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Standard Specification for Retroreflective Sheeting for Traffic Control¹

This standard is issued under the fixed designation D4956; 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.

^{ε1} NOTE—Table 13 was editorially corrected in December 2009.

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 standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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:²

B209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate

B209M Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

B449 Specification for Chromates on Aluminum

E284 Terminology of Appearance

E308 Practice for Computing the Colors of Objects by Using the CIE System

E808 Practice for Describing Retroreflection

E810 Test Method for Coefficient of Retroreflection of Retroreflective Sheeting Utilizing the Coplanar Geometry

E811 Practice for Measuring Colorimetric Characteristics of Retroreflectors Under Nighttime Conditions

E991 Practice for Color Measurement of Fluorescent Specimens Using the One-Monochromator Method

E1164 Practice for Obtaining Spectrometric Data for Object-Color Evaluation

E1247 Practice for Detecting Fluorescence in Object-Color Specimens by Spectrophotometry

E1347 Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry

E1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45°:0° or 0°:45°) Geometry

E2152 Practice for Computing the Colors of Fluorescent Objects from Bispectral Photometric Data

E2153 Practice for Obtaining Bispectral Photometric Data for Evaluation of Fluorescent Color

E2301 Test Method for Daytime Colorimetric Properties of Fluorescent Retroreflective Sheeting and Marking Materials for High Visibility Traffic Control and Personal Safety Applications Using 45°:Normal Geometry

G7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials

G147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests

G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G152 Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

3. Terminology

3.1 *Definitions*—Definitions of terms are as described in Terminology **E284** and Practice **E808**.

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

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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.

surface. There are nine types and five classes of retroreflective sheeting. Types are determined by conformance to the retroreflectance, color, and durability requirements listed in 6.1 and may be of any construction providing that those requirements are met. Type designation is provided as a means for differentiating functional performance. Typical examples of applications are provided for descriptive information only and are not intended to be limitations or recommendations. Common identifiers for each type are listed in 4.2.

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
VII	This type designation has been replaced with Type VIII
VIII	Highway signing, construction-zone devices, and delineators
IX	Highway signing, construction-zone devices, and delineators
X	This type designation has been replaced with Type VIII
XI	Highway signing, construction-zone devices, and delineators

4.2 Retroreflective sheeting shall be classified as follows (the type sequence is not indicative of performance level):

4.2.1 *Type I*—A retroreflective sheeting referred to as “engineering grade” that is typically an enclosed lens glass-bead sheeting. Applications for this material include permanent highway signing, construction zone devices, and delineators.

4.2.2 *Type II*—A retroreflective sheeting referred to as “super engineer grade” that is typically an enclosed lens glass-bead sheeting. Applications for this material include permanent highway signing, construction zone devices, and delineators.

4.2.3 *Type III*—A retroreflective sheeting referred to as “high-intensity” that is typically manufactured as an encapsulated glass-bead retroreflective material or as an unmetallized microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators.

4.2.4 *Type IV*—A retroreflective sheeting referred to as “high-intensity” that is typically an unmetallized microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators.

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

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

4.2.7 *Type VII*—Retroreflective sheeting materials previously classified as Type VII have been reclassified as Type VIII. The use of a designation as Type VII has been discontinued.

4.2.8 *Type VIII*—A retroreflective sheeting typically manufactured as an unmetallized cube corner microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators.

4.2.9 *Type IX*—A retroreflective sheeting typically manufactured as an unmetallized cube corner microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators.

4.2.10 *Type X*—Retroreflective sheeting materials previously classified as Type X have been reclassified as Type VIII. The use of a designation as Type X has been discontinued.

4.2.11 *Type XI*—A retroreflective sheeting typically manufactured as an unmetallized cube corner microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators.

NOTE 1—All retroreflective sheetings, but especially microprismatic sheetings, may have unique performance characteristics outside of the range of the standard geometries presented in the tables that define the types. Certain applications may require the use of a particular product within a particular type in order to achieve a desired level of retroreflectivity in a given situation. In these cases, information concerning additional performance characteristics must be obtained.

4.3 *Backing Classes*—The backing required for retroreflective sheeting 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:

TABLE 2 Daytime Luminance Factor (Y%)^A

Color	All except Type V		Type V	
	Minimum	Maximum	Minimum	Maximum
White	27	...	15	
Yellow	15	45	12	30
Orange	10	30	7.0	25
Green	3.0	12	2.5	11
Red	2.5	15	2.5	11
Blue	1.0	10	1.0	10
Brown	1.0	9.0	1.0	9.0
Fluorescent Yellow-Green	60			
Fluorescent Yellow	40			
Fluorescent Orange	20			

^A The luminance factors shown for fluorescent colors consist of the sum of a reflectance luminance factor and fluorescence luminance factor. The luminance factor may be determined using a good approximation to Illuminant D65, requiring an instrument with an appropriately filtered light source, or by using a bispectral photometer conforming to Test Method E2301.

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/ft²(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/ft²(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.

ing is specified for construction work zone applications, the outdoor weathering shall be 12 months.

6.1.6 *Type VI*—Minimum Coefficient of Retroreflection—**Table 7**; Outdoor Weathering—6 months, see 6.4; Daytime Luminance Factor—**Table 2**.

6.1.7 *Type VII*—Retroreflective sheeting materials previously classified as Type VII have been reclassified as Type VIII.

6.1.8 *Type VIII*—Minimum Coefficient of Retroreflection—**Table 8**; Outdoor Weathering—36 months, see 6.4; Daytime Luminance Factor—**Table 2**; Other requirements: When sheeting is specified for construction work zone applications, the outdoor weathering shall be 12 months.

6.1.9 *Type IX*—Minimum Coefficient of Retroreflection—**Table 9**; Outdoor Weathering—36 months, see 6.4; Daytime Luminance Factor—**Table 2**; Other requirements: When sheeting is specified for construction work zone applications, the outdoor weathering shall be 12 months.

6.1.10 *Type X*—Retroreflective sheeting materials previously classified as Type X have been reclassified as Type VIII.

- 5.1.1 ASTM designation (D4956),
- 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),
- 5.1.7 Supplementary information, if required by the purchaser, including:

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), and

5.1.7.3 Reboundable sheeting requirements (see Supplementary Requirement S2),

5.1.8 Indication that the sheeting is intended for work zone use, if applicable, to determine which weathering requirements apply, and

5.1.9 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; Daytime Luminance Factor—**Table 2**; Other requirements: When sheeting is specified for construction work zone applications, the outdoor weathering shall be 12 months.

6.1.2 *Type II*—Minimum Coefficient of Retroreflection—**Table 3**; Outdoor Weathering—36 months, see 6.4; Daytime Luminance Factor—**Table 2**; Other requirements: When sheeting is specified for construction work zone applications, the outdoor weathering shall be 12 months.

6.1.3 *Type III*—Minimum Coefficient of Retroreflection—**Table 4**; Outdoor Weathering—36 months, see 6.4; Daytime Luminance Factor—**Table 2**; Other requirements: When sheeting is specified for construction work zone applications, the outdoor weathering shall be 12 months.

6.1.4 *Type IV*—Minimum Coefficient of Retroreflection—**Table 5**; Outdoor Weathering—36 months, see 6.4; Daytime Luminance Factor—**Table 2**; Other requirements: When sheeting is specified for construction work zone applications, the outdoor weathering shall be 12 months.

6.1.5 *Type V*—Minimum Coefficient of Retroreflection—**Table 6**; Outdoor Weathering—36 months, see 6.4; Daytime Luminance Factor—**Table 2**; Other requirements: When sheet-

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/ft²(cd·lx⁻¹·m⁻²).

TABLE 5 Type IV Sheeting^A

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow-Green	Fluorescent Yellow	Fluorescent Orange
0.1° ^B	−4°	500	380	200	70	90	42	25	400	300	150
0.1° ^B	+30°	240	175	94	32	42	20	12	185	140	70
0.2°	−4°	360	270	145	50	65	30	18	290	220	105
0.2°	+30°	170	135	68	25	30	14	8.5	135	100	50
0.5°	−4°	150	110	60	21	27	13	7.5	120	90	45
0.5°	+30°	72	54	28	10	13	6	3.5	55	40	22

^A Minimum Coefficient of Retroreflection (R_A) cd/ft²(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 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/ft²(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.

6.1.11 *Type XI*—Minimum Coefficient of Retroreflection—**Table 10**; Outdoor Weathering—36 months, see **6.4**; Daytime Luminance Factor—**Table 2**; Other requirements: When sheeting is specified for construction work zone applications, the outdoor weathering shall be 12 months.

6.2 *Coefficient of Retroreflection*—The coefficient of retroreflection shall meet or exceed the minimum requirements for the appropriate type of sheeting (see **Table 1** and **Tables 3-10**) as specified in **7.3**.

6.3 *Daytime Color*—The color of the sheeting shall conform to requirements of **Table 2** and **Table 11** when tested in accordance with **7.4**. Daytime color requirements were developed for a limited set of retroreflective sheetings and a limited set of measurement devices. Measurement techniques appropriate for a wider range of optical technologies and instruments are under development. Some sheeting may require visual assessment to determine the acceptability of daytime appearance.

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 coefficient of retroreflection (R_A) after weathering is specified in **Table 12**.

NOTE 2—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 2** and **Table 11** 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 1 3/4-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 *Nighttime Color*—The nighttime color of the sheeting shall conform to the requirements of **Table 13**, when tested in accordance with **7.12**.

7. Test Methods

7.1 *Test Conditions*—Unless otherwise specified in this specification, 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 in this specification, 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 **B209** or **B209M**. 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 by 200 mm). Prepare the aluminum in accordance with Specification **B449**, 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:

7.3.1 For lots, rolls, or sheets of retroreflective sheeting at least 1 yd long in new (unexposed) condition, take 3 samples in accordance with Section **9.1**. Determine the coefficients of retroreflection in accordance with Test Method **E810**.

TABLE 7 Type VI Sheeting^A

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Fluorescent Yellow-Green	Fluorescent Yellow	Fluorescent Orange
0.1 ^{°B}	-4°	750	525	190	90	105	68	600	450	300
0.1 ^{°B}	+30°	300	210	75	36	42	27	240	180	120
0.2°	-4°	500	350	125	60	70	45	400	300	200
0.2°	+30°	200	140	50	24	28	18	160	120	80
0.5°	-4°	225	160	56	27	32	20	180	135	90
0.5°	+30°	85	60	21	10	12	7.7	68	51	34

^A Minimum Coefficient of Retroreflection (R_A) $\text{cd}/\text{ft}^2(\text{cd}\cdot\text{lx}^{-1}\cdot\text{m}^{-2})$.

^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 Type VIII Sheeting^A

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow-Green	Fluorescent Yellow	Fluorescent Orange
0.1 ^{°B}	-4°	1000	750	375	100	150	45	30	800	600	300
0.1 ^{°B}	+30°	460	345	175	46	69	21	14	370	280	135
0.2°	-4°	700	525	265	70	105	32	21	560	420	210
0.2°	+30°	325	245	120	33	49	15	10	260	200	95
0.5°	-4°	250	190	94	25	38	11	7.5	200	150	75
0.5°	+30°	115	86	43	12	17	5.0	3.5	92	69	35

^A Minimum Coefficient of Retroreflection (R_A) $\text{cd}/\text{ft}^2(\text{cd}\cdot\text{lx}^{-1}\cdot\text{m}^{-2})$.

^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 9 Type IX Sheeting^A

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Fluorescent Yellow-Green	Fluorescent Yellow	Fluorescent Orange
0.1 ^{°B}	-4°	660	500	250	66	130	30	530	400	200
0.1 ^{°B}	+30°	370	280	140	37	74	17	300	220	110
0.2°	-4°	380	285	145	38	76	17	300	230	115
0.2°	+30°	215	162	82	22	43	10	170	130	65
0.5°	-4°	240	180	90	24	48	11	190	145	72
0.5°	+30°	135	100	50	14	27	6.0	110	81	41
1.0°	-4°	80	60	30	8.0	16	3.6	64	48	24
1.0°	+30°	45	34	17	4.5	9.0	2.0	36	27	14

^A Minimum Coefficient of Retroreflection (R_A) $\text{cd}/\text{ft}^2(\text{cd}\cdot\text{lx}^{-1}\cdot\text{m}^{-2})$.

^B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

TABLE 10 Type XI Sheeting^A

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow-Green	Fluorescent Yellow	Fluorescent Orange
0.1 ^{°B}	-4°	830	620	290	83	125	37	25	660	500	250
0.1 ^{°B}	+30°	325	245	115	33	50	15	10	260	200	100
0.2°	-4°	580	435	200	58	87	26	17	460	350	175
0.2°	+30°	220	165	77	22	33	10	7.0	180	130	66
0.5°	-4°	420	315	150	42	63	19	13	340	250	125
0.5°	+30°	150	110	53	15	23	7.0	5.0	120	90	45
1.0°	-4°	120	90	42	12	18	5.0	4.0	96	72	36
1.0°	+30°	45	34	16	5.0	7.0	2.0	1.0	36	27	14

^A Minimum Coefficient of Retroreflection (R_A) $\text{cd}/\text{ft}^2(\text{cd}\cdot\text{lx}^{-1}\cdot\text{m}^{-2})$.

^B Values for 0.1° observation angle are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

7.3.1.1 To conform to this specification, the average of the 3 coefficients of retroreflection shall meet the minimum limits given in Section 6.2 and none of the coefficients of retroreflection obtained on any of the samples shall be less than 80 % of the values required in Section 6.2.

7.4 Daytime Color:

7.4.1 Determine the chromaticity and luminance factor $Y(\%)$ for CIE standard illuminant D65 and the 1931 CIE 2° standard observer in accordance with Practice E308, Test Methods E1347, E1349, and E2301, and Practices E991, E1164, E2152, and E2153, as applicable. The luminance factor is the sum of the reflectance luminance factor and the fluores-

cence luminance factor. Bispectral measurement provides the individual factors, while measurement with simulated D65 provides their sum.

7.4.1.1 For fluorescent specimens, it is necessary either that the physical illumination of the specimen be a good approximation to illuminant D65, requiring an instrument with an appropriately filtered light source, or else that a bispectral photometer conforming to Test Method E2301 be used.

7.4.2 There are three types of 45/0 (0/45) instruments: annular, circumferential, and uniplanar (see Fig. 1). Measurement of prismatic sheeting with circumferential instruments

TABLE 11 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
Fluorescent Yellow-Green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355

^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.

TABLE 12 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 6
VI	6	50 % of Table 7
VIII	36 ^B	80 % of Table 8
IX	36 ^B	80 % of Table 9
XI	36 ^B	80 % of Table 10

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

^B When sheeting is specified for construction work zone applications, the outdoor weathering shall be 12 months.

may require multiple measurements. Measurement of prismatic sheeting with uniplanar instruments definitely requires multiple measurements.

7.4.2.1 If the measurement geometry is circumferential, then the testing laboratory must verify that the apertures in the ring are sufficiently close for acceptable approximation to an annular measurement. This may depend on the optical construction of the specimen, and must be determined by the testing laboratory. Multiple measurements of the same specimen area at different rotations may be averaged to improve the approximation to an annular measurement.

7.4.2.2 If the measurement geometry is uniplanar, then a sequence of measurements shall be made on the same specimen area at incremental rotations, and the measurement values shall be taken as averages over all the rotations. The number of rotations shall be large enough for acceptable approximation to an annular measurement. The number depends on the optical construction of the specimen and must be determined by the testing laboratory.

7.4.3 Instruments (spectrophotometers, colorimeters) used to measure daytime color shall have 45/0 or 0/45 illumination and viewing geometry. The referee instrument shall have 10° apertures for both illumination and viewing. Use of aperture sizes deviating from these may affect the measurement results.

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 G7. 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 G7. Expose two panels per location for the number of months specified in Table 12. Conduct exposures in locations with the climate types shown in Table 14. Panel labeling, and conditioning and handling of panels prior to exposure and during evaluation periods shall be in accordance with Practice G147.

7.6.1 *Specimen Mounting for Type VI Sheetings*—Clamp the ends of 4 by 12-in. (100 by 300-mm) specimens between 1 by 8 by 5/64-in. (25 by 200 by 2-mm) 6061-T6 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 test rack. Fig. 2 is a diagram showing the arrangement of the clamping bars and the test specimen.

7.6.2 *Washing Panels After Exposure*—Following exposure, gently wash the panels using a soft cloth or sponge and clean water or a dilute solution of a mild detergent (1 % by weight in water, maximum concentration). After washing, rinse thoroughly with clean water, and blot dry with a soft clean cloth. After washing and drying, condition the panels at room temperature for at least 2 h prior to conducting any property measurements.

7.6.3 *Measurement of Coefficient of Retroreflection*—After panels have been washed, dried, and conditioned in accordance with 7.6.2, measure retroreflectance at 0.2° observation and –4° and 30° entrance angles. Report the average of the coefficient of retroreflection measured at each geometry on the two panels from each exposure location.

NOTE 3—The use of two samples per weathering deck is considered a minimum and reflects historical practice and practicality. Additional samples may be weathered, and the results averaged, to decrease the effects of variability associated with the weathering process.

NOTE 4—Weathering tests are generally performed less frequently than other tests in this specification. Judgment must be used to satisfy the user that weathering results obtained on exposed samples are sufficiently applicable to the material being supplied.

7.7 *Colorfastness*—Use one of the outdoor weathered specimens to test for colorfastness. Wash, dry, and condition panels in accordance with 7.6.2 and test as specified in 7.4.