System measured with CIE Standard Illuminant D65.

[B]The saturation limit of green and blue may extend to the border of the CIE chromaticity locus for spectral colors.

coefficient of retroreflection (R_A) after weathering is specified in Table 11.

NOTE 1—Supplementary Requirement S3. describes a method for artificial accelerated weathering which users of this specification may employ for preliminary judgment until outdoor weathering results are available.

6.5 *Colorfastness*—After the specified outdoor weathering, the specimen shall conform to the requirements of Table 10 and one of the following: Table 2, Table 6, or Table 8 when tested in accordance with 7.4 and 7.7.

6.6 *Shrinkage*—The retroreflective sheeting shall not shrink in any dimension more than 1/32 in. (0.8 mm) in 10 min or more than 1/8 in. (3.2 mm) in 24 h when tested in accordance with 7.8.

6.7 *Flexibility*—The sheeting shall be sufficiently flexible to show no cracking when tested in accordance with 7.9.

6.8 *Liner Removal*—The liner, when provided, shall be easily removed without soaking in water or other solutions, and shall not break, tear, or remove adhesive from the sheeting. (See 7.10.)

6.9 *Adhesion*—When tested in accordance with 7.5, the adhesive backing of the retroreflective sheeting shall produce a bond that will support a 1¾-lb (0.79-kg) weight for adhesive classes 1, 2 and 3 or a 1-lb (0.45-kg) weight for adhesive class 4 for 5 min, without the bond peeling for a distance of more than 2 in. (51 mm).

6.10 *Impact Resistance*—Retroreflective sheeting shall show no cracking or delamination outside of the actual area of impact when subjected to the impact test in accordance with 7.11.

6.11 *Specular Gloss*—The retroreflective sheeting shall have a specular gloss of not less than 40 when tested as specified in 7.12.

TABLE 11 Outdoor Weathering Photometric Requirements for All Climates

Type	Months[A]	Minimum Coefficient of Retroreflection, R_A
I	24[B]	50 % of Table 1
II	36[B]	65 % of Table 3
III	36[B]	80 % of Table 4
IV	36[B]	80 % of Table 5
V	36[B]	80 % of Table 7
VI	6	50 % of Table 9

[A]Testing at shorter intervals may be done to gather additional information.

[B]When the colors orange, yellow, or white are specified for construction work zone applications, the outdoor weathering time will be 12 months.

7. Test Methods

7.1 *Test Conditions*—Unless otherwise specified herein, condition all adhesively bonded and unbonded test samples and specimens at a temperature of 73 ± 3°F (23 ± 2°C) and 50 ± 5 % relative humidity for 24 h prior to testing.

7.2 *Panel Preparations*—Unless otherwise specified herein, when tests are to be performed using test panels, apply the specimens of retroreflective material to smooth aluminum cut from Alloy 6061-T6 or 5052-H38, in accordance with Specification B 209. The sheets shall be 0.020 in. (0.508 mm), 0.040 in. (1.016 mm) or 0.063 in. (1.600 mm) in thickness, and a minimum of 8 by 8 in. (200 mm by 200 mm). Prepare the aluminum in accordance with Practice B 449, Class 2, or degrease and lightly acid etch before the specimens are applied. Apply the specimens to the panels in accordance with the recommendations of the retroreflective sheeting manufacturer.

7.3 *Coefficient of Retroreflection*—Determine the coefficients of retroreflection in accordance with Test Method E 810.

7.4 *Color*—Test for Daytime Color:

7.4.1 Determine the chromaticity and luminance factor *Y* (%) in accordance with Test Methods E 308, E 1347, and E 1349 and Practices E 991 and E 1164.

7.4.2 For rotationally non-symmetrical materials, make a series of eight measurements. After each of these measurements, rotate the specimen 45° in the same direction about the axis, normal to the specimen surface and average the data. Make additional measurements until such further measurements do not result in a change in the *Y* value in excess of 1 % of the average to that point.

7.4.3 Instruments (spectrophotometers, colorimeters) used to measure daytime color should have 45/0 or 0/45 illumination and viewing geometry. The illumination angle should not vary from 45° by more than ± 10° and the viewing angle should not vary from 0° by more than ±15°, for the 45/0 condition. For the 0/45 condition, the requirements for illumination are interchanged.

7.5 *Adhesion*—Apply the sheeting to a test panel, 0.040 in. (1.016 mm) minimum thickness, prepared as specified in 7.2. Bond 4 in. (102 mm) of a 1 by 6 in. (25.4 by 152 mm) specimen to a test panel. Condition (see 7.1) and then attach the weight to the free end and allow it to hang free at an angle of 90° to the panel surface for 5 min.

7.6 *Outdoor Weathering*—Conduct outdoor exposures in accordance with Practice G 7. During exposure, test panels shall be open backed and oriented at an angle of 45° from the horizontal and facing the equator in accordance with Practice G 7. Expose two panels per location for the number of months specified in Table 11. Conduct exposures in locations with the climate types shown in Table 12. Panel labeling, and conditioning and handling of panels prior to exposure and during evaluation periods shall be in accordance with Practice G 147.

7.6.1 *Specimen Mounting for Type VI Sheetings*—Clamp the ends of 100 by 300-mm specimens between 25 by 200 by 2-mm 6061T6 aluminum bars and attach these bars to mounting strips on the outdoor exposure rack. Expose the specimens so that the long axis is parallel to the ground so that bolts used to clamp specimen ends do not interfere with attachment to the

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